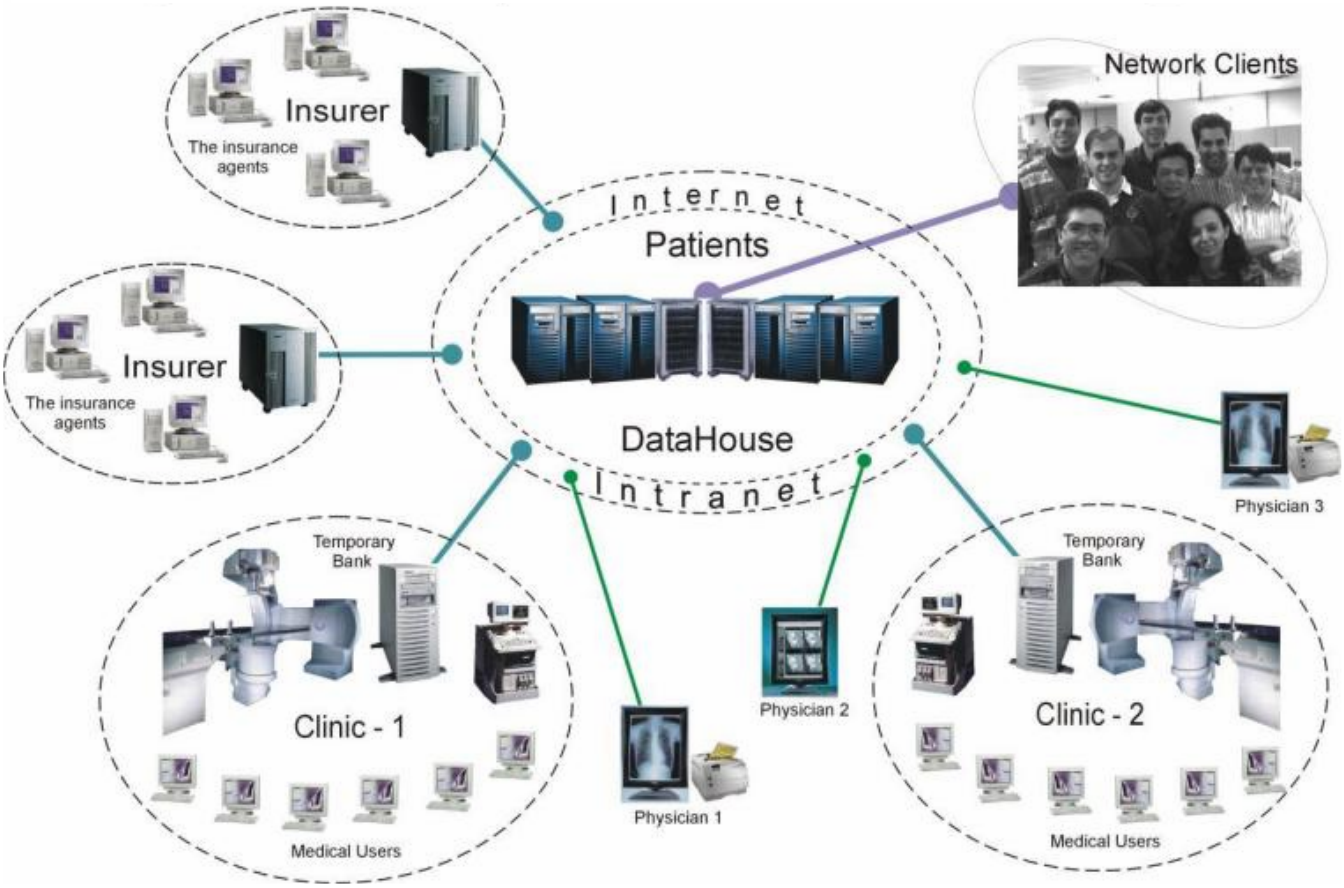
2D
Processing and Visualization of the Medical Images



Adaptive Video-Information Medical Network AS_VIMeN
- *Basis*

Moskow**. 2003.**

Adaptive Video-Informational Medical Network. **The System** *AS_VIMeN*.

