TECHNOLOGICAL TRENDS IN SIMULATION TECHNOLOGY IN AVIATION & PILOT TRAINING

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Abstract

The article gives an overview of the modern technological aspects in simulation technology used in aviation mainly for pilot training in both civil and military aviation and the use of simulators as the base of computer based training (CBT) for training of aviation personnel.

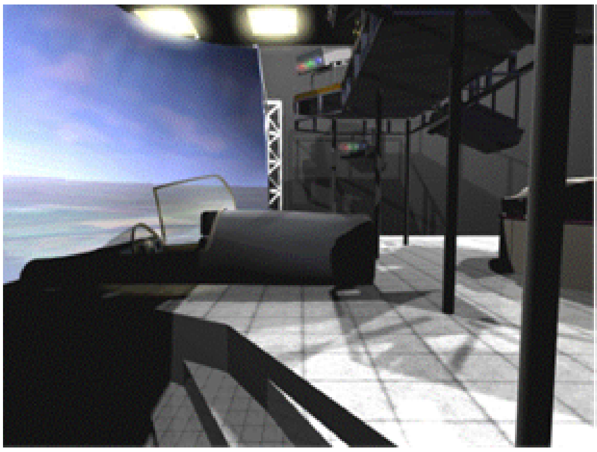


Fig. 1. Flight simulator and a projection system

In particular the article gives the technical analysis of modern technological trends in building modern virtual reality based simulation systems and their latest design parametres including the application of HLA architecture, distributed interactive simulation (DIS) and inter-connectivity of simulation technologies. Functional modelling of aircraft and of simulation based training system itself using the structured CASE supported methods for system analysis and design is provided in the article. The article also gives the information on the professional flight simulators development in the Czech Republic.

1. Introduction

Sophisticated pilot training both in military and civil applications is based on the use of wide spectrum of computer based simulation technologies, which provide new opportunities in pilot training. In accordance with the Jane´s Simulation and Training Systems (JSTS), 1999 the current simulators can be divided into the following categories:

- Flight Simulators and Flight Training Devices
- Ground-based Trainers for Non-pilot Aircrew
- Airborne Trainers – non-EW
- EW Trainers for Air Systems
- Maintenance Trainers for Air Systems
- Air Traffic and Aircraft Control Simulators
- Other Aviation Simulators and Training Devices

Simulators can further be divided according *to the level and scope of provided training as*

- Computer Based Training (CBT)
- Part Task Trainer (PTT)
- Basic Flight Trainer (BFT)
- Flight Navigation Procedure Trainer (FNPT)
- Full Mission Simulator (FMS)
- Combat Tactic Trainer (CTT)
- Tactical Flight Simulator (TFS)
- Air Combat Simulator (ACS)
- Mission Planning / Briefing / Debriefing

In this overview also the multimedia classrooms with CBT technology used for initial training of pilots can be included. The main objectives of introducing the simulation and training technologies in pilot training are to assure:

- *the high effectiveness and productivity* of pilot training,
- the pilot training safety,
- the interoperability and use of training standards,
- the aspects of the environment protection

The essential aspect of simulator based training (SBT) is the economy of pilot training. On one side the increasing complexity of aircraft systems as well as related training and on the other hand the limited financial resources determines the decision making towards the use of cost effective training methods. This is just the advantage of professional flight simulators to provide training at very low costs relative to the use of the real aircraft. The table below provides some basic comparison of cost per one hour (CPH) of training on the real aircraft and the equivalent simulator (source NTSA).

Aircraft	**Flight CPH (USD)**	**Simulator CPH (USD)**	**Ratio**
Lockheed Martin F-16 Fighting Falcon	5 000	500	1/10
Boeing F/A-18 Hornet	3 955	217	1/18
Lokheed Martin P-3C Orion	2 903	119	1/24
Lockheed S-3A Viking	4 360	143	1/30
Sikorsky SH-60 B Sea Hawk	1 724	118	1/15
Boeing CH-47 Chinook	3 000	435	1/7
Mikojan-Gurijevič MiG-29 A	5 200	126	1/41
Average			**1/21**

Another important advantage is the possibility of interconnecting the simulators into clusters using the technology of DIS (Distributed Interactive Simmulation) and thus to simulate and train the joint flight operations and missions, which has a clear application in particular in the military sector.

