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SeC
Sim-e-Child

Collaboration Project

Thematic Priority: ICT

D6.2 Updated dissemination materials

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Razvan Ionasec	Minor edits	0.3	29 August 2011
Edwin Morley-Fletcher	Final review	1.0	29 August 2011

Sim-e-Child Consortium

The partners in this project are:

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02. Lynkeus Srl (Lynkeus)
04. maat France (MAAT)
05. Technische Universität München (TUM)
06. I.R.C.C.S. Ospedale Pediatrico Bambino Gesù (OPBG)
07. Siemens Corporate Research, Inc. (SCR)
08. Johns Hopkins University (JHU)
10. American College of Cardiology Foundation (ACCF)
11. Siemens Program and System Engineering srl (PSE)

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Abbreviations

HeC	Health-e-Child
SeC	Sim-e-Child
ToF	Tetralogy of Fallot
MR	Magnetic Resonance or Magnetic Resonance Imaging
DICOM	*D*igital *I*maging and *CO*mmunications in *M*edicine (ACR-NEMA 3.0) - the DICOM standard facilitates interoperability of medical equipment by addressing the exchange of digital information.

Table of Contents

1. Introduction

1.1. Executive Summary

This document is an update of the original tools and concepts that defined Sim-e-Child's (SeC) dissemination strategy. As an update of D6.1, which covered the first reporting period, D6.2 and covers phase 2 of the project (months 11-20). The report will be updated again at the end of the 3rd phases (month 20 and 30) which also is when the project is scheduled to be completed. In this sense the tasks indicated in this Deliverable cannot be considered as exhaustive and additional activities may be added to the scope of activities undertaken to appropriately disseminate SeC.

The guidelines for SeC dissemination have been based on the following principles:

- conception of dissemination as "knowledge sharing" on a bi-directional level;
- cross fertilisation and liaison with industrial, research, and standardisation communities;
- involvement of independent experts to validate SeC protocols and entry criteria;
- transfer of results to the industrial, research, and standardisation communities;
- establishment of close collaboration with related projects;
- publication of SeC results in relevant international scientific journals;
- organisation of seminars and workshops within relevant conferences in the area, producing brochures and posters;
- set-up of a web site dedicated to the project, containing a public area for general communication
- publication and circulation to interested communities and stakeholders of an annual newsletter

The SeC Consortium is well aware that the nature of the project and its evolution may well dictate changes in the course and enactment of some of the activities set out below. In fact, numerous dissemination channels not foreseen here may come into being and may demand exploitation, while some activities deemed promising at present may later on be found to be unattractive and/or ineffective. SeC will nonetheless adhere to the above mentioned overriding principles in its further pursuit of the broadest array of dissemination activities possible.

SeC's dissemination efforts will mirror the original call for which it received funding. Namely for the internationalisation of research and development of the Virtual Physiological Human, in this direction for the duration of the project special attention will be paid to utilising the expertise of SeC's US partners in the dissemination of the results.

1.2. Overview of the document structure

The update of D6.1 is separated into three sections:

Section 2 is devoted to SeC's dissemination strategy, providing an outline of the project and its message. This will not change dramatically during the project, but as a result of SeC's first periodic review where the clinical partners were asked to define concrete clinical applications and objectives. As result specific clinical application scenarios have been designed and further pages added to the web site describing them, whilst taking into account the public nature of the site, have been developed.

Section 3 is dedicated to the channels SeC identified during the design of the project as suitable for disseminating its actions and results, the target audiences and the means for communicating with them.

Section 4 presents SeC's dissemination instruments which will only undergo minor revisions during the course of the project.

2. Dissemination Strategy

2.1. The Sim-e-Child Message

A scarcity of relevant cases, the lack of integrated data and the limited opportunities for clinical comparison are just some of the reasons why patients with rare diseases, such as congenital heart diseases, are difficult to treat. Advances in paediatric cardiac surgery, interventional cardiology, intensive care and non-invasive imaging have led to a substantial increase in life expectancy for many patients with congenital heart disease. However, difficult challenges still persist due to the evolving nature of a child's heart and vascular system.

In order to achieve better and more reliable risk stratum, to improve and personalise therapies, and to ultimately increase the patient survival rate, there is a need for comprehensive and accurate computer models to be constructed from patient specific data and simulated physical constraints. SeC is working towards these goals by building on the achievements of the HeC project which was completed in April 2010, rated as "surpassing expectations" by the EC and the winner of the ICT08 Best Exhibition Award.

Supporting Clinical Decisions

SeC expands the Grid-based eHealth infrastructure developed by the HeC project and uses the high bandwidth pan-European GÉANT research network to:

- establish a multi-site database of paediatric cardiology data, information and knowledge for translational research
- patient-specific models of the aorta and mitral valve anatomy and dynamics as well as with computational fluid dynamics models for haemodynamics simulations
- develop a grid-based platform, supporting the search, definition, execution and sharing of modelling and simulation experiments

By integrating these three elements, SeC will provide paediatric cardiology professionals in Europe and the US with a Virtual Physiological Human (VPH) decision support system and virtual laboratory. This will enable them to construct and validate multi-scale and personalised models of a growing child's heart and blood vessels. Ultimately this will support their clinical decisions and allow better understanding of their patient's condition, thanks to the huge amounts of bandwidth and computing resources made available.

E-infrastructure for paediatric cardiologists

SeC is creating the first Trans-Atlantic platform for large scale simulations in cardiology. The clinical applications are further developing the original (HeC's) grid infrastructure based on the EGI Grid middleware (the gLite technology and European Grid Infrastructure - www.egi.eu) and the enabling GÉANT network. Together they provide virtually unlimited computing power, data storage capacity and network bandwidth across continents. Drawing on these resources, the SeC platform will be able to deliver innovative predictive disease models, complex data visualisation and knowledge discovery applications at the point of care.

Fig 1: The Expansion of the HeC network to the USA

SeC's applications are based around the concept of data integration, in the way that HeC integrated the data from four European hospitals over three disease areas (cardiology, rheumatology and neuro-oncology). SeC is further integrating the legacy cardiology data with a large number of cases from an ongoing US multi-centre study, the Coarctation Of the Aorta Stent Trial [COAST] with the support of the American College of Cardiology (Washington, D.C), and with the support of Johns Hopkins Children's Centre (Baltimore, Maryland) to validate the existing models and those being developed.

As a result of Sim-e-Child's work, the Health-e-Child Grid has now been deployed at Maat and a second grid node has been designed to be cloud-based, allowing to provide flexible computing resources as required for large-scale computational experiments.

2.2. Identification of Target Groups and End Users

Achieving the mission and ambitions summarised above requires a consolidated effort aimed at establishing links with distinct - but overlapping - target groups and end-users: IT specialists, paediatric healthcare providers, and healthcare authorities and policy makers. Reaching each of these user bases involves varying approaches, but for purposes of simplification, these can be defined as either clustering activities with other ongoing actions/projects sharing similar or complementary goals, or through conference activity, be this at periodic venues or specific SeC co-organised or co-sponsored events.

Regarding the former, the project is in the position to exploit numerous opportunities: many SeC members are partners in more than one ongoing EU-funded project/network sharing overlapping missions with which HeC plans to liaise and establish and/or enhance relations. Particularly telling is the close collaboration with the Enabling Grids for E-Science project and SeC's utilisation of the EGEE's grid middleware "gLite". Other conspicuous examples of projects sharing partners with SeC are Géant and SHARE.

