2008

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A PACS integrated situational alignment framework:
a quantitative approach for successful PACS alignment and performance assessment in hospitals

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Abstract

Hospitals are investing in Information Technology and Information Systems in order to improve their processes and workflow and hence, to optimize patient care. Picture Archiving and Communications Systems (PACS) have seen gradual uptake in hospitals to achieve this goal. PACS implementations and the consecutive expansion and integration with the Electronic Patient Record requires massive investments and cultural changes by hospital (clinical) staff prior and during organizational adoption. It is therefore essential that these systems are aligned properly with the hospital operations. Alignment approaches for PACS implementations and appropriate assessment methods have been underexposed in scientific literature. In this paper, we propose the PACS integrated situational alignment (PISA) Framework, a theoretical framework that is designed for the continuous assessment, monitoring, successful alignment of PACS, and performance measures for PACS deployment in the hospital enterprise. In addition, we set out a research agenda to elaborate on this elementary topic.

Keywords: Picture Archiving and Communication Systems, Business/IT-alignment, maturity, performance measures, deployment

1 Introduction

In the constant changing health care environment, hospitals are obliged to utilize the full potential of Information Technology and Information Systems (IT/IS). Hospitals have taken on this challenge by moving towards filmless operations and investing in Picture Archiving and Communication System (PACS) [1]. PACS are workflow-integrated imaging systems that are designed to streamline operations throughout the entire patient-care delivery process [2] and encompass many components and systems related to medical imaging for clinical practices [3].
While the promise of PACS is that it can shorten the time for diagnosis, improve the efficiency and quality of the overall healthcare delivery process and make the workflow as simple as possible [2], fact-based evidence is missing. While the particularly benefits from earlier receipt of images, clinical decision making and clinical action through PACS images are hard to measure [4, 5], PACS performance has been indicated in terms of time studies for diagnosis and image based clinical action [2, 4, 5], patient throughput and productivity [6].
Although some scholars believe PACS will quickly be a matured technology [2], achieving a full filmless environment with PACS is still a high-cost venture [7]. It is therefore essential that these systems are aligned properly with the hospital operations. Often, hospitals fail to achieve higher productivity levels and operational efficiency gains with PACS, because of deployment complications [8]. In their studies Reiner et. all state that a common mistake by radiology facilities has been underestimating the potential major role that PACS has in the redesign of departmental and enterprise-wide workflow and processes [8]. A method for implementing and aligning PACS in the hospital enterprise is therefore a prerequisite that has not been developed so far on a scientific basis.

In this paper we present such a model to assesses the alignment of PACS and the PACS performance in hospitals. Since PACS is a system designed to streamline operations through the entire patient-care delivery system, it can make a significant difference in terms of throughput and clinical action. It is our starting point that theories on Business/IT-alignment, organizational fit and adoption of IT/IS provide perspectives to understand what key elements in clinical practice can be achieved [9]. Given the potential of PACS to improve productivity levels and operational efficiencies within hospitals, the question we address in this paper is as follows: *"1) how can PACS alignment and performance measures for PACS deployment in the hospital enterprise quantitatively be assessed, monitored and benchmarked and 2) how can this be improved?"*

Our approach encompasses two fundamental elements: Business/IT-alignment and PACS maturity. In general, a maturity level can be defined as an evolutionary plateau of process improvement that includes a checklist to evolve on to the next level [10]. PACS maturity refers to an evolutionary process from an immature stage of growth/maturity towards the next maturity level. From this, we assume that the deployment and adoption process of PACS is of cumulative nature. A hospital has to go through different levels of maturity before PACS is successfully implemented and optimum PACS performance is achieved. Business/IT-alignment additionally implies that the investment made in business domains, pillars, related to PACS should be balanced out in the organisation.

In this paper we present a framework - PACS integrated situational alignment (PISA) framework that aims to assess the alignment of PACS in the hospital enterprise and its relation with performance measures for PACS deployment. In doing so, we well first review levels of PACS maturity, addressing the principles of Business/IT-alignment and PACS performance perspectives. Subsequently, we develop a framework, discuss the obtained framework and set out a research agenda for application and validation. The paper ends with a summary and conclusions.

