TOWARDS IMAGE PROCESSING —
DEVELOPMENT OF A STRATEGY FOR A RADIOLOGY DEPARTMENT

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1 Motivation

The fast development of very effective but expensive digital image-processing tools in radiology has forced every larger radiological department to streamline its financial budgets for the coming decade mainly into that direction. Today 20–30 % of the patient examinations in academic radiology departments result in digital images [8,15]. New modalities for high resolution digital radiography, which enable the inclusion of classical X-ray diagnostics, will increase this percentage. It is presumed that digital examinations will make up to 50 % in 1990 and 80 % in 1995 [7,15,29].

Today digital images are often copied to films (so-called hard copies), to be then demonstrated, reported and archived. This re-introduces all typical disadvantages of the analogue method into a partly digitized flexible approach — delays due to film developing and transportation and time-consuming searches to get access to the X-ray films. This is why radiologists are asking for a comprehensive system standardizing the processing, elaboration, examination, transportation, storing and archiving of digital pictures.

Technically, the demands on such a Picture Archiving and Communication System (PACS) have considerably increased since 1982 [2]. Today, an “ideal” PACS is understood as a high-speed Local Area Network (LAN) able to digitally receive pictorial data online from any picture-processing unit, archive them centrally and allow for their access and manipulation at different diagnostic consoles. Additionally, film-copying as well as film-digitalization units form part of a PACS [23]. Besides the actual picture information a PACS should also provide all concomitant information in such a way that the authorized user can easily use them for the diagnostic process. This information has been handled for many years in so-called radiological information systems (RIS). Therefore, it is necessary to establish relationships between image data (PACS) and patient data (RIS), to organize image flows according to the work flow, to administer image stores according to access criteria and to create access mechanisms allowing for connections relevant to diagnoses. To this end, radiologists are looking for a complex data processing system which allows processing of all non-pictorial information [20] as well as pictorial information: the interfaced RIS-PACS.
2 Implementation Strategy

There are different reasons why the long-term aim of a RIS-connected comprehensive PACS (filmless radiological service) in a hospital can only be implemented in several steps [9,17,22,28]. Besides economic aspects and technical demands regarding storage capacity, modus of transfer, picture quality, standardization of communication and interfaces [6,18,19] there are problems of acceptable man-machine interaction, functionality of digital workstations, data security, etc. to be solved.

PACS have hitherto only been realized partly as laboratory installations [3,5,11,16], whilst RIS are already in routine use in many hospitals [1,4,21,26]. When introducing a PACS step by step it is important to follow an overall concept [16]. This was formulated for the Marburg Radiology Department in 1986 in cooperation with the Department of Medical Informatics and the hospital administration (Table 1). After phase 1 a commercial vendor was selected who could implement RIS and PACS and all further planning was done cooperatively with this vendor.

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<th>Phase</th>
<th>Activity</th>
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b. Establishment of a raw concept as to the computer assisted organization.  
c. Selection of a RIS/PACS vendor. |
| 2 (1986/1987) | a. Installation and implementation of the RIS.  
b. Change department from manual organization and thinking to computer supported organization and thinking. |
| 3 (1988) | a. Re-analysis of the department and its services for the hospital and for teaching.  
b. Establishment of a concept for the stepwise introduction of a PACS.  
c. Preparation for the installation of PACS.  
d. Define research project to measure efficiency of various problem-oriented diagnostic imaging strategies. |
| 4 (1989-1992) | a. Connect existing digital modalities to PACS. Install a limited number of technically elaborate workstations and several simpler workstations with limited functionality and lower resolution.  
b. Run network between the different available digital modalities and PACS.  
c. Replace conventional examination methods for thorax and skeletal diagnostics.  
d. Utilize PACS for teaching.  
e. Link wards, operating theatres, intensive care wards, etc. to PACS. |

Table 1: Milestones in RIS-PACS implementation.

3 Medical Research

The PACS concept allows the introduction of a wide range of digital methods for picture evaluation [6,8,22,27]. These include methods for quantifying picture and object parameters, methods for image enhancement, image reconstruction, and pseudo three dimensional representation as well as pattern recognition techniques for a preselection of findings [20]. Parallel to the implementation of the RIS-PACS system, intensive research will have to analyze which methods should be cost-effectively applied to which medical questions and their corresponding levels of specificity and sensitivity. These aspects which are enumerated at the end of the book are part of the stepwise introduction of PACS into radiology, which has to accompany every installation strategy for expensive medical equipment.