NASA-CR-194376

IN-90-CR
185604
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FINAL TECHNICAL REPORT

University of Minnesota Portion of the Coordinated Radio, Electron and Waves Experiment for the NASA Comet Rendezvous and Asteroid Flyby Spacecraft

NASA Grant **NAG5-983**

(NASA-CR-194376) COORDINATED
RADIO, ELECTRON, AND WAVES
EXPERIMENT (CREWE) FOR THE NASA
COMET RENDEZVOUS AND ASTEROID FLYBY
(CRAF) INSTRUMENT Final Technical
Report (Minnesota Univ.) 80 p

N94-12566

Unclas

G3/90 0185604

CRAF CREWE EXPERIMENT

C = Coordinated

R = Radio

E = Electron

W = Wave

E = Experiment

Principal Investigator : Jack D. Scudder

Instrument Manager : Tomasz Zawistowski

NASA Goddard Space Flight Center

ICR 10/10/91 at JPL

§ I: INSTRUMENT DESCRIPTION

SUMMARY OF CREWE SCIENCE

- determine density, bulk velocity and temperature of the electrons
- define the MHD-SW IMF flow configuration,
- clarify the role of impact ionization processes,
- comment on the importance of anomalous ionization phenomena (via wave particle processes
- quantify the importance of wave turbulence in the cometary interaction,
- establish the importance of photoionization via the presence of characteristic lines in a structured energy spectrum,
- infer the presence and grain size of significant ambient dust column density.
- search for the theoretically suggested "impenetrable" contact surface,
- quantify the flow of heat (in the likelihood that no surface exists) that will penetrate very deep into the atmosphere supplying a good deal of heat via impact and charge exchange ionization.

§ I: INSTRUMENT DESCRIPTION

CREWE PERFORMANCE PARAMETERS

Sensors: ....3-D Vector Electron Spectrometer VES
$\Delta E/\bar{E}=0.06$; $0.5\text{eV} < E < 6\text{Kev}$
Fastest Time Resolution = 0.5s (1 AU)
...............2 orthogonal Electric Dipoles
...............3 axis Magnetic Search Coil

was 6MHz

Receivers..............Plasma Spectroscopy Receiver PSR(4kHz-16Mhz)

...............Digital FFT Receiver (4Hz-4kHz)
Monitors: δE^2 (2axis), δB^2(3axis),
electron flux time arrival distribution

...............Time Domain Sampler (DC-100kHz)
Monitors: Magnetic and Electric Antennas
for "events"; keeps best for TM

...............Multiplexes: Packets from δE^2 and δB^2
and N_e and T_e measurements determined
on board from VES, Sounder or PSR

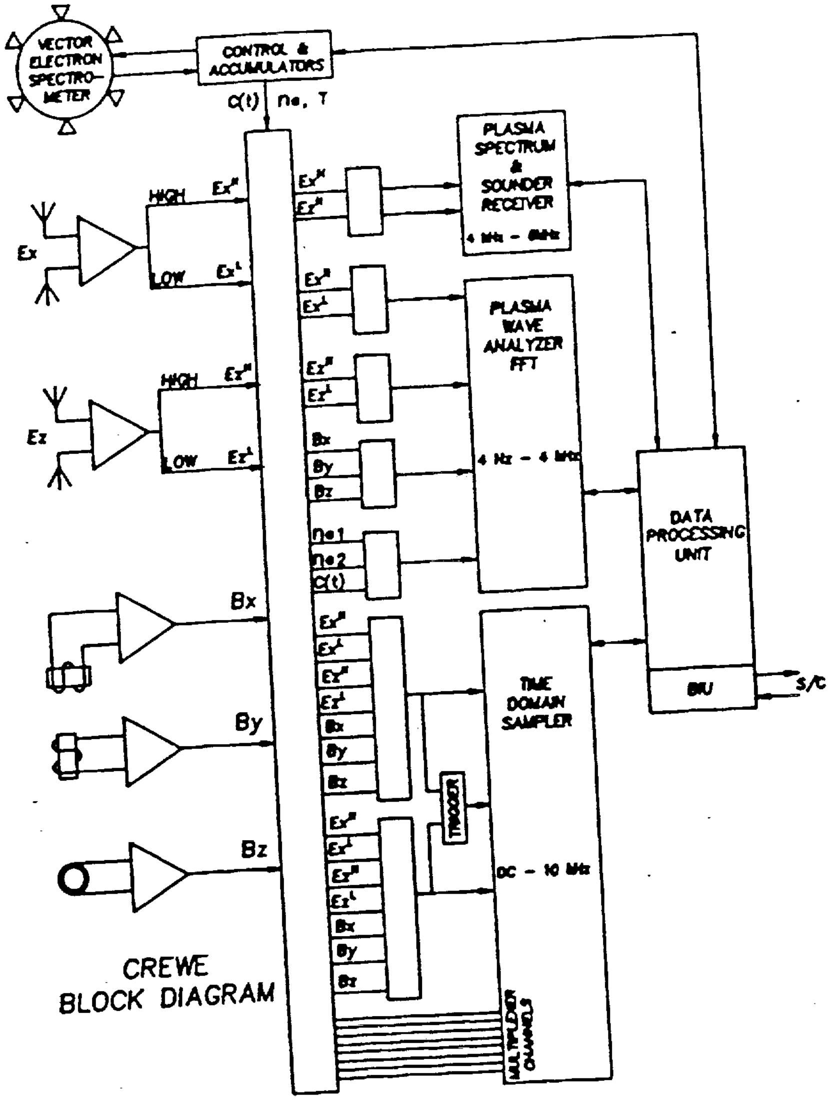
Sounder ....Uses PSR and FFT for absolute density
$0.01 < N_e < 100,000/\text{cc}$

Time Resolution.........Variable controlled by Micro-processor
Nominal Repetition Rate for All
Sensors 1s

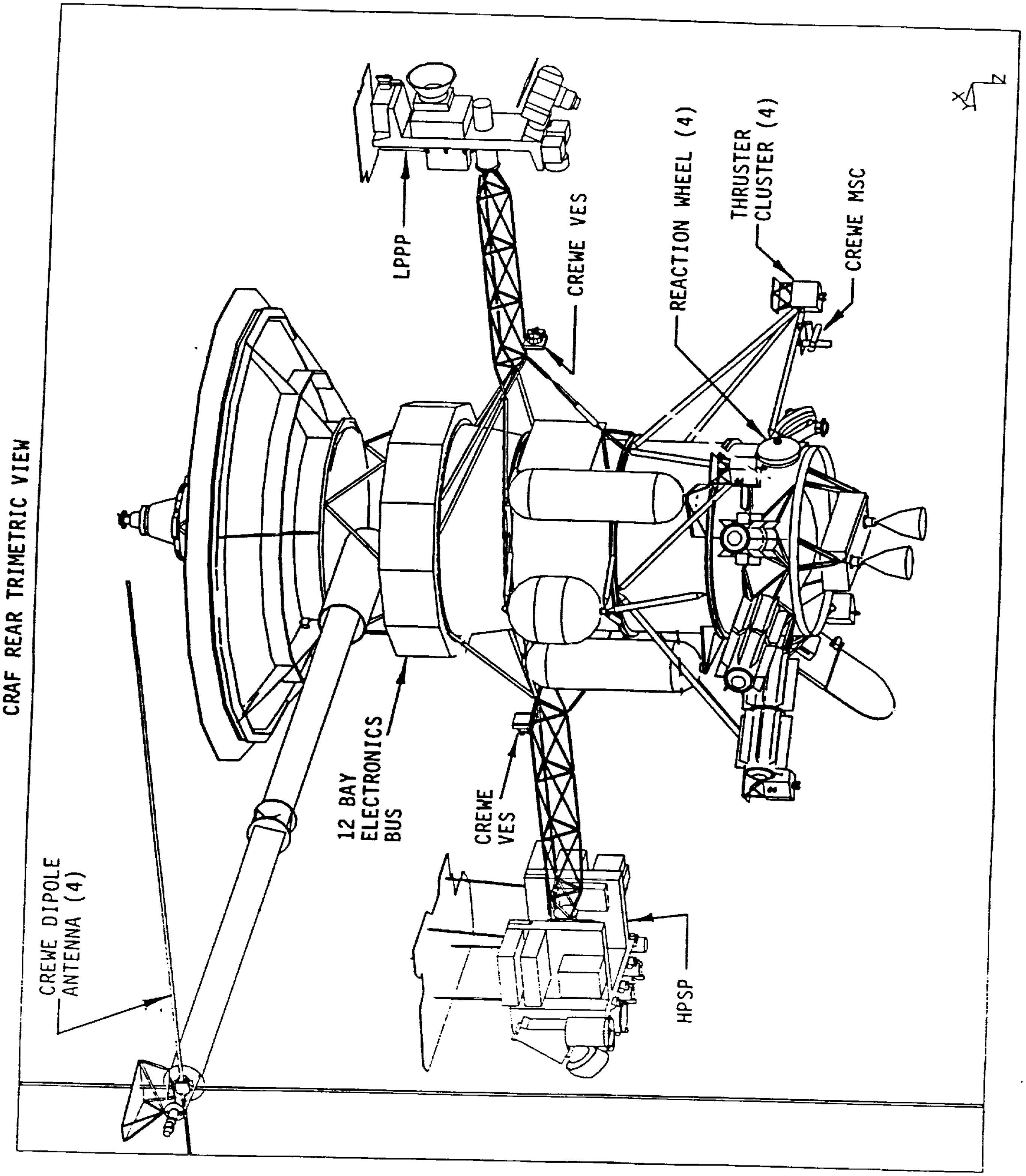
§ I: INSTRUMENT DESCRIPTION

CREWE FUNCTIONAL BLOCK DIAGRAM

1) Overall Block Diagram including 3axis MSC



CREWE DEPLOYMENT - ISOMETRIC SKETCH



CREWE FUNCTIONAL BLOCK DIAGRAM

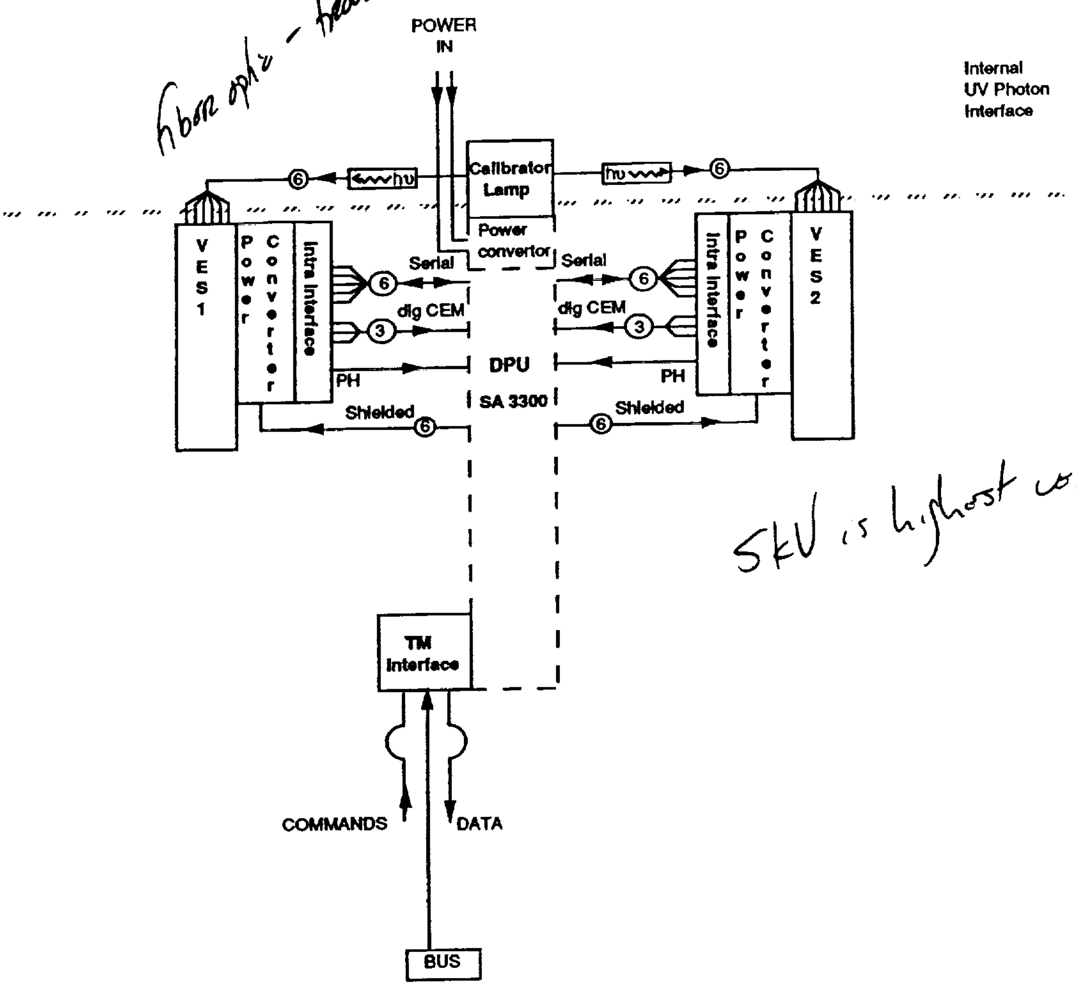
2) VES sub Block Plan
(NB Fiber Optics Cabling in S/C Harness)

CREWE Confirmation Review
10/10/91

Uses Same on WIND

VES - Functional Diagram

fiber optic - trouble!

