MODULAR ROLL-ON / ROLL-OFF DESIGN CONCEPT OF A ROTORCRAFT SIMULATION CENTER

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ABSTRACT

The topic of this paper is to present a short overview on the idea of the modular helicopter simulator concept and its implementation in the realization of 12 helicopter simulators for a simulation center of the German army aviation in Bückeburg.

TRAINING CONCEPT

It must be the objective of the army aviation corps' flight training to enable helicopter pilots to use their weapon system safely and efficiently by using the technical equipment and possibilities:

- at day and night
- in air mobile combat of combined arms
- under almost all possible weather conditions.

This is done in the so-called training equipment compound where the adequate training equipment is assigned to the respective training objective.

Partial skills are learned by means of simple procedure trainers before complex simulators and finally the original device, the helicopter, are used to merge the partial skills.

This training equipment compound allows to reduce costs and at the same time to reach those training objectives which will be demanded in the future.

Training equipment essentially consists of the following:

- **CBT** is an interactive **computer based training** equipment which is used for interactive learning of flight theoretical and technical aircraft knowledge, navigation training and radio communications.
- **Part Task Trainers** are used for hands-on training of partial capabilities. They are corresponding to the respective system in design, layout and operation.
- **Flight Simulators** and Combat Mission Simulators will be treated in detail during the further explanations.
- The **close-in combat simulator (AGDUS)** corresponds to the common equipment of the army.
- **SIRA**, the common equipment **for combat simulation**, must be extended to allow for the command and control of operations of air-mobile forces.
- *The **basic training helicopter (SHS)** is an indispensable* equipment for the basic and advanced training of aircrews.

FLIGHT SIMULATORS

Flight simulators reproduce the complete (especially dynamic) behavior of the helicopter so that all relevant targets of practical flight training to the level of mastery can be trained.

- 8 ea. HGA simulators
- 2 ea. UH-1D simulators and
- 2 ea. CH-53 G simulators

will be delivered in the period from 1999 to 2001 for the simulation center.

A modularization would be an ideal solution for the realization of such a scope of delivery (12 flight simulators), especially with regard to future flight simulators or combat mission simulators which, as opposed to flight simulators, also reproduce the helicopter's mission equipment.

PLANNING OF SIMULATOR HOURS

The number of simulators is based on a planned number of simulator hours per year as follows:

- 16894 for the basic training helicopter
  This means that with 2160 h per cockpit and year the training requirement will be satisfied with 8 SHS simulators.
- The simulator hours for the UH-1D are estimated at 5120 h per year; with 2480 h per cockpit and year 2 UH-1D simulators are required.
- For the CH-53G 4904 simulator hours per year are required. If - analogous to the UH-1D - also 2480 h per cockpit and year are estimated, 2 CH-53G simulators are required.

A Modular Simulator - Why ?

The modular architecture of one or several simulators located in one single center was the customer's idea considering that through definition of technical or functional commonalities within the basic training devices, effects of rationalization can be achieved.

The possibility of reduction of the total amount is- for example - given because the simulator hours required for 2 type-specific helicopters A=1500h/year and B=3300h/year can be covered by 2 basic modules and one type-specific module A and 2 type-specific modules B.

If we assume the conventional construction, 3 badly occupied individual simulators would be necessary. If all simulators have the same basic modules, this results in large numbers of identical modules.

With the procurement and production of larger quantities, a total cost reduction of a minimum of 10% can be realized. This cost reduction is achieved by a more efficient procurement, bulk discounts and more efficient production because of identical parts.

The considerably lower life cycle costs can be based on the facts that

- only one single modification development must be carried out for the modification of identical modules,
- fewer spare and replacement parts have to be stored and
- fewer maintenance personnel is necessary.

Moreover the later integration of new modules or elements is considerably simplified because of standardized interfaces.

Definition of Terms

First of all the essential terms have to be defined:

The **simulator** is the functional unit which consists of at least one basic module and one type-specific module.

The **simulation center** consists of 12 simulators.

A **module** is a combination of **elements** or functional units such as sound system, motion system, control loading system, etc.

Subquantities or parts of elements are **components** such as computer, disk storage, processors, pumps, panels, etc.

In general, the present concept of a modular simulator does not include any new additional elements in comparison with the conventional understanding.

New is the uncompromising separation of separable elements and the definition of their interfaces as well as the use of identical components on the module level.

A later objective is the highest possible flexibility in the operation of simulators through the exchange or use of different type-specific, sensor or tactics modules on one and the same basic module.

