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Deliverable 11.1 « Conceptual model of £1000 scanner for health care and maintenance case study »

“Constructing and Evaluating "as-is" and "to-be" OPM Models for the Healthcare sector for adoption of Vscan” : a use case to evaluate OPM respect to Virtual reality usage.

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Summary and scope of the document:

Current healthcare systems are no longer sustainable; governments around the world have come to realise that the rapidly growing demand for healthcare cannot be matched by sufficient financial resources, and that improving efficiency and cutting costs is not enough. Given this background, this report presents a systems approach to developing affordable business models based on the specific case example of novel portable ultrasound scanning device – the GE Vscan – for use in primary care. We investigated whole system changes required for adopting Vscan. Systems engineering principles are applied to represent alternative business models around this technology. Object Process Methodology (OPM) is utilized to visualise the conceptual models in order for subject matter experts to successfully

SEVENTH FRAMEWORK PROGRAMME

Project funded by the European Commission under grant agreement n°262044

participate in the development and validation of alternative healthcare systems. Through this use case, we will try to demonstrate the relevance of using virtual reality systems provided by Visionair infrastructure in order to emphasize the benefit of visualisation and interaction methods.

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1. Introduction

Medical advances, improved nutrition and better social care mean that people are living longer. Life expectancy in the UK now exceeds 80 years of age [1]. However, this change in demographics comes with extra social costs: the percentage of patients treated within the primary care system displaying age-related illnesses continues to increase. As the UK Government continues to look for ways to reduce public spending, the National Health Service (NHS) comes under increased pressure to improve efficiencies and increase services for the same level of funding year on year. Therefore, the challenge to healthcare providers is essentially to do more with less. Whilst optimisation and waste reduction will be part of this strategy, the identification and adoption of innovations that make the system more efficient and more effective will be critical to its future success.

Disruptive Innovation (DI) brings together the development of ‘simplifying’ technology with innovative business models that have the potential to deliver high value to new and existing markets. Vscan is such a device, which was launched by GE Healthcare in 2009. It is a pocket-sized ultrasound device, which can be used in the diagnosis of a range of medical conditions, such as aorta aneurysm, stroke, deep venous thrombosis, and gall stones. The ability to use such a device within the primary care will reduce the cost of such procedures, free up capacity of much larger complex systems at hospitals, speed up the diagnostic process, and be less stressful for patients. Whilst Vscan has the potential to deliver the benefits the NHS needs, there are challenges to overcome before its widespread adoption in Primary Care. One major challenge is the ability of healthcare professionals to use the device with relatively little training. These hurdles may be addressed by exploiting the portability and low cost attributes of the technology in combination with a Product Service System [2].

The project described here addresses some of the challenges in communicating complex business models to potential end users. This is a major contribution to the VISIONAIR project, where the findings from this joint research activity feed into structuring complex decision making. The aim of this project is to adopt a systems approach to developing affordable business models based on the GE Vscan for use in primary care, which is considered to be an example for disruptive innovation. The report is structured as follows: Section 2 presents literature review, covering research associated to innovation, business models, and conceptual modeling approaches. Section 3 provides an overview of the methodology that was followed for the study. In Section 4, we present the current processes for patient scanning, and offer innovative business models to tackle issues faced. Section 5 presents the results from validation and finally Section 6 presents the discussion and conclusions. The contents of this report have been included in a paper for the Conference on Systems Engineering Research (CSER’13).

2. Literature review

2.1 Innovation

According to the UK Government's Department for Business Innovation and Skills, "Innovation is the process by which new ideas are successfully exploited to create economic, social, and environmental value". Innovations can be seen as falling onto a continuum from evolutionary to revolutionary [3, 4, 5, and 6]. In today's rapidly changing competitive world, people expect unique and different products and services, which can be achieved through creativity and innovation. An ultrasound scanner is a good example: The vast majority of ultrasound scanners used across almost all the hospitals in the world are bulky, costly, and heavy. Customers and users of this equipment expect, and will welcome, any change that would bring transformation in the size, portability, look, price, accessibility and ease of use of this device [7, 8]. Innovation does not only mean coming up with an entirely new product service system [9]. It must also entail enhancing the existing product or service with a corresponding business model for better ways of adapting and using it, providing new, extra services with new features, and transforming its aesthetics [10, 11]. Several types of innovation should be considered:

- Incremental innovation – when an existing product or service is improved or upgraded.
- Radical innovation – when companies' new products or services are "new to the world" and based on breakthrough technologies.
- Disruptive innovation – the term disruptive innovation has been used to describe highly revolutionary or discontinuous innovation, in which products or services which were not available before are offered to customers [12].

There are several definitions of disruptive innovation, which serves as the case example context. Christensen [3] has postulated the theory of Disruptive innovation. He has defined a disruptive innovation as "…an innovation that cannot be used by customers in mainstream markets. Disruptive innovations either create new markets by bringing new features to non-consumers or offer more convenience or lower prices to customers at the low end of an existing market." Christensen and Rosenbloom [11] stated the following key characteristics of a disruptive innovation:

- A disruptive innovation targets customers in new ways.
- A disruptive innovation reduces gross margins.
- Disruptive innovations do not improve performance along a trajectory traditionally valued by customers.

- Disruptive innovations introduce a new performance trajectory and improve performance along parameters different from those traditionally valued by mainstream customers.

