D R A F T

Minutes of TWERL Experiment Team Meeting
Space Science and Engineering Center
The University of Wisconsin
1225 W. Dayton Street
Madison, Wisconsin

0830, 23 February 1972

I. The meeting was attended by:

Chuck Blair, UWIS	Ernie Lichfield, NCAR
Ahmed Ghais, NASA/GSFC	John Masterson, NCAR
Tom Haig, UWIS	*Bob Rochelle, NASA/GSFC
*Paul Julian, NCAR	Bruton B. Schardt, NASA Hdqrs.
**Will Kellogg, NCAR	Ferrell Stremler, UWIS (Wed. p.m.)
John Kruse, UWIS	*Vern Suomi, UWIS
*Vin Lally, NCAR	Jack Tefft, NCAR
	(*Team Member)
	(**Team Leader)

The TWERL Experiment distribution list with titles, addresses, and telephone numbers are in Attachment 1, updated 23 February 1972.

II. Approved Agenda

A. Agenda - changes, additions, and approval.

B. Approval of Team meeting minutes of 14 January 1972.

C. Report on balloon systems meeting 22 February, especially on recommendations on number of channels, with considerations of cost, complexity, data handling and processing, and TWERLE objectives - W. Kellogg, V. Lally, V. Suomi.

D. Describe the operating environment for components - M. Friedman, J. Kruse, E. Lichfield.

E. Plans for Ascension III (July flights). Cutoff date is 1 March - J. Kruse, E. Lichfield.

F. Eole program report - W. Bandeen, A. Ghais, P. Julian, R. Rochelle.

G. Integrate UWIS, GSFC (TI), and NCAR PERT charts - J. Tefft.

H. Excess capability - buoy users, survey and guide, NASA AFO letter - B. Schardt, J. Masterson

I. Data management - P. Julian.

J. Computer facilities report - A. Ghais.

K. TWERLE calendar.

L. Action items for next meeting.

III. Report on the meeting.

A. The agenda (Section II) was approved.

B. The minutes of the 14 January 1972 meeting were approved with the following corrections and changes:

Page 2, Para. 5: Insert: after 1971, (platform data rate should be considered as nominal 100 bps).

Page 3, Sub-para. D.1.b.: Change 24 to 2.4 watts.

Page 7, Sub-para. h.: In 2nd sentence, strike "or major" and add to the end of sentence, "but a weight allotment of 200 grams for the transmitter was added."

Page 9, Para. 9: Line 6, change "flat" to "flag".

Page 9, Para. 9: Add after the last sentence, "It was also agreed that NCAR would firm up answers on the number of balloon platforms to be supported and on the timeliness of the data."

C. Report on balloon system meeting 22 February.

Attendees: Blair, Haig, Kellogg, Kruse, Lally, Lichfield, Oehlkers, Rochelle, Stremler, Suomi

1. Items discussed at this meeting and presented to the Team on the following day were: The "clock", balloon flight train interference, stable oscillator, flexibility requirement for data encoder, and Ascension Island (III) flight plans.

2. Location of Clock

The clock is the timing circuit that determines the bit rate and controls the gate times for digitizing the sensor inputs. The most critical clock timing requirement is in controlling the gate time for digitizing the frequency input from the radio altimeter. In view of the timing accuracy required it was suggested that the stable oscillator in the transmitter circuit be used as the frequency source for the clock. The objection to this suggestion was that it would be simpler to build a second crystal oscillator located at the data encoder and that this oscillator would suffice for the accuracy of measurement required. The decision that followed weighed the relative merits of each system.

Cost: Essentially no difference in cost between the two systems.

Weight: Using the transmitter oscillator increased the weight due to the wire required to connect the transmitter to the data encoder (small increase, 16 grams).

Accuracy of measurement: The use of the transmitter oscillator gives the greatest accuracy. However, the separate oscillator gives sufficient accuracy (one meter).

Convenience: The separate oscillator system is somewhat more convenient since an external oscillator is not required when checking out the data encoder.