The task of ***Adaptive Video-information Medical Network*** (**AS_VIMeN**) is improvement of quality of clinical service and diagnostics of patients, improvement of quality of training for higher school and transition of clinics completely onto electronic document circulation. The complex solution for transition of medical and technological process of clinics to completely digital technology lies in establishing **AS_VIMeN**-based medical management. Separate elements of the program were implemented and successfully approved on working machines and systems.

AS_VIMeN is a real time network thus representing entirely new toolkit of representation, reception and storage of medical images in the digital form, their processing and displaying at television screen or printing with photographic quality.

AS_VIMeN allows to keep and treat both non-formalized and formalized case records and medical studies with authorized access to the visual and text information.

The network allows to combine in a uniform complex most types of medical equipment, previously incompatible, provide standardization of information representation, irrespective of equipment own working standard and presence of own system of information digitizing in the following fields of diagnostics:

- roentgen-diagnostics;
- angiography;
- isotope diagnostics;
- computer tomography;
- Ultrasound-diagnostics;
- thermovision;
- endoscopy;
- electrographic diagnostics;
- pathological anatomy etc.

AS_VIMeN provides distribution and processing of video-information at each workplace using processing capacity of the whole network, that consolidates maximum processing, typical to separate automated workplaces represented:

- in mono- or a multiscreen mode;
- in static and dynamic modes (cinema).

The Knowledge Base is being built in process of accumulation of the information in the Database, becoming basis for formalization of video image and giving principal opportunity to create the Standard of representation of the medical videographic information for the further processing, opening road to automation of diagnostics, creation of **3D**-image Databases, for biovisualization and creation of **3D** designs.

Flexibility of electronic part of **AS_VIMEN** is based on user-programmable **FPGAs** (or **ASIC**) and on a set of system construction technical elements, electronically realizing objective model of system.

Flexibility of **AS_VIMEN** software and user interface of the is realized through special language of parallel programming **CAPER**, that renders powerful developer toolkit for programmers and experts in applied field.

Flexibility of connecting **AS_VIMEN** to basic technological medical equipment is carried out by highly qualified team of experts, **Siemens**, **GE** and **Philips** certified. The Team has accumulated wide practical experience of installation, adjustment and servicing especially complex closed medical systems and the equipment, including non-standard tasks of management computerization.

• BASIC Medical And Technical Features of AS_VIMeN.

The system of high-speed ***Global Operative Synchronous Video of Memory*** **GOSVIM** with the frame organization has the capacity of **1GB - 16GB**, and provides the following opportunities

- working in a parallel mode of up to 50-100 working places;
- working simultaneously at 5-10 working places in a cine-mode;
- interframe manipulations in real time (subtractive roenthgenology);
- compatibility with various TV standards in a parallel mode;

System of high-speed Operative Storage of Network Information on **RAID** with parallel access, by **FC-AL SCSI** or **InfiniBand** of channels, and with storage capacity **(5-10)TB** and more.

Long-term storage on **DVD-RAM** optical disks for fast access to a file in global archive memory with capacity from **125GB-1.5TB** and more.

A set of the Specialized Processors for manipulations above the staff:

- compression - decompression of images and geometrical transformations;
- various filters and kinds of effects;
- Fourie-analysis, convolutions of images;
- transformation **RGB - YUV - RGB** (brightness, chroma, saturation);
- **RGB-PAL-NTSC-SECAM-HDTV-DVD-RGB** transformation;
- multiscreen manipulations, multi monitors displays;
- transformation from a series of **2D**-dimensional to **3D**-dimensional images and more;

System of ***Universal Intellectual Interfaces*** (**UII**) **AS_VIMEN** for connection with medical equipment, is intended for linking and management of any hardware of different generations and modifications, made by miscellaneous companies, with built-in signal digitizers or without them.

If digitizing system (hardware) is not present in the given equipment the installation of **Universal Intellectual Interface** within **AS_VIMEN** network raises the equipment to a higher class apparatus since it enables computerized management with simultaneous expansion of possible operation modes previously not available internal system of operation.

Visualization of images and texts on a paper at Printer Stations with high resolution and photographic quality in a pseudo-real time, replacing traditional photos, thermo- and x-ray films (traditional sources of the medical information). Besides, perfect reproduction of results, including color images in such areas as endoscopy, pathological anatomy and other, are possible with black-and-white and color laser and jet printers.

• Linking AS_VIMeN To Medical Equipment.

