

## COMANCHE TACTICS EXPERT FUNCTION

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### Abstract

On today's battlefield, survivability depends upon planning and reaction time. With the multitude of tasks required of the pilot during combat, the workload is unmanageable without assistance. The Comanche possessed the capability to automate many of the combat tasks required for success. This tactics expert function would assist the crew in making time critical decisions on how best to employ the aircraft while maximizing its survivability against a host of potential threat systems. Specific components of the tactics expert function and their implementation are discussed.

### Tactics Expert Function

The Tactics Expert Function (TEF) is designed to provide crew situational awareness, reduce pilot workload and decrease response time for selected tactical tasks. TEF provides these capabilities in a flexible format and consists of the following modules:

- a. Route Planner
- b. Sensor Control
- c. Observation Point / Battle Position (OP/BP) Planner
- d. Priority Fire Zone (PFZ) Planner
- e. Threat Response
- f. Automatic Attack Planner
- g. Intervisibility Display

### Route Planner:

Both the onboard Operational Flight Program and the ground based Aviation Mission Planning System have the capability of route planning. The Route Planner is designed to automatically optimize the path between waypoints to maximize the survivability of the aircraft while following constraints set forth in the flight plan. Terrain is subdivided by a 150 m grid, and

each cell is weighted based on cultural features, graphic overlay, terrain features, the probability and cost of detection, and threat lethality. When the cost of each square in the grid has been computed, a flyable path is determined which satisfies flight plan specifications and minimizes total costs.

Cultural and tactical feature costs are calculated by applying a weight factor to each grid cell at the position of the features. Cultural features, such as residential areas, churches, and schools, are determined from vector product map data, and grid weights are applied according to a weighting factors table. Tactical features such as troop positions and No Fire Zones are included within the Graphics Overlay, which is editable from either the Operational Flight Program or the Aviation Missile Planning System.

Terrain costs are derived from Rectified Digitized Terrain Elevation Data (DTED) and weighted based on the suitability of an area for concealment and observation. The Masked Terrain Exposure Factor measures the ability to hide in an area and is based on the percentage of cells within 5 kilometers to which that area is visible. The Unmasked Terrain Exposure Factor indicates how well the aircraft can observe its surroundings from that position. The overall Terrain Exposure Factor is based on the optimization of the masked and unmasked factors.

The route planner also considers the threat sensor detection and weapon lethality costs. The sensor detection cost is determined by first finding the threat's area of visibility using Rectified-DTED data over the distance of its sensor detection range as attenuated by a constant level of aircraft signature. The weight of this cost factor varies with the type of mission; sensor detection cost factors are higher for covert types than overt. The threat weapon lethality cost is determined by applying a threat weapon lethality factor. This factor is applied to the area visible to a weapon within its lethal range and indicates the

possible severity of damage to the aircraft. For single threats or threats whose envelopes do not overlap, the route planner ensures that the three-dimensional path remains outside the engagement range or reaction time of all known threats; for multiple threats whose envelopes overlap, the route is calculated to maximize aircraft survivability.

The flight plan, altitude, and airspeed of the flight determine how the above factors are weighted. The flight plan sets forth the constraints under which the path must be generated. The plan is assumed to contain the mission objective and may include several restrictions, including the location of the waypoints, fixed estimated times of arrival and departure, available fuel, the maximum number of interim points between waypoints, and the total number of interim points in the flight plan. The type of flight can be selected as Nap of Earth, Contour Flight, or Low Level, each of which correlates to an airspeed and altitude above ground level assumed in planning. A fourth option sets no restrictions on speed or altitude. The flight type is used to calculate flight plan performance and determine weighting factors used in the route planner.

A future enhancement for the Comanche was a signature auto router. This feature expanded the routing functionality by including the unique signature of the aircraft. Detectability would be reduced and survivability enhanced by orienting the aircraft fuselage relative to the threat for optimal signature performance. The orientation information is provided to the pilot via cockpit symbology and integrated into the flight controls coupler for automated maneuvering.

