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NASA
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Scientific and Technical Information Branch

WIND-WEIGHTING FOR SOUNDING ROCKETS WITH A TELEMETRY SYSTEM

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INTRODUCTION

A wind-weighting system has been developed for remote operations using an automatic tracking telemetry antenna, digital ranging system (TRADAT - Trajectory Data System), and modified transponder radiosondes. Wind data is printed out as wind velocity in meters per second, direction in degrees, and altitude at which the data is taken. The system was used operationally in January 1984 at Fort Yukon, Alaska, to wind weight the Terrier Malemute flight 29.Ø2l.

Tests were run at Wallops Flight Facility comparing the data from the radiosonde telemetry system and an FPS-16 radar for wind-weighting. A typical Terrier Malemute rocket was used to wind weight. Launcher settings for azimuth and elevation were compared to see how close the readings would agree. Using several different runs with both the radar and telemetry system tracking the same radiosonde, it was found that the elevation settings were within Ø.2 degree and the azimuth within one degree for all runs. There were some problems encountered with the telemetry system due to local interference on the 4Ø3 MHz band, which made it impossible to obtain continuous TRADAT range data. It should be noted that the radiosonde contains a super regenerative 4Ø3 MHz receiver which has a very broad receiving range by nature and is, thus, susceptible to interfering signals. No problems with interference were experienced when using the system in Alaska and good range was obtained.

A block diagram of the system is shown in Figure 1. Consisting of the automatic tracking antenna, TRADAT, transmitter, and radiosonde, the system is portable and breaks down into small containers for shipment to remote sites. Two people can assemble the system in several hours and be ready to support tracking. In its present configuration, the system is also used to support telemetry needs in L-band, 1680 MHz, and S-band frequencies. The TRADAT system is also used to provide trajectory data for remote rocket launches where radar is not available. Wind data has been received to

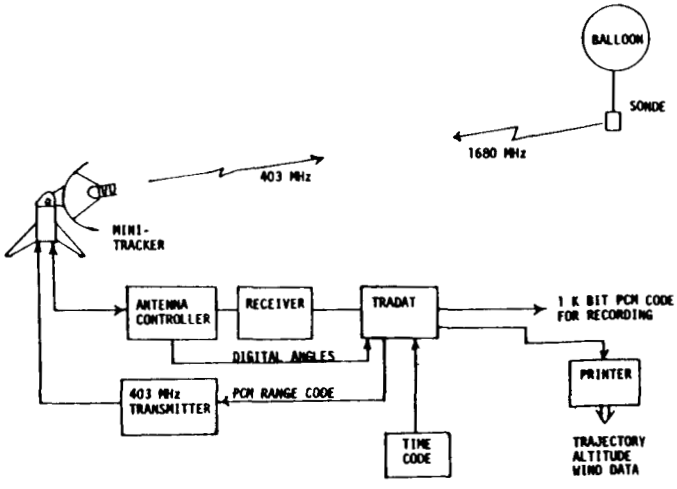

FIGURE 1 - BLOCK DIAGRAM WIND-WEIGHTING SYSTEM

altitudes above 30 kilometers and slant ranges in excess of 150 kilometers. Figure 2 shows a photograph of the minitracker and TRADAT.

The system operates by transmitting a PCM code at a rate of 3.9 kilobits from the TRADAT unit through the AM transmitter and transmitting antenna to the radiosonde which is attached to a weather balloon. The radiosonde receives the PCM modulated signal from the ground, detects it, and retransmits back to the ground on the standard 1680 MHz frequency. The 1680 MHz signal is received by the minitracker antenna and the return PCM code is sent to the TRADAT unit which times the period for the code to make the round trip. This time period gives the slant range to the sonde. Azimuth and elevation angles to the sonde are provided by the tracking antenna which with the slant range gives the position of the sonde relative to the tracker. Wind velocity and direction are calculated in software routines of the TRADAT microprocessor by fitting one-second ground-range points to a least-squares curve and then taking the slope of the tangent at the midpoint to provide velocities.

