Chapter 3

GPS and Its Application

GPS, Global Positioning System, is an advanced technique well developed and widely applied in recent years. By receiving the signals from the GPS satellite, it is easy to get the three-dimensional position information for any point on the earth. Because of its ability of all-weather, global, three-dimensional positioning, the coordinate system used should not be a local coordinates of any country or region, but a global coordinates. At present, the coordinates used by GPS is WGS-84, which is a global uniform geographic coordinates. WGS-84 belongs to protocol coordinate system and its origin located at centroid of the earth is also perfectly defined.

An important problem in GPS measurement application is to determine the difference of benchmark of geographic measurement between local coordinate system (for example, China 1954 Beijing coordinate system and 1980 national coordinate system) and global coordinate system and take transformation between them. In order to get highly precise absolute position and navigation, we have developed a GPS coordinate transformation software with Visual C to process the data rapidly. Because of the difference among the independent coordinate system in different country, the error among the coordinate systems should be seriously treated during the application of GPS data. In other word, if higher precision is required, the coordinate transformation is necessary.

In order to apply GPS in precise detection and controlling forest damage, we have developed the GPS coordinate transformation software and flight line design software, and so on.

1. GPS coordinate transformation system software

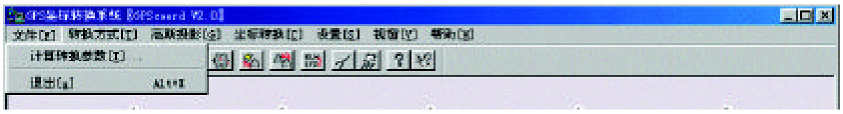
This software has a friendly user interface and can be directly installed on the computer with Windows 95, Windows 98, and so on. The following figure is a illustration of the interface.

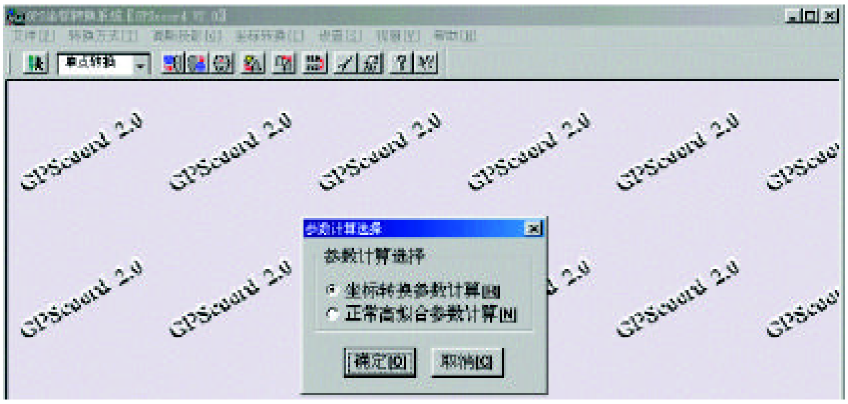
In terms of the difference in the data transformation mode, this software can be divided into two parts: single point mode and file mode, and their functions also vary respectively.

1.1 Main function of single point transformation mode

1.1.1 Calculation of transformation parameters

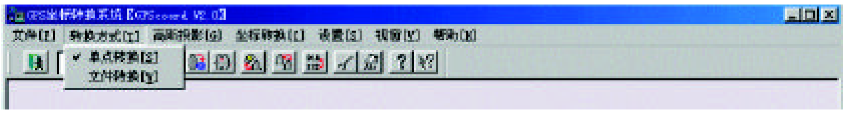
This software sets the lower precision coordinate and elevation transformation parameters that are suitable for country range as default parameters inside. At the same time, it provides users the interface to calculate local coordinate and elevation transformation parameters. Users take coordinate and elevation transformation in local region with data existed to get a special transformation parameter as local value that will be used in high precision transformation