2.2 Business Models

One of the most crucial points of a business strategy is its business model. In order to make business models understandable to all the stakeholders involved, including managers, implementers, and users, alternative business models need to be described visually in a standardized way by a conceptual model. Despite the proliferation of Multi Agent modelling systems, their support for software engineering characteristics, notably accessibility, expressiveness and flexibility, is not sufficient [13]. Different conceptual modelling tools can represent or even simulate business models and enable the examination of relationships between human and technological resources. Notable among those are Unified Modelling Language (UML), and its extension System Modelling Language (SysML), Integration Definition (IDEF), Business Process Modelling Notation (BPMN), Event-driven Process Chain (EPCs), Petri net, Functional and Object-Oriented Methodology (FOOM), and Object-Process Methodology (OPM). OPM brings together all “the system lifecycle stages (specification, design, and implementation) within one frame of reference, using a single diagramming tool, a set of object-process diagrams (OPDs) and a corresponding subset of English, called object-process language (OPL) that is intelligible to domain experts and nontechnical executives who are usually not familiar with system modelling languages.” [14]. Besides, as Kabeli and Shoval [15] explains unlike other methodologies, “which utilize a multitude of diagram types and notations covering various aspects of the modelled system, […] OPM utilize only a small number of diagram types, which combine data and functional modelling.” These make OPM easy to learn and implement in short timeframe, and easy to understand by non-specialist people. In order to make a modelling methodology and language helpful for decision-making, it must meet usability requirements that include the ability to model complex systems in one simple diagram, which is easy to learn and implement in a short timeframe, and is also easy to understand by all the stakeholders. Additionally, the model must be executable for visualizing and comprehending the system's dynamic aspects and show the impact of processes on objects and specifically interactions between resources and the processes that consume them. OPM appears to best meet these criteria for modeling and demonstrating business models, and was therefore adopted in this research. As part of the joint research activities of Visionair, Cranfield University collaborated with Technion – Israel Institute of Technology to develop and validate alternative OPM-based business models of Vscan as a disruptive technology for primary healthcare.

2.3 Object-Process Methodology Approach

OPM – Object-Process Methodology [16] is a holistic approach to the study and development of systems. OPM integrates the object-oriented and process-oriented paradigms into a single frame of reference, in which function, structure and behaviour, the three major aspects of each man-made system, co-exist in the same OPM model without highlighting one at the expense of suppressing the other. The elements of the ontology upon which OPM is based are entities and links. Entities are objects and processes (which are "things") and states. Objects are what a system or a product is, possibly at states, which are potential situations of objects, while processes are what a system does. Links are divided into structural links and procedural links. Structural links express static relations between pairs of entities. Procedural links connect entities to describe the behaviour of a system. Together, they realistically describe how objects are generated, transformed or consumed, and how their states are changed, enabling one to model interactions, e.g., between resources and the activities that consume them.

OPM brings together the system lifecycle stages (specification, design, and implementation) within one frame of reference, using a single diagram type—a set of object-process diagrams (OPDs) and a corresponding subset of English, called object-process language (OPL) that is intelligible to both domain experts and nontechnical executives, who are usually not familiar with system modelling languages [14]. As Kabeli and Shoval [15] explain, unlike other methodologies, which utilize a multitude of diagram types and notations, covering various aspects of the modelled system, OPM's single diagram type combines data and functional modelling, making OPM easy to learn and implement in a short

3. Methodology / Networking and collaboration

A literature review we conducted initially revealed research gaps, which provided a basis for semi-structured interviews with six subject matter experts, including a radiologist, a medical director, a clinical and education strategy manager, and a surgeon. The total interaction time was over 15 hours and assisted with identifying the issues involved in current scanning practices within the healthcare sector in the UK and defining the "AS-IS" OPM model, as well as in developing potential improvements in order to update this model. Based on the findings from the interviews, we developed the business models through brainstorming sessions and subsequent OPM model construction. This involved collaboration between Cranfield and Technion, where online meetings were set up to share findings and to develop OPM models. Four business models were developed and validated through interactions with three stakeholders from the healthcare sector, each lasting around one hour.

4. Results: innovation propositions for the Healthcare sector

4.1 The AS-IS model

The AS-IS model describes the typical journey of a patient who presents a number of symptoms. Based on these symptoms, the General Practitioner (GP) decides that an ultrasound scan is required to support a diagnosis. The GP assumes that the condition is not critical and therefore no emergency procedures are invoked. The model concludes that during the final consultation, a course of remedial therapy is started, which is outside the scope of this study. The process starts with the patient contacting their local surgery to make an appointment to see their GP. The availability of the GP is checked by the surgery receptionist, who informs the patient as to when she or he should show up for the initial consultation. Upon arrival, the patient is booked in at the administration desk by the surgery admin assistant.