The System works with various medical apparatuses (such as computer tomographer, Angio complex with DSA, computer isotope systems, computer (Ultrasound) sonography)

Apparatus with own signal digitizing and mathematical processing system are linked to network by **Universal Intellectual Interface**, providing access, change of a representation format (if there is a necessity), information transfer to and from **AS_VIMeN** (with parallel use of temporarily free resources of apparatus).

Informational communication exchange between **Global Video RAM** and is carried by bilateral synchronous copper or optical channel up to **1GBps**, transferring 1024*1024*16b format frames with 25/30 frps frequency in real time.

Joint operation of **AS_VIMeN** and workplace is provided by ***Graphic Station of Visualization*** (**GSV**) for keeping case record, the description of the images received, for communication with Network Upper level and, as a result of implementation of **UII** - devices of adaptation, connection to **Printer Station**.

Apparatus without built-in signal digitizing system (Roentgen - the diagnostic equipment with TV systems, including Angiography complexes without **DSA**, endoscopy, electronic and usual microscopy, cinema demonstration equipment – various projectors).

Built-in or additionally purchased television system under **UII** management is tuned for synchronous work with **AS_VIMEN**. At the same time the medical equipment works in special modes of operation as determined and managed by **UII**, controlled from the keyboard of **Graphic Station of Visualization**, by a choice of parameters of medical and technical process of reception and recording video information to **Global RAM**, maintaining optimum S/N ratio.

Work with **Printer Station**. When printing images the frame is sent to special processor forming printer image of high resolution (**Printer Station** features dependable) with subsequent printing operation in a pseudo-real time mode.

Listing patient case record and the accompanying documentation is provided by direct communication **Graphic Station of Visualization - Printer Station**.

Optimization of expenses for printer stations occurs because one Printer Station works with several Graphic Stations, carrying out printing of patient image(s) to paper instead of expensive roentgen- photo films.

• *GENERALIZATION*

AS_VIMEN is entirely new systemotechnical approach to designing and constructing the medical and technical computer systems, consolidating equipment rooms, network, processor and video information registration resources as the uniform synchronous mechanism within the structure of medical institution. The complex allows to increase the efficiency of studies and efficient use of expensive apparatuses by retrieving a part of their work after receiving the initial information, thus leaving apparatuses to fulfill their exceptional tasks. Simultaneously all workplaces have the same maximal potential as all of **AS_VIMeN Network**.