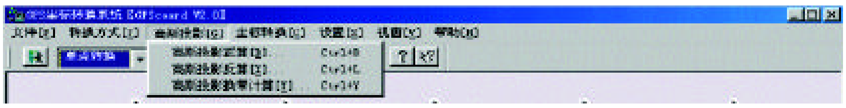
1.1.2 Choice of transformation mode

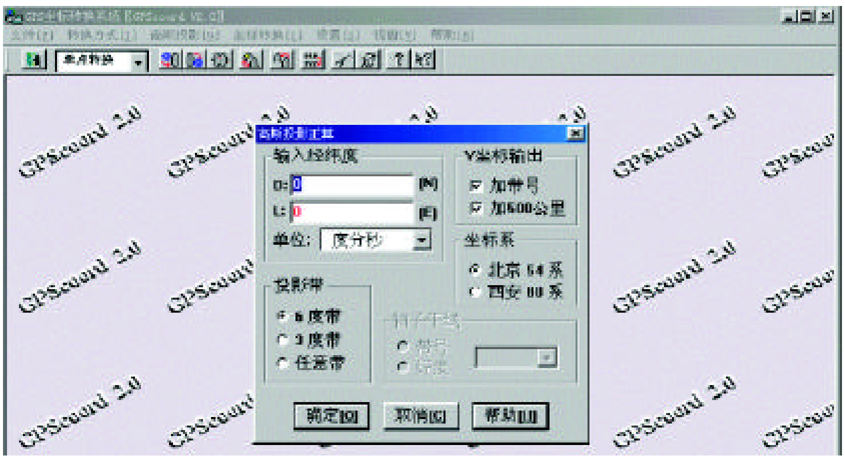
According to the magnitude of data, users can choose different data organization mode.

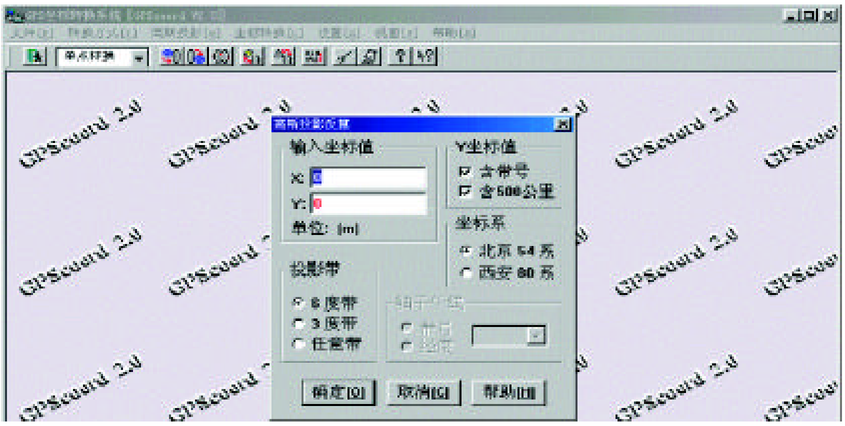


1.1.3 Gauss projection's positive and negative calculation and zonal change calculation

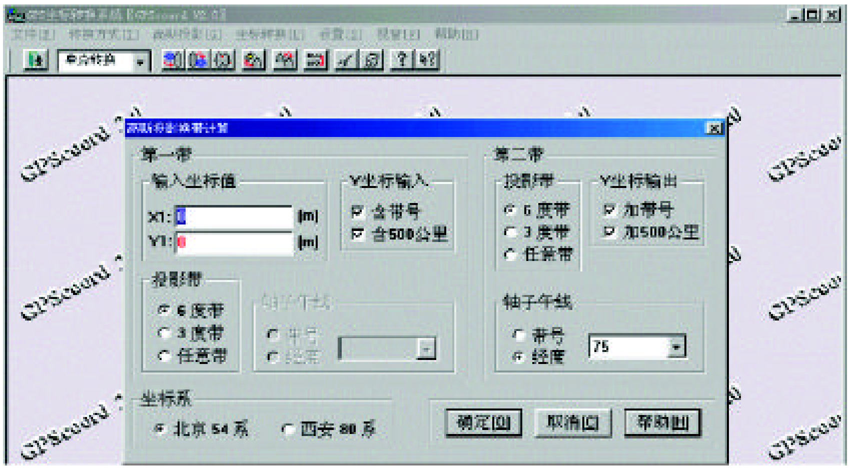
The topographical map series in each country adopt UTM or Gauss projection mode. Because topographical maps are often basic map for management in forest production, the problems of positive and negative calculation to coordinate often occur.





