TACTICAL MAPPING IN COMBAT AIRCRAFT

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ABSTRACT

During the last decade Geographical Information Systems (GIS) have been increasingly used in computer aided planning and mapping. An application of GIS in combat aircraft is tactical mapping. Tactical mapping enables the pilot to recognize spontaneous complex-air-to ground relations such as danger zones and dead space. Tactical information (e.g. flight path, danger zones) is combined with selected geographical information (e.g. rivers, contours) and displayed on a monitor. This geographical information and some tactical data (e.g. danger zones) are derived from a GIS. The main aspect of a tactical map is to permit the pilot good visual interpretation of the displayed information.

INTRODUCTION

Improved mission effectiveness for combat aircraft requires both pilot-friendly generation of the target area scenario and an easy-to-recognize representation of the threat assessment.
Modern methods of computer aided mapping provide new ways of developing tactical representation given to the pilot. A precondition for this is a computer relevant data-base holding geographical information.
In the following the evaluation of "Tactical Maps" is described. They are to be regarded as possible "display formats" in cockpits of the future.
The graphic hardware used is Bosch's CAD Station PIC 1000. The host computer is a DEC VAX 750.

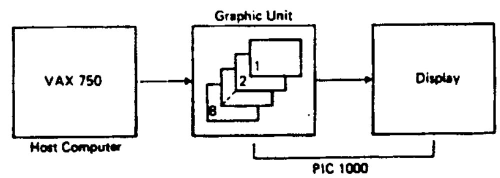

Figure 1: Hardware configuration used for developing "Tactical Maps"

GIS DEVELOPMENT

The first step is development of a GIS using the DLMS-DTED and the PACE data-base. The chosen test area is the landscape of the Black Forest (Longitude = 8-10 degree, Latitude = 48-49 degree). The raw data are provided by the "Digital Landmass System Terrain Elevation Data-Base" (DLMS-L1-DTED) of the Defense Mapping Agency (USA) and the "Project of Automated Charts Europe" (PACE) data-base of the Directorate of Military Survey (UK). The DLMS-L1-DTED data contain the heights above a specified level (NN) in a 3 x 3 seconds arc raster (3 x 6 for latidudes greater than 50 degrees). The coordinate frame is the World Geodetic System 1972 (WGS 72). The PACE data contain all the cartographic objects (features) needed for automated plotting of the "Tactical Pilotage Chart" (TPC) and the "Operational Navigation Chart" (ONC). The features are split into more than 200 categories. The coordinates are $\bar{x},\bar{y}$, digitized from the sheets of the "Joint Operation Graphics" (JOG).
For the GIS the coordinate frame of the European Datum 1950 (ED 50) is chosen. The coordinates are UTM. Thus the following transformations are necessary:

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- PACE

$x(UTM)=a01+a11*\bar{x}+a21*\bar{y}+a31*\bar{x}*\bar{y}$
$y(UTM)=a02+a12*\bar{x}+a22*\bar{y}+a32*\bar{x}*\bar{y}$

The coefficients are evaluated by four points known in $\bar{x},\bar{y}$ digitised and x,y UTM. They are implicitly given in the data-base for each sheet.

- DLMS-DTED

$L,B,H(ED\ 50)=f(d_i,p_i,m,L,B,H(WGS\ 72))$

The vector of rotation d_i, the vector of translation p_i and the scale-factor m are the parameters needed for the coordinate frame transformation WGS 72 to ED 50 for the chosen area.

$x,y(UTM),H=f(L,B),H$

Hence an isometric height raster in the UTM System is evaluated by linear interpolation. For this the four heights in the neighbourhood of the desired raster point are taken into account.

$H_{nm}= f(x_i,y_i,H_i) \quad i=1,2,3,4$

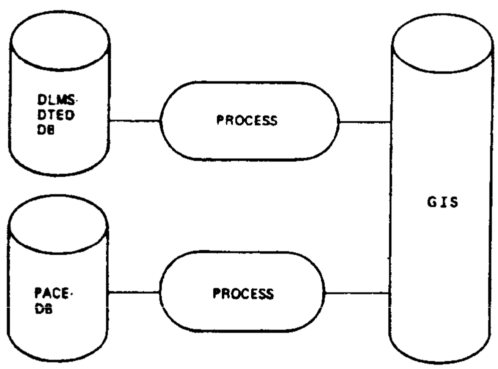

Figure 2: Development of a GIS

GEOGRAPHICAL AND TACTICAL INFORMATION

Using the GIS geographical and tactical information is derived and presented on the monitor. The scale chosen is 1 : 250,000. On the monitor this means one Pixel is equal to 127 meters. The tactical information derived from the GIS is sensor-covering:

- optical visibility (sensor = eye of the pilot)
- electrical visibility (sensor = radar, e.g. threat from a SAM-site)

Tactical information that is not derived from the GIS (e.g. home base), is stored seperately in a tactical data-base.

