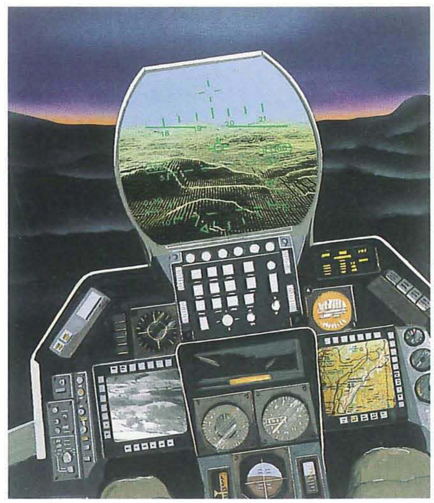
Total Terrain Avionics

GEC AVIONICS

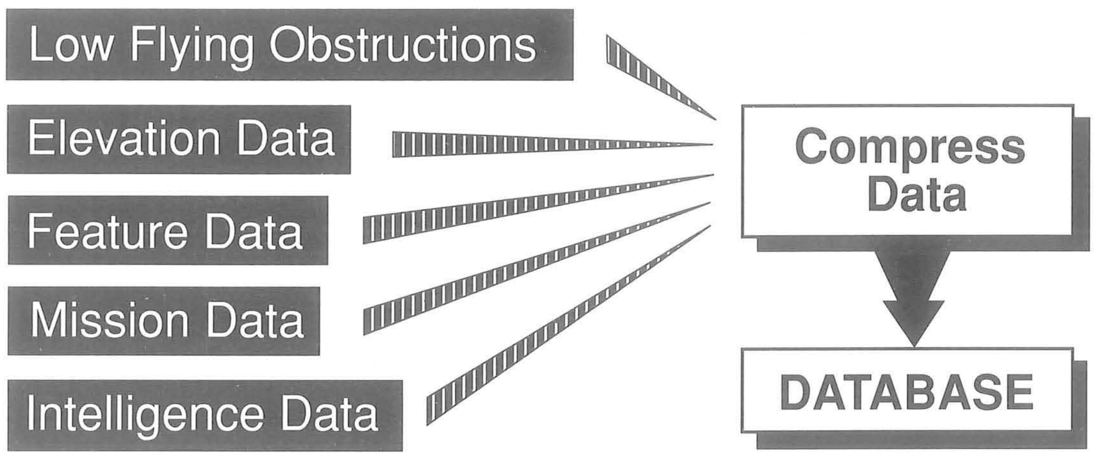
T^2A

..when surprise
means success..



T^2A ....total terrain avionics

The compression, storage and exploitation of wide areas of comprehensive digital terrain and feature data to optimise mission effectiveness and enable safe day and night covert low level flight operations in all weather conditions