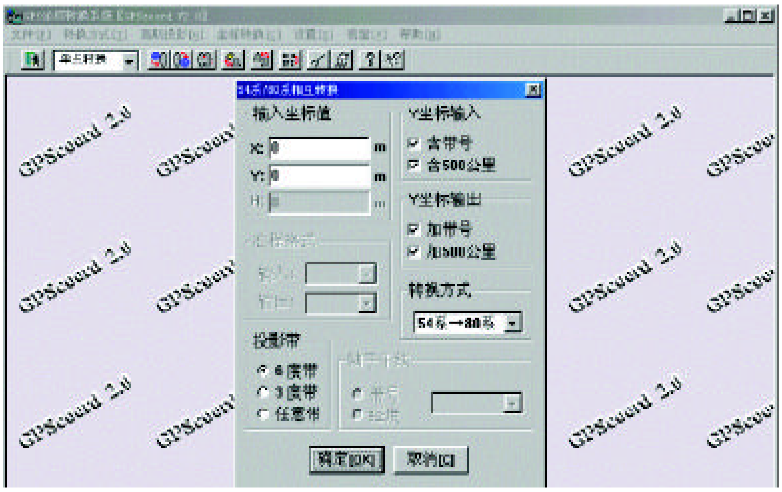


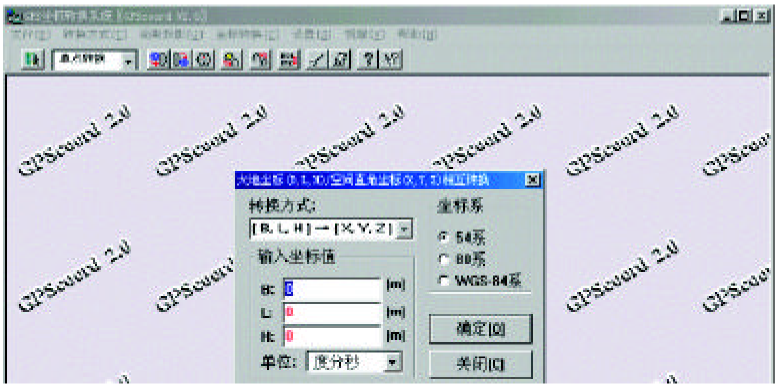
Because the UTM and Gauss-Kruger projection adopt zonal projection mode and has distinction between 3 degree zone and 6 degree zone, users will encounter the problem about the right angle coordinate system when they use the different scale topographical map or make operation at the edge of different zone. For the facility of analysis, it is necessary to make the zonal transformation calculation to uniform the coordinate system.



1.1.4 Cross transformation among WGS-84, Beijing 1954 and Xi'an1980 coordinate system

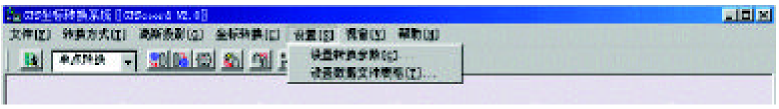
Because the topographical map surveyed at different time adopt different coordinate, users often confront the problem of transformation and joining. We must resolve the problem that exits in the high precise cross coordinate transformation of geographic coordinates, Gauss-Kruger coordinates, spatial right angle coordinates among different systems.

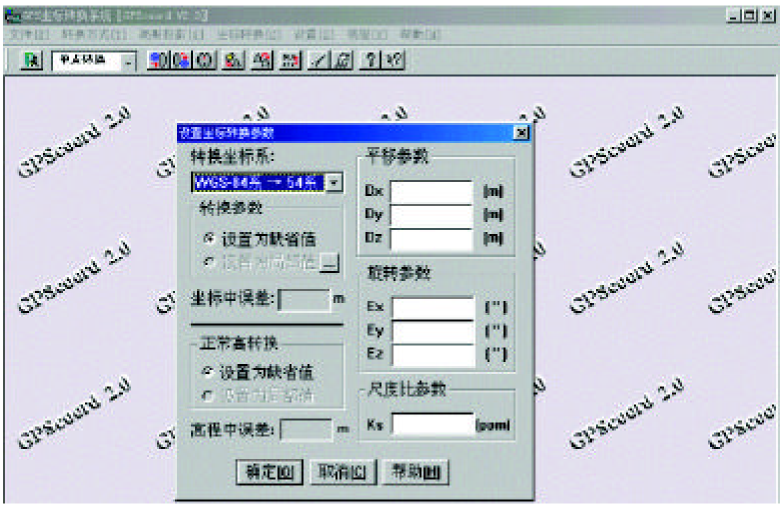




1.1.5 Setting transformation parameters

Users can set the coordinate and elevation transformation parameters (for example, provided by the third attendee) as default value or local value.





