TROPICAL WIND, ENERGY CONVERSION, REFERENCE LEVEL EXPERIMENT (TWERLE)

Status Report

(For Period Ending 30 April 1972)

The major activity for this period was the engineering meeting held on 5 April at NCAR. The minutes are attached to this report as well as the status of the University of Wisconsin work during the reporting period.

Minutes of TWERLE Engineering Meeting
Physical Science Research Building
National Center for Atmospheric Research
Boulder, Colorado

0900, 5 April 1972

I. The meeting was attended by:

Neil Carlson, NCAR

*Paul Julian, NCAR

**Will Kellogg, NCAR

John Kruse, UWISC

Vin Lally, NCAR

Ernie Lichfield, NCAR

John Masterson, NCAR

Claude Morel, NCAR

Mike Olson, NCAR

Landis Parsons, NCAR

Sig Stenlund, NCAR

Jack Tefft, NCAR

(*Team Member)

(**Team Leader)

II. Agenda

A. The tentative agenda was presented and an outline of the flight train sub-system was handed out to all attendees.

B. An additional topic was added, "TWERLE/RAM Electronic Interface with Buoys" (see attached memo, 4 April 1972).

MEMO TO: Will Kellogg, TWERLE Team Leader 4 April 1972

FROM: John Masterson

SUBJECT: TWERLE/RAM Electronic Interface with Buoys

On the 18th of April in Washington there will be an informal meeting with a number of potential buoy users of the T/R System. Although we know the general definition of the oscillator-modulator-digitizer, it would be extremely helpful if, at the TWERLE Engineering Meeting on 5 April, one more step could be taken to define the oscillator, the modulator, and the digitizer in specifications such that the users of drifting buoys could begin sizing up the extent of the work that will be required for them to participate in the Nimbus F experiment.

I therefore strongly urge that at the Engineering Meeting on the 5th a short time be devoted to defining, as best we can at this time, specifications for the transmitter, modulator, and digitizer as they may apply to buoys.

(END OF MEMO)

cc: Paul Julian
Vin Lally
Ernie Lichfield

III. Report on the Meeting

A. Ernie Lichfield, Chairman, opened the meeting with a brief discussion on the Buoy Interface topic. Time did not permit the fulfillment of the request from John Masterson to better define the specifications as they apply to buoys.

B. Jack Tefft discussed the TWERLE procurement plans by pointing out two extreme methods; Type "A" (Figure 1) in which the fabricator performs "Assembly only" jobs according to drawings and specifications; acceptance testing, final adjustments, and flight packaging are accomplished at a central facility. The fabricator in this case provides exact copies of the prototypes generated during the development phases.

Type "B" (Figure 2) procurement would require the fabricator to perform all assembly, testing, calibration, and flight packaging, with only sample testing and limited system integration performed at a central facility.

It was quickly realized that either of these two methods would not provide TWERLE the necessary flexibility for post-TWERLE procurements and for other users to acquire platforms.

The greatest control over production of sub-systems can be maintained through utilization of a central facility.

There are two sources for finished sub-systems:

1) Do it yourself
2) Contract to a company and allow it to provide:
    a) Complete sub-system with testing and calibration, or
    b) Assembly only

TWERLE costs will be lowest if NCAR "buys" the people and operates the central facility.

