Satrack

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Abstract: SATRACK has been a significant contributor to the development and operational success of the Trident Weapon System, and it continues to provide a unique monitoring function that is critical to the maintenance of the U.S. sea-based strategic deterrent. The guided-missile came into existence when Werner Von Siemens suggested a concept for guiding submarines in the late 19th century. Satrack is an acronym for a satellite tracking system that uses a GPS i.e Global Positioning System for sending signals to the missile launched in the space. Satrack has fulfilled all the guidance subsystem requirements and has provided a weapon system error model which is possible only due to its ability to detect and allocate major error contributors that are responsible to miss the predetermined path of the guided missile. During the missile flight, signals sent by the GPS are received at the missile, then they are translated to s band frequencies and relayed to the ground station. In this way, satrack can track the missile to keep it in a proper trajectory. This guidance system evaluation concept is the best in the current test and evaluation technology for guided weapons systems.

Keywords: Satrack, Guidance, Missile.

I. INTRODUCTION

Satrack can be defined as the system that offers an evaluation of the system that guides the ballistic missiles.SATRACK is a system that was developed to provide an evaluation methodology for the guidance system of the ballistic missiles. SATRACK receives, rebroadcast, records and tracks the satellite signals sent by the GPS signals.

The major purpose of its development to validate the integrated weapon system designs. The great benefit offered by the Satrack facility is that all the data received from the test flights can be further used for getting a guidance error model. This recorded data can produce a model having comprehensive guidance error. In short, the Satrack facility results in the solution having the best flight path of the missile.

SATRACK was developed to validate and monitor the Trident missile guidance error model in the System Flight Test Program. It is the primary instrumentation and processing system responsible for accuracy evaluation of the Navy's Strategic Weapon System. Instrumentation and processing systems available when the Trident Development Program began could not meet this need. APL conceived and led the development of the SATRACK system to fulfil this requirement. Prototype instrumentation required for the missile and ground station data collection functions were developed at APL to validate the concept, and we generated specifications controlling the development of the operating missile and ground station hardware. The SATRACK processing facility includes a unique pre-processing hardware and software configuration and an extensive post processing analysis capability. Additionally, the APL satellite tracking facility has operated as a backup SATRACK recording site for all East Coast test flights since 1978. SATRACK fully met all its guidance subsystem evaluation requirements and also provided weapon system error model insights that would not have been possible without its unique ability to detect and allocate small error contributors to miss distances observed in the flight test program. SATRACK not only validated the Trident system accuracy, but the test-derived and validated system error models have allowed the command authority to confidently assign and allocate targets to sea-based strategic resources.

II. EVOLUTION

Satrack technology started to evolve when the Global Positioning System had been developed in the year 1973. It would have been a great advantage if the use of GPS is considered in the satellite test program. Only the changes in the missile and ground station design were required. The satrack development is initiated to bring into existence the missile with the GPS facilities included. The evolution of the satrack is as follows:

- Satrack 1- A technology project to develop the processing system using a Trident 1 missile (1973-1983)
- Satrack 2- The operational system designed to meet system requirements of Trident 2 missile (1983-present)
- Satrack 3- Current system upgrade and future applications

2.1 Satrack 1

It was aimed at analysing the insights needed to achieve improved accuracy in the existing Trident 1 missile and developing the evaluation system with improved accuracy taking into account the major error contributors. Satrack 1 was the development over the tracking methods and large Kalman filter design required in the early test flight programs. It used 4 GPS antennas over the s band antennas which were placed in missile circumference. As the spacing between the antenna elements was much wider, the signal sums caused the strong interferometer null patterns. The translator was time-multiplexed with two interferometers and the multiplexing rate was set high enough to track both the inputs simultaneously when the signal was strong. The signal is significantly refracted at GPS prime frequency (L1=1575.42 MHz) and it needs to be corrected for precision positioning. For this purpose the GPS provides additional frequency L2=1227.60MHz) which is used with the prime frequency to compute the needed correction for signal refraction. The L1 frequency could be modulated using two range code modulations, one with 2 MHz bandwidth and other with 20 MHz bandwidth. L2 could be modulated using only 20 MHz bandwidth. Narrow bandwidth code is called as clear/acquisition (C/A) code and wide bandwidth code is called as precision (P) code. The main problem associated with satrack 1 was regarding the antenna design which was providing very poor gain over a large region. (i.e less than 14 dB over 15% coverage region.) This poor gain was coupled with the GPS satellite signal levels hence creating a challenging condition for signal tracking.

2.2 Satrack 2

Satrack 2 was related to the accuracy evaluation requirements of the D5(Trident 2) missile. It began in 1981. It was aimed at using a dual-frequency GPS signal capability to permit ionospheric corrections and tracking 12 dual frequencies from left to right (i.e 48 range codes). As we know the L2 signal could only be modulated using P-code. The satrack 2 technology aims to modulate the L2 signal using C/A code as well as P-code. To achieve this switching between the two codes would be impractical as it could cause the effect on other users. The alternative to this is to use another GPS frequency called L3 frequency which needed to be derived from the same frequency source as the positioning signals. The frequency should be selected such that it could support the C/A code modulation. This was considered as the baseline for satrack 2. The satrack 2 technology provides overlaying of the two GPS signals on the same translator channel. The separation of the signals could be done during the signal tracking operation by the code differences but at the expense of increased noise n each signal. Advancement was in the antenna used. Depending upon the analysis of phase noise characteristics of the different configurations wraparound antenna was chosen. This antenna was chosen because it minimized the phase variations in the missile roll plane. These were all the upgrades in the satrack 1 systems.