2.3. Making the Goals of the Project and SeC's Concrete Clinical Objectives Clearer

Material to update the SeC website was developed over the summer of 2011 to take into account the Consensus Report that came out of the first Periodic Report. The EC requested that the website "make to goals of the project clearer", this effort is being made in conjunction with the work that the EC requested the clinical partners do more clearly define the clinical objectives of the project. The result of this cooperative work will be a new section on the website called "Clinical Objectives and Applications". The section will have two parts, one that outlines how SeC's is creating and validating 3D aortic arch models from MRI data of patients with aortic wall complications and how these automatically patient-specific 3D aortic arch geometrical models estimated from MRI images provide a better understanding of the geometry of aortic arch anomalies and might be utilised to preoperatively evaluate best treatments. The second area will explain SeC's desire to use the rendering of aorta model and flow field visualization.

3. Dissemination channels

3.1. Conferences and clustering/networking events

The first reporting period saw SeC's work heavily disseminated in conjunction with the preceding HeC project. In March 2010 the work and objectives of SeC were presented as part of HeC's final dissemination efforts. HeC had been invited by the EC to present its work at the invitation only ministerial day that preceded the World of Health IT and the EC's high level eHealth conference which for the first time were being held at the same time in Barcelona within the eHealth week 2010. As a concrete example of how HeC's results were to be exploited, SeC's objectives were central to all dissemination activities.

The second reporting period saw SeC having to disseminate it would without the support of the concluded HeC project. As a result SeC focused more on cost efficient dissemination channels such as the publication of articles, conferences that SeC was specifically invited to and high levels of cooperation within the VPH community. As a result of this approach, the consortium partners were heavily involved in the VPH community's attempts to gain funding through the EC's FET initiative and the subsequent development of the VPH-FET initiative. Additionally SeC tried to place itself at the heart of the Argos initiative, by both being presented at the EC's EU-US eHealth cooperation workshop in April and developing the Cardiology section of the ARGOS VPH Policy Brief.

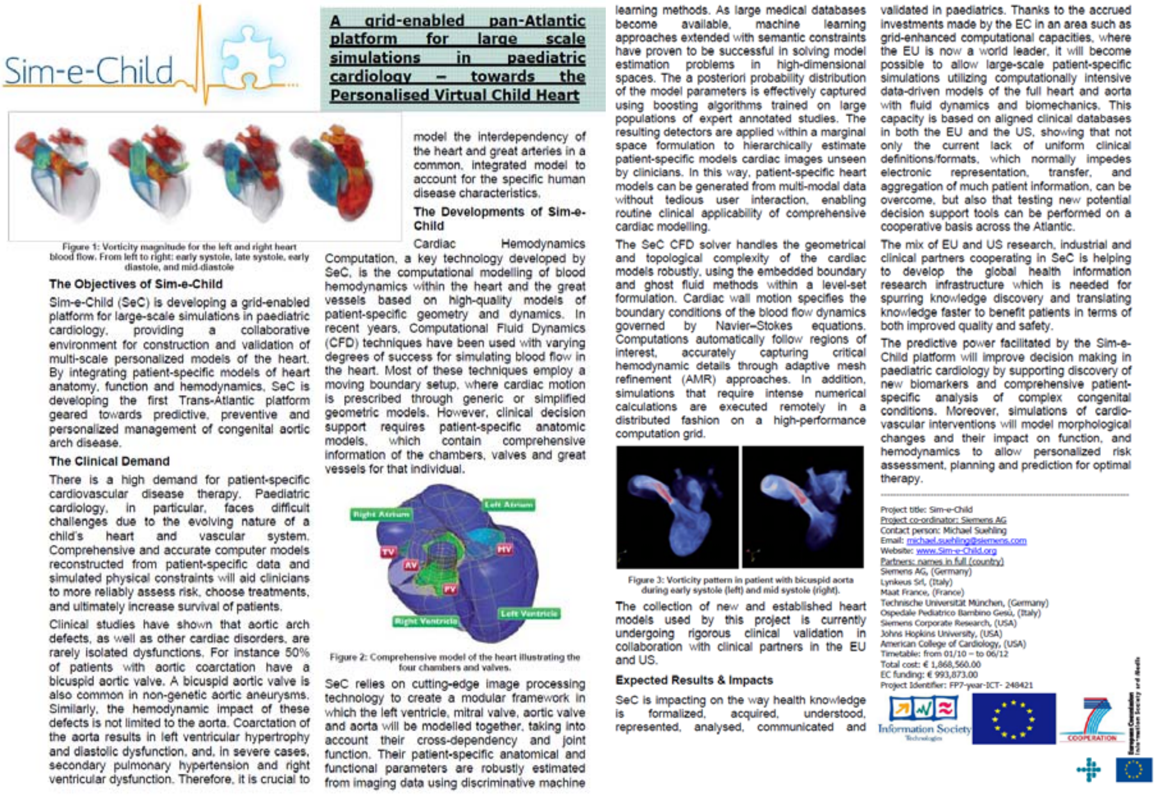
As was promised in the DoW SeC was still present at a number of high profile international conferences across the world. During the reporting period some of the major ones were:

conhIT (Berlin, Germany, April 2011):

SeC was one of the exhibitors at the conhIT Industrial Fair, Europe's largest Healthcare IT conference that presented the full range of eHealth products and services. Along with established solutions conhIT also features quality innovations and trends in Healthcare systems. In addition to having a booth populated with posters, a power point presentation and videos of some of SeC models, SeC's Coordinator Michael Suehling from Siemens participated in a panel discussion on the EU's endeavours in eHealth arena. The discussion was entitled "An EU of opportunities: eHealth activities at European level and the programs of the European Commission" which EC-Representative Loris Di Pietrantonio also participated in.

The following link is to a conhIT article including a video of the panel discussion: www.healthtechwire.com/PremiumPro-Single.244+M54af3bd27ce.0.html, the video is also available through YouTube at www.youtube.com/watch?v=LkRTyNtutP0.

In advance of the conference SeC developed a new two page fact sheet tailored to the ConHIT audience:



Sim-e-Child

Figure 1: Vorticity magnitude for the left and right heart blood flow. From left to right: early systole, late systole, early diastole, and mid-diastole

A grid-enabled pan-Atlantic platform for large scale simulations in paediatric cardiology – towards the Personalised Virtual Child Heart

The Objectives of Sim-e-Child

Sim-e-Child (SeC) is developing a grid-enabled platform for large-scale simulations in paediatric cardiology, providing a collaborative environment for construction and validation of multi-scale personalized models of the heart. By integrating patient-specific models of heart anatomy, function and hemodynamics, SeC is developing the first Trans-Atlantic platform geared towards predictive, preventive and personalized management of congenital aortic arch disease.

The Clinical Demand

There is a high demand for patient-specific cardiovascular disease therapy. Paediatric cardiology, in particular, faces difficult challenges due to the evolving nature of a child's heart and vascular system. Comprehensive and accurate computer models reconstructed from patient-specific data and simulated physical constraints will aid clinicians to more reliably assess risk, choose treatments, and ultimately increase survival of patients.

Clinical studies have shown that aortic arch defects, as well as other cardiac disorders, are rarely isolated dysfunctions. For instance 50% of patients with aortic coarctation have a bicuspid aortic valve. A bicuspid aortic valve is also common in non-genetic aortic aneurysms. Similarly, the hemodynamic impact of these defects is not limited to the aorta. Coarctation of the aorta results in left ventricular hypertrophy and diastolic dysfunction, and, in severe cases, secondary pulmonary hypertension and right ventricular dysfunction. Therefore, it is crucial to model the interdependency of the heart and great arteries in a common, integrated model to account for the specific human disease characteristics.