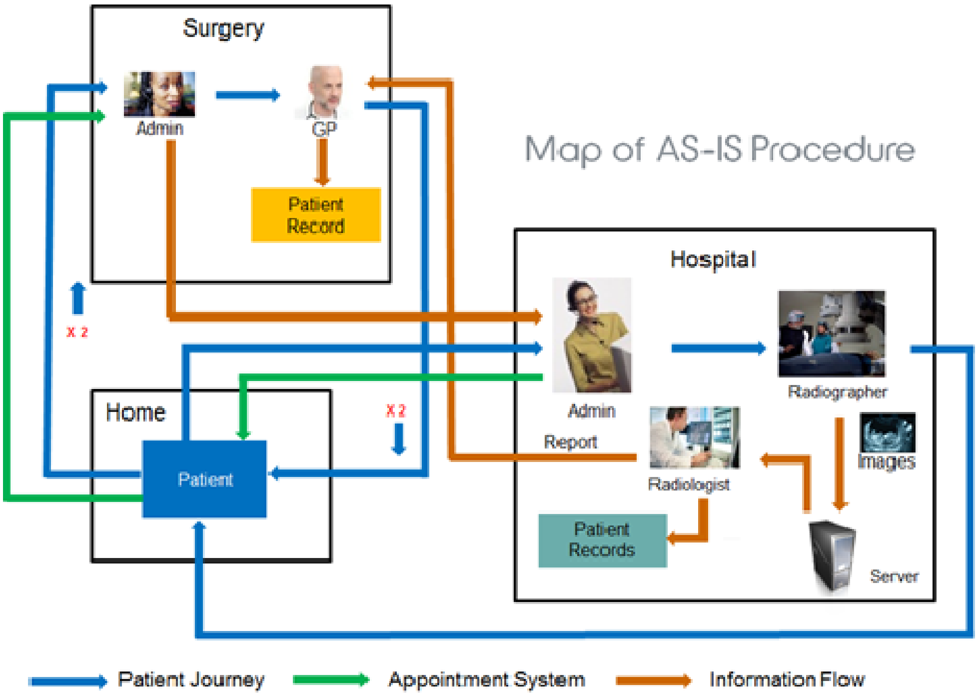

Fig 1. Current procedure for scans

During the initial consultation, the GP decides that an ultrasound scan is required. A request is made to the nearest hospital with the appropriate resources. As a result, the patient's records are updated. Then, the patient returns home. On return, the patient contacts the hospital administration to confirm that they are available to attend on the nearest available date for procedure. The waiting time depends on the current load of the radiology department and the availability of radiographers and equipment to complete the scan. On arrival at the hospital, the hospital admin assistant books in the patient at the administration desk. At the allotted time, the patient is admitted to the radiology centre, where he will be prepared for the procedure. The radiographer then performs the scan and uploads the images on the radiology server for later analysis and reporting. The patient is then discharged and returns home. At some point, the patient’s ultrasound images will be downloaded by a departmental radiologist, who complete the analysis and compile a report on the findings. This report is sent by (physical or electronic) mail to the GP, and the patient’s hospital records are updated with the results. Upon receipt of the report, the GP concludes the diagnosis and the surgery (infirmary) receptionist contacts the patient to return to the surgery for a follow-up consultation. The patient travels from home to the surgery and books in via the administration system as before. During the follow-up consultation, the GP advises the patient on any further follow up treatment that may be necessary. The patient surgery records are updated to reflect the outcome and further treatments necessary. The patient subsequently returns home. The patient's journey is summarised in Figure 1, which shows the physical movement of the patient between home, surgery, and hospital, together with the flow of information throughout the process. However, this diagram does not represent the personal and social cost experienced by the patient. These may include travelling costs using one's own or public transport, time off from employment and sundry costs, such as payment for parking at the hospital, which adds another dimension of complexity.

4.2 Recognition of potential improvements

A number of servitization business models were developed to improve the current process whilst satisfying the needs of key stakeholders involved in the diagnostic process. These include:

- The Patient: Benefits should include the reduction in the distance travelled and the time taken from the initial consultation to the start of any remedial treatment.
- The GP: With the decision now resting with the GP as to where to purchase services such as ultrasound procedures, all business models should result in savings when compared with the cost of purchasing such services from the hospital as described in the current process.
- Clinical Commissioning Groups: Any opportunity to reduce the overall group budget will be of interest for groups of General Practices combined under the management of a commissioning team.
- Improvements in the healthcare environment have to be made in order to improve patient experience and reduce hospital costs. Some potential improvements are defined below.

- Scanning procedures are expensive for hospitals. Therefore, reducing the number of patients who need to receive a scan would reduce hospital costs.
- Too many patients are sent to the hospital for basic check-up. Therefore, hospitals become too crowed and the waiting time to perform a scan is very long (up to six weeks).
- Due to the length of the waiting time to have a scan and receive the first diagnosis, disease are not treated at their earlier stage. This can be dangerous for patients' health. Diagnosing patients' disease at an earlier stage thanks to a new device would reduce this bottleneck in the healthcare system.
- Avoiding a journey to the hospital would be a great improvement in the patient experience. It would reduce the length of the journey from their home to the hospital. It would also reduce the parking cost of the hospital, which appears as the first reason given by patients to avoid hospital.

4.3 "TO-BE" models

Existing ultrasound scanners employed in radiology departments are expensive, complex to operate and are not designed for mobility. Therefore, the existing process is designed around bringing the patient to the resource. The portability and lower cost of Vscan makes it possible to reverse this by taking the resource to the patient and making it more widely available. In order to be able to develop the business models, four criteria of development have been specified. The first criterion is technical limitations of the Vscan. What is the impact of any technical limitation? If business models require technicalities not provided by the device, then they cannot be qualified. The second one is the competency of the people using it. If the user of the Vscan is able to use it without external assistance, then this criterion is validated. The third criterion refers to medical and legal issues. If some restrictions exist, then the business model is not qualified. Finally, the fourth criterion is about organizational issues. If drastic organizational changes that are incompatible with surgeries' actual organisation are needed, then the business model is not qualified. Four business models were developed:

- Business Model 1: GP completes scan at surgery
- Business Model 2: Radiographer visits surgery each week
- Business Model 3: Radiologist visits surgery each week
- Business Model 4: Mobile radiographer visits patient at home

The following section focuses on Business Model 3, which was considered to be the most beneficial in terms of patient satisfaction and cost savings.

4.3.1 TO-BE Business Model 3

Business Model 3 is based on the services of a visiting diagnostic radiographer, who is qualified to capture images, analyse the results, and provide the GP with a report on the findings. Figure 2 provides an overview of the overall system. All patient reports will be completed as a batch for all patients seen during the day of the radiographer visit. On receipt of the report, arrangements may be made for the patient to return to the surgery for final consultation and start of remedial treatment. A variation of this process may make it possible to complete the report immediately after the image capture while the patient is still at the surgery. This has the advantage of being able to start any remedial treatment immediately and reducing the number of patient journeys to two but will depend on the workload and schedule of the radiographer.

