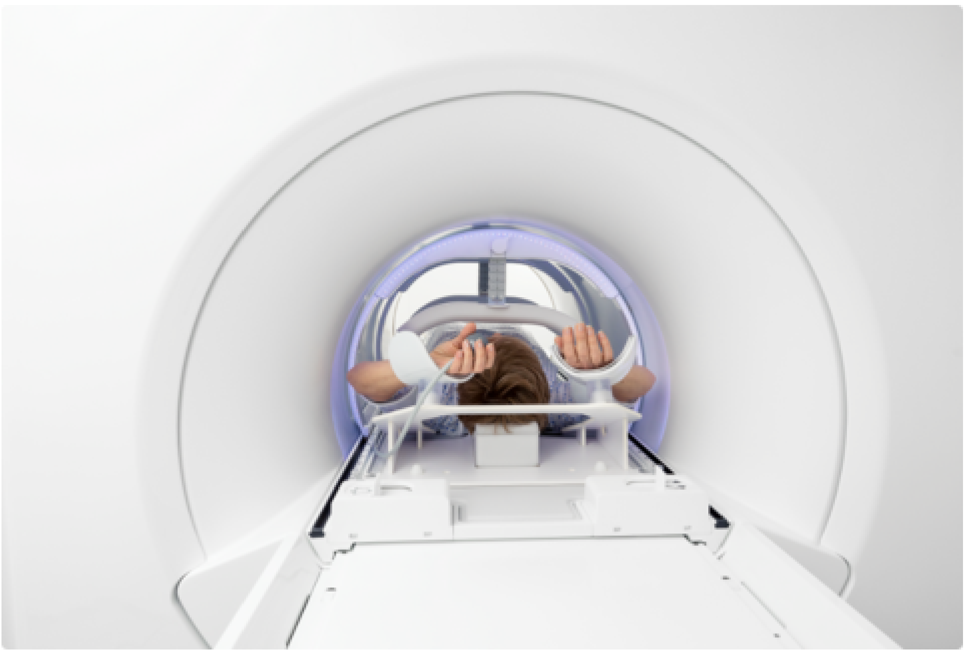
STARLIT project sees potential of MR image guidance to significantly improve radiation treatment quality

focus.elekta.com/2020/11/starlit-project-sees-potential-of-mr-image-guidance-to-significantly-improve-radiation-treatment-quality/

November 5, 2020

In the light of advances in MR-guided radiation therapy (MRgRT) and the development of Elekta Unity MR-Linac, the multinational STARLIT (System Technologies for Adaptive Real-time MR Image-guided Therapies) consortium is a unique multidisciplinary collaboration of industrial and clinical partners, that are driving innovation development to improve treatment accuracy and minimize dose to healthy tissue in MR-guided radiation therapy.



The aim of the project, which was established in 2017 and is partially funded by ITEA, is to develop MRgRT-associated innovations that will enhance the quality of life for cancer patients by improving treatment accuracy and minimizing unintended dose to healthy tissue. Through multidisciplinary collaboration, STARLIT aims to develop technologies, systems and software that address the emerging opportunities and needs of real-time MRgRT so they can be brought to the market as quickly and efficiently as possible.

To ensure the applicability and effective adoption of its innovations, the STARLIT consortium deliberately represents a variety of stakeholder perspectives, from application owners and technology providers, to care providers. It is a unique and effective collaboration of industrial and clinical partners, bringing together two large equipment manufacturers (Elekta and Philips), three highly-regarded university medical centers where Elekta Unity is installed (University Medical Center Utrecht, The Netherlands, where the MR-Linac originated, and two very early adopters: Netherlands Cancer Institute, Amsterdam, The Netherlands; and Academic University Hospital Uppsala, Sweden) and six small or medium enterprises (SMEs)* with unique and necessary capabilities related to dosimetry, quality assurance, open interfaces for clinical research, and complimentary 4D motion detection systems.

“The technology developed through the STARLIT consortium serves to accelerate MR-guided radiation therapy product innovation,” says Chantal Dussault, Head of Engineering MR-Linac at Elekta. “For example, a prototype was built on Elekta Unity to detect the location of the tumor during radiation therapy and better target the treatment. The prototype successfully demonstrated motion detection, with matching instructions sent to the multi-leaf collimator to dynamically form the beam during treatment to account for the shape of the tumor. At the same time, the delivered dose was reconstructed in near real-time. For the first time, STARLIT provided the opportunity to assemble the required, different technologies together with Unity, and the lessons learned have been an important and exciting step in the product development process. The innovations that will evolve from the project are anticipated to further reduce treatment times and make radiation therapy even more precise.”

A focus on working groups

Given the breadth of technologies associated with MRgRT, the STARLIT research project has been divided into multiple working groups (Work Packages or WPs), each focusing on a different aspect to drive the technology forward in an appropriate and efficient manner. Some of the technical innovations explored by these working groups include:

- 4D motion characterization by ultrafast 2D and 3D MRI, including image segmentation
- 4D rigid and deformable motion control concurrent with treatment delivery
- Motion correction and motion correlation for dosimetric feedback and beam control
- Real-time dose accumulation and MRI-based instantaneous adaptive planning
- Optimization of the MR-Linac for MRI Biomarker discovery
- Online plan adaptation based on daily MRI biomarkers (e.g. diffusion and perfusion)
- MRI compatibility of motion sensing, fixation and treatment delivery devices
- Safety functions, quality assurance protocols, and integrated human experience

The project leaders have been delighted to report a number of achievements in the three years that the STARLIT project has been underway.