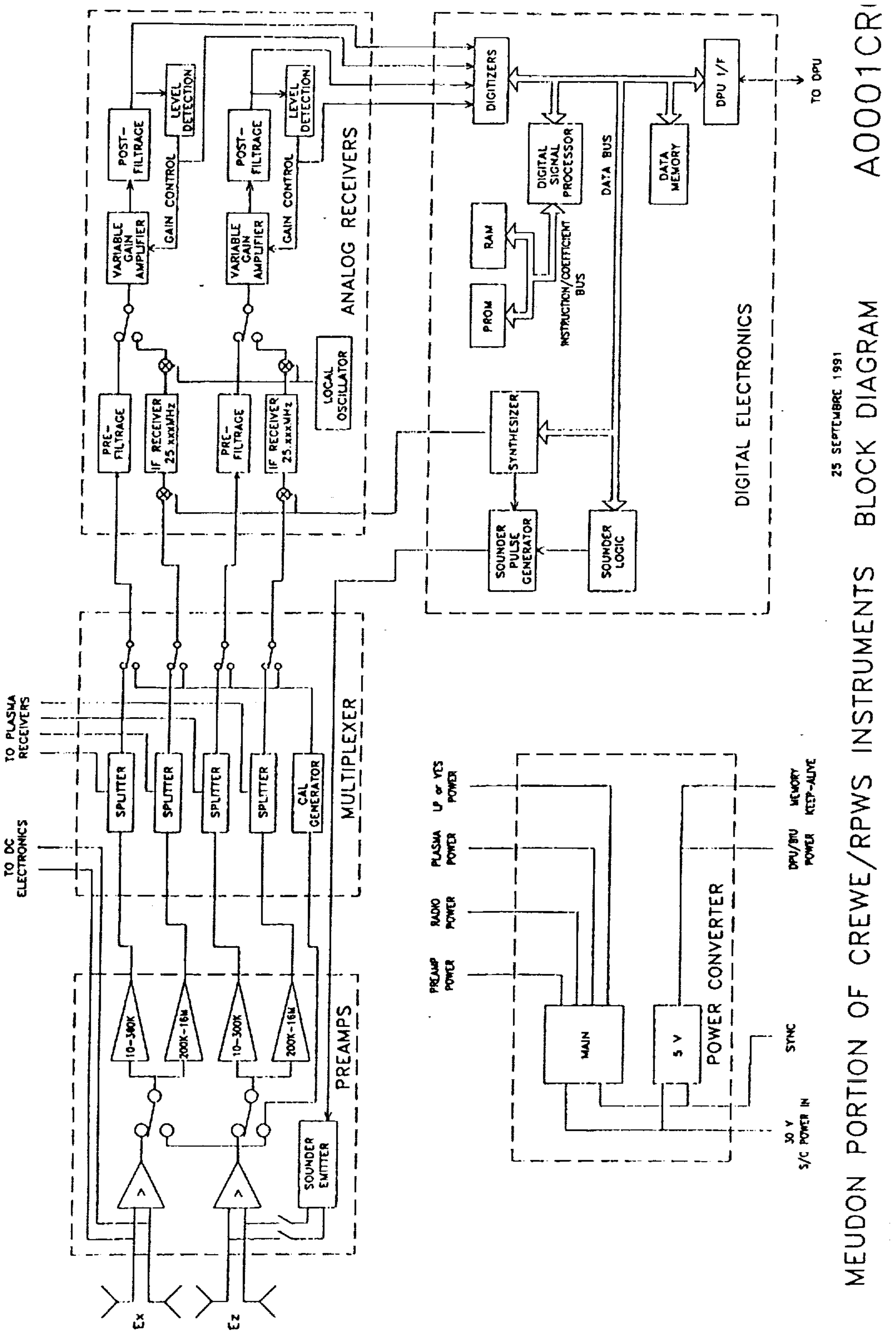


5kV is highest voltage

VES - Vector Electron Spectrometer

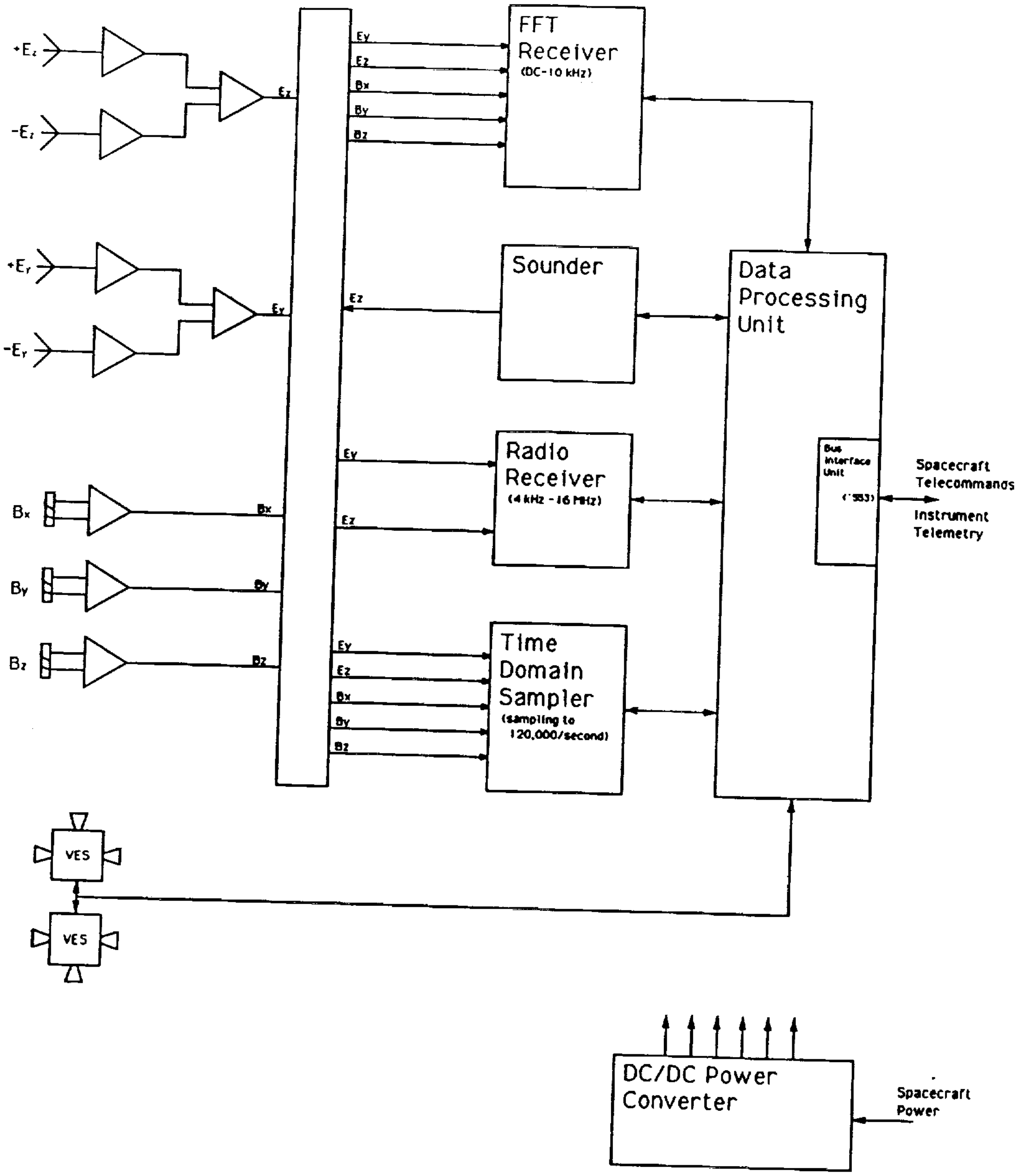
CREWE FUNCTIONAL BLOCK DIAGRAM

3) French sub Block



CREWE FUNCTIONAL BLOCK DIAGRAM

4) Minnesota sub Block Plan

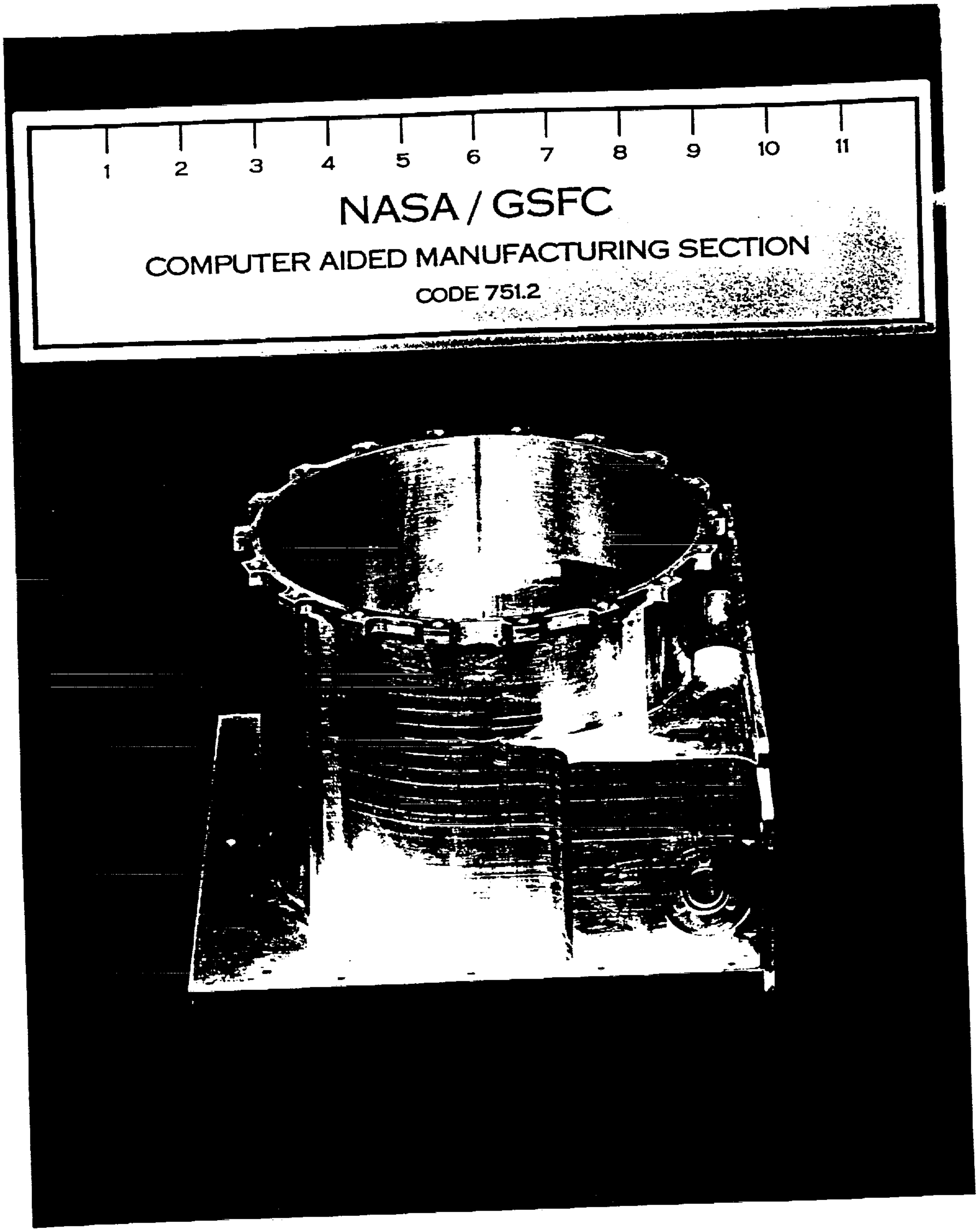


CRAF/CREWE Overall Block Diagram

A

§ I: INSTRUMENT DESCRIPTION

VIEWGRAPHS OF GGS HARDWARE THAT IS PROTOTYPICAL FOR CREWE SUBASSEMBLIES:
VES from SWE: Solid Block Magnesium; Central Column; Green Analyzers



§ I: INSTRUMENT DESCRIPTION

CREWE DESIGN CHANGES SINCE JUNE '87

1. Electric Dipoles to be deployed in a crossed orthogonal configuration at the outboard end of the magnetometer astromast.

2. Search Coil now a three axis device for $ was 1

3. VES package split to remove field of view incursions, which appear to be recurring, however ..... see below.

4. Internal UV calibrator for inflight balancing of VES channeltron gains.

§ I: INSTRUMENT DESCRIPTION

CREWE PERFORMANCE VS ORIGINAL PROPOSAL

THE INSTRUMENT PERFORMANCE IS AS PROPOSED EXCEPT FOR

1) A Cassini RPWS commonality dictated extension of the high frequency range of the PSSR to 16 (vs 6) Mhz

&

2) A shift to a three (3) vs ~~2~~ 1 axis Magnetic Search Coil sensor provided by CRPE in direct response to the findings of Comet Flotilla to Comet Halley and Commonality with Cassini RPWS

&

3) The proposed long and short antenna roots have been collocated and placed at the outermost possible extremity of the magnetometer boom to maximally fulfill the "free" dipole approximation for the antenna plasma coupling

&

4) Making use of larger data rates made possible by MM-II bus architecture. Instrument output had always been compressed to match the TM allotment, with provisions for 115kbs wide band acquisition. Somewhat larger data rates require less on board computation and compression.

CREWE NEW TECHNOLOGY

1.) Radiation hardened Sandia 3300 and 3304 microprocessor and timing control unit. Used in GGS/Wind/Waves, GGS/Wind/SWE and GGS/Polar/Hydra subsystems as well as on numerous rocket flights.

2.) Suitable crossed Electric Dipole antenna and deployment mechanism that achieves a small thermal "flutter" together with a simultaneously low mechanical Q. Several Zero-G flights have been undertaken with different prototypes.

§ I: INSTRUMENT DESCRIPTION

CREWE PRESENT DEVELOPMENT STATUS/ACCOMPLISHMENTS

1. Fabricated a magnetically clean electric preamp and measured stray magnetic field. Demonstrated that NO waiver is required for electric preamps located in close proximity to the magnetometer. This issue depends on the distance between the preamp/antenna assembly and the VHM. Exploring METGLAS shielding properties if further shielding required to not interfere with VHM.

2. Separated VES package at modest weight and power penalty to accommodate field of view considerations. Full mechanical equivalent of VES manufactured out of Mg for Wind SWE and UNDER mass target. Cf Appendix I graph. GGS/WIND/SWE = "CREWE VES engineering model" approaching subsystem integration.

3. VES Power Supply designs completed. CREWE prototypes built as SWE flight components.

4. Dipole Studies with vendors A & B have been conducted at a very small cost; Several concepts have been deployed in zero G several times (videos available). Modifications procured and also deployed 8 times in zero G flights with video-recording.

5. Radio receivers engineering unit were integrated as WIND/Waves subsystem. Flight unit for WAVES approaching final build up and integration. Engineering proofing is establishing credibility of CREWE mass numbers.

§ I: INSTRUMENT DESCRIPTION

CREWE DEVELOPMENT PLANS:

```
        SUBSYSTEM                      Supplied By:      Integrated At:

1. Vector Electron Spectrometer :-- NASA-GSFC-------- ---------→ :
                                :                                 :
2. UV Calibrator ---------------:                                 :--→GSFC
                                :                                 :
3. Antenna Deployment Mechanism-:                                 :
................................ ................  .......... :
                                                                  :
4. PSSR,Electric Preamps             MEUDON-France---→ |          :
                                                       |          :
                                                       |          :
5. TOMSC, Preamps, Sounder           CRPE-France-----→ |-Meudon-→ :
                                                       |
6. Flight DPU, TDS, FFT              Minnesota-------→ |

7. Receiver Enclosures               Minnesota-------→ |
 GSE.............................    Minnesota-------→ |
    ............................     Minnesota........ .......... ;
```

*BRIEF DESCRIPTION OF SUPPORT EQUIPMENT:

For the CREWE investigation:

We will design and build a ground support computer system which will allow us to test and calibrate the CREWE instrument at our home institutions. In general we will have four sets of support equipment. These sets will be located at GSFC, Meudon and Minnesota with the fourth used at JPL and the Cape for bench level checkout as well as spacecraft level functional testing. Much of this equipment and software will remain useful in the early phases of the mission.

Each set will consist of a VAX data analysis computer with several attached X-windows workstations. The VAX will be equipped with a large disk drive for program and telemetry data storage. We will use 4mm Digital Audio Tapes for data exchange and archival. Each VAX will be connected to the NASA Science Internet/DECnet (SPAN) such that data and programs can be exchanged electronically.

This computer will be equipped with data processing software which allows simple and consistent access to the telemetry for CREWE engineers and scientists. We will implement a layered approach to data analysis software such that CREWE team members access CREWE telemetry using mnemonic representations of telemetry words. This layered approach will allow us to move the bulk of CREWE analysis software to a variety of different computer platforms with minimal effort. In porting to a new platform, the only change which will be needed is at a low level interface layer. All upper layers will remain intact. The idea is to avoid having to write and rewrite CREWE analysis software at the various phases of the mission.

Each set will also consist of a Remote Terminal Interface Unit (RTIU) which will function as the CREWE spacecraft simulator. These RTIUs will be connected to the Bus Interface Unit of the CREWE instrument and will send instrument telemetry to the VAX computer via an ethernet/TCP/IP interface. Plans for the RTIU are to be provided by JPL.

Where necessary, we will have a Power Module which will simulate the power to the various CREWE subsystems.

We will also have several sets of equipment to stimulate the CREWE sensors. These will be remotely commandable (IEEE-488) units which provide for routing of test signals from either external generators or internal calibrated noise sources to each of the electric antenna inputs. They also provide inputs to the Helmholtz tests coils contained in the mumetal box for testing of the search coils. Test routines will be run on the data analysis computer which will send HPIB commands to control this stimuli equipment in a standard manner.

We will also design and build a relay (or switch) box which will provide adaptation of the tests signals from the stimuli rack to the electric preamp inputs. It will contain switchable attenuators, dummy antennas, and sounder resonators. This unit will be capable of undergoing thermal vacuum testing and functions with internal batteries.

We will also supply a mu-metal box which will shield the CREWE search coils from ambient magnetic fields most of the time during testing both at our home test facilities and at JPL. This box provides a magnetic shield and also provides physical protection for the search coil. With internally mounted Helmholtz coils, the mu-metal box can also provide stimulation of the 3-axis magnetic search coil. This box will be suitable for thermal vacuum testing.

For the <u>VES</u> Spectrometers: We will also use battery powered stimuli to verify preamp function and UV calibrator integrity. We assume that our GSE can gain access to the telemetry of CRAF/CREWE during thermal vacuum testing

*INSTRUMENT/SUPPORT EQUIPMENT TEST CONFIGURATION:

<u>Receivers:</u>

"...For all S/C level functional testing it will be required to have the stimuli rack as close to the S/C as possible (goal: 5 meters from preamp unit). This rack will have connections to the switch box which must be mounted within 50 cm of the preamps, to the mumetal box, and to the CREWE checkout computer.

This setup will not be required for aliveness and EMC tests. It will also be used extensively for bench tests.

We will supply copies of the stimuli racks we have developed for ISTP. These are remotely commandable (IEEE-488) units which provide for routing of test signals from either external generators or internal calibrated noise sources to each of the electric antenna inputs. They also provide inputs to the Helmholtz tests coils contained in the mumetal box supplied by the CRPE for testing of the search coils.

We will also design and build a switch box which will provide adaptation of the tests signals from the stimuli rack to the preamp inputs. It will contain switchable attenuators, dummy antennas, and sounder resonators."
-Manning

VES:

We propose to have an "internal test" mode of the flight DPU that can stimulate the amplifiers of all 6 analyzer subassemblies to fire. This internal test for circuit integrity during system test is disabled with a externally accessible flight connector so that the DPU cannot stimulate the amplifiers in flight or via "pick-up". The UV calibrator can be checked out via the diode termination in the same flight connector mentioned above. This is particularly important after the VES is reintegrated after channeltron refurbishment and the UV fiber optics connector has to be reattached to the VES optic chamber.

* PRELAUNCH CALIBRATION:

Receiver:

After shipment to the Cape we will want to perform a final long functional test which will require 1 Day for CREWE by itself if all goes well with all powered at room temperature in place. This is all. Unless something anomalous has come up during the S/C I&T phase we do not require that the receivers be removed from the spacecraft...."

VES:

Facilities: The calibration facilities consist of a high vacuum chamber which houses ion and electron guns as well as a moveable platform where the instrument is placed. For calibration at low energy, the vacuum system is placed inside a set of Helmholtz coils which are used to null out ambient magnetic fields.

The charged particle optics are designed to produce a large, uniform ion or electron beam which fills the entrance slit of a calibrated instrument. This procedure best reflects the operating condition of the instrument, as well as allowing for small errors in the positioning of the instrument. The primary electron gun operates over a wide energy range, for 0.1 to 50keV. For calibration below 100eV a second electron gun is used. this gun is placed close to the instrument to reduce the effect of residual magnetic fields on the electron beam.

The instrument platform can move in up to three linear dimensions and along two rotational axes. The flexibility given by the large number of motions allows us to calibrate the instrument over two angles, to obtain the profile of the particle beam, and to rotate into the beam different sensors of the instrument or to move into place diagnostic instruments without breaking vacuum.

Requirements: The parameter space over which the instrument must be calibrated includes polar and azimuthal angles, energy, and intensity. The instrument must possess a relative calibration over this parameter space within 5%. Also intercalibration of the various sensors that comprise the VES must be accomplished within 5%. A minimum accuracy of the absolute calibration is 50%.

Procedure: The instrument will be placed into the vacuum chamber. After pump down an electron beam will be fired at the instrument. The beam profile will be monitored periodically to check for any variation. The beam intensity will be monitored simultaneously with the calibration to provide a normalization factor to the instrument output. The instrument will be calibrated according to the recipe given below:

A. Fix energy of electron beam

B. Scan azimuthal and polar angles of instrument to obtain angular resolution.

C. Rotate next sensor into electron beam

D. Repeat angular scans until all sensors are tested.

E. Step the energy

F. Repeat until several energies are tested

G. Fix energy and set sensor to center angle (maximum signal)

H. Vary beam intensity up to the maximum counting rate of the instrument.

I. Step energy and repeat step G until sufficient energies are tested

J. Rotate the next sensor into the beam

K. Repeat steps F-I until all sensors are calibrated

By following the above procedure and closely monitoring the electron beam, the instrument will be calibrated systematically and accurately. The results of the calibration will be stored in a laboratory computer for further use and distributed as needed. Steps will be taken to backup the data to ensure its safety.

* SPACECRAFT SYSTEM TESTING REQUIREMENTS/CONSTRAINTS:

Receivers:

"... - require connection of the switch boxes to the electric preamp assembly for all functional testing, EMC and aliveness test excluded

- require connection of stimuli rack to switch boxes, mumetal box, and experiment checkout computer for these same tests
- require S/C level conducted and radiated compatibility tests on the complete spacecraft
- require full functional test at the Cape ..."

VES:

Because flight channeltrons will not survive system thermal vacuum testing without contamination, it is required that the VES sections of CREWE be returned to GSFC for refurbishment after system testing. During system test, resistors will be located in most of the channeltron locations.

During the refurbishment period, flight channeltrons will be installed and the geometrical constants determined for each of the six analyzers (horns) which make up the VES subsystem. It is currently budgeted as an 8 week exercise on GGS, which includes a post refurbishment limited functional test in an ultra clean thermal-vacuum system.

*SUPPORT EQUIPMENT/STIMULI REQUIREMENTS FOR S/C TEST

Receivers:
(See Above)

VES:
(See Above: In particular note the battery operated pulser and UV output checker)

*OPERABILITY IN ROOM AMBIENT ENVIRONMENT

Receivers:

"... Our receivers can be operated in any reasonable clean ambient environment. The radio receivers and antenna/antenna deployers have no high voltages nor exposed critical surfaces.

Antenna: mechanical deployers will NOT operate correctly in 1-G room environment.

Search Coils (TOMSC): The TOMSC are usually NOT operable in earth's field without some additional provisions and are usually store in their mu-metal shield.

VES:

The VES preamplifiers and interface circuits can be operated in ambient conditions at low humidity. The high voltages (bias and stepping supplies) may not be operated except in a clean room below 10^{-6} torr.
* Purge Requirements

o The VES subassemblies (2) require continuous dry nitrogen purge (99.99996% water free) from time of initial integration onto the spacecraft, until "red tag" items are removed at the launch site. This is especially critical after the flight channeltrons have been retrofitted after the S/C system test.

o The instrument should essentially always have a positive pressure of dry inert gas inside it (N_2, He). this can be achieved by a flow through the instrument (the flow rate can be as low as a few cc/s), or through a plastic bag which encloses the instrument. The purpose is to exclude dust and moisture.

o The most dangerous period for dust and moisture is during launch operations. We would request that the s/c shroud be cleaned internally, and a flow of dry gas be maintained through it until approximately 1 minute of lift-off, as has been done before. In the event of a launch abort, the flow of gas should be restored as soon as possible. The gas should not be at a lower temperature that the surrounding atmosphere, to prevent condensation if the flow is interrupted.