Basic Module

The basic module contains all those elements providing the functions equally necessary for all simulators.
A careful distinction must be made between hardware and software elements. Software, which is different for different simulators, does not belong to the basic module. The hardware however, that is the computer on which this software is running, can be designed as a standard for all simulators and belongs to the basic module.

As a consequence there must be only one basic module configuration for the simulation center.

A basic module consists of 3 groups of elements:

- **Group 1** are the primary elements included in every simulator, such as simulation computer, operating system, type-specific-independent and parameterizable type-specific, sensor and tactical software, interfaces, image generator, display system, motion system, control loading system, sound/audio system, data recording, etc.
- **Group 2** are the elements such as the database for out-of-cockpit view, but without special attributes for sens and tactics, as well as the instructor operator station.
- **Group 3** are the elements such as briefing/debriefing, database generation system, lessonplan station, energy supply, air-conditioning.

Type - Specific Module

Fundamentally the type-specific module contains all type-specific parts which are necessary for the representation of helicopter subsystems. Not included are the whole mission avionics system and the sensor parts which are necessary for accomplishing the

mission such as night-vision-goggles, Forward Looking Infrared, etc.
For each helicopter type an individual type-specific module with corresponding interfaces to the other modules is required.
The type-specific module consists of elements like the cockpit including the complete equipment which means instrumentation, controls, a conventional cockpit interface with digital inputs and outputs and analogous inputs and outputs, seats with seat-shaker as well as the Flight Controls such as Control Column, Collective Pitch and pedals.
Not included in the type-specific module is the cockpit instructor console if it can be realized separately from the cockpit. Naturally, the functional separation of basic and type-specific module is not limited to the hardware, but also valid for the software.

GENERIC- / SPECIFIC SOFTWARE

Generic or data-driven software is a parameterizable software which can be used universally for different modules of a module type. This software performs the tasks by initialization and configuration with type-specific data.
As the generic software is independent of specific requirements, it is a part of the basic module.
The appertaining specific data is part of the respective module whose functionality has to be reproduced.

Specific software is the one which performs a specific task of a certain module and cannot be used for tasks of another module of the same or a different module type.

Generic software is, for example, the motion model or weather model but also models for helicopter dynamics or the rotor blade.

Specific software is, for example, the Flight Director model of the different helicopter models.
Independent of the type, the generic as well as the specific software can run on the computer of the basic module.

SENSOR MODULE

Each sensor type requires an individual sensor module. Such a module contains all elements necessary for recording, processing and displaying all mission dependent sensor signals from this sensor type.
The simulation of the out-of-cockpit view is one exception.

Typical sensor modules are:
- Night Vision Goggles
- FLIR
- Radar
- Sonar

A sensor module generally consists of the following components:

- Sensor image generation
- Post processors for specific image effects
- Sensor image presentation
- Sensor database
- Software for the simulation of certain operating modes
- Original device or controls and
- Interfaces within the module and to other modules

TACTICS MODULE

The tactics module contains all elements of mission avionics, self-protection and weapon parts of the own helicopter as well as all parts for the generation and representation of the mission scenario.

As the helicopter simulators treated in this paper have no tactics module in the required realization phase, this will not be further considered.

MAIN TOPICS OF REALIZATION

In the development of 12 simulators by means of modern simulation technology the main emphasis is attached to:

- Implementation of the future-oriented modular concept to reduce procurement and life cycle costs by using the latest technology.

- Integration of 11 channel high-performance image generators with 8 channels for dome projection, 2 channels for NVG simulation and one instructor eyepoint.
  Channel performances of 1,54 million pixels, a pixel filling rate of 300 million pixel / sec. and appr. 3200 polygons / channel, the image generator can simultaneously represent 64 moving objects with 6 degrees of freedom and manage 256 dynamic coordinate systems.

- For the display system a partial dome construction has been chosen. 8 liquid crystal light valve projectors guarantee a field-of-view of 240° horizontally and 90° vertically with a resolution of approx. 8 to 10 arcmin.

- Realization of a realistic night-vision-goggles simulation.
  The original components are used and the image amplifier tubes are replaced by cathode ray tubes. The NVG are slaved to the head movements without delay by a 240 Hz headtracker and a precalculation of the line of vision.
- Design for a quick and easy exchange of cockpits in order to integrate type-specific modules of other helicopter types into the simulator without problems. The construction consists of three separable segments; the type-specific front cockpit, the middle, the on-board instructor console and the rear part, the so-called walk-away module. The parts can be driven to the back from the dome, are easily separable from each other and can be integrated again in a new configuration.

