Creating Correlated Geographical Databases for an Aircraft and Support Systems

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ABSTRACT: *Geographical databases are used in many functions in an aircraft system. An operational military aircraft system does not only consist of the aircraft but also ground based mission support and training systems where databases are used. In the Aircraft there are databases for the electronic map and the navigation subsystem. In mission planning and evaluation systems there are databases for terrain analysis, 3D-visualisation, 2D-map visualization etc. In the training simulator system are the databases for OTW (Out-the-Window) visualization, IR/Radar sensor imaging, IOS (Instructor/Operator Station) 2D-maps and of course a copy of the aircraft databases.*

For the usefulness and credibility of the whole system, it is crucial that the geographical databases are correlated and it is easy to imagine effects of databases not being correlated. The problem is very similar to what is found in distributed simulations where connected simulators use different natural environment databases.

This paper describes design principles and architecture of the Digital Map Generating System (DMGS) developed to support the Swedish Gripen fighter and its support systems (training simulators and mission planning system) with correlated geographical databases.
The DMGS has three basic functions

- *Import geographical data from different formats and store them in a database.*
- *A core system with database for storage of geographical data and editor to modify and adjust geographical data*
- *Export modules that export selected data to the appropriate format for use in the respective systems*

The system is based on ESRI Arc-GIS and ERDAS Geosystems IMAGINE.

1. Introduction

This paper discusses the database aspects of creating correlated geographical databases for a complete weapon system. In this case the Gripen aircraft weapon system including support systems as training simulators and mission planning and evaluation systems. The problem is very related to the problem of creating common or correlated databases for the synthetical natural environment in a distributed simulation. This problem is actually a part of the problem of supporting the whole aircraft system with correlated databases.

In this paper are the principles described of a system that can solve the problem of creating correlated geographical databases for several applications.

2. Use of geographical data in the aircraft system

2.1 Aircraft

The aircraft system is equipped with an electronic map that is presented at the pilot electronic displays. The map has several levels of details (zoom-levels) with information helping the pilot to navigate and accomplish his mission. The display system uses geographical databases to draw the maps. The map databases can be updated wit new areas of interest or with updated geographical data.

Several functions of the navigation system in the aircraft use geographical databases for calculations or reference. One example is a special runway database with runway information in the area of operation.

2.2 Mission Planning and Evaluation System

The mission planning and evaluation system is used by the pilot for on-ground planning and evaluation of the aircraft missions. The system use GIS-type (Geographical Information System) of geographical databases for 2D-mapping and geographical analysis. These databases contain a lot of vector- and feature based information in combination with aerial photographs.

The mission planning and evaluation system also includes functionality for 3D fly-through of planned or performed mission. For this is a 3D-database in OpenFlight format used. As the system runs on a PC platform, the 3D-visualisation has PC-performance.

2.3 Training System

The high-fidelity training simulator in the training system has a 360 degree dome OTW (Out-The-Window) –visualization system using SGI computers for image generation. The aircraft simulation also includes IR and radar sensor imaging where databases are used. These are all high performance systems that can utilize large and detailed image databases.

In the training systems are other systems connected that use geographical databases. The IOS (Instructor and Operator System) use 2D-map databases to display the scenario situation picture. The CGF (Computer Generated Forces) uses GIS-type of databases to determine realistic tactical behavior and for calculating interactions with environment and other entities.

Of course is also the aircraft represented in the training simulator with its on-board geographical databases. The training system is thus the "ultimate" test of the natural environment database correlation problem. The pilot has to experience one synthetic environment that correlates with the geographical information provided by the aircraft.

3. System Design

3.1 System principles

The basic principles of the DMGS system shown in figure 1 is that an Import module imports and stores data in a central database. Several data formats can be imported by using different import modules. Data from different regions don't need to be imported simultaneously and if necessary can the data be edited during this stage.

Then selectable data is treated in an export module to the desired database format. Several export modules exists for exporting data to different formats. Depending on the capabilities in the export modules can the databases be tailored to a desired application.

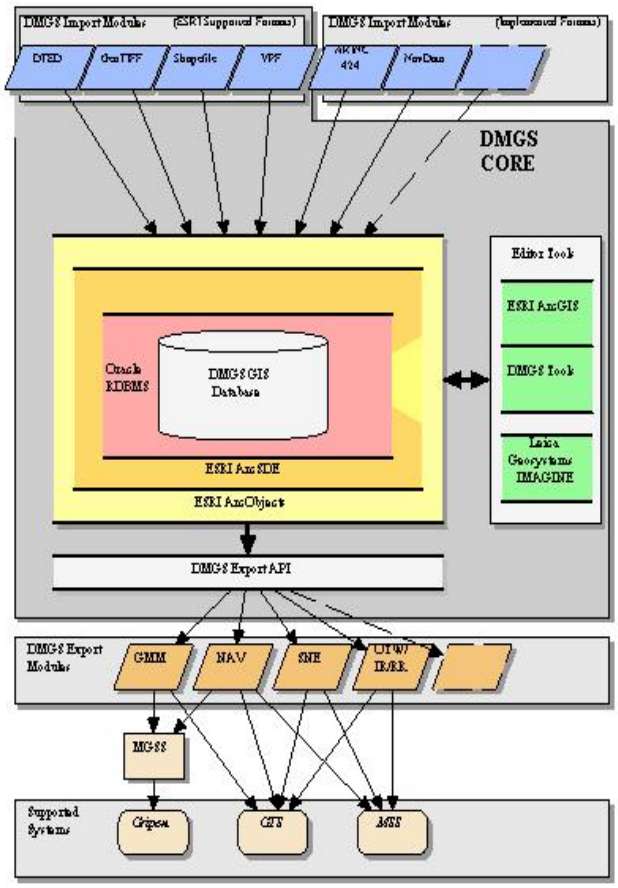

Figure 1: DMGS system principle.