2.3 Satrack 3:

Satrack 3 can be viewed as the advanced satrack technology which taking the full advantages of the technological growth in the processing hardware and software. This technology is used to guide all the present-day ballistic missiles. This technology is designed to be compatible with the satrack 1 and satrack 2 technologies so that C4 and D5 missiles can also be guided using this technology. This is a big advantage of satrack 3. This technology is intended to serve both range safety and post-flight evaluation objectives for a variety of range applications.

III. SYSTEM DESCRIPTION

3.1 GPS translator

It is a light hardware which remains fixed in the missile. The GPS signals are received by the translator. These signals are amplified and shifted to an intermediate frequency. Further, signals get altered for covering the satellite signal modulation bandwidth. After that, the signals get amplified for transmitting to the ground stations.

The GPS Translator does the following things:

1. Receiving the satellite signal.
2. Further, it is translated to a missile telemetry frequency.
3. The received signal gets rebroadcasted.

3.2 Ground Telemetry Stations

The signals are received by the missile from the GPS satellites and they get translated to a different frequency. They further relayed to the ground telemetry stations. The data for the playback and post-processing is recorded by the ground telemetry stations. The missile receives satellite signals that are translated to the S-band frequencies with the use of the missile hardware named as translators. The data is then recorded from the ground-based telemetry station after reception via the antenna after digitizing the signals. To offer real-time tracking solutions, the C/A signals are used by the ground sites.

3.3 Post Flight Tracking and Data Processing

This module is most vital part of the Satrack technology. The GPS signals are received, racked and recorded for many days surrounding the missile light at the GPS tracking sites. Further, these signals are received by the missile during the light and translated in frequency. It gets further transmitted to the surface station. The recorded data is used by the post-light process to offer satellite ephemerides clock. This tracked signal data is estimated from the post-light receiver. All the data element and the system models are used by the missile processor after the signal tracking data for producing the light test data products.

IV. WORKING

The meaning of guidance is the process of guiding the path of an object towards a given point. If the target is moving relative to the guided object then the process of guidance is dependent upon the position and velocity of the moving target. Nowadays all the ballistic missiles are guided with the help of GPS satellites. Satrack has been a significant contributor to the development and operational success of present day ballistic missiles. It is basically used to provide a unique monitoring function for evaluating the error model of any weapon system. Satrack basically validates and monitors the missile guidance error model in the flight test program. The reason behind using the satrack for evaluating and validating the error model is its ability to receive record, rebroadcast and track the satellite signal. It identifies the major error contributors that are responsible to miss the track of the missile from its predetermined path.

A. What is a Guidance System?

The guidance system in a missile is similar to the human pilot of an airplane. Guidance system of any missile mainly contains two systems.

1) Attitude control system: This system maintains the missile in the ordered flight path by controlling the missile in roll, pitch and yaw. This system also works as an autopilot which damps out the fluctuations causing the missile to deflect from its trajectory.

2) Flight path control system: The function of the flight path control system is to determine the flight path which is best suited for the target interception and generate the orders for the attitude control system to maintain that path.

B. Inertial Guidance System

The principle of inertia is basically used in the guidance system of missiles. This system provides the intermediate push to the missile to bring it back on the proper path. The inertially guided missile receives the programmed information before its launch. Even if there is no electromagnetic contact between the missile and the launching station, the missile is able to make corrective adjustment in the flight path itself.

Inertial guidance measures all in flight accelerations and attitude control system generates corresponding correction signals to maintain the proper fight path. The use of inertial guidance takes much of the guesswork out of long range missile delivery. The unpredictable outside forces acting on the missile are sensed by the accelerometers and the solutions generated by them helps the missile to correct its path. This system is reliable than any other long range guidance missile.

For a number of days surrounding the missile, the GPS ground stations receives, tracks and records the GPS signals. . During the missile launch, signals of GPS are received by missile, changed in frequency, and are given to the surface station. The missile signals are received and separated by the tracking antenna. The post-flight process uses the recorded data to give satellite ephemerides & clock estimates tracked signal-data from the post-flight receiver, and missile guidance sensor data. After the signal tracking data are corrected, all the analyzed data and the system elements are used by the missile processor to produce the data products.

V. CONCLUSION

SATRACK is a significant contributor to the successful development of and operational success of the Trident weapons system. It provides a unique monitoring function that is critical to the maintenance of strategic weapons systems.Over the years, there is a great contribution made by the Satrack for the successful development and success of the Trident weapon system. There is an important role played by it in offering a perfect monitoring system for the maintenance of the missile trajectory. The recent research and development in this field are responsible for bringing the latest technology translator, receiver, data recorders, and missile processors in the programs related to the missile flight.

VI. REFERENCE

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