Robust, Autonomous Terrain Referenced Navigation

Flight Profile Functions

Covert Terrain Following

Ground Collision Avoidance

Ground Proximity Warning

Obstacle Cueing

Terrain Overlay

Approach Overlay

Tactical Displays

Video Maps

Mission Overlays

Relative Heights

Threat Intervisibilities

Terrain Screening

Perspective Views

Weapon Aiming

Precise Target Cueing

Passive Target Ranging

Accurate Height Above Target

Successful First Pass Attack

Tactical Routeing

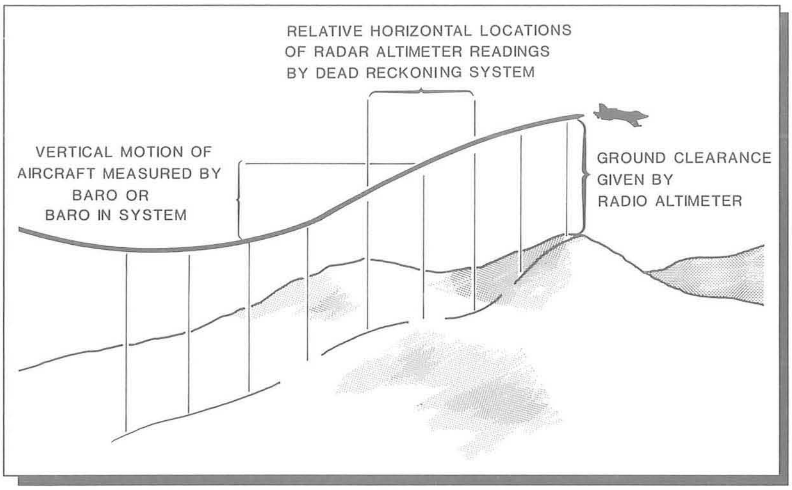
Terrain and Threat Avoidance

Cost Evaluated Re-routeing

Minimum Defence Exposure

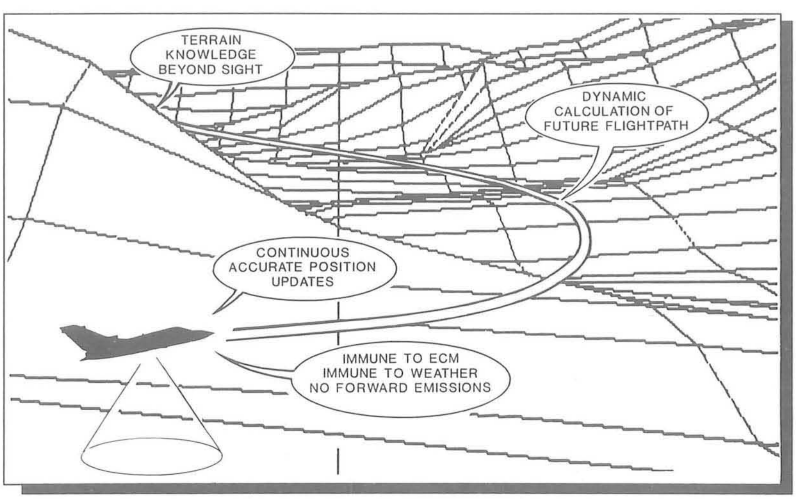
T²A Principles

Terrain Referenced Navigation



The heart of T²A lies in its automatic and highly accurate Terrain Referenced Navigation (TRN)

- Baro altitudes minus radar altimeter readings are horizontally scaled by the DR navigation system to give ground profile measurements.
- Measured ground profiles are matched with terrain elevation data to derive continuous, accurate three dimensional position updates.
- TRN models DR navigation system drift rates to minimise position error growth in flight over water or flat terrain .
- In flat terrain, overflight of only single isolated features immediately and substantially increases TRN accuracy.
- Even after prolonged flight over water, TRN rapidly converges to accurate fix generation without pilot intervention.
- TRN confidence factor is continually displayed to pilot, giving reassurance of automatic navigation quality.



Situational Awareness

- Combination of accurate TRN position with terrain database gives complete three dimensional situational awareness of the surrounding terrain and its mapped obstacles.
- Emphasis during a mission can therefore be placed on surviveability rather than navigation.

Total Terrain Avionics

Total Terrain Avionics enhances mission effectiveness by providing safe low level covert operation by day and by night in all weather conditions whilst :

- Reducing pilot workload
- Increasing situational awareness
- Maintaining ground clearance, even in aggressively manoeuvring flight
- Reducing detectability
- Providing updated minimum risk penetration routeing
- Enabling autonomous approach to destinations or targets with pinpoint accuracy

Applications

Total Terrain Avionics has a wide range of applications, covering :

- Attack, close air support and fighter escort aircraft
- Fighter defence aircraft
- Support and attack helicopters
- Special operations forces
- Transport aircraft
- Stand off missiles

Features

Total Terrain Avionics achieves its purpose by:

- Compressing a wide area coverage of terrain elevation and feature data into an on-board store
- Decompressing and using this data in flight to provide a range of mission enhancing real time capabilities
- Customizing the required capabilities into individual digital terrain systems for particular applications

Capabilities

T^2A multiple covert capabilities can conveniently be grouped as follows:

- Robust, autonomous high accuracy terrain referenced navigation
- Flight profile functions at six levels, ranging from fully automatic covert terrain following to pilot interpreted terrain situation head up display
- Tactical head down displays at three levels, extending from digital video moving maps, through enhanced intervisibility displays to perspective views
- Accurate target cueing and weapon aiming solutions for successful first pass attacks
- Tactical routeing providing updated minimum cost terrain and threat avoidance routeing
- Laser radar timely detection of unmapped obstructions to enhance obstacle avoidance

Status

GEC Avionics has been developing T^2A capabilities since 1977. In the period 1983-1986 GEC Avionics and the Royal Aerospace Establishment flight demonstrated the viability of terrain referenced navigation, terrain following and digital map generation ând display using both fixed wing and helicopter platforms.
Since 1986 GEC Avionics digital terrain systems have successfully flown on the US NAVAIR A-6 Real Night Program, the USAF AFTI/F-16 Program and the UK Tornado Upgrade selection trials.
As a result, GEC Avionics digital video map generators are in production for the British Army Phoenix RPV ground station and the Harrier GR Mk7 night attack aircraft. In addition the GEC Avionics SPARTAN TRN/TF system has been selected for the UK Tornado Upgrade Programme.
GEC Avionics digital maps are currently flying in helicopter applications and a range of T^2A digital terrain systems is under consideration for several more new and upgrade aircraft and helicopter programmes.

