Grant Agreement number: 224565

Project acronym: ARAKNES

Project title: Array of Robots Augmenting the KiNematics of Endoluminal Surgery

Funding scheme: Large-scale integrating project (IP), FP7-ICT-Challenge 3: Components, systems and engineering/Micro/nano systems

Project website address: www.araknes.org

Publishable summary-month 24

Start date of project: 01/05/2008 Duration: 48 months

1 Publishable summary

1.1 Summary Description of the Project Objectives

The ARAKNES project stems from the innovative idea to transfer the technologies of bi-manual laparoscopic surgery to the endoluminal surgical approach, thus further reducing the operative trauma and enhancing the therapeutic outcome of minimally invasive surgical procedures for morbid obesity and gastro-esophageal reflux. This transfer of technologies is enabled by the incorporation of mature and advanced micro-nano-bio technologies and ICT.

In this framework, **the ultimate goal of ARAKNES is to integrate the advantages of traditional open surgery, laparoscopic surgery (MIS), and robotics surgery into a deeply innovative system for bi-manual, ambulatory, tethered, visible scarless surgery, based on an array of smart microrobotic instrumentation.**

The system being proposed will enable advanced endoluminal surgery and single port laparoscopy by means of novel bio-robotic and microsystem technologies that are achievable in the time frame of the project and will enable safe endoluminal surgery, by serving also as a platform towards the realisation of transgastric and transluminal approach.

The essential components of the ARAKNES system include:

1. A flexible oro-pharyngo-oesophageal access port and an umbilical access port, both purposely developed for advancing the flexibility and the degrees of freedom more and more necessary during current and future surgical operations.
2. A set of assistive and operative miniaturized robots allowing a bi-manual operation inside the abdomen or the stomach and introduced orally, from the umbilicus or transgastrically.
3. An imaging system consisting of (i) endoscopic stereo-cameras at the distal end of the robotic platform, to restore depth perception, combined with panoramic cameras embedded in the access ports and (ii) additional vision modules for increasing points of view and surgical operations safety and flexibility.
4. Photonic-based and chemical-based devices integrated in the platform, thus allowing the performance of tissue interrogation tasks normally not available during traditional laparoscopy: e.g. in-vivo confocal microscopy, laser Raman/elastic scattering spectroscopy, optical coherence tomography, molecular diagnosis, tissue ischemia monitoring etc. Additional inertial sensors will be also integrated for monitoring the kinematics of the platform, for motion assistance and for localization.
6. The components of the system (internal operative camera, assistive, operative and monitoring micro-robots) will be developed mainly as tethered modules, to solve energy problems and stability of the platform.
7. The operating console incorporating the image of the operative field will have intelligent features bridging the perceptual link between the surgeon and the micro-robotic end effectors. In addition, haptic interfaces and augmented reality solutions will be incorporated in the surgical console, thus enabling an effective and friendly interaction between the operator and the platforms/tools/tissue. Finally, advanced computer software will enable the surgeon to execute the intended procedure 'virtually' (when needed in problematic cases) before actual performance.

1.2 Description of the Work Performed in the Second Year and Main Achievements

The **Hybrid Access Approach** (oesophageal access + umbilical access for the ARAKNES robot) has been pursues with success. The final prototype of the oesophageal access port has been delivered; in parallel, prototypes of umbilical access ports have been provided by the Consortium.

Robots for both oesophageal and umbilical access have been developed: bimanual manipulators with internal motors or cable actuated are already prototyped. In parallel, a manipulator with oral access and stabilization based on abdominal needles has been prototyped, thus preserving effectively the concept of double access and double instrumentation.

Visualization technologies have been developed and are already at a good level of integration with the above mentioned robots. In addition to main vision modules integrated into the access ports and in the robotic frame, accessorial vision modules preserving the concept of flexibility, interchangeability and modularity of ARAKNES have been developed.

Two specific microsystems for monitoring the surgical operation and for assessing the quality of tissues (in terms of early detection of pathologies) have been developed, respectively based on spectroscopic analysis and chemical sensing.

The **ARAKNES console** overall design is defined and prototyped components are available. The console architecture already allows the integration of developed technologies for surgical planning, haptic feedback, etc.

Assessment and validation procedures have been defined. Test-beds for assessing in phantom all modules of the ARAKNES platforms have been developed, and flexible technologies for adapting the test beds to module / access changes are already available.

The **teleoperation control** of the ARAKNES platform is progressing affectively, both as regards the overall architecture and as regards the low-level driving and operation of robot actuators and sensors.