Thus the simulation technology provides the effective tool for basic, continuing, maintaining and advanced pilot training including type retraining.

2. Technological Composition of the Flight Simulators

The professional flight simulators consist of the the following components:

- Cabin, instrument panels & control system
- Visualization system
- Instructor's workplace
- Software
- Computer technology
- Electrical equipment & installation

2.1 Cabin, instrument panels & control system

- Design & arrangement (including drawings)
- Cabin panels and their layout
- Cabin I/O elements (including indications of scope of debugging)
- Digital / analogue displays
- Control system (Steering wheel & alternatively Joystick, Pedals, Trimmers, Engine control lever)
- Navigation system
- Communication (radio/intercom & their recording)
- Audio system

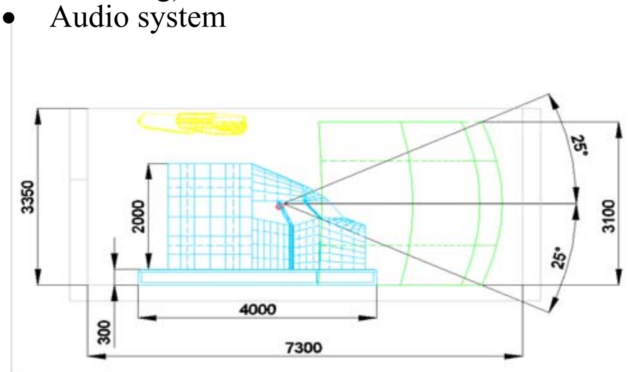
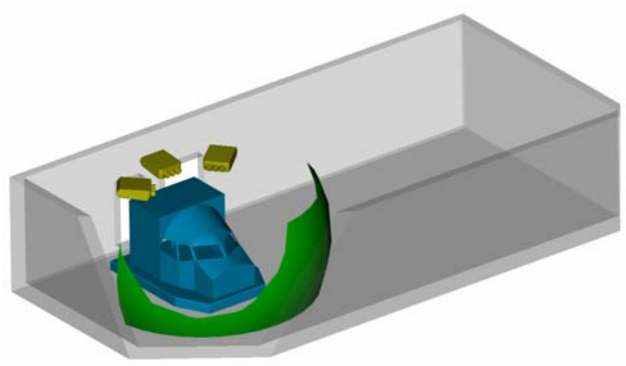