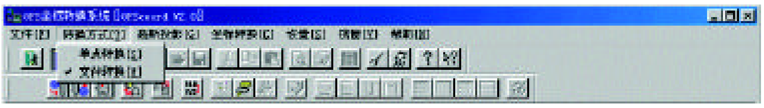
1.1.6 Setting data file table

For the facility of understanding and output, users can make diverse setting for the data table.

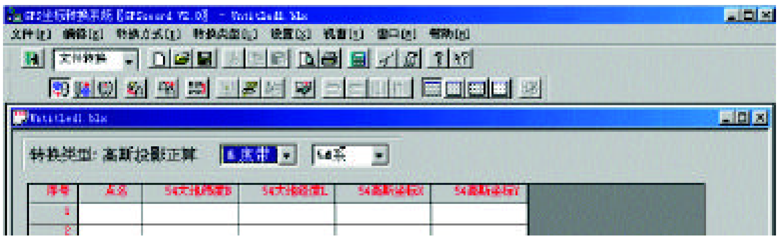
1.1.7 Windows and Help

Convenient tool buttons and illustration for help.

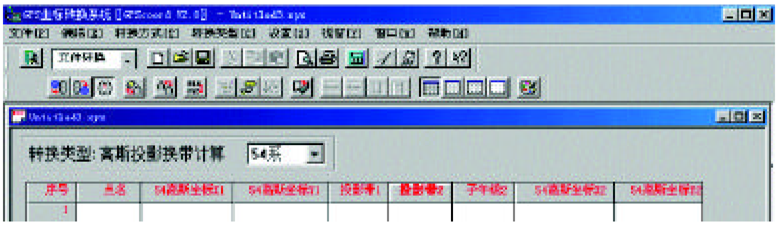
1.2 Main function of file conversion mode



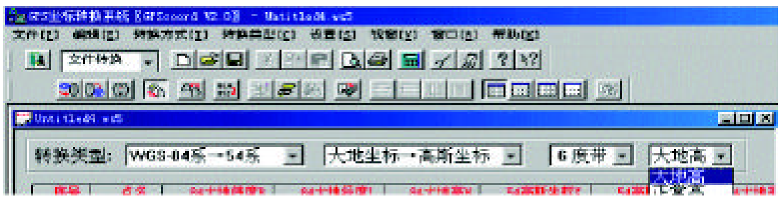
1.2.1 Gauss-Kruger projection's positive and negative calculation



