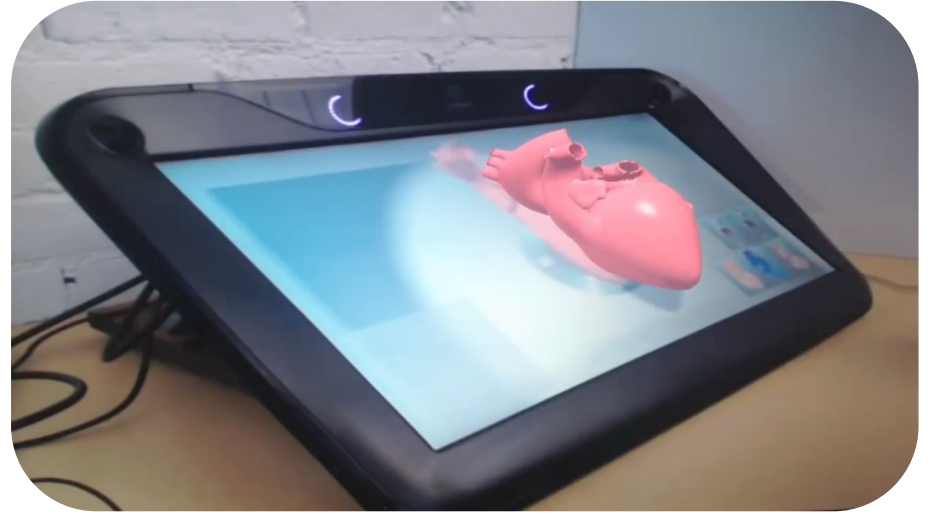


The Living Heart 3DEXPERIENCE



3DEXPERIENCE®



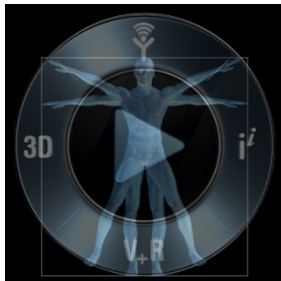
Jean Colombel

Vice President

Life Sciences Industry

Dassault Systèmes

Dassault Systèmes



a Scientific company

Combining **Science**, **Technology** and **Art** for a sustainable society



14,000 passionate people

- 123 nationalities / 172 sites
- One global R&D / 56 labs
- Game changing **3DEXPERIENCE** solutions



>200,000 enterprise customers

- 12 industries in 140 countries
- 25 million users



12,600 partners

- Software, Technology & Architecture
- Content & Online Services
- Sales
- Consulting & System Integrators
- Education
- Research



Long-term driven

- Majority shareholder control
- **Revenue: \$3.2 Bn***
- Operating margin: 30.8%*

* Figures as of FY 2015 / Non-IFRS

Innovation is Dassault Systèmes DNA



Transportation & Mobility



Aerospace & Defense



Marine & Offshore



Industrial Equipment



High-Tech



Consumer Goods - Retail



Consumer Packaged Goods - Retail



Life Sciences



Energy, Process & Utilities



Architecture, Engineering & Construction



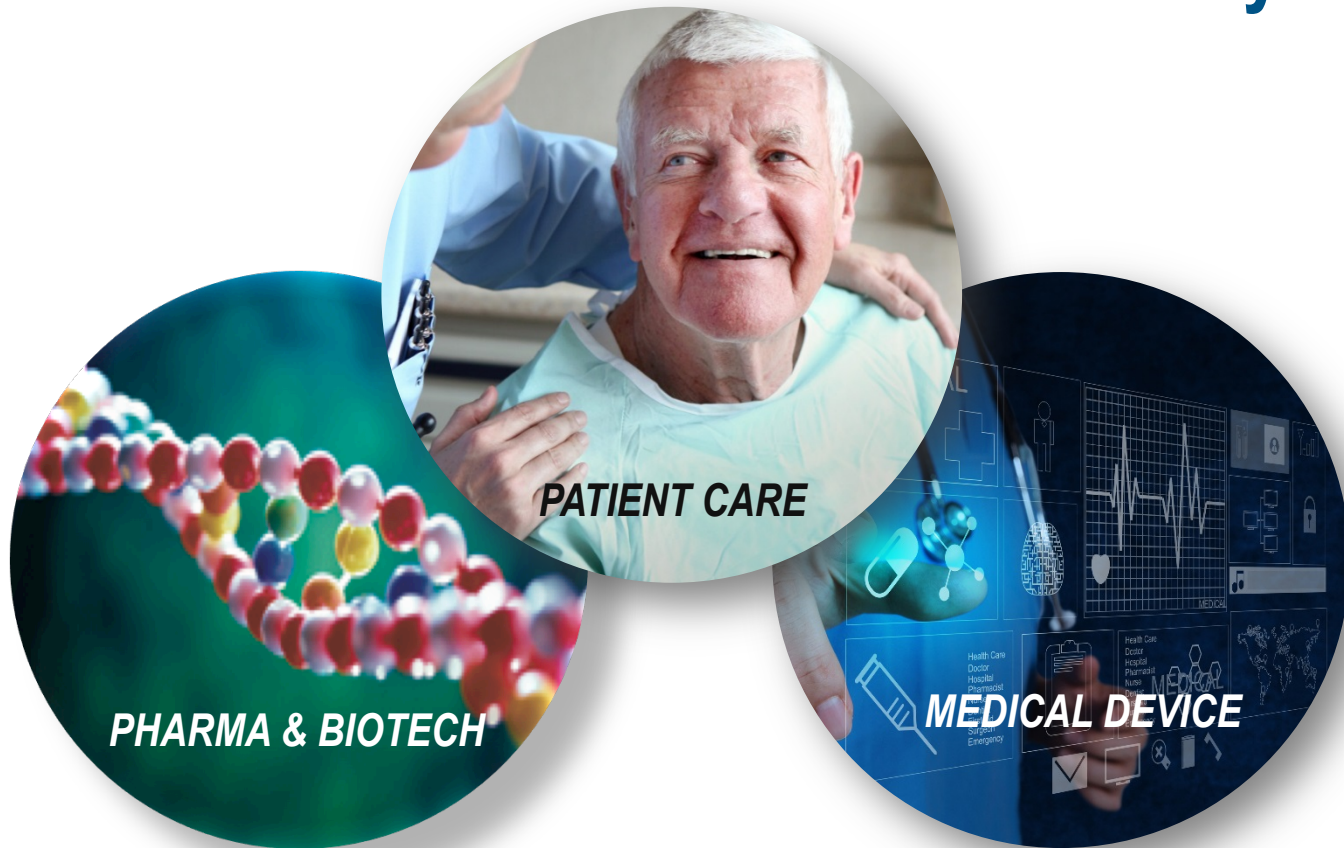
Financial & Business Services



Natural Resources

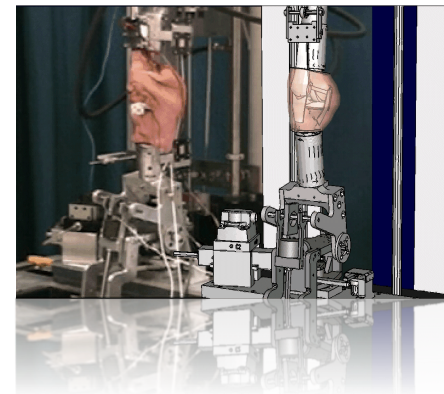
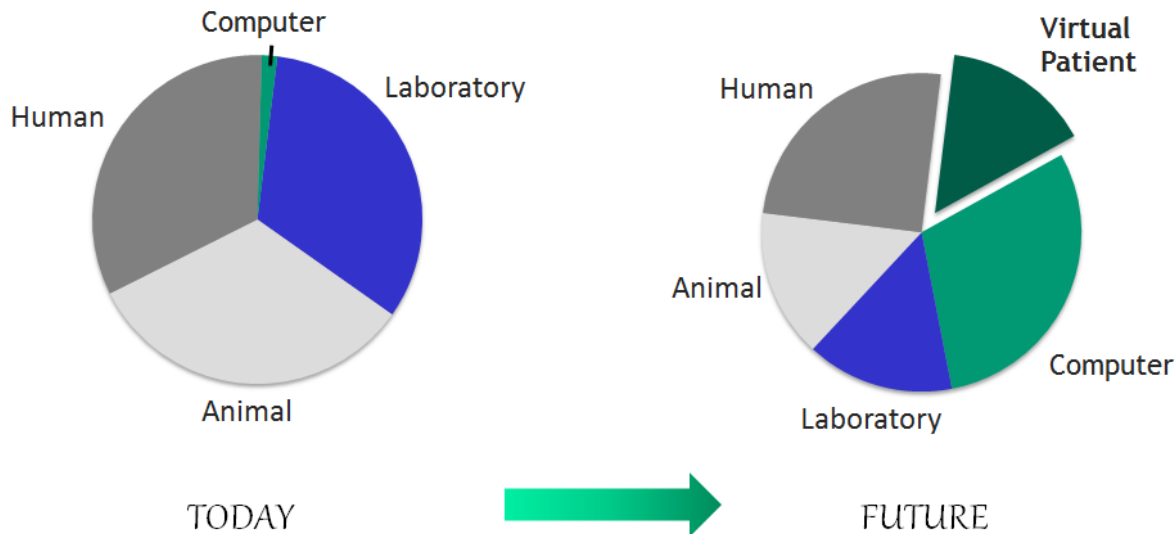


Life Sciences Innovation at Dassault Systèmes



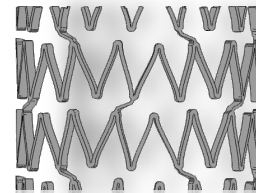
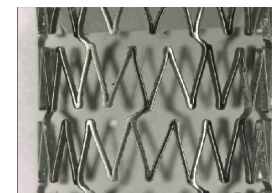
Medical Device Innovation - Application of Simulation