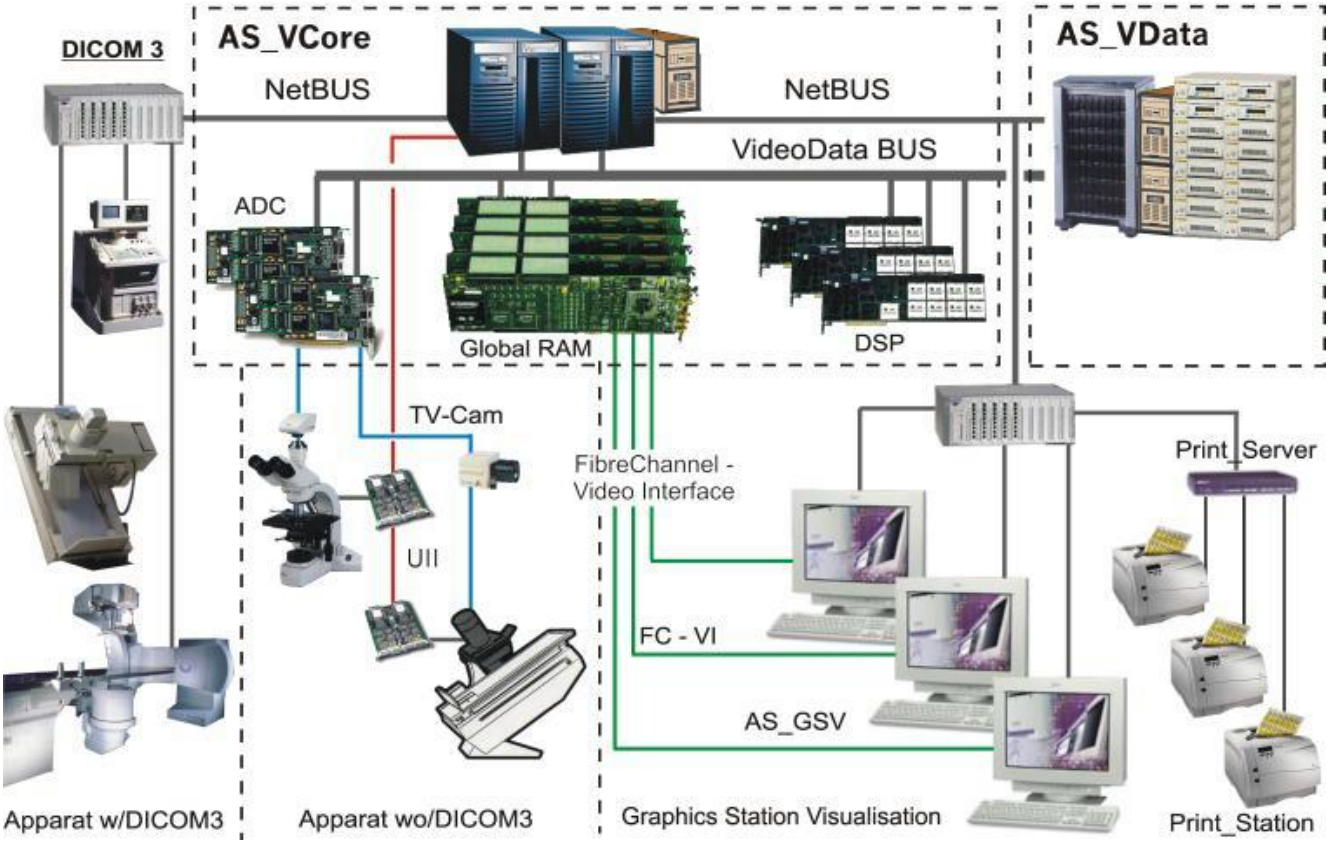
Adaptive Video-Informational Medical Network *AS_VIMeN*. **Real-Time**.

• *Medical aspects of construction of system.*

Real time **AS_VIMeN** allows:

1. To provide safety, completeness, availability and reliability of the medical information, automation of information streams and their processing in real time; Use of a computer as the intellectual tool when making decisions in diagnostic and medical application.
2. To optimize treatment and diagnostic process in clinics, to increase continuity in treatment of a patient. Adaptation to any level of inquiry of the Network Client through capacities of database and **Client-AS_VIMeN** user interface. To regulate process of patients visits on the basis of "**Network Procedures Planning**" technology.
3. The control of the use of material items, registration of operations and account for the materials and medicines used, calculation of treatment cost for various categories of patients. Thus enabling main warehouse management in different subdivision of clinic (at workplaces of Chief Nurse), including warehouses of procedure rooms.
4. To improve information interrelations between structural divisions of clinics, including administration and subdivisions, servicing clinic operation, strengthening coordination of activities between different divisions. Rational use of professional working time due to re-distribution of functions between the person and machine.

Adaptive Video-Informational Medical Network **AS_VIMeN.** The Architecture.



- ***Technological aspects of a structure of system.***

1. Maintenance of the authorized access of the personnel to the data of the patients, non-destruction of entered data with absolute binding to time, rigid administration of the data and access to them at a level of Client-To-Server architecture under MS WinNT-4.0, Win XP operational system and Inprise "InterBase" database.

2. Maintenance of integrity and safety of data by hardware-software means: **RAID** and **UPS** systems. Maintenance of ready-to-edit reference database system of complex by Medical Administrators of system, applying new technologies, materials, price calculations and categories.

3. Granting to **Medical Administrators of clinics** / divisions (as Special Users) an opportunity of creation of the individual environment of interaction with a network and patients' data presentations, using the specialized toolkit of generation of hierarchical structures and links for formalization of medical technologies and filling up of flexible Databases makes up the adaptive technology developed by authors of the project. Availability to time changes of data presented and their display to the carrier does not result in a spelling anew program maintenance, and is defined (determined) by the Honey - manager by change of the environment of interaction the User - **AS_VIMEN**.

4. Granting to the Specialized Users of an opportunity of visualization of the data of statistics and the all-round analysis of activity of the organization, drawing up of normative documents under the reporting on the basis of the Database for which last is sufficient. Adaptation to any level of inquiry of the User by opportunities of Databases.

