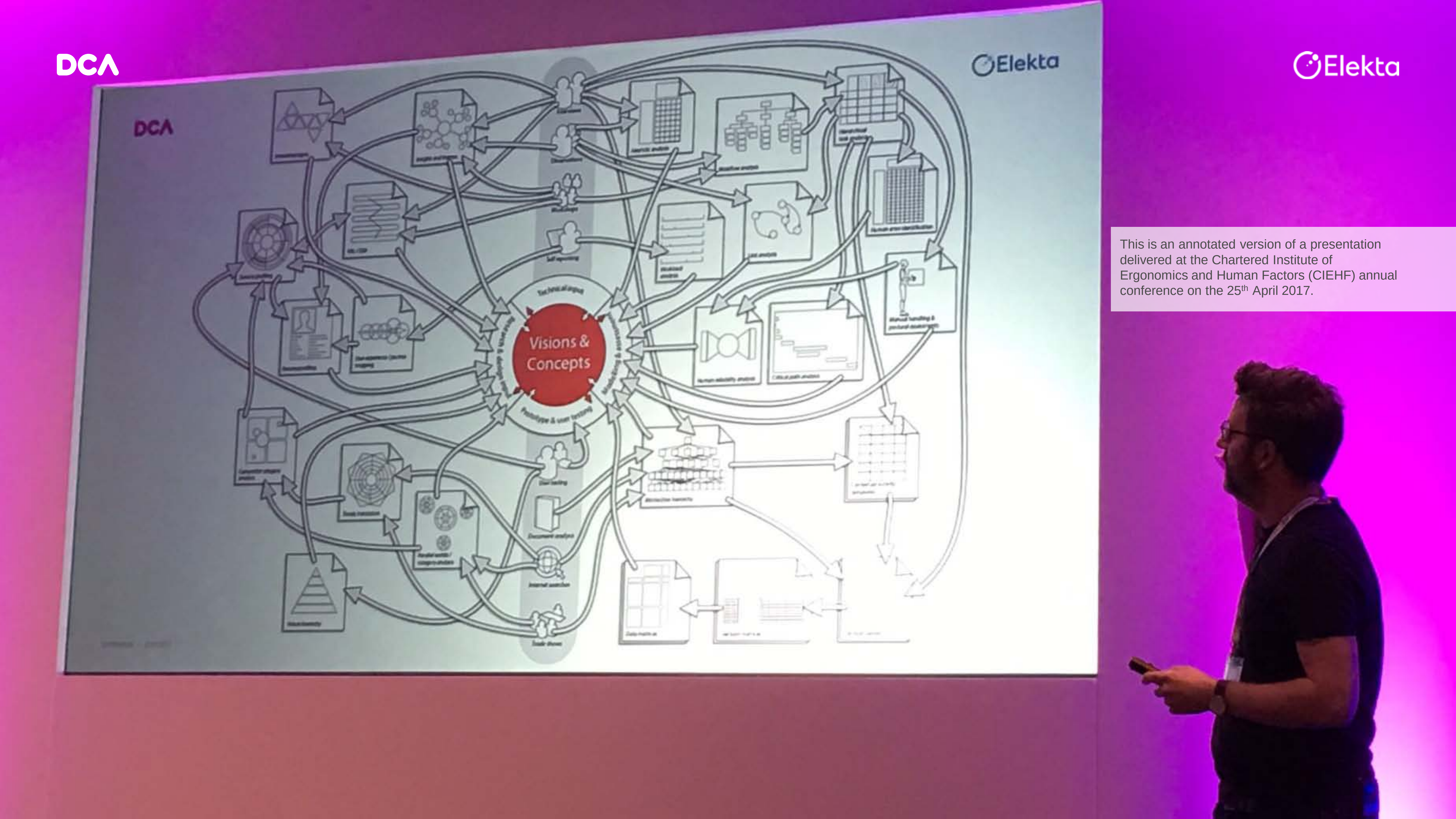
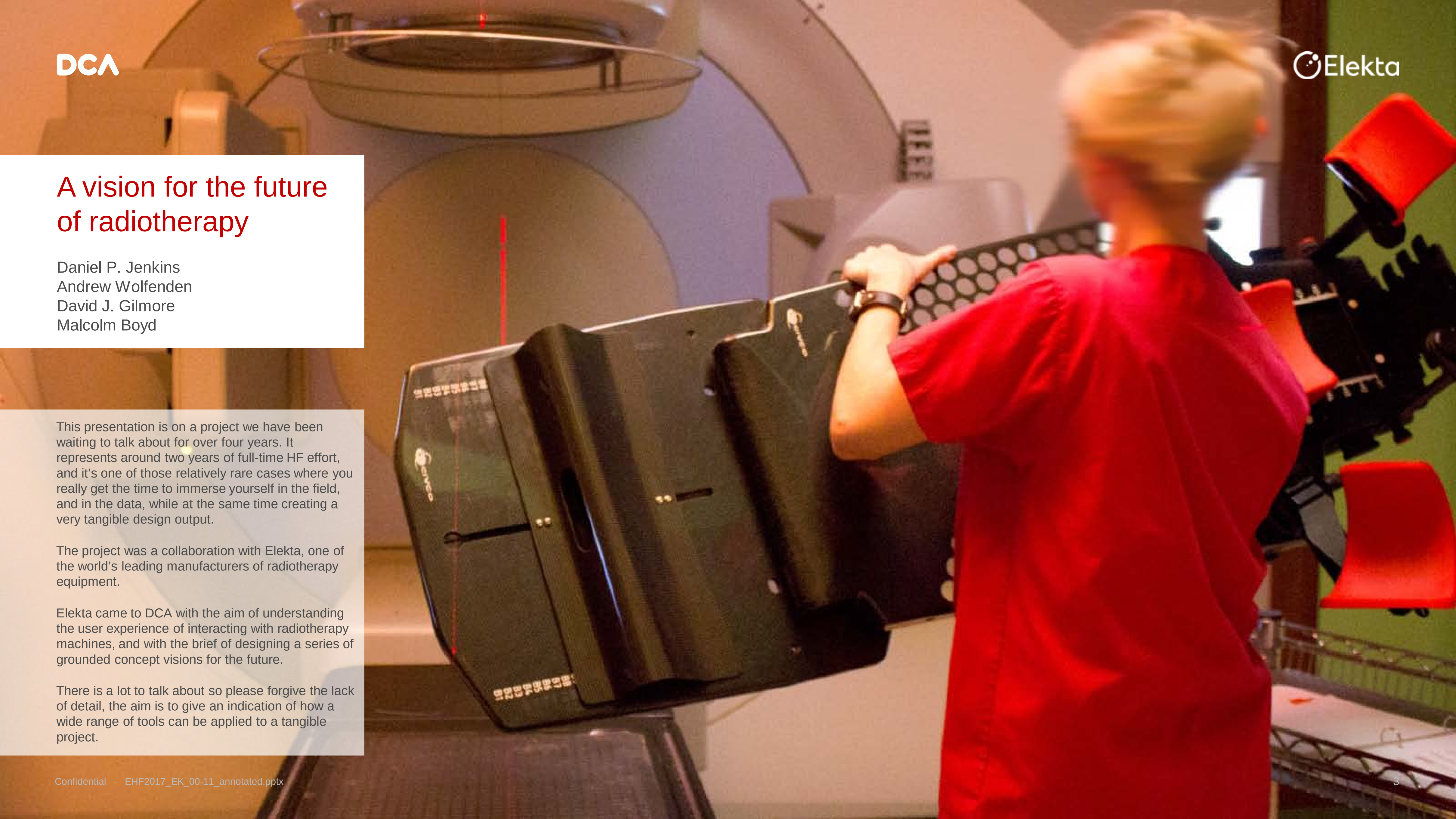
DCA Elekta



This is an annotated version of a presentation delivered at the Chartered Institute of Ergonomics and Human Factors (CIEHF) annual conference on the 25th April 2017.



A vision for the future of radiotherapy

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This presentation is on a project we have been waiting to talk about for over four years. It represents around two years of full-time HF effort, and it's one of those relatively rare cases where you really get the time to immerse yourself in the field, and in the data, while at the same time creating a very tangible design output.

The project was a collaboration with Elekta, one of the world's leading manufacturers of radiotherapy equipment.

