A MOBILE RANGE SYSTEM TO TRACK TELEMETRY FROM A HIGH-SPEED INSTRUMENTATION PACKAGE

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ABSTRACT

As renewal interest in building vehicles based on hypersonic technologies begin to emerge again, test ranges anticipating in supporting flight research of these vehicles will face a set of engineering problems. Most fundamentals of these will be to track and gather error free telemetry from the vehicles in flight. The first series of vehicles will likely be reduced-scale models that restrict the locations and geometric shapes of the telemetry antennas. High kinetic heating will further limit antenna design and construction. Consequently, antennas radiation patterns will be sub-optimal, showing lower gains and detrimental nulls. A mobile system designed to address the technical issues above will be described. The use of antenna arrays, spatial diversity and a hybrid tracking system using optical and electronic techniques to obtain error free telemetry in the present of multipath will be presented. System tests results will also be presented.

KEY WORDS

Hybrid tracking system, spatial diversity, multipath, reconstruction of loss data, frame counter, optical aid, GPS based radiosonde.

INTRODUCTION

Telemetry from a small hypervelocity vehicle presents two major problems. The tracking system may have quantified to have adequate gain and high angular acceleration relative to the mutating RF target detection rate, yet in the present of multipath raise the question whether it can track over the entire flight course. This is especially an open question during the initial, high g acceleration phase. The existence of multipath creates another variable virtually impossible to quantify and therefore solved (1).

There are numerous solutions or approaches may be pursued. For example, one can build an intelligent tracking computer which, given the expected flight path, can accurately track the vehicle with programmed capability to response to possible anomalous deviations and minimize the bit error rate.

The solution that we have chosen to overcome the potential difficulties during the initial high g phase is a hybrid optically aided manual track, which relinquishes control to conventional auto track as soon as the target is out of the multipath region.

MOBILE RANGE SYSTEM

The mobile range system is comprised of a telemetry tracking van integrated with real-time mission control and a C-band radar. The telemetry tracking is augmented with 3 remotely operated telemetry relay stations. Their function is to acquire the telemetry, translate and retransmit it back to the telemetry tracking van. This not only provides redundancy, but also spatial diversity, a key to recovery lost data resulted from target rotation and antenna nulls. Since the subsystems are conventional range equipment, we will only describe the augmentations relevant to the acquisition and processing of telemetry from hypervelocity vehicles.

Telemetry Tracking

Most commercial available tracking systems have input ports to allow external devices to take control of the system and accept pointing vectors. A microcontroller based optical pointing device was built for this purpose. The microcontroller perform parallax correction, initial manual control, and send pointing vectors to the tracking system. Manual tracking is used when multipath is present. An operator operating the optical tracker can be seen in Figure 1.

Radar

Figure 2 shows the radar tracking system. The radar data is encoded as PCM data stream and is sent to the telemetry data processing system located in the telemetry van. GPS based radiosonde measurement of upper air profiles of pressure, temperature, humidity, wind speed and direction are also encoded in the data stream also. The upper air soundings are used to calculate aeronautical parameters of the test vehicles along the flight paths and for range safety operation.

Remote Telemetry Relay Stations

Figure 3 shows the remote stations. The antennas are mounted on a 15-foot high antenna mast. The top antenna provides the serial computer link for remote operation. The middle is a helical antenna for relaying the PCM in L-ban back to the telemetry tracking van for real-time processing. The bottom Yagi antenna is for the S-band downlink. At the base is the RF electronics, bit synchronizers, computer, and batteries. The deployment of the three stations is shown in Figure 4.

RECONSTRUCTION OF LOSS DATA

Telemetry acquired by the mobile tracking system is first examined for missing frames first. Then the time when the frames are lost and the frame numbers are logged. A search of the corresponding frames acquired by remote station 1, 2, and 3 is performed in that order. The first occurrence of a good frame is used to replace the missing one in the data stream of the mobile tracking system and the search is ended. The processed is repeated until all the missing frames are found and replaced. Currently, the software to reconstruct loss frame run in a Unix workstation. In the future the software will run in the telemetry acquisition equipment in real-time.

SYSTEM SIMULATION AND TESTING

A small instrumentation package was built to provide a PCM data source. A microcontroller gather data from three accelerometers, a pressure transducer, and clock out a PCM stream through the serial port. The PCM frame was consisted of 16 8-bit words. The microcontroller was programmed to clock out the bit at 500,000 bits per second producing a frame rate of 15,625 frames per second. The microcontroller also embedded in the data stream a 16-bit code used for frame synchronization, a 16-bit frame counter for frame identification. The rest of the words were filled with static bit patterns for data link error analysis. The data system also included a C-band radar transponder for testing the radar tracking.

Two patch antennas were used for the transmission of the S-band telemetry and transmit the return pulses of the C-band radar transponder.

To determine tracking system has the required slew rates to track high velocity vehicles, the instrumentation package was mounted on a pod of an F-18 and various flight paths were flow against the tracking system. The ratio of the transmit power to the distance to the tracker was picked so that the F-18 simulated a vehicle traveling at Mach 5, transmitting at 5 watts, at a distance of 5 miles from the tracking system. The slew rates, in the case here, were about 15 degree per second in elevation and azimuth.