2 PACS integrated situational alignment (PISA) framework

In this section we propose the PISA framework resulting from different levels of PACS maturity, fundaments of Business/IT-alignment and PACS performance dimensions.

2.1 PACS Maturity

The concept of PACS was introduced as early as 1982 and after more than twenty years of research, development and implementations, PACS has become an integrated component of today's healthcare delivery system [11]. Although PACS is now a well-established technology, achieving a filmless environment with PACS is still a high-cost venture [7]. A successful method for implementing and aligning PACS in the hospital enterprise would therefore be a prerequisite, and insight into the current and desired level of maturity of PACS valuable to the hospital.
Theories on information systems and information technology (IS/IT) maturity and adoption are well established in business and IS/IT literature going back to the early 70's. The concept of the stage hypothesis was introduced by Nolan [12] in 1973, extended [13] and frequently discussed and adapted [14-16]. In general, the IS/IT maturity models provide insight into the structure of elements that represent process effectiveness of IS/IT in organizations [17].

A qualitative meta-analysis approach [18, 19] is performed over 34 relevant scientific papers on PACS. These 34 papers all concern maturity, growth and development aspects of PACS. Five levels of PACS maturity can be extracted from these original sources by applying a process focus. With the progression towards maturity level 5, operational efficiencies, IS/IT-integration and qualitative care using PACS technology expand. The five maturity levels are:

I. PACS Infrastructure
The initial level of PACS maturity is described as the basic and unstructured implementation and usage of image acquisition, storage, distribution and display. Technical and organizational problems arise with PACS at this maturity level owing to the lack of implemented (technical) standards and the dramatic "cultural" changes that would result from PACS implementations [20].

II. PACS process
At level two most of the initial pitfalls have been covered by second generation PACS implementations [8, 21, 22]. The PACS process maturity level focuses on effective process redesign, initial integration with various (imaging) information systems including the HIS and RIS [23], optimizing manual processes in radiology and initiating transparent PACS processes outside radiology. The focus of this maturity is still only on medical images and is therefore restrictive in managing (hospital) workflows.

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III. Clinical Process Capability
The "clinical process capability" maturity level is represented by the evolution of PACS towards a system that can handle workflow and patient management [24], hospital-wide PACS distribution, communication and image-based clinical action. This evolution of PACS requires important alterations in terms of processes, multimedia data and the level of integration of health information systems.

IV. Integrated managed innovation
This fourth level of maturity can be characterized by the initial integration of PACS into the electronic patient record (EPR) and cross-enterprise exchange of digital imaging data and supporting material. This maturity level goes beyond the 3rd maturity level with the adoption of emerging technologies like computer-aided diagnosis (CAD) and computer-assisted readings (CAR), resulting in decision support for clinical PACS usage. At this level PACS is also applied for statistical information [25], intelligent data-mining purposes and quantitative control mechanisms [26].

V. *Optimized Enterprise PACS Chain*
The final maturity level is the "optimized enterprise PACS chain". At enterprise level, and with PACS fully integrated into the EPR, the system can be maximized for efficiency purposes and clinical effectiveness [27]. Process characteristics at this maturity level include PACS and web-based technology, large system integrations, see also [28] and image distribution though web-based EPR [26]. The adoption of PACS within the wider EPR and healthcare facility integration is continually optimized and the operational improvements yield process innovations and overall efficiencies in the continuum of the patient-care delivery process.

We use the maturity concept as one element of our framework. Another element of our framework is the concept of Business/IT-alignment, which will be discussed next.