#### Observation Point/Battle Position Planner:

The Tactics Expert Function also includes a planner to determine the best observation point and battle position. The recommendations are made based on DTED data, the grid weights used by the route planner, and several other components affecting the suitability of a location as an observation or attack by fire position.

The presence of backdrop is the first of these components. A line of sight is

calculated from the EA/NAI to the potential OP/BP. If there is terrain above the projected ray, the cell is considered to have a backdrop.

Another consideration is the range to the target. The range from each potential cell to the enemy is computed. Those cells whose ranges fall in the latter third of the sensors' and weapons' ranges are preferred for observation points and battle positions, respectively.

Cells whose altitudes are level with or higher than the target are also desirable. This attribute enhances the aircraft's view of the target.

The position of the sun or moon is also considered in the choice of observation points and battle positions. The sun or moon should be to the side of or behind the aircraft. In particular, the Tactics Expert Function is designed to choose points such that the sun will not obstruct the view of the target, and the moon will not highlight the aircraft from the perspective of the enemy.

The terrain should also provide cover and concealment so the aircraft can remain masked from threats. The existence of a direct line of sight to known threats is considered, as is the terrain exposure factor of the cell, which represents the possibility of unknown threats. Similar to the route planning algorithm, a cell is considered desirable if it provides concealment while offering the aircraft a view of the surrounding terrain.

The area surrounding a cell is maximized such that nearby cells are also suitable OP/BPs and multiple aircraft have sufficient room to disperse. However, battle positions are chosen to be separated by at least 600 meters.

The route cost to travel from the aircraft's current position to a proposed OP/BP is calculated using the Route Planner. Positions that can be reached with lower route costs are preferred.

Finally, the OP/BP should be located so that it provides mutually supported fields of view, designation, and fire throughout the engagement area. The line of sights from the cell to the boundary points (vertical and horizontal) and the center of the EA/NAI are used to determine the percentage of the area that can be seen from the cell. Also, those cells that can

support the direction of fire and avoid exclusion zones/criteria are preferred.

The planner acts upon a point selected in the tactical situation display. An annular area is centered on the point, and the space between the predefined inner and outer radii is searched for optimal OP/BPs. The Tactical Expert Function returns choices of the best calculated OP/BPs and can display them on the map, flight display, or Helmet Mounted Display.

#### Priority Fire Zone Planner:

The priority fire zone planner is capable of dividing a priority fire zone into several subzones. The priority fire zone is created when the crew selects an area or feature. The zone can then be divided into several subzones, where the number of subzones created is based upon crew preference. The crew can alter the number of subzones after they are drawn by incrementing or decrementing the previous number. Subzones are created with the primary consideration of keeping an equal number of targets in each zone; the secondary consideration is to create subzones of equal area. The subzones are oriented such that they are divided by lines parallel to the direction of fire.

#### Threat Response:

The Tactics Expert Function Threat Response component provides the Comanche crew with tactically informed recommendations on how to respond to newly encountered threats. As the new threats are detected, they are evaluated, and a determination of response necessity is made. If the threat is determined to be sufficiently severe, a recommendation is provided to the crew on how to respond to it. The Tactics Expert Function facilitates and expedites the pilot's own response, whether or not the pilot chooses to follow the recommendation.

The Threat Response component continually monitors the Tactical Threat Manager for changes. Particularly, a threat response evaluation is initiated if a new threat is added to the database, or if a current threat's state changes (i.e., from not emitting to emitting). Once a new threat is detected, a preliminary evaluation is

conducted to determine the severity. A Threat Response Threshold file is used to determine threat response necessity. Based on what is known about the target, primarily in terms of range and lethality, response thresholds are defined that determined whether a reaction is necessary.

If the initial evaluation indicates that the situation demands action, the threat becomes a "cued threat", and the Tactics Expert Function conducts a more comprehensive assessment of the situation to determine the course of action that it will recommend to the crew.

