Desktop GPS Analyst
Standardized GPS Data Processing and Analysis on a Personal Computer

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ABSTRACT

In the last few years there has been a proliferation of GPS receivers and receiver manufacturers. Couple this with a growing number of DoD test programs requiring high accuracy Time-Space-Position-Information (TSPI) with diminishing test support funds and/or needing a wide area, low altitude or surface tracking capability. The Air Force Development Test Center (AFDTC) recognized the growing requirements for using GPS in test programs and the need for a low cost, portable TSPI processing capability which sparked the development of the Desktop GPS Analyst. The Desktop GPS Analyst is a personal computer (PC) based software application for the generation of GPS-based TSPI.

Keywords

DGA, PC, GPS, TSPI, BET, Windows, GUI, Visual Basic, C++.

INTRODUCTION

Precision accuracy requirements, decrease in test support funds, and wide area , low altitude or surface tracking of test items have all contributed to the migration to Global Positioning System (GPS) instrumentation as the primary TSPI sensor source. Today, single instrument GPS is capable of providing TSPI accuracy and tracking coverage commensurate with multiple instrument best estimate of trajectory solutions. The Air Force Development Test Center, Eglin AFB, 96 CG/SCW in conjunction with an Office of Secretary of Defense funded Airborne Instrumentation System (AIS) developed by NAWC-WD China Lake, and a

Central Test and Evaluation Improvement Program, Test Technology and Demonstration (TTD&D) effort have supported the development of a universal GPS inertial aiding and differential correction program. Requirements for the program demanded a tool that can be used by an operational tester without extensive TSPI experience.

At present DGA supports a NovAtel 12 channel receiver using coarse acquisition (CA) code and a Range Applications Joint Program Office (RAJPO) High Dynamic Instrumentation System (HDIS) using precision (P) code airborne and ground reference receiver suites with new receiver types being added to satisfy requirements.

OVERVIEW

The Desktop GPS Analyst (DGA) software guides the user through a series of software program steps that merge airborne and reference receiver GPS data for the generation of TSPI data products. Inertially aided absolute TSPI solutions and unaided or aided differentially corrected TSPI solutions can be obtained with this software. The software allows the user to select receiver type to account for differences in receivers due to manufacturer and/or measurement availability. This approach permits creation of a standardized set of GPS measurement data that can be processed using a state-of-the-art Square Root Information Filter/Smoother (SRIF/S) as a Best Estimate of Trajectory (BET) algorithm. The resulting TSPI solution can be exported to either custom user software or commercial-off-the-shelf (COTS) software in either ASCII or binary formats.

DGA operates in the Microsoft Windows environment using separate but coordinated application programs. The application programs include: Common Airborne Processing System (CAPS), Advanced Test Data Optimal Processor (PC-ATDOP) and DGA itself. Each application program can be executed independently of the DGA environment but without having access to DGA quality control features. Furthermore, the independence of these applications simplifies the task of adding new functionality and extending the capabilities of DGA handling new receivers and satisfying new requirements.

The DGA graphical user interface was written using Visual Basic to allow rapid prototyping of the overall approach. C++ was used to develop the support libraries for handling file input/output, calculations and other functions where performance or portability were issues. PC-ATDOP which contains the SRIF/S was developed in FORTRAN and is executed on several platforms besides the PC including Digital AXP and Cray computers.

GUIDED PROCESS

The key concept of the Desktop GPS Analyst is the Guided Processing Sequence (figure 1). Invoking this window allows the user to process both airborne and reference receiver GPS data using a step-by-step icon-based approach. Grayed-out icons represent inactive process steps while the currently active processing step is highlighted in color. To execute the active step the user clicks over the active icon and is presented with information about the processing to be performed and/or the processing step is executed. As processing steps are completed DGA keeps track of this information allowing the user to save and exit from the processing cycle and reinitiate processing at the exit point later.

