No. 570 | Mar-Apr 2019

THE ERGONOMIST

Bringing human factors to life

ergonomics.org.uk

THE FUTURE OF RADIOTHERAPY TREATMENT

The role of human factors in delivering ground-breaking therapy

AVIATION APPRENTICESHIPS

Ensuring sufficient skills for control centre operations 22

DIFFICULT DECISION-MAKING

A toolkit for dealing with unfolding scenarios 24

REDUCING RISK

Sharing best practice for improving patient outcomes 28

The future of radiotherapy treatment

Millions of people worldwide benefit from radiotherapy every year, and the treatment cures more people than cancer drugs. **Dan Jenkins** and colleagues describe a project in which human factors played a critical role in the design of new equipment that delivers the therapy to patients

The Elekta Unity, the world's first high-field imaging MR Linac

Every so often, an opportunity arises to design systems that are truly transformative. Often as the result of the introduction of a fundamentally new technology, these revolutionary systems allow new tasks to be conducted or they allow existing tasks to be completed in a new way. The design of new systems opens exciting possibilities for human factors practitioners. It also brings up concerns and challenges as it's difficult to predict how a new technology system will shape future work. Observing current behaviour on legacy systems provides just part of the picture.

Elekta Unity, the first high-field MR-linac, is an example of ground-breaking technology because it overcomes the technical barriers that have hindered the integration of precision radiation therapy by combining magnetic resonance (MR) imaging with a linear particle accelerator for highly targeted, real-time radiotherapy. Fast moving, electrically charged particles are strongly influenced by a powerful magnetic field, so keeping them on track while near an MRI seemed like an impossibility before research found breakthroughs. It's now a system that is being used by clinicians in healthcare institutions around the world.

The new MR-linac allows the exact location of tumours to be identified during treatment delivery. MR imaging provides radiotherapists with a much clearer description of the location of a tumour than is possible with more conventional computed tomography-based systems which use x-rays. What's more, MR imaging is particularly adept at differentiating soft tissues making it especially relevant to tumours in the abdomen; the location of 65% of tumours. This increased confidence around the location of a tumour allows cancer cases to be treated with radiotherapy that was previously not viable because of the location of nearby critical tissue. The greater confidence in the location of dose delivery also opens the possibility of treating with fewer instances of higher doses.

The right tools for the job

Human factors practitioners have the skill and toolsets to help frame the design and its base architecture at the earliest stages of development where the objective is also to inspire and inform the design. Most explorations of human work draw on the same core data collection approaches:

1. **Observations in a naturalistic setting** (the 'real world')
2. **Observations in a lab setting** (simulations or user trials)
3. **Interviews**
4. **Self-reporting**
5. **Literature reviews**

For revolutionary systems, observing and documenting current work (using descriptive models), or work as expected (using prescriptive models as described in standard operating procedures or SOPs), only provides part of the picture. More formative tools, such as cognitive work analysis, are required to describe how work could be conducted.

As such, there is much that can be learnt from using a range of different tools. When new tools are introduced to a discipline, there's often the tendency to compare them to more traditional approaches, highlighting the limitations and weaknesses of these established approaches. While this is an important part of discussing the value of the new, it can result in a complete rejection of the old – akin to 'throwing the baby out with the bathwater'. In practice, it's often advantageous to draw on the relative strengths of each of these method types.

In the case of Elekta Unity, a mixed methods approach was established that sought to learn from current work as prescribed using SOPs, work as disclosed via interviews, current work as done through observations, and future work as imagined using formative modelling, all at the earliest stages of the design process, seeking to maximise the value of the full toolkit.

This involved drawing from the same core sets of data collection approaches and analysing them with a diverse range of tools. The core data set was informed by studying several different areas: the current use of legacy equipment, Linacs using CT imaging across seven treatment centre visits spread across North America, South America and Western Europe; observations of over 360 patient treatment sessions; after-hours walk-throughs; over 50 stakeholder interviews; and extensive literature reviews.