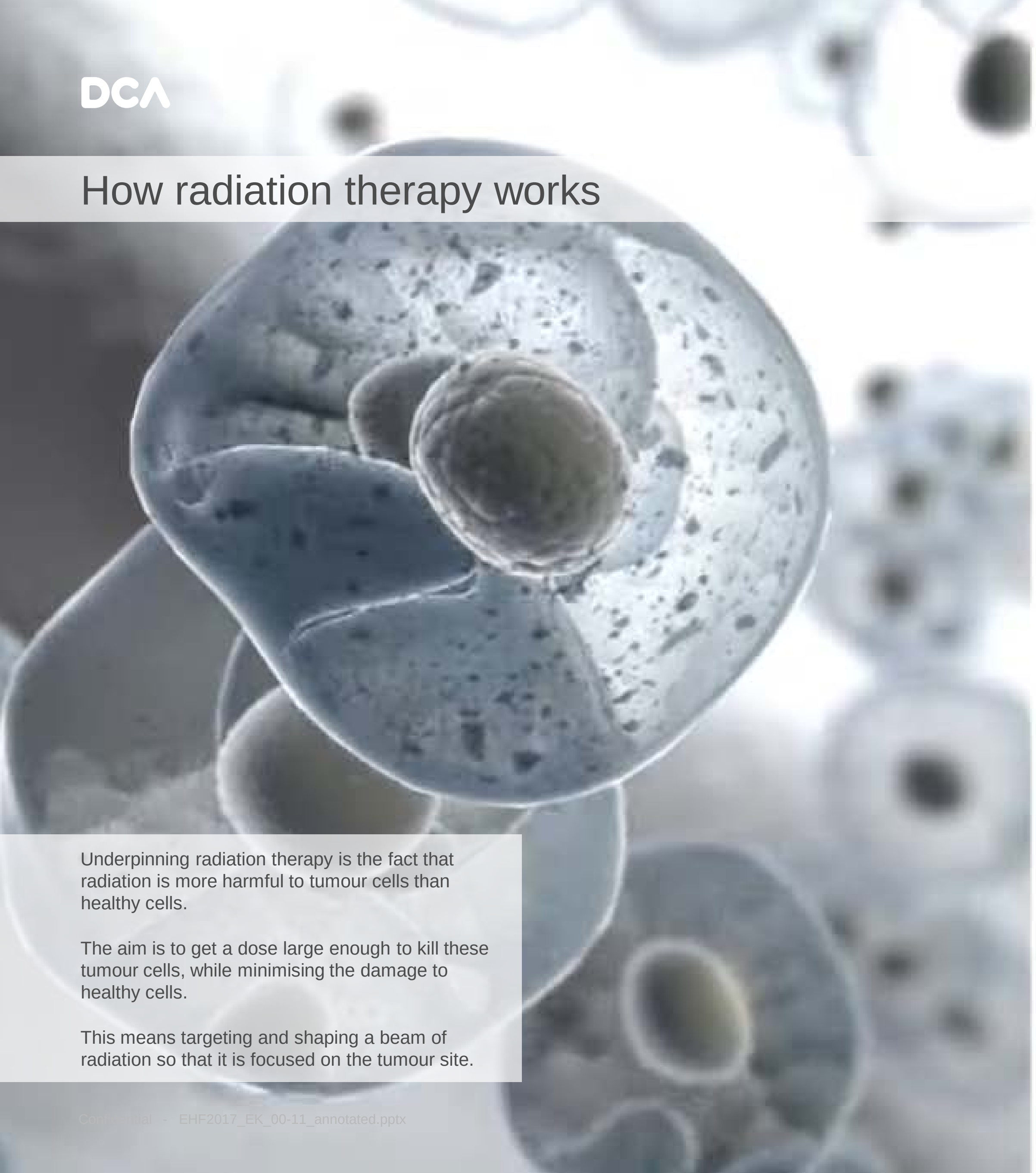
Elekta came to DCA with the aim of understanding the user experience of interacting with radiotherapy machines, and with the brief of designing a series of grounded concept visions for the future.

There is a lot to talk about so please forgive the lack of detail, the aim is to give an indication of how a wide range of tools can be applied to a tangible project.

Let’s start with a very quick introduction to radiation therapy, it’s very brief, but hopefully it gives a bit of context.

What is radiation therapy?

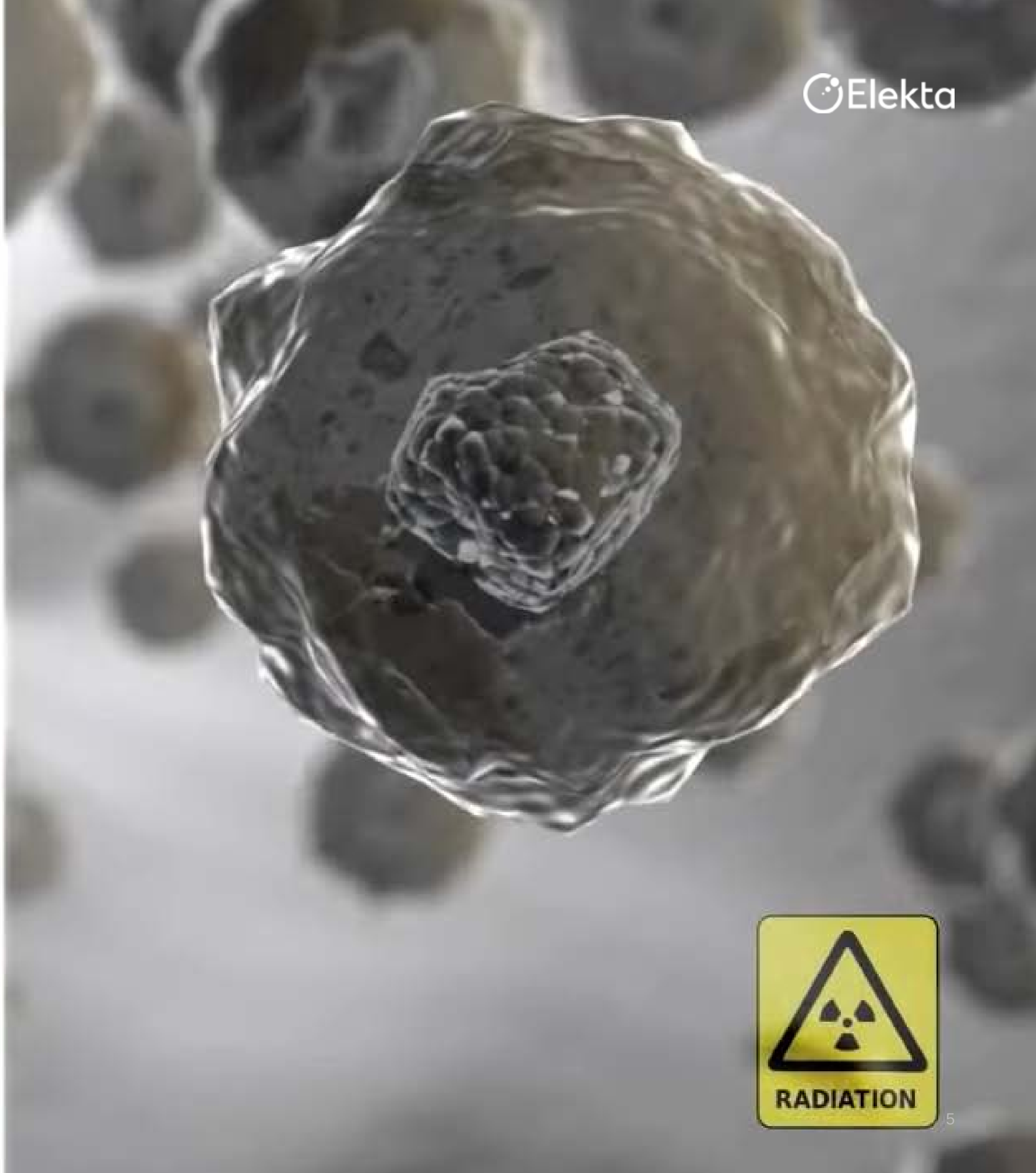
How radiation therapy works

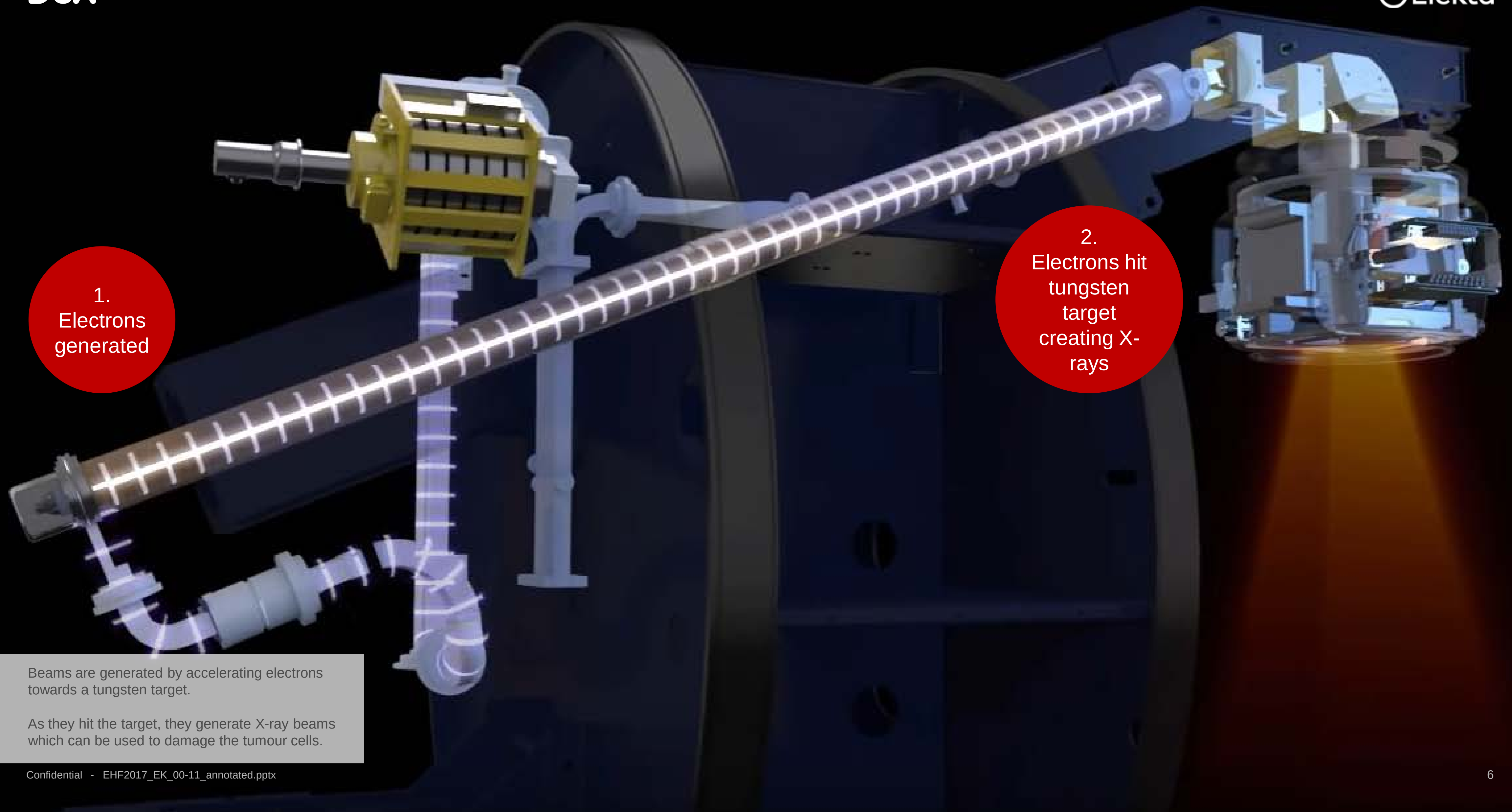


Underpinning radiation therapy is the fact that radiation is more harmful to tumour cells than healthy cells.