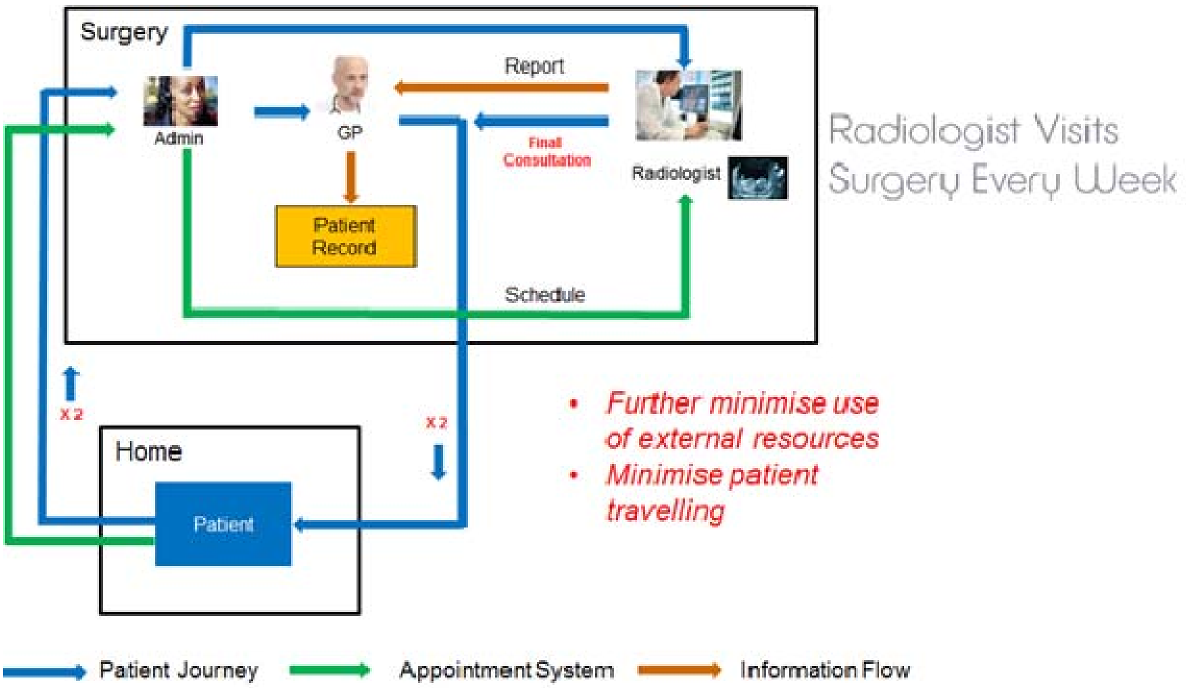

Fig. 2 TO-BE Business Model 3

Figure 3, which is a snapshot of an Object-Process CASE Tool (OPCAT) screen, represents all stakeholders involved in Patient Treating process. People, agents in OPM terminology who handle the process are GP, Surgery Receptionist, and Visiting Diagnostic Radiographer. The instruments required are Scanner, GP Server and Laptop. It also shows objects affected by the Patient Treating process: Patient, Patient Medical Status and Patient Record. Figure 4 shows the sub-processes of the Initial Consulting process are the Initial Appointment Setting, Surgery Arriving, Initial Consulting Executing, Sonography Appointment Setting and Leaving. This OPD illustrates one of the most interesting aspects of OPM modelling. It shows how sub-processes affect Patient Location and Patient Medical Status by changing their states. The state of Patient Location is affected by the Surgery Arriving process, so it changes from home to surgery. Similarly, Patient Medical Status changes from not diagnosed to in need of scan during the Initial Consulting Executing process. Initial Consulting Executing generates an object called Scan Request. This last step requires executing the next process, Sonography Appointment Setting.