Sources of Scientific Evidence Accelerating Innovation



Test

Simulation



Test data courtesy SRI. Abaqus model courtesy NDC

Credit: MDIC Modeling and Simulation Project

Support for Modeling and Simulation by FDA is Clear


FDA U.S. Department of Health and Human Services
U.S. Food and Drug Administration

Advancing Regulatory Science with M&S at FDA

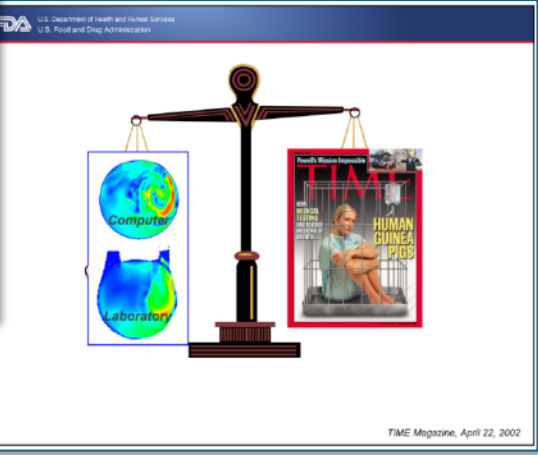
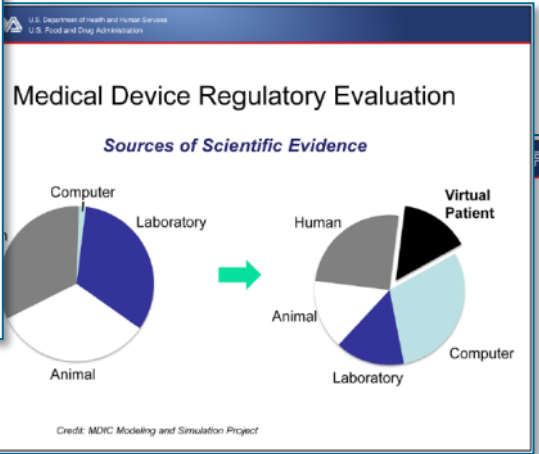
FDA has identified an important role for M&S in its strategic priorities.

- #1 Modernize Toxicology
- #2 Stimulate Innovation in Clinical Evaluations and Personalized Medicine to Improve Product Development and Patient Outcomes
- #4 Ensure FDA Readiness to Evaluate Innovative Emerging Technologies
- #5 Harness Diverse Data through Information Sciences to Improve Health Outcomes

<http://www.fda.gov/downloads/ScienceResearch/SpecialTopics/RegulatoryScience/UCM268225.pdf>

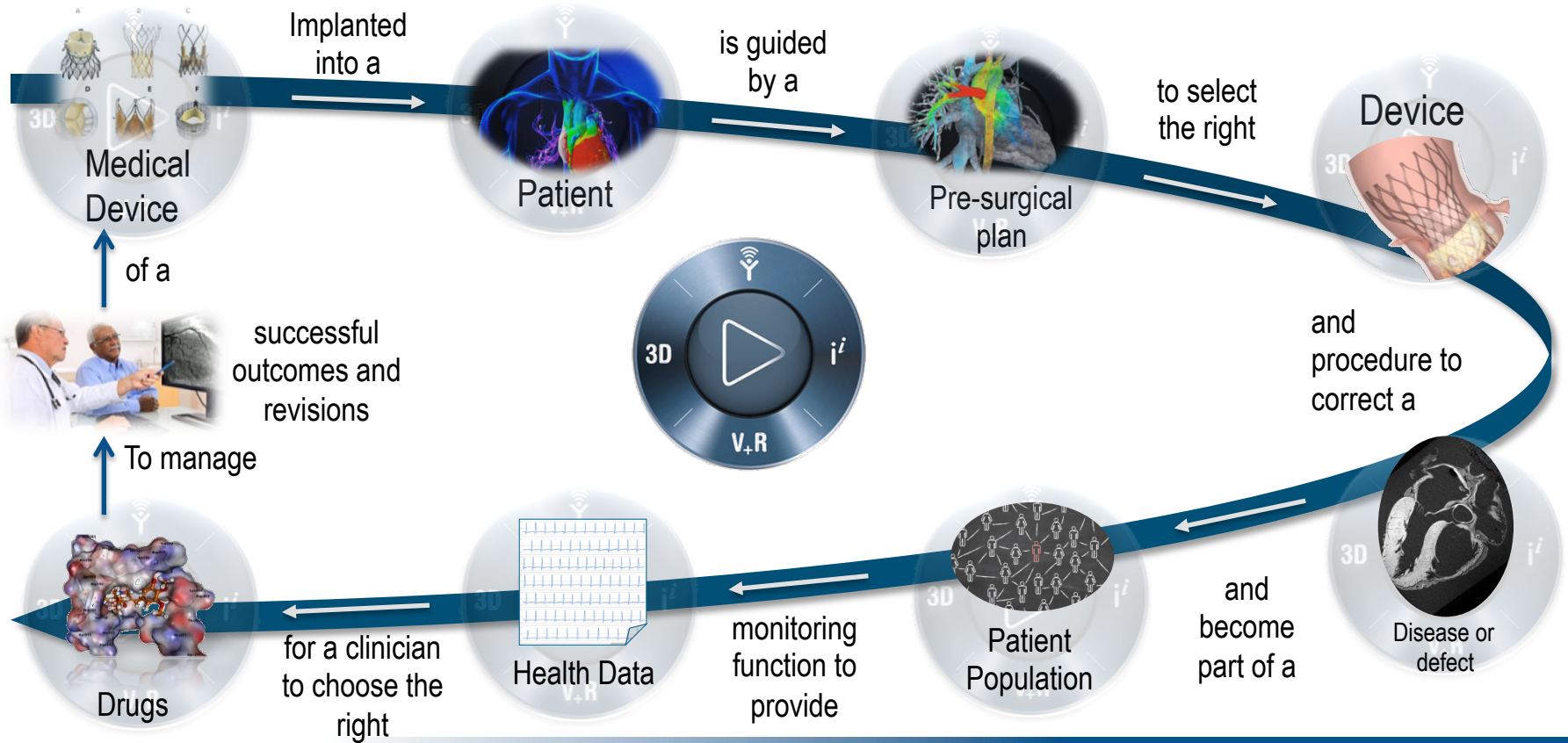


Computational models of cells, organs, and systems, such as virtual physiologic patients for testing medical products and predicting product safety and efficacy.

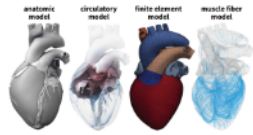


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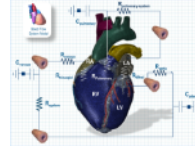
Digital Healthcare & Medical Device Innovation



Listening to Healthcare Specialists

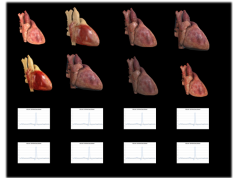
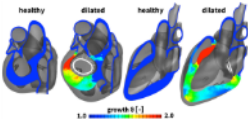


Anatomically Correct
Healthy Heart
(Electro, Mechanical, Fluid)



Understand Disease States

- Atherosclerosis
- Cardiomyopathies
- Arrhythmias



Medical Device Design/Training

- Improved Product Design
- Quality & Patient Safety
- Accelerate Time to Market
- Accelerate Clinical Trials

Advancing Regulatory Science with M&S at FDA

FDA has identified an important role for M&S in its strategic priorities.

Key Milestones/Tools:

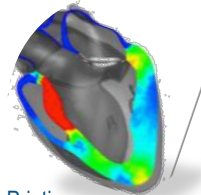
- AS Medical Technology
- AS Simulation Immersion in Clinical Evaluation and Personalized Medicine to Improve Product Development and Patient Outcomes
- AS Enhance FDA Readiness to Evaluate Innovative Emerging Technologies
- AS Harness Clinical Data through Information Sciences to Improve Health Outcomes

Computational models of cells, organs, and systems, such as virtual algorithms, standards for testing medical products and predicting product safety, cost efficiency.

Personalized

Pre-Surgical Plan

- Anatomical Insight
- Device Selection
- Procedure Planning
- Outcome Prediction



3D Printing

- Patient Specific Surgical Planning
- Patient Specific Device

Diagnosis

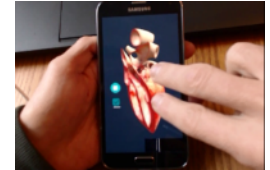
Personal Heart Analysis Workflow:

- Image & Data Analysis
- Physician
- Patient
- Device

3D Heart Models: Various anatomical models and device options are shown.

Education

- Patient Engagement
- Pre/Post Surgery
- On-Going Care



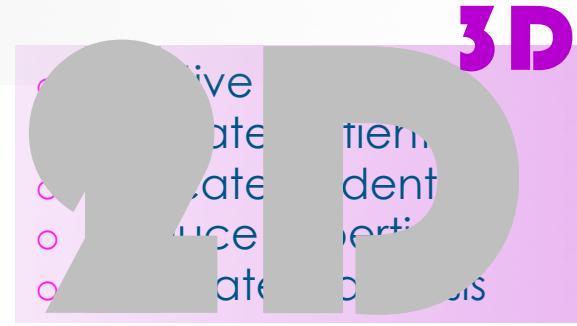
3 Minutes of 3D - Cardiology

Did You Know? The heart is made of muscle. After working and without great rest, it keeps going and keeping you alive. It can pump 60-100 gallons of blood every minute. It's about the size of your fist. Can you believe you can live without it?