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SPARTAN Terrain Referenced Navigation and Terrain Following System

Safe Low Level Operations
SPARTAN is a highly accurate, flight proven autonomous terrain referenced navigation and covert terrain following system which enables safe low level operations by day and by night in all weather conditions, leading to successful first pass attacks.

Enhanced Mission Effectiveness
SPARTAN is highly resistant to ECM, immune to weather, requires no forward emissions and minimises the approach warning available to ground and air defences. Its operation is automatic, reducing cockpit workload and freeing crews to concentrate on formation protection and overall mission objectives.

Operational Area Coverage
SPARTAN holds up to 600,000 square kilometres coverage of digital terrain data, compressed into an onboard, rugged semiconductor store which can be rapidly reprogrammed at first or second line.

Autonomous, Accurate Navigation
The elevation profile of overflown terrain is measured by a series of radar altimeter readings. This profile is compared with the stored terrain data to provide accurate fixes every two seconds.
The navigation correlation algorithm is robust requiring no position priming and having a high tolerance to any database errors.
This navigation accuracy ensures precise waypoint steering and fixpoint cueing to aid en-route mission monitoring.

Covert, Passive Terrain Following
From the accurate navigation position, SPARTAN looks ahead in the terrain database in wings level or turning flight to calculate the vertical flight path required to maintain necessary ground and obstacle clearances at the selected manoeuvre limits. This path is followed either manually, using the flight director, or automatically, via the aircraft autopilot.

High Integrity
Comprehensive internal monitoring is carried out to ensure that a high level of integrity is maintained at all times. This includes a number of TF system monitors that provide effective and automatic ground proximity warning and avoidance.

Obstacle Cueing
Mapped obstacles computed to be within sight are cued in the correct position on the HUD. Obstacle cueing is prioritized on the basis of their height and range to avoid display clutter.

Successful First Pass Attack
First pass attack success is ensured by the provision of precise target steering and cueing, together with the output of target parameters to weapon aiming calculations.

Maturity of Design
Under development for a decade, SPARTAN has been extensively flight demonstrated on a variety of low level attack aircraft, including Tornado, A-6E Intruder and AFTI/F-16.

SPARTAN has been selected by the UK Ministry of Defence for the Royal Air Force Tornado upgrade programme.

Outline Specification
Size : .... $^3/_4$ ATR short LRU
Weight : .... 15 Kg
Interface : Mil-Std-1553B
MTBF : .... 3000 hours
Environmental : Mil-Std-810
Mil-Std-461/462
Power : 200W
Coverage : .... 600,000 sq km
Full Database
Reprogramming : ....13 mins
(via 1553B)

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Tactical Routeing

Mission Planning

The overall mission planning function, normally carried out on the ground, is performed using the best available intelligence data and falls into two levels:-

- Level 1: The nomination of navigation waypoints, initial points and objectives or targets.
- Level 2: The establishment of detailed tactical routeing between those points.

Some air vehicle roles and missions deny the completion of mission planning before take off. Defensive reaction or the updating of mission objectives and intelligence can produce changed circumstances in flight. The need for airborne planning and replanning is then forced upon aircrew, imposing requirements for speed and accuracy in achieving an optimum solution at a time when they can ill afford distraction from the en-route tasks in hand.

Tactical Routeing

GEC Avionics Tactical Routeing Algorithm (TARA) provides automated support to aircrews in airborne route planning and replanning, reducing cockpit workload. Aircrews are freed to concentrate on immediate mission and formation needs. Overall mission surviveability is also enhanced by the rapid derivation of minimum cost routeing.

TARA

On initiation of TARA airborne route planning, aircrew are invited to define the end objective, any desired intermediate waypoints and any updated prohibited transit areas. All further activity is fully automated from this point. TARA then accesses its terrain and updated intelligence database in support of its derivation of the optimum route. The following parameters are addressed, being prioritized on the basis of their local importance.

- Threat avoidance
- Threat intervisibilities
- Terrain following
- Fuel costs
- Time costs
- Terrain avoidance
- Obstructions
- Aircraft performance
- Prohibited transit areas
- Intervening waypoints

Starting from the current position, heading and speed, a best first search technique is employed to discover the optimum route, with continuous fine tuning of the search parameters to meet the changing requirements of local scenarios. The waypoint to waypoint routeing is displayed to aircrew on the video map and steering information to maintain the route is provided by flight director symbology.