The aim is to get a dose large enough to kill these tumour cells, while minimising the damage to healthy cells.

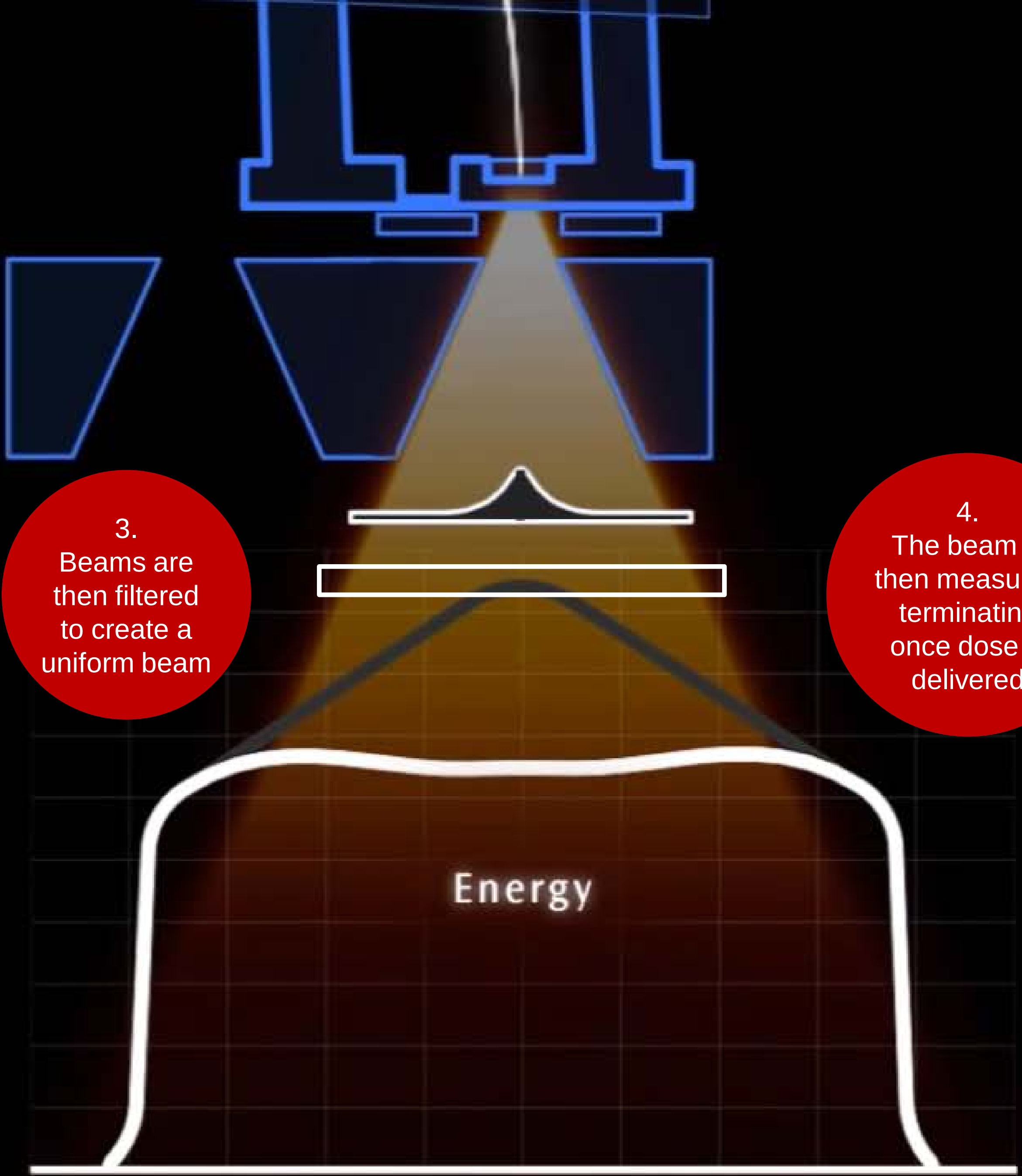
This means targeting and shaping a beam of radiation so that it is focused on the tumour site.





Beams are generated by accelerating electrons towards a tungsten target.

As they hit the target, they generate X-ray beams which can be used to damage the tumour cells.



3.
Beams are then filtered to create a uniform beam

4.
The beam is then measured terminating once dose is delivered

Before leaving the machine, the beam of radiation is filtered, shaped and measured.

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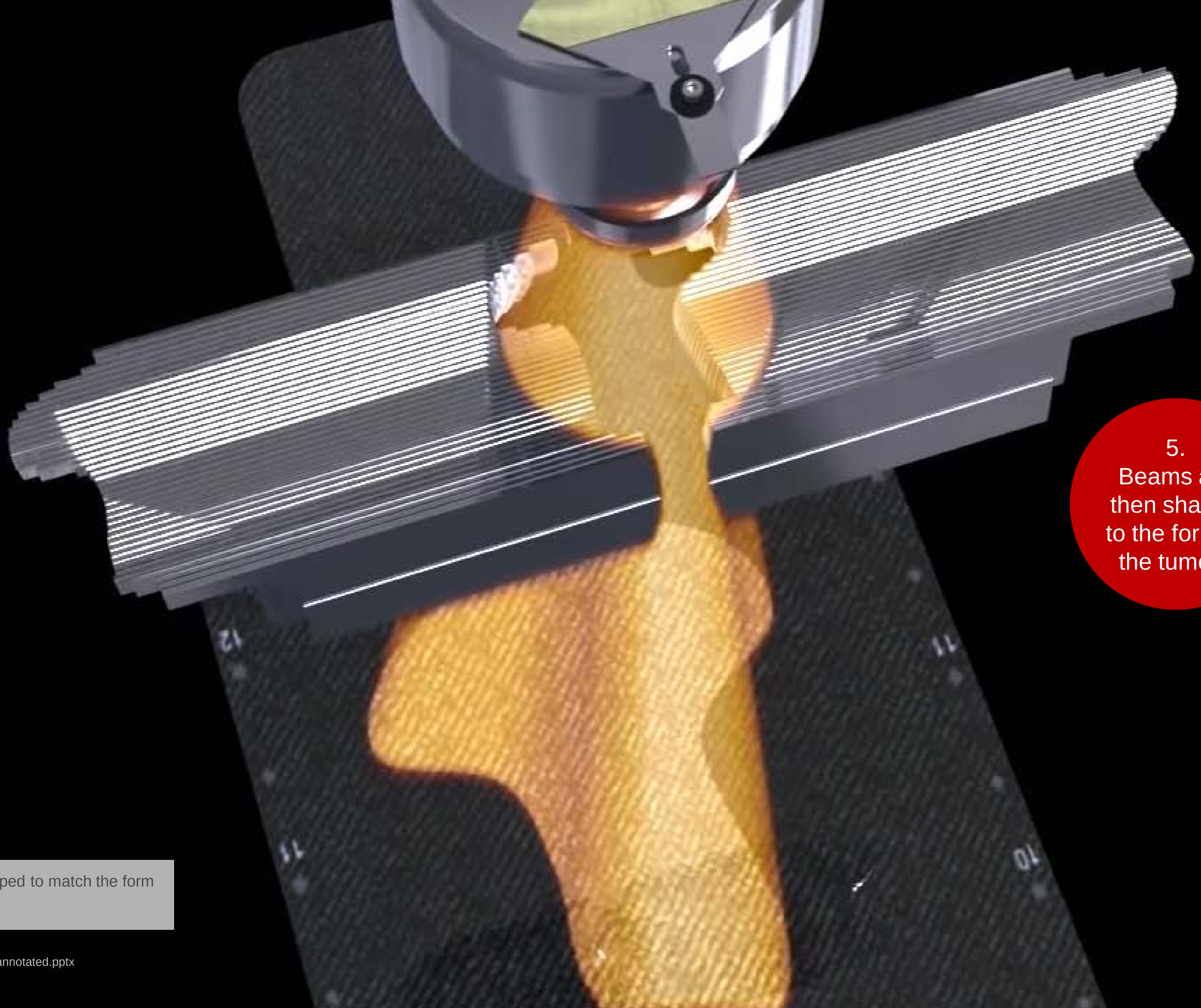


5.
Beams are then shaped to the form of the tumour

The beam is dynamically shaped to match the form of the tumour or target site.