§ III: LIST OF DELIVERABLES/SCHEDULE

MEUDON:

- electric preamps
  1 EM
  1 FM
  1 FS (common with RPWS)
- PSSR receiver and sounder
  1 EM
  1 FM
  1 FS (common with RPWS)
- CREWE (except VES) power converter
  1 EM
  1 FM
  1 FS
- stimuli rack and switch box for stimuli inputs
  delivered with EM
  3 sets in all available for CREWE and RPWS testing

MINNESOTA:

Hardware:
- TCM (all receiver box tcm's)/which are common with RPWS's
- GSE EU:3 (Meudon,GSFC,Minnesota)
- DPU EU ______; FU ______
- TDS EU ______; FU ______
- FFT EU ______; FU ______

Software:
- Executive Operating System EV: ________; FV________

GSFC:

- TCM(Unique to CREWE)
- 2 VES units for Flight; 1 Complete VES EM
- Antenna Assembly 2 for Flight (one for Cassini and costed by RPWS)
  Spare 4? monopoles
  Spare 1 cannister assemblies

CRPE:

-TCM (Common with RPWS)
- EM Triaxial Magnetic Search Coil
- FM Triaxial Magnetic Search Coil
- FS Triaxial Search Coil common Spare with RPWS

(NB: The common TCM's with RPWS can be the SAME item provided phasing of TCM's is acceptable to the project)FY90-94

HARDWARE AND SOFTWARE AND DELIVERABLES

DESCRIPTION	DELIVERY TO JPL preliminary	Delivery to JPL final	REMARKS
Reliability and Quality Assurance Plan	with EIP	10/10/91	
Experiment Implementation Plan		10/10/91	
Flight Software Work Implementation Plan	3 mths before PIRDR	Approved by PIRDR	
Safety Plan	Standard GSFC Safety Plan	10/10/91	
Instrument Safety, Operations and Handling Document		/93	
Inputs to the STSE Functional Requirements Document		/92	
Preliminary Parts and Materials List	Aug 91		Preliminary parts list delivered; materials list pending
1 Set of 8x10 Color Prints and Dupl. Color Negs. of CREWE Instrument, Ckt. Boards, and Special Components			
Investigation Description and ScienceRequirements Document	/86	/87	
Parts Program Plan (PPP)		TBD	
Materials ID and Usage List (MIUL)	TBD	TBD	

HARDWARE AND SOFTWARE AND DELIVERABLES

Description	Delivery Date to JPL	Remarks
CREWE FRD Updates	As generated	
Flight Hardware Long Lead Items	As developed	Cost/Schedule details for Long Lead Hardware Components
Review and Review Data Package		
Investigation Confirmation Review (ICR)	10/10/91	
ICR Data Package	10/10/91	
PIRDR	TBD	Will be held after a PDR at GSFC
PIRDR Data Package	10 days before PIRDR	
FIRDR	Before Start of PFU fabrication	Will be held after a CDR at GSFC
FIRDR Data Package	10 days before FIRDR	
Electronic Packaging Review	TBD	
Subsystem Delivery Acceptance Review (SDAR)	Concurrent with PFU	
CREWE Management Reviews at GSFC	Quarterly	By the Director of Science (technical progress, scheduel, budget)
JPL ESD Survey	Before PFU Start	
JPL Facilities & Operations Safety Survey	Before PFU Start	Survey of all facilities used for environmental tests of assembled flight hardware

HARDWARE AND SOFTWARE AND DELIVERABLES

Description	Delivery Date	Remarks
MANAGEMENT & COST REPORTS & SCHEDULES		delivered to JPL
Monthly Technical Progress Reports	1-st of each month for proceding month	delivered to JPL
Work Breakdown Structure	1 Month after MOU agreement day	delivered to JPL
Financial Reports	10-th of each month for preceding month	delivered to JPL
HARDWARE AND SOFTWARE		
Engineering Model Unit (EMU)	6/1/94	delivered to SAF
EMU Software Code and Listings	6/1/94	
PFU Software Code and Listings	1/15/95	
Bench Checkout Equipment (BCE) Set	6/1/94	delivered to SAF
System Test Support Equipment (STSE) Set	1/15/95	delivered to SAF
Non-magnetic CREWE Handling Fixture	6/1/94	
Temperature Control Model(TCM)	6/15/94	
Flight Spare Components	1/15/95	to be retained by PI in bonded stores
One Set of Shipping Containers (EMU)	6/1/94	
One Set of Shipping Containers (PFU)	1/15/95	
PROGRAM OPERATING PLAN (POP) INPUTS	Twice Yearly, 15 Jan and 31 May	

HARDWARE AND SOFTWARE AND DELIVERABLES

Description	Delivery Date to ~~JPL~~ GSFC	Remarks
MEUDON HARDWARE		
Electric preamps EM	10/1/93	
Electric preamps FM	8/1/94	
Electric preamps FS	TBD	
PSSR receiver and sounder - EM	10/1/93	
PSSR receiver and sounder - FM	8/1/94	
PSSR receiver and sounder - FS	TBD	
CREWE power converter - EM	10/1/93	
CREWE power converter - FM	8/1/94	
CREWE power converter - FS	TBD	
Stimuli rack and switch box for stimuli inputs delivered with EM - 3 sets (CREWE/RPWS)	1/15/95	
MINNESOTA HARDWARE		
BB DPU	8/1/92	
DPU - EM	10/1/93	
DPU - FM	8/1/94	
DPU - FS	TBD	
TDS, FFT - EM	10/1/93	
TDS, FFT - FM	8/1/94	
TDS, FFT - FS	TBD	
GSE	1/15/95	
GSFC HARDWARE		
VES - EM	6/1/93	
VES - FM	2/1/94	
VES - FS	TBD	
DIPOLES - EM	10/1/93	
DIPOLES - FM	8/1/94	
DIPOLES - FS		
CRPEIS HARDWARE		
MSC, sensor and preamp - EM	1/3/94	
MSC, sensor and preamp - FM	8/1/94	
MSC, sensor and preamp - FS	TBD	

§ III: LIST OF DELIVERABLES/SCHEDULE

Schedule: See overall Bubble Chart in Appendix V:

```
                                                                    LAUNCH
FY      88        89         90          91         92         93
??      91        92         93          94         95         96  (12/95)
--      L-5       L-4        L-3         L-2        L-1        L
UNIT

TCM  ------------------------------*(?)
ENG                                       *
MODEL   DESIGN-|FAB-----|-I-|-TEST------|

FLGHT                                                 *
UNIT                   |-----FAB------|--I--|-TEST-|
                    a)
BCE     ASSEMBLE|
                                   b)*
TCM                    |---------|

SOFTWARE       ----------DEVELOPMENT------|||||||||||||||||||||||||||
```

§ IV: FLIGHT & SUPPORT EQPTMENT AND SOFTWARE SCHEDULE

All required test and diagnostic software for flight and ground systems is in Minnesota's/ UNH deliverable's depending on contract award. They will provide the following mix of hardware and software elements:

4 Ground support systems to include:
  - VAX data analysis computer
  - X-windows terminals
  - laserprinter
  - RTIU

Additional waveform generators

3 Breadboard DPU systems to include:
  - microprocessor board
  - memory board
  - interfaces
  - BB Bus Interface Unit
  - diagnostic port
  - logic analyzer interface

1 Engineering Model CREWE1 (Meudon) enclosures to include:
  - converter (2)
  - analog receiver
  - digital receiver

2 Engineering Model CREWE electric preamplifier units
1 Thermal Control Model CREWE electric preamplifier unit
1 Engineering Model of the CREWE2 stack (DPU, FFT and TDS)
1 Flight Model CREWE1 (Meudon) enclosures to include:
  - converter
  - analog receiver
  - digital receiver

1 Flight Model of the CREWE2 stack (DPU, FFT and TDS)

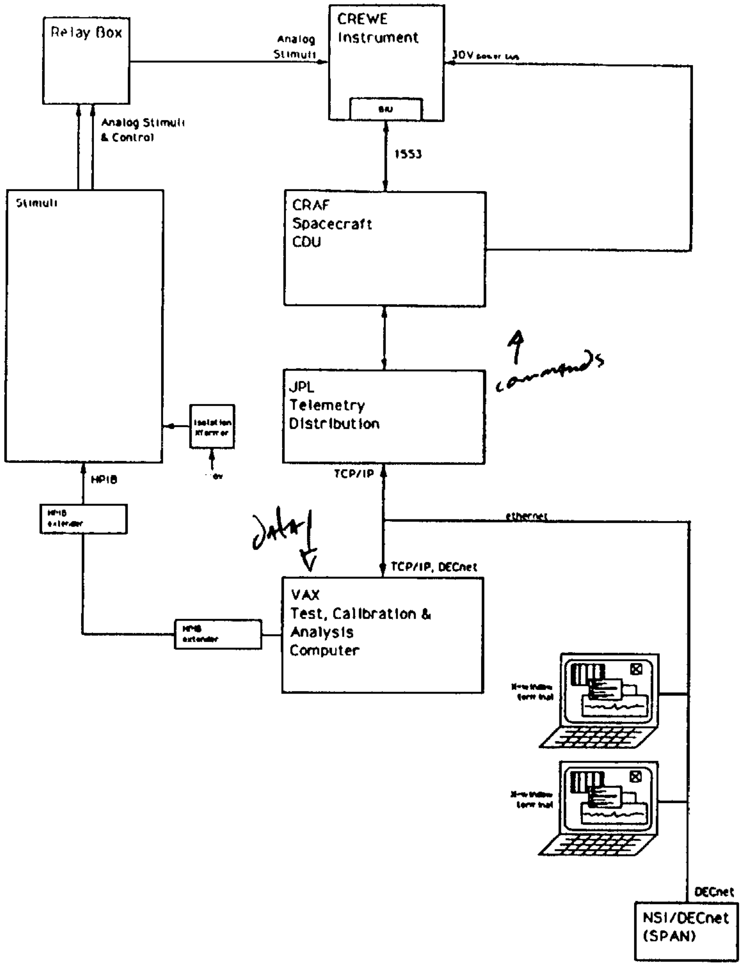
Minnesota/UNH will provide the following software elements:

GSE system software
GSE software specific to the Minnesota end of CREWE
Flight kernel software for two CREWE processors (DPU and CREWE2 digital receiver)

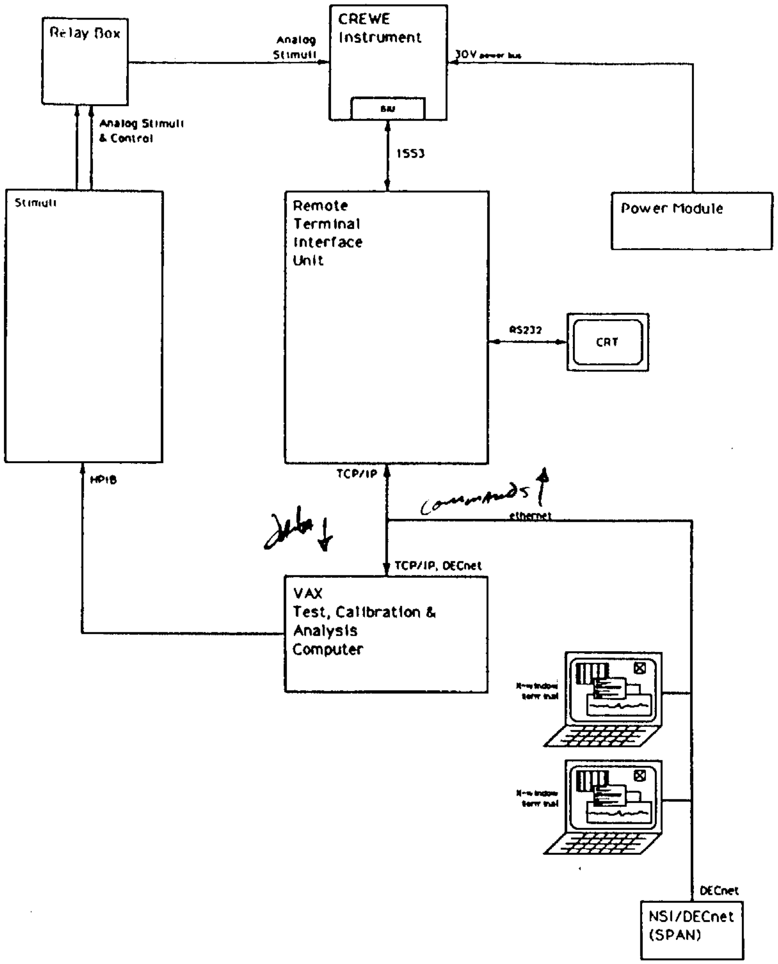
Specific Flight software for CREWE DPU
Specific Flight software for CREWE2 receivers

Schedule: See Minnesota Bubble Chart Appendix IV

CRAF CREWE 10/10/91 §IV "Flight and Support Eqpmnt/Soft Schedule" -21-



CRAF/CREWE GSE
Spacecraft Checkout Mode



CRAF/CREWE GSE
Bench Checkout Mode

§ V: CREWE ACCOMMODATION ISSUES

1) Status of Mechanical Interface Drawing

All CREWE ICD drawings and support materials known to GSFC are found in Appendix II. It should be noted that these drawings are extremely provisional and have not been approved. They are, therefore, not under configuration control at this time.

Note, that the VES housing is the GGS/WIND/SWE outline and it may not be appropriate for the CRAF truss attachment. These details remain TBD and the VES packaging is representative, but not complete in every detail.

While these drawings are as up to date as the US mail there are updates where JPL's drawings may differ as in TOMSC placement; connectors TBD vs defined, circular vs D type,etc

2) Level 2.5 Requirements not met and impact of Investigation (PI/JPL)
    a) mounting and FOV:

Requirement # 7005/23104: "Dipole antennas can not be aligned </ = 1 degree of a given S/C axis" Capability 2 deg (3σ)

Accept S/C Capability - CREWE

Requirement # ????? 22826

Equipotential specifications.

Requirement # 22321/23112 "No S/C structure within 30° of VES sensors FOV can not be met. Capability: No structure within 5°)"

The unobstructed clear FOV for the six separate analyzers of the VES are non-negotiable. The inability of the S/C designers to accept an equipotential condition on the exposed S/C surface < 1V between any two points, implies that additional steps must be sought to protect the immediate vicinity of that bundle of trajectories that fill the FOV of the six "horns" of the VES. Because the primary measurement is of electrons, surface potential irregularities along S/C surfaces near this cone of trajectories can affect what is measured in the FOV. In particular particles that were intended for the FOV may be deflected away from it; those not normally in the FOV can be deflected into it, corrupting the measurement. It should be recalled that the ONLY way on CRAF to determine the motional electric field that powers the plasma neutral interaction is by determining the electron bulk velocity; it is this crucial measurement that is compromised by allowing S/C surfaces to crowd this solid angle subtended by each of the 6 "horns" of the VES.

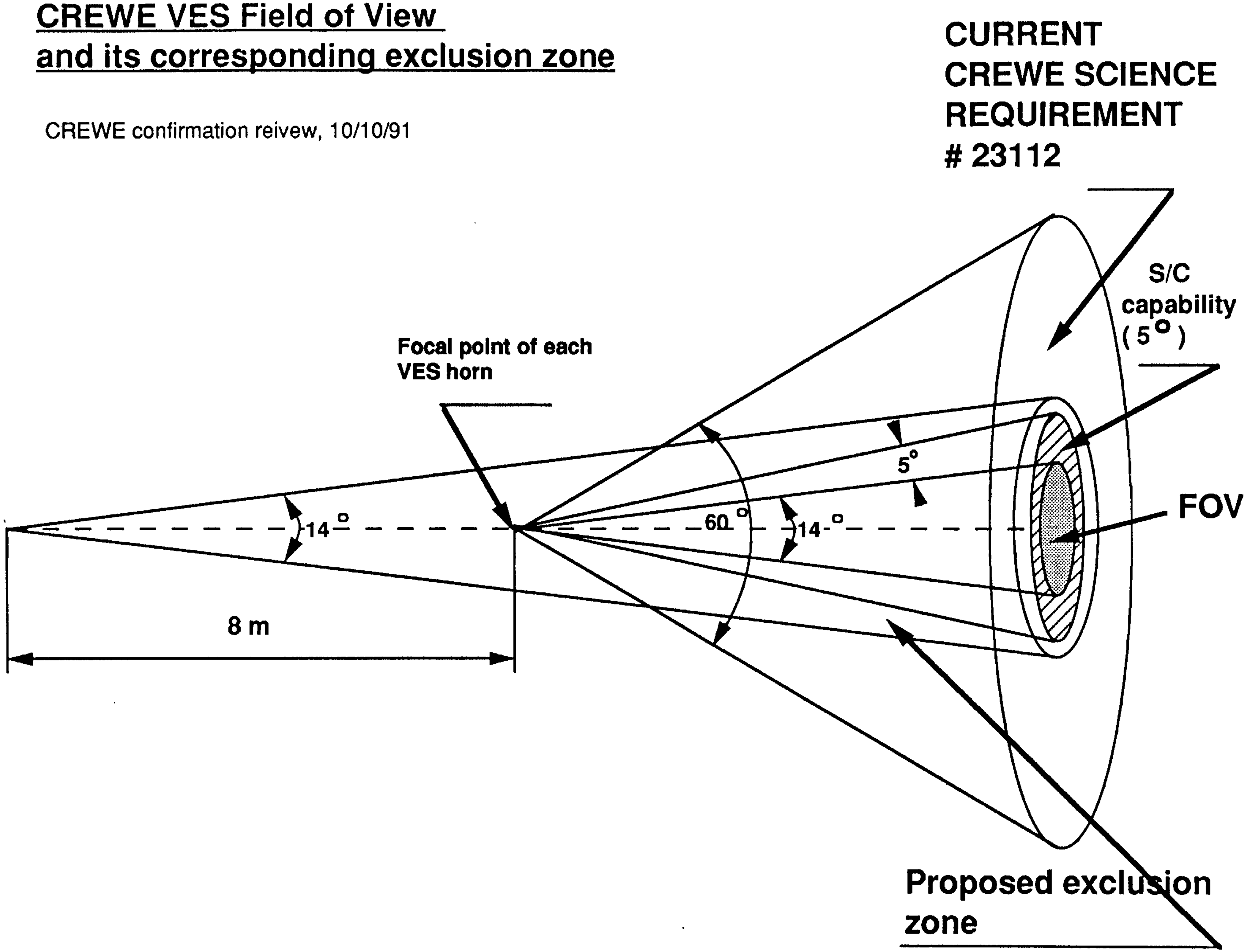
§ V: CREWE ACCOMMODATION ISSUES

While seeking to understand the difficulties in our accommodating our request, it occurred to us that a less restrictive mathematical condition might not give so many conflicts while still protecting our measurement. The objectionable requirement was that ±30° be free from obstruction.

What really is required to preclude intrusions within a conical field of view that is similar to the detectors field of view, but with its vertex displaced away from the analyzer's aperture, so that its enveloping surface is a fixed impact distance away from the conical field of view's enveloping surface. In this way as illustrated in figure on the next page, the apex angle of the cone of exclusion is not 60°, but rather the 14° of the analyzer. Ideally, one would like <u>nothing</u> in this outer cone which has a displacement from the FOV cone of 1 meter in all directions.
WE NEED TO DISCUSS THE INCURSION ON THE 5° CONE AND HOW THIS REQUIREMENT IS BEING INTERPRETED cf figure on next page for an interpretation.VES FOV STUDY:

CREWE VES Field of View and its corresponding exclusion zone

CREWE confirmation reivew, 10/10/91



§ V: CREWE ACCOMMODATION ISSUES

Requirement # 11421/23101; 22323/23102

11421/23101 Doubtful. VES sensors cannot be aligned to within ±8mrad of each other. Capability unknown."
22323/23102 VES sensor alignment relative to the S/C axes can not be known to </=0.5 deg. Capability: Y,Z axes = 1.6°, X axis = 2.51°".

Implies RSS = 3.4° for any given analyzer and nearly 5° between any two FOV's if errors were random.

Science Impact on analysis and model independent character of U_e and $\underline{E}$

The current expected angular precision of the boom latching is coarse compared to the angular precision of the FOV of the VES.

The VES concept originally started as a subsystem bolted together on a single truss; it was separated in the interest of obtaining a clear, clean and uncluttered FOV and vicinity in the sense of concerns above in a). The VES concept exploits the **mirror symmetry** of deployment of opposite pairs of analyzers, which are on opposing trusses of CRAF. The poor reproducibility of the truss deployment implies that a correspondingly poor degree of collinearity between the two analyzers of each pair can be achieved. Currently, the uncertainty in the actual deployment implies a 1 sigma chance that the supposedly mirror symmetric analyzers will be actually misaligned by more than their instrument angular width. This translates into a MAJOR difficulty with the determination of the bulk velocity in a model independent way.

Notice, that post hoc knowledge of the angular offset does not correct for the actual misalignment. The misalignment can be addressed with this knowledge with 1) a significant loss of precision for the derived physical quantity, which is already the difference between two large numbers, and 2) additional computational expense for the onboard and ground software.

We have considered other possible solutions, including splitting the VES into 3 parts, each part containing an anticollinear pair. The thought was that each pair could then be located as appropriate, while retaining anticcollinearity of FOV's within each pair. It is difficult to locate suitable locations on CRAF for this option. Another solution considered is two orthogonal pairs mounted in a plane perpendicular to a support truss of one of the platforms with the third orthogonal pair located in the magnetometer boom knuckle. This option has not been studied long, however; it would require a careful study of the magnetic shielding of the bias and stepping supplies from interfering with the inner or high field magnetometer.

Requirement # 22828/23138: Not met the Power Synch Problem needs more work

Requirement # 22827/23138: Ditto (what is it?)

Response: We were led to understand that this issue has been closed with the standardization of convertor frequencies to be multiples of 50kHz and crystal controlled. This needs JPL clarification.

Requirement # new "Can not place magnetic search coils to obtain the specified cylindrical "regions of avoidance". Capability: not yet known.

Response: The TOMSC measurements are crucial to the CREWE science. I understand that this problem is being worked in parallel with testing of the Galileo spare for noise levels. After this test this mounting location problem will be attacked. RPWS is taking the lead on the placement and interference question in consultation with CREWE.

Defer to RPWS response: 10/14/91

Requirement # 9742/23276 "Doubtful. Constraints/sharing and thermal constraints inside 1.43 AU will probably prevent continuous operation during early and late cruise. We have requested reexamination of the Project decision to keep the dipole antennas stowed until after the Venus and Earth flybys"

Response: Power envelope capability is requested. We will design mode/modes that can ensure with CREWE internal buffering, if necessary, that can given regular sampling of these portions of the mission. Please advise.

Requirement 11015/23276 Doubtful. Thermal constraints inside 1.43 AU may prevent CREWE from measuring the solar wind proton temperature density and velocity vector at least 4 hours/week during cruise.

Response: 1) The middle "e" in CREWE stands for electrons! Assuming that proton should be electrons, WHAT is the capability? What power profile for CREWE would permit more suitable data coverage, even if CREWE DPU does compressions for limited contact time with DSN? We can define a mode that will suitably reduce power. It is difficult to defend scientifically that 4hours/week is a meaningful cruise science scenario!

§ V: CREWE ACCOMMODATION ISSUES

Requirement #35181/23276 "Doubtful. Power constraints/sharing will probably prevent continuous operations between start of far encounter and end of mission. We have requested reexamination of the Project decision to keep the dipole antennas stowed until after the Venus and Earth flybys."

Response: Continuous operations implies regular sampling intervals. Last time I looked "far encounter" starts AFTER earth flybys.