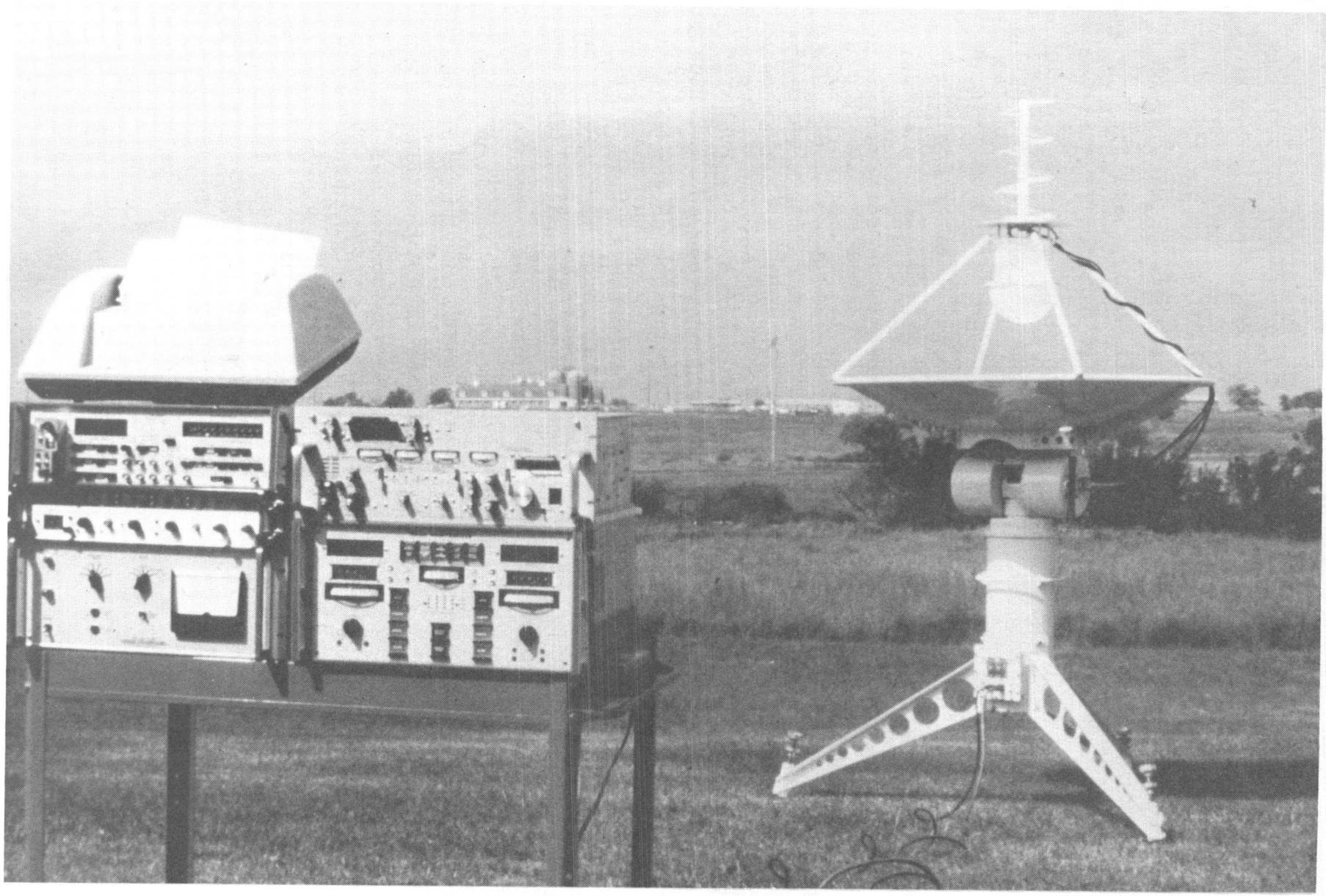

FIGURE 2 - MINITRACKER AND TRADAT

TRACKING ANTENNA

The automatic tracking antenna used was a 1.8-meter-diameter system developed by Oklahoma State University known as a "mini-tracker." It is a single-channel monopulse-type tracker which provides digital angle readout, as well as telemetry data. A 401-406 MHz helical antenna is mounted on the front of the feed pod to allow transmission of the ranging code to the sonde. The dish antenna receives the down link and automatically tracks the radiosonde in the standard 1680 MHz meteorological band.