The Developments of Sim-e-Child

Cardiac Hemodynamics Computation, a key technology developed by SeC, is the computational modelling of blood hemodynamics within the heart and the great vessels based on high-quality models of patient-specific geometry and dynamics. In recent years, Computational Fluid Dynamics (CFD) techniques have been used with varying degrees of success for simulating blood flow in the heart. Most of these techniques employ a moving boundary setup, where cardiac motion is prescribed through generic or simplified geometric models. However, clinical decision support requires patient-specific anatomic models, which contain comprehensive information of the chambers, valves and great vessels for that individual.

Right Atrium
Left Atrium
TV
MV
AV
PV
Right Ventricle
Left Ventricle

Figure 2: Comprehensive model of the heart illustrating the four chambers and valves.

SeC relies on cutting-edge image processing technology to create a modular framework in which the left ventricle, mitral valve, aortic valve and aorta will be modelled together, taking into account their cross-dependency and joint function. Their patient-specific anatomical and functional parameters are robustly estimated from imaging data using discriminative machine learning methods. As large medical databases become available, machine learning approaches extended with semantic constraints have proven to be successful in solving model estimation problems in high-dimensional spaces. The a posteriori probability distribution of the model parameters is effectively captured using boosting algorithms trained on large populations of expert annotated studies. The resulting detectors are applied within a marginal space formulation to hierarchically estimate patient-specific models cardiac images unseen by clinicians. In this way, patient-specific heart models can be generated from multi-modal data without tedious user interaction, enabling routine clinical applicability of comprehensive cardiac modelling.

The SeC CFD solver handles the geometrical and topological complexity of the cardiac models robustly, using the embedded boundary and ghost fluid methods within a level-set formulation. Cardiac wall motion specifies the boundary conditions of the blood flow dynamics governed by Navier–Stokes equations. Computations automatically follow regions of interest, accurately capturing critical hemodynamic details through adaptive mesh refinement (AMR) approaches. In addition, simulations that require intense numerical calculations are executed remotely in a distributed fashion on a high-performance computation grid.

Figure 3: Vorticity pattern in patient with bicuspid aorta during early systole (left) and mid systole (right).

The collection of new and established heart models used by this project is currently undergoing rigorous clinical validation in collaboration with clinical partners in the EU and US.

Expected Results & Impacts

SeC is impacting on the way health knowledge is formalized, acquired, understood, represented, analysed, communicated and validated in paediatrics. Thanks to the accrued investments made by the EC in an area such as grid-enhanced computational capacities, where the EU is now a world leader, it will become possible to allow large-scale patient-specific simulations utilizing computationally intensive data-driven models of the full heart and aorta with fluid dynamics and biomechanics. This capacity is based on aligned clinical databases in both the EU and the US, showing that not only the current lack of uniform clinical definitions/formats, which normally impedes electronic representation, transfer, and aggregation of much patient information, can be overcome, but also that testing new potential decision support tools can be performed on a cooperative basis across the Atlantic.

The mix of EU and US research, industrial and clinical partners cooperating in SeC is helping to develop the global health information research infrastructure which is needed for spurring knowledge discovery and translating knowledge faster to benefit patients in terms of both improved quality and safety.

The predictive power facilitated by the Sim-e-Child platform will improve decision making in paediatric cardiology by supporting discovery of new biomarkers and comprehensive patient-specific analysis of complex congenital conditions. Moreover, simulations of cardio-vascular interventions will model morphological changes and their impact on function, and hemodynamics to allow personalized risk assessment, planning and prediction for optimal therapy.

Project title: Sim-e-Child
Project co-ordinator: Siemens AG
Contact person: Michael Suehling
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Website: www.Sim-e-Child.org
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Technische Universität München, (Germany)
Ospedale Pediatrico Bambino Gesù, (Italy)
Siemens Corporate Research, (USA)
Johns Hopkins University, (USA)
American College of Cardiology, (USA)
Timetable: from 01/10 – to 06/12
Total cost: € 1,868,560.00
EC funding: € 993,873.00
Project Identifier: FP7-year-ICT- 248421

Pediatric & Adult Interventional Cardiac Symposium (Boston, USA, July 2011)

Giacomo Pongiglione also co-directed the Pediatric & Adult Interventional Cardiac Symposium (Pics & Aics 2011), which took place in Boston, USA, from 23rd to 27th July 2011, where SeC's clinical advances were presented in conjunction with the announcement of the Paediatric Cardiology Digital Repository the completion of which is due in the first half of 2012 at the 5 OPBG sites across Italy (more details on this important development are given in section T6.6).

AEPC validation paper on Right ventricle quantification – presented in Granada, Spain, 2011

Association for European Paediatric Cardiology, 18-21 May 2011.

SeC at MICCAI 2011 (Toronto, September, 2011)

Two workshop publications at MICCAI 2011 – to be presented in September in Toronto

Other Major Dissemination Events

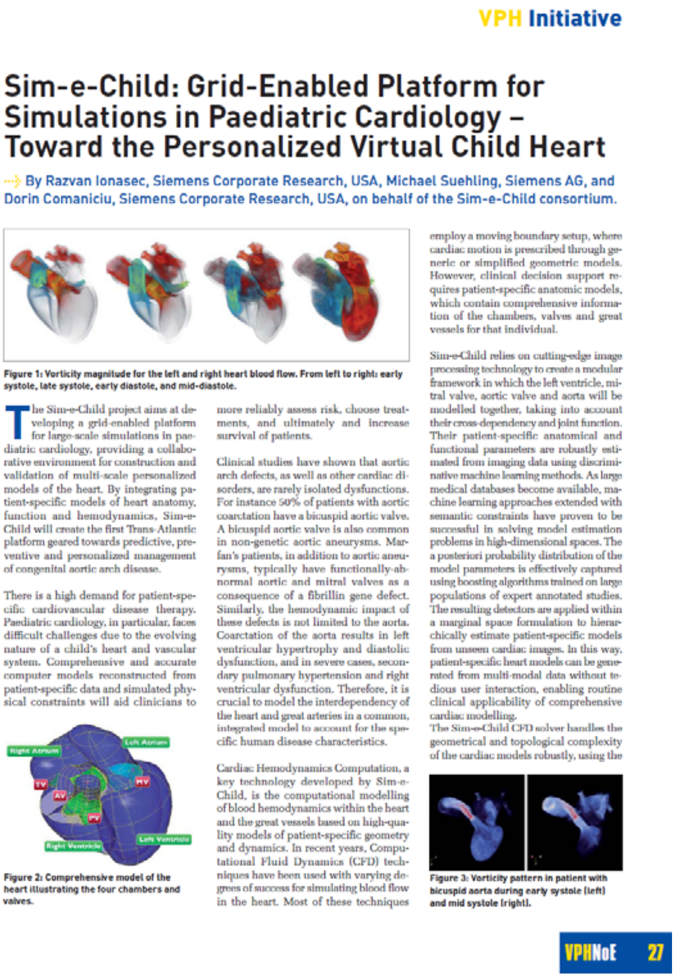
In the autumn of 2010 the SeC project was disseminated throughout Italy in conjunction with GARR, the Italian network of University research centres. SeC's Project Manager, Edwin Morley-Fletcher, wrote an article which was published in the "GARR News" magazine, and was subsequently invited to present SeC's objectives on the first day and through GARR's booth at the First National Conference on Health Research which was held in Cernobbio, near Milan, on the 8/9th November 2010 (http://www.garr.it/eventiGARR/cernobbio-ws/programma.php).

SeC's Final Conference

In the second reporting period the SeC partners began discussion about hosting a final conference. The final conference will be designed to disseminate the results of the SeC and involved renowned experts in the VPH field to explain their work and to assess and validate the work of SeC. The conference is planned to be held in either Brussels or Baltimore/Washington D.C. in the spring of 2012.