The 4 PCM data streams were recorded on disk and screened for missing frames and bit error in the PCM words. No error or missing frames was found in the region of interest.

CONCLUSION

A conventional telemetry tracking system augmented with an optical tracking aid and an array of telemetry relay stations to provide spatial diversity can be used to acquire research quality data from a hypersonic vehicles in flight.

REFERENCES

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Figure 1 – Optical Tracker

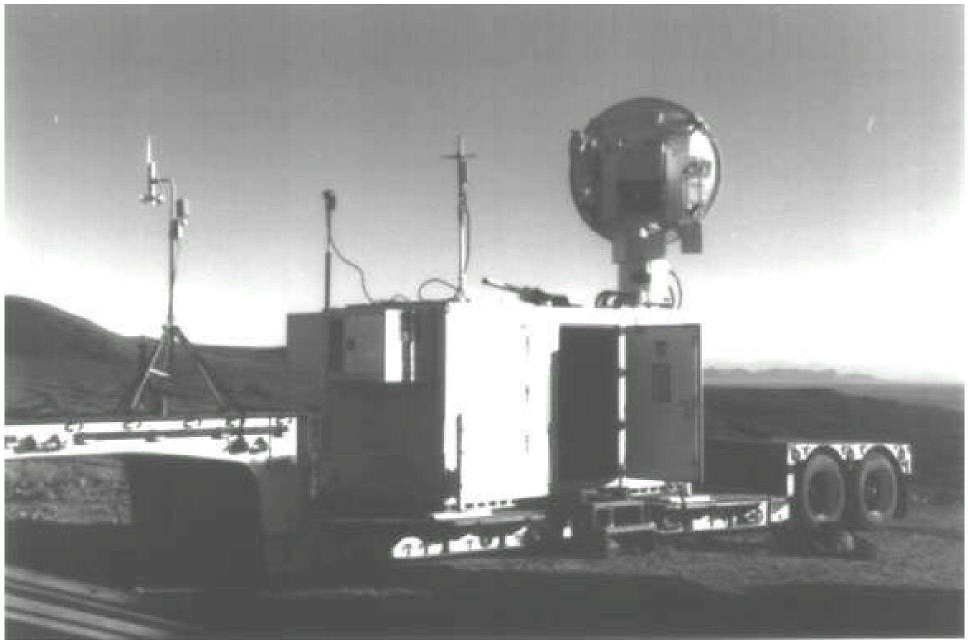

Figure 2 – Radar Tracking System

Figure 3 – Remote Stations

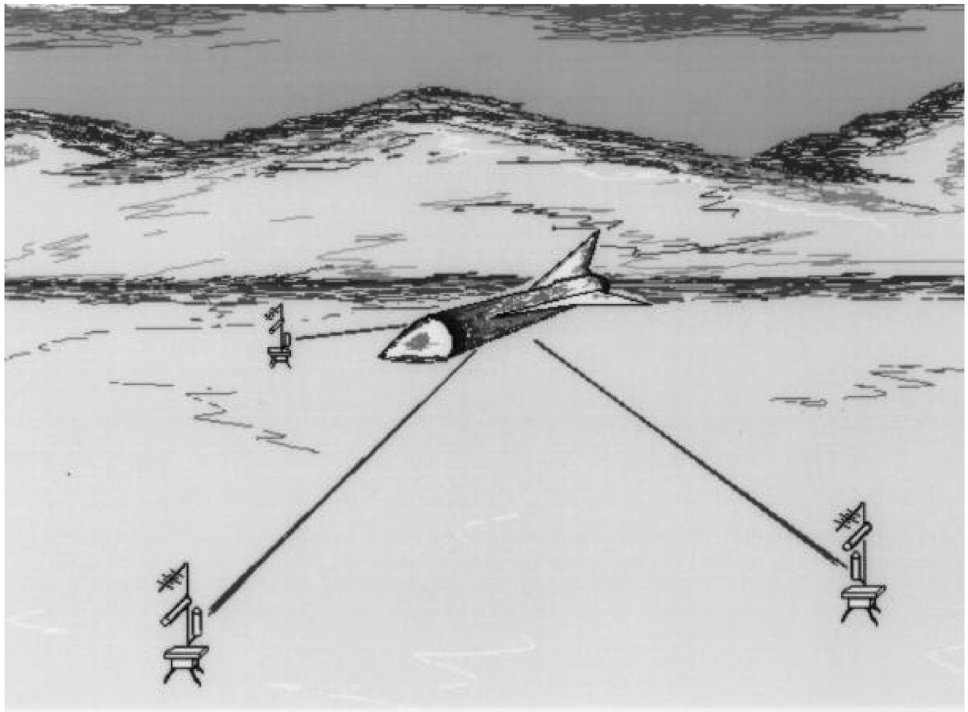

Figure 4 – Deployment of Three Stations