The core methods used to process this data can be broadly segregated into descriptive and formative approaches.

The descriptive approach

Radiotherapy is typically a highly structured process that follows a well-rehearsed workflow. As such, Hierarchical Task Analysis (HTA) was a fitting backbone for the descriptive analysis. In the first instance, we used HTA to explore the variability in workflows, or work as done, by exploring the observed differences between treatment locations such as lung, prostate or breast, and geographic location, as well as treatment centre types, such as a large teaching hospital with many Linacs and a large radiotherapy department to regional cancer treatment centres with a single Linac and a small team. It soon became apparent that the variability was relatively limited. Where it did exist, it tended to be at the detailed 'leaf-level' of the task model or in the detailed 'plans' of the HTA.

Given the limited variability and the relatively close match between work as prescribed and work as done, HTA proved to be a valuable approach. The main advantage of HTA was its large range of extensions, such as Critical Path Analysis and Link Analysis. The core model provided a common task description that could be explored in greater detail.

The temporal nature of the task was explored by assigning average base-level task times recorded from over 350 observations to each sub-task in the HTA. Critical Path Analysis was then used to identify areas in the task flow that offered the greatest potential for efficiency savings. Link analysis was used to time map the tasks in a spatial setting of a plan view of a typical treatment and control room. This revealed opportunities to optimise the layout of physical controls and objects that healthcare professionals and patients interact with, as well as the location of physical and digital information displays.

The HTA model also proved valuable in evaluating the safety of the system, both from a physical, manual handling, perspective, using a tool called REBA or Rapid Entire Body Assessment, and →

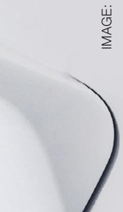
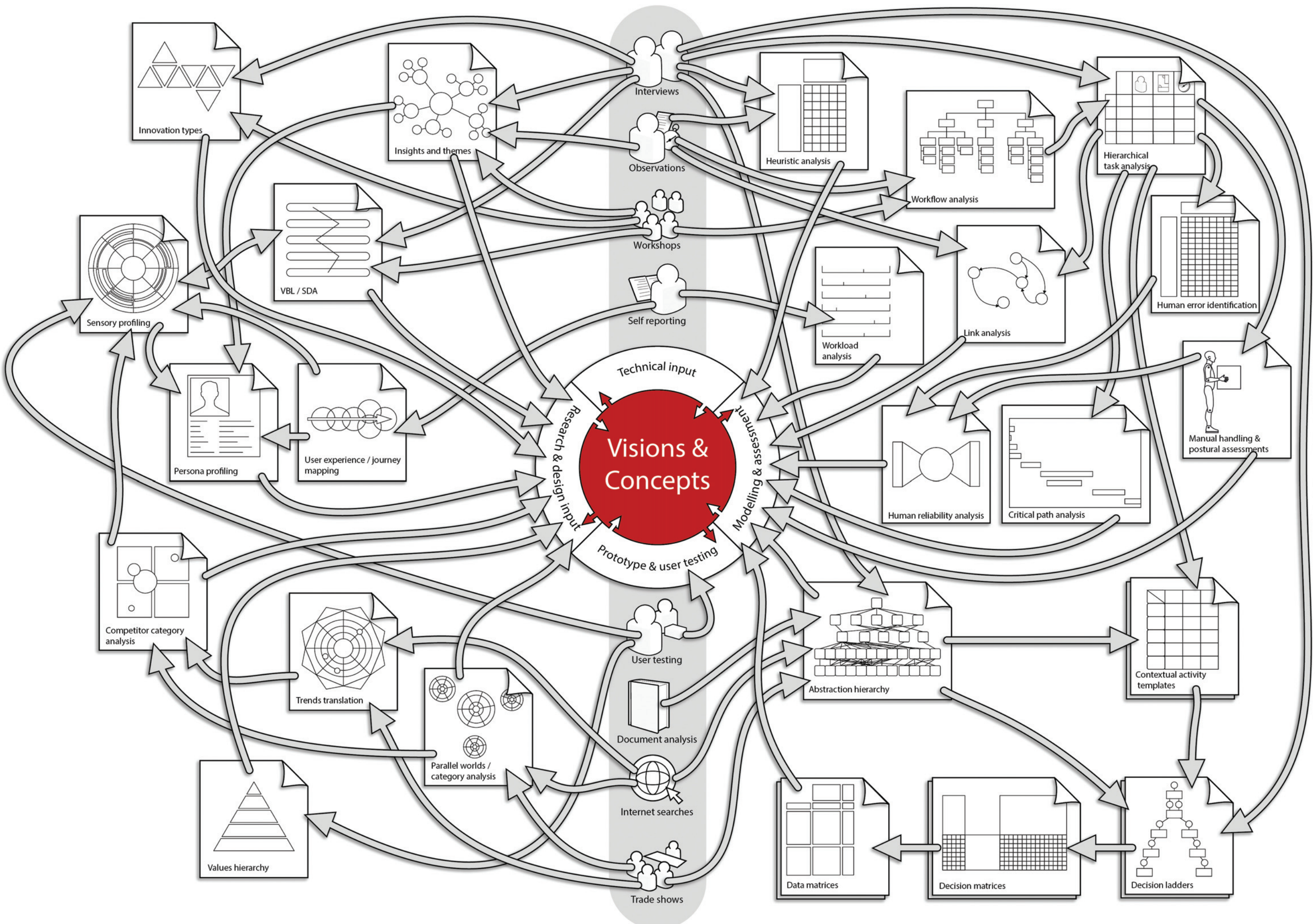