Adaptive Video-Informational Medical Network *AS_VIMeN*. **The Basis**.

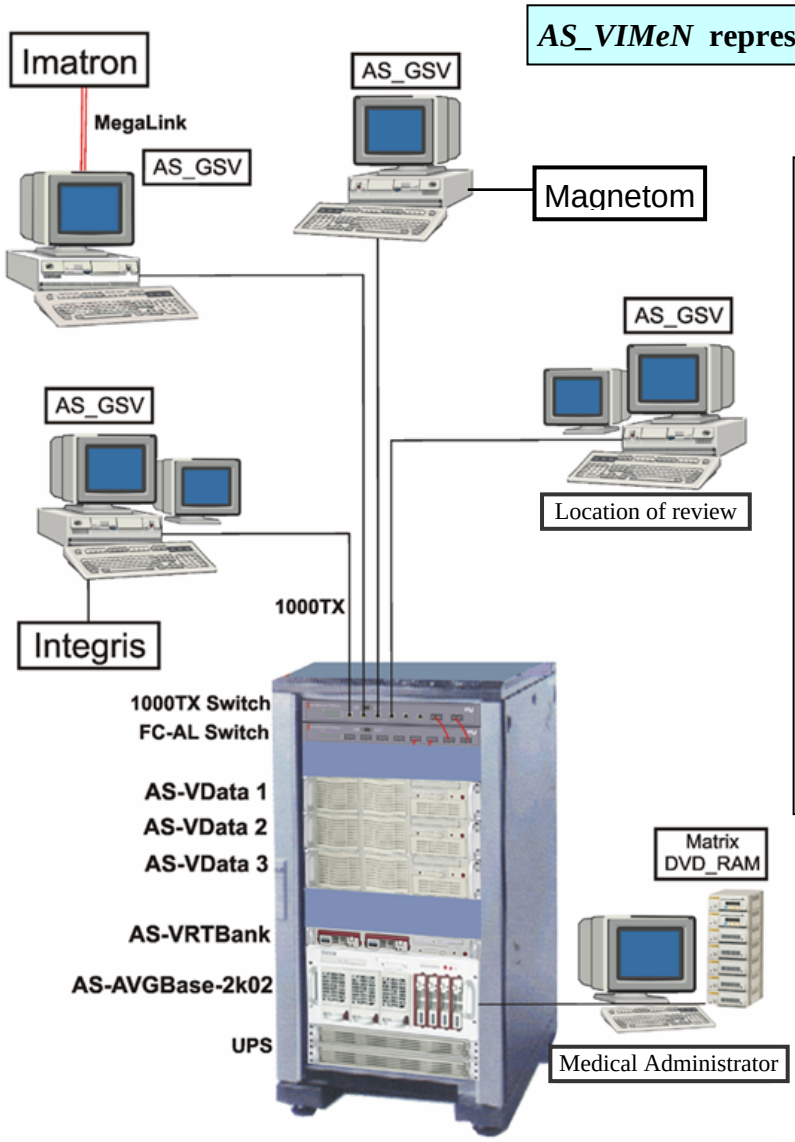
• *Bottom (User) level of hierarchy of visualized information*

– Graphic Station of Visualization (AS_GSV)

Any authorized employee (i.e. doctor, nurse) on a workstation can have access to the data of patients under the right of access protected by the password, according to the defined roles of users.

All **Graphic Stations of Visualization** are equal at the level of users - the program application is called by the personnel according to roles and password, given to the user by the **Medical Administration**, who has the right to veto on calls of certain applications or applications parts. Thus for each Role there exists corresponding 'edition' of application with various rights of access and attributes. The authorization to work with applications by password protected and rules of access, is assigned by the **Medical Administration** (of System, Clinic, Division) and according to the authorization lists. The additional applications for specialized user are loaded similarly on request according to established rights and a priority rights.

The universal identifier of the patient and "***Navigator***" on the Database and manipulations is " **the Virtual Patient** " - the unique identifier of the patient. Medical Procedures Planner represents the system of management built in AS_ViMan - the application, which using the navigator, plans treatment, schedules patient visits to doctors, counts expenses when servicing patients. Example of construction of a network element **AS_VIMeN** in medical department.