1.2.2 Gauss-Kruger projection's zonal change calculation

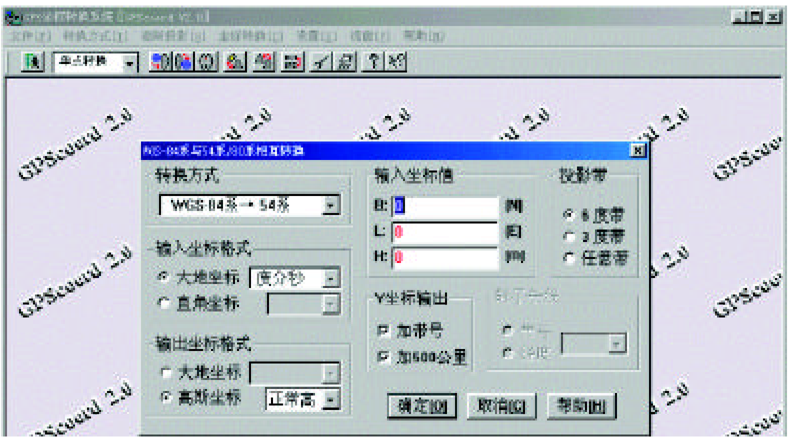


1.2.3 Cross transformation among the three coordinate systems

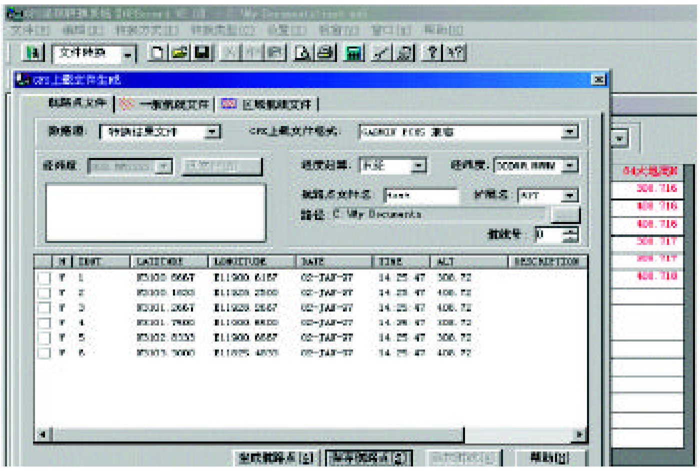


1.2.4 Conversion NMEA-0183 real-time outputting data to 54 or 80 system

The main aim is to realize the integrity of GPS and GIS through converting the 0183 data provided by GPS receiver to plane right-angle coordinate system matching with topographical map data.

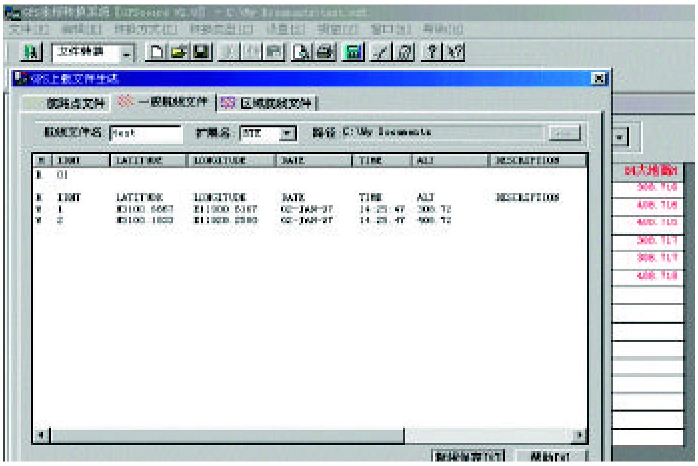


1.2.5 Calculation of GPS waypoint is the basic data for GPS navigation.



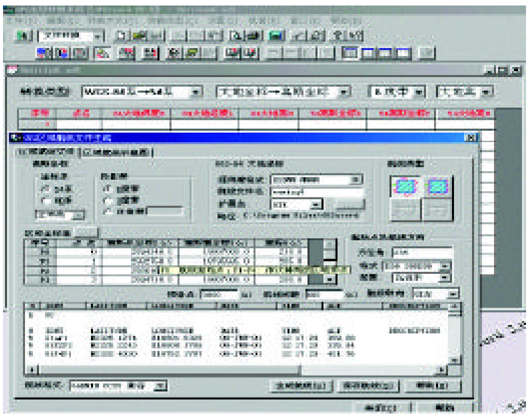
1.2.6 Calculation of flight line file with waypoint

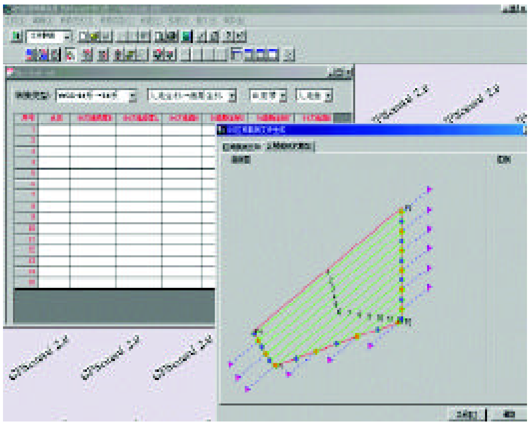
To compile flight line (or route) file with selected waypoint data.



1.2.7 Calculation of route file with flight line type

Forest flight task usually chooses its flight mode according to the topographic condition, such as double direction flight, single direction flight, interval flight, and so on. So different flight line sequence will come into being in the same task region with different flight type.





1.3 Upload of flight line and download of flight track

In forest production department, most users use the GPS receiver of GARMIN Company as navigation tool. Our receiver is GARMIN GPS 195, and the flight waypoint or flight route file can be directly converted to the data format (*.RTE) recognized by GARMIN receiver.