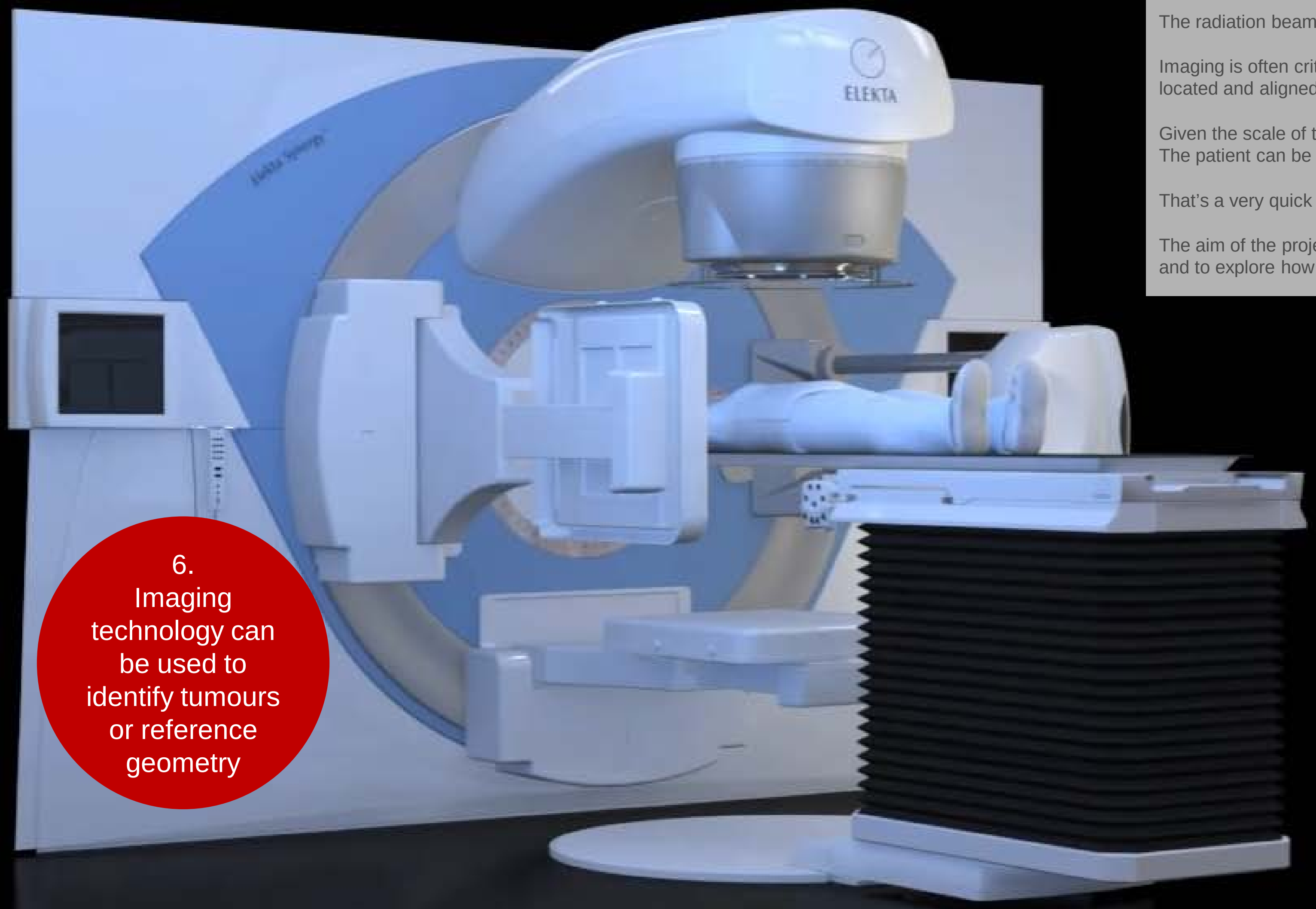
The radiation beam exits the machine from the head of the Linac.

Imaging is often critical to the process as it allows the tumour to be located and aligned with the radiation beam.

Given the scale of the machine, the beam tends to be fixed in location. The patient can be moved to the beam using a movable table.

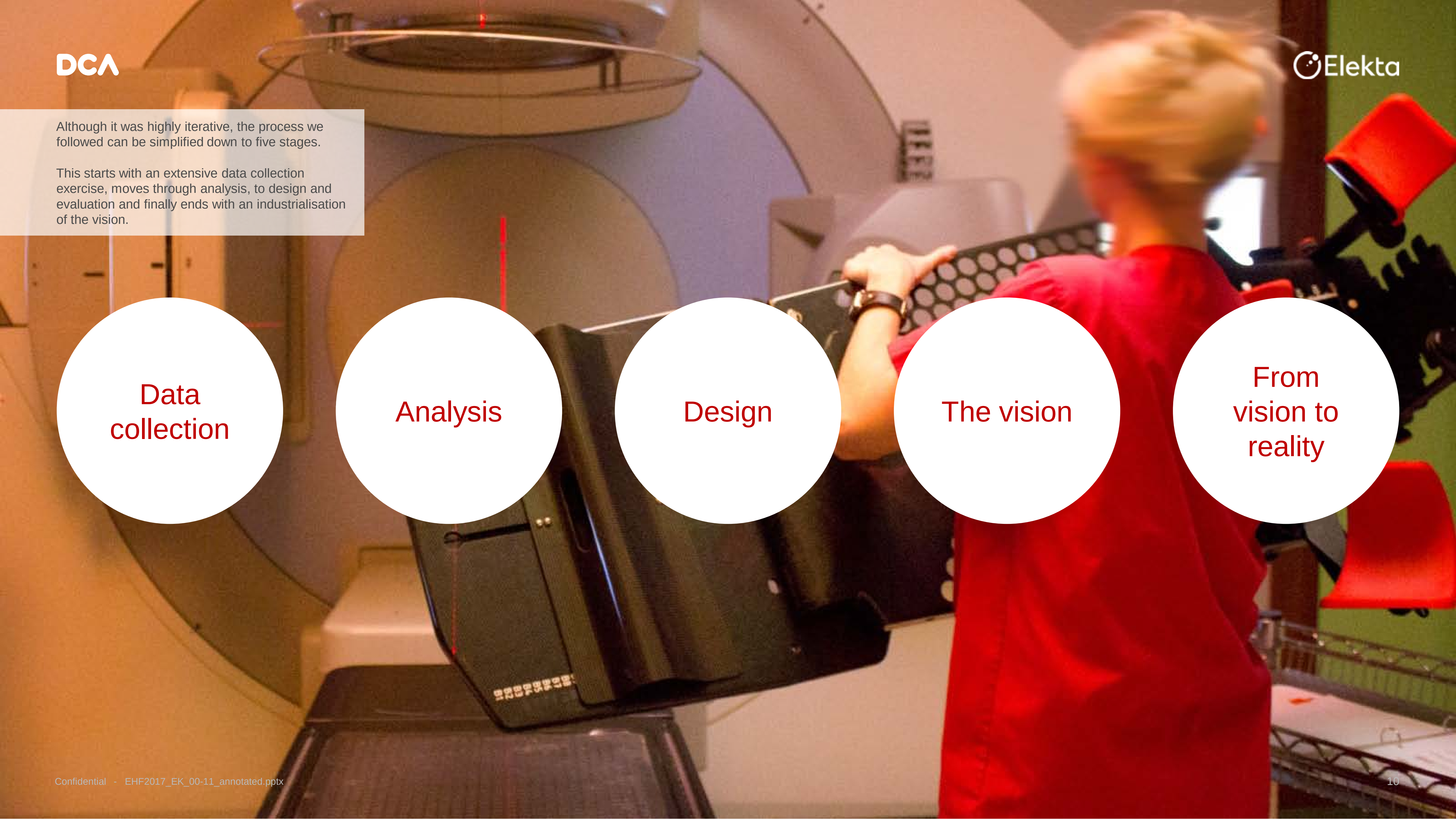
That’s a very quick introduction, but hopefully it covers the basics.

The aim of the project was to understand the human side of the system and to explore how system performance could be improved.



6.
Imaging technology can be used to identify tumours or reference geometry

7.
The patient can be positioned to the beam on a moveable table



Although it was highly iterative, the process we followed can be simplified down to five stages.

This starts with an extensive data collection exercise, moves through analysis, to design and evaluation and finally ends with an industrialisation of the vision.

- Data collection
- Analysis
- Design
- The vision
- From vision to reality

Data collection

DCA worked with Elekta on this project between 2010 and 2012 creating an evidence-base built from:

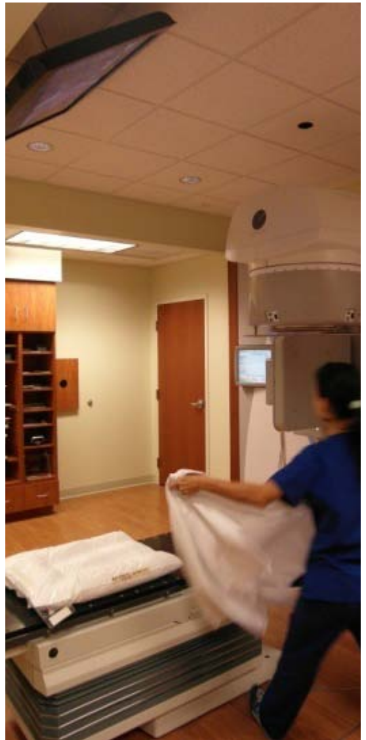
- 7 treatment sites visited worldwide
- Over 90 hours of observation at treatment centres (~360 treatment sessions)
- 30 interviews with healthcare professionals worldwide (fieldwork and phone interviews)
- 23 interviews with Elekta internal stakeholders from business, clinical specialists, technical, complaints, training, safety, regulatory and marketing
- 2 tradeshow visits

Ethnography

Observing approximately 360 treatments across seven treatments sights.

After-hours interviews and walkthroughs.

Two researchers following the workflow in the treatment room and the control room.



Because of the radiation, much of the workflow must be delivered from a separate control room.

This is a typical control room set up with two radiotherapists, one leading the treatment and the second in a checking role, they alternated this for each treatment.

Attention must be divided between CCTV footage of the patient and displays communicating the equipment and treatment status.

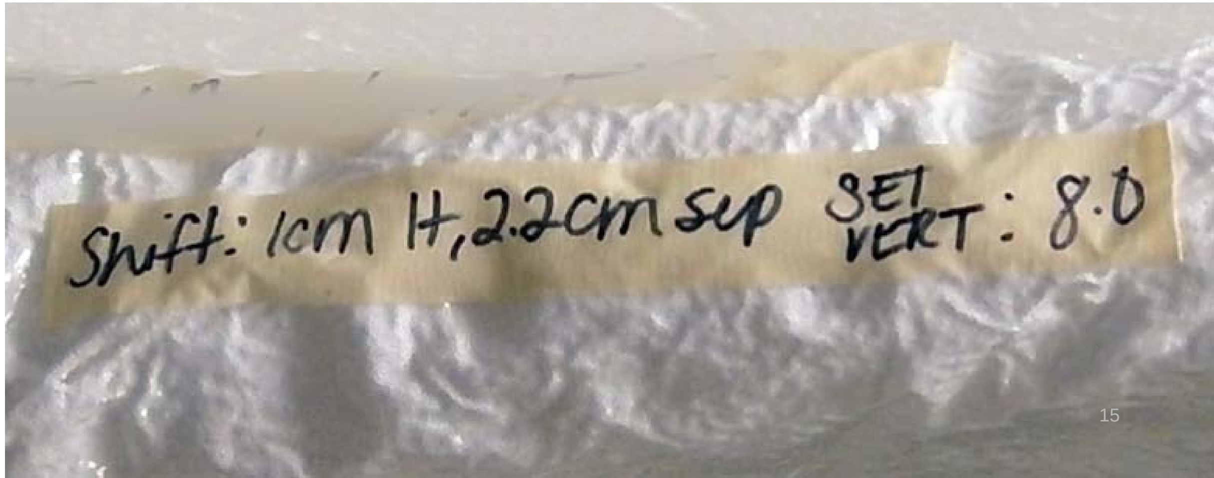
Latent needs

Even before processing any of the data, we were able to observe a range of latent needs within the system.