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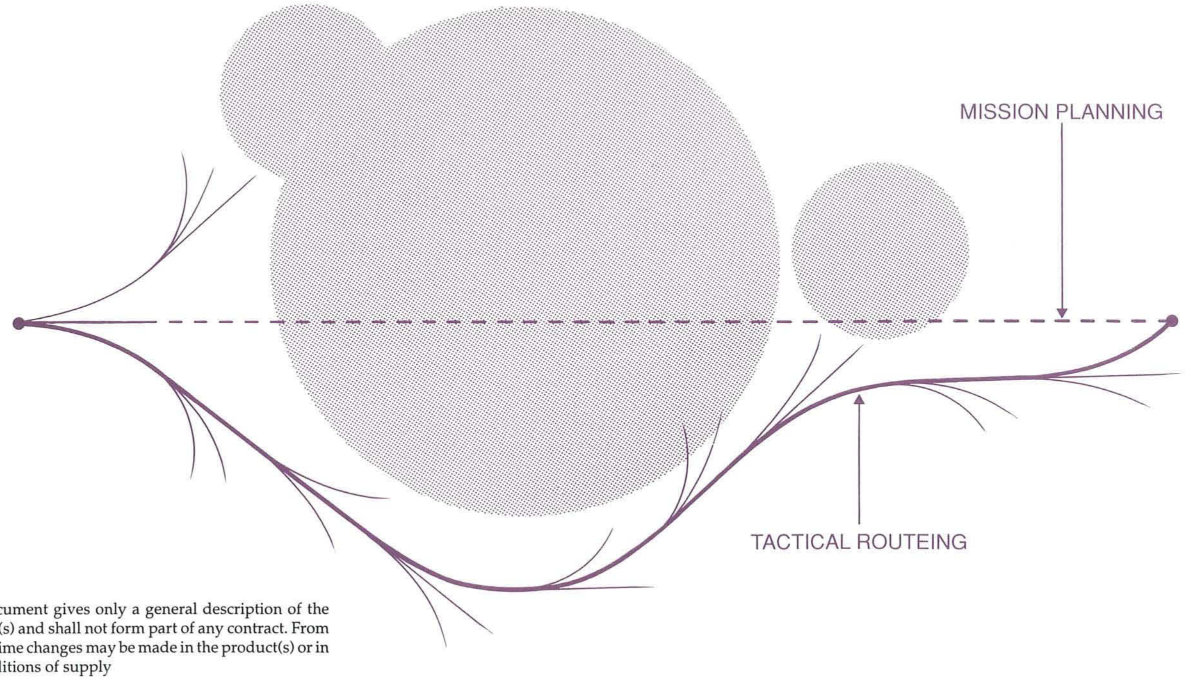
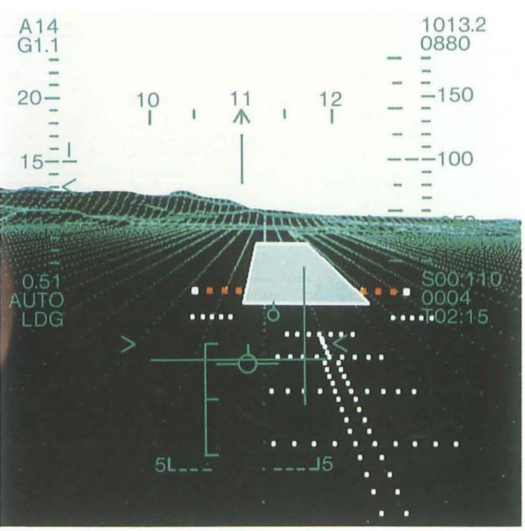


T^2A Flight Profile Functions



Flight Profile Requirements

The basic low level flight profile requirement of all air vehicles is to adjust their flight paths to suit the surrounding terrain and obstacles. Detailed requirements vary between air vehicle types, and even within the operation of any single type, as immediate objectives change between transit, patrol, reconnaissance overflight, attack or approach and landing.

Situational Awareness

T^2A uses wide area coverages of comprehensive terrain elevation and feature data to derive continuous accurate position updates, using the robust and flight proven SPARTAN Terrain Referenced Navigation algorithm. The combination of this accurate navigation information with the terrain database gives continuous provision of complete three dimensional situational awareness with reference to the surrounding terrain and its mapped obstacles.