Other considerations: 1) possible interference caused by transporting clock signal over long 28-foot line.

2) Decision to use oscillator from transmitter places constraints on transmitter design. For example, a 50 mc oscillator design is not acceptable since it is too difficult to frequency divide from 50 mc.

If the transmitter oscillator were used as the clock frequency it would be desirable to shift the bit rate frequency to some convenient sub-multiple of the stable oscillator. Dr. Rochelle from Goddard agreed that it would be acceptable to make a small change in bit rate frequency.

3. Balloon flight train interference

Optical and RF shading effects on the flight train on some Ascension Island flights were presented and discussed. The flight train with approximate dimensions is shown in Fig. 1. Coaxial wires between the antenna and the balloon may have RF effects.

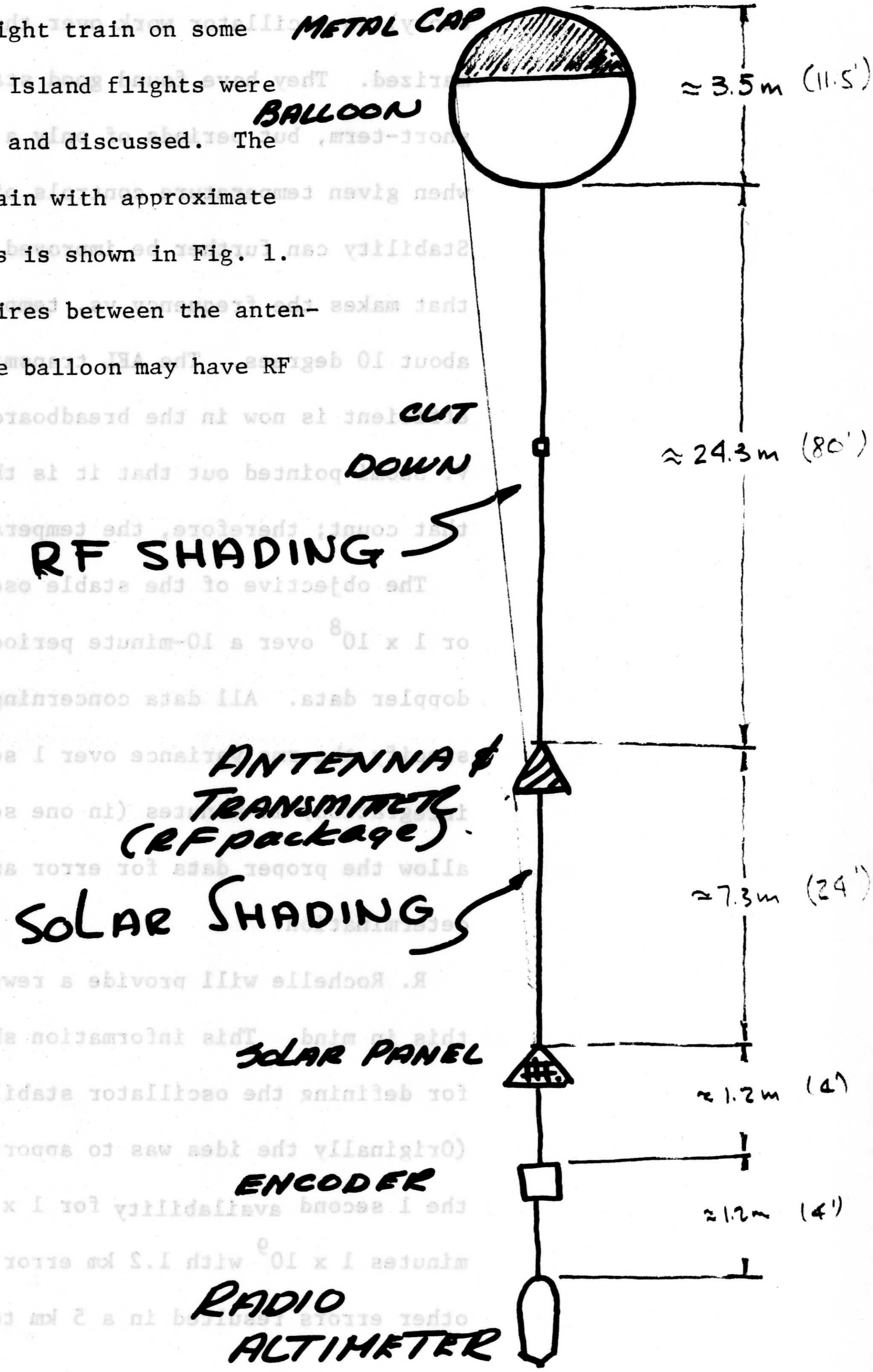

FIGURE 1.

4. Stable oscillator

The work accomplished by AEL (American Electronics Laboratory) on oscillator work over the last two years was summarized. They have found good stability for long-term and short-term, but periods of only a few minutes can be stabilized when given temperature controls of fractions of a degree. Stability can further be improved by temperature compensation that makes the frequency vs. temperature flat over a range of about 10 degrees. The AEL transmitter which is 40 to 45% efficient is now in the breadboard form and should be improved. V. Suomi pointed out that it is the gradients in the crystal that count; therefore, the temperature control should reduce these.

The objective of the stable oscillator is 1 x 10^9 per minute or 1 x 10^8 over a 10-minute period. This should give satisfactory doppler data. All data concerning oscillator stability should specify the rms variance over 1 second, 1 minute (in one second integration) 10 minutes (in one second integration). This will allow the proper data for error analysis of the doppler position determination.

R. Rochelle will provide a rewrite of the specifications with this in mind. This information should be available to B. Schardt for defining the oscillator stability in his AFO memorandum. (Originally the idea was to apportion the errors equally between the 1 second availability for 1 x 10^8 and the drift over 15 minutes 1 x 10^9 with 1.2 km error to each factor. This plus the other errors resulted in a 5 km total error rms.)