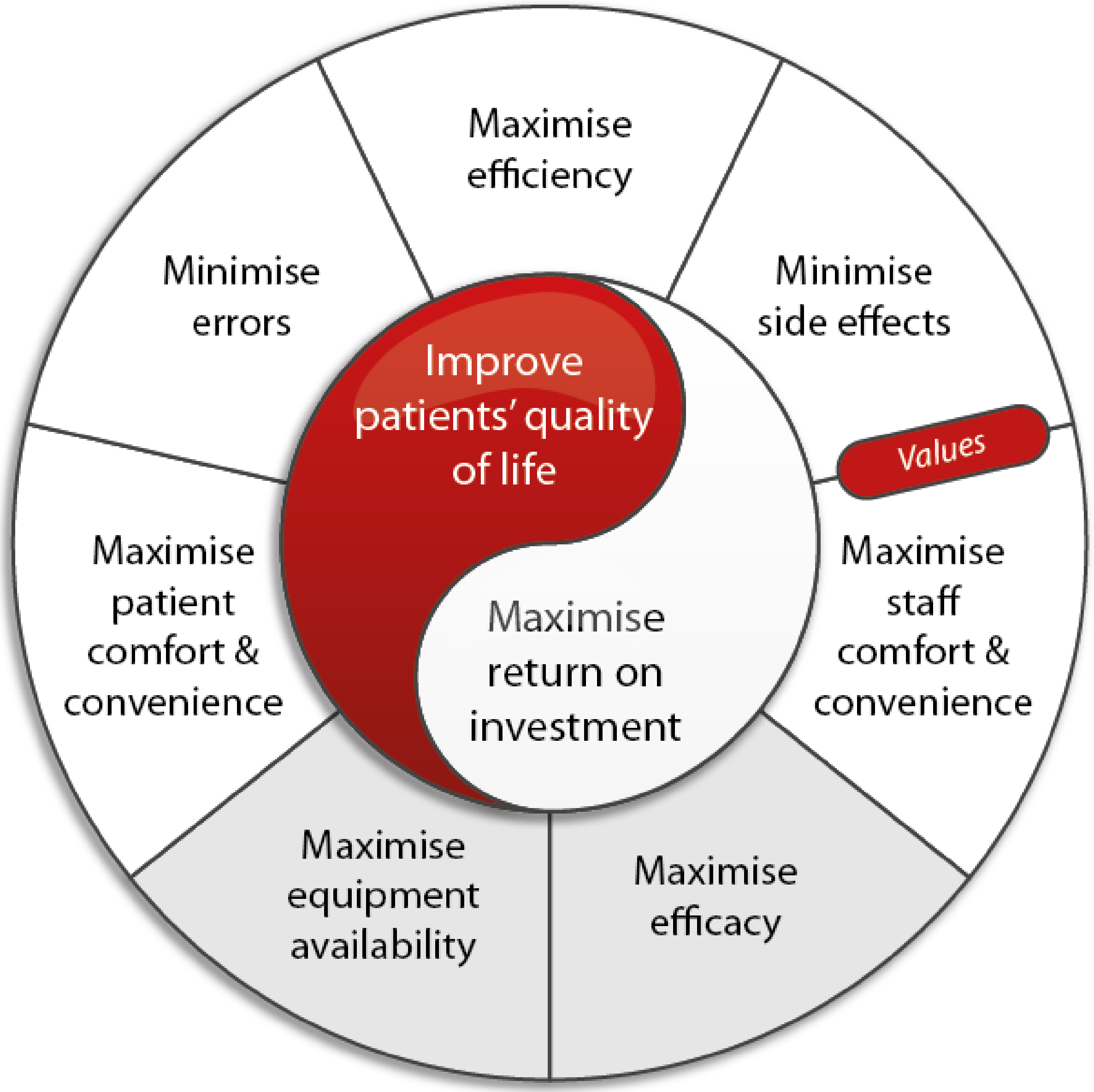
Faster throughput was a key theme in some locations , notably Brazil, where there were long waiting lists to gain access to radiotherapy machines. We learnt a lot from the current efficiency saving processes that had been adopted at different sites.

Access to information was also a key theme. Information about the patients setup was often recorded on their unique support aids.

This showed a very clear latent need for greater information at the point of use.



Analysis



The first stage of the analysis was to define metrics of system performance.

At the highest level, the functional purpose of the system is twofold, firstly to improve patients quality of life but also to return on investment. The relative balance placed on these changed by market.

The measure of performance included efficiency, errors, side effects, comfort and convenience, equipment availability and efficacy.

Hierarchical task analysis (HTA)

Identify the patient and relate them to the schedule
4.1
Patient registration

Set up the machine to receive the patient, add setup aids
4.3
Machine preparation

Configure setup aids, position the patient
4.5
Patient set up

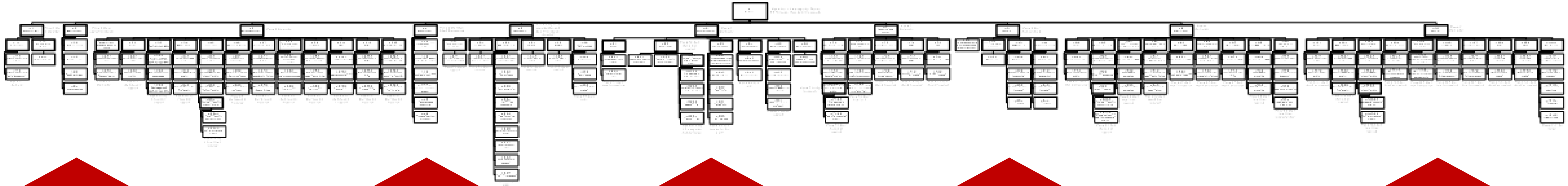
Adjust the position of the patient, retract panels (if required)
4.7
Prepare for beam

Remove immobilisation devises, help patient
4.9
Unload patient

The cornerstone of the analysis of the current system was an HTA. The treatment process is largely linear and decomposes well into task steps.

There are 10 high level sub-tasks in the process that were found to be uniformly followed.

Variation between sites tended to occur at the base level operation level.



4.2
Manage patient
Explain the treatment process

4.4
Patient loading
Sit the patient on PSS and lay them down

4.6
Verification imaging
Image the patient (if required)

4.8
Beam on
Treat patient

4.10
Clean up
Wipe down machine, reset ready for next patient

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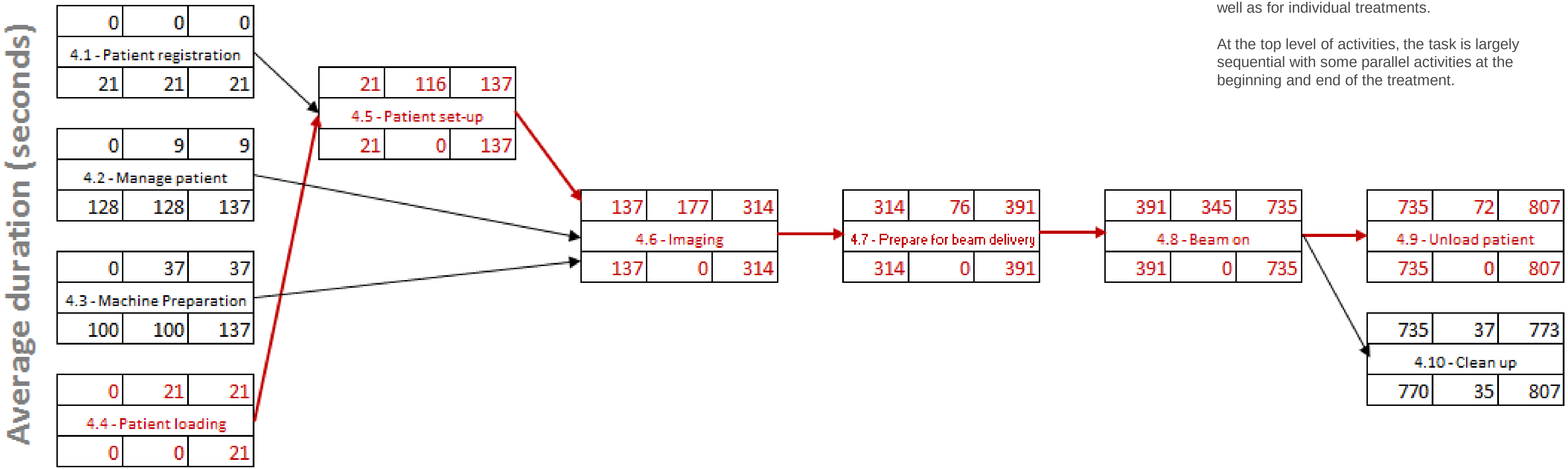
Critical path analysis (PERT charts)

This chart shows average task completion times broken down by stages (as described in the HTA)