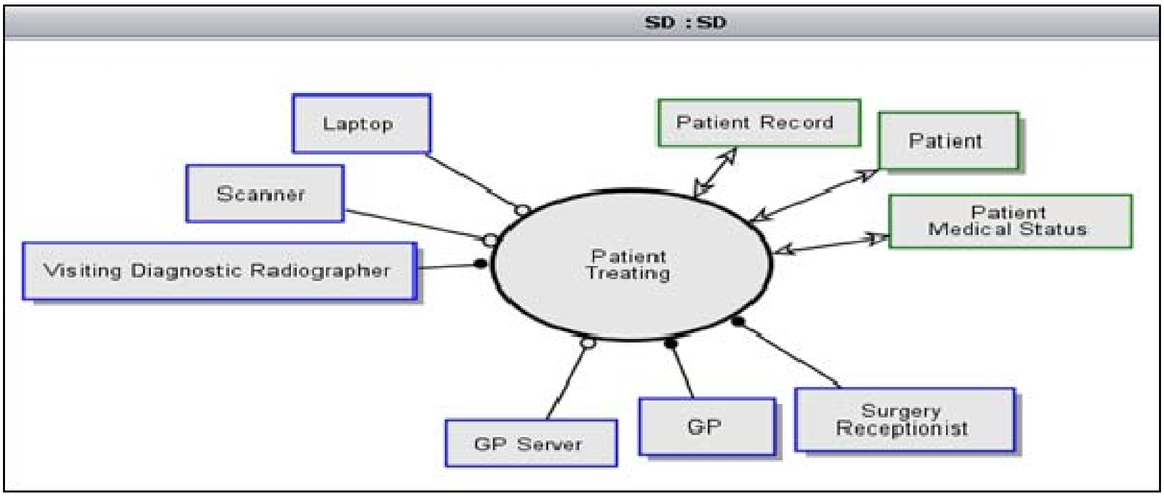

Fig. 3 Patient Treating: OPM Business Model 3 overview

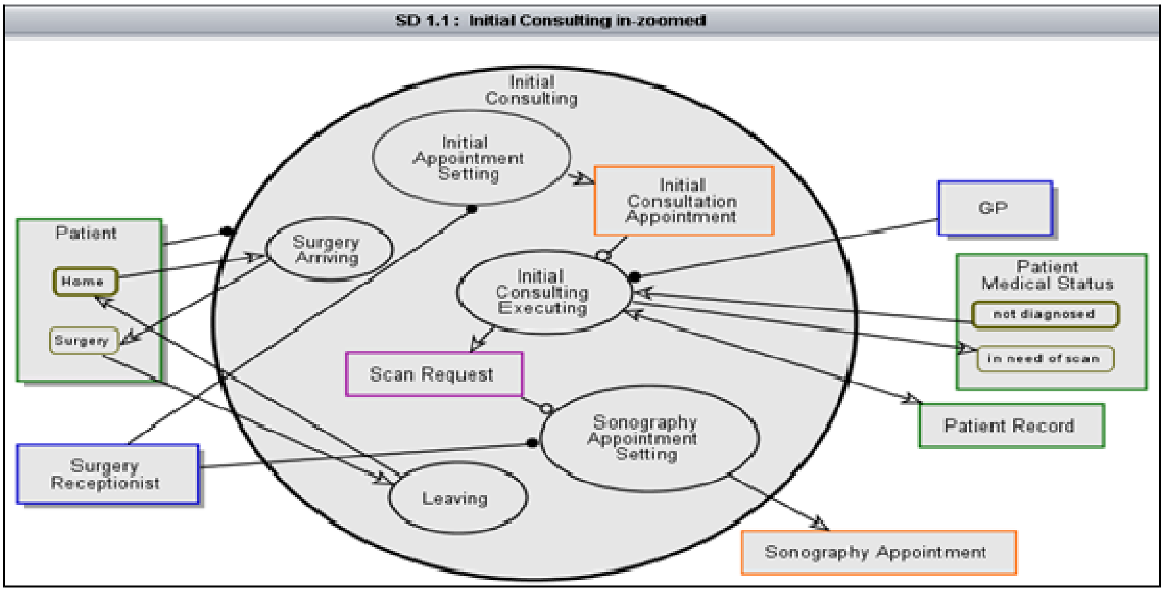

Fig. 4 Initial Consulting process in-zoomed

The main sub-process for Ultrasound Scanning involves the initial condition assessment through Sonography Appointment. This process is divided into two sub-processes: Surgery Ultrasound Procedure and Images Treating. At the end of this process, a Report is generated. First of all, the patient arrives at the Surgery, so the Patient location changes from home to surgery. The following step is Patient Scanning. This process requires Visiting Radiographer and Scanner, and changes the Patient Medical Status from in need of scan to scanned. Images Set is generated and is required for Image Set Uploading process. Then the Patient location changes back from surgery to home. Finally, the Image Set Uploading process is executed and generates Report Request, as covered in Figure 5.

As a follow on to the Ultrasound Scanning process, a Report is generated and sent to the GP Server. Subsequently, as illustrated in Figure 6, the last main sub-process, Follow Up Consulting is undertaken. It is composed of four sub-processes: Appointment Setting, Surgery Arriving, Consulting Executing, and Leaving. These sub-processes affect Patient location and Patient Medical Status. The state of the Patient location is affected by the Surgery Arriving process and changes from home to surgery. The same for Patient Medical Status, which changes from not diagnosed to in need of scan during Consulting Executing process. At the end the Final Diagnosis is generated and symbolises the final output of the highest process, Patient Treat.