V. Suomi proposed the following: "The basic objective is that the frequency measured over 1 second average and 1 minute average, that is, one minute apart over a period of 15 minutes, shall not deviate by more than .28 x 15 x $\sqrt{2}$ equalling 5.9 Hz. This combines both the short- and long-term instabilities together."

It was pointed out that it may require as long as three hours from the time the sun is 5 deg above the horizon and the package becomes electrically activated to obtain temperature equilibrium. V. Lally is to investigate this for a change of temperature over a period of one hour and three hours and report by the next meeting.

The stable oscillator continues to be the major element of the platform design and development.

5. Flexibility Requirements of Data Encoder:

The purpose of this discussion was to define the input requirements of the data encoder so that design work could proceed on that portion of the system. Dr. Suomi insisted on flexibility and argued that a multi-channel system did not cost much more ($20-30 per package). He offered to pay the additional cost ($6,000) out of his own salary if necessary. It was conceeded that the cost of the extra parts for providing 16 inputs was not great but that the cost of additional sensors and calibration may well be considerable.

A compromise system was evolved that would be designed to accept the presently-defined (see below) TWERLE sensor inputs, but which would include a few additional parts so that at a later date other sensor inputs can be added. See Figures 1 and 2. The presently-defined sensor inputs are as follows:

Altimeter: The input from the altimeter is a frequency which will be digitized by counting into a counter. Altitude will be transmitted using two 8-bit words. Eight-bits containing the least significant bits and 8 bits containing the must significant bits.

Pressure: The output from the pressure sensor is a sensor frequency and a reference frequency. Digitization is accomplished by counting up for the sensor and then down for the reference. Pressure will be transmitted using two 8-bit words, 8 bits containing the least significant and 8 bits for the most significant.

Air Temperature: Air temperature input is a temperature dependent resistance. This is digitized by converting resistance to frequency and counting up on a counter. A reference resistor will be included for down counting to obtain a difference. Air temperature will be transmitted on a single 8-bit word.