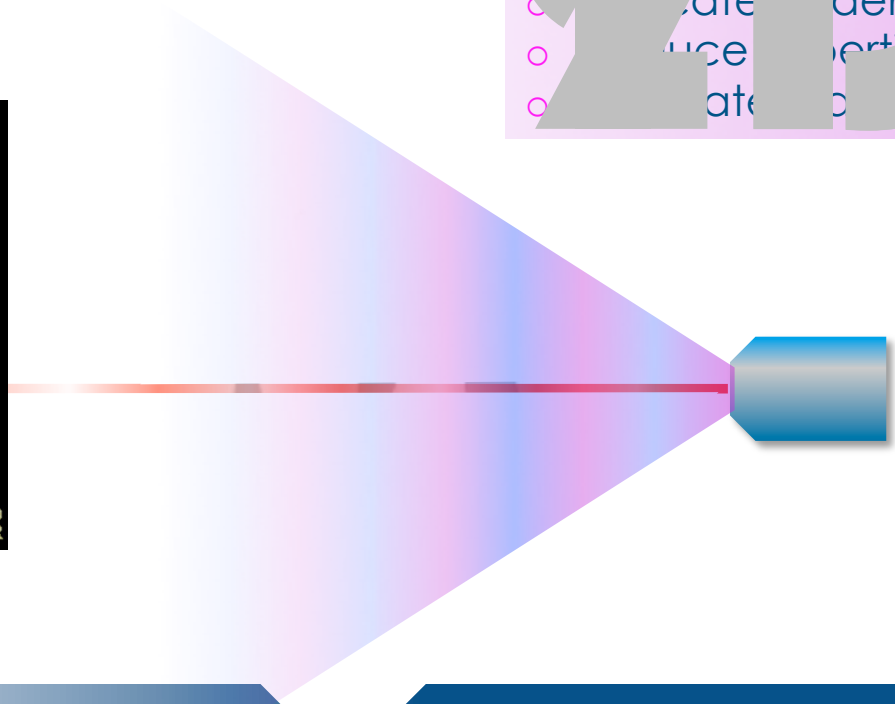
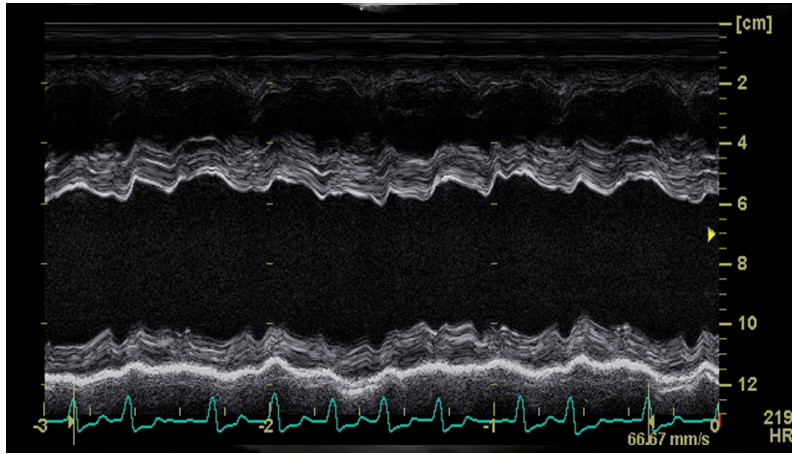
Did You Know? The heart has 4 chambers. The two upper chambers are called atria and the two lower chambers are called ventricles. The heart pumps blood to all parts of the body.

Did You Know? The heart is a muscle. It can get bigger and stronger. It can also get smaller and weaker. It can be damaged by disease. Can you believe you can live without it?

Value of 3D

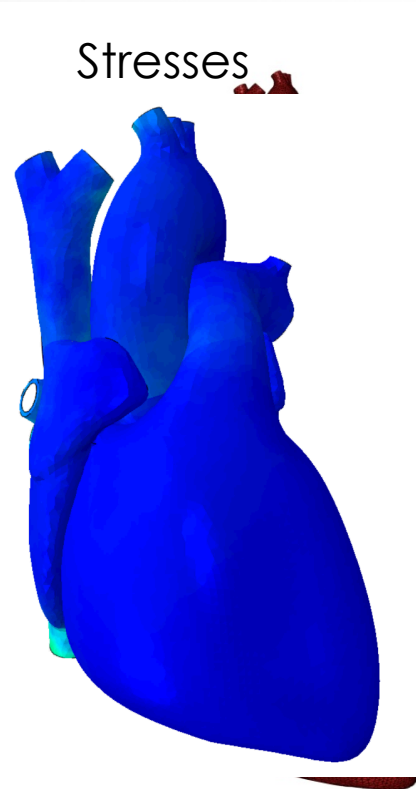
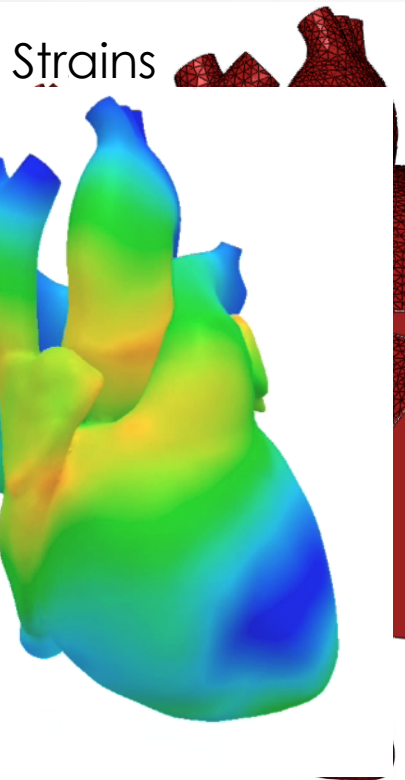
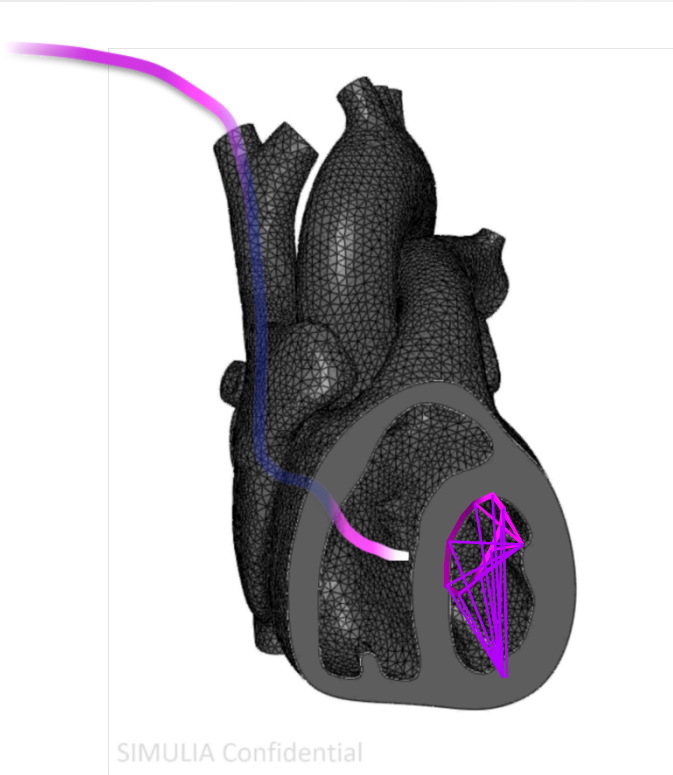


Echocardiography:



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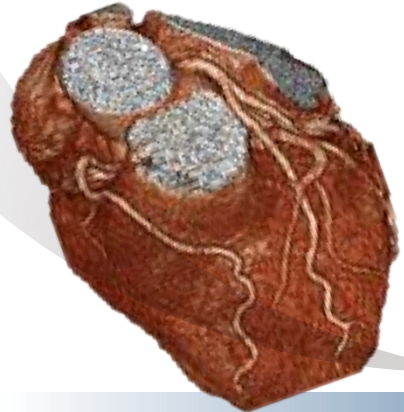
Value of Simulation



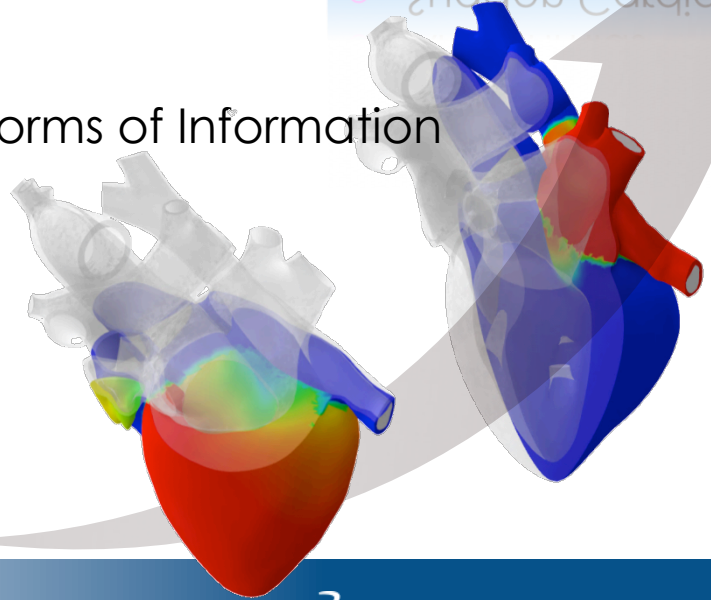
Value of Simulation



Anatomic Information



New Forms of Information



- Heart Failure
- Heart Attack
- Arrhythmias
- Sudden Cardiac Death



Project Members

Researchers



California Medical Innovations Institute

Ghassan Kassab, Ph.D.
President



Kumaran Kolandaivelu, M.D., Ph.D. and Cardiologist
Instructor of Medicine, Harvard Medical School, Medical Director, Clinical Research Center, Massachusetts Institute of Technology