For the calculation of the sensor-coverings the earth's curvature is taken into account by the following approximation formula:

$\Delta H=s^2/(2*R)$

The derived partial geographical information comprises:

- elevation tints
- relief maps illuminated from several directions
- feature maps
- perspective views of the morphology

The elevation tints show the areas above a given height H = const. The painted shade lightens with height. The relief maps show a shading of the terrain illuminated from a given direction. The best impression is given by illuminating from the North-West.
The following features (selected from the PACE object-categories specified for the ONC and summarized) are chosen for the maps:

- waters of first order
- streets of first order
- towns with more than 10,000 inhabitants
- railways of first order

More information is not practical for the interpretation by displaying it on the graphic monitor on this scale. An assistant grid of latitude and longitude can be additionally calculated.
The pespectiv views show a central projection of the terrain with and without threat. The 3D impression of the morphology is given by the deformation of the grid-planes. The observer's orientation can be that of the pilot or any other.

Parameters necessary for the derivation of the geographical and tactical information are the 3D position and the attitude of the observer (usually the pilot).

Figure six gives a summary of the above-mentioned tools.

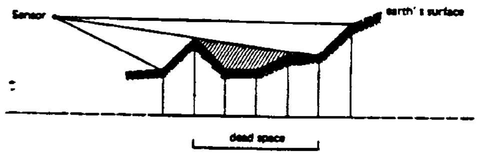

Figure 3: Sensor covering, dead space

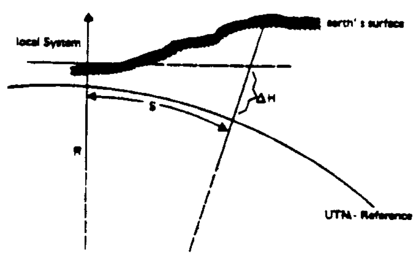

Figure 4: Earth's curvature

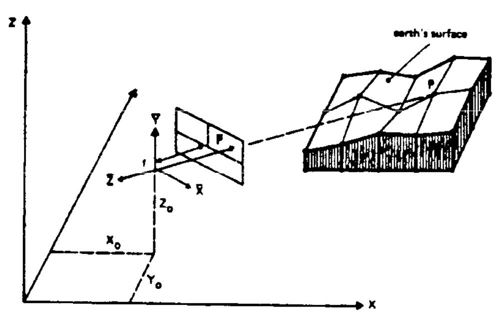

Figure 5: Central projection

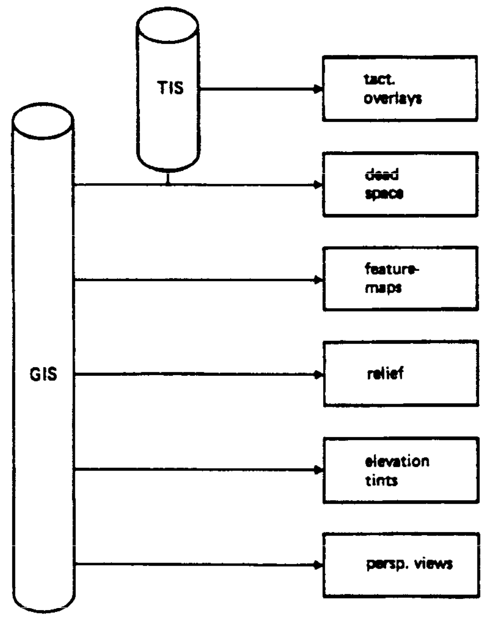

Figure 6: Tools organisation chart

EXAMPLES OF "DISPLAY FORMATS"

The derived geographical and tactical information have to be combined in a manner such that the pilot is given the best assessment in his operations. With the exception of the perspective views all the information is stored as pixel data in several layers of the frame buffer and can be selected by pushing a button. The sensor coverings and the elevation tints are transparent. The Figures 7 to 11 show examples of displayed geographical information combined with tactical information for applications in combat aircraft recommended by ESG.

Figure 7: Relief map with elevation tints (670 m and 1000 m), waters and geographic grid. SAM covering for flight height 100 m above terrain, flight path.