SeC and the VPH Community

On behalf of the SeC project Siemens Corporate Research in the US and Siemens AG in Germany produced an article for the VPH Network of Excellence's 2011 edition of their newsletter. The piece entitled "Sim-e-Child: Grid-Enabled Platform for Simulations in Paediatric Cardiology – Toward the Personalized Virtual Child Heart" focused on introducing the VPH community to the work of SeC and the longer term goal of using simulations of cardio-vascular interventions to model morphological changes and their impact on function and hemodynamics to allow clinicians to personalised risk assessment, planning and for the prediction of optimal therapy. Below is an image of the first page of the article.


VPH Initiative

Sim-e-Child: Grid-Enabled Platform for Simulations in Paediatric Cardiology – Toward the Personalized Virtual Child Heart

By Razvan Ionasec, Siemens Corporate Research, USA, Michael Suehling, Siemens AG, and Dorin Comaniciu, Siemens Corporate Research, USA, on behalf of the Sim-e-Child consortium.

Figure 1: Vorticity magnitude for the left and right heart blood flow. From left to right: early systole, late systole, early diastole, and mid-diastole.

The Sim-e-Child project aims at developing a grid-enabled platform for large-scale simulations in paediatric cardiology, providing a collaborative environment for construction and validation of multi-scale personalized models of the heart. By integrating patient-specific models of heart anatomy, function and hemodynamics, Sim-e-Child will create the first Trans-Atlantic platform geared towards predictive, preventive and personalized management of congenital aortic arch disease.

There is a high demand for patient-specific cardiovascular disease therapy. Paediatric cardiology, in particular, faces difficult challenges due to the evolving nature of a child's heart and vascular system. Comprehensive and accurate computer models reconstructed from patient-specific data and simulated physical constraints will aid clinicians to more reliably assess risk, choose treatments, and ultimately and increase survival of patients.

Clinical studies have shown that aortic arch defects, as well as other cardiac disorders, are rarely isolated dysfunctions. For instance 50% of patients with aortic coarctation have a bicuspid aortic valve. A bicuspid aortic valve is also common in non-genetic aortic aneurysms. Marfan's patients, in addition to aortic aneurysms, typically have functionally-abnormal aortic and mitral valves as a consequence of a fibrillin gene defect. Similarly, the hemodynamic impact of these defects is not limited to the aorta. Coarctation of the aorta results in left ventricular hypertrophy and diastolic dysfunction, and in severe cases, secondary pulmonary hypertension and right ventricular dysfunction. Therefore, it is crucial to model the interdependency of the heart and great arteries in a common, integrated model to account for the specific human disease characteristics.

Cardiac Hemodynamics Computation, a key technology developed by Sim-e-Child, is the computational modelling of blood hemodynamics within the heart and the great vessels based on high-quality models of patient-specific geometry and dynamics. In recent years, Computational Fluid Dynamics (CFD) techniques have been used with varying degrees of success for simulating blood flow in the heart. Most of these techniques employ a moving boundary setup, where cardiac motion is prescribed through generic or simplified geometric models. However, clinical decision support requires patient-specific anatomic models, which contain comprehensive information of the chambers, valves and great vessels for that individual.

Sim-e-Child relies on cutting-edge image processing technology to create a modular framework in which the left ventricle, mitral valve, aortic valve and aorta will be modelled together, taking into account their cross-dependency and joint function. Their patient-specific anatomical and functional parameters are robustly estimated from imaging data using discriminative machine learning methods. As large medical databases become available, machine learning approaches extended with semantic constraints have proven to be successful in solving model estimation problems in high-dimensional spaces. The a posteriori probability distribution of the model parameters is effectively captured using boosting algorithms trained on large populations of expert annotated studies. The resulting detectors are applied within a marginal space formulation to hierarchically estimate patient-specific models from unseen cardiac images. In this way, patient-specific heart models can be generated from multi-modal data without tedious user interaction, enabling routine clinical applicability of comprehensive cardiac modelling.
The Sim-e-Child CFD solver handles the geometrical and topological complexity of the cardiac models robustly, using the

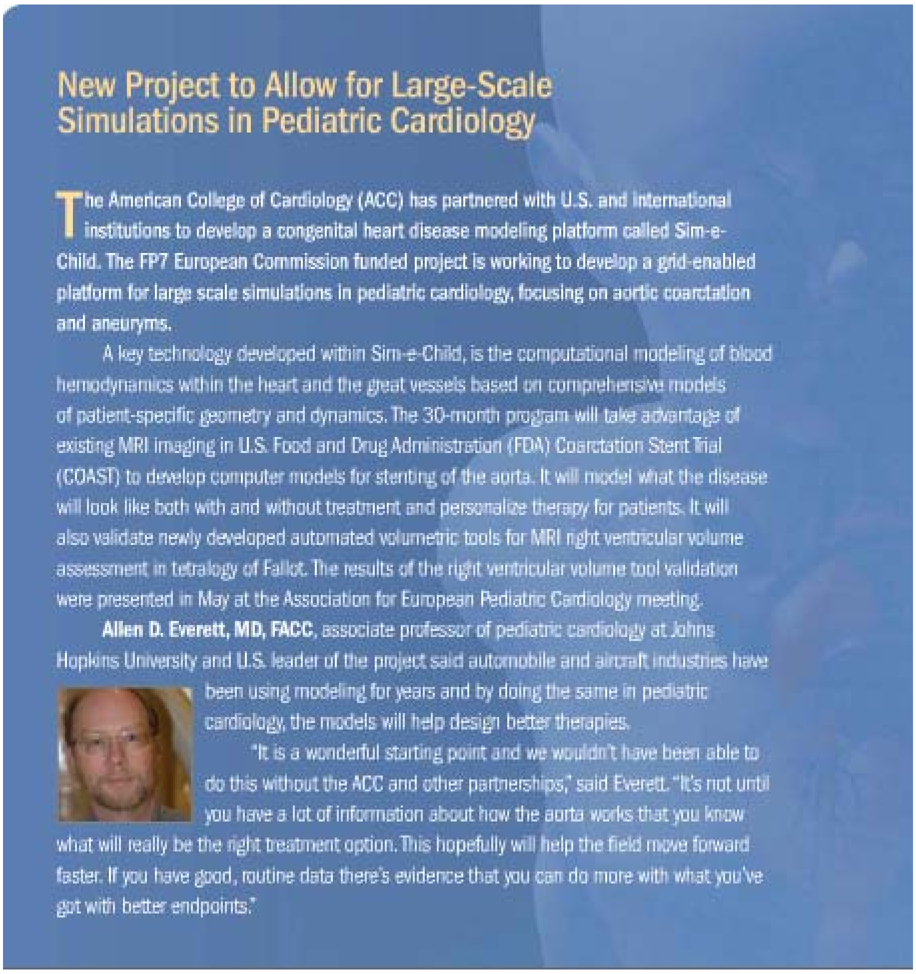
Figure 2: Comprehensive model of the heart illustrating the four chambers and valves.

Figure 3: Vorticity pattern in patient with bicuspid aorta during early systole (left) and mid systole (right).

VPHNoE 27

Figure 2: SeC article in the VPH NoE's 2011 Newsletter

In the May/June edition of the member publication of the ACC "Cardiology" Allen Everett of JHU was interviewed about the work of SeC and how the automobile and aircraft industries have been using modelling for years and how by doing the same in paediatric cardiology, the e-models will help design better therapies.



New Project to Allow for Large-Scale Simulations in Pediatric Cardiology

The American College of Cardiology (ACC) has partnered with U.S. and international institutions to develop a congenital heart disease modeling platform called Sim-e-Child. The FP7 European Commission funded project is working to develop a grid-enabled platform for large scale simulations in pediatric cardiology, focusing on aortic coarctation and aneurysms.