Pressure Sensor Temperature: A thermistor will be used to measure the temperature of the pressure sensor, in the same form as was used for the air temperature measurement.

Basic TWERLE Transmission Format:

Word 1	Word 2	Word 3	Word 4	
Air Temperature	Ambient Pressure LSB	Pressure Sensor Temperature	Altitude LSB	Frame 1
Ambient Pressure MSB	"	Altitude MSB	Altitude LSB	Frame 2
Air Temperature	"	Pressure Sensor Temperature	Altitude LSB	Frame 3
Ambient Pressure MSB	"	Altitude MSB	Altitude LSB	Frame 4

MSB = Most Significant Bits
LSB = Least Significant Bits

Figure 1

Flexibility Potential:

Additional future inputs can be added by providing external switching circuits. Timing signals for controlling the switches will be provided at terminals on the data encoder board.

TWERLE Input Circuit Block Diagram

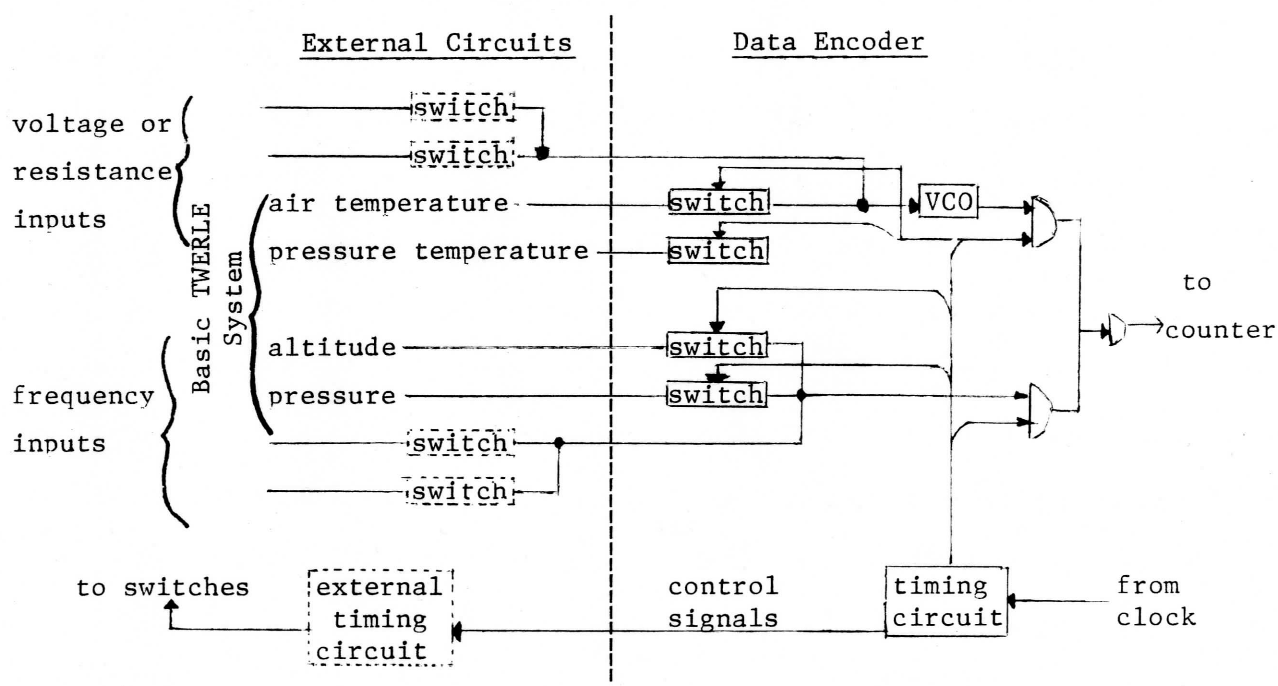

Figure 2

The types of inputs that will be acceptable are:

1. Frequency inputs

    a. Compatible with radio altimeter frequency range and up count only.

    b. Compatible with pressure sensor input (includes reference frequency for up down count).