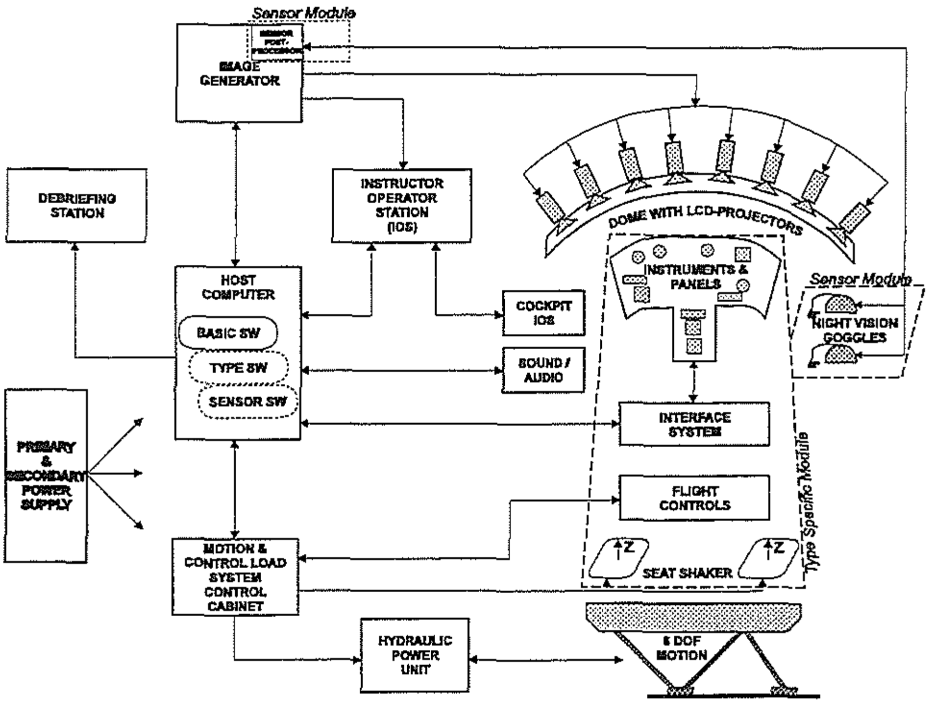

Figure 1: *Bockdiagram of 1 Simulator*

- Realistic simulation of helicopter dynamics by using a powerful and flexible rotor blade model.

- Use of a high performance hydraulic motion platform with 6 degrees of freedom and a control force simulation of latest technology by using electromechanical drives. The simulation of high-frequency vibrations of the cockpit cabin is also supported by a seatshaker for the pilot and the co-pilot respectively.

- Implementation of a standardized operating concept for all instructor and debriefing stations, for hardware layout as well as software functionality.
  The instructor has the possibility to control and monitor the training operations via an external instructor station, an on-board instructor station or a portable LCD panel. They all have an identical functionality and also enable the crew to use the simulator without instructions.
  A logical, graphical user interface improves the overview, optimizes interventions and reduces the attention levels.

- Each of the 12 simulators receives a debriefing station; their networking will avoid a fixed attachment of simulator and debriefing station and achieve a large organizational flexibility.
  The central element of the debriefing station is an instructor station identical graphics workstation with an independent image generator. Data filing and the presentation of all mission relevant information and actions, also with the out-of-cockpit view as experienced by the crew and from other perspectives, communications, etc. are guaranteed.
  In addition, a lecture-room is equipped with a debriefing component of the same functionality so that a follow-up discussion can also be performed with a large audience.

- Software development will be in accordance with the Allgemeiner Umdruck 250, also called V-model, a standard of the German Armed Forces, comparable to DOD STD 2167 A. The software structure supports the modular architecture. All parameterizable type-specific-, sensor- and tactics-dependent software is common as far as possible to all modules. Only the data records are assigned to the respective module.

- Realization of simulation software in the programming language ADA, expecting to be able to effect modifications and adaptations fast and at low costs and to port the basic module software for future helicopter simulators easily and without problems on any computer platforms.

- The 12 simulators of the center are networked

- Lessonplan and database generation will be taken into consideration especially in the light of provisions for preparing exercises in the sense of mission rehearsal.