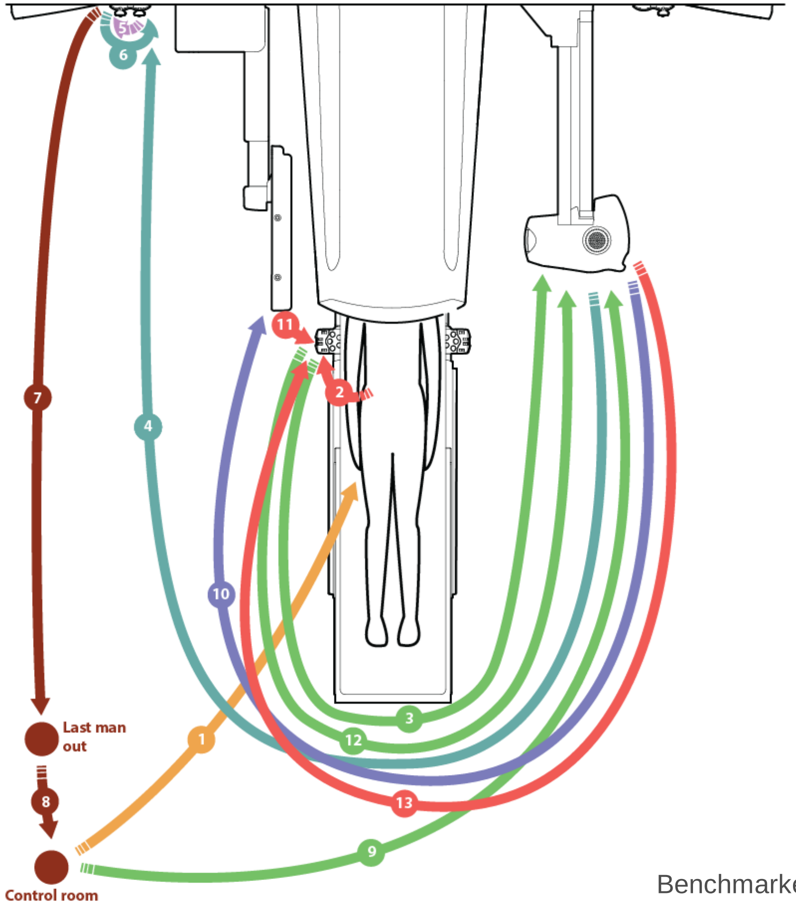
Data from the HTA could be explored in PERT (Program Evaluation Review Technique) charts to identify the critical path.

Understanding this critical path is an important step in reducing treatment times.

These were completed based on site averages as well as for individual treatments.

At the top level of activities, the task is largely sequential with some parallel activities at the beginning and end of the treatment.

Link analysis



Benchmarked system

Likewise, we expanded on the task model (HTA) using Link analysis diagrams

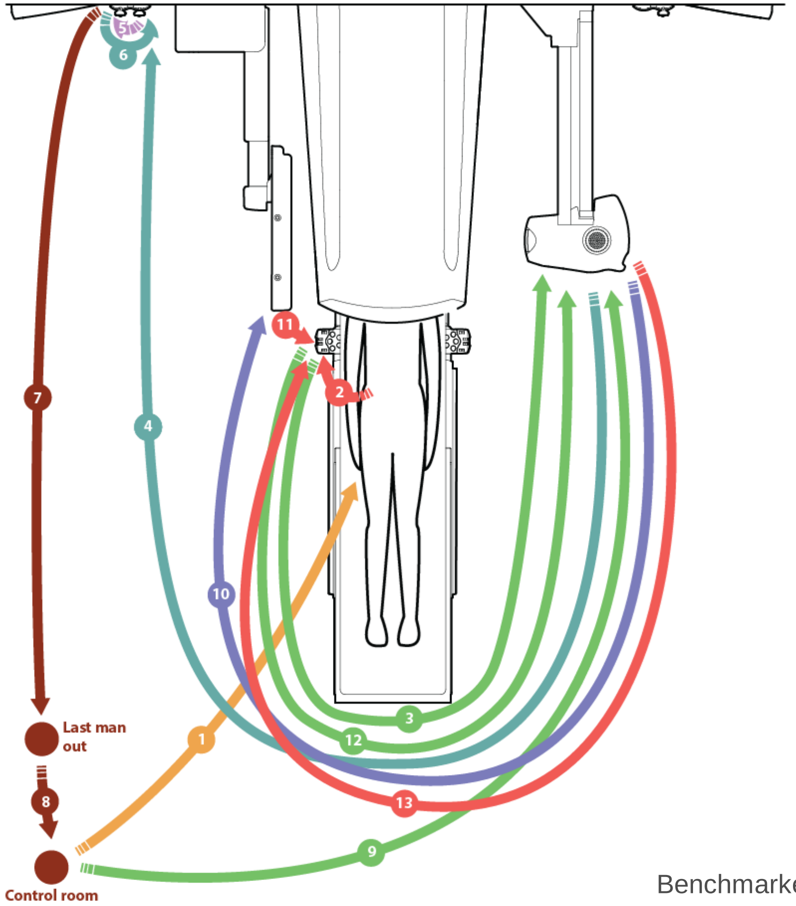
This diagram shows a link analysis model for a typical treatment setup.

Each of the numbered arrows indicated a movement made by the radiotherapist. A total of 13 moves are required in a typical treatment. Much of this stems from a requirement to manually interact with elements of the machine (e.g. deploy and retract imaging panels), or move to control locations.

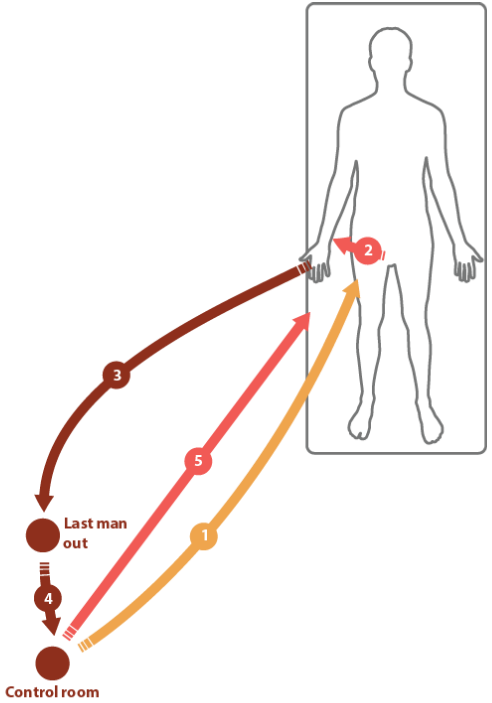
Link analysis

The diagram on the right shows how this could be simplified for the vision, for the same task we were able to reduce the number of movements from 13 to 5.

Much of this has been achieved by bringing the controls to the point of use, reducing the need to move around the treatment room.