2. Resistance inputs

3. Voltage inputs

6. TWERLE Team action

Attachment 2 was provided by Prof. Suomi to define the requirements and provide additional details on the Energy Conversion experiment of TWERLE. This material impacts the design of the data channel encoder being worked on by Lichfield, as well as the cost of the balloon platform package. Considerable discussion followed with respect to whether Lichfield's current design (see 5. above) should be considered as a maximum increase in complexity, number of channels, and cost or should be considered as merely an example with a more complicated system ultimately possible.

As a result of the foregoing discussion, the following resolution was unanimously adopted by the Team: "With the purpose of providing more flexibility than the originally proposed single-frame (four channel) system, it was agreed that the TWERLE balloon platform system will be designed to provide a data format giving the option of four different frames in sequence. It is understood that the specific choice of sensor information in the current plan can be changed to a limited extent and that it will be possible to use the system in a more restricted mode if desired; that is, with only four channels." See Figures 1 and 2 above in Para. 5.

D. Guidelines for prototype component selection and subsystem qualification

1. Operating temperature range - Electronic components will be required to operate over a temperature range of +40°C to -40°C. The assembled systems must also operate over this temperature range, but they need not meet the accuracy of measurement or frequency stability requirements over this range. The temperature performance of each subsystem will be defined independently.

2. Storage temperature - Component types will be qualified for use in the production units by thermally cycling the components between +40°C and -80°C, as follows:

   number of cycles: 5

   cycle period: 80 min.

   Hot: 20 min.

   Cool: 20 min.

   Cold: 20 min.

   Heat: 20 min.

   Subsystems will be qualified by the same thermal cycling as was used for qualifying the components, with the number of subsystems tested to be a minimum of 10.

E. Plans for Ascension Island III (July flights)

Table I shows the status as of 18 February of balloons launched in October and November from Ascension and Christchurch.

The Ascension Island schedule was discussed on February 22 at the engineering meeting. Attachment 3 is a memorandum of 18 February from Kruse which outlines proposed flights for Ascension III. Attachment 4 is the outline of the plan for the July test for Ascension Island as presented by Lichfield.

Ground checkout and on-site test equipment discussion is included as Attachment 5.

RAVEN Superpressure TWERLE Balloons

	Christchurch		Ascension I	
	Capped	Uncapped	Capped	Uncapped
Still Flying (No. of days)	97,94,89	97,89	116,104	104,89
Lost Due to Weather			71	3,3,56
Lost Due to Cutdown			6,5	

Table I. Number of days (lifetime) of balloons launched from Christchurch and Ascension I. October and November 1971.

F. Eole Program Report

Julian, Ghais, and Rochelle reported on their visit and discussions with Professor Pierre Morel, the principal scientific investigator of the Eole Program, and M. Jack Muller, Eole Project Manager, and their respective associates. Attachments 6a, 6b, 6c, and 6d are the respective trip reports of the TWERLE Team members who visited the Laboratory of Meteorological Dynamics of the National Center for Scientific Research (CNRS) and the CNES Space Center of Toulouse. Among the discussion of the highlights of the reports were:

1. The French have solved the software and the "ambiguity" problem with which they were confronted shortly after getting their first data from the system.

2. The satellite and the balloon system has performed very well. The "mean time to failure" for balloon and/or electronics is 147 days and counting.

3. W. R. Bandeen, the GSFC/Eole Project Scientist, who is also leader of the Eole data interpretation group for the United States, will receive Eole data and will distribute it to U.S. users, e.g., GSFC, NCAR, NOAA, etc.

4. There appears to be insufficient information on the radio frequency interference (RF) for a comprehensive RF survey to be made using the Eole data. Ghais reported that there was interference, but the times and the strength of the interference was not documented sufficiently well to produce a survey that would be significantly helpful to TWERLE. The Eole project knows that their sensor (housekeeping and ambient) is affected by the interference; however, their system designers took calculated risks on the ability of the satellite and platforms to lock on their respective carriers in spite of RF. They were successful in spite of some noise.