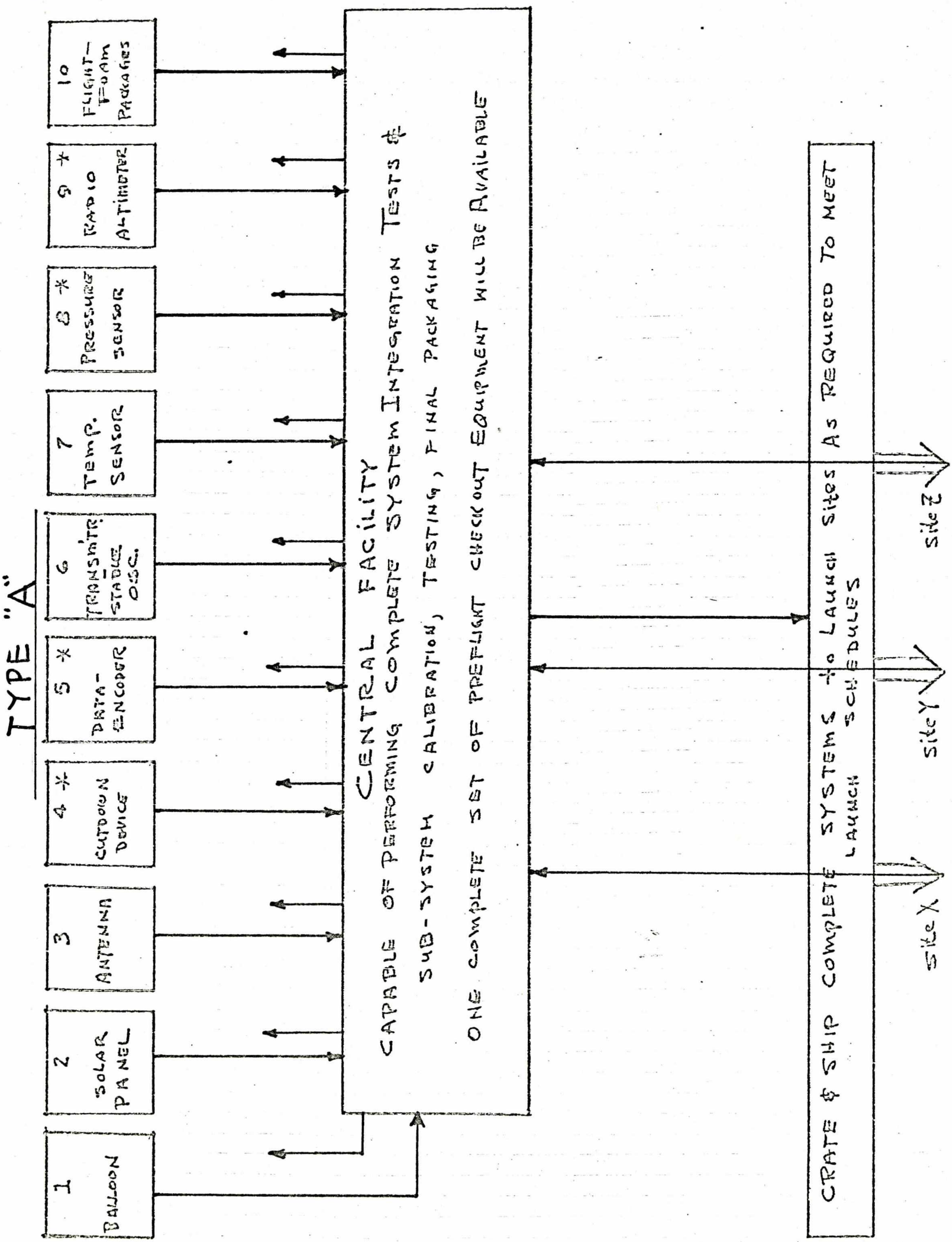
TYPE "A"
1 BALLOON
2 SOLAR PANEL
3 ANTENNA
4 * CUTDOWN DEVICE
5 * DATA-ENCODER
6 TRANSMITR - STABLE OSC.
7 TEMP. SENSOR
8 * PRESSURE SENSOR
9 * RADIO ALTIMETER
10 FLIGHT- FOAM PACKAGES
CENTRAL FACILITY
CAPABLE OF PERFORMING COMPLETE SYSTEM INTEGRATION TESTS &
SUB-SYSTEM CALIBRATION, TESTING, FINAL PACKAGING
ONE COMPLETE SET OF PREFLIGHT CHECKOUT EQUIPMENT WILL BE AVAILABLE
CRATE & SHIP COMPLETE SYSTEMS to LAUNCH SITES AS REQUIRED TO MEET LAUNCH SCHEDULES
Site X
Site Y
Site Z