Fig. 2. General simulator cockpit layout



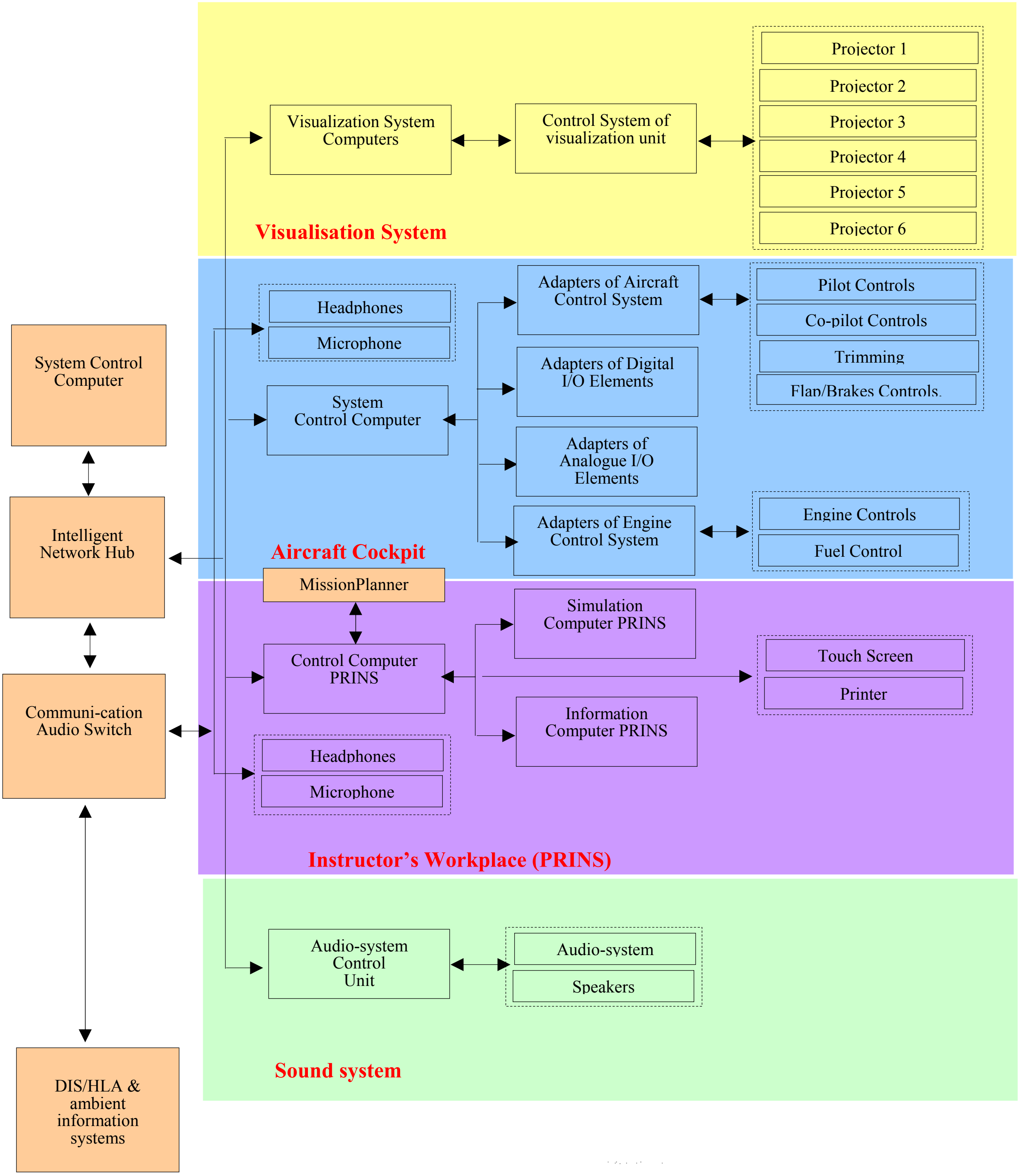


Fig. 3. Block Scheme of the Typical Flight Simulator

Functional analyses of I/O elements, i.e. controlers and displays, whose functions shall be simulated shall further be conducted. The detailed analyses of cockpit panels is made as shown in the Fig. 4.

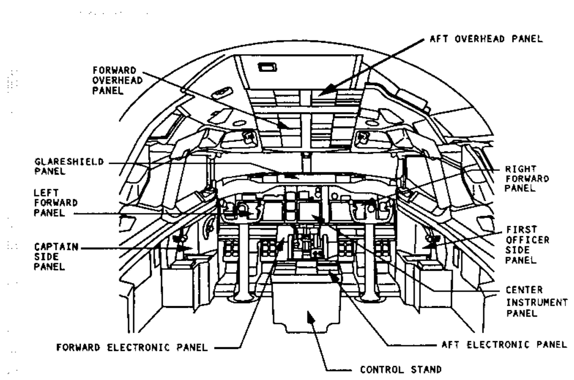
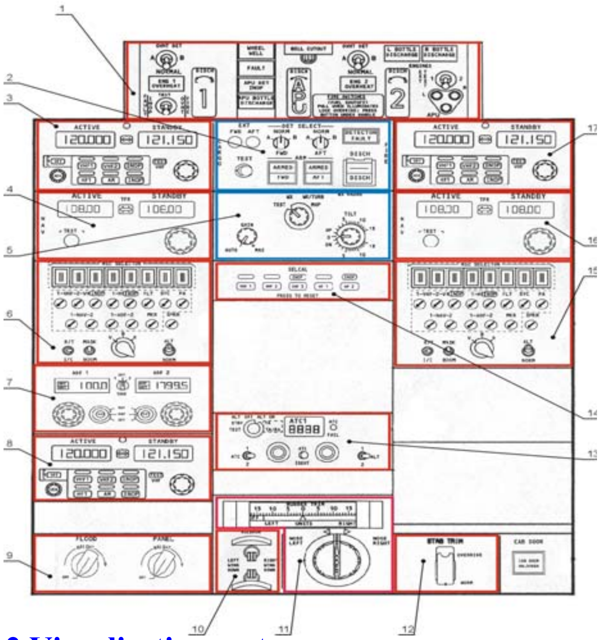