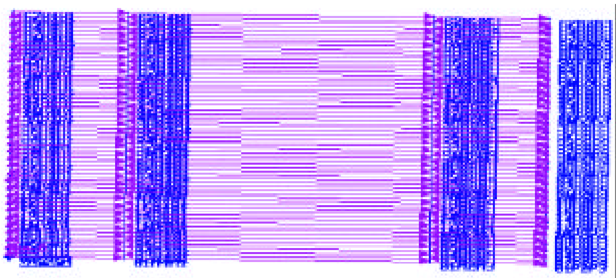
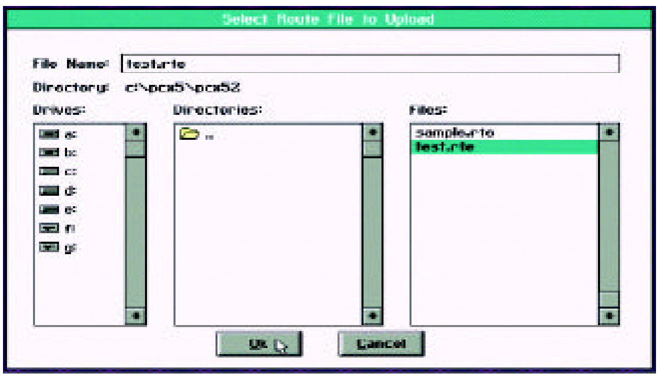


Fig. 3.1 Route, waypoints and preparatory waypoint



At the same time, we can upload the data (for example, flight track data) from the receiver for analysis.

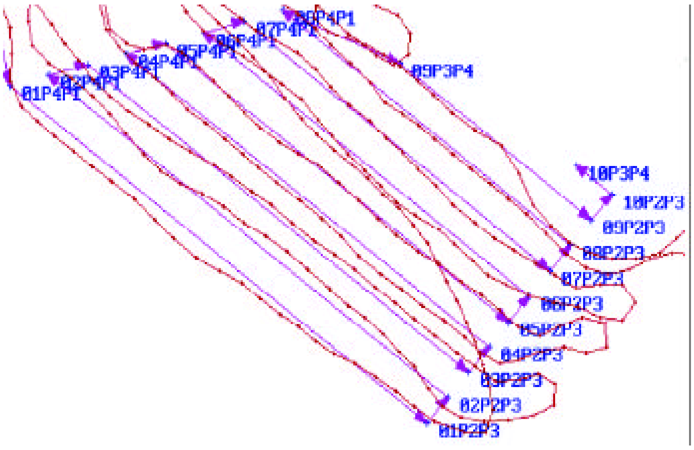


Fig. 3.2 Comparison of route and track

2. Differential GPS positioning

Since May 1st 2000, the United State has abrogated the SA policy, which promotes the precision of GPS real-time positioning from 100m to 15m or so, but for more precise positioning and navigation task (for example, air spraying), DGPS technology that is better must be adopted to improve the positioning precision to meter level or sub-meter level.

DGPS is a technology with base station at known point, amendatory value of observation were measured and conveyed to the mobile station through digital radio system. Mobile station observes the satellite pseudo-distance code that can be used for positioning calculation after differential amendment.

To well understand the GPS and the technology related with GPS and rapidly apply them in practice of the flight detection, preventing and controlling of forest diseases and insects, we used three suits of real-time dynamic differential GPS system whose basic components are displayed as follow:

Base station	NovAtel 3151R
Mobile station	Garmin 195 (Navigation), TRIMBLE AgGPS 132 (Positioning)
Digital radio station	TM32
Amplifier	RFA96£-35W
Antenna	full direction 15DB (used in base station)
	Knife antenna (used in mobile station onboard aeroplane)
	Scourge antenna (used inside forest)
GPS antenna	Mp surveying antenna (ST430 in base station, ST410 in mobile station)