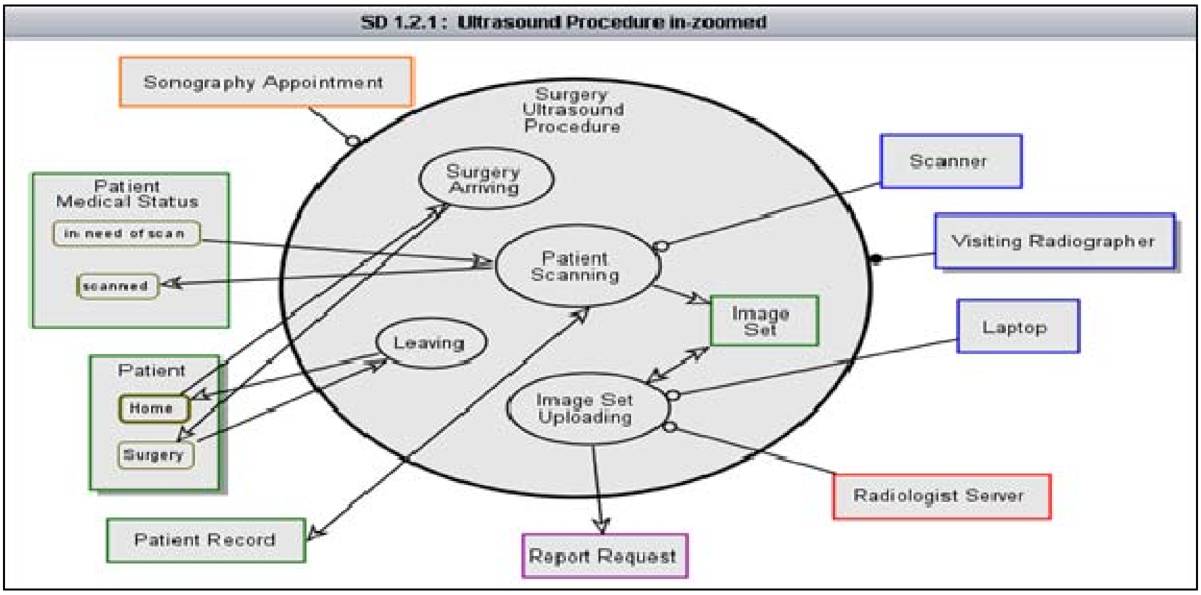

Fig. 5 OPD of Surgery Ultrasound Procedure in-zoomed

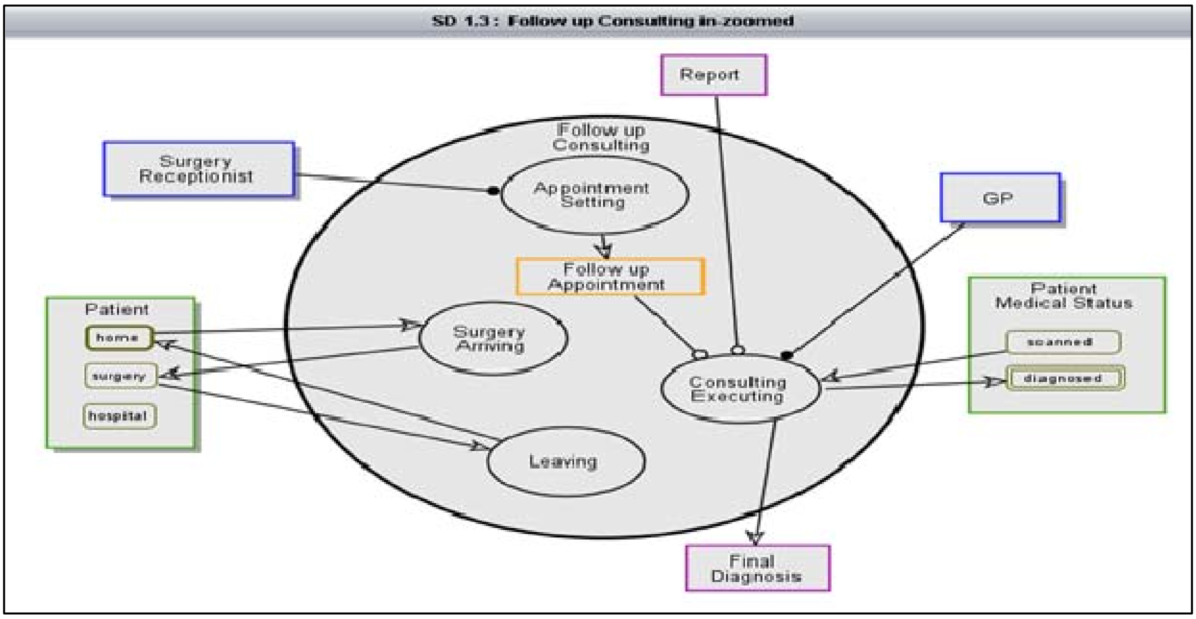

Fig. 6 OPD of Follow up Consulting process in-zoomed

4.3.2 Alternative TO-BE Business Models

- Business Model 1 - The first business model considered is based on the use of the Vscan directly by the GP during the initial consultation. The model is dependent upon the ability of the GP to be able to complete the procedure and analyse the images presented. Since such skills are part of the basic medical training, it will be necessary for GPs to undergo further training to improve their skills and demonstrate competence in the use of ultrasound procedures.
- Business Model 2 - This model assumes that the GP elects to outsource ultrasound procedures to a visiting radiographer who attends surgery on a weekly basis.
- Business Model 4 - The final Business Model fully exploits the portability attribute of Vscan and involves a radiographer visiting the patients at their homes.

5. Validation

Prior to face-to-face validation with subject matter experts internal qualification of the business model took place, as described in Section 4.3.1. Based on these criteria the proposed business models were validated and semi-structured interviews were adopted. Three validation sessions involved assessing the applicability of each of the proposed business models. An overview of the stakeholders is provided in Table 1. The interaction with each partner lasted around an hour. Overall, it was recognised that across the business models demonstration through OPM helped to understand the models quickly and thoroughly.

Table 1. Stakeholders involved in validation

Stakeholder	**Function**	**Years of experience**	**Location**
S1	GP and Associate Medical Director of NHS Bedfordshire PCT	20	Bedford, UK
S2	GP	20	Bedford, UK
S3	CEO of CCG	30	Bedford, UK

Table 2 summarises the positive and negative aspects of the business models developed.

Table 2. Overview of positive and negative aspects for the business models

Model	**Impact on Patient**	**Impact on GP**
1	+ Single visit to their local surgery to complete the diagnosis and commence any remedial treatment. + With faster interventions the clinical outcome should have a higher chance of success. + No further travelling costs or car parking fees incurred. + Less social costs in not having to make arrangements for further time off from employment to attend the radiology centre or return to the surgery for further consultation	+ Lowest operational cost for the GP as it does not involve the services of a radiographer, radiologist or the use of any hospital equipment and services.
2	+ Only local visits are required thereby reducing the travel cost and the waiting time to a maximum of one week for a scan.	+ GP not required to train to use the equipment and has no adverse impact on their capacity for patient consultation + Provides a 'One stop shop' for the GP with a fixed fee for managing the weekly ultrasound – Fixed cost irrespective of the number of patients processed. – Cost of both radiologist and radiographer
3	+ Reduces the number of visits made by the patient and allows for immediate follow up for any remedial treatment.	+ Radiologist is qualified to analyse the results of the scan and provide patient reports to the GP – Higher premium for senior

		radiologist
4	+ Waiting time for a scan may be reduced. + Procedure is conducted in the privacy of patients own home. + Benefit to aged patients who may suffer from mobility problems.	+ Convenience of providing their patients with a high quality service whilst outsourcing the process to a self-employed radiographer. – Added cost of travelling time and expenses associated with each patient visit.

6. Potential implementation of OPM

6.1 Vivid OPM

Vivid OPM model is the dynamic visualization tool of OPM. The Cranfield team provided relevant data to develop the animations for the business models, whilst Technion was responsible for the development of Vivid OPM models. A Vivid animation was developed for each business model.

The Vivid animation is based on OPM Models and looks like a video clip. Relevant objects are used to illustrate different elements of a system, and objects move on the screen throughout the whole process and subtitles explain what is happening. The animations help to easily understand the business models with no background requirements.