3.2 System components

DMGS is built on commercial components that have been integrated into a system. Special tools or functions have been developed based on the native functionality of the components. Main components are:

- ESRI ArcGIS product suite
- ERDAS imagine
- Oracle database

From the ESRI product suite are ArcMap used for the graphical user interface, ArcObjects class function library is used for developing tools and functions and ArcSDE is used for database management.

ERDAS imagine is used for raster data managing and geoprocessing.

Oracle database is the RDBMS (Relational Database Management System) of DMGS. All access to the database is done through the ArcSDE API.

3.3 Database

The database structure and workflow is shown in figure 2.

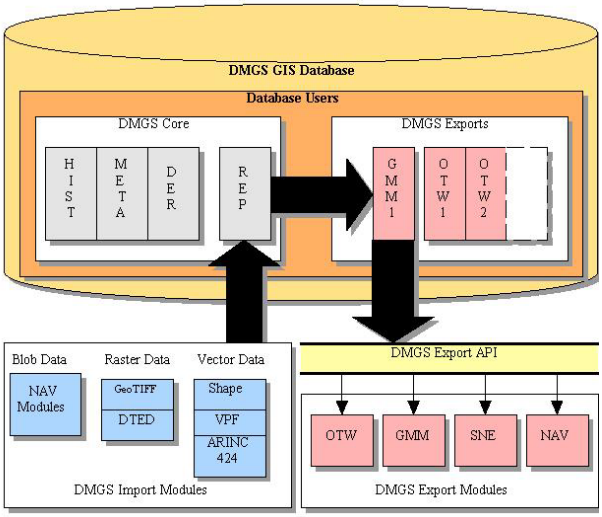

Figure 2: DMGS Database structure and workflow

Imported geographical data is stored in the REP (Repository) workspace. Meta- and change history data are stored in the workspaces META and HIST respectively. The change history data logs all changes made to data in the REP workspace, which enables traceability of all changes made to the data.

Data that is processed can be saved for future re-use can be stored in a DER (Derived) workspace.

When an export module is started, an export workspace is created with the data used by the module. Data can then be processed without affecting the original database. This is important because sometimes data is "distorted" in the export phase as when for example generalizations are made. This is changes you don't want to be made on the original data.

Another important function of the database is that when data is edited in the import phase, a virtual database layer is created where changed data only is stored. Not until all changes are made and the new dataset is verified, is the data in REP affected. This increases the reliability of the system and secures against corrupted databases.

3.4 Import and edit data

The import modules main functions are to import and edit geographical data. Imported data format can be divided into two categories namely Raster and Vector data.

Raster data are mainly image data in GeoTiff format but also elevation data in DTED format.

Vector data is geographical data defined as point, line or polygon data. Currently imported formats are Shape, VPF(Vector Product Format) and ARINC 424 (Runway data) formats.

All imported data is characterized. An important characteristic for all data is in which Coordinate system data is defined. In DMGS is imported data stored in its native format because there exists no general loss-less transfer between coordinate systems. The system has functionality to transform between "all" known coordinate systems but data is transformed when needed to avoid loss of accuracy.

An important characteristic for Vector data is the feature coding. In DMGS was the FACC (Feature Attribute Coding Catalogue) selected. It was chosen, as it is a recognized NATO standard and has proved to be working sufficiently well. A major work when importing data from a new supplier is to define mapping tables from the supplier's feature coding standard to FACC.

3.5 Export data

3.5.1 OTW

With the OTW (Out The Window) export module are visual image terrain databases produced. The terrain database is in OpenFlight format that can be loaded into a 3D engine. The database is produced from data in the DMGS GIS database. The database is produced in a process were several tools are used to refine data. The user can interact with the process by choosing tools and define parameters and choose alternatives in Graphical user interfaces.

3.5.2 GIS

The SNE export module produces GIS type of database that can be used for 2D-map viewing or terrain analysis. The output database Saab SNE proprietary format used in the Mission planning system. In the SNE database are data organized in layers of information. During the export process can the user decide which information and in which level of detail that should be included in each layer.

3.5.3 Aircraft electronic map

The Gripen Moving Map (GMM) export module produces the Aircraft moving map database. The database is a Gripen Aircraft proprietary format. Similar to the SNE database it is divided into layers of information. During the export process can the user decide which information and how much generalization should be done in each layer.

3.5.4 Navigation data

The navigation data export module produces databases for several functions in the aircraft navigation system. Databases are in Gripen aircraft proprietary formats. Depending on which navigation database is produced, has the user a set of available operations that can be applied on the data.

4. End Notes

The DMGS system was developed to enable more efficient production of geographical databases for a complete aircraft system including the aircraft, mission planning systems and training simulators.

The core functionality of the system is the central database containing all geographical data and the modular design with import and export modules that can be individually extended without redesigning the whole system.

The success of the system development is very much based on the use of existing commercial tools (GIS-tools) that had very much of the basic functionality needed for the system.

5. References

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