IMAGE: ELECTA UNITY



Visions and concepts research model

from a cognitive level predicting opportunities for 'error' using TRACEr or Technique for the Retrospective and predictive Analysis of Cognitive Error.

The formative approach

At a more formative level, tools from cognitive work analysis were used to explore how work could be conducted. Hierarchies were constructed to explore the relationships between the physical objects in the system such as new and existing technology, and the higher order systems values of efficacy, efficiency, safety, inclusiveness, satisfaction and flexibility. Decision ladders were used to describe how information across digital displays, documentation, staff interactions, the physical environment and the verbal and non-verbal patient cues were currently being used to guide treatment sessions and to explore how they could be used in the future. The flexibility, variability and resilience of the system were also explicitly explored.

Inspiring and informing design

The purpose of this detailed analysis was to inspire and inform the design of a vision for the future at the infancy of the project. This vision was created six years before the first patient was treated with the system; the intention was to form a basis for the detailed design that was technologically grounded and evidence-driven. Some of the notable features of the design, such as the low table top or 'couch' that the patient lies on, were informed by anthropometric datasets and manual handling assessments of those assisting and positioning patients. Engineered safeguards were inspired and informed by 'error' predictions and carefully considered against their impact on system resilience.

The approach also provided a detailed description of the information requirements of the system. This ensured that the right information was displayed, in the right place, at the right time, to the right people, in a suitable format that complements information drawn from human interactions and the physical environment.

The output was a three-minute video describing a vision for the patient experience for the future system, backed up by detailed reports. This formed the target for a full-scale development programme that resulted in the design of Elekta Unity, the world's first high-field imaging MR-linac, that was used to treat its first patient in September 2018, ushering in a new era in the battle against cancer.

Dan Jenkins leads the research team and **Malcolm Boyd** is a Senior Sector Manager at DCA Design international. See www.dca-design.com. **David Gilmore** is Director of User Experience at Elekta. The Elekta Unity project was awarded the 2018 HFES User Centred Design Award, a 2018 iF Design Award, and a 2018 Good Design Award. See www.elekta.com