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Clinical Cardiologists



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Gregor Theilmeier, M.D.
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Professor

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Associate Professor of Mechanics and Computation

[simula . research laboratory]



Kirill Klyshnikov, Ph.D.
Assistant Professor

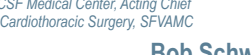


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Associate Professor



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Associate Professor of Surgery, UCSF Medical Center, Acting Chief of Cardiothoracic Surgery, SFCVAC



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Professor, Founder, Director MAIDROC Laboratory,



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Raymond Watrous, Ph.D.
Biomedical Engineering Scientist



Sebastian Kozerke, Ph.D.
Full Professor of Biomedical Imaging at the Department of Information Technology and Electrical Engineering



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Professor, Department of Surgery, University of Minnesota and Principal Investigator for the Visible Heart Lab located at University of Minnesota



UC San Diego

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Liviu Klein, M.D., M.S.
Director, Mechanical Circulatory Support and Heart Failure Device Programs

Bob Schwengel, M.D., FACC
Cardiologist

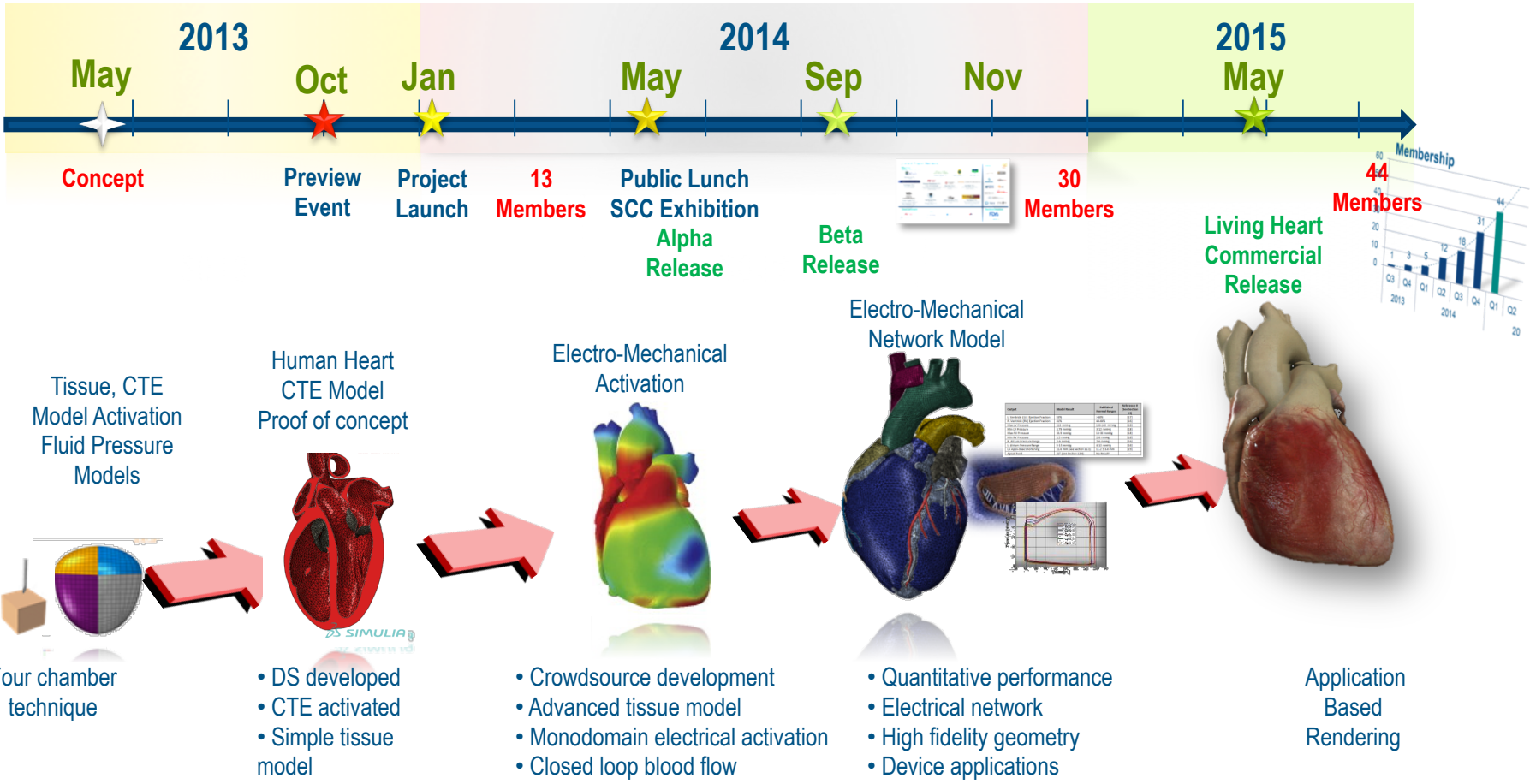
Industry



Regulators / Associations

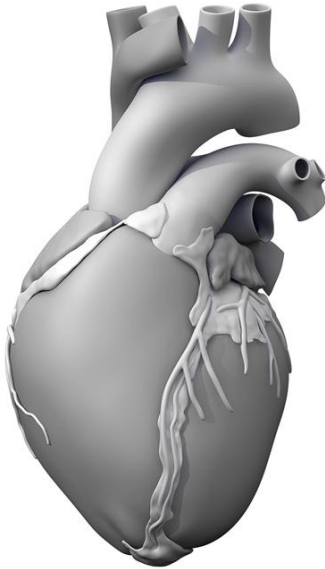


Regulators/Associations

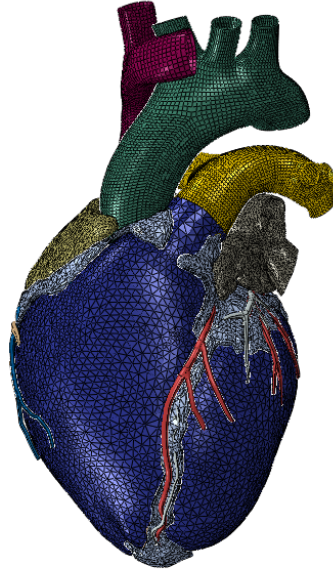


Heart Model Geometry

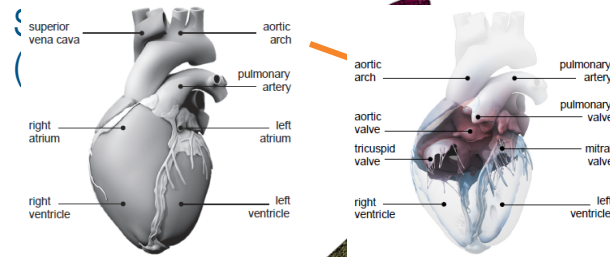
Courtesy of Zygote Media Group, Inc



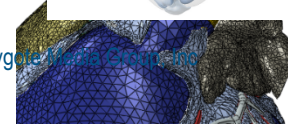
CAD Geometry



Finite Element Meshes



Courtesy of Zygote Media Group, Inc

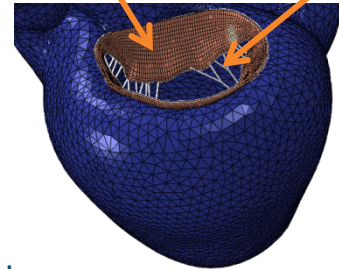


Aortic Arch (Shells)

Pulmonary Trunk (Shells)

Mitral Valve (Shells)

Chordae (Trusses)