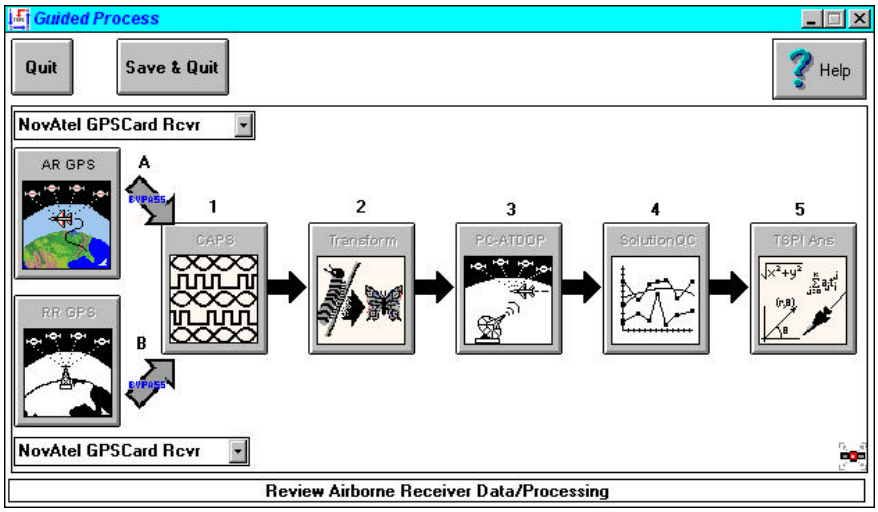
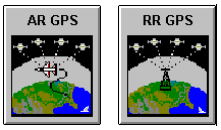


Figure 1…Guided Process Sequence Window

Guided Process - Information Steps A and B



When a new processing sequence is initiated the user must select the airborne and reference GPS receiver types from the two available list boxes. This selection allows DGA to build necessary components used in later processing steps. Once the receiver types have been determined the user is given the opportunity to review the specifics of transforming raw airborne and reference measurements into a TSPI solution. This is accomplished by invoking in turn the relevant Help File pages for first the airborne and next the reference receiver steps. These non-processing steps educate the user on the details of the receiver measurements and how to extract the engineering unit results from the raw instrumentation data files. More experienced users can bypass these 2 informational steps and proceed directly to step 1.

Guided Process - Data Extraction

The initial task for the user is to extract from the raw data files the data to used to develop the TSPI solution. This function is performed by a separate software application CAPS. Clicking the CAPS icon causes DGA to automatically create the Session (SES) and Output Product

Descriptions (OPD) necessary to perform all raw data extraction and engineering unit conversions. In addition, it provides the user the path to the Data Dictionary (DIC), which contains the bit level descriptions of all airborne and reference receiver variables for DGA supported receiver types. Once these files are constructed, DGA invokes the CAPS application for the user. Now the user is in CAPS and must first convert the raw data file to a CAPS STD file, this standardizes receiver message structure for the engineering unit conversion functions, and second invokes the Session File to perform the actual engineering unit conversions.

The user repeats the above process for both the airborne and reference receiver data files before proceeding to the next processing step. The measurements extracted during this step include airborne receiver navigation, pseudoranges and optionally inertial data, as well as reference receiver differential corrections, ephemeris and satellite position data. Together CAPS and DGA provide a standardized method for extracting GPS data, and allow the expansion of DGA to support new receiver types with minimal software development costs.

Guided Process - Receiver Data Quality

Once the measurements have been extracted, the user is given a first opportunity to perform some quality monitor functions in the form of two graphical presentations. First is a polar plot (figure 2) of the reference receiver observed satellite configuration with estimates of the vertical and horizontal position errors or dilution of precision (VDOP, HDOP) associated with the specific satellite configuration. Depending upon the geometry for the available satellites no further processing may be warranted. In addition, the user is presented the satellite-by-satellite availability of airborne receiver pseudoranges and reference receiver differential corrections (figure 3), as well as indicating time intervals where 4 or more satellites were present with both pseudorange and corresponding corrections data. If pseudoranges and corrections are available from less than a common set of 4 satellites there is no need to continue as no solution can be computed.