2.2 Business/IT-alignment theories

Business/IT-alignment refers to applying IT/IS in an appropriate and timely way, in harmony with business strategies, goals and needs [29]. It addresses both how IT/IS is in harmony and how it should be aligned with the business domain. The classical Strategic Alignment Model of Henderson and Venkatraman [30] is the best known model for leveraging and aligning IT/IS in organizations. The scholars argued that the difficulty to create value from investments in IT/IS is caused by the lack of alignment between the business - and IT strategy. Furthermore, they reasoned that a dynamic process to ensure continuous alignment between the business and IT/IS domains is of main importance and is to often lacking in organizations. These dimensions require strategic fit and functional integration in order to leverage the value of IT/IS.

Subsequently, Turban et al.[31] developed a model for Business/IT-alignment which incorporated culture, individual and individuals and roles as relevant dimensions that – next to organizational strategy, management of business processes and organizational structure – are assumed to contribute to the successful implementation and adoption of IT/IS in organizations. All these dimensions contain mutual relations with each other and should be in equilibrium as long as no significant changes occur in the environment or in one of the components. When changes do occur in one of the dimensions, their model argues that this will have a significant effect on other dimensions as well.

A shortcoming of the Turban et al. model is that it does not clearly demonstrate how the components of the model interact and dependent on each other. This lack was addressed by Scheper [32] leading to another extension of the business/IT concept and model. Scheper restructured the model by defining the following five dimensions:

(1) Strategy and Policy: this dimensions concerns the organisation of strategy and policy processes;
(2) Organization and Processes: concerns the importance of processes as a basic principle for organisational development;
(3) Monitoring and Control; this dimension focuses on financial and non-financial monitoring and control by the management;
(4) Information Technology; concerns the way organisations deal with information technology: hardware, software and infrastructure;
(5) People and Culture: this final dimension reflects the value and significance of the employees for an organisation.

Different from the other alignment-models, Scheper additionally developed levels of maturity for each of the five dimensions (ad-hoc, process, system and chain level). Doing so, alignment can actually be measured by the comparative levels of maturity on each of the five dimensions. The differences between the positions of an organization on each of the dimensions (i.e. the 'gaps' between the dimensions) determine the level of alignment. Obviously, the absolute maturity level should also be incorporated, as it becomes more difficult for organizations to achieve alignment when business dimensions are highly matured. Scheper's model then defines the performance of the organizations in two ways:

1. The level of maturity on each of the five dimensions and

2. The alignment between the five dimensions.

Scheper's hypothesis states that maturing on each dimension and balancing out the different dimensions will significantly improve the performance of organizations.
Empirical evidence for this model was obtained through the application of the model in Dutch housing corporations. The model has been also been applied to the field of Customer Relationship Management, Product Lifecycle Management and e-procurement [33-35]. In all cases, the assumed positive relationship between maturity, alignment and performance was supported by empirical survey among 30 to 60 Dutch organizations

Our integrated alignment framework for PACS will be based on the five dimensions of Scheper's alignment/maturity model. Next to this, PACS performance is third element our framework is build on. This will be the topic of the next section.

2.3 Enterprise PACS performance dimensions

A world-wide applied approach to an integral evaluation of organizational performance is the Balanced Scorecard (BSC) as developed fifteen years ago by Kaplan and Norton [36, 37]. The BSC is a performance management model that provides a comprehensive view on the business's most relevant issues and improvements. Not only does the BSC provide a measurement framework, that improves alignment of actions to the strategic goals of an organisation, it also provides a platform for identifying priorities [38].

In health care, the BSC has been particularly embraced on the clinical side as a tool for measuring and improving the quality of care [39]. Hospitals are starting to adopt performance measurement systems like the BSC and as the industry experience with the BSC grows and successes are shared, use of the BSC in healthcare is continuing to expand [40].
In a previous study [9] the BSC has been adapted to incorporate a wide range of non-market performance measures according to the hospital's strategic perspectives. In addition, it was applied to identify those components that are essential to the workflow of a patient's clinical journey. To do so, the BSC was transformed based on their relevance to workflow, PACS and consistent with fundamentals of hospital strategies [41]. This process has lead to a new model, the *PACS-BSC* [9, 42, 43].