#### Determining Response Recommendation:

The Tactics Expert Function considers several factors in determining the most appropriate response to recommend. It considers the status of the aircraft and its ability to perform necessary actions, the mission status and objectives, and whether the mission is covert or overt. Surroundings considerations include whether the environment is day or night as well as local terrain information from DTED. Tactical factors include the location of friendly priority fire and no fire zones and the tactical points of interest from the Graphics Overlay database.

The Tactics Expert Function also uses information from the Threat Planning Database to determine the response recommendation. This information includes information from the Tactical Threat Manager database, a Threat Response Threshold file which contains the response thresholds defined by what is known about a target's range and lethality, and the target validity confidence. Recognized targets have the highest confidence, followed by targets detected via the Aviation Survivability Equipment and targets handed off to the Comanche. Automatic Target Detection/Classification detected targets have a slightly lower confidence rating.

The Threat Response function also considers the effectiveness of the Comanche's onboard countermeasures, which consist primarily of its Low Observable (LO) capabilities: radar, infrared, visual, and aural signatures. The threat recommendation also considers the target's primary and alternate acquisition modes (e.g., radar, infrared, etc), the time to impact

of the threat's weapons, and the time to impact of the Comanche's weapon in flight.

The final consideration for response recommendation is the status of available weapons. The Tactics Expert Function determines whether the Comanche is capable of neutralizing a target with its available weapons stores. If the stores are insufficient, an attack is not recommended. Consideration is made for the possibility of target handoff and indirect fire. Finally, the ordinance expenditure impact on mission objectives is taken into account.

The computational time constraint to determine the response recommendation is selected such that the Comanche threat response is sufficiently faster than the threat's reaction time. The threat response is composed of the time taken to compute the recommendation plus the time for the pilot to understand the recommendation and take action to address the situation. The threat's reaction time varies according to the type of threat.

Providing Response Recommendation: The Tactics Expert Function always recommends a response to a cued hostile or unknown threat. Possible responses are to Avoid, Mask, or Attack, and this recommendation is provided to the pilot within 2 seconds of determining that a reaction is necessary. While the Tactics Expert Function prepares the pilot to effectively execute any of the three options, it does not preclude the pilot from acting counter to the recommendation.

The response recommendation of Avoid is selected when the Comanche is not in imminent danger. Threat Avoidance automatically cues the Route Planner Function to reevaluate the situation using grid weights with updated information including the newly detected threat. If the Tactical Expert Function determines that the present route will avoid threat detection without interruption of the mission, the recommendation is made to continue on route. Furthermore, if increasing speed or changing altitude is determined to significantly decrease the probability of detection, that action is also recommended.

The recommendation to change course can be made when the aircraft is not in imminent danger. This recommendation is made when the Tactical Expert Function

determines that detection by the threat will occur if the Comanche remains on course, but that detection could be avoided if the course is altered. In this scenario, the Automatic Route Planner is cued, and a new route around the threat or threats is generated which minimizes the likelihood of detection and maximizes aircraft survivability. In these cases where a new course is plotted, the altered route will be displayed to the pilot within 2 seconds.

The Mask option is recommended in times when the aircraft is in imminent danger. The criteria are that detection is imminent, or detection has already occurred, but contact can be broken and engagement avoided through the use of terrain. A masking area is calculated as a position which will break the lines of sight to the cued threat and other threats in the area. The masking area is displayed on the Tactical Situational Display as an amorphous geo-referenced tint. The Route Planner is simultaneously cued, and a route is calculated to the masking area. The time required to reach the masking position and achieve masking from threats is calculated and displayed to the pilot. This estimation is based on the planned route to the position and approximated aircraft maneuvering times.