Figure 1

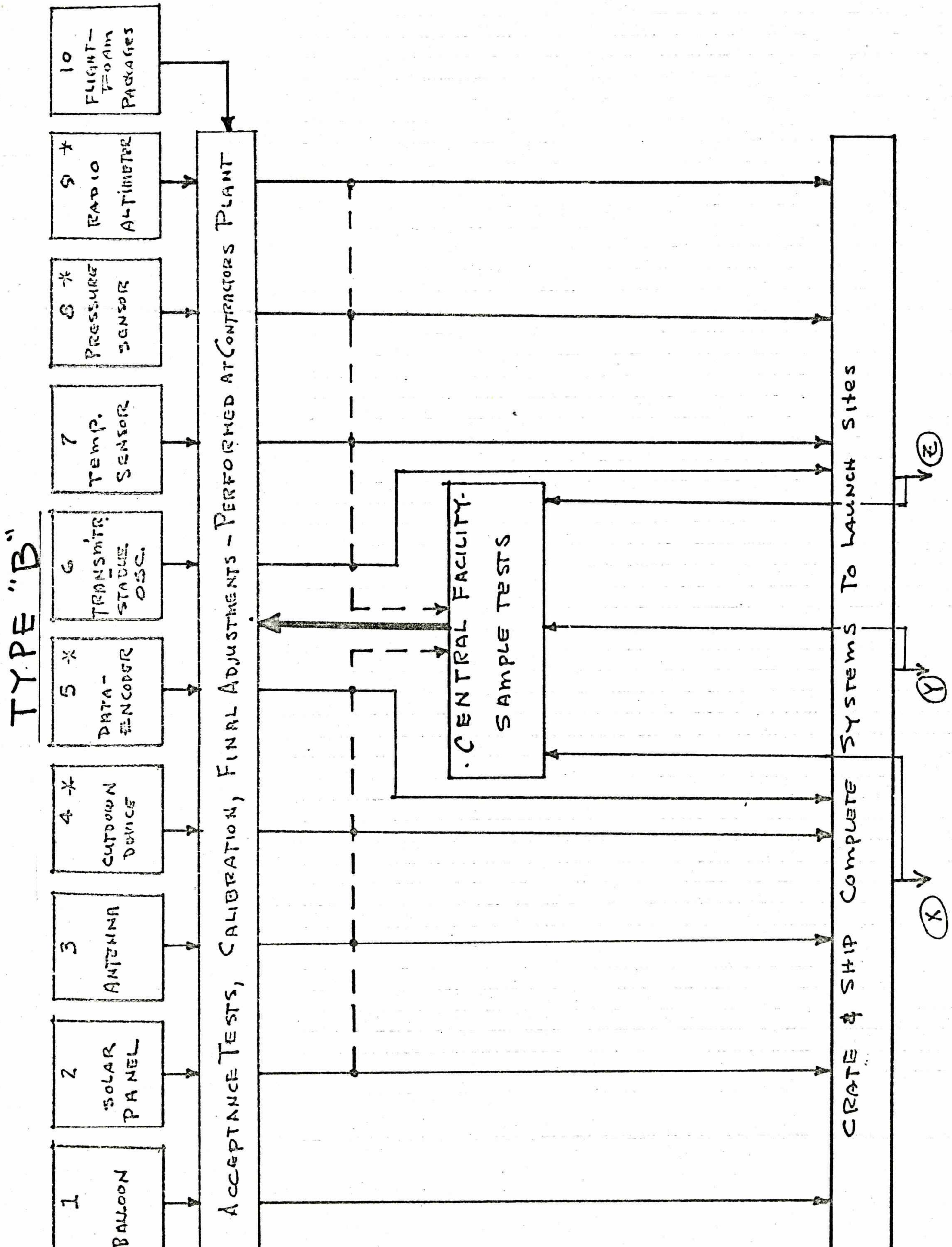
TYPE "B"
1 BALLOON
2 SOLAR PANEL
3 ANTENNA
4 * CUTDOWN DEVICE
5 * DATA-ENCODER
6 TRANSMTR. STABLE OSC.
7 TEMP. SENSOR
8 * PRESSURE SENSOR
9 * RADIO ALTIMETER
10 FLIGHT-TRAIN PACKAGES
ACCEPTANCE TESTS, CALIBRATION, FINAL ADJUSTMENTS - PERFORMED AT CONTRACTORS PLANT
CENTRAL FACILITY-SAMPLE TESTS
CRATE & SHIP COMPLETE SYSTEMS TO LAUNCH SITES
X
Y
Z

Figure 2

The engineering and prototype development phase (in which we are currently involved) should produce the following items for a complete bidders' package on each sub-system:

1. Provide a complete set of drawings, schematics, and printed circuit layouts. (An alternate would be to provide completely etched printed circuit boards in lieu of layouts.)