TRANSMITTER

The transmitter is AM modulated and operates from 401 MHz to 406 MHz in 1 MHz steps. It has an output power of about 22 watts when operating at 70% AM modulation. The TRADAT PCM ranging code FM modulates a 70 KHz IRIG channel 18 VCO contained in the transmitter which then AM modulates the transmitter carrier.

TRADAT

The TRADAT system was developed by Oklahoma State University to provide trajectory data for sounding rocket payloads. It utilizes azimuth and elevation digital data from the tracker along with the slant range data from the ranging code to provide the positional data of the target. The data is processed by an internal microcomputer to provide both a printer output and a 1-kilobit PCM data code. The printer output (see Figure 3 for sample) provides either longitude and latitude or ground range north and east of the target, in addition to altitude, and slant range at rates of one per second, six per minute, or one per minute. When operating in the six-per-minute or one-per-minute rate, additional programming is included to provide target vertical and horizontal velocities in meters per second, plus horizontal direction (see the underlined data in Figure 3). Since the direction printed out is the direction of target movement, 180 degrees is added to that value to produce the correct wind direction. The 1-kilobit code is provided for recording; it contains azimuth and elevation angles, slant range,

N A S A

WALLOPS FLIGHT CENTER

TRADAT: TRAJECTORY DATA

VEHICLE: LAUNCH DATE: 2/6/84

LAUNCH TIME: LAUNCH SITE: 2109t

COORDINATES:	ALT(KM)	LAT(DEG)	LONG(DEG)
TRACKER	+00.0000	+00.0000	+000.0000
SITE 1	+00.0000	+00.1250	+000.0000
SITE 2	+00.0000	+00.0000	+000.1250

TRACKER TO SITE1: RANGE 013.821 KM AZ 360.00 DEG

STATUS INDICATOR DEFINITIONS:
1 ORIGIN(T,1,2);2 AZ MODE;3 EL MODE;4 FLAG;5 BW SELECT(1,,5);6 FIXED-SWEPT(F,S)
7 GOOD/BAD SMOOTHED RESULT (G,B);8 # DATA POINTS REPLACED IN SMOOTHING

TIME HH:MM:SS SMOOTHED	STATUS 123456 7 8	MSLA (KM)	GR/N,E OR LAT/LONG (KM) OR (DEG)	AZ (DEG) VZ(M/S)	EL (DEG) VH(M/S)	SR (KM) H(DEG)
06:09:50	TSS05F	ALT000.32	GR000.19 N-000.05 E+000.18	AZ105.40	EL59.15	SR000.37
SMOOTHED	G 00	ALT000.28	GR000.21 N-000.06 E+000.21	VZ-046.0	VH024.1	H 104.82
06:09:00	TAA05F	ALT000.03	GR000.33 N-000.09 E+000.32	AZ106.11	EL05.30	SR000.35
SMOOTHED	G 00	ALT000.03	GR000.32 N-000.08 E+000.31	VZ+003.0	VH004.5	H 283.48
06:09:10	TAA05F	ALT000.06	GR000.28 N-000.09 E+000.27	AZ108.08	EL12.47	SR000.29
SMOOTHED	G 00	ALT000.07	GR000.28 N-000.08 E+000.27	VZ+002.7	VH006.6	H 260.21
06:09:20	TAA05F	ALT000.10	GR000.24 N-000.12 E+000.21	AZ119.08	EL22.77	SR000.26
SMOOTHED	G 00	ALT000.10	GR000.23 N-000.11 E+000.20	VZ+003.1	VH008.5	H 252.61
06:09:30	TAA05F	ALT000.13	GR000.20 N-000.14 E+000.14	AZ135.53	EL33.88	SR000.24
SMOOTHED	G 00	ALT000.14	GR000.20 N-000.14 E+000.14	VZ+002.3	VH007.6	H 250.94
06:09:40	TAA05F	ALT000.18	GR000.20 N-000.19 E+000.08	AZ157.37	EL41.30	SR000.27
SMOOTHED	G 00	ALT000.18	GR000.20 N-000.18 E+000.08	VZ+003.4	VH007.8	H 243.6[illegible]
06:09:50	TAA05F	ALT000.23	GR000.23 N-000.23 E+000.01	AZ177.27	EL45.33	SR000.33
SMOOTHED	G 00	ALT000.23	GR000.24 N-000.24 E+000.02	VZ+009.8	VH011.8	H 213.86
06:11:00	TAA05F	ALT000.28	GR000.29 N-000.28 E-000.07	AZ192.30	EL44.14	SR000.41
SMOOTHED	G 00	ALT000.27	GR000.28 N-000.27 E-000.07	VZ+005.3	VH009.9	H 239.49
06:11:10	TAA05F	ALT000.33	GR000.36 N-000.33 E-000.14	AZ203.17	EL42.11	SR000.49
SMOOTHED	G 00	ALT000.26	GR000.29 N-000.27 E-000.12	VZ+003.0	VH009.1	H 255.71