WP 1: Requirements and Usability

Dr. Samuel Fransson, Medical Physicist at Uppsala University Hospital, Sweden, comments: “We have developed prototypes for fixation devices for a repeatable and comfortable setup, crucial for smooth treatments given the longer adaptive treatment time compared to conventional non-adaptive linac treatments. We have also obtained clinical feedback for the real-time surveillance graphical user interface, ensuring that the finished product will be of clinical relevance.”

WP 2: Motion Detection

Diagnostic MRI is often performed at 3T scanners with high-performance gradients. “The goal of this work package was to ensure that fast imaging capabilities developed for diagnostic MR systems can be translated to the MR-Linac,” clarifies Dr. Johan van den Brink, Principal Scientist at Philips MRI. “To this end, we have developed technologies for radiolucent high-density coil arrays, which are necessary to enable robust accelerated imaging through coil sensitivity encoding. Philips has brought to market Compressed SENSE for ultrafast and motion robust 3D and 4D imaging, which provides the modeling basis for fast motion sensing during treatment using 2D radial acquisition strategies. We have also demonstrated that the performance of recently developed distortion-free diffusion imaging methodologies is virtually identical on Unity and Ingenia systems.”

WP 3: Motion Coordination

Commenting on the work relating to the real-time estimation of abdominal patient motion, Dr. Silvain Bériault, research scientist at Elekta, says: “One key outcome of our work is the real-time estimation of 3D-cine motion of the target and organs-at-risk (OARs), with a frequency of > 5 Hz and a detection accuracy < 2 mm on target and OARs. We have also worked on the design of new markers and image processing methods for improving automatic source detection accuracy (from > 2mm to ~0.8 mm) in prostate brachytherapy (using plastic needles), prostate brachytherapy with an MRI robot (using titanium needles) and cervix brachytherapy (using plastic applicators).”

WP 4: Treatment Delivery

Also a research scientist at Elekta, Dr. David Tilly reports, “A real-time adaptive radiotherapy prototype has been implemented where a tracking algorithm adapts the radiation to the constant stream of MR images, increasing dose to the target and minimizing dose to healthy tissue. Instantaneous confirmation of treatment delivery is achieved by real-time dose accumulation, which reads the machine settings in real-time to enable safe delivery of real-time adapted radiotherapy.”

“In addition, functional imaging quality capabilities, such as diffusion-weighted imaging, have been found to be equal to that of comparable diagnostic MR scanners. Patient studies utilizing functional imaging are ongoing.”

“A robotic, MR-compatible brachytherapy afterloader has also been designed and will be tested in a clinical environment.”

WP 5: Demonstration of integration and dose reduction

Professor Bas Raaymakers from the University Medical Center Utrecht comments, “It is exciting to see that we are closing in on the promise of the hybrid MR-Linac system by using real-time MRI for real-time adaptations. The developed tracking has been demonstrated and the latencies for hardware feedback are quantified and shown to be adequate for real-time performance. Also, the fact that dose can be reconstructed during radiation delivery opens new opportunities as this can serve as a starting point for repeated adaptation and move us towards dose guided treatments instead of geometry guided treatments.”

“Additionally, MRI guided brachytherapy has been proven very effective in the clinic and the MRI compatible brachytherapy afterloader allows further exploration of real-time MRI feedback for these treatments.”

WP 6: Standardization, dissemination and exploitation

“The STARLIT consortium has done an exceptional job in disseminating the technological advances developed within the project to many conferences/symposia and peer-reviewed scientific journals,” says Marco Luzzara, Senior Director of Medical Affairs and Clinical Research at Elekta. “STARLIT deliverables have shown the potential of the Elekta Unity system to the radiation oncology community, contributing significantly to a wider adoption. The project has also improved cooperation with many SMEs and allowed them to expand their market capabilities by leveraging the new technologies developed in STARLIT."

"The STARLIT team has also provided significant input and information to reach consensus within the IEC standardization committees and working groups," he adds.

As image-guided radiation therapy advances, IEC has developed a Technical Report, IEC TR 62926, which describes the architectural and design requirements for gating and tracking applications. Johan van den Brink has participated in the working group to ensure essential alignment with the architecture of Unity. In addition, a new work item proposal (NWIP) is being prepared for an IEC standard that covers the MR-Linac as a system.

As phase one of the STARLIT project comes to an end, Luzzara comments, "It has been a pleasure to work with such a highly skilled and motivated team. The technology developed within STARLIT is impressive and will potentially contribute to a significant improvement in the quality of radiation therapy treatments."

For more information about the STARLIT research project, **click here.**

**The six SMEs that form part of the STARLIT consortium are: C-RAD AB, Modus QA, I-TV Medizintechnik GmbH, MR Code BV, MR Coils BV and Quantib BV.*