2. A complete engineering design and results of environmental testing.

3. Procure early, any long-lead components.

4. Qualify components for temperature and pressure environment.

5. Qualify assemblies for temperature and pressure environment.

6. Fabricate at least 10 engineering models of each sub-assembly, some to be used in pre-production inspection, testing, etc. by fabricator.

Each of the 10 sub-systems were completely discussed on the work-sheets, and the most reasonable (at this time) procurement method was indicated. These comments are summarized on the following pages which includes current status and updated power, weight, and cost budgets.

A compromise "A" and "B" procurement plan was developed and is outlined in Figure 3.

The meeting was adjourned by Chairman Lichfield at 1630.

1

Balloon

5 April 1972

ELECTRONIC | MECHANICAL

A) TECHNOLOGY

1) Status of Development

a) General - Present design has payload capacity of 1400 grams plus cap. Balloon diameter = 3.505 m.

b) Weight - 3300 gm

Power - N/A

Cost - $500.00 each (including leak testing)

B) SPECIAL PROBLEMS

1) Unique, Non-standard Parts

2) Thermal Considerations

3) Flight Configuration

4) Others

C) TESTING

1) Method - Freon detection during pre-stressing.

2) Equipment Required

a) In-plant - Halogen detector and volume measuring system.

b) In-field - Send production samples to Christchurch Station for ground and field testing.

D) PROCUREMENT - Type B

1) Prototype Development - Complete

2) Specifications & Drawings - Review final drawings after Asc III.

3) Engineering Models - Flight test 20 engr. models - AscIII

E) GENERAL REMARKS

1) Minimum of 9 months will be required to fabricate final series of flight balloons.

2) All balloons should be ready to ship to sites by April-May 1974.

3) Balloon procurement should start by July 1973.

2

Solar Panel

5 April 1972

	ELECTRONIC	MECHANICAL
A) TECHNOLOGY		
1) Status of Development		
a) General	Prototype 60% complete	Need a foam support under panels
b) Weight - 161 gm		
Power - N/A		
Cost - $215.00 each		
B) SPECIAL PROBLEMS		
1) Unique, Non-standard Parts	None	
2) Thermal Considerations		
3) Flight Configuration		
4) Others		
C) TESTING		
1) Method - Solar simulator (sun lamps)		
2) Equipment Required		
a) In-plant- (central facility) =	Sun lamps	
b) In-field - Voltmeter (power output) and visual inspection		

D) PROCUREMENT

1) Prototype Development - 60% complete

2) Specifications & Drawings - 30% complete

3) Engineering Models - A special circuit board punch has been designed to speed up fabrication of engineering models.

E) GENERAL REMARKS

1) The individual panels could be shipped to launch sites in flat position - then install voltage regulator in field.

3

Antenna

5 April 1972

	ELECTRONIC	MECHANICAL
A) TECHNOLOGY 1) Status of Development a) General b) Weight Power Cost		Raven Ind. now fabricating 10 prototypes of unfurlable design.
B) SPECIAL PROBLEMS 1) Unique, Non-standard Parts 2) Thermal Considerations 3) Flight Configuration-------------	What affect will any wires above antenna have on performance?	
4) Others - Antenna impedance is not 50 Ω - Transmitter should be located at apex to eliminate matching network, which is heavy, bulky, and hazardous.		
C) TESTING 1) Method - Impedance measurements at 400 MHz, out of near field of antenna (~ 6 feet away). 2) Equipment Required - To be determined a) In-plant b) In-field		

D) PROCUREMENT

1) Prototype Development

2) Specifications & Drawings

3) Engineering Models

E) GENERAL REMARKS

1) Several prototypes will be mechanically tested during Asc. III and several will be tested by GSFC/UWISC for impedance and RF pattern.