---

c) Thermal

Thermal issues have at least three aspects of concern:

1) We do not wish to control the thermal interface of the VES with RHU's; the background enhancement from the RHU is unacceptably high since the VES represents a 2π collector for an attached RHU. We propose to use resistive strip heaters, which will simplify the thermal control problem as they can be turned off.

2) We are concerned about the enhanced thermal stress to the electric dipole boom deployer and antenna if it remains stowed for 2+ years through all the Venus maneuvers. We are concerned that there is not enough money to mount a convincing test program that will assure all that the antennas will deploy after that amount of thermal forcing in the caging device.

3) Finally, we are concerned about the thermal flutter specification being levied on closest solar approach rather than on closest solar comet approach where the pointing requirements are most obviously warranted

d) Instrument/CDS Compatibility (bus traffic, bursty data, etc.)

CREWE does not transmit bursty data.

Operability (699-131?)

§ V: CREWE ACCOMMODATION ISSUES

At the present time there are no known conflicts

3) Problems with Pointing Requirements (e.g. Sun Pointing)
The attitude of the spacecraft should not cause any analyzer to dwell within ±14° of the sun if the high voltage is on in the VES. If during a maneuver the FOV of an analyzer migrates through the solar direction in less than **TBD** (η30s) secs it may be acceptable to leave the VES high voltage on. We wish to understand by simulation the extent to which such turn-off conditions will interfere with data acquisition.

EQUIPOTENTIAL CONTROL:

4) Instrument Conformance with Level -3 Requirements (PI)
List and Discuss ALL level 3 requirements for which a waiver will be requested or for which , for any reason compliance has not been included in current resource requirements.

Level 3 Requirements laid on PI by project:

a) We have not included resource requirements to meet the strict flutter tolerance at 0.6AU.
b) Instrument operability impact for rotating through FOV
c)

§ VI: RESOURCE REQUIREMENTS

MASS

(A RHU holder on the electric preamp brings the dipole assembly weight to 5 kg, and a calibrator + power convertors will jack the VES weight estimate by 1 kg. It is still within our allowance.)

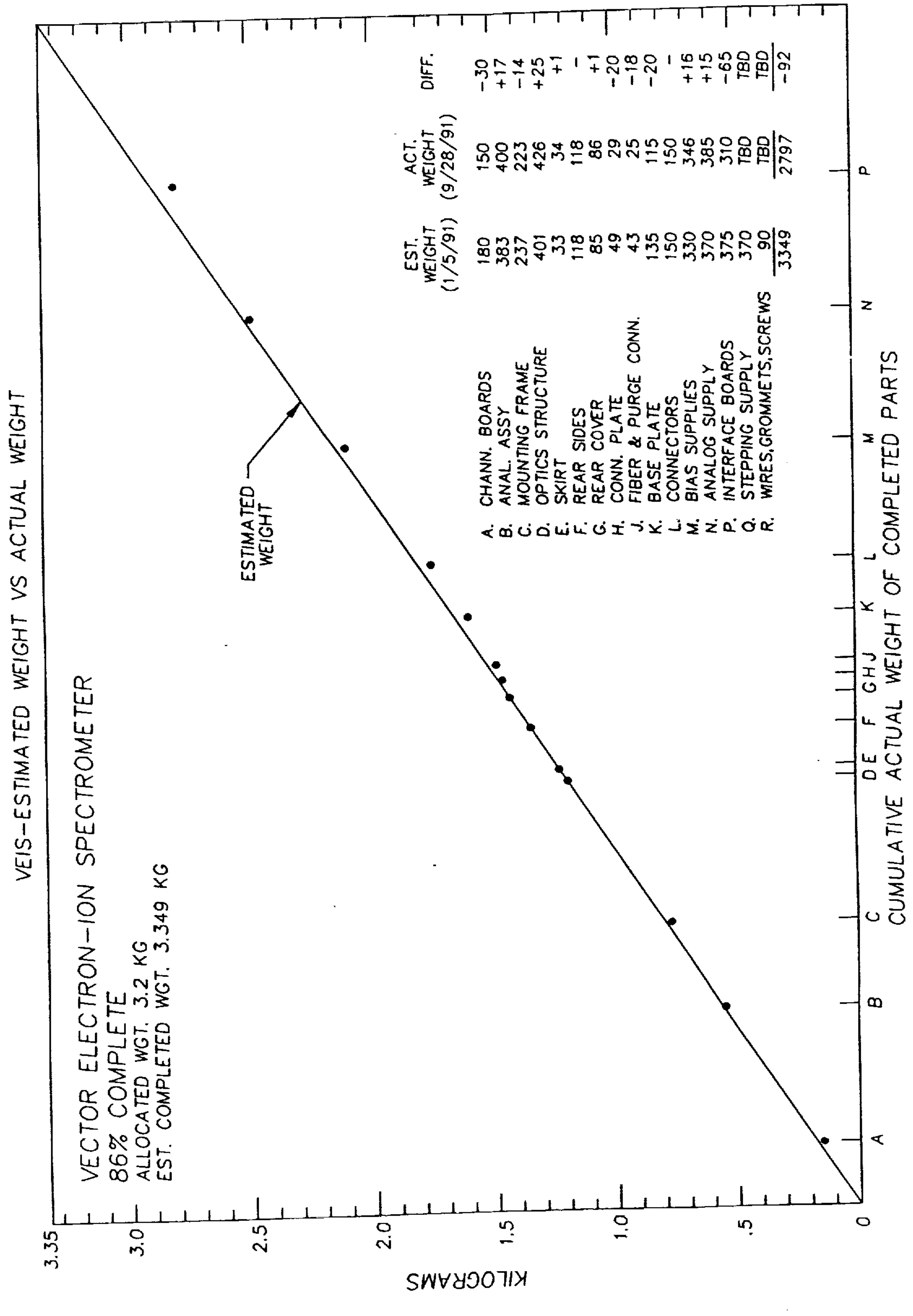
CREWE Confirmation Review, 10/10/91

Mass Breakdown (kg)

	Assembly	Mass 1991	
1.	VES (2 units) with Calibrator and Local Power Convertors	7.20	
2.	Electric Field Preamp and Electric Antenna Dipole	5.00	
3.	Search Coil Sensor	0.98	}
4.	Search Coil Preamp	0.30	
5.	DPU Electronic Assembly and FFT, TDS	6.05	
6.	PSSR	3.30	
	Total	22.83	
	Current Mass Allocation	24.	

Since 1988 all subsystems have undergone a full proofing as flight units either for GGS/Wind Waves or GGS/Wind SWE. Oversights[§] have been detected in the estimating of the 1988. Major oversights were in DPU box estimates and mistaken ISEE analyzer used for the VES 127° analyzers. RHU masses[*] are another major redistribution of responsibilities. Change of scope[‖] to keep the VES intracalibrated seemed appropriate for a mission of this duration. The numbers presented for confirmation are refined re the proposal being based on measured GGS masses.

MASS HISTORY of VES Subsystem on GGS/WIND



VEIS-ESTIMATED WEIGHT VS ACTUAL WEIGHT

VECTOR ELECTRON-ION SPECTROMETER
86% COMPLETE
ALLOCATED WGT. 3.2 KG
EST. COMPLETED WGT. 3.349 KG

		EST. WEIGHT (1/5/91)	ACT. WEIGHT (9/28/91)	DIFF.
A.	CHANN. BOARDS	180	150	-30
B.	ANAL. ASSY	383	400	+17
C.	MOUNTING FRAME	237	223	-14
D.	OPTICS STRUCTURE	401	426	+25
E.	SKIRT	33	34	+1
F.	REAR SIDES	118	118	-
G.	REAR COVER	85	86	+1
H.	CONN. PLATE	49	29	-20
J.	FIBER & PURGE CONN.	43	25	-18
K.	BASE PLATE	135	115	-20
L.	CONNECTORS	150	150	-
M.	BIAS SUPPLIES	330	346	+16
N.	ANALOG SUPPLY	370	385	+15
P.	INTERFACE BOARDS	375	310	-65
Q.	STEPPING SUPPLY	370	TBD	TBD
R.	WIRES,GROMMETS,SCREWS	90	TBD	TBD
		3349	2797	-92

§ VI: RESOURCE REQUIREMENTS

PEAK POWER BY MODE

The CREWE instrument has a variety of modes, parametric in telemetry and power consumed. The following table defines 11 modes that are scientifically viable and depending on resource allocations may be used to maximize science return:

TM:	2000bps	4000bps	115,000bps
All Subsystems	1	2	3
All - VES	4	5	6
All - Receivers	7	8	-
Comatose	9		
Sleep	10		
Calibrate	11		

JPL Mission Modes	CREWE MODES	
Early Cruise	1,2,3,7,8	
Late Cruise	1,2,3,7,8	
Venus	1,2,3,7,8	
Earth	1,2,3,7,8	
Asteroid	3,6	
Remote Sensing	1,2,3,7,8	
In Situ	1,2,3,7,8	
Analysis RS	1,2,3,7,8	
All On	1,2,3	
Calibration/Sampling	11	"Who's calibrating?"
Mass Harmonic	1,2,3,4,5,6,7,8	
Tail Excursion	1,2,3,7,8	
Bakeout	9,10	
Super RS	1,2,3,4,5,6,7,8	
Calibration RS	1,2,3,7,8	
Calibration IS	11	

VI: CREWE PRIMARY POWER REQUIREMENTS

MODE 1	All systems	2000 bps	Primary= 21.6	Allocation = 21.9
MODE 2	All systems	4000 bps	Primary = 21.6	Allocation = 21.9
MODE 3	All systems	115 Kbps	Primary = 22.1	Allocation = 21.9
MODE 4	All systems minus VES	2000 bps	Primary = 18.46	Allocation = 18.3
MODE 5	All systems minus VES	4000 bps	Primary = 18.46	Allocation = 18.3
MODE 6	All systems minus VES	115 Kbps	Primary = 18.9	Allocation = 18.3
MODE 7	All systems minus receivers	2000 bps	Primary = 9.5	Allocation = TBD
MODE 8	All systems minus VES	4000 bps	Primary = 9.5	Allocation = TBD
MODE 9	Comatose minus VES	-	Primary = 4.65	Allocation = 4.2
MODE 10	Keep alive	-	Primary = 4.65	Allocation = 4.2
MODE 11	Calibrate VES	2000 bps	Primary = 9.77	Allocation = TBD

Summarizes pages 31 through 34 in the ICR package

§ VI: RESOURCE REQUIREMENTS

10-1-91 CREWE Peak Power

Assy	Mode	Avg Pwr	Peak Pwr	Duration	Lvl Cnf	Data rate
[A		secondary	secondary			1
2000 bps	"All subsystems"					
Converter		3.74	4.11			
VES		2.5	2.75			
HEATER (VES)		2.0	2.0			
DPU		1.5	1.65			
TDS		2.0	2.2			
FFT		1.75	1.92			
El.Preamp		1.1	1.21			
PSSR		2.45	2.7			
Mag. Preamp		.1	.11			
BIU		.5	3.0			
	2					4000
bps	"All sybsystems"					
Converter		3.74	4.11			
VES		2.5	2.75			
HEATER (VES)		2.0	2.0			
DPU		1.5	1.65			
TDS		2.0	2.2			
FFT		1.75	1.92			
El.Preamp		1.1	1.21			
PSSR		2.45	2.7			
Mag. Preamp		.1	.11			
BIU		.5	3.0			

3

115000bps
"All subsystems"

Converter	3.74	4.11
VES	2.5	2.75
HEATER (VES)	2.0	2.0
DPU	1.5	1.65
TDS	2.0	2.2
FFT	1.75	1.92
El.Preamp	1.1	1.21
PSSR	2.45	2.7
Mag. Preamp	.1	.11
BIU	.86	3.0

4

2000bps
"All subsystems minus VES"

Converter	3.35	3.68
DPU	1.5	1.65
TDS	2.0	2.2
FFT	1.75	1.92
El.Preamp	1.1	1.21
PSSR	2.45	2.7
Mag. Preamp	.1	.11
BIU	.86	3.0

5

4000bps
"All subsystems minus VES"

Converter	3.35	3.68
DPU	1.5	1.65
TDS	2.0	2.2
FFT	1.75	1.92
El.Preamp	1.1	1.21
PSSR	2.45	2.7
Mag. Preamp	.1	.11
BIU	.86	3.0

6

115000bps
"All subsystems minus VES"

Converter	3.35	3.68
DPU	1.5	1.65
TDS	2.0	2.2
FFT	1.75	1.92
El.Preamp	1.1	1.21
PSSR	2.45	2.7
Mag. Preamp	.1	.11
BIU	.86	3.0

7

1000bps
"All subsystems minus receivers"

Converter	1.29	1.41
VES	2.5	2.75
HEATER (VES)	2.0	2.0
DPU	1.5	1.65
Mag. Preamp	.1	.11
BIU	.5	3.0

8

4000bps
"All subsystems minus receivers"

Converter	1.29	1.41
VES	2.5	2.75
HEATER (VES)	2.0	2.0
DPU	1.5	1.65
Mag. Preamp	.1	.11
BIU	.5	3.0

9
"Comatose"

Converter	1.26	1.38
DPU	1.5	1.65
BIU	.5	

10
"Keep alive"

Converter	1.26	1.38
DPU	1.5	1.65
HEATER (VES)	2.0	2.00
BIU	.5	

11
"Calibrate"

Converter	1.26	1.38
VES	2.65	2.97
HEATER (VES)	2.0	2.0
DPU	1.5	1.65
BIU	.5	3.0

Real Year K$ FY 90-96 (Development)

Science Support
Hardware Support(including any JPL support identified separately)

G.2 Launch = 12/95 Reported: 8/90

The following is a cost break down of the CREWE experiment as it was 8/90 with nominal launch 12/95 in thousands of real year dollars:

File A:JDSDFBGT CREWE COST ********REVISED 8/14/90******

	FY90	FY91	FY92	FY93	FY94	FY95	TOTAL
Hardware-FY90K$							
GSFC OTHER	94	201	318	368	226	77	1283
GSFC ANTENNA	59	129	219	159	10	0	575
CS WY	1.6	2.2	3.5	4.0	4.0	2.6	17.9
SUBCON. UMN	42	391	686	872	198	35	2223
SUBCON. UNH	5	40	63	46	36	33	223
HDW SUBTOT.DIR.	200	761	1286	1444	469	144	4304
HEAD TAX RATE(K)	1.7	1.7	17.3	17.3	17.3	17.3	
HEAD TAX	2.7	3.7	60.6	69.2	69.2	45.0	250.4
LEP TAX RATE(%)	3.1	3.6	5.3	5.3	2.1	2.1	
LEP TAX	6.4	28.4	72.0	80.8	10.1	3.1	200.8
HARDWARE TOTAL	209	793	1419	1594	549	192	4755
RYK$	209	831	1568	1856	674	251	5389
Science-FY90K$							
GSFC OTHER	0	0	28	66	54	66	214
CS WY	.0	.9	1.1	1.1	1.1	1.1	5.3
SUBCON. UMN	5	39	99	117	117	154	530
SUBCON. UNH	0	0	0	0	0	11	11
SUBCON. UKS	1	2	2	2	2	5	15
SCI SUBTOT.DIR.	6	41	128	185	173	236	770
HEAD TAX RATE(K)	1.7	1.7	17.3	17.3	17.3	17.3	
HEAD TAX	.0	1.5	19.0	19.0	19.0	19.0	77.7
LEP TAX RATE(%)	3.1	3.6	5.3	5.3	2.1	2.1	
LEP TAX	.2	1.5	7.2	10.3	3.7	5.1	28.0
SCIENCE TOTAL	7	44	154	214	196	261	876
RYK$	7	46	171	249	241	340	1054

§ VI: RESOURCE REQUIREMENTS

Real Year K$ FY96-EOP MO/DA

	FY96	FY97	FY98	FY99	FY00	FY01	TOTAL
MO/DA-FY90K$							
GSFC OTHER	110	110	110	110	110	110	662
CS WY	2.1	1.1	1.1	1.1	1.1	1.1	7.6
SUBCON. UMN	105	71	61	61	66	138	502
SUBCON. UNH	27	27	22	27	44	55	203
SUBCON. UKS	4	5	8	20	42	55	135
MO/DA SUBTOT.DIR	247	214	202	219	263	357	1501
HEAD TAX RATE(K)	1.7	1.7	1.7	1.7	1.7	1.7	
HEAD TAX	3.6	1.9	1.9	1.9	1.9	1.9	12.9
LEP TAX RATE(%)	2.1	2.1	2.1	2.1	2.1	2.1	
LEP TAX	5.3	4.6	4.3	4.7	5.6	7.7	32.2
MO/DA TOTAL	256	221	208	225	270	367	1546
RYK$	355	326	326	376	479	691	2554

MO/DA	FY02	FY03	TOTAL
GSFC OTHER	110	110	221
CS WY	1.1	2.1	3.2
SUBCON. UMN	121	121	242
SUBCON. UNH	55	55	109
SUBCON. UKS	55	55	109
MO/DA SUBTOT.DIR	340	340	681
HEAD TAX RATE(K)	1.7	1.7	
HEAD TAX	1.9	3.6	5.4
LEP TAX RATE(%)	2.1	2.1	
LEP TAX	7.3	7.3	14.6
MO/DA TOTAL	349	351	701
RYK$	700	748	1449

RYK$ TOTALS	
HARDWARE TOTAL	5389
SCIENCE TOTAL	1054
MO/DA TOTAL	2554
CREWE TOTAL	8997
HEAD TX INCL ABOVE	346
LEP TX INCL ABOVE	275.6

NOTE:

$$\text{LEP TAX} = \frac{\text{(SUBTOTAL DIRECT) X (DECIMAL LEP TAX RATE)}}{\text{(1- DECIMAL LEP TAX RATE)}}$$

TERMINATION LIABILITY IS 50% OF TERMINATION YEAR COST

CREWE AREAS of DEVELOPMENT RISK/CONCERN

1. Changing S/C configuration and current design of reaction wheels limits the tip deflections allowed on the dipoles due to thermal flutter. Requirement has been laid on at **minimal solar distance** rather than at the larger of (minimum solar distance of S/C (0.63AU), or distance of minimum solar approach **at** the comet (1.05AU))

2. Location of TOMSC is still not certain with the recent MM/II redesign. Reaction wheel noise source and assessment of present location potentially represent a serious risk to meaningful science return from that subsystem.

3. The costed antenna deployment system is not known to reliably deploy after the thermal stresses of being stowed for 2 1/2 years as currently being discussed.

4. We have two general concerns about the integrity of S/C level tests in Thermal Vacuum. It is our understanding that the S/C will never be together in vacuum prior to deployment in space. At the system level various current paths and possibilities for interference are not seen until after launch. At the CREWE level the testing of whether CREWE works properly requires that both sides of the VES be in the thermal vacuum chamber at the same time. Will this be possible?

5. SA3300

6. Who Deploys Antenna + Software/Level Control; Common interface philosophy says out DPU should control it. That places our peak power at +10watts over our average power, causing a gross omnipresent inefficiency in our convertors for the life of the mission. It also impacts the quality control of the software that is to control this deployment and hence its overall cost.

§ VII: STATUS OF MAJOR CONTRACTS

STATUS OF MAJOR CONTRACTS

*) 506 Authority All Comes to GSFC LEP

**) Contracts from PI Organization:

1) Antenna	Awaiting lifting of CRAF Project Limbo
2) Co-I's Minnesota	"
University of New Hampshire	"
3) Stepping Supplies	"
4) Bias Supplies	"
5) Channeltrons	"
6) Calibrator Assembly and optical fibers	"

CRAF CREWE 10/10/91 §VII "STATUS of MAJOR CONTRACTS"-39-

NON-NASA FUNDED EFFORTS

o CREWE is a joint venture with two groups in France and a US contingent.

o The two French groups are at CRPE in Paris and the other is at MEUDON observatory in the suburbs of Paris.

o Attached APPENDIX III letter endorsing participation.

*Summary of Agreements (deliverables, schedule etc.) with foreign co-I's

"... - CNES and NASA split cost and study effort for CREWE antennas
- Minnesota supplies mechanical housings to Meudon at no charge to the French
- Minnesota supplies checkout computer to Meudon at no charge to the French
(agreements based on Ulysses and ISTP cooperations)

* Copies of Documents describing Foreign Commitments with authorizing agency approvals.