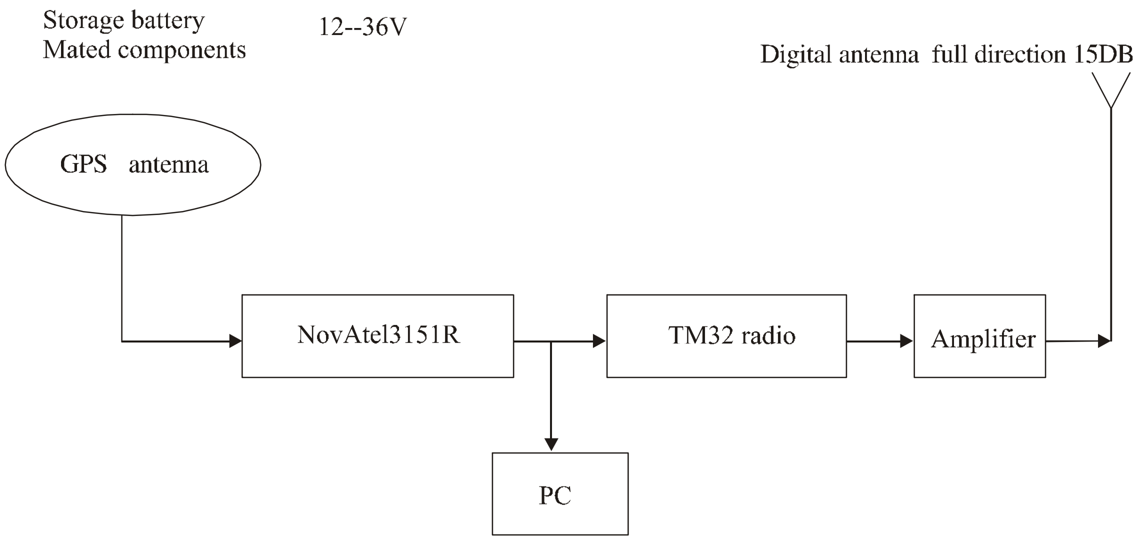


Fig. 3.3 The structure of the base station

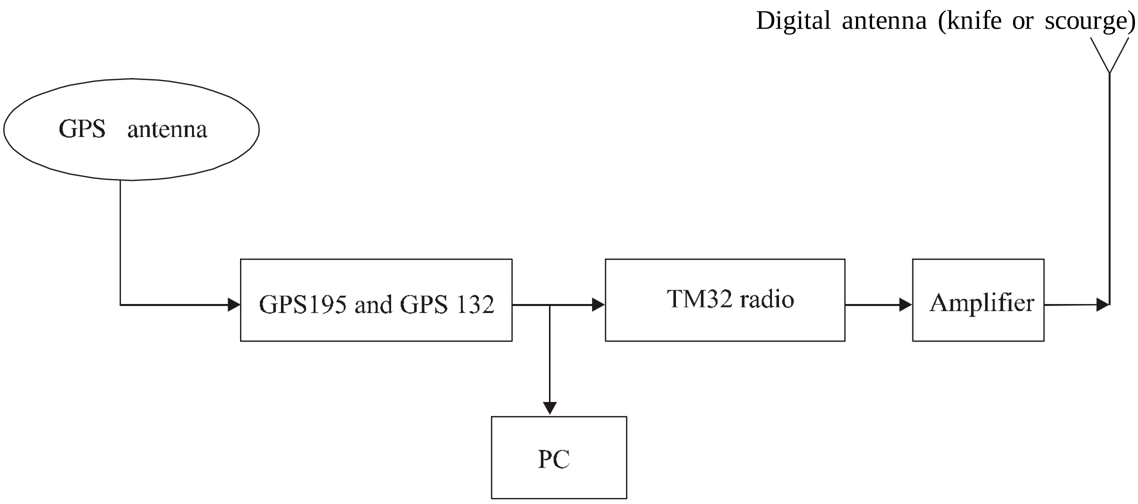


Fig. 3.4 The structure of the mobile station

GARMIN GPS 195 is a 12 channel navigation product, which obviously can satisfy our request of highly dynamic real-time navigation, and also mainly is used in navigation in practice. TRIMBLE AgGPS 132 receivers are combined with high-performance GPS reception with radiobeacon DGPS capability. Additionally, AgGPS 132 receiver contains The Choice™ technology, enabling OmniSTAR and Racal LandStar real-time differential capabilities. Users can get sub-meter positioning precision, so it is a good choice for high precision positioning.

For insuring the data quality and lowering error rate, high frequency communication equipment (frequency is 450-470Mhz) is adopted. Because its signal can be transmitted directly, it is especially suitable for air real-time navigation. The baud rate of data transmission is usually 9,600.