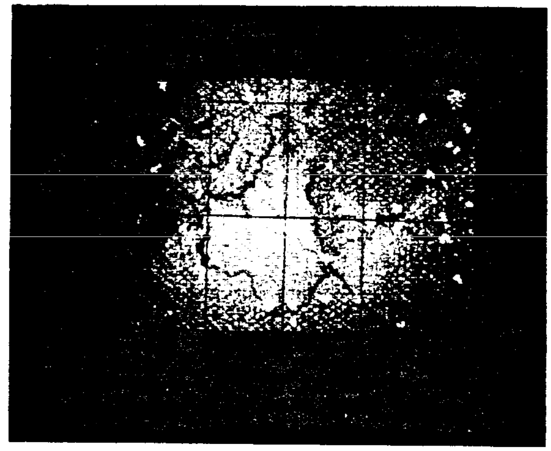

Figure 9: Map with elevation tint (670m), waters, streets, towns, railways and geographic grid.

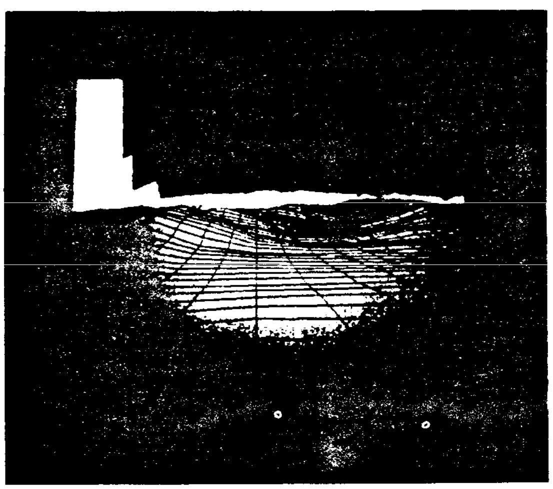

Figure 8: Perspective view of the morphology, observer located at the position L = 8°04′, B = 48°20′, 150 m above the terrain. Threat shown as a red cloud.

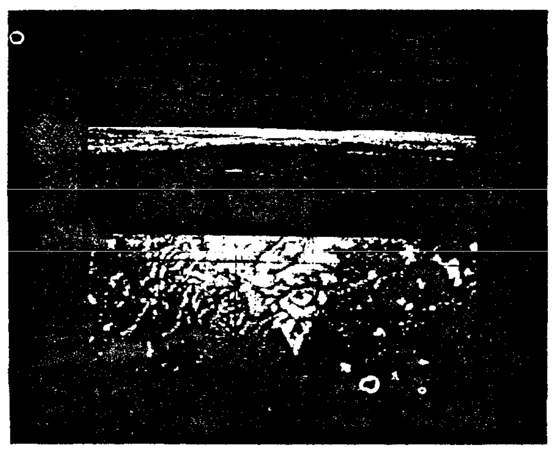

Figure 10: Bottom: geographic information like Figure 9 and relief including the area visible for the pilot flying at a height of 60 m above terrain (located at the aircraft symbol). Top: pilot's perspective view of the morphology.

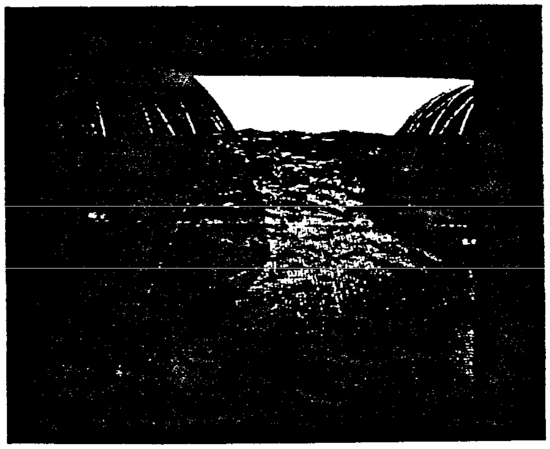

Figure 11: perspective "over"-view of the morphology from a desired area. Contour lines, rough threat environment.

CONCLUSION

The FACE data base and the DLMS-DTED are suitable for new tactical representations on displays in combat aircraft. A great advantage of the FACE data base is selectivity. For that a decluttering of the information is possible without renounce on them. If the tactical information predominates, the geographical information can be reduced successively. Thus the pilot is not inundated with information.
The selection of a scale larger than 1 : 200,000 is not to be recommended, because the cartographic generalization of the FACE data base would lead to inconsistencies.

ACKNOWLEDGEMENTS

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