1.3 Description of the Main Results of the Second year

- Number of published paper with ARAKNES acknowledgments: **26**, 3 still under evaluation
- Number of patents: **8**
- Number of derivative devices: **23**
- Number of lectures on ARAKNES: **33**
- Number of press releases: **10**
- Number of master/bachelor theses performed or under preparations on ARAKNES topics: more than **20**
- Number of PhD students trained in the ARAKNES Consortium: **15**
- Number of exchanges of students and researchers within the Consortium: **4**

1.4 Expected Final Results and Impact

The expected impact of ARAKNES is summarized below:

A. Substantial improvement on various aspects of smart systems integration: higher product quality and reliability, increased miniaturisation, integration and functionality, lower costs, reduced power consumption, higher speed requirements and/or shorter time-to market.

B. Transformation of industrial production by adding intelligence to process control and the manufacturing shop floor, and by improving logistics and distribution - thereby increasing productivity.
C. Increased market share for European companies across different industrial sectors by delivering systems with new functional capabilities and improved quality within a competitive timeframe.

All the expected outcomes of ARAKNES relevantly address one or more of the aspects illustrated in the above three points.

A relevant set of expected results is related to derivative devices that can be commercialized at the end of the project. These potential products, that can be components of the overall ARAKNES system adapted for different use still related to diagnosis and therapy, can be grouped in the following categories:

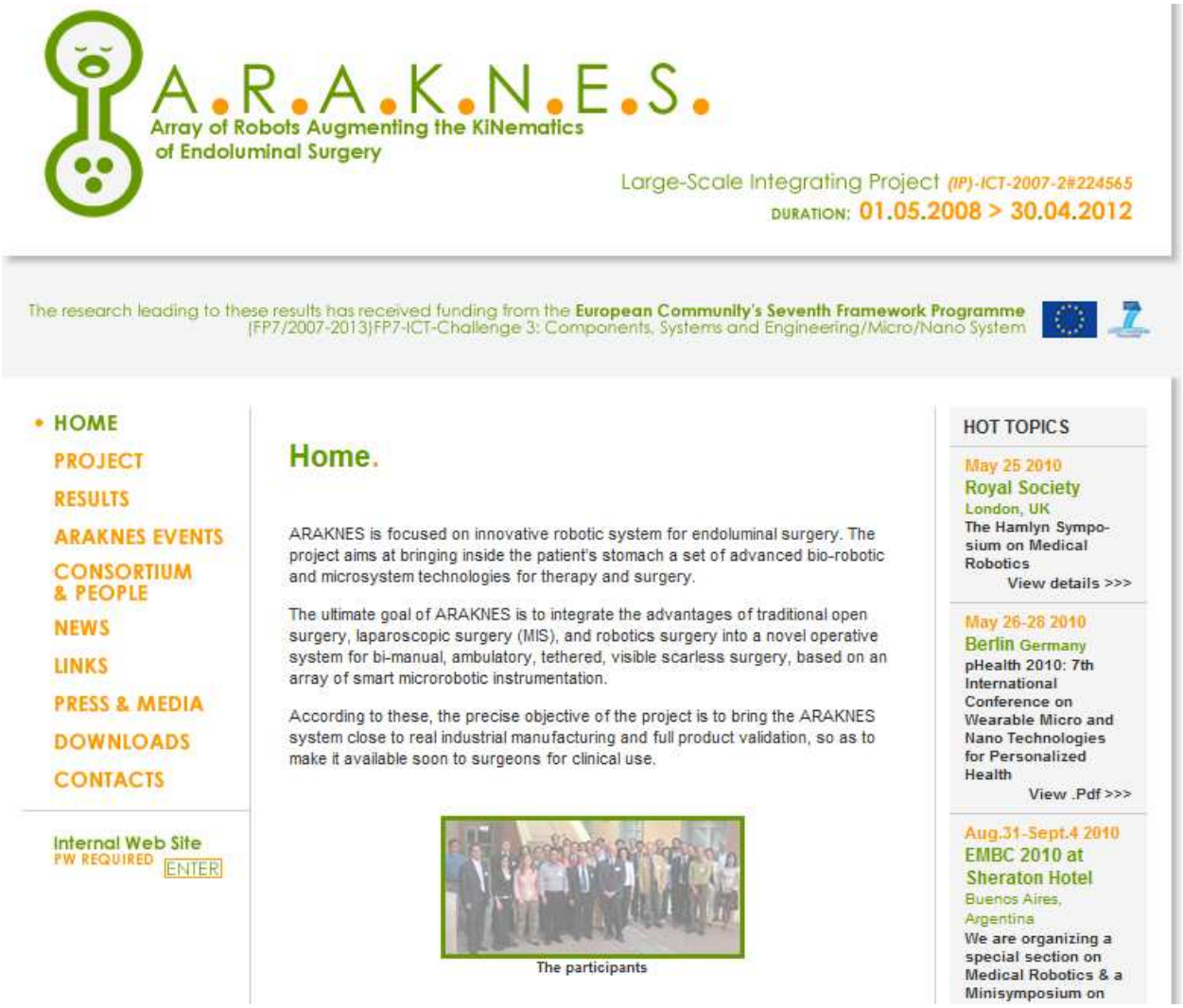
- Innovative surgical instruments
- Novel endoluminal vision systems
- Adaptation of Micro- and Nano- devices to a surgical scenario
- Innovative Human Machine Interface
- Array of Robots
- Teleoperation Techniques
- Novel surgical procedures
- Novel procedures/equipment for Computer Aided Surgery