5. It requires approximately 35 minutes to reduce 75 balloon interrogations and the ephemeral data on the CDC 6600 with peripheral CDC 1700's.

6. Julian described in detail the Eole data processing and the solutions used to obtain the true positions of the balloons. Ghais further augmented the report on data reduction and the communication problems. Ghais showed slides of the Eole balloon status board.

7. Rochelle reported that for Tiros N the French have proposed an effective power supply (battery and solar cells) for the platforms which will be necessary due to the 3:00 p.m. sun synchronous orbit.

8. Action item - Team Leader will write a letter of appreciation on behalf of the TWERLE Team to Pierre Morel of CNRS and a similar letter to Mr. M. Jack Muller of CNES for their cooperation with the TWERLE Team, and suggest their participation as visitors in future Ascension Island tests as well as continuing to work with the TWERLE group.

G. Integrate UWIS, GSFC (TI) and NCAR PERT Charts -J. Tefft.

Tefft presented a 1972 PERT chart combining NCAR with Wisconsin and Goddard (TI). Although they were all presented on the same chart, the symbols and numbers refer to events on the individual charts of the three Team organizations for which the key was not included. It is understood that Tefft will rework this chart for inclusion as Attachment 7 to the minutes.

The procurement philosophy of the balloon platform was discussed. Haig noted that he was not clear as to how NCAR would carry out its procurement. As a result of this discussion, Haig was asked to head up a small group with representatives of NCAR and NASA to outline procedures and plans for procurement of the platforms. Procurement plans are outlined in the TWERLE technical manual.

The transfer of funds from NASA/GSFC to NSF is still tied up by lawyers on the "new technology clause".

H. Excess capability - buoy users, survey and guide, NASA AFO letter - B. Schardt, J. Masterson.

Schardt reported that the AFO (Applications for Flight Opportunities) has moved through NASA relatively rapidly, so quickly that he has become alarmed that people have not looked at it. It is ready to be signed by Mr. Charles W. Matthew, Associate Administrator for Applications. He expects it to be mailed to the extensive (3,000) mailing list by the 15th of March. This document (Attachment 8) will request a letter of intent from those who intend to propose or use the system and then they subsequently will be sent additional information such as the user's guide and updated information from the TWERLE Team. A final proposal should reach NASA by the 30th of June when they will be reviewed by NASA and the TWERLE Team.

It was pointed out in discussions that the experiment should be oriented, if possible, toward GARP.

Masterson reported on the interest of scientific investigation in the oceanographic community and on some inquiries from atmospheric scientists. No firm figures will be available until responses to the AFO are received, but preliminary estimates indicate that there is a possibility of about 400 TWERLE platforms being used within the excess capacity of the T/R System. Attachment 9 is a tentative list of those who have shown an interest as users and the number of platforms.

I. Data management - P. Julian

The question of real time and perishability of the data was discussed. After 12 hours operational forecasting, centers, such as NMC, do not have use for the data. For research purposes, of course, the data are unperishable. Julian is continuing to work on the use of asynoptic data (continuous data flow). Ghais plans to batch process the data every 12 hours. At this point Suomi pointed out that "why not batch process the data every eight hours to coincide with the three manpower shifts." This would require less computer time per batch and would serve the experimenters more effectively. Suomi further pointed out that we must differentiate between the "operational experiments" and "operations".

J. Computer facilities report

Ghais prepared a memo on the T/R System data reduction and dissemination which he handed out (Attachment 10) and from which he made his presentation. The highlights of the discussion were:

1. Ghais proposed that the TWERLE data be batch processed in seven orbits every 12 hours. This includes the scanning of data to eliminate grossly wrong doppler data, as well as the ephemeris updating. This is based on the RAMS document (GSFC X-752-70-376) which includes the details.