Benchmarked system



Potential

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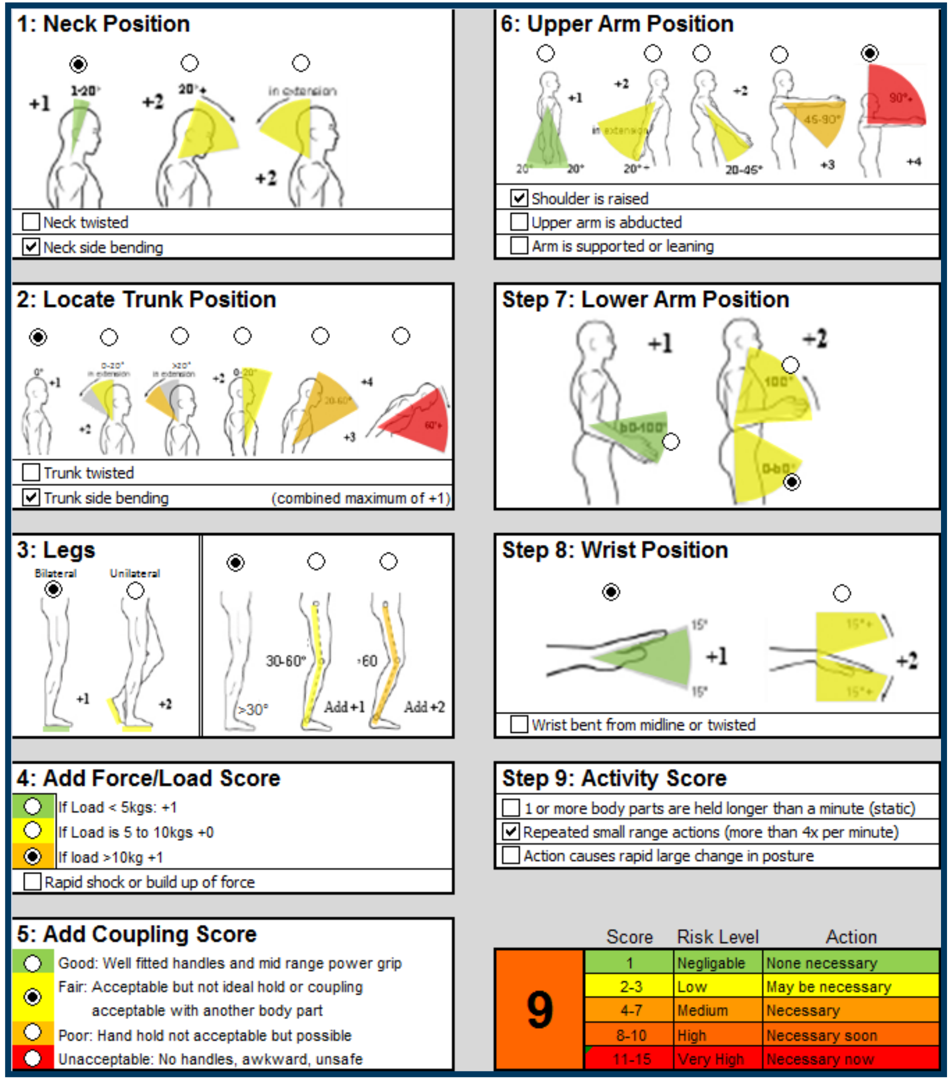
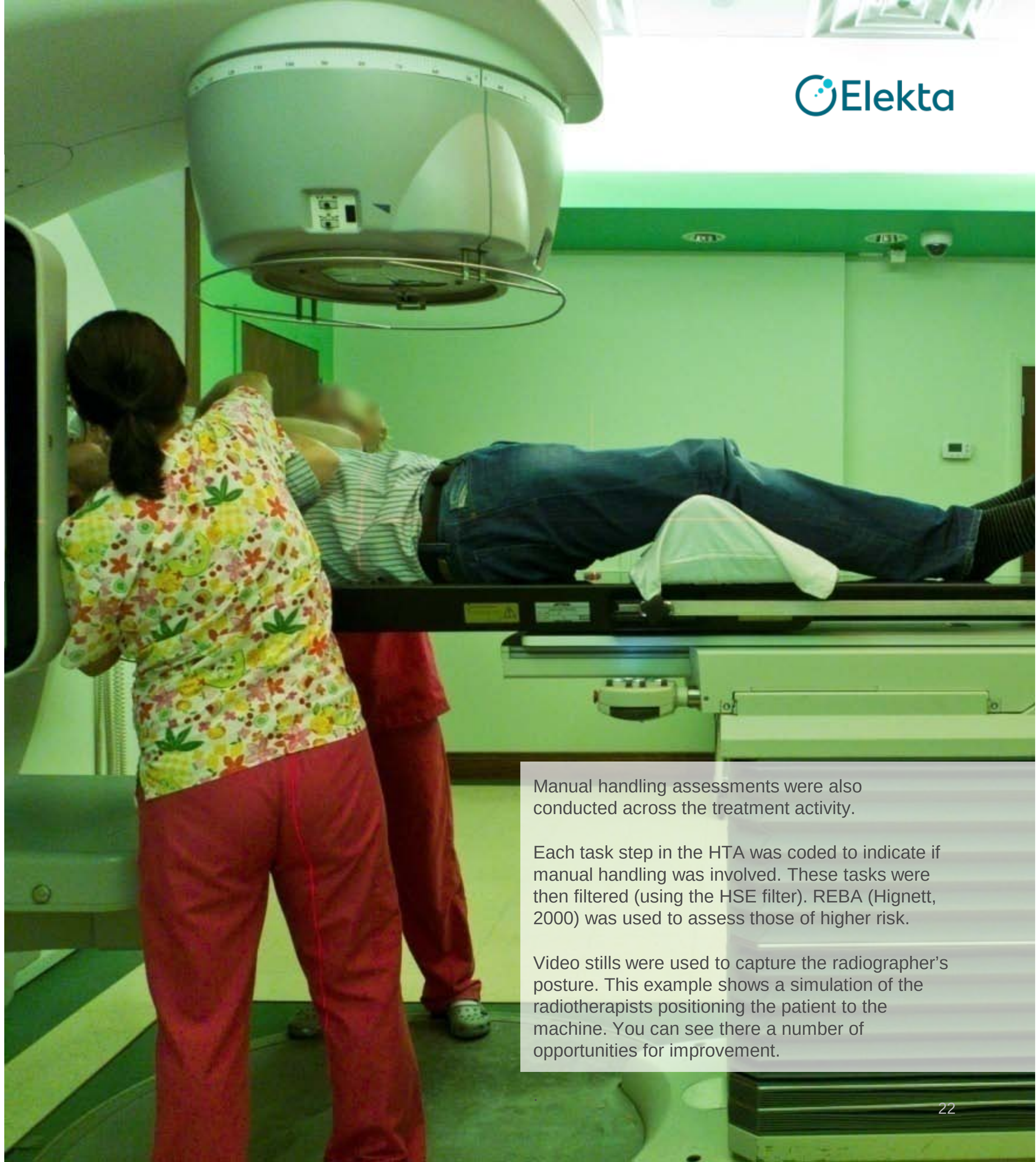
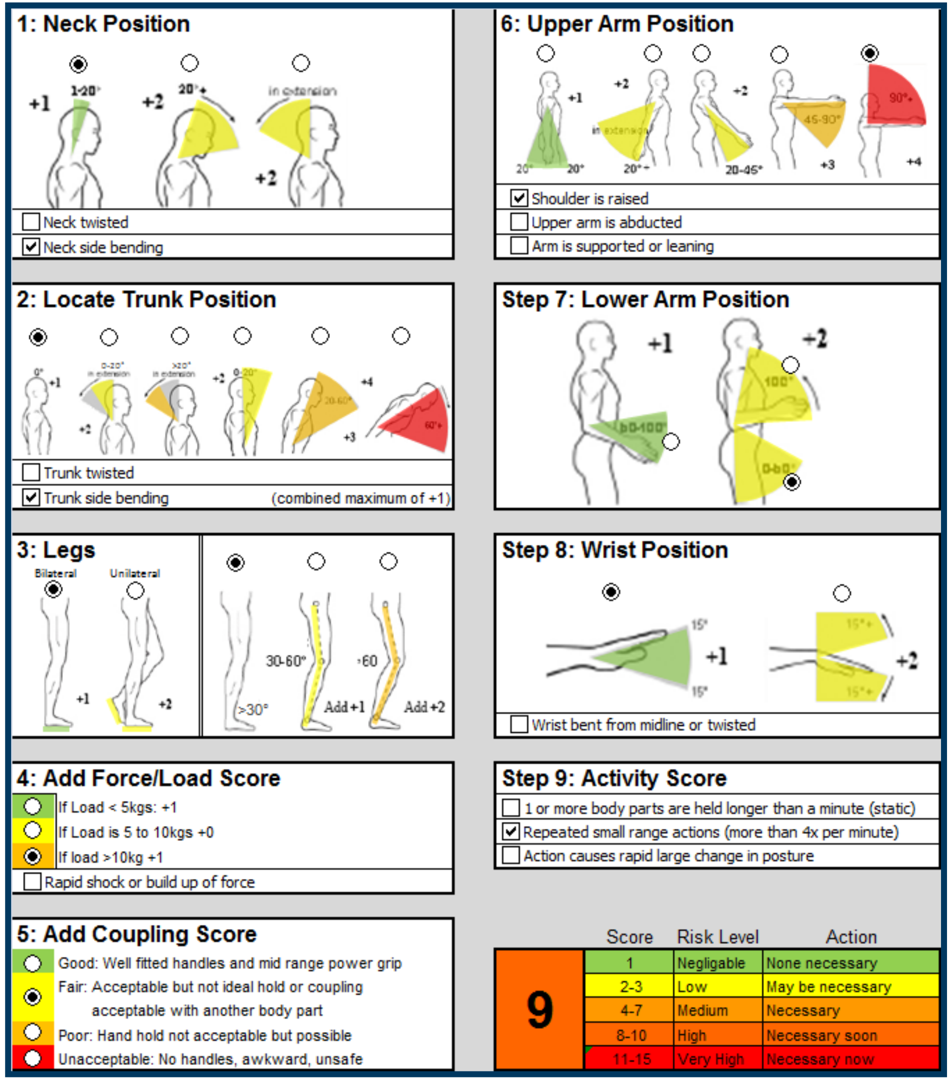




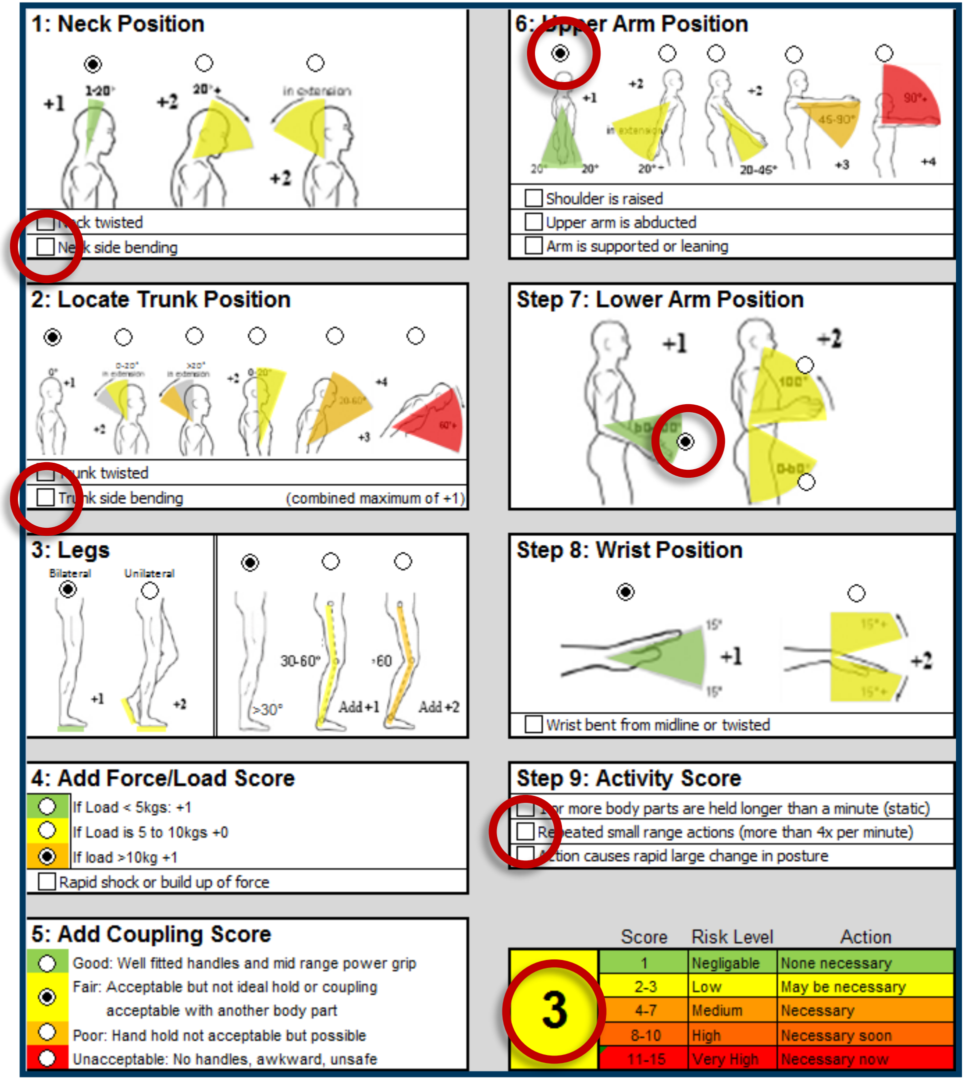
Manual handling assessments were also conducted across the treatment activity.