"- proposal commitments and gentlemen's agreements define sharing of responsibilities
- letter giving CNES approval has been sent"

CRAF CREWE 10/10/91 §VIII "Non NASA Funded Efforts" -40-

§ IX: STATUS OF EIP AND IM PLAN

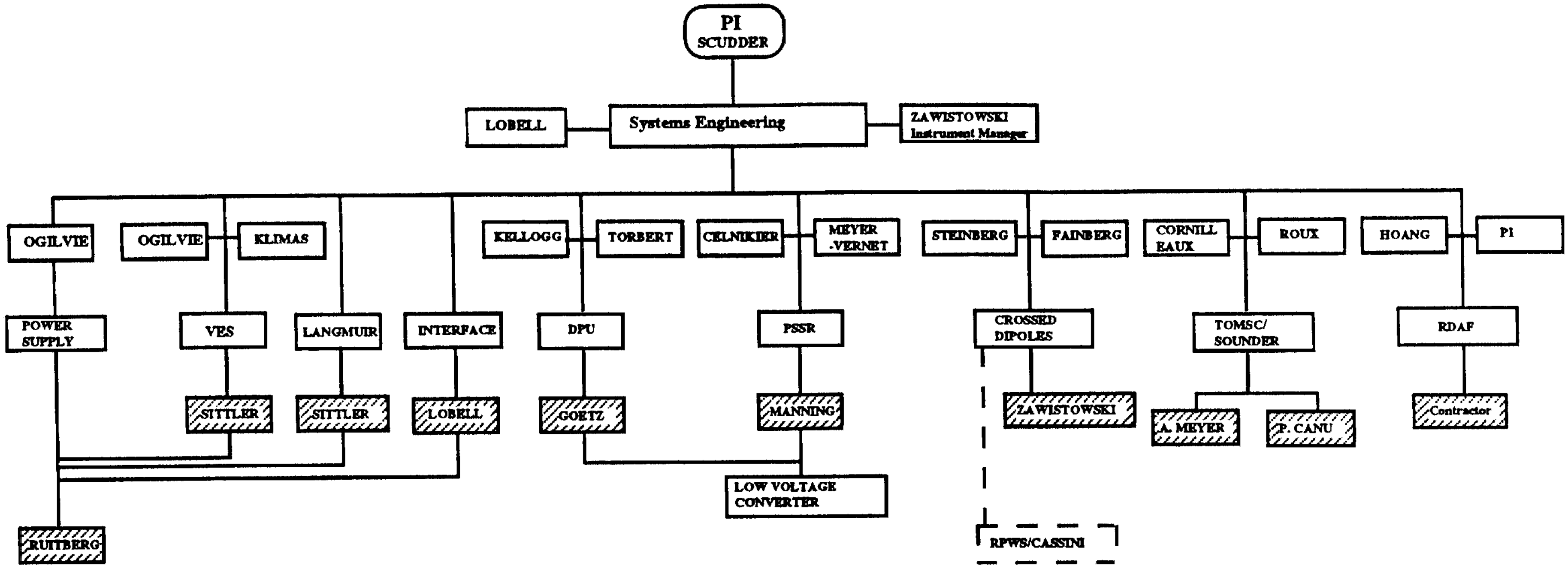
o The EIP has been drafted and one of its major options has not been exercised: the fabricator of the DPU hardware. Both Minnesota and UNH have expertise and capability in this with GGS/WIND/WAVES on the one hand and (GGS/WIND/SWE,GGS/POLAR/HYDRA and rockets) on the other. Depending on the cost constraints, the participation in hardware deliverables may still change depending on contract proposals. Whatever, the outcome the group that does NOT supply the DPU will write the software for it as an internal cross check on the machine and its function.

o The Flight Antenna development contract has been outlined with GSFC procurement. It will contain an "fly off" clause in which multiple models of flight concept MAY be selected (with a $ cap per vendor <30K) for zero G deployment as a basis for the award of the further definition and flight fabrication phase of the contract. There will thus be a two phase contract.

o The other procurements represent rather short lead times and are not such pacing items as the above two are.

CRAF CREWE 10/10/91 §IX "Status of EIP and IM Plan" -41-

CREWE



LEGEND:

☐	SCIENCE RESPONSIBILITY - BROAD POLICY OF SUBSYSTEM FUNCTION PURPOSE
▨	SUBSYSTEM RESPONSIBILITY- SUBSYSTEM IMPLEMENTATION, FORM, FIT, FUNCTION, DRAWING SCHEDULE, BUDGET AND REPORTING
VES	VECTOR ELECTRON SPECTROMETER
PSSR	PLASMA SPECTROSCOPY SOUNDER RECEIVER
TOMSC	THREE AXIS ORTHOGONAL MAGNETIC SEARCH COIL
RDAF	REMOTE DATA ANALYSIS FACILITY

CREWE Confirmation Review
10/10/91

§ X DESCOPE OPTIONS

1. In prior (stand-alone CRAF) science descope plans we considered that the easiest hardware to simplify or remove would be one of the dipole assemblies of the electric field antenna. Unfortunately, this has little effect on the final price since the development of the deployer system is the cost intensive portion of the contract. In the Cassini connection the second antenna is more crucial to Saturn science; because it is a common subsystem it could not be descoped without consultation between the PI's and NASA.

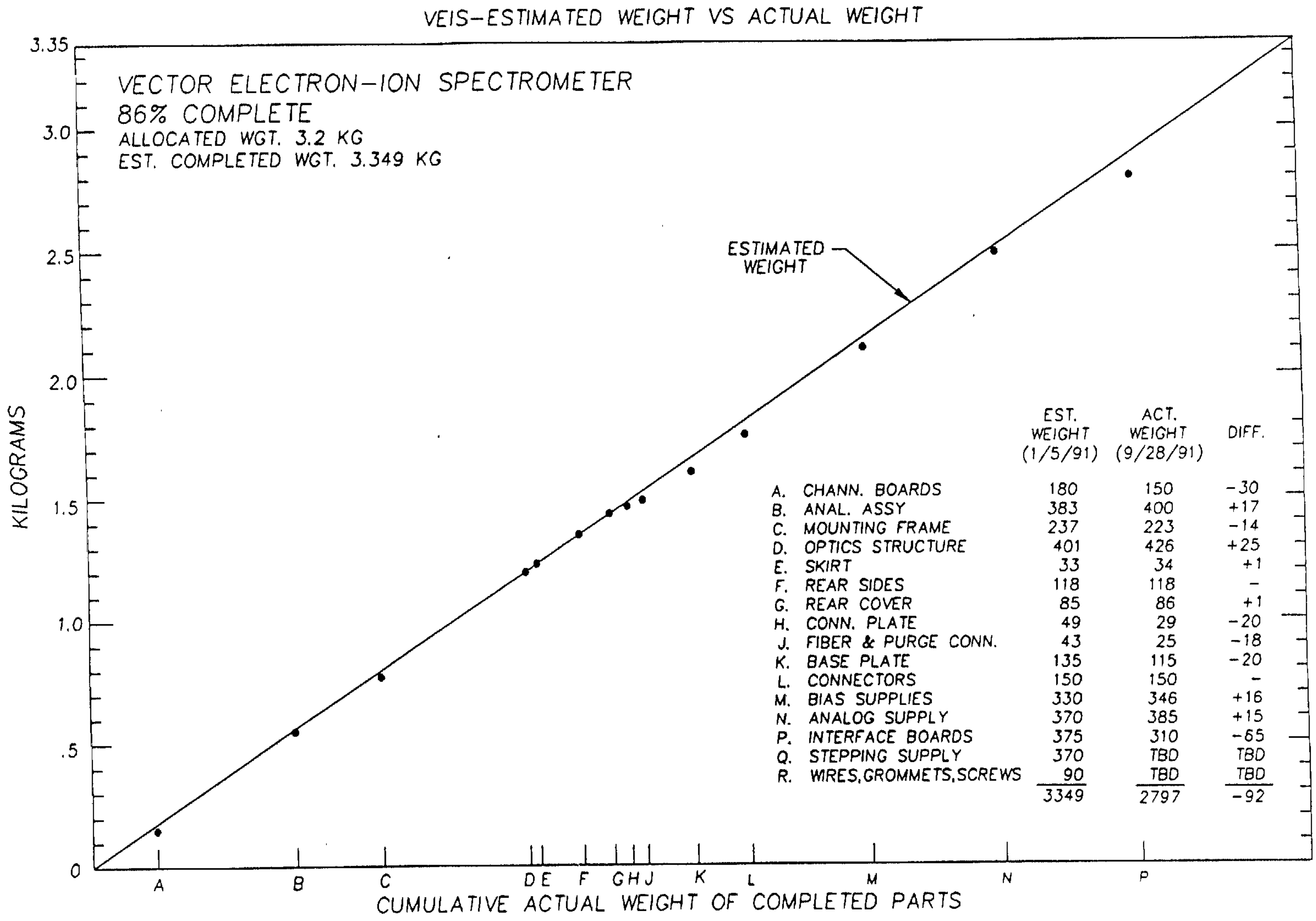
2. Ruling out common instrumentation on RPWS and CREWE as having conflicting science requirements for being descoped, the unique implementations between RPWS and CREWE should be reexamined for possible savings to the CC Project for not building and developing two unique DPU's. Iowa got an institutional commitment to rebate to their investigation, the normal overhead charge for the DPU portion of their investigation, if it stays "in house", which they do not realize if they contract with Minnesota or UNH to build it. Conversely Minnesota will not institutionally forgo its institutional surcharge to make its DPU look more fiscally attractive to Iowa. Thus, DPU commonality which once appeared attractive, and was in fact proposed, is precluded. Within CREWE's own team we have two experienced DPU builders with SA3300 experience. As outlined in the EIP we will bid out the DPU job against the functional specifications for CREWE. The co-I group that does not win

the DPU hardware competition will write the flight software and become the in-house critic of the DPU implementation starting at the in-house critical system design review. If the winner exceeds his contractural cost or cannot sustain his contracted activity, we can rescope this activity within the team to the DPU of possibly lesser power, but still within the original cost cap of the CREWE investigation at a TBD risk for compromising CREWE science. The cost savings cannot be quantified at the present time.

1.) What can be done to reduce CREWE's mass.

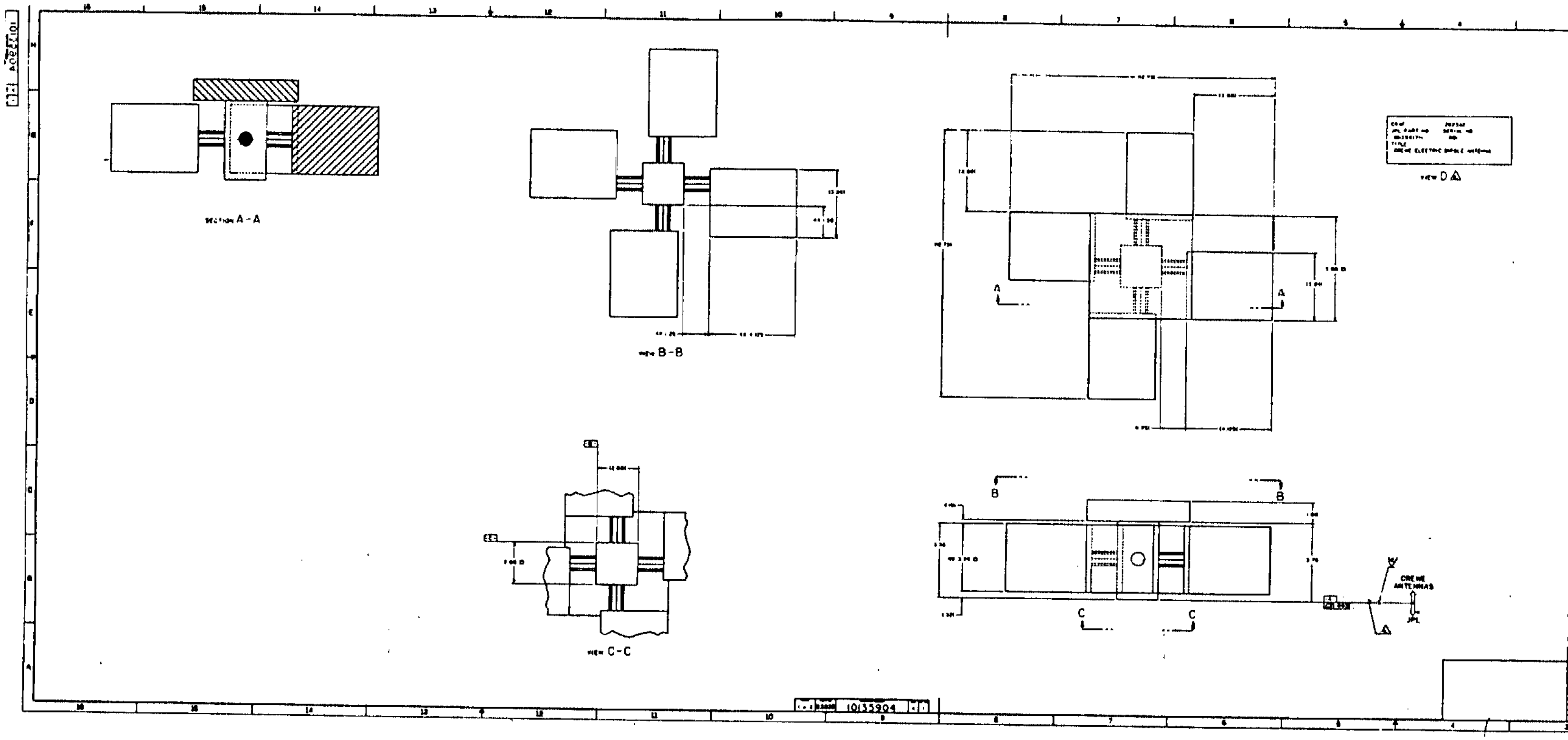
We have proofed all the boxes for the receivers and the VES in magnesium to demonstrate the reliability of our weight estimates. Participating in GGS with analogous subsystems in flight configurations with constrained resources gives us confidence that further weight reductions are unlikely without science compromise.

Appendix I. SWE VES Mass Evolution Design ---> Farbricaton:



	EST. WEIGHT (1/5/91)	ACT. WEIGHT (9/28/91)	DIFF.
A. CHANN. BOARDS	180	150	-30
B. ANAL. ASSY	383	400	+17
C. MOUNTING FRAME	237	223	-14
D. OPTICS STRUCTURE	401	426	+25
E. SKIRT	33	34	+1
F. REAR SIDES	118	118	-
G. REAR COVER	85	86	+1
H. CONN. PLATE	49	29	-20
J. FIBER & PURGE CONN.	43	25	-18
K. BASE PLATE	135	115	-20
L. CONNECTORS	150	150	-
M. BIAS SUPPLIES	330	346	+16
N. ANALOG SUPPLY	370	385	+15
P. INTERFACE BOARDS	375	310	-65
Q. STEPPING SUPPLY	370	TBD	TBD
R. WIRES,GROMMETS,SCREWS	90	TBD	TBD
	3349	2797	-92

.Appendix II. ICD Drawings Known to CREWE



12 SEAL CONNECTORS PER JPL SPECIFICATION [illegible] VOL. II SUBSECTION [illegible]

11 TORQUE CONNECTOR FASTENERS PER JPL SPECIFICATION [illegible] VOL. II SUBSECTION [illegible]

10 CONNECTOR MOUNTING PER JPL SPECIFICATION [illegible] VOL. I SUBSECTION [illegible]

9 INSTALL CONNECTORS PER JPL SPECIFICATION [illegible]

△8 ACTUAL CG LOCATION SHALL BE PROVIDED PRIOR TO DELIVERY OF INSTRUMENT

△7 SPACECRAFT HARDWARE REFERENCE DESIGNATION, ASSEMBLY PART NUMBER, SERIAL NUMBER AND ASSEMBLY TITLE TO APPEAR AS SHOWN IN THIS AREA.

△6 IDENTIFY CONNECTOR REFERENCE DESIGNATION IN AREA SHOWN ADJACENT TO CONNECTOR

△5 NOTHING SHALL PROTRUDE BEYOND THIS SURFACE.

4 MOUNTING SURFACES SHALL BE BARE ALUMINUM, TITANIUM OR AN APPROVED CONDUCTIVE COATING TO ACCOMMODATE ELECTRICAL, GROUNDING AND THERMAL REQUIREMENTS.

3 THE INSTRUMENT SHALL BE ALIGNED TO THE DATUMS -E- AND -D- WITH THE ACCURACIES SPECIFIED IN FUNCTIONAL REQUIREMENTS [illegible]

2 THE ABBREVIATION "CREWE ANTENNAS" STANDS FOR COORDINATED RADIO, ELECTRON AND WAVES EXPERIMENT ELECTRIC DIPOLE ANTENNA.

△1 THIS IS THE INTERFACE CONTROL DRAWING FOR THE CREWE ELECTRIC DIPOLE ANTENNA, JPL PART NUMBER [illegible], REFERENCE DESIGNATION [illegible]. JPL DRAWING NUMBER [illegible] SHALL CONTAIN THE FOLLOWING NOTE: "THIS ASSEMBLY MEETS THE INTERFACE REQUIREMENTS OF JPL INTERFACE CONTROL DRAWING 10135904."

NOTES: UNLESS OTHERWISE SPECIFIED.

DRAWING AS RELEASED IS INCOMPLETE
ADDITIONAL INFORMATION IS REQUIRED

INTERFACE CONTROL DRAWING

INFORMATION ONLY

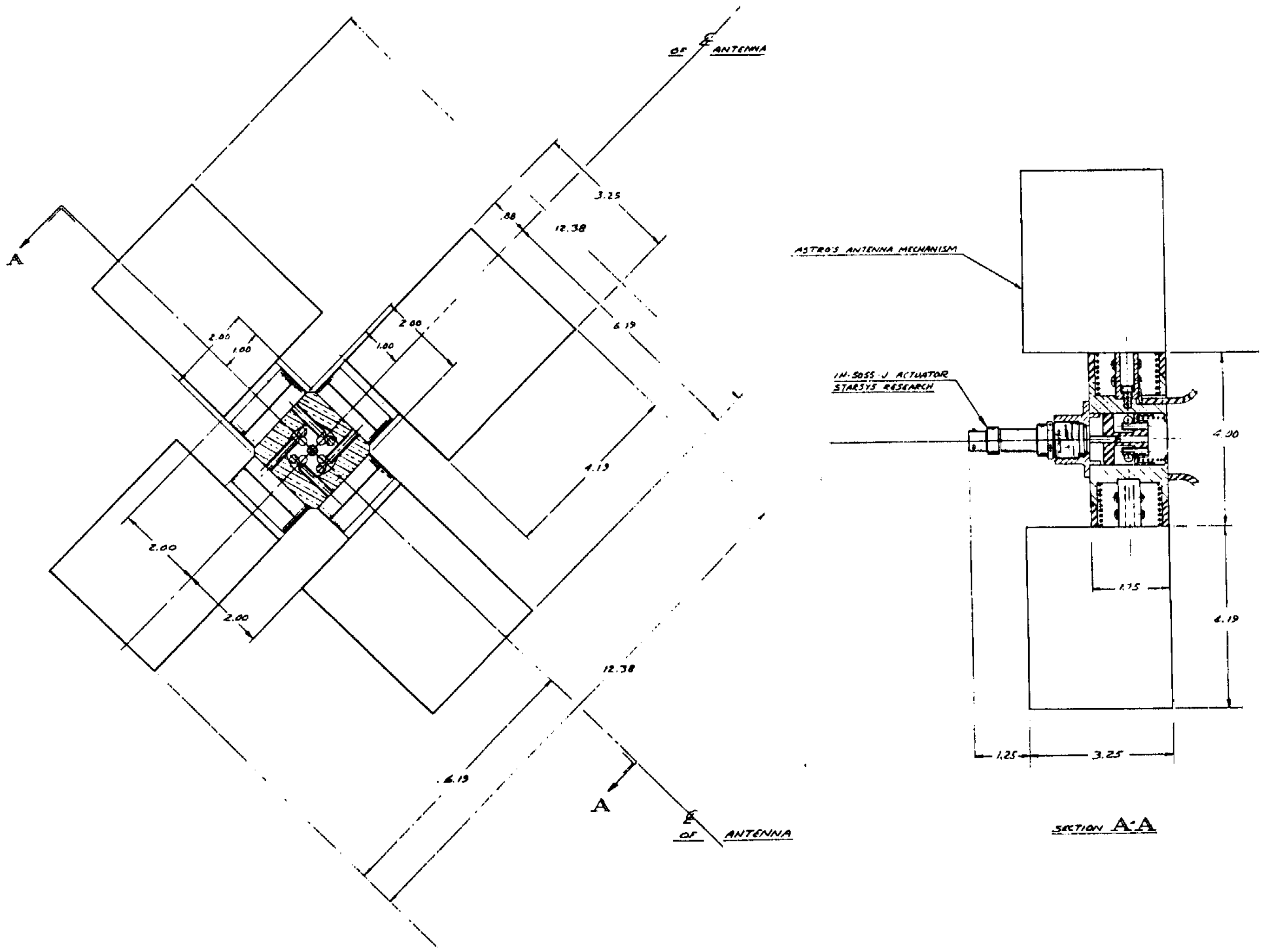
JET PROPULSION LABORATORY

ELECTRIC DIPOLE
ANTENNA
(CREWE ANTENNAS)
INTERFACE CONTROL DRAWING

J 23835 10135904

TES:

1. INTERPRET DRAWING PER DOD-STD-100



SECTION A-A

PARTS LIST

QTY REQD	ITEM NO.	PART/IDENT NO.	DESCRIPTION	MATERIAL	MATL SPEC

UNLESS OTHERWISE SPECIFIED

DO NOT SCALE DRAWING

DRAWN ISSY MORENO 9 27 91

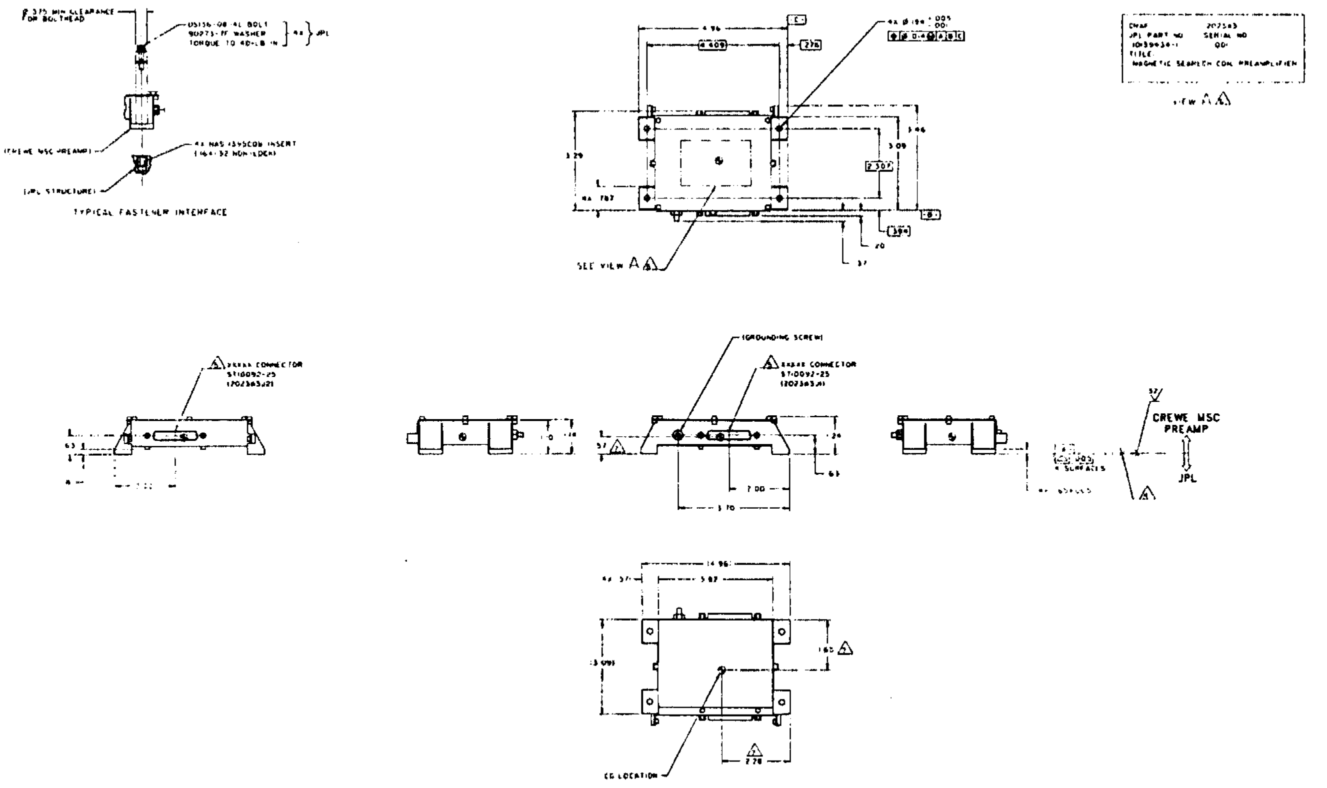
ASTRO

TITLE L.O.-CRAF/CASSINI ANTENNA

SIZE E FSCM NO. 34488 DWG NO. 54339001

SCALE FULL

ORIGINAL [illegible] OF POOR QUALITY



[illegible]

9. INSTALL CONNECTORS PER [illegible] AS INDICATED (TBD)

[illegible]

5. MOUNTING SURFACES SHALL BE [illegible] ELECTRICAL BONDING AND THERMAL REQUIREMENTS

3. THE ABBREVIATION CREWE MSC PREAMP STANDS FOR THE TEAM COORDINATED RADIO ELECTRON AND WAVE EXPERIMENT MAGNETIC SEARCH COIL PREAMPLIFIER

1. THIS IS THE INTERFACE CONTROL DRAWING FOR THE CREWE MAGNETIC SEARCH COIL PREAMPLIFIER [illegible] JPL DRAWING [illegible] SHALL CONTAIN [illegible] MEETS THE INTERFACE REQUIREMENTS [illegible] DRAWING NUMBER 10135923

NOTES: UNLESS OTHERWISE SPECIFIED

APR 2 0 1991

INTERFACE CONTROL DRAWING **CHECK PRINT**

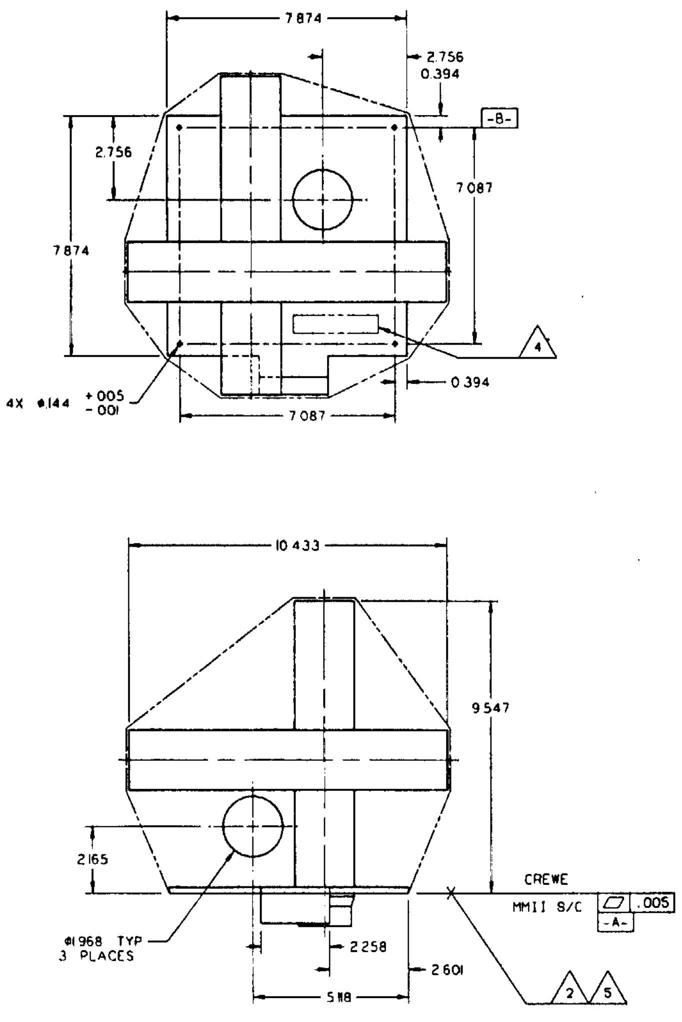
WORK ORDER NO. 6167
CHK PRT DIST DATE APR 3 0 1991
[illegible] DATE MAY 1 7 1991
BEERTENBACH
122

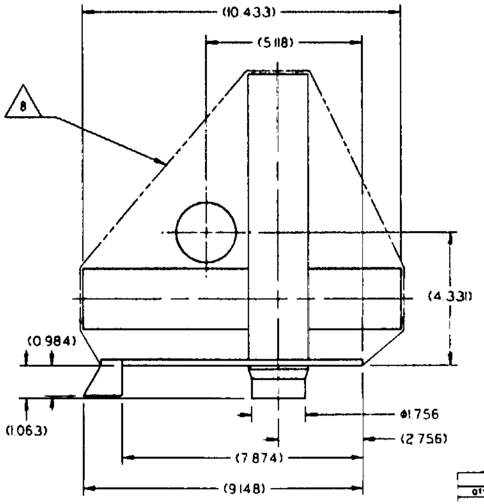
JET PROPULSION LABORATORY

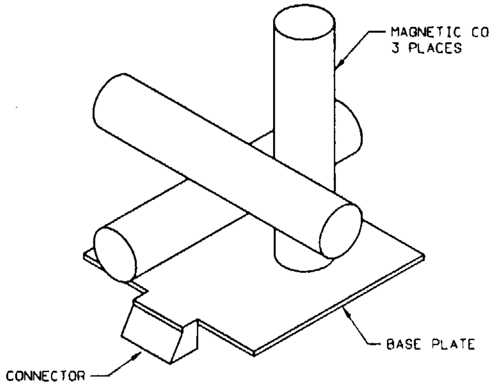
[illegible] MAGNETIC SEARCH COIL CREWE MSC PREAMP INTERFACE CONTROL DRAWING

J 23835 10135923

REVISIONS															
LTR	ZONE	DESCRIPTION		DWN	CHK	STRUCT	MAT'L	THRM CONT			ENGR	DSGN SUPV	DATA MGT	RELEASE DATE	
A		INITIAL RELEASE	2B	SEE TITLE BLOCK										03-19-90	







8 THERMAL BLANKET LOCATIONS TBD

7 WASHER AND FASTENER DESIGNATIONS TBD

6 C.G. LOCATIONS TBD

5 MOUNTING SURFACES SHALL BE BARE ALUMINUM, TITANIUM OR AN APPROVED CONDUCTIVE COATING TO PROVIDE ELECTRICAL GROUNDING

4 SPACECRAFT MODIFIER, REFERENCE DESIGNATION, ASSEMBLY NUMBER, SERIAL NUMBER, AND ASSEMBLY TITLE TO APPEAR IN AREA SHOWN

3 THE INSTRUMENT SHALL BE ALIGNED TO DATUMS -A- & -B- WITH THE ACCURACIES SPECIFIED IN CRAF-3-170

2 NOTHING SHALL PROTRUDE BEYOND THIS SURFACE EXCEPT WHERE NOTED

1 ALL DIMENSIONS IN INCHES

NOTES: UNLESS OTHERWISE SPECIFIED

INTERFACE CONTROL DRAWING

QTY REQD		ITEM NO	REF DES	FSCM NO	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	SPECIFICATION	MATERIAL OR NOTE	ZONE

PARTS LIST

NEXT ASSEMBLY
USED ON
APPLICATION

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES
DECIMALS ANGLES
.XX ± .03 .XXX ± .010 ± 1/2°
MACHINE FINISH √
DO NOT SCALE DRAWING
INTERPRET DWG PER DOD-STD-100
MATERIAL

CONTRACT NO
APPD DATE
DWN J. McGOWN 1-25-90
CHK
STRUCT
MAT'L
THRM CONT
CHGR
ENGR

JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA CA 91109
RELEASED THROUGH SECTION 352

CREWE MAGNETIC
SEARCH COIL (MSC)
ICD

SIZE D
FSCM NO 23835
10135890
REV A
SCALE 1/2
UNCLASSIFIED
SHEET 1 OF 1

CAD GENERATED

CREWE_ICD

D 10135890

LTR	ZONE	DESCRIPTION		DWN	CHK	STRUCT	MATL	THRM CONT			CHGR	DSGN SUPV	DATA MGT	RELEASE DATE
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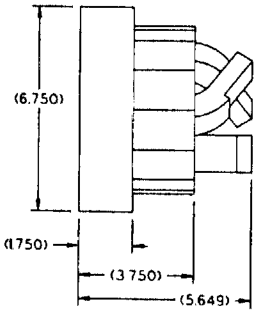
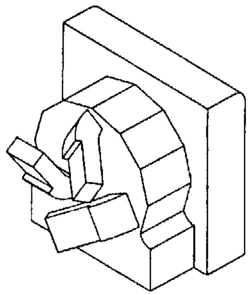
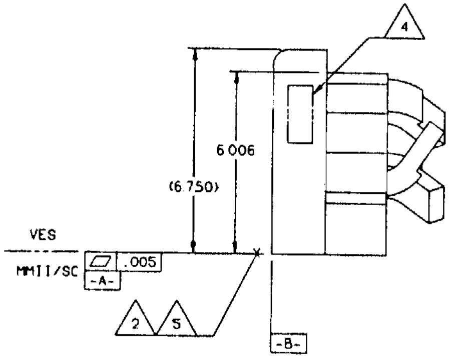
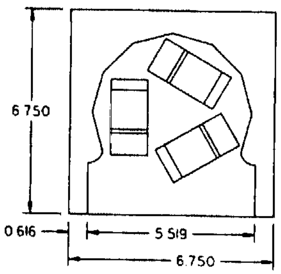








11 MOUNTING FASTENER LOCATIONS TBD

10 COVER JETTISON ENVELOPE IS TBD

9\. THERMAL BLANKET LOCATIONS TBD

8 WASHER AND FASTENER DESIGNATIONS TBD

7 CG LOCATIONS TBD

6 CONNECTOR LOCATIONS TBD

5 MOUNTING SURFACES SHALL BE BARE ALUMINUM, TITANIUM OR AN APPROVED CONDUCTIVE COATING TO PROVIDE ELECTRICAL GROUNDING

4 SPACECRAFT MODIFIER, REFERENCE DESIGNATION, ASSEMBLY NUMBER, SERIAL NUMBER, AND ASSEMBLY TITLE TO APPEAR IN AREA SHOWN

3 THE INSTRUMENT SHALL BE ALIGNED USING DATUMS -A- & -B- WITH THE ACCURACIES SPECIFIED IN CRAF-3-170

2 NOTHING SHALL PROTRUDE BEYOND THIS SURFACE EXCEPT WHERE NOTED

1 ALL DIMENSIONS IN INCHES

NOTES UNLESS OTHERWISE SPECIFIED

INTERFACE CONTROL DRAWING

QTY REQD		ITEM NO	REF DES	FSCM NO	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	SPECIFICATION	MATERIAL OR NOTE	ZONE

PARTS LIST

NEXT ASSEMBLY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES
DECIMALS .XX ± .03 .XXX ± .010 ANGLES ± 1/2°
MACHINE FINISH √
DO NOT SCALE DRAWING
INTERPRET DWG PER DOD-STD-100
MATERIAL

CONTRACT NO
APPD DATE
DWN J McGOWN 1-25-90
CHK
STRUCT
MATL
THRM CONT
CHGR
DSGN SUPV

JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA CA 91109
RELEASED THROUGH SECTION 352

CREWE VECTOR ELECTRON
SPECTROMETER (VES)
ICD

SIZE D FSCM NO 23835 10135889 REV A
SCALE 1:2 UNCLASSIFIED SHEET 1 OF 1

JPL 2738-2-3 REV 12-84 VES.ICD

D 10135889

CAD GENERATED

§ XI BRINTON QUESTIONS

Appendix III. Participation Documentaion from French

APPENDIX B

TWX 002

Rcv: @1IM/2.06274 Line: 2A

*NASA GSFC*****

*NASA GSFC*****

692 Scudder

DESPA 204464F

FROM : DR. M.COMBES, DIRECTEUR DU LABORATOIRE DE RECHERCHE
SPATIALE
OBSERVATOIRE DE PARIS-MEUDON
92190 - MEUDON

TO : DR. J. SCUDDER, CODE 692
NASA/GSFC

PLEASE FIND HEREWITH COPY OF CNES LETTER ON FRENCH PARTICIPATION TO CRAF MISSION. ORIGINAL WILL BE SENT TO MRS M.FINARELLI, NASA HQ, WASHINGTON, DC 20546, USA.

C.N.E.S.
DIVISION DES AFFAIRES INTERNATIONALES
2, PLACE M. QUENTIN
PARIS FRANCE

PARIS LE 15 NOVEMBRE 1985

MME M. FINARELLI
NASA
WASHINGTON DC
20546 USA

CHERE MADAME,

VOUS ALLEZ RECEVOIR UNE PROPOSITION EN DEUX EXEMPLAIRES EN REPONSE A L'APPEL A EXPERIENCE CRAF, INTITULEE (CREW/CREPE) DONT LE RESPONSABLE SCIENTIFIQUE EST J. SCUDDER (NASA/GSFC).
LES SCIENTIFIQUES FRANCAIS ASSOCIES A CETTE EXPERIENCE SONT DRS L.CELNIKIER, C.C. HARVEY, S. HOANG, N. MEYER-VERNET ET J.L. STEINBERG DU LABORATOIRE DE RECHERCHE SPATIALE DE L'OBSERVATOIRE DE PARIS
ET P.CANU ,N. CORNILLEAU ET A. ROUX DU CRPE.
CETTE PROPOSITION EST EN COURS D'EXAMEN AU CNES ET NOUS VOUS FERONS CONNAITRE PROCHAINEMENT NOTRE POSITION A CE SUJET.
JE VOUS PRIE DE CROIRE, CHERE MADAME, -A L'ASSURANCE DE MES SENTIMENTS DISTINGUES.
M. CHEVREL
CHEF DE LA DIVISION DES AFFAIRES INTERNATIONALES.