AS_VIMeN **represent software & hardware complexes:**

- The apparatus of the *Graphics Database* of the medical images **AVGBase-2k02**.
- The multicomputer *Centralized Data House* of the patients **AS-VDATA**.
- Multicomputer *Temporary Data House* of the patients of fast access **AS-VRTBank**.
- The apparatus **AS_GSV** of review, processing and visualization of the medical images **MedDigiView**.
- The apparatus **AS_GSV** of processing and visualization of the medical images **DICOM3View**.
- The apparatus of *Digitization* of the medical images of a high-resolution **ADSP-50** and conversion of datas in the format **DICOM3**.

- ***Middle - Server level of visualized information temporary storage:***
  - Local Server core AS_VTemp and AS_View viewer

Temporary DataBank is located on local server core, and contains data on patients, previously chosen and imported by user from Global, with which users work directly. From **Global DataBank** the originals of the chosen series of shootings of the patient are copied ton **Temporary DataBank**, for visualization and the viewing by **MedDigiView** application, called by the user from **AS_GSV** - Graphic Station of Visualization.

All graphic and text information processed by this or that way is saved to local server core, including newly added scripts of the processing, significant frame as chosen from a series of shooting, comments and summaries, with subsequent authorized import of data to **Global DataBank**. The information on the shooting, when exported to **Global DataBank**, is kept forever, and is available to other authorized users, besides it could be also copied to long-term archives etc

Records that are currently unused, or are already processed and imported, could be removed from **Temporary DataBank** for the pure sake of clean accessible physical space, without losing processing results.

- ***Top - visualized information Server level of hierarchy:***
  - Server core AS_VIMeN - AS_Vcore - General manager AS_VIMeN

The **Server Core**, where **AS_VIMeN** information undergoes initial processing, special protection against unauthorized access is provided. The **Server Core** keeps the data, prepares and gives out it by user inquiry, provides all-system administration, archives all data, creates backup copies, fills up **AS_VData Database**.

The information when entered to database, after confirmation of a correctness of the data, stays in remains in database forever, and can only be transferred onto long-term archive permission of the **Chief System Administrator** in strictly stipulated cases. Incorrect data becomes inactive only after realization of procedure of pseudo-destruction carried out by their **Medical Administrator**, with upon confirmation of destruction procedure issued by **Chief System Administrator**, fixing the procedure of pseudo-removal, thus the data remains on server in hidden for users form.

All medical information is systematized under the **ICD-10** international classification.

All electronic documents entered into **Database AS_VIMeN**, can serve as proof for legal disputes between the patient and any third party (clinic, the insurance company and so on).

Forbidden operations are blocked at a level of the software!!
The interrelated information can not be removed at a level of protection of base of the data.

"Network Planning" parallel procedure is implemented at server level only for systems on the basis of one clinic to supervise medical personnel of clinic and professional workplaces, to plan and account for operating time of the specialized equipment.

Adaptive Video-Informational Medical Network *AS_VIMeN*. **Program Modules**.

- ***The Modules installed on the apparatus of the** Graphics Database:*

- **Patient-Navigator** – module of the **Graphics Database** with possibility of import of datas from the format **DICOM3**;
- **RAW-SDIConv** – module of conversion of datas in the format **DICOM3** under the control of the **Graphics Database**;

- ***The Modules installed on computers of** Centralized Storages – Patients Data House:*

- **SDIC-RAWConv** – module of decoding of datas from the format **DICOM3** in the format **RAW** in **Temporary Storage** under the control of the **Graphics Database**;
- **Opto-Archive** – module of archive storage on **DVD-RAM** for restoring the lost datas of the patients;

- ***The Modules installed on** Apparatuses of Processing and Visualization:*

- **1MedDigiView** - module of stream processing and visualization of the graphic datas, with output to the second graphics screen monitor of a high-resolution (2048*1536), or
- **2MedDigiView** - module of the extended processing and visualization with possibility of simultaneous output on the screen monitor of a high-resolution of two (2048*1536) selected images for the comparative analysis:
  - One module **1MedDigiView** or **2MedDigiView** on each apparatus of visualization;

- **1ZoneView** – module of a Zonal graphic data processing visualization, raised by the module visualization and processing with output to the second graphics screen monitor of a high-resolution (2048*1536), or