When the Tactical Expert Function determines that the avoidance, evasion, and masking of a cued threat are either inappropriate or impossible and the threat is sufficiently lethal to the Comanche, the Tactics Expert Function recommends Attack. Cues are provided to the pilot for maneuvers and weapons selection. An Attack recommendation immediately cues the Automatic Attack mode, if it is selected on. Otherwise, the pilot will engage the target using standard means.

#### Automatic Attack:

The Automatic Attack mode provides an automated target engagement process which significantly reduces the Comanche's response timeline. When the Automatic Attack mode is selected on and is cued by an Attack recommendation from the Tactics Expert Function, a process immediately begins to prepare for engagement of the target.

The process starts with the Target Unique Identification number (TUI) of the target being passed to the Target Acquisition System for tracking. If the target is a secondary tracked target, or if it is not being tracked at all, it becomes the primary tracked target. Next, weapons options are evaluated with respect to their abilities to neutralize the threat. The weapons which are currently available are compared against threat neutralization requirements. If stores are insufficient to neutralize the threat, the Tactical Expert Function will recommend that the Comanche fly to a masking position and handoff the target. If the available weapons are considered sufficient to neutralize the threat, the most appropriate available weapon is chosen from the stores.

Once the weapon is selected, it is automatically armed. The pilot is cued when the weapon is ready to fire, and the only action he is required to take is to pull the trigger. When the weapon is launched, the splash timer starts, and if necessary, the laser is fired for target designation. Throughout the entire process, Threat Response continually monitors the Tactical Threat Manager for additional threats.

If an additional threat is detected while the Comanche is attacking another target, the Tactics Expert Function assesses the time to impact of the threat's weapon and the time of impact of the Comanche's weapon in flight. Based on the relative severity of each target, the first attack may be interrupted to prosecute the higher priority threat.

#### Sensor Control:

Target Acquisition System control is accomplished when the Automatic Attack mode is triggered by the Threat Response feature. This function automates the pointing of the sensors to the target of interest, thereby, reducing response time and pilot workload.

#### Intervisibility Display:

The Tactics Expert Function provides a set of line of sight tools to increase the pilot's situational awareness. The area line of sight calculations can be performed from the ownship, from threats, or from pilot-selected points on the map. The

line of sight computations can be limited to the range of the Comanche's or the threat's sensors, the range of the threat's weapons, or the horizon. Altitude choices are also given. The "From Altitude" can be selected as the ownship altitude, the altitude of a threat, raised 9 feet to compensate for sensor height, or the ground elevation of a pilot-selected point. "To Altitude" choices are ground level or ownship.

The area where a clear line of sight exists is displayed with a tint on the Tactical Situational Display. The area intervisibility is stored in a grid file as the minimum Mean Sea Level altitude necessary at a certain grid cell to achieve a clear line of sight. The grid file is recalculated when the selected point changed position or if a selected threat's sensor capabilities were updated. An update also is initiated if the "To Altitude" varied.

The area line of sight tints include threat zones, ownship intervisibility, and selected point intervisibility. The threat zones are displayed in two layers; one layer indicates the area in which the threat can detect the Comanche, and the other indicates the area in which the threat is lethal. The ownship and selected point displays each depicts their respective areas of intervisibility.

The Tactical Situational Display additionally offers Height Above Threshold and Scan options. The Comanche has two versions of the Height Above Threshold feature. The first is a conventional version with three layers that depict a Hazardous area, a Risk area, and a "No Data" area. The safe area is not tinted. The second version is derived from Radar Scan data gathered when the radar is in the Terrain Profile Mode. It also has three layers: a Hazardous area, a Risk area, and an "Unknown" area for sections in the radar shadow. The radar scan data is updated at a periodic rate.

#### Conclusion

The Comanche Tactics Expert Function assists the pilot by reducing workload and response time for many tasks. These tasks include planners for routes, observation point / battle positions, priority fire zones, and automatic attack. Also

included are capabilities for threat response, sensor control, and an intervisibility display. This integrated feature provided the pilot

synergy from onboard components and data from the digital battlefield.