A key technology developed within Sim-e-Child, is the computational modeling of blood hemodynamics within the heart and the great vessels based on comprehensive models of patient-specific geometry and dynamics. The 30-month program will take advantage of existing MRI imaging in U.S. Food and Drug Administration (FDA) Coarctation Stent Trial (COAST) to develop computer models for stenting of the aorta. It will model what the disease will look like both with and without treatment and personalize therapy for patients. It will also validate newly developed automated volumetric tools for MRI right ventricular volume assessment in tetralogy of Fallot. The results of the right ventricular volume tool validation were presented in May at the Association for European Pediatric Cardiology meeting.

Allen D. Everett, MD, FACC, associate professor of pediatric cardiology at Johns Hopkins University and U.S. leader of the project said automobile and aircraft industries have been using modeling for years and by doing the same in pediatric cardiology, the models will help design better therapies.

"It is a wonderful starting point and we wouldn't have been able to do this without the ACC and other partnerships," said Everett. "It's not until you have a lot of information about how the aorta works that you know what will really be the right treatment option. This hopefully will help the field move forward faster. If you have good, routine data there's evidence that you can do more with what you've got with better endpoints."

http://www.bluetoad.com/publication/index.php?p=33&pp=1&ver=html&i=76525&zoom=0

Months 10-20 also saw cooperative work with the VPH community undertaken by Lynkeus and Siemens (with OPBG as an associate partner) which were both part of a failed VPH-FET Flagship Coordination Action proposal that sought to unite three RTD communities – the Virtual Physiological Human Initiative (VPH-I), Computer Assisted Radiology & Surgery (CARS) community, and the Association for Medical Education in Europe (AMEE) to develop radically new, integrative, ICT-facilitated models and solutions for delivering well-being and health services to global citizens. ITsMe^2 would have tried to realise the most advanced digital representation (or "virtual avatar"), of every individual for life, evolving, 'learning', becoming an increasingly personalised description of our anatomy, physiology, emotional and physical-social environment as new data and information become available.

In parallel in Q1 of 2011 OPBG became a "founding member" of the VPH Institute, and Giacomo Pongiglione was appointed as Board Member to the Institute.

3.2. International Outreach

SeC at the EC's EU-US cooperation on eHealth

Following the signing of the Memorandum of Understanding between the EU and the US related to ICT for Health activities in 2011, the European Commission organised a workshop in April 2011 to present "ongoing and planned actions" together with the US Office of the National Coordinator for Health Information Technology. SeC was asked by the EC to develop a 2 page fact sheet for distribution among the participants which can be seen below.

ICT for Health – Resource book of eHealth Projects – FP7 – Sim-e-Child

Sim-e-Child - A grid-enabled pan-Atlantic platform for large scale simulations in paediatric cardiology

Sim-e-Child

Sim-e-Child is providing a collaborative environment for multi-scale and personalized models of a growing heart and vessels including computational fluid dynamics. It operates as an extension of the Health-e-Child grid-enabled platform and interconnects the Health-e-Child databases with new data from two US multicenter studies.

Project Objectives

The objective of the Sim-e-Child is to strengthen the impact of the Health-e-Child project by creating an international simulation and validation environment

The FP7 Sim-e-Child (SeC) project is developing a grid-enabled platform for large scale simulations in paediatric cardiology, providing a collaborative environment for constructing and validating multi-scale and personalized models of a growing heart and vessels.

SeC was designed to establish international cooperation, by linking the EC funded FP6 Health-e-Child (HeC) project with leading institutions such as the American College of Cardiology, Johns Hopkins University, Technical University of Munich, and Siemens Corporate Research. SeC is an extension of the HeC platform that:

- Interconnects the HeC database with new data from two US multicenter studies;

- Enhances and expands the HeC heart model with existing models of the aorta, aortic valve and mitral valve, and with computational fluid dynamics;
- Integrates the HeC Gateway and Case Reasoner with versatile tools for simulation workflow composition and sharing of scientific experiments.

The objective of SeC is to strengthen the impact of the HeC project by creating an international simulation and validation environment for paediatric cardiology, supported by integrated data repositories. The project will advance the state-of-the-art by providing comprehensive and patient-specific models for the dynamic and longitudinal interactions occurring in the left heart, with a focus on the congenital aortic arch disease and repair.

The Sim-e-Child project is developing a grid enabled platform for large scale simulations in paediatric cardiology

Project Description

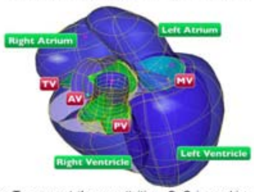
The FP7 SeC STREP started work in January 2010 as a follow-up to the FP6 HeC IP. As an early member of the Virtual Physiological Human (VPH) research community, the HeC project worked for over 4 years to build an integrated healthcare platform for paediatrics. The HeC platform utilises the EGEE gLite grid middleware to integrate innovative predictive disease models, complex data visualization and knowledge discovery applications, with the ultimate goal of supporting clinical decision making.

SeC is extending the VPH work successfully carried out by HeC in cardiology and in developing a Grid powered eHealth platform in three major ways.

1. With the support of the American College of Cardiology and Johns Hopkins, SeC is validating HeC's heart modelling capabilities using ongoing clinical US trial databases (the Coarctation Of the Aorta Stent Trial [COAST] and the National Registry of Genetically Triggered Thoracic Aortic Aneurysms and Cardio vascular Conditions [GenTAC]) in collaboration with the Bambino Gesù Paediatric Hospital (OPBG) in Italy.

SeC is extending the VPH work successfully carried out by HeC in cardiology and in developing a Grid-powered eHealth platform

2. The HeC models are being expanded by integrating existing Siemens Corporate Research models of the aorta, aortic valve and mitral valve. The heart valves represent a critical component for the multiscale modeling, simulation, understanding and prediction of the whole heart function and this work represents the first data-driven modeling of the complete valvular apparatus. Furthermore the final models will include blood flow modelling and flow visualization from the Technical University of Munich. The new and comprehensive heart model will be applied to congenital aortic disease, thus enriching the portfolio of applications available on the HeC platform.



3. To support these activities, SeC is working to developing a grid-enabled platform for large scale simulations in paediatric cardiology, by integrating the HeC's Gateway and CaseReasoner (HeC's application for similarity search and decision support) with tools for simulation workflow composition and sharing of scientific experiments. This integration work is leading to the development of a collaborative environment for constructing and validating multi-scale and personalized models of a growing child's heart and vessels. Advanced clinical measurements will be derived, such as wall stress, wall shear stress, elasticity, distensibility, stiffness, fluid structure interactions and aortic wall bio-energetics. The models in development will allow the simulation of interventions on morphology, dynamics, and hemodynamics of the aorta to make personalized predictions of optimal therapy.

Expected Results & Impact

SeC is impacting on the way health knowledge is formalized, acquired, understood, represented, analysed, communicated and validated in paediatrics. Thanks to the accrued investments made by the EC in the area of grid-enhanced computational capacities, it will become possible to allow large-scale patient-specific simulations utilizing computationally intensive data-driven models of the full heart and aorta with fluid dynamics and biomechanics. This capacity is based on aligned clinical databases in both the EU and the US, showing that not only the current lack of uniform clinical definitions/formats, which normally impedes electronic representation, transfer, and aggregation of much patient information, can be overcome, but also that testing new potential decision support tools can be performed on a cooperative basis across the Atlantic.