FIGURE 3 - TRADAT PRINTER DATA

```
06:11:20 TAA05F ALT000.38 GR000.45 N-000.38 E-000.23  AZ211.46 EL40.50 SR000.59
SMOOTHED   G 01 ALT000.37 GR000.43 N-000.37 E-000.23  VZ+006.1 VH012.3 H 244.57

06:11:30 TAA05F ALT000.42 GR000.55 N-000.42 E-000.34  AZ218.58 EL37.87 SR000.69
SMOOTHED   G 00 ALT000.42 GR000.52 N-000.41 E-000.32  VZ+005.5 VH010.7 H 248.02

06:11:40 TAA05F ALT000.47 GR000.64 N-000.47 E-000.43  AZ222.63 EL36.52 SR000.79
SMOOTHED   G 00 ALT000.48 GR000.64 N-000.47 E-000.44  VZ+009.8 VH017.1 H 236.50

06:11:50 TAA05F ALT000.52 GR000.73 N-000.50 E-000.53  AZ226.68 EL35.16 SR000.90
SMOOTHED   G 00 ALT000.53 GR000.73 N-000.50 E-000.53  VZ+007.5 VH011.7 H 248.55

06:11:00 TAA05F ALT000.59 GR000.82 N-000.54 E-000.61  AZ228.71 EL35.96 SR001.01
SMOOTHED   G 00 ALT000.59 GR000.82 N-000.54 E-000.62  VZ+009.5 VH009.7 H 242.05

06:11:10 TAA05F ALT000.64 GR000.92 N-000.57 E-000.72  AZ231.59 EL35.03 SR001.12
SMOOTHED   G 00 ALT000.65 GR000.91 N-000.57 E-000.71  VZ+006.3 VH010.3 H 254.01

06:11:20 TAA05F ALT000.71 GR000.95 N-000.57 E-000.75  AZ232.73 EL36.75 SR001.18
SMOOTHED   G 00 ALT000.71 GR000.95 N-000.57 E-000.76  VZ-005.1 VH009.5 H 029.66

06:11:30 TAA05F ALT000.70 GR000.94 N-000.55 E-000.76  AZ234.00 EL36.97 SR001.17
SMOOTHED   G 00 ALT000.71 GR000.92 N-000.54 E-000.75  VZ+025.7 VH029.0 H 236.64

06:11:40 TAA05F ALT000.78 GR001.02 N-000.59 E-000.83  AZ234.82 EL37.49 SR001.29
SMOOTHED   G 00 ALT000.78 GR001.03 N-000.59 E-000.85  VZ+006.9 VH010.8 H 252.72

06:11:50 TAA05F ALT000.83 GR001.13 N-000.64 E-000.93  AZ235.73 EL36.43 SR001.40
SMOOTHED   G 00 ALT000.85 GR001.12 N-000.63 E-000.92  VZ+005.6 VH005.9 H 260.24

06:13:00 TAA05F ALT000.92 GR001.14 N-000.65 E-000.94  AZ235.38 EL38.88 SR001.47
SMOOTHED   G 00 ALT000.91 GR001.18 N-000.66 E-000.98  VZ+004.8 VH009.7 H 225.66

06:13:10 TAA05F ALT000.96 GR001.25 N-000.66 E-001.07  AZ238.04 EL37.46 SR001.58
SMOOTHED   G 00 ALT000.96 GR001.25 N-000.67 E-001.05  VZ+005.3 VH009.5 H 242.57

06:13:20 TAA05F ALT001.04 GR001.32 N-000.70 E-001.12  AZ238.00 EL38.15 SR001.68
SMOOTHED   G 00 ALT001.03 GR001.33 N-000.71 E-001.12  VZ+006.3 VH007.7 H 254.45

06:13:30 TAA05F ALT001.07 GR001.39 N-000.76 E-001.17  AZ237.02 EL37.69 SR001.76
SMOOTHED   G 00 ALT001.08 GR001.39 N-000.72 E-001.18  VZ+007.4 VH006.7 H 253.48

06:13:40 TAA05F ALT001.15 GR001.45 N-000.78 E-001.23  AZ237.74 EL38.35 SR001.85
SMOOTHED   G 00 ALT001.15 GR001.45 N-000.76 E-001.24  VZ+005.1 VH010.9 H 272.93


06:13:50 TAA05F ALT001.22 GR001.53 N-000.77 E-001.33  AZ239.96 EL38.43 SR001.96
SMOOTHED   G 00 ALT001.21 GR001.55 N-000.79 E-001.33  VZ+007.1 VH008.6 H 245.30

06:13:00 TAA05F ALT001.25 GR001.65 N-000.80 E-001.44  AZ240.94 EL37.04 SR002.07
SMOOTHED   G 00 ALT001.27 GR001.64 N-000.80 E-001.43  VZ+008.4 VH008.3 H 266.57

06:13:10 TAA05F ALT001.33 GR001.73 N-000.79 E-001.53  AZ242.66 EL37.58 SR002.18
SMOOTHED   G 00 ALT001.34 GR001.72 N-000.82 E-001.52  VZ+005.0 VH013.4 H 284.05

06:13:20 TAA05F ALT001.41 GR001.78 N-000.82 E-001.58  AZ242.69 EL38.28 SR002.27
SMOOTHED   G 00 ALT001.41 GR001.78 N-000.83 E-001.58  VZ+006.4 VH005.3 H 262.40

06:13:30 TAA05F ALT001.48 GR001.82 N-000.83 E-001.61  AZ242.65 EL39.15 SR002.34

SMOOTHED   G 00 ALT001.46 GR001.82 N-000.82 E-001.63  VZ+006.4 VH006.7 H 290.92
```