4
Cutdown

5 April 1972

	ELECTRONIC	MECHANICAL
A) TECHNOLOGY 1) Status of Development a) General b) Weight - 45 gm Power - 0.07 w Cost - $57.00 ea.	70% complete	Final package design to be completed
B) SPECIAL PROBLEMS 1) Unique, Non-standard Parts 2) Thermal Considerations 3) Flight Configuration 4) Others		
C) TESTING 1) Method 2) Equipment Required a) In-plant - Bench test coil b) In-field - Bench test coil		

D) PROCUREMENT

1) Prototype Development

2) Specifications & Drawings

3) Engineering Models

E) GENERAL REMARKS

5

Data Encoder

5 April 1972

	ELECTRONIC	MECHANICAL
A) TECHNOLOGY 1) Status of Development a) General b) Weight - 150 gm Power - 0.1 w Cost - Est. = $100.00-$150.00	Digi-GHOST is prototype of TWERLE data encoder	
B) SPECIAL PROBLEMS 1) Unique, Non-standard Parts 2) Thermal Considerations 3) Flight Configuration 4) Others	Plug-in module for temp. & pressure sensors.	
C) TESTING 1) Method 2) Equipment Required a) In-plant b) In-field		

D) PROCUREMENT - Type A

1) Prototype Development - COS/MOS units are being considered for final design.

2) Specifications & Drawings

3) Engineering Models - Estimated production rate = 2/day.

E) GENERAL REMARKS

1) L.S.I. technique not economical until quantities of 10,000 are reached.
2) Internal clock vs. stable osc. for clock still under discussion.
3) Operating temperature range ≈ -20°C to 0°C.

6
Transmitter
Osc.

5 April 1972

	ELECTRONIC	MECHANICAL
A) TECHNOLOGY 1) Status of Development - UWISC/ a) General b) Weight - oven 100 gm transmitter 100 gm Power - 0.5 w (RF off) Cost - $250.00 ea.	Pierce Osc. gives ultra-stability at constant temp.	Dewar flask inside styrogoam ball; op temp. = -35°C
B) SPECIAL PROBLEMS 1) Unique, Non-standard Parts 2) Thermal Considerations 3) Flight Configuration 4) Others	oven; aged crystals -20°C is outside package temp. used for design. (High side of cold goal).	Pre-aging of crystals is required after assembly in oven flas Set-up of transmitter for final tuning.
C) TESTING 1) Method 2) Equipment Required a) In-plant b) In-field	20 day aging of crystal and osc. at -20°C. Major equipment at	

D) PROCUREMENT - Type "A or B" (not yet clearly defined)

1) Prototype Development - UWISC and RF Sources

2) Specifications & Drawings

3) Engineering Models - Prorotype (could be combination of UWISC and RF sources)

E) GENERAL REMARKS

1) Summary of RF Sources work; oven stabilized osc; thermal resistance (C = 85°watt) - oven controller adjacent to crystal case - Requires 45 min. to stabilize to 1 part in 10^9. 10 MHz osc. - 1 ma @ 12 vdc Weight = 45 gm. Transmitter is operating at efficiency = 55% (w/out osc.)

7

Temp. Sensor

5 April 1972

	ELECTRONIC	MECHANICAL
A) TECHNOLOGY 1) Status of Development a) General - "Chimney" mount has been discarded. Two types will be tested at Ascension - (A) French EOLE and (B) Fork-type. b) Weight - 20 gm Power - 0.05 w. Cost - $50.00 ea.		
B) SPECIAL PROBLEMS 1) Unique, Non-standard Parts 2) Thermal Considerations 3) Flight Configuration 4) Others - Thermistors must be classed according to temp. char. (from factory cal. data). After this classification, they must be matched to proper resistance network.		
C) TESTING 1) Method 2) Equipment Required a) In-plant b) In-field		

D) PROCUREMENT - Type "A-B" - mfgr. provides bead, cal, data and mount. Central facility matches temp. sensor to its own resistance network, which will plug into any data encoder.