Fig. 4. Overall view of cockpit panels (Boing 737-800)

Aft electronic panel scheme



2.2 Visualisation system

The specific solution of the visualization system includes the design of technological concept, design of projection system (e.g. 6-channel projection) and projection screen (e.g. spherical screen).

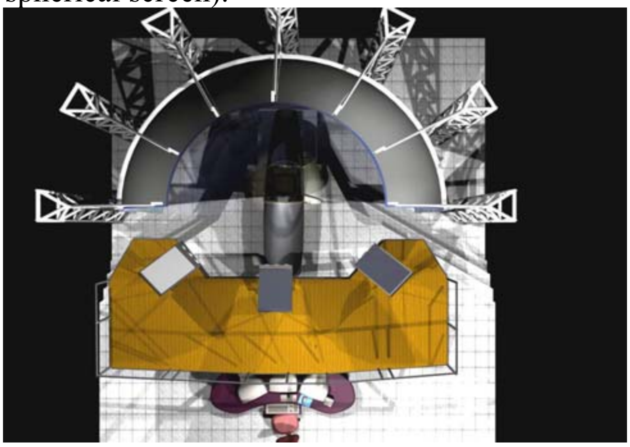


Fig. 5. The 6-channel projection system and a spherical screen

The typical projetion range of images is 200° horrizontally (extendable to 300°) a 100° (+65°a -35°) vertically.

Fig. 6. The 6-channel projection system and a spherical screen (backward view)

2.3 Instructor's workplace

The instructor's workplace is made as a combination of hardware and software that will make it possible to control the whole trainer from the functional point of view, to choose or combine flight tasks, and to monitor and evaluate the process of training. It makes possible to choose training tasks from a set of standard tasks, and to interactively configure them if necessary (the standard tasks set is not a part of the delivery). The tasks configuration makes possible e.g. to set and influence conditions of flight (weather, emergency procedures), to supervise pilots’ activities (display of the aircraft position in the space, immediate navigation situation), to monitoring of the pilot's activity, to move across tasks (to stop, go forward or back, replay), to display of approach to the airport etc.

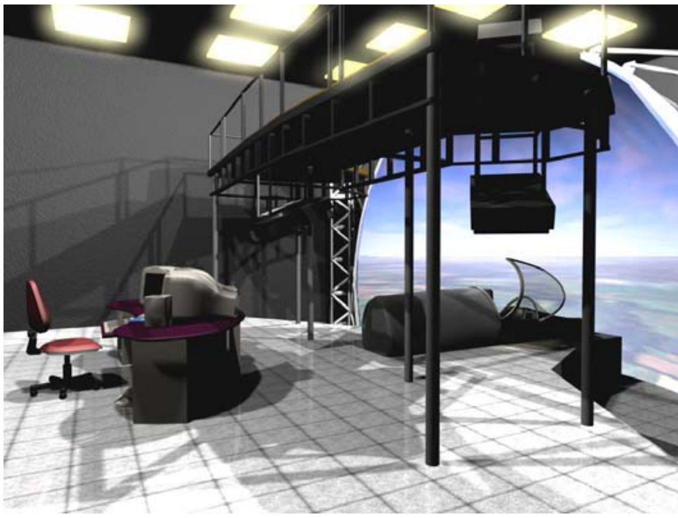


Fig. 7. Typical placement of the Instructor’s workplace

2.4 The software

The simulators system software is built as modular, open and real-time with the application of HLA (High Level Architecture) standards, based on the aircraft functions process analysis and the object analysis of modules performed with the support of CASE technology (support systems for the development of information systems and program applications). Solutions are mainly based on the mathematical models represented by an extended set of differential equations that describe the complex behaviour and functions of the plane and of its systems enabling the complete simulation of flying properties of the aircraft, of its engines, auto-pilot, navigation, aircraft systems etc. The typical structure of the software can be seen in the Fig. 8 below:

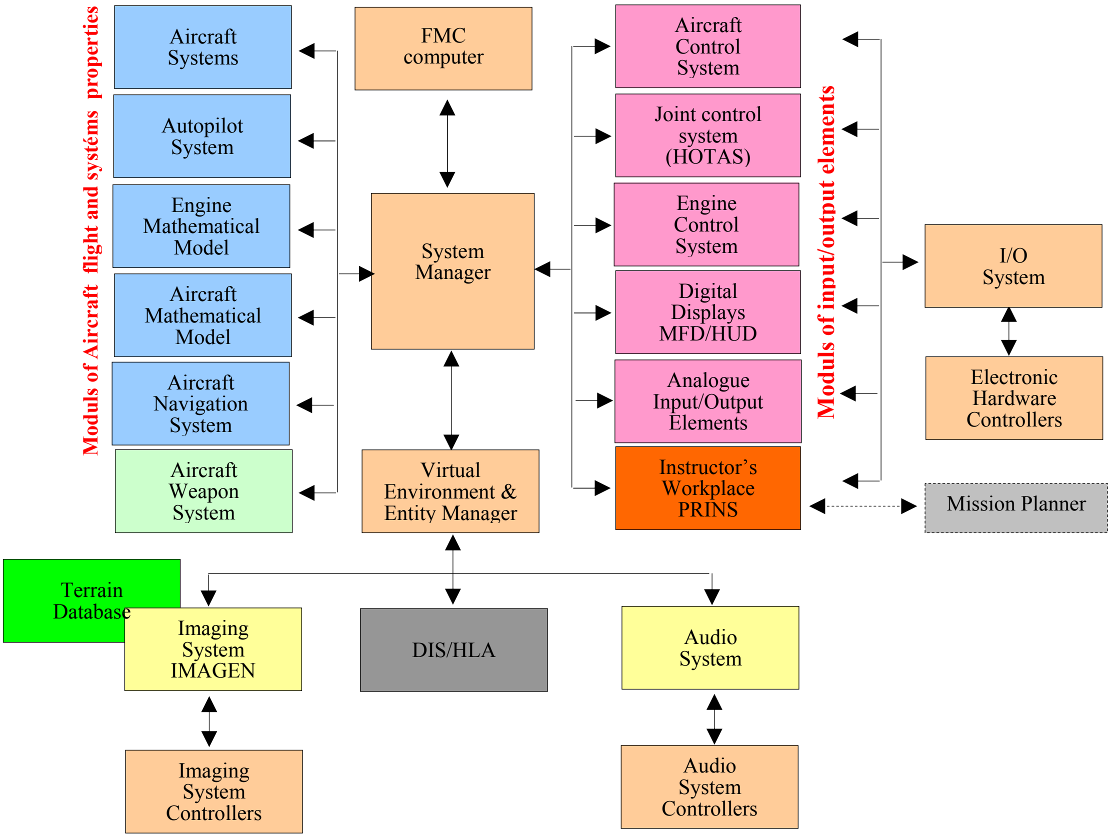


Fig. 8. Modular structure of the flight simmulation software

In case of military application the weapon simulation modul or frequently a joint weapon-navigation complex is another integral component of the simulator software.