Project Acronym: SeC
Project title: Sim-e-Child
Project co-ordinator: Siemens AG
Contact person: Michael Suehling
Email: michael.suehling@siemens.com
Website: www.Sim-e-Child.org
Partners: names in full (country)
Siemens AG (Coordinator), (Germany)
Lynkeus Srl, (Italy)
Maat France, (France)
Technische Universität München, (Germany)
Ospedale Pediatrico Bambino Gesù, (Italy)
Siemens Corporate Research, (USA)
Johns Hopkins University, (USA)
American College of Cardiology, (USA)
Timetable: from 01/10 – to 06/12
Total cost: € 1,868,560.00
EC funding: € 993,873.00
Instrument: STREP
Project Identifier: FP7-year-ICT- 248421

Information Society Technologies

COOPERATION

European Commission Information Society and Media

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Figure 3: SeC's flyer at the EU-EC eHealth Cooperation Workshop

SeC and Argos

The SeC partners jointly developed part of the ARGOS VPH Policy Brief which was put forward as a proposal for the extension of Memorandum of Understanding that was signed by Vice-President of the European Commission Nellie Kroes and United States Secretary of Health and Human Services Kathleen Sebelius last year as a direct result of Aneesh Chopra, US Chief Technology Officer, positive reaction to it and his recommendation that it should be extended to more advanced technologies, such as VPH. Specifically, Edwin Morley-Fletcher from Lynkeus was invited to coordinate the development of a short summary of the success stories in EU-US collaboration on VPH research for cardiology, where SeC was identified as:

Developing the first grid-enabled trans-Atlantic platform for large-scale simulations in paediatric cardiology and offering an online collaborative environment for the construction and validation of multi-scale personalised simulations of a growing heart and vessels. Thanks to this EU-US collaboration, SeC is bringing forward HeC's promising anatomical and physiological models. Three of SeC's most advanced research areas are:

- SeC/HeC heart modelling capabilities being validated on an FDA clinical trial database (i.e. the Coarctation Of the Aorta Stent Trial [COAST] by the Johns Hopkins University hospital, in collaboration with the American College of Cardiology, and on newly collected independent MR data at Johns Hopkins and Bambino Gesù hospital in Rome,
- Based on high-quality models of patient-specific geometry and dynamics, SeC's "Cardiac Hemodynamics Computation" engine being developed to simulate and analyze the blood hemodynamics within a child's heart and aorta,
- SciPort, an online facility for sharing scientific experiments, providing users with a multi-site, Web-accessible database of SeC's paediatric cardiology data, information and knowledge for translational research and to support the definition, execution and sharing of scientific cardiac modelling and simulations.

Thanks to its enabling trans-Atlantic cooperation, SeC's goal is to ultimately provide clinicians with a model-driven decision support system capable of better personalising congenital aortic disease treatment and assessing when to intervene on patients

A copy of the study can be downloaded here: www.biomedtown.org/argos/reception/brief

4. Dissemination Instruments

4.1. Project Logo

In the first 4 months SeC decided on a final logo that will accompany all official project dissemination material.

4.2. Communication templates

SeC has a uniform PowerPoint template that all project's presentations are presented using. Below is a copy of the title screen.

4.3. Public Website

During the first phase of SeC the project delivered the first version of the projects website (www.sim-e-child.org). The website was designed to be completely compatible with the directions laid out by the EC for all dissemination materials and Annex II of the Grant Agreement. The website currently contains sections entitled:

- About

- Partners
- Events
- Public Documents
- Newsletter
- Publications
- Links
- Health-e-Child
- Contacts

In July 2010 the website was updated at the EC's request to include news from the High Tech Wire service. The website will be updated later in the project to reflect the achievements of the projects as opposed to the goals of the project as it is currently doing.

Figure 4: The SeC website home page

4.4. Simulation Portal

SeC has engaged a significant infrastructure setup and migration in the first reporting period, aimed at interconnecting HeC and SeC, according to the SeC work plan and with the ultimate goal of making HeC's mature components sustainable and therefore reusable in SeC in the first phase of the project, while giving SeC a significant technical basis onto which further elaborating. This infrastructure setup is now well advanced and the SeC Web portal, with public and private parts, providing users with access to the grid and integrated applications is now up and running.

As of month 10, the portal provides users with access to:

- The SeC Grid infrastructure and computing resources, using a standard and internationally recognized GridPMA certificate. The Portal is cross platform and therefore works under MS W7/XP, major Linux distributions and Mac OS X in latest version
- The SciPort database and interfaces for manipulating data and simulations' outputs (please note that SciPort is being integrated to the security infrastructure; it will therefore be possible to enter SciPort directly once logged in the SeC portal soon),
- The Desktop Fusion facility, a remote desktop service allowing to run demanding and/or "Web unaware" applications such as the HeC Case Database, the HeC Patient Browser as well as the HeC CaseReasoner). Additional tools to support researchers in their daily activities to store electronic documents, to blog/forum/wiki project information etc

Figure 6: The SeC Portal's Public home page

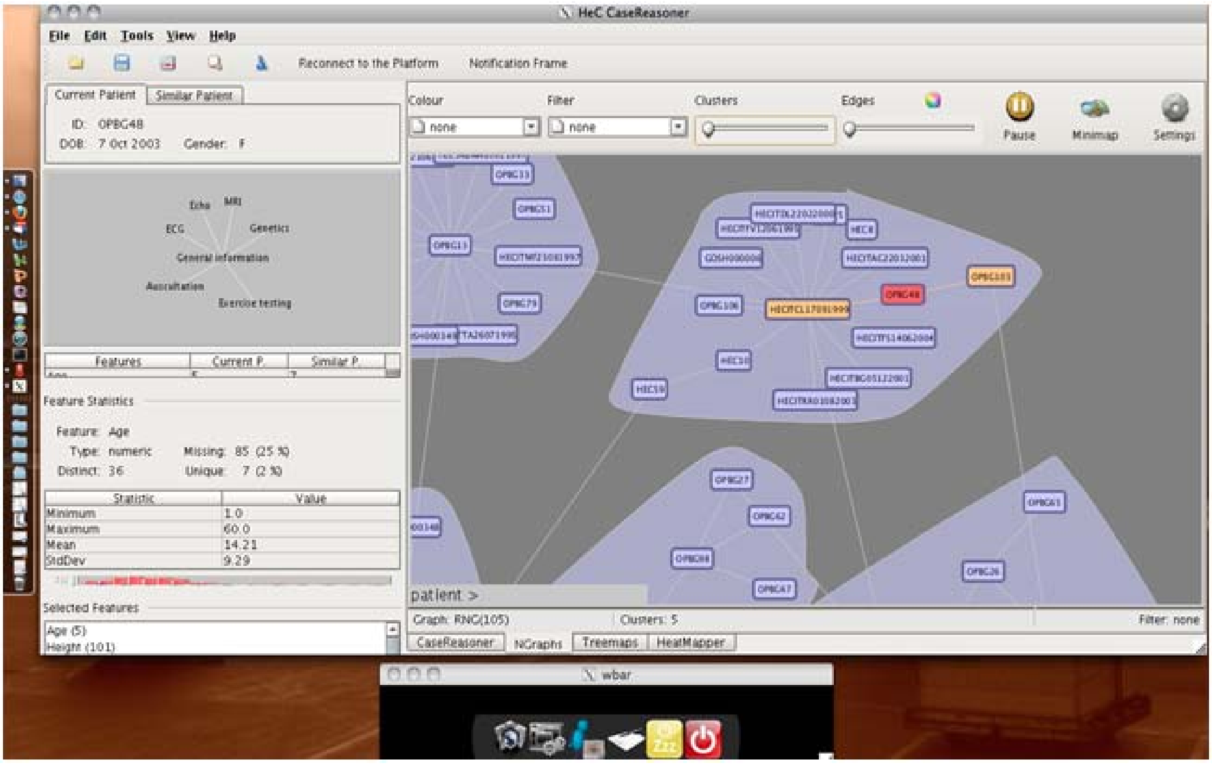

Figure 7: HeC's CaseReasoner working through the SeC portal

4.5. Newsletter

The first SeC newsletter was published in month 12, as was promised in the SeC's original DoW. The newsletter included sections on SeC's grid infrastructure and web portal, the heart modelling and cardiac blood flow simulation work of 2010 and highlights of the dissemination events of the first 12 months. The newsletter was distributed to interested parties, used at all dissemination and networking events and uploaded to the website. In advance of the ConHIT conference the Newsletter was updated to reflect the progress of the conference. Below are some copies of a few of the newsletters pages:

An Introduction to Sim-e-Child

The FP7 STREP Sim-e-Child (SeC) started in January 2010 and has now completed its first 12 months of work. The objective of the SeC is to strengthen the impact of the FP6 Integrated Project "Health-e-Child" (HeC) which was completed in April 2010, rated as "surpassing expectations" by the EC and the winner of the ICT08 Best Exhibition Award, by creating an international simulation and validation environment for paediatric cardiology, supported by integrated data repositories. The project is working to go beyond the state-of-the art by providing comprehensive and patient specific models for the dynamic and longitudinal interactions occurring in the left heart, with a focus on the congenital aortic arch disease and repair.