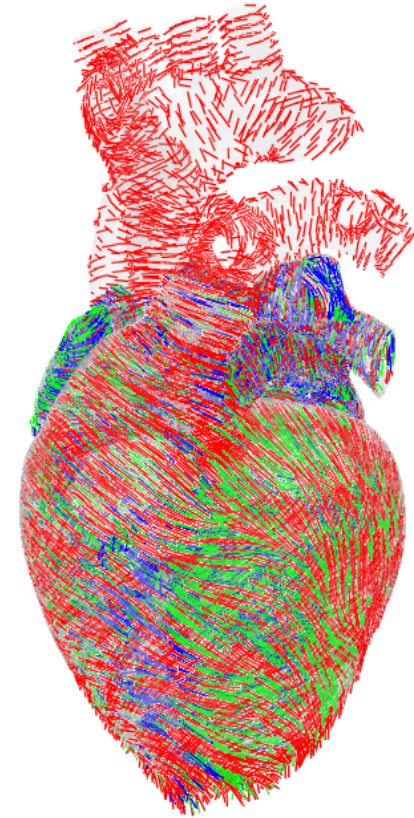


Mechanical Model

Accurately capture fiber orientation distributions

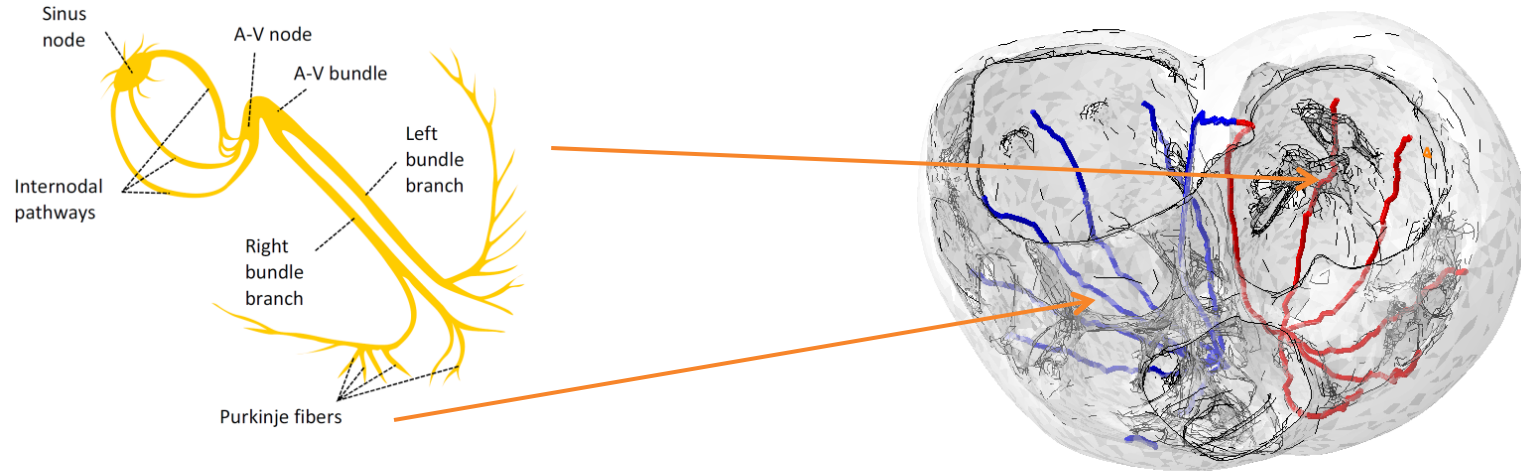
The fiber orientations are complex due to

- Heart geometry
- The orientations change across the heart surface
- The orientations change through the thickness of the heart wall



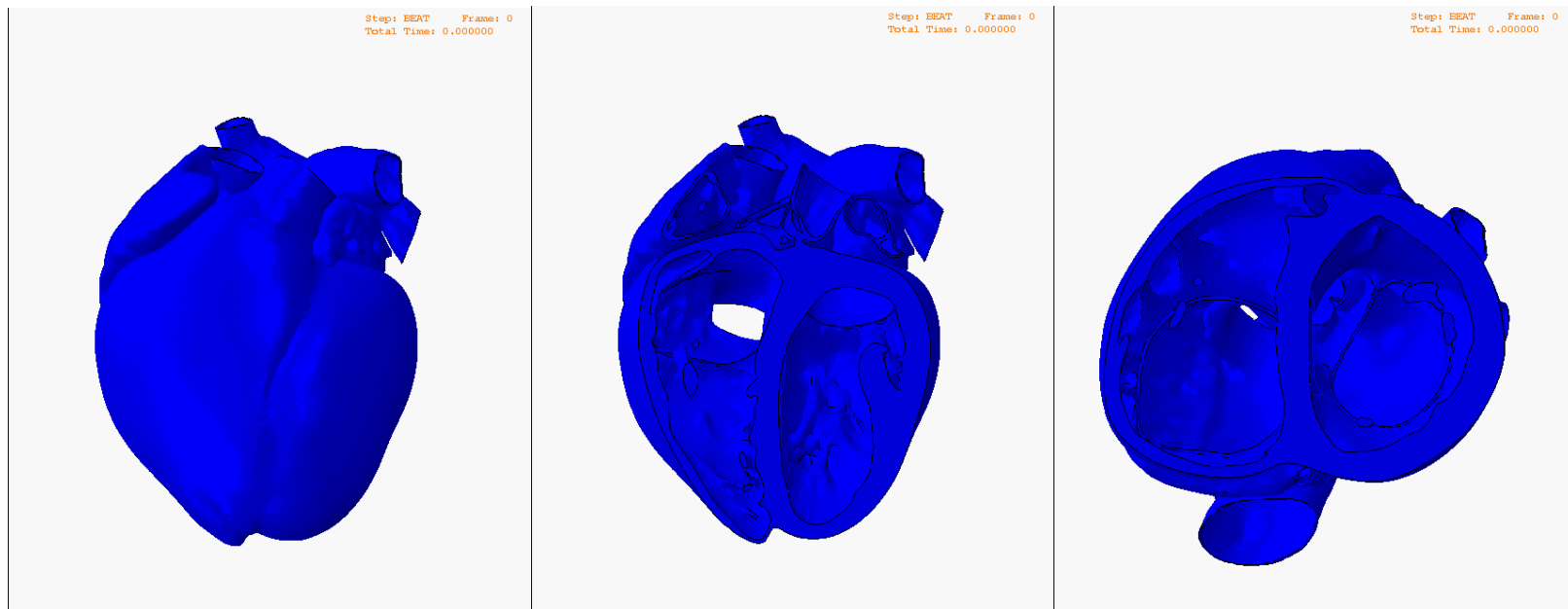
Electrical Model

Electrical pathways simulated using hybrid-network approach



Electrical Simulation

Electrical Potential



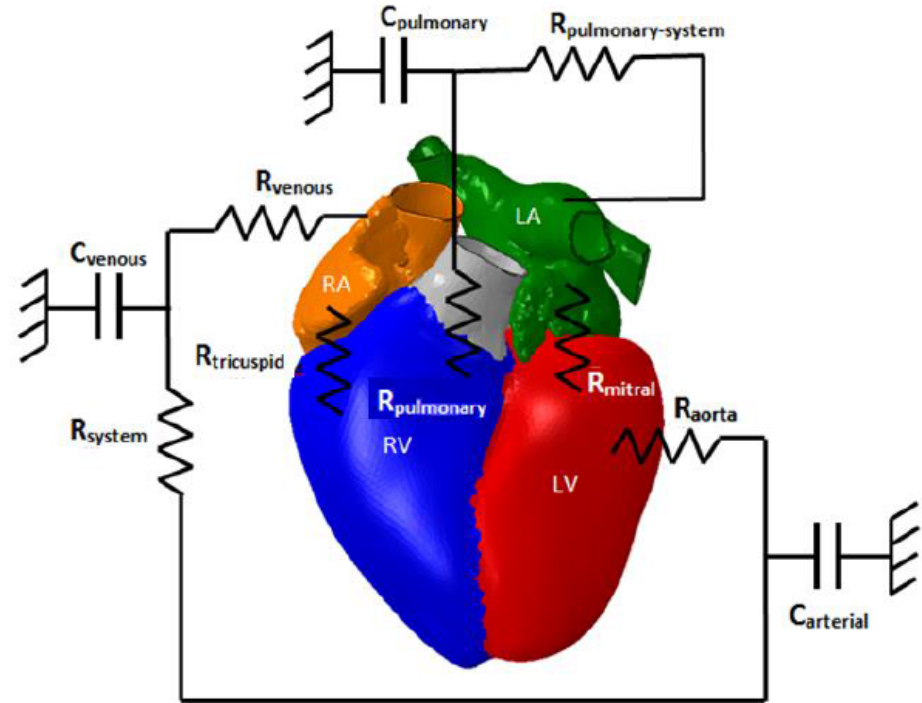
Long-axis

Long-axis

Short-axis

Blood Flow Model

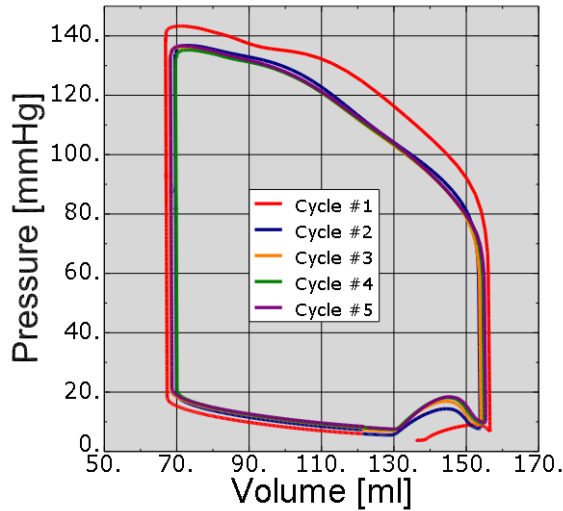
The blood flow within and outside the heart is modeled using a hybrid 3D/
lumped parameter approach