- In order to obtain the IFR certification, the German Aviation Authority in Braunschweig will be involved as early as possible in the development process.
  The simulators should have this certification so that a certain percentage of IFR simulator hours will be accepted as actual flying hours.

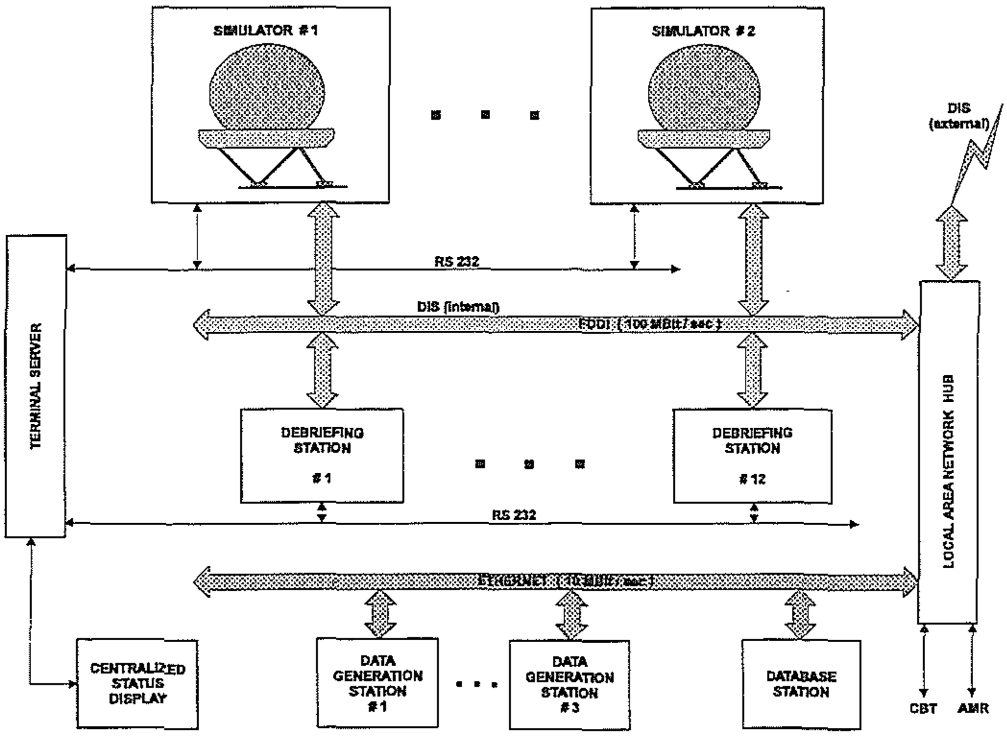

Figure 2: *Blockdiagram of Simulation Center*

via an FDDI-connection and can execute common exercises according to the DIS protocol.

An open system will be integrated so that the networking can also be extended to other DIS capable simulators via a wide-area network.

- A prototype database with the size of 100.000 km^2 will be delivered together with the 12 simulators.
  This database contains one highly detailed training area of about 2.500 km^2 and 3 insets of about 2 - 6 km^2 each with very high detail.
  The database will also have the attributes for simulation of NVG view and for sensor modules, e.g. Infrared or FLIR, which may be required at a later time.

- A high availability on the basis of the simulators' modular structure is to be obtained at reasonable maintenance expenditure.
  Common components relieve the logistics and a central status display will facilitate maintenance and repair, supported by a mobile maintenance station.

FIGURES

Figure 1 outlines the layout of one of the 12 simulators. The individual modules are marked accordingly and linked to each other by clearly structured interfaces.
The hardware and software parts of the type-specific module can be seen very clearly here. It is this module which will finally turn a generic helicop-

ter simulator into a UH-1D, CH-53G or SHS-type helicopter.

Figure 2 shows the combination of 12 simulators with supporting facilities such as debriefing stations, data generation stations, database station and the central status display.
Each simulator is linked via the network with the other elements so that there is no fixed assignment of a simulator to a data generation station or debriefing station. This allows very flexible training operations and an optimum use of free resources.

The linking of the simulators for jointly exercising common missions and with other DIS-capable simulators is effected via an FDDI connection.
The interfaces for linking the CBT component and the AMR (training administration computer) are also allowed for.
For the simulation center 12 identical basic modules, 2 type-specific modules UH-1D, 2 type-specific modules CH-53G, 8 type-specific modules SHS and 8 identical sensor modules will be delivered in accordance with the modular concept.