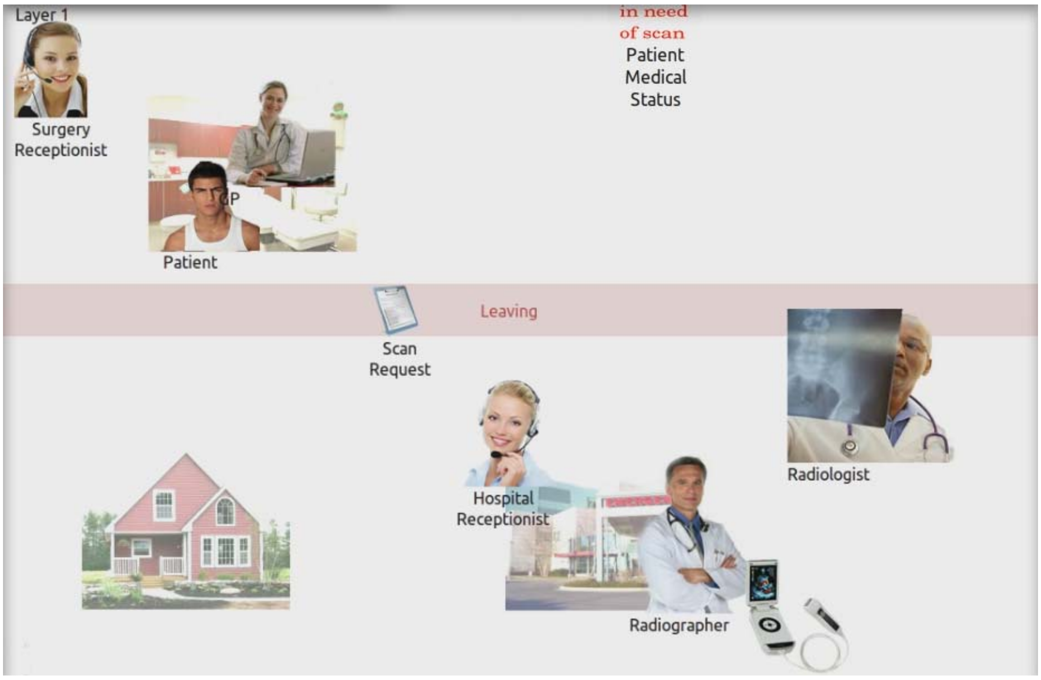

Figure 7. Sample screen of Vivid animation

Vivid OPM is an extension to the OPM graphical output and is intended to visualise the execution of OPCAT through movement of icons representing objects throughout the operating environment. Whilst this concept has the potential to allow non-experts to use the package it is very early stages of development. Table 3 summarises the positive and negative aspects experienced in this approach of visualisation.

Table 3: Positive and negative of Vivid OPM

Vivid OPM	
Strengths	**Weaknesses**
• Has the potential to visualize relationships at a high level • Easy to understand for non-experts	• Customized software needed to develop and run • In an early stage of development

OPCAT has the OPM-based simulator which is a Java application that executes the OPM model. It enables comprehension and evaluation of behavioral aspects of the model of the system under development or research. The Vivid OPM Java plug-in tracks the objects' state transitions and sends updates to the communication server. The GUI client-side task is to visualize graphic elements of the model and to enable the user to control the model visualization.

6.2 Multi-touch table

OPM helps to realise the different parts of the system, and how they interact. An extension of OPM is to provide the opportunity for those in separate locations to build and adjust different elements of OPM. Along these lines, multi-touch devices assist in building communication across separately located members of a system, whilst also providing the opportunity to view the same image and to make adjustments. This may involve use of a software program that facilitates this. MindMeister serves as an example, where the user can share the OPM image and adjustments can be made and/or the OPM models can be developed and validated in collaboration.

6.3 Virtual reality

The Vscan is equipped with an abdominal probe with the use of which GP can investigate the following organs:

Table 4: Application of Vscan

LIVER	o gallstones o any type of los o dilation of the biliary tract o thrombosis portal vein o evaluation of intrahepatic vessels o arterial and portal
PANCREAS	o chronic pancreatitis o carcinoma of the head
SPLEEN	o splenomegaly associated with cirrhosis and not o metastatic lesions o infarct and rupture (in case of trauma)
KIDNEYS	o kidney's calculations o renal cell carcinoma o dilatation of the urinary tract o malformation, o polycystic kidney disease o arteriosclerotic kidney
BLADDER	o bladder polyps o diverticula
GALBLADDER	
ABDOMINAL AORTA	o aneurysmal dilatation o calcification of the walls
FEMALE PELVIS	o uterine fibroids o ovarian masses
TESTICLE AND SCROTUM	o hydrocele o varicocele o testicular tumors o cysts

Virtual reality has a role with enhancing the quality of images, where the GP would prefer to analyse results from ultrasound scan in 3d rather than 2d (which is the form of demonstration in Vscan). This would assist with understanding a more complete picture of the organ of interest. Furthermore, it may also assist in reducing the time to diagnose the patient and the quality of diagnosis may increase. This in turn can be fed back to the OPM models that capture the various systems and it may be possible to realize the more beneficial business models and to redesign the OPM models. Virtual reality may also help to deskill the process of diagnoses and this may have cost savings as lesser GP get involved and instead nurses get involved. Furthermore, virtual reality may also provide the opportunity to share images from a surgery to a hospital where the expert may be located, whilst to a larger extent results from many surgeries may be shared.

6.4 CAVERN – Computer-based Augmented Virtual Environment for Realizing Nature – is proposed as a quantum leap in molecular biology research

OPM-based conceptual modeling, which has long been used for designing and communicating complex man-made systems, is beginning to play an increasingly important role in facilitating human comprehension of complex biological systems. OPM provides for faithfully and intuitively modeling biological processes and substances that undergo these processes or enable them in a single, bimodal graphic and textual model. The processes, which occur at varying spatiotemporal scales, are modeled at increasingly refined levels of complexity, enabling one to inspect the system at any desired level of detail while not losing sight of the overall view of the functioning system across compartment boundaries and abstraction levels.