The *adapted* PACS-BSC model retains Kaplan and Norton's intention to evaluate outcomes from the perspective of the organizations' strategy and to be flexible to whatever those outcomes and strategy may be. It has been validated case study interviews, using qualitative coding as a method [44]. Obtained data were reviewed on three different occasions using open, axial and selective coding respectively. The coding process resulted in the following selective codes, categorized according to the four dimensions of the PACS-BSC model which could be used for structured evaluation purposes:

- *Clinical Business Processes*: Diagnosis Process, Time Savings & Image-Based Clinical Action, Organisational Communication and Examination Request & Report-Turnaround-Time;
- *Quality and Transparency*: Simplicity & Transparency, Quality of Workflow and Agile Workflow;
- *Information System*: Availability & Accessibility, PACS Integration and System Robustness;
- *Patient*: Patient Waiting Time and Patient Throughput & Flow.

The PACS-BSC supports the process of integrative evaluation of PACS impacts on hospital workflow in terms of the patient's clinical journey [9, 42, 43]. The adapted PACS-BSC does not support the measurement of quantitative performance measures that are required when analysing PACS alignment and performance measures for PACS deployment. For this, an overview of relevant and most used performance measures / metrics is required. It will be part of our framework to select the relevant performance measures for PACS deployment.

2.4 PISA framework

Our conceptual framework is depicted in Figure 1. The figure consist of three elementary components. Five PACS maturity stages are depicted on the horizontal axis and on the vertical axis the five business dimensions. At the bottom we find the third part of the framework: PACS performances divided into four dimensions containing different categories.

We designed the PISA framework as an instrument to measure alignment of PACS in the hospital enterprise and performance for PACS deployment in order to mature PACS towards a higher level of maturity resulting in higher PACS performance. The PISA framework measures PACS maturity for each of the five business dimension. Figure 1 depicts a possible outcome of such an assessment using our framework. The maturity score on each business dimension is represented by a dot. As argued above, we define perfect alignment of PACS if the dots form a vertical line in the different business dimensions. The framework claims that alignment of the business dimensions is positively related to PACS deployment performance by its four performance dimensions. The framework can be made situational by adapting what is defined as 'to-be' and 'best-practice', hence enabling the measurement, monitoring, and comparison of PACS alignment through self-assessment in the hospital enterprise.

For the operationalisation of the framework, we will develop a measurement (i.e. a questionnaire) containing for each business domain several specific PACS features we want to address. Based on these features, items will be formulated, 10 to 15 (2-3 per maturity level) for each of the five business dimensions (strategy & policy, organization & processes, monitoring & control, information technology and people & culture and). Subsequently we will pre-structure the answer categories in order to link the questions to each of the five PACS maturity levels.

Specific PACS features that will be included in the questionnaire include the following:

1. *Strategy and Policy*: description of a PACS strategy; PACS alignment with other hospitals; monitoring of PACS innovation (in the market);
2. *Organisation and Processes*: image and document distribution; re-engeneering of PACS processes; image based clinical action; clinical diagnosis and decision support;
3. *Monitoring and Control*: workflow monitoring, (business) continuity management, status and patient management;
4. *Information technology*: system integration; capacity management, system functionality, integration within the EPR; chain integration
5. *People and Culture*: PACS (processes) training and PACS process/procedure knowledge.

Typical performance measurements for PACS deployment are: patient throughput [6], patient satisfaction, report turnaround time, image and report availability, average patient's stay, accessibility of previous examinations [45], time to image availability and time to image based clinical action [4, 5], (radiologist) diagnostic accuracy [46] and effective clinical communication [47].

Both the PACS specific features for each of the business domains and the PACS performance measurements require further specification, development and validation before the framework is empirically applied. Note that the PACS performance measurements are independent of the maturity part of the framework.