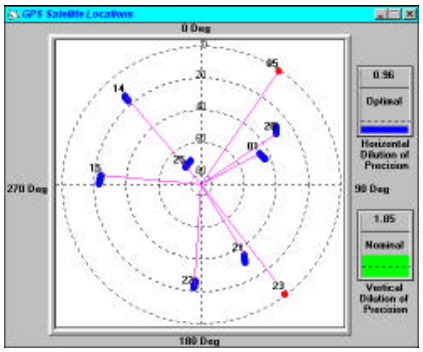


Figure 2…Satellites, HDOP & VDOP Estimates

GPS data processing requires the airborne receiver or participant collect pseudorange measurements from a minimum of 4 satellites to obtain a accurate solution. In addition, the reference receiver provides satellite ephemeris and differential corrections for the same satellites being collected by the participant.

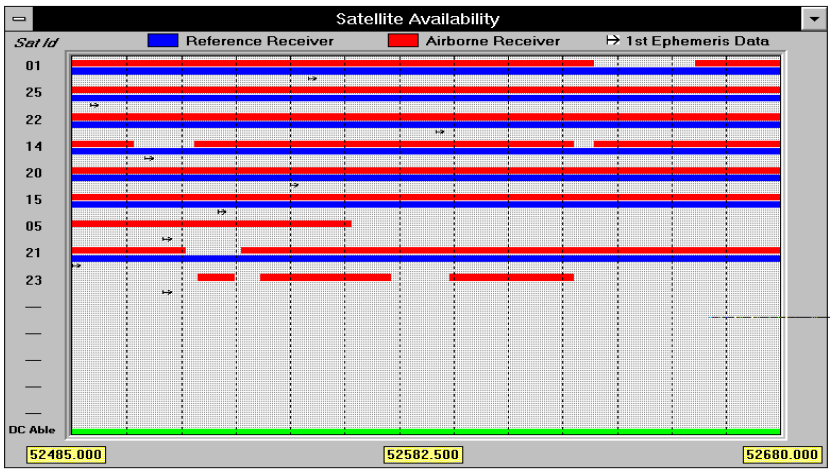


Figure 3…Satellite Measurement Availability

The corrections are used to remove tropospheric, ionospheric, space vehicle and selective availability errors (CA-Code receivers only). Error estimates for the TSPI solution are valid only if there are five pr more GPS satellites for input measurements.

Guided Process - Measurement Transformation

Now with all required data extracted, the user executes the measurement transformation step which merges the contents of the individual measurement files together into the standard format accepted by the PC-ATDOP software. Depending on the receiver types this processing step will derive parameters not available from the original input measurement files but which are needed for PC-ATDOP execution. During this step the user is presented in real-time details of the processing being performed (figure 4) including event time, GPS data measurement types detected for specific satellites. A selected type of TSPI solution (aided absolute, unaided differential, aided differential) can be obtained based on data availability.