1) Prototype Development

2) Specifications & Drawings

3) Engineering Models

E) GENERAL REMARKS

Perhaps the thermistors should be procured early to accommodate time required for calibration, matching networks, etc.

New glass mount has been designed w/round holes (same area).

8

Pressure Sensor

(UWISC) 5 April 1972

ELECTRONIC | MECHANICAL

A) TECHNOLOGY
   1) Status of Development - The accurate test gages have not yet arrived at Madison
      a) General

      b) Weight - 100 gm

         Power - 0.1 w

         Cost - $100.00 each

B) SPECIAL PROBLEMS
   1) Unique, Non-standard Parts --------Capacitor in oscillator circuit and pressure capsule.

   2) Thermal Considerations

   3) Flight Configuration

   4) Others - Calibration: A) Run tests at same pressure but different temps to generate family of curves - or -
      B) Calibrate at one temp. and use mean or RMS values.

C) TESTING - ≈ 3 pressure points and 6 temperature points.
   1) Method

   2) Equipment Required - Frequency counter ≈($5,000.00); TI Bourdon tube test set (≈ $1,874.00). UWISC now building test set w/digital display.
      a) In-plant

      b) In-field

D) PROCUREMENT - Type "A"-"B"
   A calibration facility must be established and operated at central facility.
   1) Prototype Development

   2) Specifications & Drawings

   3) Engineering Models

E) GENERAL REMARKS

(UWISC) 5 April 1972

9
Radio
Altimeter

	ELECTRONIC	MECHANICAL
A) TECHNOLOGY 1) Status of Development a) General b) Weight Power Cost	COS/MOS are being used; Altimeter has been improved.	
B) SPECIAL PROBLEMS 1) Unique, Non-standard Parts 2) Thermal Considerations 3) Flight Configuration 4) Others	Final adjustments, (see below)	
C) TESTING 1) Method ----------------In Plant= 2) Equipment Required a) In-plant b) In-field--------------------	Temp. chamber tests, RF alignment at operating temperature and stripline resonator adjustments. Field test set now designed, no hardware available yet. (Estimate 90 days to assemble)	

D) PROCUREMENT - Type "A & B"

A foreign manufacturer presents problems, due to government regulations

1) Prototype Development

2) Specifications & Drawings - UWISC can provide dwg/specs. to reproduce the altimeter, but the tuning techniques will require training.

3) Engineering Models

E) GENERAL REMARKS

J. Kruse will follow-up on status of mfgr. in Israel, as to current production capacity and report back to NCAR Contracts Office.

10
Flight Foam
Packages

	ELECTRONIC	MECHANICAL
A) TECHNOLOGY		
1) Status of Development - Decisions	have not been made yet on	all sub-systems.
a) General		
b) Weight		
Power		
Cost		
B) SPECIAL PROBLEMS		
1) Unique, Non-standard Parts		
2) Thermal Considerations	What color on outside surface?	
3) Flight Configuration		
4) Others	Static electricity shield?	
C) TESTING		
1) Method		
2) Equipment Required		
a) In-plant		
b) In-field		

D) PROCUREMENT Type "A"