7. Discussion and Conclusions

This use case, demonstrates that OPM, one of the visualization and interaction methods proposed by Visionair infrastructure supports thse modeling of a process. Now, our main objectives are first to emphasize the OPM benefits by using it in the validation process with VR system on this 1000$ scanner use case, and then to demonstrate that OPM could be integrated from the first step of a TNA to its achievement.

Whether in the accomplishment of this use case in VR checking or in the complete support of a TNA, OPM can be used to drive a virtual reality scene in order to check the validity of the described process. Then to get a kind of user centered design activity, within VR driven by OPM, to check the collaboration between the actors of the process. These are future works that we propose to investigate.

As identified in the literature review and experienced by the team in the development phase of building the business models, there is no single modeling language that completely suits the needs of expressing the interaction of objects and processes that form the business model. OPM was found to have a close match to our needs. Indeed, non-experts were also able to understand and interact with OPM. The language and the simulation software (OPCAT) were used to ensure the completeness of the design of each model. Table 3 summarises the positive and negative aspects of OPM we found in the application to this project.

No technical limitations have been found preventing the implementation of business models 1, 2, 3 and 4. Furthermore, the competency of people does not represent the bottleneck in implementing any of these models. According to the statements of the stakeholders, a non-specialist can use the Vscan device without any problem. The stakeholders S1 and S3 have also stated that it is possible for a radiographer to make a diagnosis. S3 has highlighted that “it takes over a year to train a radiographer. This includes attendance at a part-time postgraduate theory course. They gain practical experience under supervision, in both scanning technique and report writing”. This statement permits to qualify part of the TO-BE business model 2, which states that the radiographer will make the scan and will be able to diagnose any abnormal images. Those images will be sent to a radiologist to make the report. For the normal ones, the radiographer will decide not to take any further actions. The stakeholders interviewed have indicated no medical or legal issues regarding the four business models. Finally, from an organisational point of view, it is possible to implement these models without disrupting the organisation of surgeries. OPM has been shown to be a suitable approach to deconstruct a complex problem into smaller, more manageable areas. Along these lines, this applied research has enabled to demonstrate a case study from the healthcare sector and illustrate the application of OPM as highly flexible for explanatory visualization purposes.

Table 5. Positive and negative aspects of OPM for our business modelling activities

OPM	
Strengths	**Weaknesses**
• Shows interaction between objects and processes • Hierarchical structure with processes constructed in layers. • Intuitive to use • Easily upgradable • Multipurpose user interface (graphic and language statements) • OPCAT simulator shows execution in a dynamic way	• Level of detail: can be too high for non-experts • Need understanding of target process, which is similar to many other modelling methods • Customized software to develop and run • No quantitative structure (yet) to analyse cost benefit

This joint research activity is envisaged to add value to the Trans-national accesses by offering a detailed conceptual modelling tool that can help to breakdown the visualisation problem that needs to be addressed prior to the actual implementation. Rigorous implementation of the approach can result in improved visualisation outcomes in an efficient and effective manner.

8. References

[1] Professor David Leon, London School of Hygiene and Tropical Medicine 2011, Accessed from: http://www.lshtm.ac.uk/pressoffice/press_releases/2011/lifeexpectancy.html, Access date: 12/08/2012.

[2] O. Mont, 2002, Clarifying the Concept of Product-Service System. Journal of Cleaner Production 10(3), 237-245.

[3] C.M. Christensen, 1997, The Innovators Dilemma: when new technologies cause great firms to fail, Harvard Business School Press, Boston, Massachusetts

[4] J. Tidd, J. Bessant, and K. Pavvit, 1997, Managing Innovation: Integrating technological, market and organizational change, John Wiley & Sons Ltd, Chichester

[5] P. Trott, 1998, Innovation Management and New Product Development, Pearson Education, Harlow

[6] R.W. Veryzer, 1998, Discontinuous Innovation and the New Product Development Process. Journal of Product Innovation Management, (15), 304-321

[7] C. Baden-Fuller and M. Pitt, 1996, Strategic Innovation, Routledge, London.

[8] C.W.L. Hill, G.R. Jones, 1998, Strategic Management: An Integrated Approach, Houghton Mifflin Company, Boston, NY.

[9] J. Hwang, M. Christensen, 2008, Disruptive Innovation In Health Care Delivery: A Framework For Business-Model Innovation, Health Affairs, 27(5), 1329-1335

[10] G. Hamel, 2000, Leading the Revolution, Harvard Business School Press, Boston, Massachusetts

[11] C.M. Christensen, R. Rosenbloom, 1995, Explaining the attacker's advantage: technological paradigms, organisational dynamics and the value network. Research Policy 24, 233-257

[12] F. Lettice, P. Thomond, 2003, Disruptive Innovation: The Challenges for Managing Knowledge, International Ecotechnology Research Centre, Cranfield

[13] D. Dori, I. Reinharz-Berger, A. Sturm, 2003, OPCAT – A Bimodal CASE Tool For Object-Process Based System Development

[14] A. Sturm, D. Dori, O. Shehory, 2010, An Object-Process-Based Modeling Language for Multi-Agent Systems. IEEE Transactions on Systems, Man, and Cybernetics – Part C: Applications and Reviews, 40(2), 227-241

[15] J. Kabeli, P.Shoval, 2004, Comprehension and quality of analysis specifications—a comparison of FOOM and OPM methodologies

[16] D. Dori, 2002, Object-Process Methodology – A Holistic Systems Paradigm, Springer Verlag, Berlin, Heidelberg, New York