The Sim-e-Child Consortium

In addition to some of the original HeC partners (Siemens AG, Ospedale Bambino Gesù, maat France and Lynkeus Srl), three major US centres of excellence (John Hopkins Children's Centre, Siemens Corporate Research and the American College of Cardiology), and two further European partners (Technische Universität München and Siemens Program and Systems Engineering, Romania) complete the consortium.

The Goals of Sim-e-Child

Since the development of the project's proposal, the SeC consortium has been working to improve clinical outcomes of paediatric cardiology patients. The treatment of paediatric congenital heart disease is hampered by the scarcity of relevant cases, the lack of integrated data and the limited opportunities for clinical comparison among others. Yet, advances in paediatric cardiac surgery, interventional cardiology, intensive care and non-invasive imaging have led to a substantial increase in life expectancy for many patients with congenital heart disease. However, difficult challenges still persist due to the evolving nature of a child's heart and vascular system. In order to achieve better and more reliable risk stratum, to improve and personalise therapies, and to ultimately increase the patient survival rate, SeC is focused on developing comprehensive and accurate computer models from patient specific data and simulated physical constraints.

In Sim-e-child we are enhancing cardiac models by utilising international collaboration beyond the European research area to validate our models on additional data. Also, the models developed in Health-e-Child are being expanded by integrating existing Siemens Corporate Research models of the aorta, aortic valve and mitral valve together with blood flow modelling and flow visualisation from the Technical University of Munich. The new and comprehensive heart model will be applied to congenital aortic heart disease and repair, thus enriching the portfolio of applications available in Health-e-Child and broadening its end-user community.

Michael Sühling
Sim-e-Child Project Coordinator, Siemens

Sim-e-Child: a 30-month Specific Targeted Research Project co-funded under the 7th Framework Programme priority "Information Society

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Sim-e-Child's Heart modelling results of 2010

Besides technical interoperability requirements elicitation and infrastructure bridging, the work focused also on the development and validation of a comprehensive cardio-vascular anatomical model enabling first patient-specific haemodynamics simulations. The main achievements were:

- The existing HeC heart models were validated by the clinical partners on MRI data from Tetralogy of Fallot (TOF) cases. Using linear regression and Bland Altman plots, left and right ventricular systolic (LV ESV and RV ESV) and diastolic volumes (LV EDV and RV EDV) and ejection fractions (LV EF, RV EF) were compared between manual and automated methods. In addition, the average processing time per patient was compared between techniques.
- The existing HeC heart models were extended by integrating and enhancing existing Siemens Corporate Research models, of the aortic and mitral valve. To exploit the morphological, functional and pathological dependencies and variations of the different heart valves, the pulmonary valve (PV) and tricuspid valve (TV) have been modelled in addition. The heart valves represent a critical component for the analysis, modelling, and simulation of the whole heart function and this work represents the first data-driven modelling of the complete valvular apparatus.

Above: Comprehensive, patient-specific heart model including the complete valvular apparatus.

Patient-specific Cardiac Blood Flow Simulations

SeC Clinicians were provided with first, simulated, patient-specific cardiac blood flow across the entire cycle. Thanks to this work clinicians will, for instance, benefit from a better understanding of the vorticity which can convey crucial information about the formation and dynamics of potentially harmful "spins". By integrating these elements, SeC will provide paediatric cardiology professionals in Europe and the US with a Virtual Physiological Human based decision support and virtual laboratory. This will enable them to construct and validate multi-scale and personalised models of a growing child's heart and blood vessels. Ultimately this will support their clinical decisions and allow better understanding of their patient's condition.

Above: CFD blood flow simulation results based on patient-specific anatomical model: Vorticity pattern in patient with bicuspid aortic valve during early systole (left) and mid systole (right).

Sim-e-Child: a 30-month Specific Targeted Research Project co-funded under the 7th Framework Programme priority "Information Society Technologies"

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Figure 8: SeC's first Newsletter

The newsletter can be found at: www.sim-e-child.org/2/sec_s_first_newsletter_1502279.html

The second newsletter is scheduled to be published at the end of 2011.