- **2ZoneView** – module of the extended Zonal Processing with possibility of simultaneous output on the screen monitor of a high-resolution of two (2048*1536) selected images for the comparative analysis:
  - One module **1ZoneView** or **2ZoneView** on each apparatus of visualization;

- **MeasGraph** – module of measurings and applying of psevdo-graphics units;

- **Opto-CD** – module of recording on **CD-ROM** the disk of results of researches - for transmission to the patient with the system of visualization of datas on any computer;

- **ViewPrint** – module of review, preliminary printed processing and immediately of printing of the selected results with the conclusion on them;

- **Doc-WriView** – module of creation of accompanying documents: the descriptions, conclusions, diagnoses (addition to the unit of printing **View-Print**). The extension up to **PDF** of the document in the unit **PDF-WriView** is possible.

GLOSSARY OF TERMS

ADC – Analog-to-**D**igital **C**onverter – system of video digitizing for different TV-standard signals coming from medical equipment.

ADM – system of real time video digitizing of medical equipment TV-signals based on DSP-processor by TI TMS320C6201.

AGVBase2000™ – graphic database with support of DICOM3 files import.

AS_DICOM3 – server for collection and storing DICOM3 format files for further processing and export to graphic database

AS_GSV™ – Graphic **V**isualization **S**tation – hardware and software complex for real time and pseudo real time processing of graphic images containing patient data.

AS_VCore™ – Server **C**ore for primary processing and storage of graphic information with further output according to the request of User. Administration of the system.

AS_VData™ – fast dynamic array of data storage with hardware mirroring and protection systems. Consists of two components ***Matrix RAID*** and ***Matrix DVD-RAM***.

AS_VIMeN™ – Adaptive Videoinformation Medical Network - complex system of automation of clinic and inter-clinic exchange.

AS_VIMeN-IC™ - Adaptive Videoinformation Global Medical Network – complex system of automation of inter-clinic exchange.

AS_VIMeN-RT™ – Adaptive Videoinformation Real Time Medical Network - complex system of automation of inter-clinic exchange in real time.

AS_VServ – Server support at the level of AS_DICOM3 group of servers and **General Data Server** itself.

DSP Board - Digital **S**ignal **P**rocessing **– signal processing system based on** DSP–processors produced by TI and of TMS320C6xxx series.

Equipment w/DICOM3 –DICOM3 standard medical equipment.

Equipment w/o DICOM3 – medical equipment without built-in system of signal digitizing

FC-VI™ – Fiber **C**hannel **V**ideo**I**nterface **–** system of synchronous video data transfer in real time mode to be displayed at Users monitor(s).

File-VideoFrame™ – universal data format for representing video flow data in unified standard

General Data Server – Servers within AS_**VServ** for processing graphic databases

General DATABANK – consists of **AS_VServ** and **AS_VData**

Global DATABANK – unified inter-clinic patients' database.

Global RAM – system of storage of graphic data with parallel data output to several users simultaneously in real time mode, including cine-mode.

ICD-10 – International Classification of Diseases

Matrix DVD-RAM – hardware complex of matrix optical disk drives for archiving and back-up purposes.

Matrix RAID – hardware complex of matrix HDD drives for secured storage and fast access to graphic database

MedDigiView™ – application for viewing and visualization of patients' graphical data

Medical Administrator - Medical Administrator of the system. Carries out DICOM3 files import, amends and edits **ICD-10,** issues passwords and access level for graphic database users.

Medical Recorder – system of data printing to paper, films and so on.

NetBUS – multichannel network bus

Network Client – authorized user of **AS_VIMeN/IC/RT™**

Patients' DATAHOUSE – system of global storage, processing and output of patients' information consisting of **Global DATABANK** and **Network Layer**.

Print_Server – print server.

Print_Station – network print station.

Switch (Network) – fast network parallel switch of data flows

Technical Administrator – person responsible for system function**.**

Temporary DATABANK – databank for temporary storage faster access and visualization patient graphic data.

Network Layer – network infrastructure with fast access.

UII™ – Universal **I**ntellectual **I**nterface **–** adaptive system for managing complex objects – medical equipment - such as Roentgen apparatus, Angiosystems and so on.

VideoData BUS – specially designed bus for fast synchronous graphic data transfer in File-VideoFrame™ format

Virtual Patient – method of representing a patient by anatomical systems and objects.