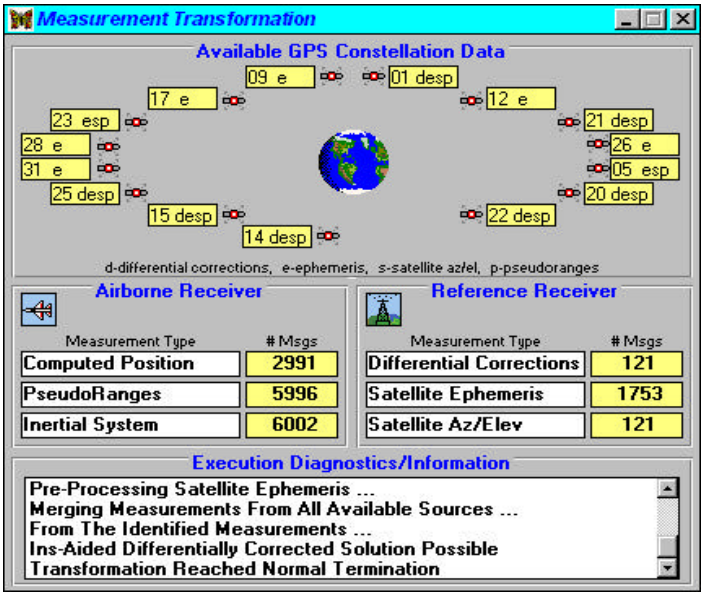
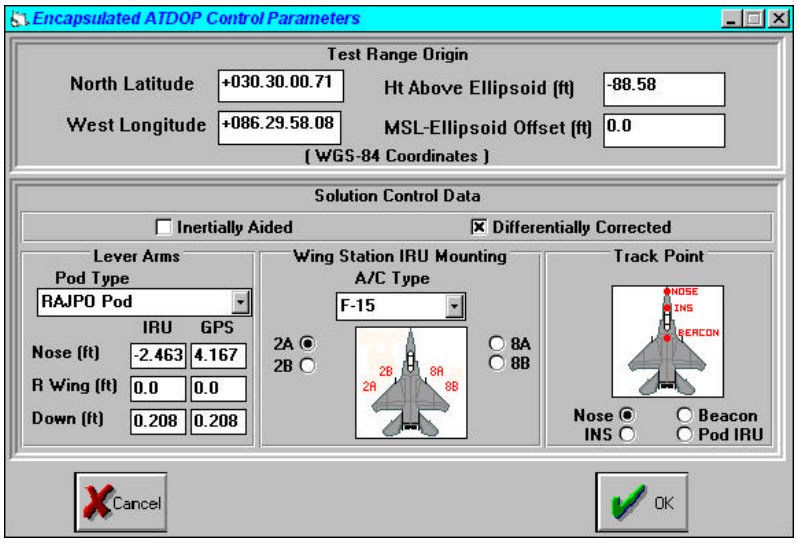


Figure 4…Measurement Transformation Window

Guided Process - TSPI Processing

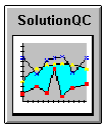
Having converted the receiver measurements to a standard format the data is ready for input to the BET software. This application is PC-ATDOP which employs square root information filter optimal estimation algorithms. Before this development effort PC-ATDOP was a workstation based application used by multiple DoD test ranges for processing multiple sensor instrumentation data. For DGA this application was migrated to a PC and fitted with a Windows

dialog interface (figure 5) which is used to setup and control PC-ATDOP execution. The user can select the appropriate lever arms for either IRU or GPS antenna location depending upon system configuration and can select aircraft type, wing station where airborne receiver pod is mounted and TSPI solution track point. These user inputs are used to construct various PC-ATDOP control parameter inputs critical to proper filter execution.



In addition to the setup dialog, PC-ATDOP was provided with sufficient robustness to allow it to be used in the field by persons having minimal training in the operation of this type software.

Guided Process - Solution Quality Assessment



At this point in the processing cycle the user TSPI solution has been generated. The next step is to perform some standard quality control checks on the BET results. To accomplish this the user is automatically presented with a X-Y plot comparing PC-ATDOP's estimate of the error in the original airborne receiver absolute TSPI solution versus PC-ATDOP's estimate of its own differentially corrected TSPI solution (figure 6). In addition the user can select any parameter from any of the original receiver measurements used by PC-ATDOP and can selectively plot the various residual errors generated by PC-ATDOP during its execution to further understand the quality of the generated TSPI solution.

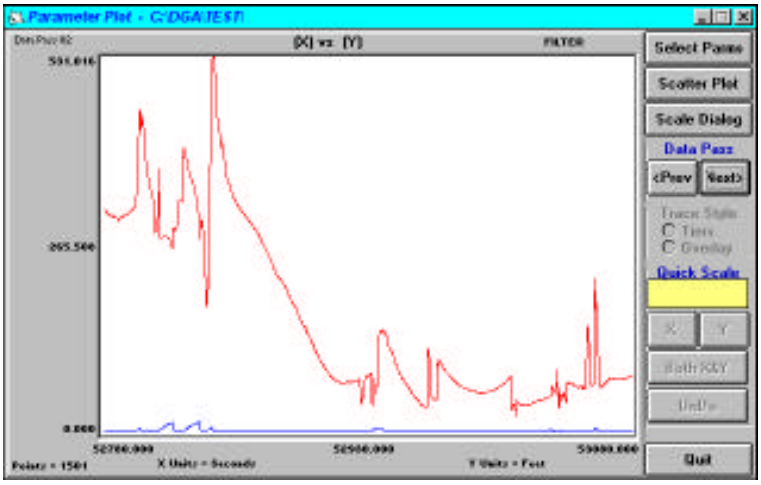
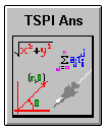