The constructed PISA framework provides hospitals with an instrument to assess, monitor and benchmark PACS alignment and PACS deployment performances. With the outcomes of such an assessment, hospitals can formulate a strategy to optimize PACS alignment and improve the performance of the adopted PACS system. The PISA framework currently does not directly provide steps to improve alignment. For this purpose a set of measurements can be defined which are organized into projects that take into account the risks involved, investment costs, critical success factors and benefits.

However, the outcomes of an assessment can be used as good starting point in order to align all business dimensions to the same PACS maturity level using a situational roadmap.

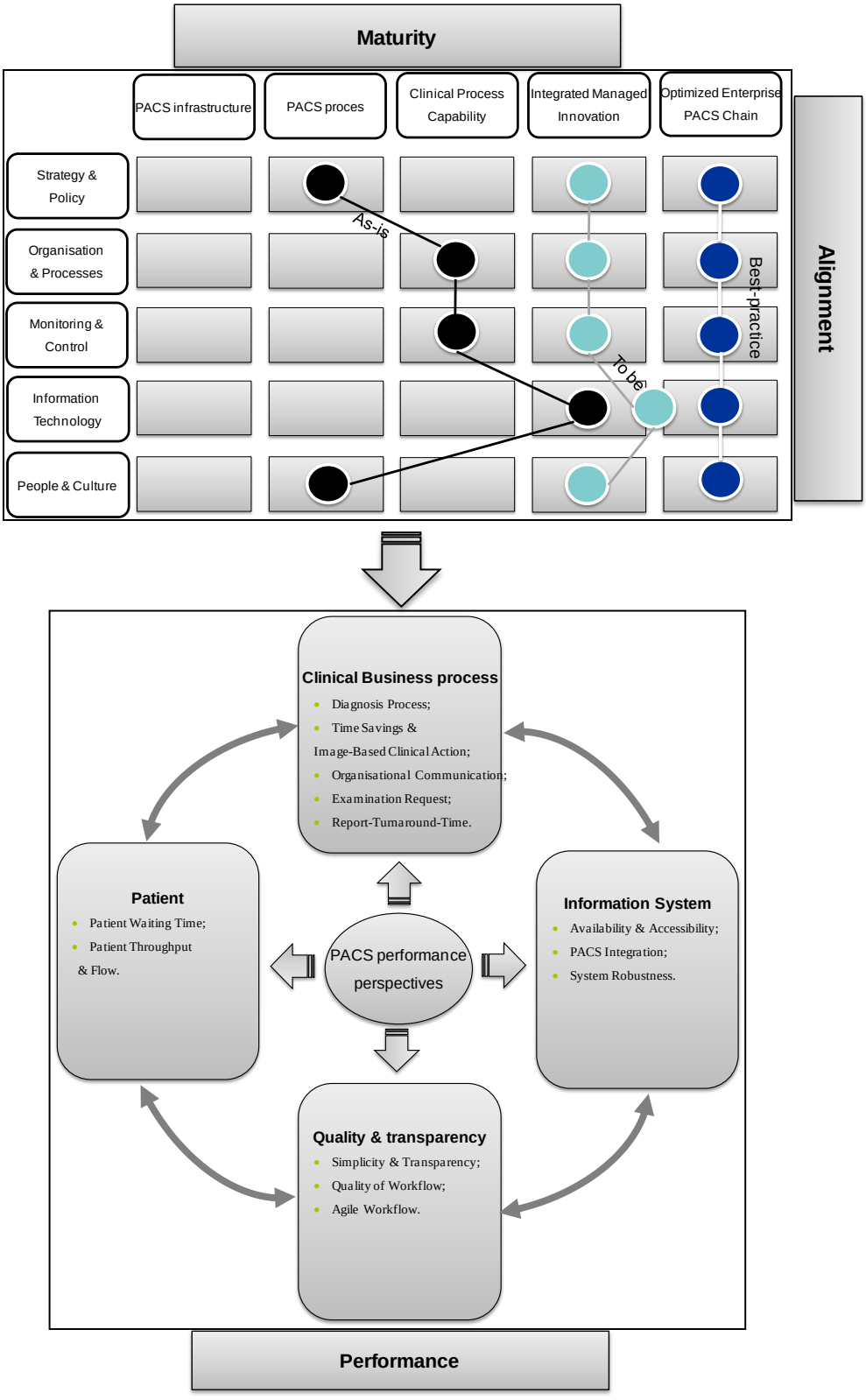

Figure 1: the PACS integrated situational alignment (PISA) framework

This situational roadmap should describe the current level of alignment (as-is) and the ambition the hospital has with PACS (to-be). Consecutively, actions should be monitored in order to bring a the hospital to the next level of PACS maturity and alignment. Based on the PISA framework we suggest the following elements to be included in such a situational roadmap for PACS:

- Step 1: assess the current state of PACS alignment in the hospital using the PISA framework (and corresponding questionnaire). This should be done by a relatively small group of radiologist, IT-management, nurses, physicians, doctors so a comparison can be made between the scores. This allows for discussing purposes;
- Step 2: Next to a current state, also a "to-be" situation should be determined. This is done in the exact same way as step 1 with the difference that now the questionnaire should be answered with a focus on the ambition the hospital has with PACS, the "to-be" situation;
- Step 3: Scores should be benchmarked against the best-practice in the hospitals. Based on the "as-is", the "to-be" and the best-practice, a growth path can be determined. Important to note is that hospitals should critically benchmark their scores with the best-practice since best-practice level (Optimized Enterprise PACS Chain) could be irrelevant for their particular situation;
- Step 4: Determine the desired maturity level and growth path for PACS. This can be done by highlighting the low-maturity dimensions (for instance strategy & policy) and compare these with the desired level of maturity (could be best-practice). Hospitals should not be too ambitious in wanting to grow more than one maturity level at the time;