FIGURE 3 - TRADAT PRINTER DATA (continued)

plus time-of-day at a rate of 10 per second. The data can be played back to the TRADAT and processed at a later date.

SONDES

The system will operate with several types of transponder balloon radiosondes and also transponder Super Loki datasondes. The VIZ transponder sonde, Model 1399-402, is a modified sonde, manufactured by VIZ Manufacturing Company, which does not contain the standard meteorological portion of the sonde and has a modified filter in the 403 MHz receiver output to accept TRADAT data. The Space Data Corporation wind sonde will also operate with the TRADAT data when the receiver band pass filter is modified for a 70 MHz center band frequency. The Space Data Corporation Super Loki transponder datasonde will operate with TRADAT data when its receiver filter is modified and the modulation is limited to less than 70 percent AM modulation. About 35 VIZ-type sondes were flown in Alaska for wind-weighting, resulting in data that successfully wind-weighted the rocket.

DATA FOR WIND-WEIGHTING

The real-time Fort Yukon data from the printer was used since wind-weighting was required up to about 30 minutes before launch. The wind velocity, direction, and altitude are taken and manually plotted on a chart of wind velocity and direction versus altitude (see Figure 4). The chart is set up so it is divided into 20 separate altitude levels. A horizontal line is drawn through the points in a given level so as to give an average wind and direction for that level. A program has been written for the Hewlett-Packard 97 calculator which takes the wind components for each altitude, along with weighting factors for a given rocket, and generates the launch settings for the desired flight azimuth and quadrant elevation (QE) for the wind effect. The program is a standard one that is used by Wallops Flight Facility for wind-weighting in the field.