1) Prototype Development

2) Specifications & Drawings

3) Engineering Models

E) GENERAL REMARKS

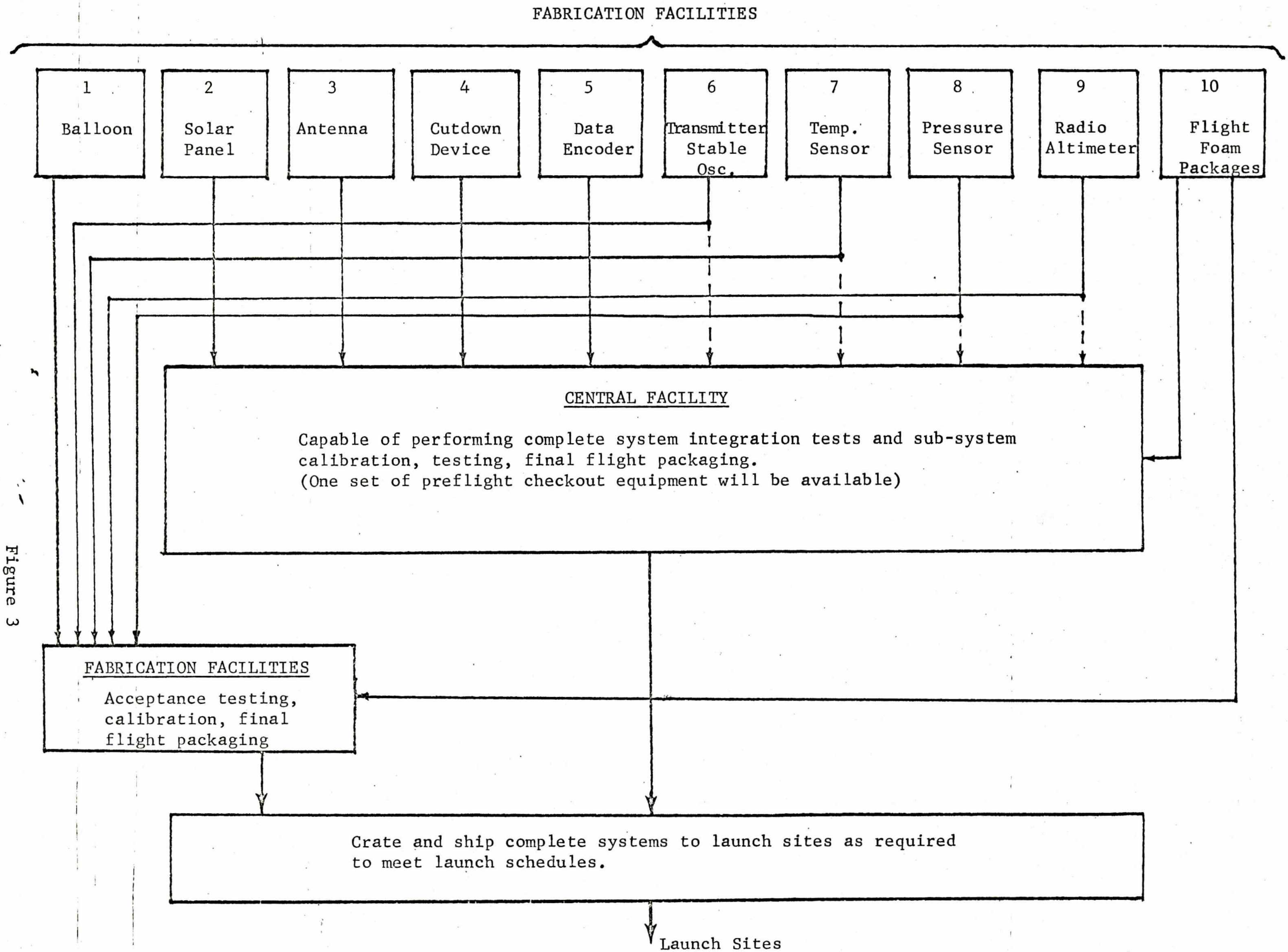
FABRICATION FACILITIES
1 Balloon
2 Solar Panel
3 Antenna
4 Cutdown Device
5 Data Encoder
6 Transmitter Stable Osc.
7 Temp. Sensor
8 Pressure Sensor
9 Radio Altimeter
10 Flight Foam Packages
CENTRAL FACILITY
Capable of performing complete system integration tests and sub-system calibration, testing, final flight packaging.
(One set of preflight checkout equipment will be available)
FABRICATION FACILITIES
Acceptance testing, calibration, final flight packaging
Crate and ship complete systems to launch sites as required to meet launch schedules.
Launch Sites

Figure 3

TROPICAL WIND, ENERGY CONVERSION,

REFERENCE LEVEL EXPERIMENT

(TWERLE)

April 1972

Status Report

Prime Contract No. NSF-C660

Subcontract No. NCAR 6-72

The effort and progress achieved by the University of Wisconsin in the various subsystem areas are included in the following report.