- Step 5: Set out all improvement activities and make deliberate investments that are required in order to achieve the desired level of PACS maturity and alignment. As mentioned earlier, for this purpose a set of measurements can be defined which are organized into projects that take into account the risks involved, investment costs, critical success factors and benefits. In the course of the execution of all (hospital-wide) activities, the level of alignment between the business dimensions should monitored. Good governance and control is important in order to oversee the impact of investments and monitor the level of alignment.

3 Discussion & conclusions

Applying theories of alignment in the field of PACS and medical informatics is a relatively new concept that is currently lacking in scientific literature. With this paper, we believe that we have made a contribution to the theoretical and empirical application of PACS alignment. We demonstrated that the alignment perspective can be applied to a specific technology within the medical informatics domain. Based on previous studies on PACS and accompanying results, we conclude that optimal PACS performance is dependent on important organizational aspects of hospital operations. We have taken on these suggestions and elaborated on organizational alignment of PACS with the introduction of the PISA framework.

Therefore, this alignment framework addresses the main organizational and PACS dimensions that require careful attention when implementing PACS and realize optimal PACS performance.

The PISA framework provides a practical framework for hospitals that want to assess PACS alignment, or are deploying a PACS system, and hospitals that are aiming to start with this trajectory. We explicitly incorporated performance measures for PACS deployment into our framework since perfect alignment is a prerequisite for optimum PACS performance.

The PISA framework is specifically developed for PACS. However, the concept of applying an alignment perspective can also be applied to other medical IS/IT projects. For this purpose the framework requires adaptation. Specific maturity levels need to be developed (for instance using meta-analysis) – and for each business domain several specific features - and also the performance dimensions need to be customized. The concept of applying an alignment framework to other medical IS/IT through generalization is a topic for further investigation.

Before the constructed PISA framework will be empirically applied to all Dutch hospitals, a user group discussion using groupware software will be organized in order to validate the framework. We will invite

professionals working in hospitals, consulting business and medical informatics industry. After this validation, the framework will applied to all Dutch hospitals using PACS and data will be collected using online surveys. The obtained results will be analyzed using multivariate statistical analysis for measuring the relationship between the level of alignment and performance measures for PACS deployment.

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