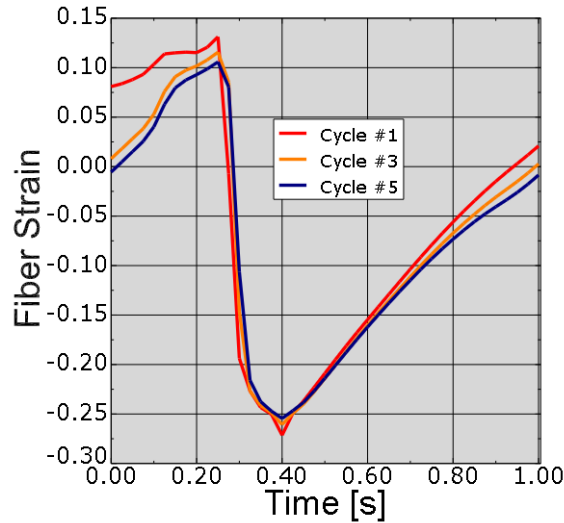
Verification – Mechanical Model

Achieving Steady-State

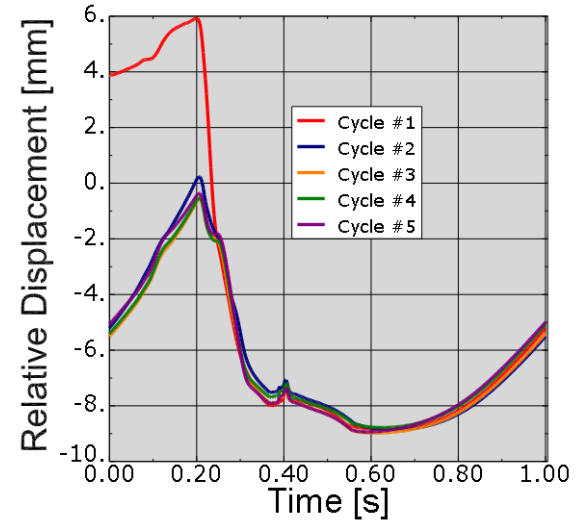
Steady state achieved in 3 cycles



Left Ventricle



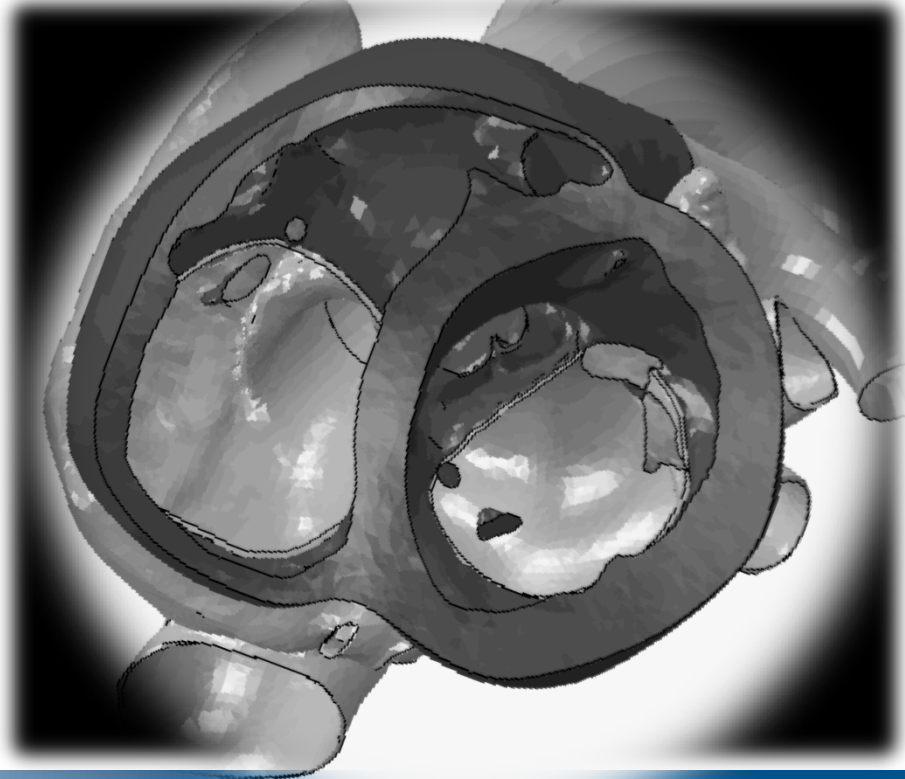
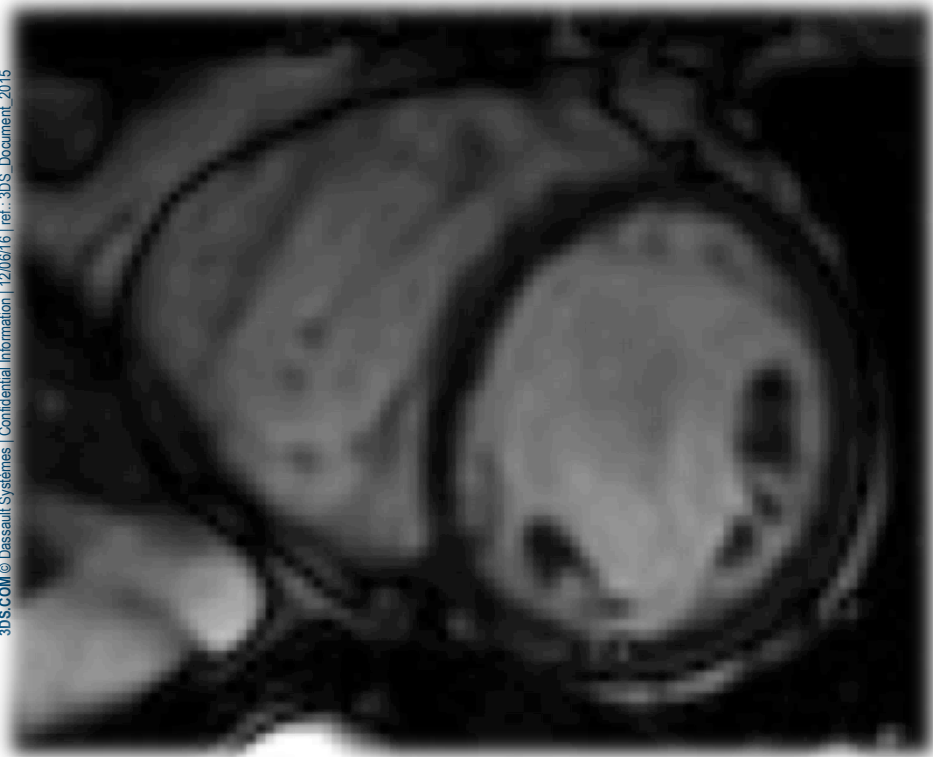
Left Ventricle Wall



Apex-to-Base Shortening

Validation: Motion Comparison

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Dassault Systèmes Signs Research Agreement with the Food and Drug Administration for its "Living Heart Project"

*The Project Accelerates Towards Next Generation Patient Experience
for Treatment and Diagnosis of Heart Diseases Through Key
Milestones and Crowdsourcing*

LAS VEGAS — November 12, 2014 — [Dassault Systèmes](#) (Euronext Paris: #13065, DSY.PA), the 3DEXPERIENCE Company, world leader in 3D design software, 3D Digital Mock Up and Product Lifecycle Management (PLM) solutions, today announced that it has reached a significant milestone in its project aimed at driving the creation and use of simulated 3D personalized hearts in the treatment and diagnosis of heart diseases and medical device development. Powered by Dassault Systèmes 3DEXPERIENCE platform's realistic simulation applications, [The "Living Heart Project"](#) announced in May of this year, has rapidly moved its first realistic 3D heart simulator into beta test, validated the efficacy of a device and has surpassed 30 contributing member organizations.

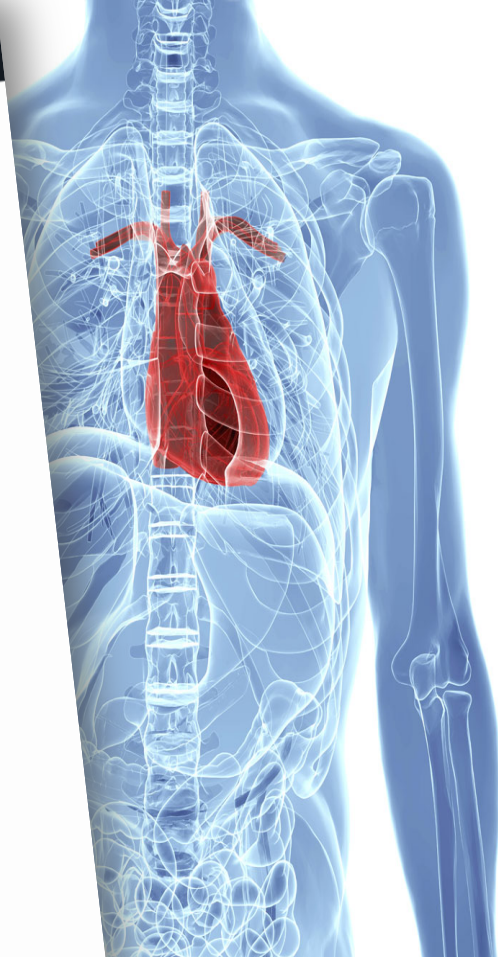
As a key step of this initiative, Dassault Systèmes has signed a five-year collaborative research agreement with the [United States' Food and Drug Administration](#) (FDA) which will initially target the development of testing paradigms for the insertion, placement and performance of pacemaker leads and other cardiovascular devices used to treat heart disease.

Using a technology crowdsourcing model that protects the intellectual property of each member, yet enables all to share the outcome, the "Living Heart Project" is being developed closely with leading cardiologists, medical device companies and academic researchers who participate in the evaluation of the simulated heart model's use in testing medical devices, improving clinical diagnosis and guiding pre-surgical planning.