TWERLE TECHNICAL REVIEW

STABLE OSCILLATOR

Status: A 50 MHz oscillator design has proven the required stability. A proportional control oven in a -70°C environment has demonstrated -25°C control within one hour and 15 minutes. (Temp. stability maintained with 250 mw)

Plans: The oven study will continue with the thermister placed next to the crystal which is isolated from the rest of the chamber by styrofoam. A 50 MHz oscillator will then be placed in the flask and stability tests will be run.

SCHEDULE FOR COMPLETION OF OSCILLATOR

1 May--10 May	Build and run oven tests
10 May--31 May	Integrate oven and oscillator
1 June--31 December	Run life tests on various oscillator approaches
1 July--1 September	Integrate oscillator with transmitter
1 September--15 October	Test engineering transmitter
15 October--31 December	Test and write specifications

TRANSMITTER

Status: Have tested a quadrature couple that would satisfactorily perform the $\pm$ 60° modulation. A simulation of the satellite receiver has been done to investigate the ratio of signal to noise for the proposed modulation scheme. Have also simulated the locking of a radio altimeter transmitter at the 400 MHz level to our stable 4 MHz oscillator in order to study its frequency spectrum.

Plans: Build and test a 3 state, strip line modulator. Try a phase lock loop approach to the output transmitter as well as the sampler approach to determine which requires the least power.

Schedule for Completion of Transmitter

1 May--1 June	Test various modulation approaches
1 June--15 August	Test the phase lock and sampler approach while integrating stable oscillator into the design.
16 August--15 September	Build and test an engineering model
15 September--15 October	Build and test 8 transmitters at different frequencies for delivery to NASA
15 October--31 December	Make final design changes and write specifications

ALTIMETER

Status: The altimeters on order have been promised for delivery on 1 June. They will have greater output power and on the average, 20 db greater sensitivity. A new 415 MHz lighter antenna is presently being design tested. An altimeter test set is designed and 60 percent completed. RF boards of the new design have been ordered.

Plans: Receive and check out altimeters on the new test set. Check out new antennas with the units. Pack them for Ascension.

Schedule for Completion of Radio Altimeter:

1 May--1 June	Test and build new antenna design,; complete the test set
1 June--15 June	Check out units and pack for trip
22 June--8 July	Fly from Ascension Island
30 July--1 January	Make final design changes, write specifications

HELICAL ANTENNA

Status: Studying NASA's design

Plans: Receive and check out unit built by Raven Industries

Schedule for Completion of Antenna

1 May--1 August	Evaluate and test engineering model
1 August--15 October	Evaluate test results
15 October--1 January	Make final design changes and write specifications

PRESSURE SENSOR

Status: Life tests are continuing on the Viz and Vaisala capsules, measurements being made with the new and more accurate TI gauge. Four of the eight required circuit boards have been built. Ninety percent of all parts are on hand including 32 printed circuit boards.

Plans: 1) Run a temperature cycle test on a punched-through capsule

2) Back-fill a capsule with air to 150 mb and commence testing for aging effects

3) Build up two arrays of the following:

2 VIZ 1" Capsules

2 VIZ 2" Capsules

2 VAISALA Capsules

4) Prior to the end of the present life tests, run an adaption test to check if the 150 mb pressurized storage and shipping containers are a requirement.

5) Use the present bell jars to temperature cycle one array from 0° to -70° while at 150 mb and run one array at 23°C constant and 150 mb.

6) Initiate tests on the new Viz internal capacitor capsule and the bellows.

Schedule for Completion of Pressure Sensor

1 May--10 May	Complete circuit boards, continue life tests, build arrays.
10 May--7 June	Run array tests and select the lowest aging capsule

7 June--14 June	Assemble capsules to circuit boards and package
12 June--19 June	Run calibration curves and pack units for shipping
22 June--8 July	Fly units from Ascension
20 June--1 September	Continue life tests on various capsules
1 September--1 January	Make final design changes and write specs