A Board devoted to the Project Exploitation and involving members from Academia and Industry is continuously monitoring the field and is taking time by time corrective measurements **for maintaining the project competitiveness in the R&D international scenario.**

1.5 Promoting Material, Contacts, Web-Site

The project LOGO is illustrated below.

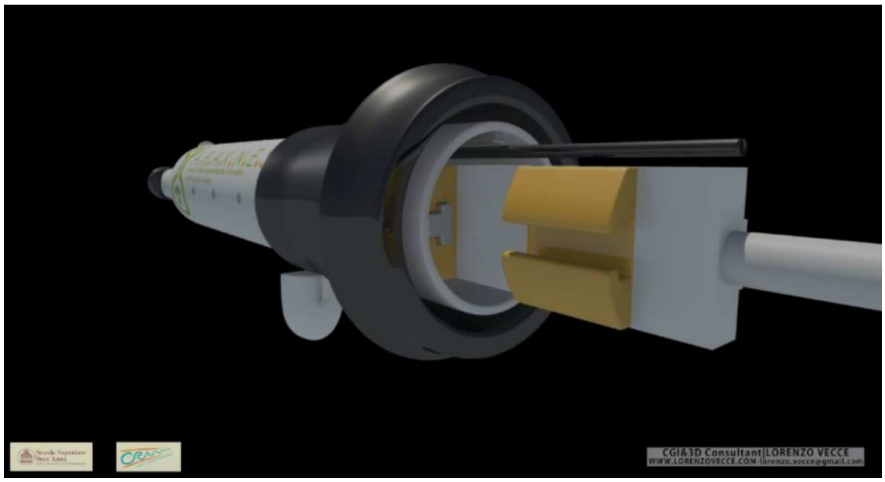
The project website has been activated within one month from the beginning of the project and it is the following: http://www.araknes.org/. The homepage is depicted below. The interface is very effective but simple.



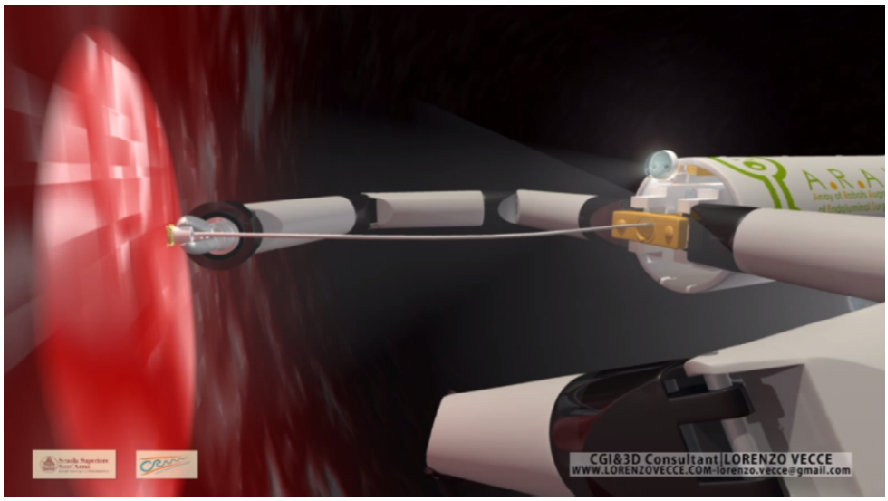
From the downloading area, it is possible for all users to download the public project presentation, the project brochure and the project Logo for an easier dissemination.

The project coordinator of ARAKNES is Prof. Paolo Dario (paolo.dario@sssup.it). The e-mail address for asking more information is info@araknes.org.

The ARAKNES coordinator has appointed a 3D senior modeller for representing realistically the mechanical designs and the different concepts developed by ARAKNES. Preliminary sketches have been already reported at the end of the first project year. Below, we report few pictures illustrating some sketches from 2 simulations: the first simulation presents the introduction of the abdominal motorized robot through the umbilical port with the opening of the arms inside the abdomen. The second simulation illustrates the operation of the abovementioned robot in combination with the chemical sensor for monitoring intra-operatively the tissue oxygenation.



A sequence of the ARAKNES robot assembly



The ARAKNES robot placing the tissue oxygenation sensor on the tissue.