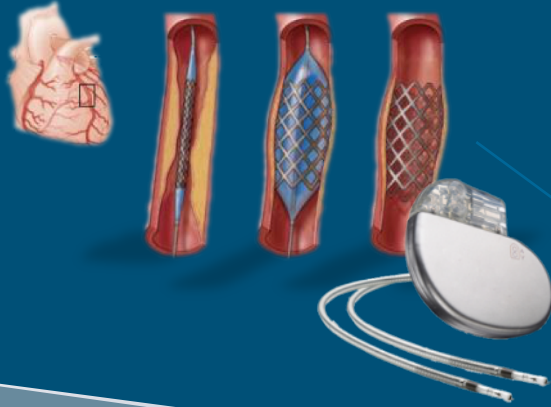
The 30 contributing member organizations, which include more than 100 cardiovascular specialists from across research, industry and medicine, have access to the heart simulator for collaboration of the program via crowdsourcing. The researchers have entered into a Material Transfer Agreement (MTA) with the goal of accelerating the development of patient reliability and



The Living Heart Project



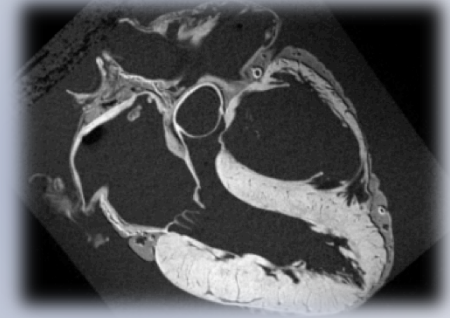
Medical Devices



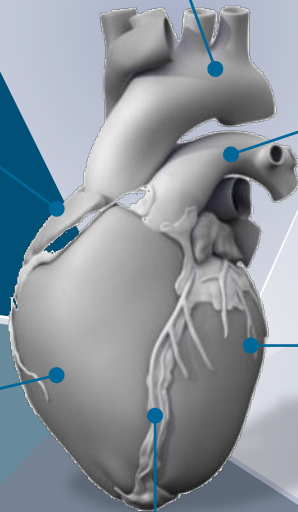
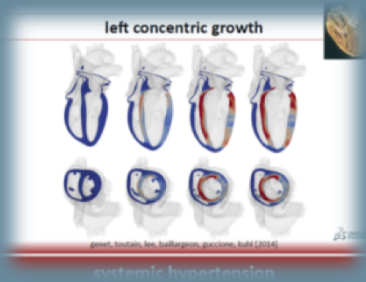
3DPrinting



Medical Image Enhancement



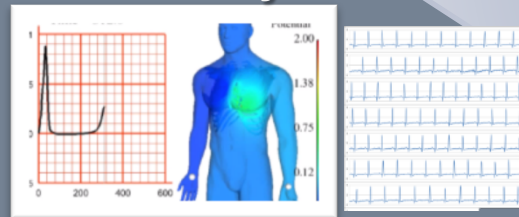
Heart Disease - diagnosis & treatments



Bio-treatments

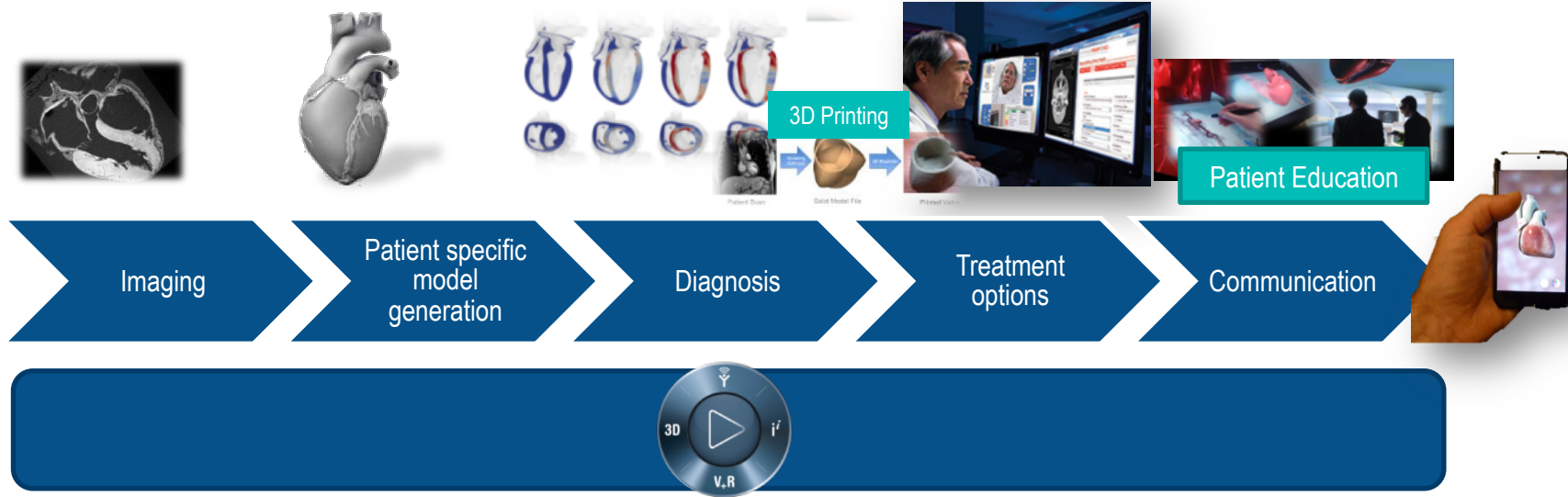
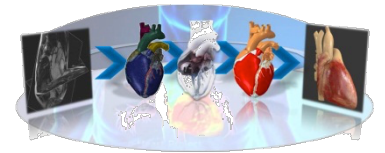


Data Analytics



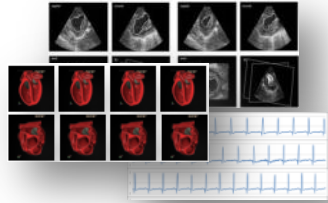
Towards a new Patient Care Experience

Application of Simulation-based solutions



Personal Heart Analysis Workflow

Image & Data Analytics

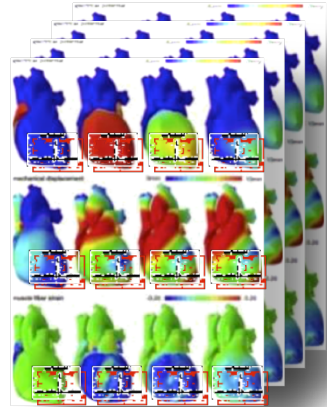


Physician

Download
Analysis
Report



Store/Compare to
Data Bank



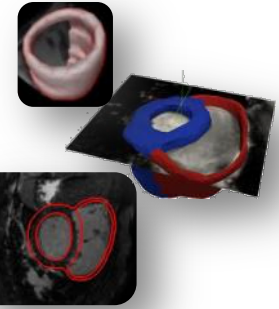
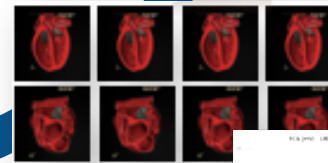
Differential
Analysis

CT/MRI/ECG
Images

Image
Segmentation,
Model building
on HPC

Patient Heart Model

Heart Simulation on
HPC



Virtual Pre-Surgical Planning – Annuloplasty Ring Sizing



Clinician can virtually implant a mitral valve ring and view the effect of implant

Minimize Stress on annulus and sutures

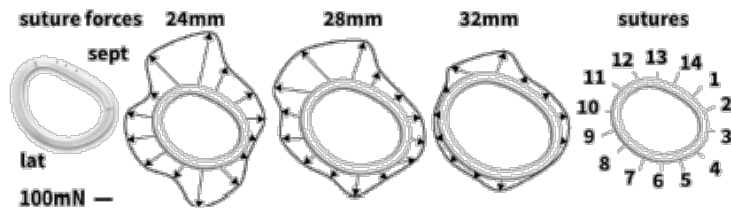
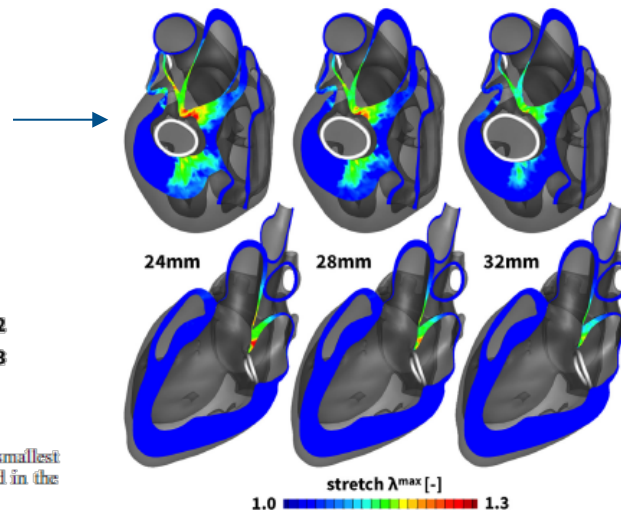


Figure 8. Suture forces upon ring implantation. Suture forces are largest for the 24 mm ring and smallest for the 32 mm ring. Suture forces are largest in the antero-septal regions, sutures 12 and 13, and in the postero-lateral regions, sutures 5 and 6; see Table III.