2. There is no ambiguity problem with the T/R System. The problem is one of iterative convergence in the presence of noise with different initial points and this can be solved. It would be helpful if an estimate of balloon positions were provided by NCAR; however, this is not essential. Two or three passes will be processed in every case with some assumption about balloon acceleration.

3. The computer could process 200 platforms, including ephemeris data, in 15 to 30 minutes. This would include all platforms in a 12-hour period, regardless of the number of orbits involved.

4. It is assumed at this time that an on site computer at Goddard, assuring dedicated time of one-half to one hour every 12 hours, can be used.

5. They expect to go to a contractor to develop the software prior to the production of the software for the final program.

6. Suomi brought up the question of utilizing the manpower shifts of eight hours each to process the data every eight hours rather than every 12 hours. This is noted above, Section I.

7. Ghais replied to a question that readout at Fairbanks or at Rosman would not inhibit or prevent the reception of any data from platforms in those regions.

8. Ghais also replied that they do not have firm figures on the number of platforms that can be accommodated in view at one time. This is inferred to be still in the neighborhood of 200.

K. TWERLE calendar

The tentative TWERLE calendar for Team meetings and activities was discussed, and an updated calendar follows, with the next meeting scheduled for Boulder on Tuesday, 4 April. The following meetings are blocked out; however, the schedule may be changed by decisions at each meeting.

Calendar 1972

Event	Place	Date
Team Meeting (preceding day an engineering meeting)	New Orleans	14 January
Eole Project Visit	France	16-21 January
Team Meeting (preceding day an engineering meeting)	Madison	23 February, Wednesday
Team Meeting	Boulder	4 April, Tuesday
Team Meeting	Goddard	18 May, Thursday
Flight Tests (TWERLE-3)	Ascension Island	June-July
Team Meeting	Cancelled	June-July
Team Meeting	Madison	29 August
Team Meeting	Goddard	3 October, Tuesday
Team Meeting	Boulder	14 November, Tuesday
Team Meeting	Madison	19 December, Tuesday

NOTE: This has been prepared in response to the expressed desire of the Team to hold approximately monthly meetings until the end of the year, during the period of testing and setting design specifications. We will probably be able to go to a more relaxed schedule in 1973.

L. Action items

The following items were generated at the meeting or are continuing and require status reports:

1. Status report on pressure sensor design and development - Suomi.
2. Revision (or restatement) of specifications for stable oscillator - Rochelle.
3. Report on stable oscillator (including oven design) - Kruse.
4. Study on warmup times for balloon electronics - Lally.
5. Review in detail of Ascension Island III flight plans - NCAR/UWIS.
6. Review of pre-flight checkout system - NCAR/UWIS.
7. Procurement philosophy; plan, specs, tests, etc. - Haig.
8. Excess capacity- plan for integration into T/R program - Schardt, Masterson.
9. Report on probability of platform interference, data processing, etc. - Ghais.
10. Status of RAMS on Nimbus F - Cote.
11. Nimbus F schedule and status - Schardt.
12. PERT/BAR chart TWERLE schedule - Tefft.
13. Site planning and negotiations - Julian, Tefft.

LIST OF ATTACHMENTS

(attachments to be mailed separately)

1. TWERL Experiment Distribution List.
2. Note on requirements and details of the Energy Conversion investigation of TWERLE - V. Suomi.
3. Memorandum from J. Kruse on NCAR/UWIS Engineering meeting of 8 February 1972.
4. Plans for July test flights from Ascension Island.- E. Lichfield.
5. Ground checkout and on site test equipment.
6. Eole visit trip reports.

    a. W. R. Bandeen
    b. P. R. Julian
    c. A. F. Ghais
    d. R. W. Rochelle

7. Combined NCAR/GSFC/UWIS PERT charts - J. Tefft.
8. Proposed AFO - B. Schardt.
9. Excess capacity of T/R on Nimbus F - J. Masterson.
10. Memorandum from A. Ghais on T/R data reduction and dissemination.