Flight Profile Functions

The situational awareness generated by T^2A is used to support a wide variety of requirements, by offering a range of six covert flight profile functions. Depending on the application, these functions may be used as stand alone features or may be combined into more comprehensive systems.

Terrain Situational Overlays

Pilot's Low Altitude Terrain Overlay

- PLATO terrain grid display, oriented along and across the line of flight, provides terrain situational awareness.
- Horizon and intermediate ridges are identified as solid lines across the line of flight.
- Basic Mode displays only grid corners to complement sensor displays without obscuring detail.
- Stand Alone Mode displays full grid.
- Terrain cues
  - Groundspeed by streaming of grid towards vehicle.
  - Distance by convergence of grid.
  - Height by relative size of grid.

Obstacle Cueing

Terrain screening calculations are performed on mapped obstacles and their unscreened vertical extent determined. Obstacles are then cued in their correct positions on the Head Up or Helmet Mounted Display.

Approach Displays

The addition of runway positional information into the terrain database permits the dynamic generation and display of perspective overlay views to aid landing approach. Line-up and elevation cues are provided in a familiar and readily interpreted form by the insertion of runway approach lighting symbology.

Ground Proximity Warning

Kinematic Horizon

- Examines digital database to identify terrain and obstructions ahead.
- Calculates and links the lowest acceptable flight vectors in the arc ahead and displays them in the form of a Kinematic Horizon which undulates as high terrain and obstacles appear and pass by.

Ground Collision Avoidance

Ground and Obstacle Collision Avoidance Technique (GOCAT)

- Utilises a digital terrain database to derive timely and accurate warnings of ground and obstacle collisions.
- Continually tests that current flight path can be made safe by the execution of a vertical manoeuvre involving acceleration at a nominated critical level.
- Operates in hilly terrain and in turning flight without unnecessary constraints on the pilot's freedom of action.
- Tunable to suit both gently and aggressively manoeuvring air vehicles.
- Functions over the full range of air vehicle operation.

GOCAT maximises surviveability without impeding mission success.

SPARTAN TRN/TF

Combines TRN with covert automatic or manual Terrain Following (see separate brochure).

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Weapon Aiming

Requirement
Accurate delivery of free fall weapons requires height above target to determine weapon forward throw and range to target to prompt weapon release. Target cueing also assists the pilot in the difficult acquisition task.

HATRAC
GEC Avionics 'Height Above Target and Range Calculation' (HATRAC) is a further operational function derived from T^2A to provide improved weapon aiming. HATRAC continuously establishes accurate target heights, ranges and sightlines, even in manoeuvring flight, thus enhancing surviveability and enabling successful attacks on the first pass.

Planned Attacks
Planned attacks require targets to be nominated to HATRAC by insertion on the ground or in flight.

• Target Cueing:
Successful attack completion requires acquisition of the target in time to make tracking corrections. Late acquisition can often lead to a missed attack. The highly accurate navigation position provided by Terrain Referenced Navigation (TRN) is compared with the target position, as defined within the terrain database, to determine the precise sightline to the target. This information is used to drive cueing symbology on the HUD or Helmet Mounted Sight, in both azimuth and elevation, thus leading to timely target acquisition.

• Weapon Aiming Triangle:
The establishment of current height above target, target plan range and target sightline is achieved by continuous comparison of TRN and defined target positions and heights, to derive the dynamically varying weapon aiming triangle.

Unplanned Attacks
Continuously Computed Impact Point (CCIP) mode is widely used for unplanned attacks against opportunity targets that are not held in the system. The bomb fall line is displayed on the HUD with a short cross bar indicating the ground impact point for an immediately released weapon. The aircraft is flown so that the target tracks along the aiming line until overlaid by the CCIP, at which point the pilot releases the weapons.
The use of radar altimeter height to calculate forward throw over sloping terrain gives false positioning of the CCIP, leading to early release (weapon undershoot) on downward slopes and late release (weapon overshoot) on upward slopes. Active ranging sensors can be used to reduce the error. HATRAC, however, is able to examine the relative terrain height under the bomb fall line to determine the true CCIP and maintain its correct display for accurate unplanned attacks.

Enhanced Mission Effectiveness
HATRAC precise target cueing and continuous derivation of target ranges and angles is independent of aircraft manoeuvres. Crews are therefore able to undertake evasive manoeuvres during attacks with confidence of a successful release and target hit on the first pass. This combination of increased attack surviveability and successful first pass attack greatly enhances mission effectiveness.

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UNPLANNED ATTACK