REGARDS,
M. COMBES

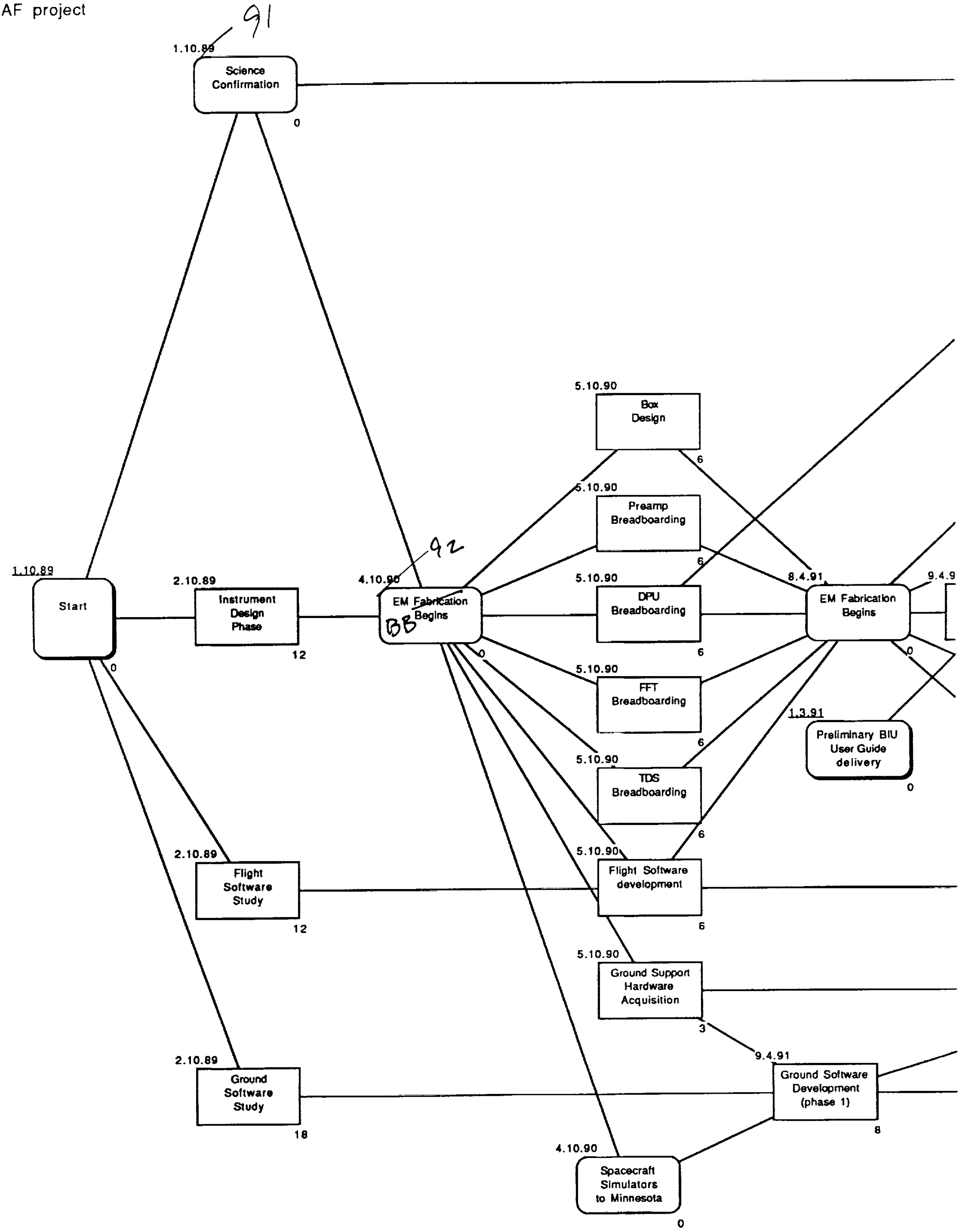
DESPA 204464F
*NASA GSFC*****

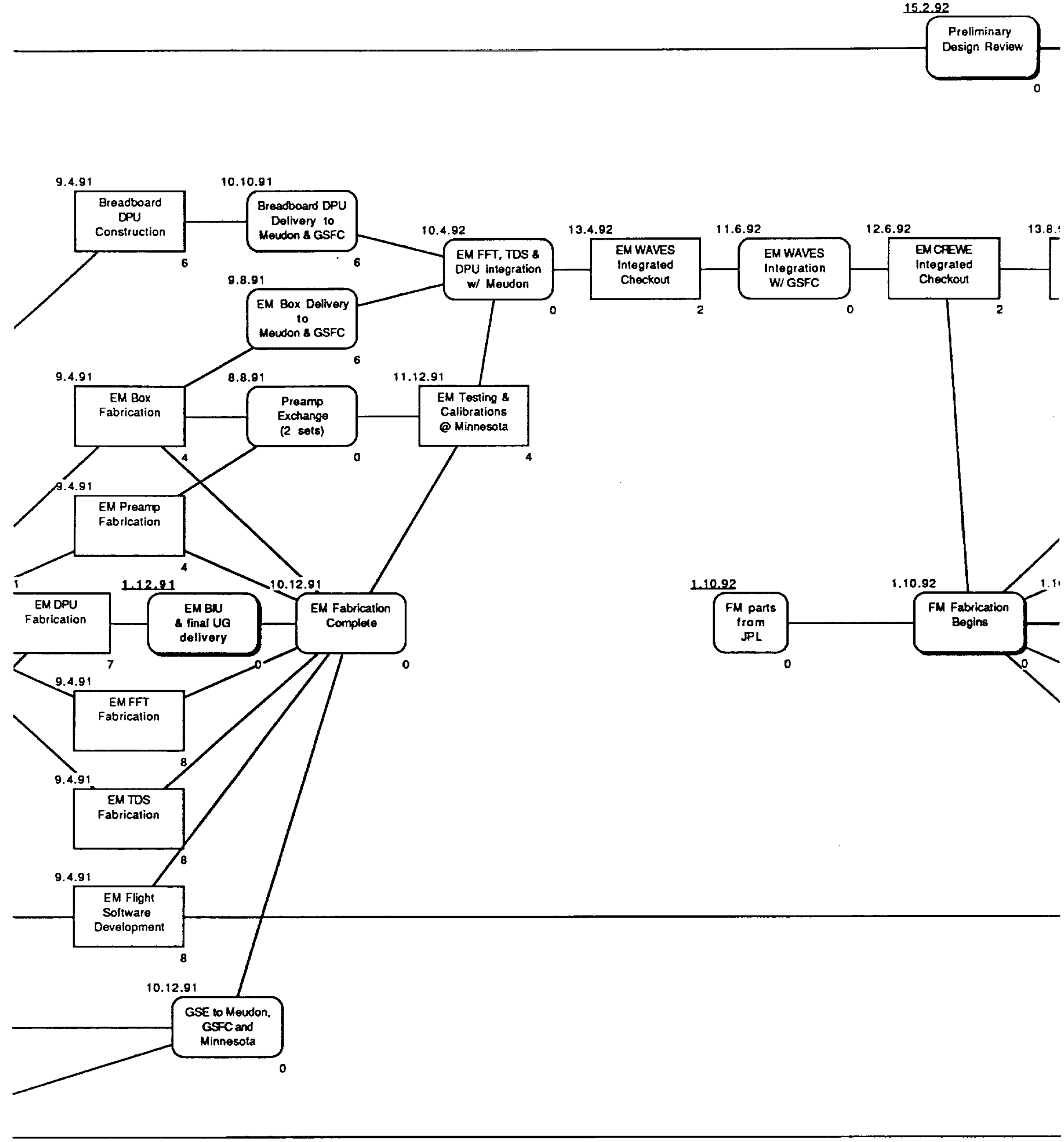
TO REPLY FROM TELEX I OR II (TWX) DIAL 100 FROM EASYLINK USE /WUW.

§ XI BRINTON QUESTIONS

Appendix IV Minnesota Bubble Chart

Minnesota activity
CREWE experiment
CRAF project




15.2.92
Preliminary Design Review
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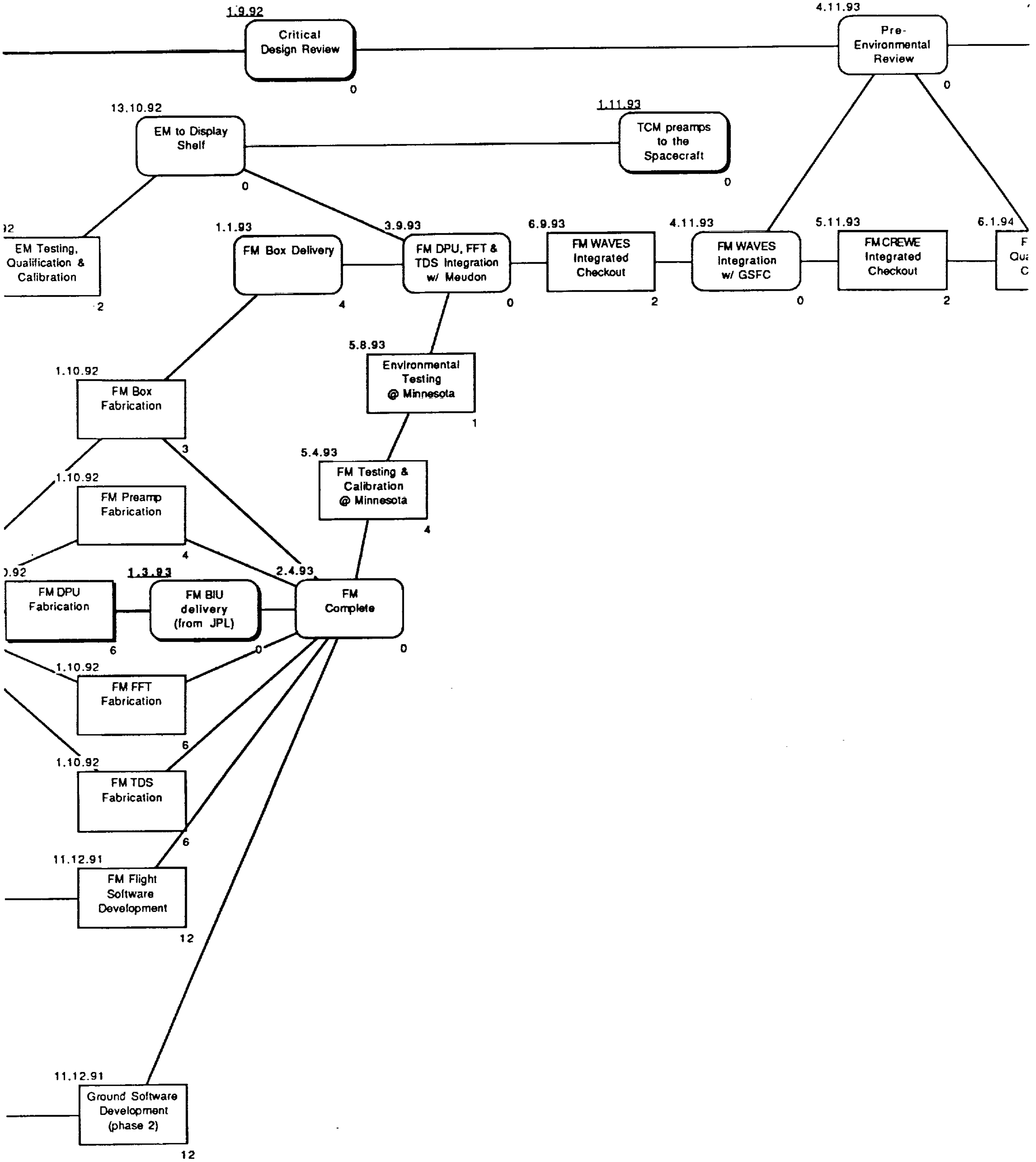
9.4.91
Breadboard DPU Construction
6
10.10.91
Breadboard DPU Delivery to Meudon & GSFC
6
10.4.92
EM FFT, TDS & DPU Integration w/ Meudon
0
13.4.92
EM WAVES Integrated Checkout
2
11.6.92
EM WAVES Integration W/ GSFC
0
12.6.92
EM CREWE Integrated Checkout
2
13.8.
9.8.91
EM Box Delivery to Meudon & GSFC
6
9.4.91
EM Box Fabrication
4
8.8.91
Preamp Exchange (2 sets)
0
11.12.91
EM Testing & Calibrations @ Minnesota
4
9.4.91
EM Preamp Fabrication
4
1.12.91
EM BIU & final UG delivery
0
10.12.91
EM Fabrication Complete
0
EM DPU Fabrication
7
1.10.92
FM parts from JPL
0
1.10.92
FM Fabrication Begins
0
9.4.91
EM FFT Fabrication
8
9.4.91
EM TDS Fabrication
8
9.4.91
EM Flight Software Development
8
10.12.91
GSE to Meudon, GSFC and Minnesota
0


1.9.92
Critical Design Review
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4.11.93
Pre-Environmental Review
0
13.10.92
EM to Display Shelf
0
1.11.93
TCM preamps to the Spacecraft
0
92
EM Testing, Qualification & Calibration
2
1.1.93
FM Box Delivery
4
3.9.93
FM DPU, FFT & TDS Integration w/ Meudon
0
6.9.93
FM WAVES Integrated Checkout
2
4.11.93
FM WAVES Integration w/ GSFC
0
5.11.93
FM CREWE Integrated Checkout
2
6.1.94
F
Qu
C
5.8.93
Environmental Testing @ Minnesota
1
1.10.92
FM Box Fabrication
3
5.4.93
FM Testing & Calibration @ Minnesota
4
1.10.92
FM Preamp Fabrication
4
.92
FM DPU Fabrication
6
1.3.93
FM BIU delivery (from JPL)
0
2.4.93
FM Complete
0
1.10.92
FM FFT Fabrication
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1.10.92
FM TDS Fabrication
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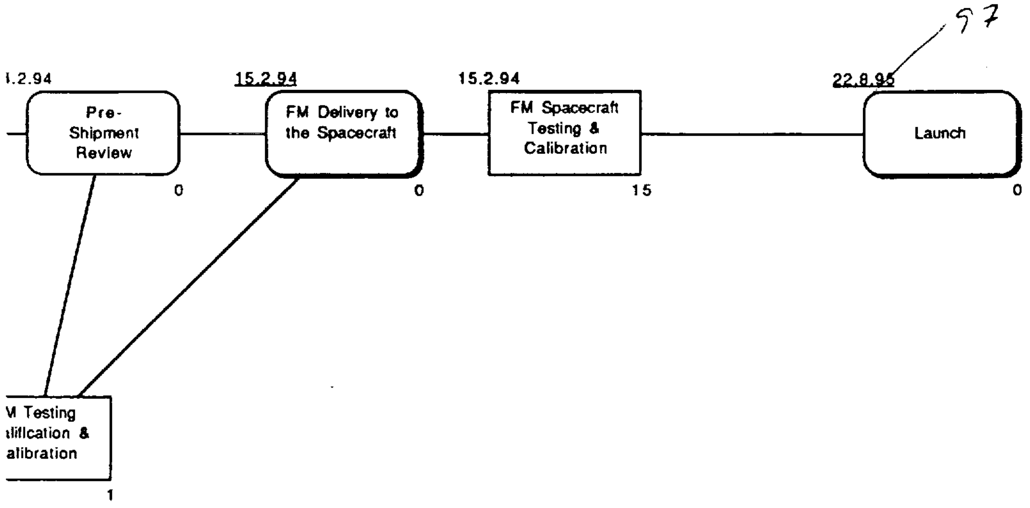
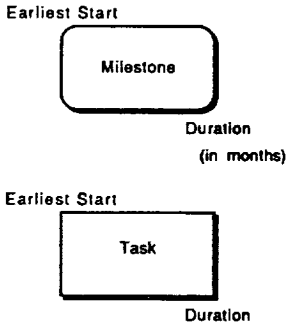
11.12.91
FM Flight Software Development
12
11.12.91
Ground Software Development (phase 2)
12



.2.94
Pre-Shipment Review
0
15.2.94
FM Delivery to the Spacecraft
0
15.2.94
FM Spacecraft Testing & Calibration
15
97
22.8.95
Launch
0
M Testing
ilification &
alibration
1

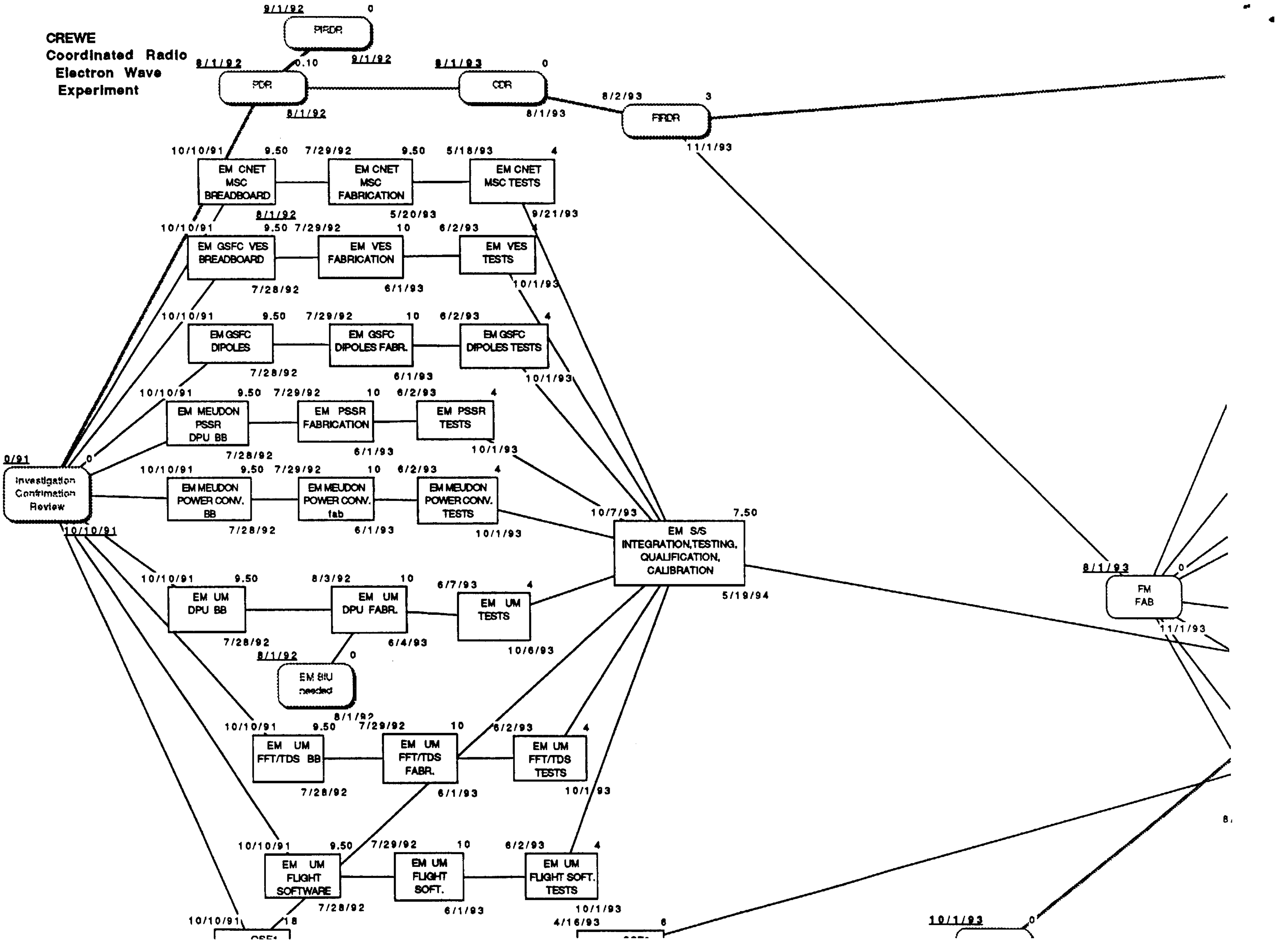


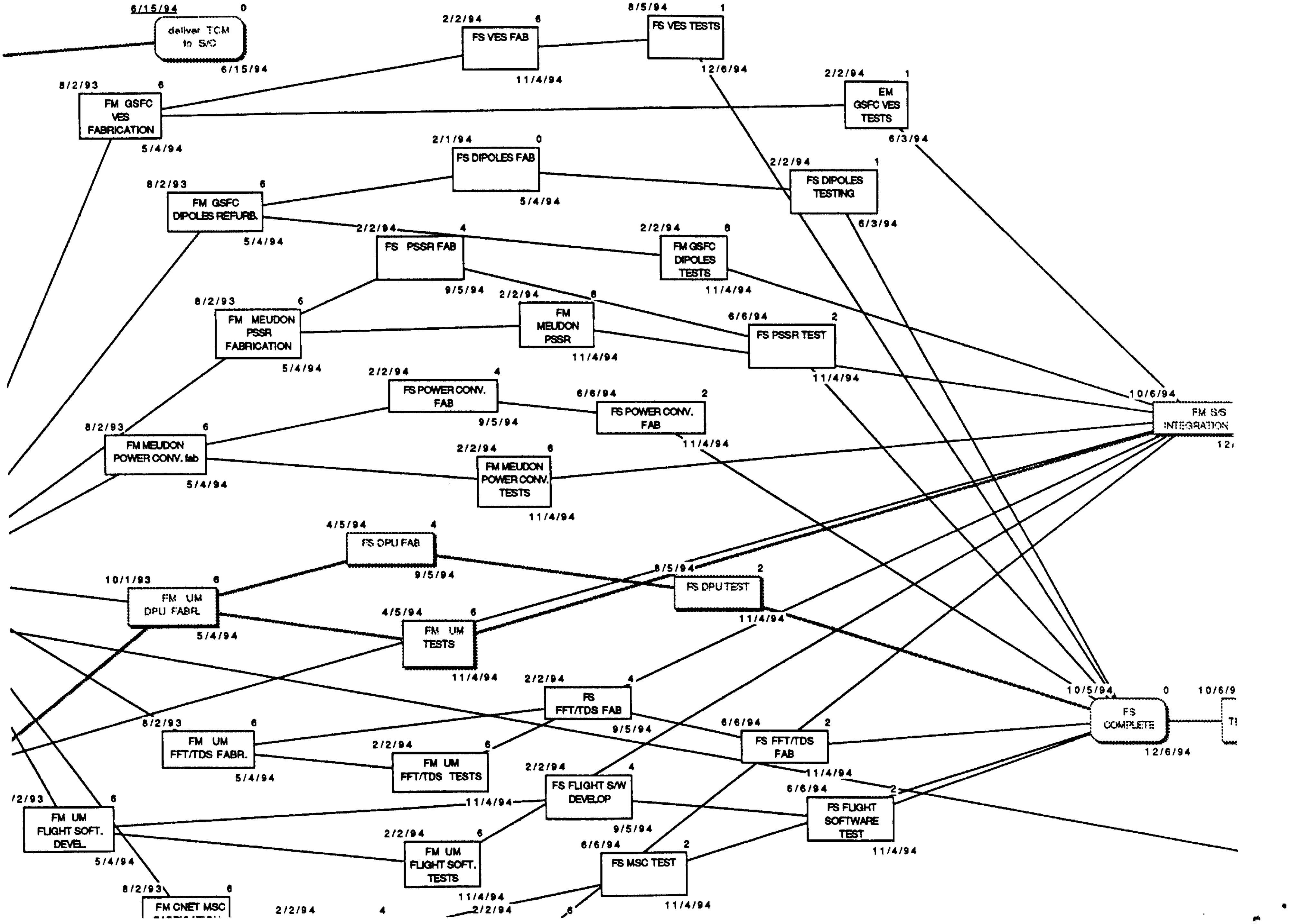
Earliest Start
Milestone
Duration
(in months)
Earliest Start
Task
Duration