4.6. International scientific journals List

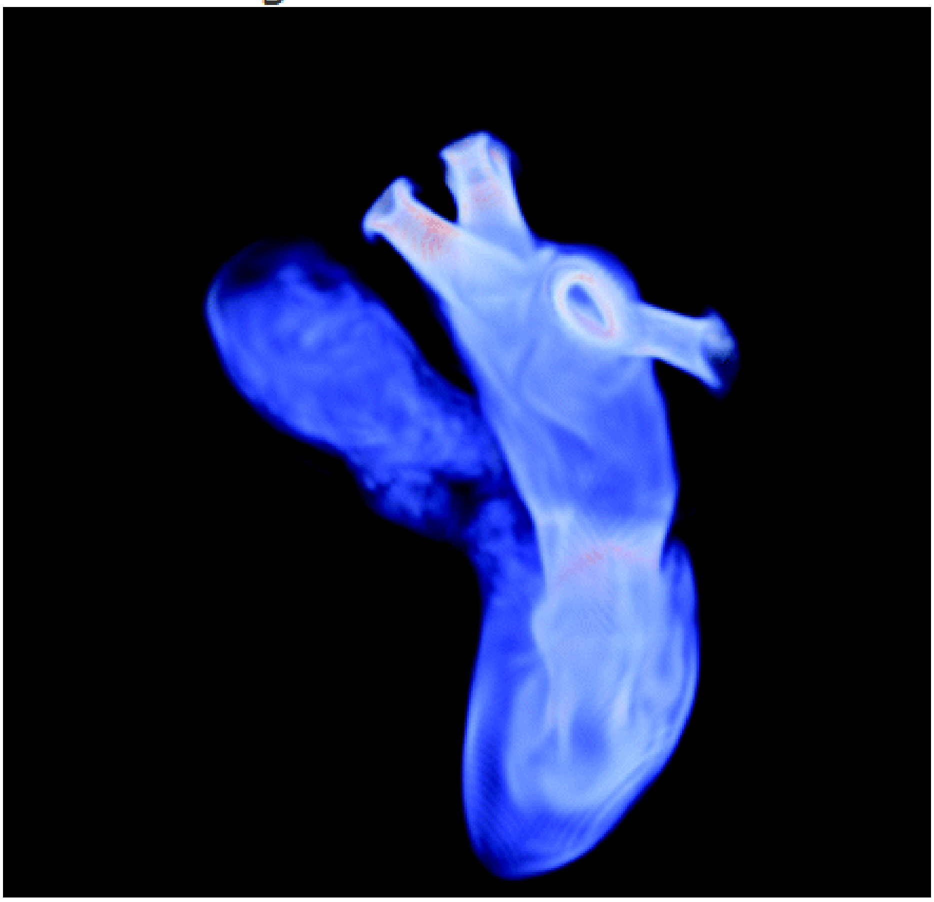
Reporting Period 2

- Carotti A, Albanese SB, Filippelli S, Ravà L, Guccione P, Pongiglione G, Di Donato RM, Determinants of outcome after surgical treatment of pulmonary atresia with ventricular septal defect and major aortopulmonary collateral arteries., J Thorac Cardiovasc Surg. 2010 Nov
- Gagliardi MG, Papavasileiou L, Pongiglione G., Rescue treatment by percutaneous closure of interatrial septal defect or PFO in infants with Berlin heart., Catheter Cardiovasc Interv. 2011 March
- Tuo G, Volpe P, Bondanza S, Volpe N, Serafino M, De Robertis V, Zannini L, Pongiglione G, Calevo MG, Marasini M., *Impact of prenatal diagnosis on outcome of pulmonary atresia and intact ventricular septum.,* J Matern Fetal Neonatal Med. 2011 Jun
- Ionasec R., Suehling M., Comaniciu D., *Sim-e-Child: Grid-Enabled Platform for Simulations in Paediatric Cardiology Toward the Personalized Virtual Child Heart – VPH NoE 2010*
- Voigt, T. Mansi, V. Mihalef, R. Ionasec, A. Calleja, E. Mengue, P. Sharma, H. Houle, B. Georgescu, J. Hornegger, D. Comaniciu*: Patient-Specific Model of Left Heart Anatomy,*

Dynamics and Hemodynamics from 4D TEE: A First Validation Study, Sixth International Conference on Functional Imaging and Modeling of the Heart, FIMH 2011, May 25-27, 2011.

- V. Mihalef, R. Ionasec, G. Georgescu, I. Voigt, M. Suehling, D. Comaniciu: *Patient-specific modelling of whole heart anatomy, dynamics and haemodynamics from four-dimensional cardiac CT images*, Royal Society Interface Focus Journal, June 6, 2011.
  This article, a preliminary version of which had first been presented at the Virtual Physiological Human Conference 2010, Brussels 2010, has been highlighted in the cover page of the Royal Society's Interface Focus journal:

Cover image



Cover image: Patient-specific cardiac blood flow vorticity magnitude. Data obtained through Computational Fluid Dynamics using as input the patient's heart anatomy and dynamics. (See pages 286–296; image courtesy of Viorel Mihalef.)

http://rsfs.royalsocietypublishing.org/content/1/3.cover-expansion

- Vitanovski, D., Tsymbal, A., Ionasec, A., Greiser, A., Schmidt, M., Mueller, E., Lu, X., Funka-Lea, G., Hornegger, J., Comaniciu, D., *Accurate Regression-based 4D Mitral Valve Surface Reconstruction from 2D+t MRI Slices; in Machine Learning in Medical Imaging*, MICCAI Workshop 2011.

- Ralovich, K., Ionasec, R. I., Mihalef, V., Georgescu, B., Everett, A., Navab, N., and Comaniciu, D., *Computational Fluid Dynamics Framework for Large-Scale Simulation in Pediatric Cardiology*; in Computational Biomechanics for Medicine VI (CBM6), MICCAI Workshop, 2011.

Reporting Period 1

- Amodeo A, Brancaccio G, Michielon G, Filippelli S, Ricci Z, Morelli S, Gagliardi MG, Iacobelli R, Pongiglione G, Di Donato RM., *Pneumatic pulsatile ventricular assist device as a bridge to heart transplantation in pediatric patients*, Artif Organs. 2010 Nov;34(11):1017-22.
- Barcudi S, Sanders SP, Di Donato RM, de Zorzi A, Iacobelli R, Amodeo A, Gagliardi MG, Borgia F, Pongiglione G, Rinelli G., *Aberrant left innominate artery from the left descending aorta in right aortic arch: echocardiographic diagnosis*, J Am Soc Echocardiogr. 2010 Feb;23(2):221.e5-7.
- Brancaccio G, Amodeo A, Ricci Z, Morelli S, Gagliardi MG, Iacobelli R, Michielon G, Picardo S, Parisi F, Pongiglione G, Di Donato RM., *Mechanical assist device as a bridge to heart transplantation in children less than 10 kilograms*, Ann Thorac Surg. 2010 Jul;90(1):58-62.
- Carotti A, Albanese SB, Filippelli S, Ravà L, Guccione P, Pongiglione G, Di Donato RM., *Determinants of outcome after surgical treatment of pulmonary atresia with ventricular septal defect and major aortopulmonary collateral arteries*, J Thorac Cardiovasc Surg. 2010 Nov;140(5):1092-103.
- Cavallini M, Di Zazzo G, Giordano U, Pongiglione G, Dello Strologo L, Capozza N, Emma F, Matteucci MC., *Long-term cardiovascular effects of pre-transplant native kidney nephrectomy in children*, Pediatr Nephrol. 2010 Dec;25(12):2523-9. Epub 2010 Sep 25.
- Comaniciu, D., *Patient-Specific Modelling of Whole Heart Anatomy, Dynamics and Hemodynamics from 4D cardiac CT Images*, Interface Focus 2010 - (invited publication-submitted)
- De Caro E, Smeraldi A, Trocchio G, Calevo M, Hanau G, Pongiglione G., *Subclinical cardiac dysfunction and exercise performance in childhood cancer survivors*, Pediatr Blood Cancer. 2011 Jan;56(1):122-6.
- De Caro E, Spadoni I, Crepaz R, Saitta M, Trocchio G, Calevo MG, Pongiglione G., *Stenting of aortic coarctation and exercise-induced hypertension in the young*, Catheter Cardiovasc Interv. 2010 Feb 1;75 (2):256-61. Erratum in: Catheter Cardiovasc Interv. 2010 Jun 1;75 (7):1143.
- Everett, A., Development and validation of a novel automated learning based algorithm for quantification of MRI right ventricular volume in Tetralogy of Fallot, submitted abstract for the 45th Annual Meeting of the Association of European Paediatric Cardiology, to be held in Granada, Spain in May 2011.
- Gagliardi MG, Papavasileiou L, Pongiglione G, Rescue treatment by percutaneous closure of interatrial septal defect or PFO in infants with berlin heart, Catheter Cardiovasc Interv. 2010 Sep 17
- Grbic S., Ionasec R., D. Vitanovski, Ingmar Voigt, B. Georgescu, , N. Navab, D. Comaniciu, *Complete Valvular Heart Apparatus Model from 4D Cardiac CT*, Medical Image Computing and Computer Assisted Intervention (MICCAI), Beijing, China, September 20-24 2010.
- Ionasec R., Georgescu B., Navab N., Comaniciu D., *Patient-Specific Modelling of Whole Heart Anatomy, Dynamics and Hemodynamics from 4D cardiac CT Images*, BMT – 2010, Rostock2010

- Vitanovski D., Razvan Ioan Ionasec, A. Tsymbal, B. Georgescu, M. Huber, Joachim Hornegger, D. Comaniciu, *Cross-modality Assessment and Planning for Pulmonary Trunk Treatment using CT and MRI imaging*, Medical Image Computing and Computer Assisted Intervention (MICCAI), Beijing, China, September 20-24 2010.
- Mihalef, V., Ionasec, IR., Sharma, P., Georgescu, B., Huber, M., Comaniciu, D., *Patient-Specific Modelling of Whole Heart Anatomy, Dynamics and Hemodynamics from 4D cardiac CT Images*, Virtual Physiological Human Conference 2010, Brussels 2010.