Figure 6…Parameter Plot of Solution Error Estimates

Guided Process - TSPI Parameters



The final step is to extract or derive the TSPI parameters or answers needed by the users follow-on application (figure 7). The results from PC-ATDOP are in a standard binary file format that supports any number and/or kind of sensor. The binary format may not lend itself to direct usage by other application software; therefore, the last step of the guided process allows the user to select from a set of commonly required TSPI answers. These answers can be written to either a binary or ASCII file in any order, in English or metric units and to any user selected filename and location. Additionally, the user can create a Mission Analysis and Reporting System (MARS) compatible TSPI file. MARS is another PC-based application supporting test and analysis of electronic warfare systems.

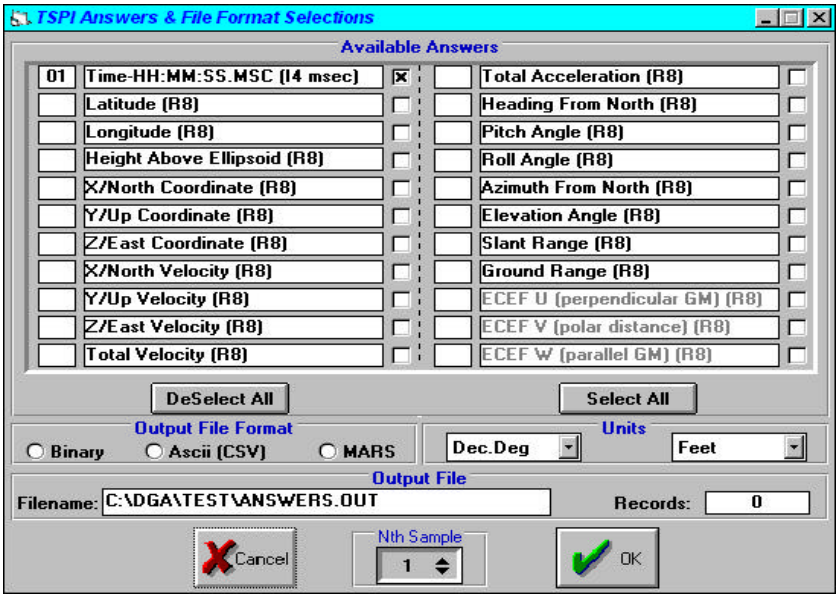


Figure 7…TSPI Answers Window

With the generation of the TSPI answer file or files in the user requested format for use with other custom or COTS software the Guided Process is complete. If the need to re-execute any steps in the sequence arises the option exists to reset the guided sequence to the step where reprocessing is to begin and rerun the affected steps. Also, CAPS and PC-ATDOP can be executed either by selecting the appropriate program icon from the main DGA toolbar or totally outside DGA.

CONCLUSION

The Desktop GPS Analyst software brings a standardized approach to the generation of TSPI data products from GPS data. The software is composed of multiple applications with GPS receiver specific raw data formats handled at the front end which allows for a consistent, repeatable method for obtaining quality TSPI data products.

It is written for any 486 PC running PC-DOS or MS-DOS, Windows 3.1, Windows 95 or Windows NT and having sufficient free disk space. It uses standard Windows controls to provide GUI behavior familiar to all PC users. The intended

audience ranges from novice users to TSPI specialists. For more information concerning DGA, contact Mr Neal Urquhart at (DSN) 872-8470 or (904) 882-8470.

REFERENCES

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