SUMMARY

This system can provide wind-weighting for sounding rockets at remote sites when a telemetry

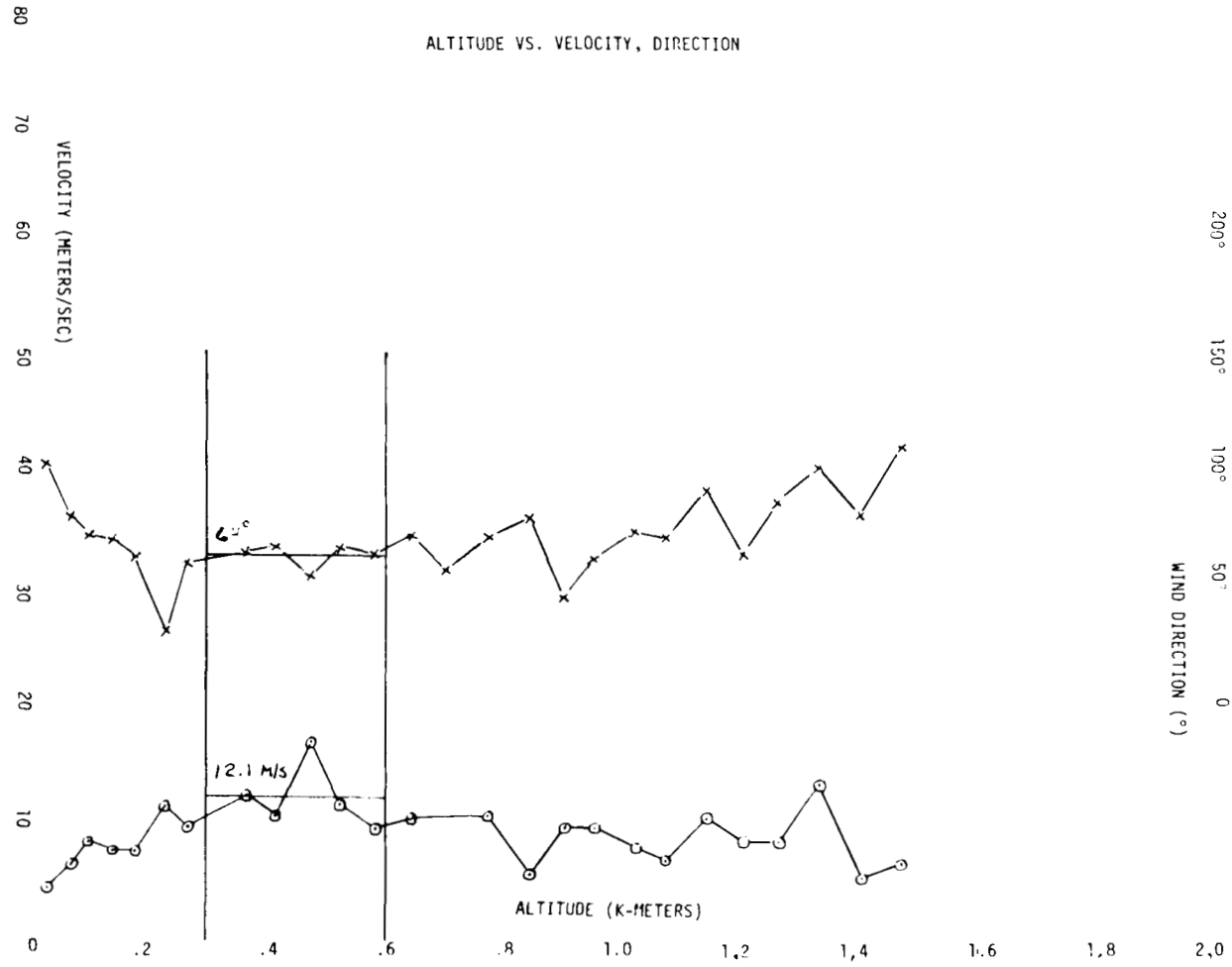

FIGURE 4 - PLOTTED DATA

tracker is available, but a radar is not. A simple modification to the transponder sondes is all that is required for operation with the TRADAT system. The entire system can be easily shipped and assembled in the field to provide support for telemetry data and rocket trajectory, as well as wind-weighting. Further tests are planned in the future to determine the actual accuracy which can be expected from the system.

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15. Supplementary Notes

16. Abstract

This paper describes a system to provide wind data which can be used for wind-weighting sounding rockets. The system uses an automatic tracking telemetry antenna and ranging system together with an inexpensive airborne transponder-type radiosonde.

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