Fig. 3.5 DGPS and its application

3. Flight quality assessment

After the ground static, ground vehicle mobile, air flight mobile test of DGPS' software and hardware installed, we participated the practice of the flight monitoring, preventing and controlling of forest diseases and insects in many provinces in China, such as Anhui Province, Guangdong Province, Guangxi Zhuang Autonomous Region. Our tasks mainly lie in applying the DGPS technology in flight navigation to completely replace the traditional practice mode of manual navigation that costs so much manpower and material resources, and take flight evaluation to assure the quality of detection, prevention and controlling in terms of the recorded flight track data. Two figures beneath are two tracks in a practice of prevention and controlling, one is without GPS navigation(Fig.3.6) , the other is with GPS navigation. The flying quality greatly improves(Fig.3.7). Combined with GIS, we can get the precise position and range of regions that are omitted or repeated during spraying(Fig.3.8).

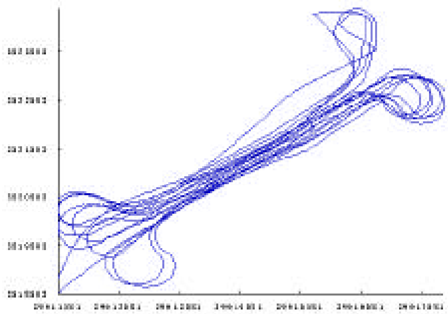


Fig. 3.6 Plane track in protection without GPS navigation

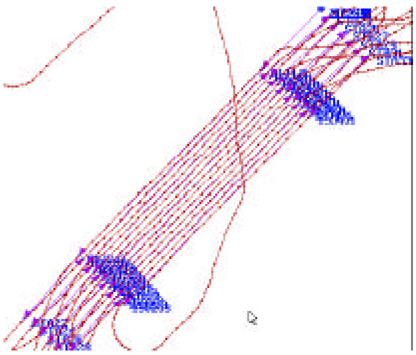


Fig. 3.7 Plane track in protection with GPS navigation (purple–designed flight line, red–flight track)

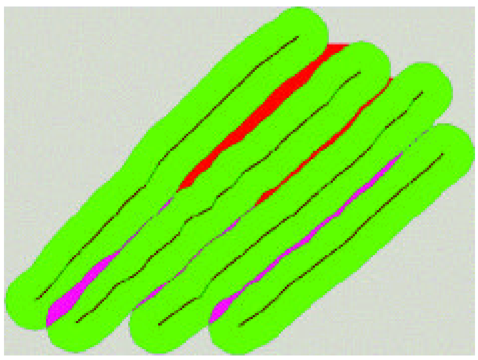


Fig. 3.8 Integration of GPS and GIS in flight assessment

4. Applications of DGPS in management of forest insects and diseases

Through whatever detection method, airborne or satellite remote sensing, we can get different scale hazard point or region. As for forest protection managers, sufficient information of disease and insects is important to choose correct prevention and controlling measure. How to rapidly and precisely determine the correct location where hazard happens and correctly analyze the cause is crucial to lowering loss of forest damage. GPS's function of navigation and positioning provides possibility and technological assurance for the rapid positioning of the calamity location.

4.1 Navigating in air prevention

To prevent forest insects and diseases by plane is a widely used technique and it is usually navigated by ground people or by the experience of the pilot. The backward navigating method has caused that some areas are not sprayed while some other areas are double sprayed. This has greatly impeded the efficiency of prevention. Since the 1990s, the technique of GPS has been widely used in various fields, and it provides a possibility to improve the navigating system of the aerial prevention system.

Since 1998, DGPS has been introduced into the aerial prevention system in China, the efficiency has been heightened and the cost has been reduced. The most important is that high spurting accuracy is achieved so that measures can be taken for the areas that are not spurted. With the application of intelligent spurting system, the aerial prevention techniques will be highly heightened.

4.2 Positioning and repositioning of damage point

In satellite remote sensing monitoring, DGPS should be utilized to accurately position the coordinates of control points so as to obtain the better rectification and registration of multi-temporal images. It can also be used to position the investigation point *in situ*. DGPS is also essential in airborne video monitoring. It is used to correct and join the images so that the damage point can be accurately positioned. Once the damage area has been detected by remote sensing, the navigating capacity of DGPS should be utilized to find the individual damaged trees so that measures can be taken accordingly.

Fig. 3.9 GPS application in hazard point recovery and investigation

State Administration of Forestry is now equipping GPS for all the monitoring stations in China. It can be sure that GPS technology will be widely used in the monitoring and prevention of forest insects and diseases.

5. Acknowledgments

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