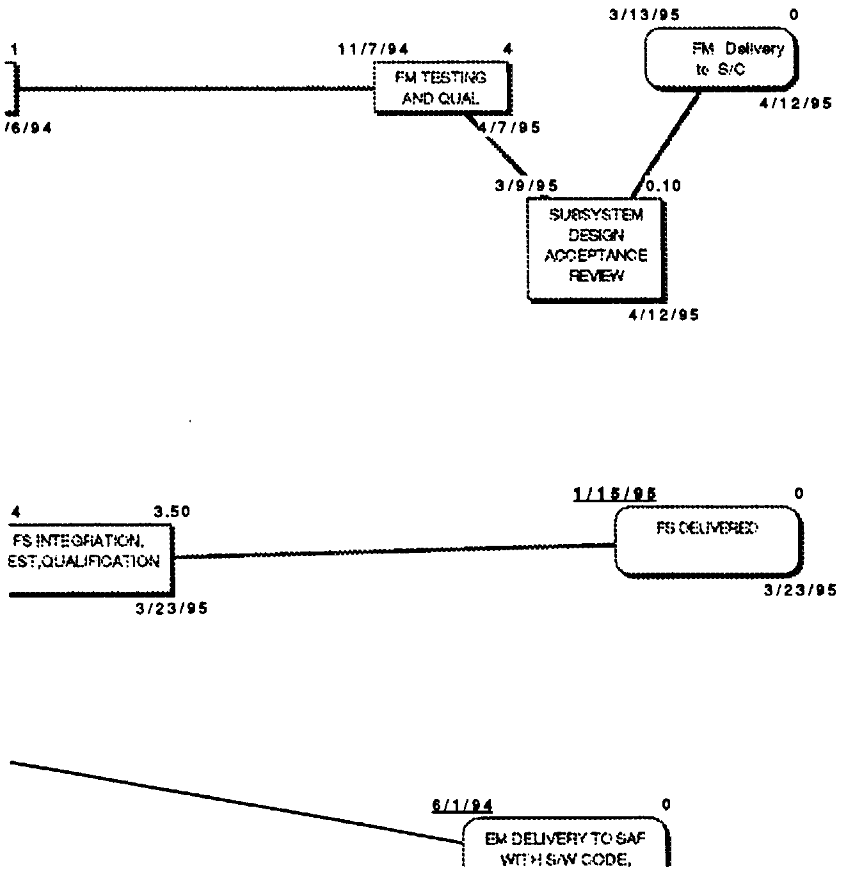
§ XI BRINTON QUESTIONS

Appendix V CREWE Bubble Chart

CREWE
Coordinated Radio
Electron Wave
Experiment




6/15/94
0
deliver TCM to S/C
6/15/94
2/2/94
6
FS VES FAB
11/4/94
8/5/94
1
FS VES TESTS
12/6/94
8/2/93
6
FM GSFC VES FABRICATION
5/4/94
2/2/94
1
EM GSFC VES TESTS
6/3/94
2/1/94
0
FS DIPOLES FAB
5/4/94
2/2/94
1
FS DIPOLES TESTING
6/3/94
8/2/93
6
FM GSFC DIPOLES REFURB.
5/4/94
2/2/94
4
FS PSSR FAB
9/5/94
2/2/94
6
FM GSFC DIPOLES TESTS
11/4/94
8/2/93
6
FM MEUDON PSSR FABRICATION
5/4/94
2/2/94
6
FM MEUDON PSSR
11/4/94
6/6/94
2
FS PSSR TEST
11/4/94
2/2/94
4
FS POWER CONV. FAB
9/5/94
6/6/94
2
FS POWER CONV. FAB
11/4/94
8/2/93
6
FM MEUDON POWER CONV. fab
5/4/94
2/2/94
6
FM MEUDON POWER CONV. TESTS
11/4/94
10/6/94
FM S/C INTEGRATION
12/
4/5/94
4
FS DPU FAB
9/5/94
10/1/93
6
FM UM DPU FABR.
5/4/94
8/5/94
2
FS DPU TEST
11/4/94
4/5/94
6
FM UM TESTS
11/4/94
2/2/94
4
FS FFT/TDS FAB
9/5/94
8/2/93
6
FM UM FFT/TDS FABR.
5/4/94
2/2/94
6
FM UM FFT/TDS TESTS
6/6/94
2
FS FFT/TDS FAB
11/4/94
10/5/94
0
FS COMPLETE
12/6/94
10/6/9
T
/2/93
6
FM UM FLIGHT SOFT. DEVEL.
5/4/94
2/2/94
4
FS FLIGHT S/W DEVELOP
9/5/94
11/4/94
6/6/94
2
FS FLIGHT SOFTWARE TEST
11/4/94
2/2/94
6
FM UM FLIGHT SOFT. TESTS
11/4/94
6/6/94
2
FS MSC TEST
11/4/94
8/2/93
6
FM CNET MSC
2/2/94
4
2/2/94
6


1
/6/94
11/7/94
4
FM TESTING AND QUAL
4/7/95
3/13/95
0
FM Delivery to S/C
4/12/95
3/9/95
0.10
SUBSYSTEM DESIGN ACCEPTANCE REVIEW
4/12/95
4
3.50
FS INTEGRATION, EST,QUALIFICATION
3/23/95
1/15/95
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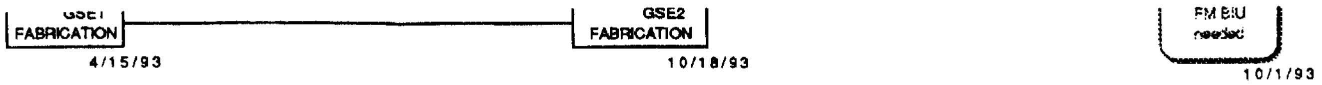
FS DELIVERED
3/23/95
6/1/94
0
EM DELIVERY TO SAF WITH S/W CODE,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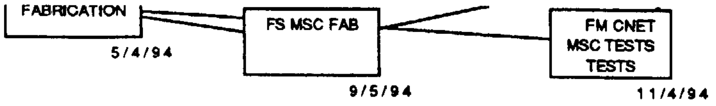
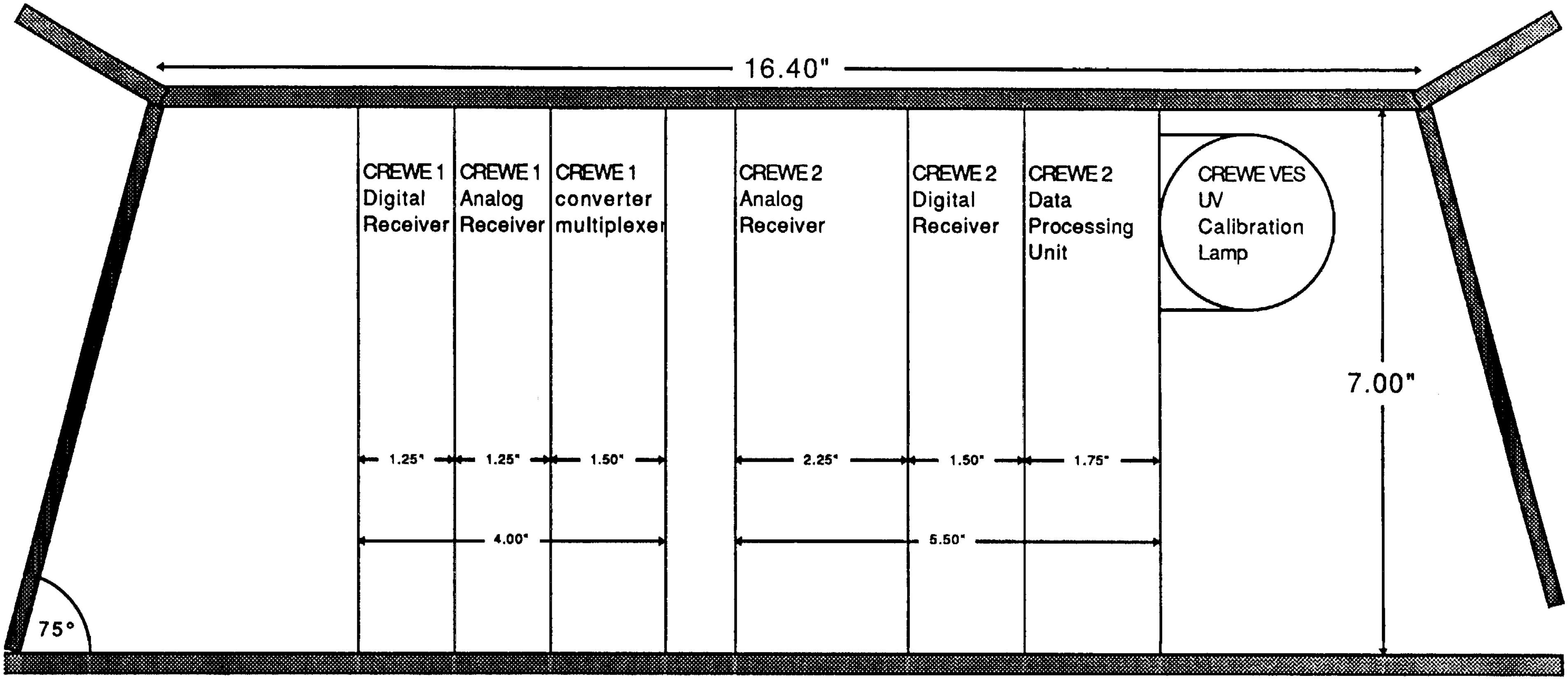
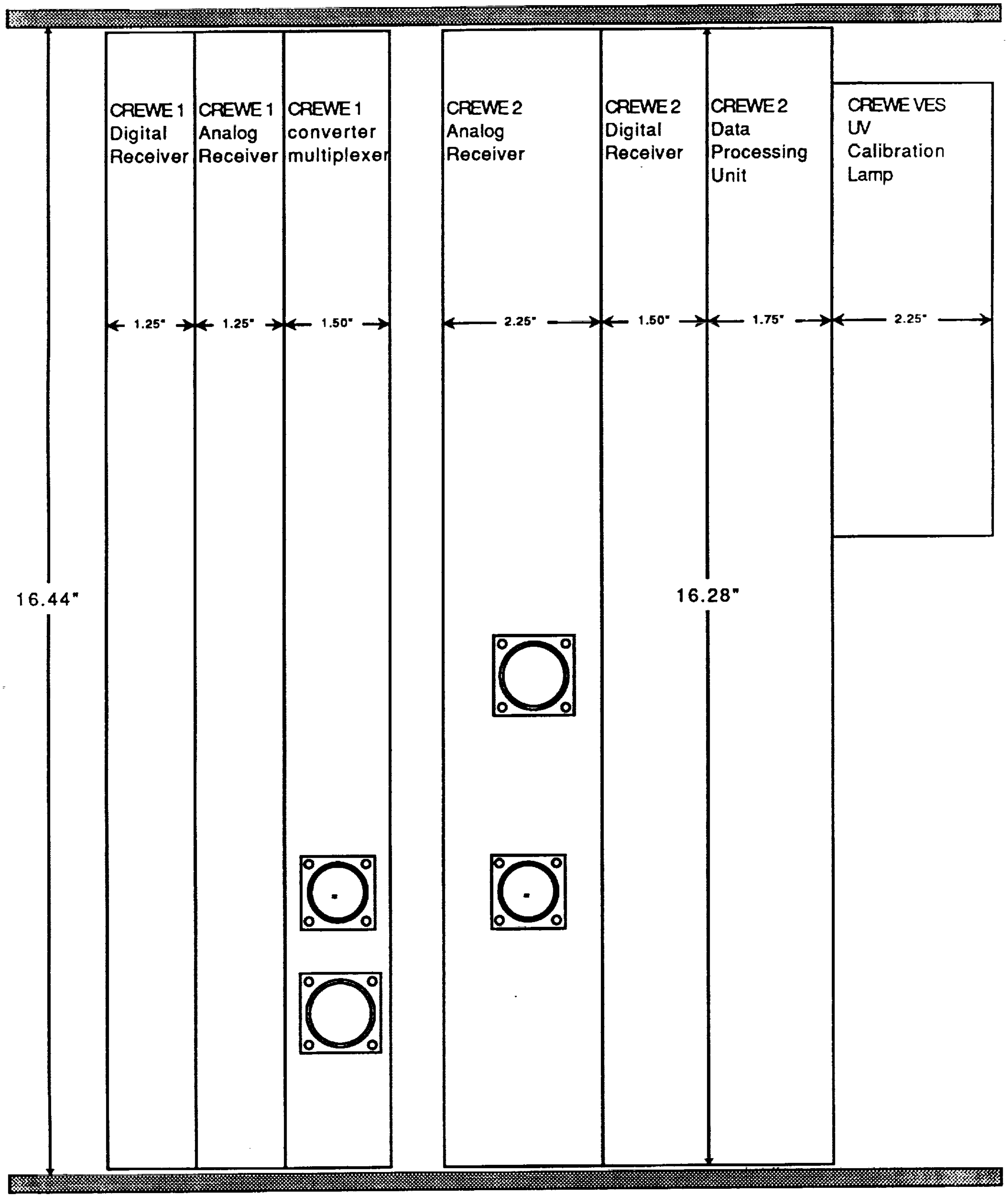
4/15/93
GSE2
FABRICATION
10/18/93
FM BIU
needed
10/1/93

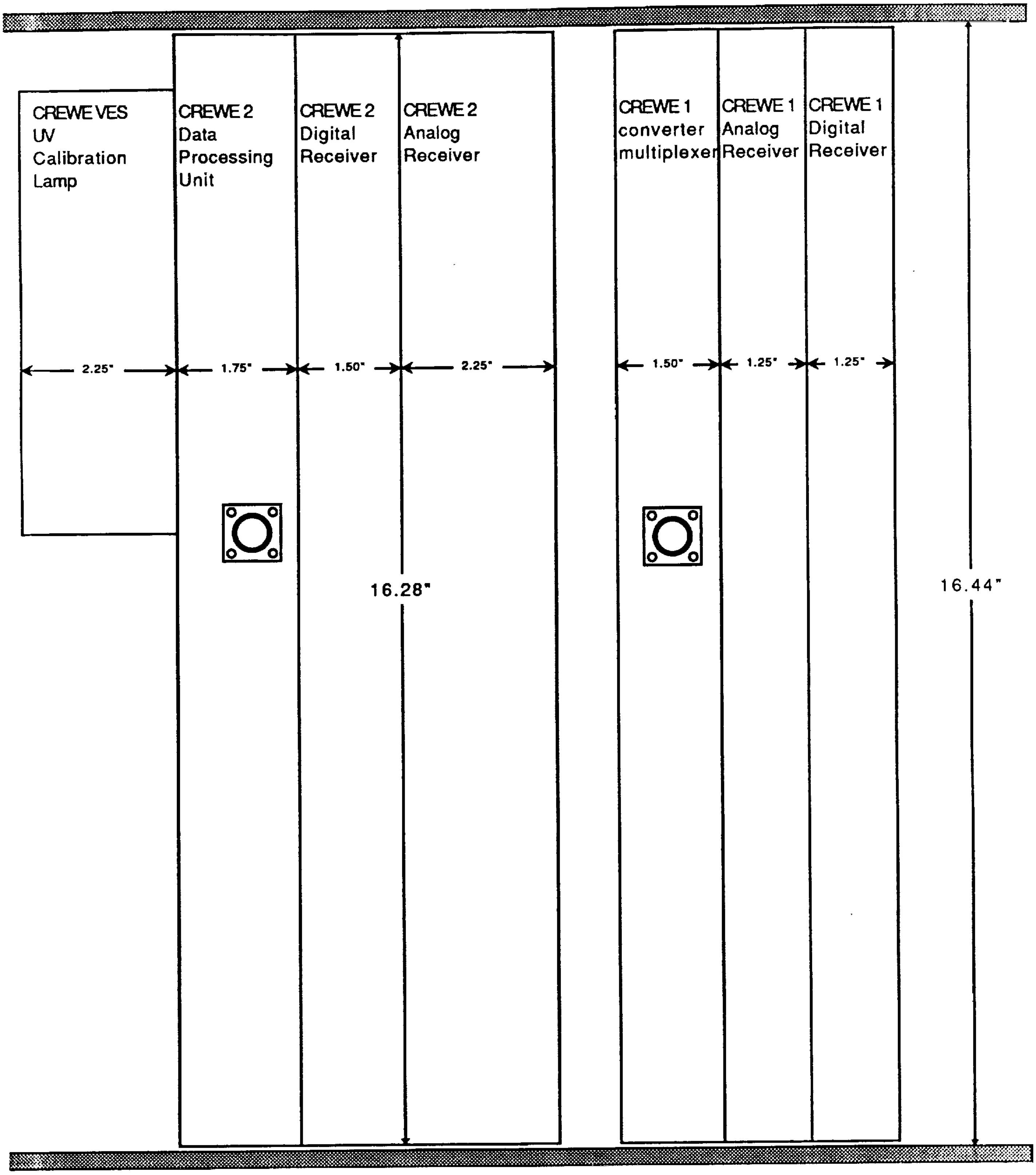

FABRICATION
5/4/94
FS MSC FAB
9/5/94
FM CNET
MSC TESTS
TESTS
11/4/94



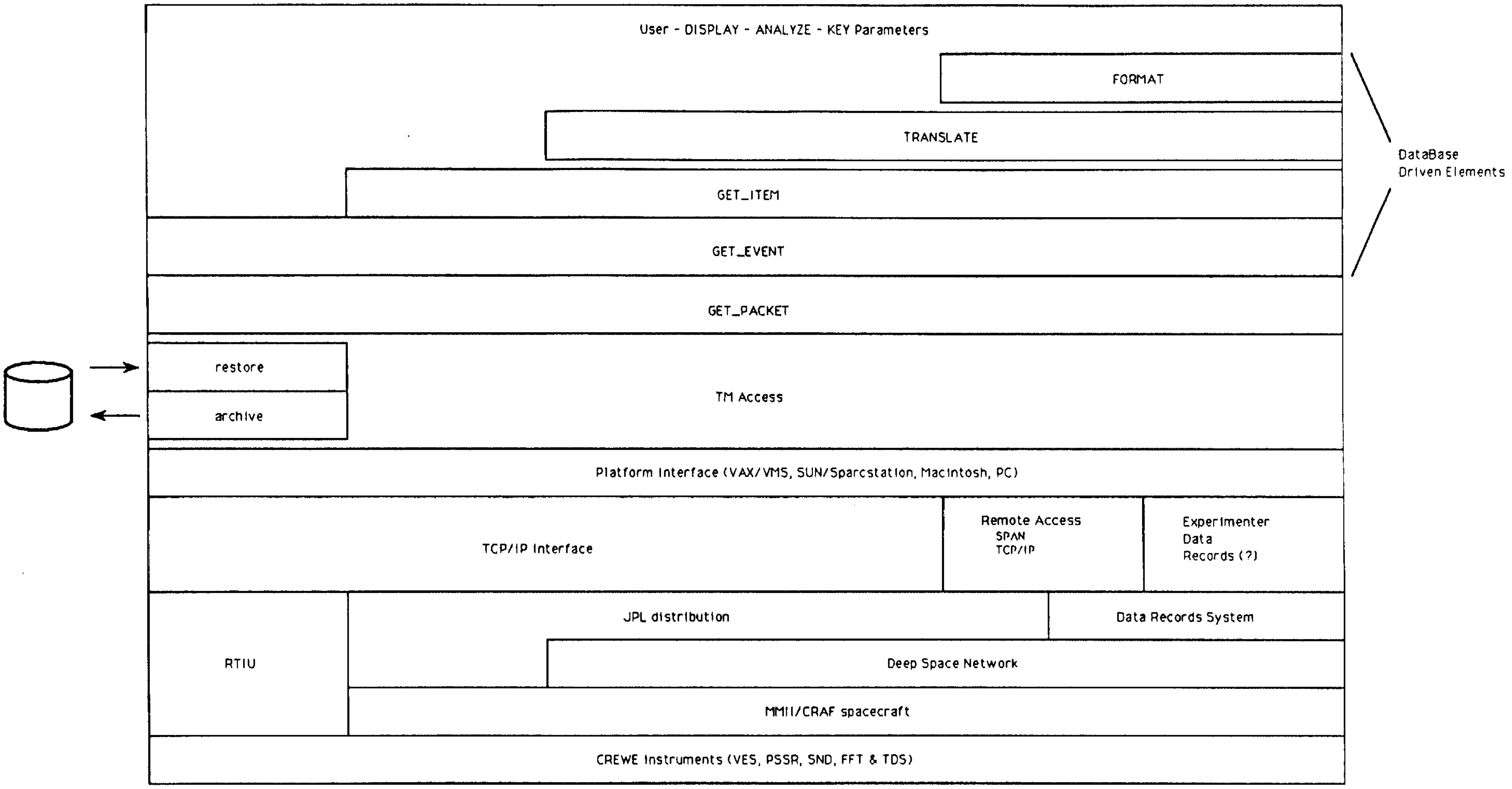
CRAF/**CREWE** spacecraft bay (looking down)
(half scale)(12 bay bus)



CRAF/**CREWE** spacecraft bay outboard
(half scale)



CRAF/**CREWE** spacecraft bay inboard
(half scale)



CRAF/**CREWE** telemetry layers