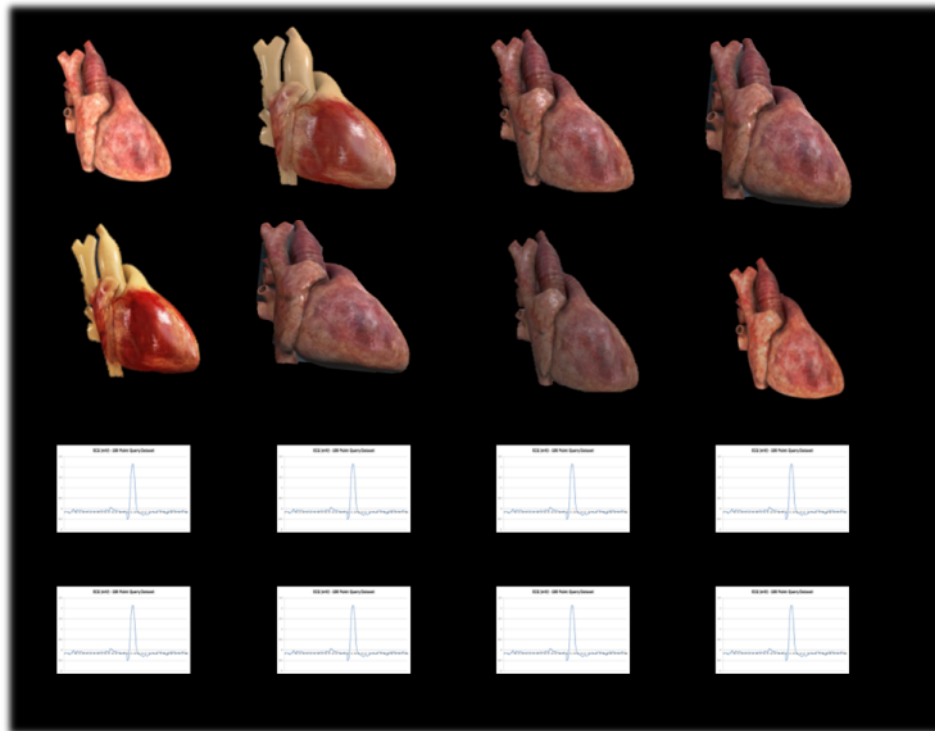
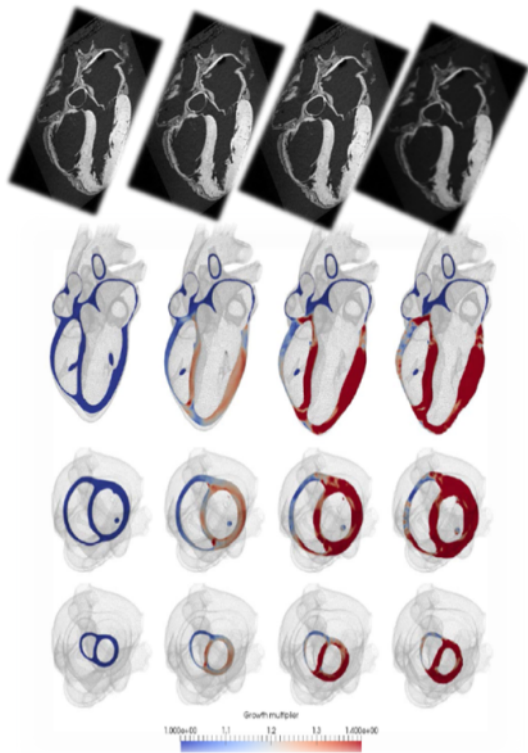
Table I. Annular dimensions of healthy and dilated annulus.

	Mitral annular area [mm ²]	Mitral annular perimeter [mm]	Septal-lateral distance [mm]	Commissure-commissure distance [mm]
Healthy	581.05	88.07	27.47	23.72
Dilated	988.01	116.50	36.14	36.66

Changes in mitral annular area, mitral annular perimeter, septal-lateral distance, and commissure-commissure distance.



Future: Digital Diagnostic Reference Library



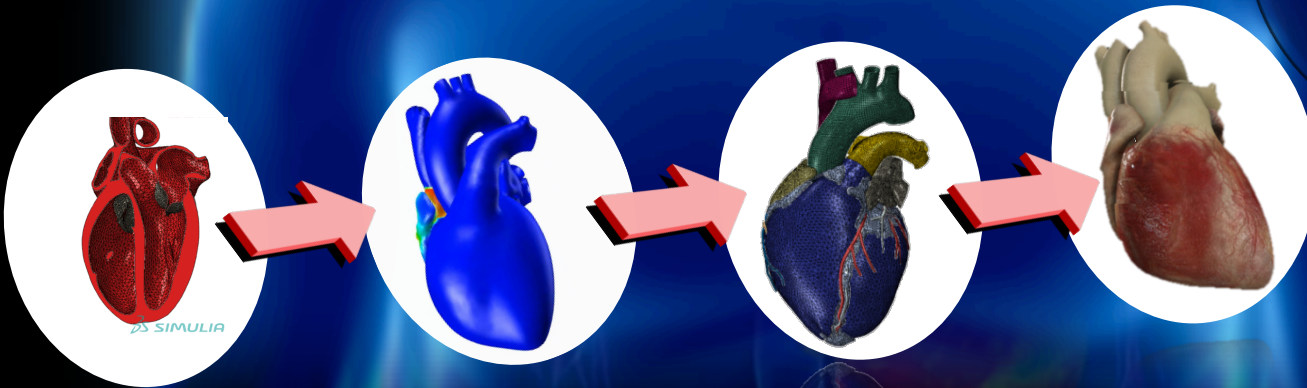
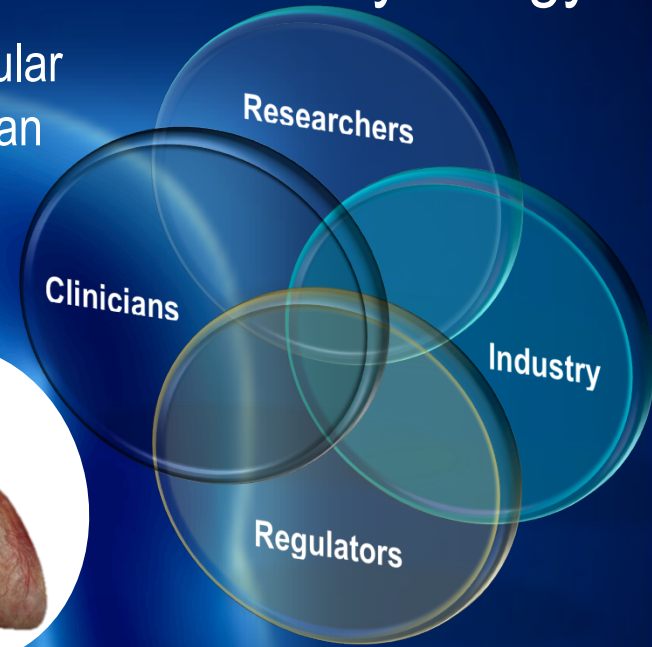




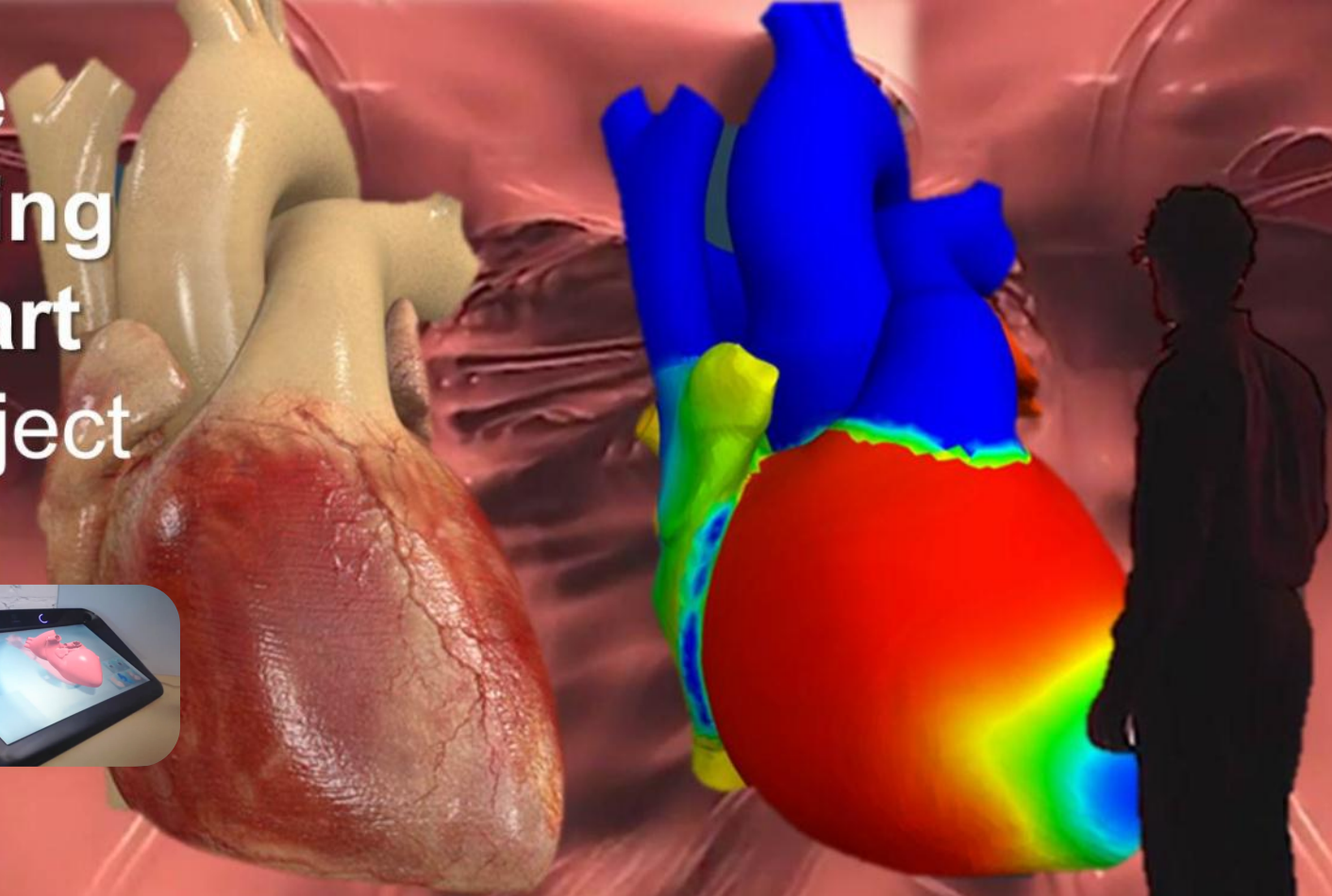
The Living Heart Project

Model-based Innovation from Mechanical to ElectroPhysiology

Establishing an unified foundation for *in silico* cardiovascular medicine and serving as a common strategy for creating an effective path for rapidly translating current and future innovations directly into improved patient care.



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