Software is made on the basis of process and/or rather object-oriented methodology and applies principles of HLA (High Level Architecture) design supported by CASE tools. The structured approach assures:

- To keep transparency of the software
- To provide full and inspectional documentation of the softeare designed
- To assure maintainnability of the software

2.5 Computer technology

The modern professional simulators represents an autonomous system without external connections. The computer technology used comprises the following parts:

- Electronic hardware (e.g. quite progressive CAN buses & electronic boards, converters, digital displays, electric motors, etc...)
- Image generator (hardware, e.g. projectors)
- Computer network (topology, configuration, system interconnection, records, interfaces)
- Computer technology (system control computer, computers of digital instruments, instructor's workplace computers, display system computers)
- Safety & reliability (data backup,...)

2.6 Electrical equipment & installation

The electrical equipment and installation of a simulator includes construction preparations, heavy current installation & system safety (electricity, air conditioning, construction safety), energy supply backup (UPS), requirements of servicing and maintenance etc.

3. Interconnection of simulators

The significant advantage of the modern flight simulation is the interconnection of simulators using the DIS (Distributed Interactive Simulation). The interconnection is technically implemented even on the digital telephone line and uses the special electrical adapters and a communication software.

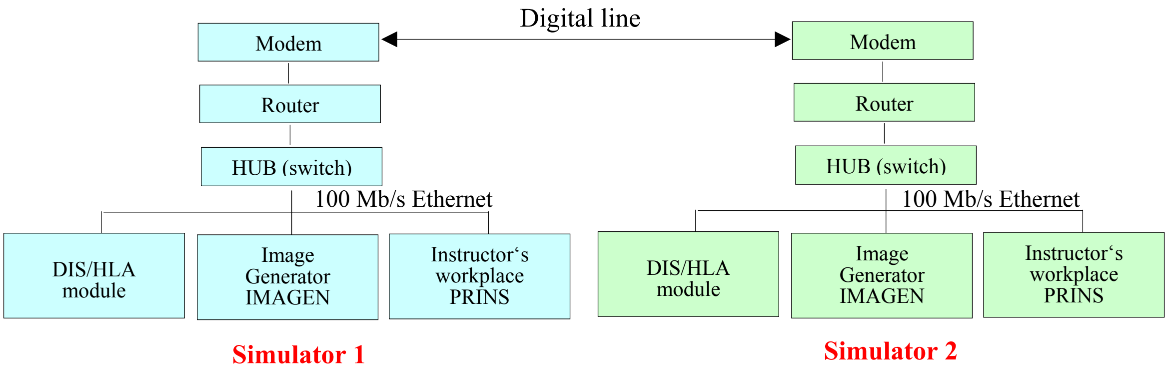


Fig. 9. Block scheme of the simulator's interconnection and real snap of the projection screen

4. Conclusions

The article above provides a general overview of technological aspects of the modern building of the professional flight simulators. The article summarise the experience with buidling the military and civil simulators in the Czech Republic. The article demostrates the structure of components of the simulators and also demonstrate the methodology. The problems of integration of the simulation technology systems into complex training systems for development of multi-level skills mainly in pilot training is also an important part of the article.

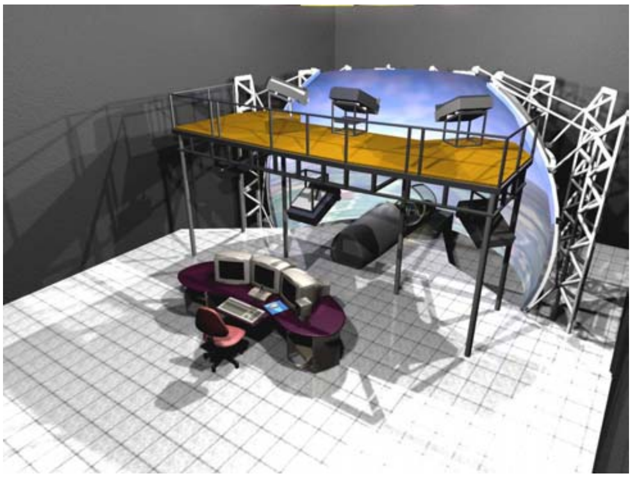


Fig. 10. The overall layout of the military aircraft simulator

5. References

The article is based mostly on the in-company materials:

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