Each task step in the HTA was coded to indicate if manual handling was involved. These tasks were then filtered (using the HSE filter). REBA (Hignett, 2000) was used to assess those of higher risk.

Video stills were used to capture the radiographer's posture. This example shows a simulation of the radiotherapists positioning the patient to the machine. You can see there a number of opportunities for improvement.



By reducing the height of the table for setup, the risk to the operators can be greatly reduced – as shown on the example on the right



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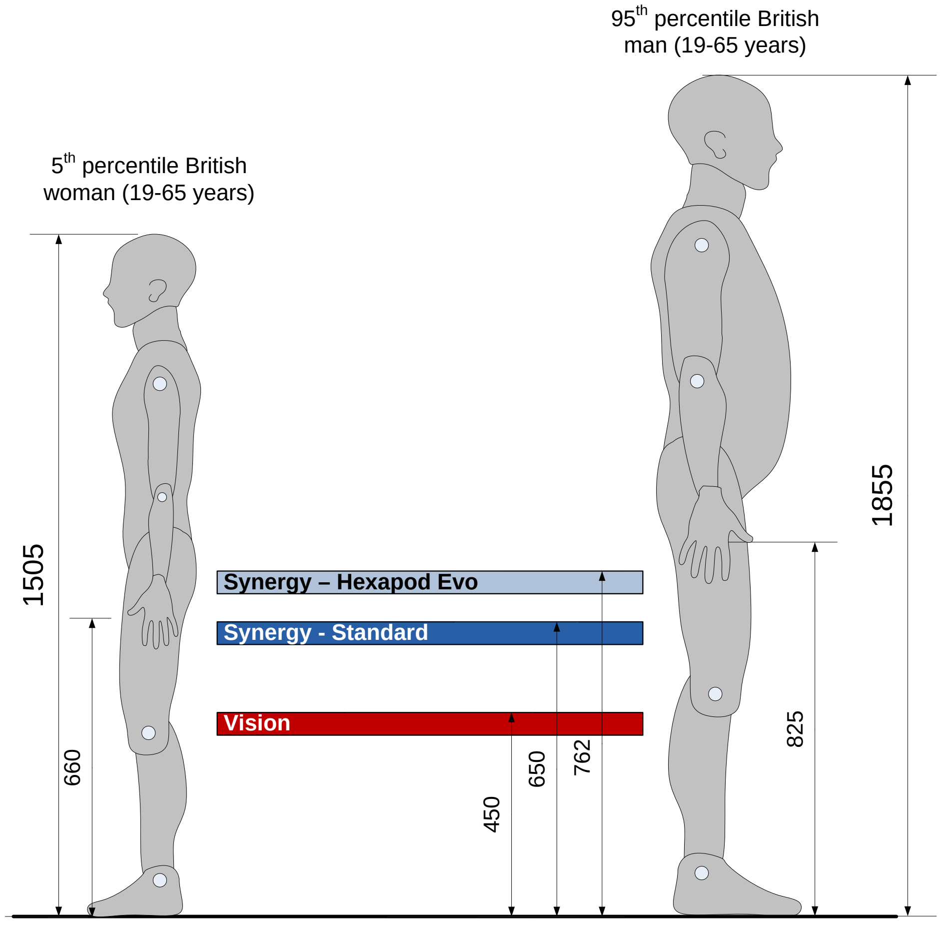
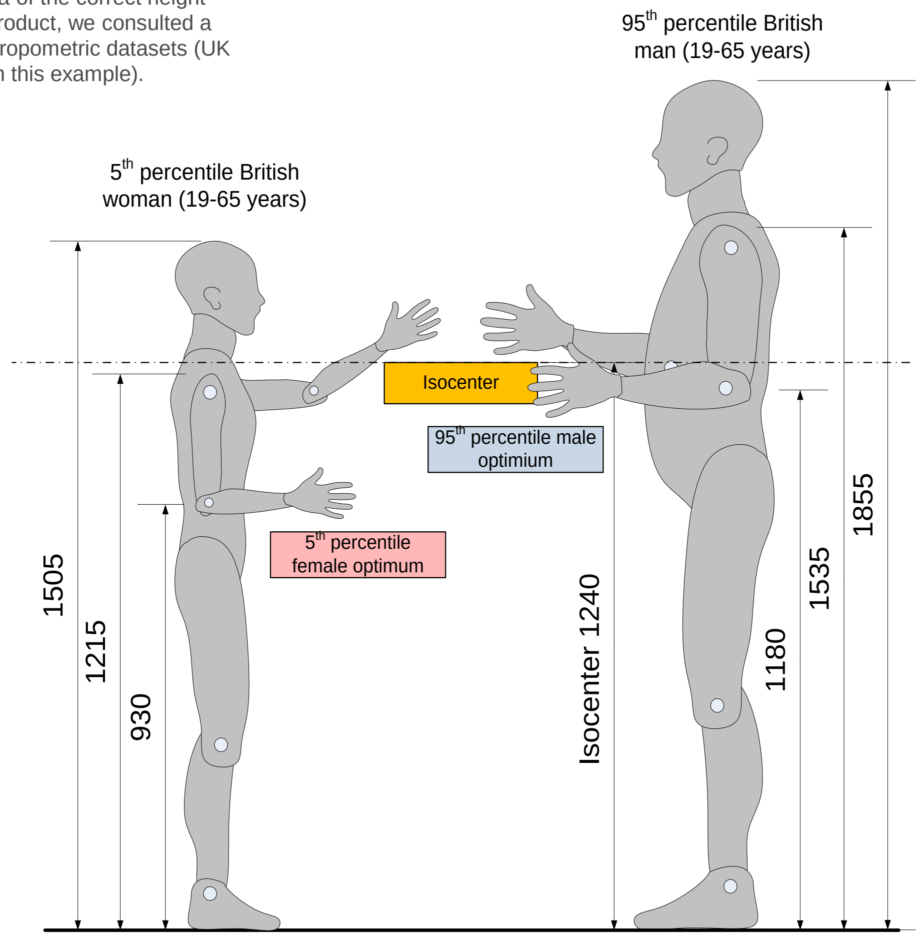


All dimensions in mm, based upon Pheasant & Haslegrave (2006) Table 10.1, without shoes

To get an idea of the correct height for a global product, we consulted a range of anthropometric datasets (UK data shown in this example).



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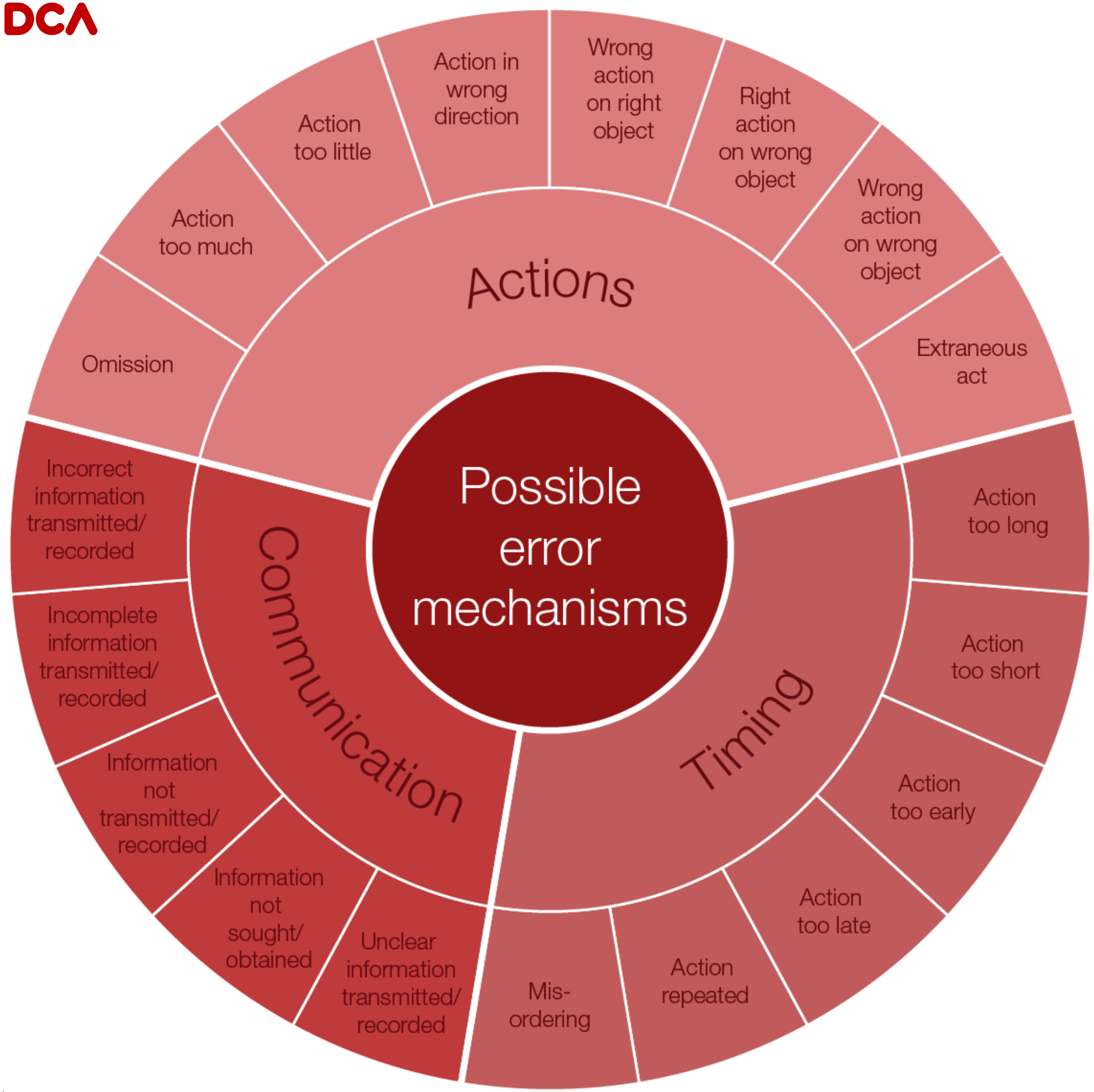
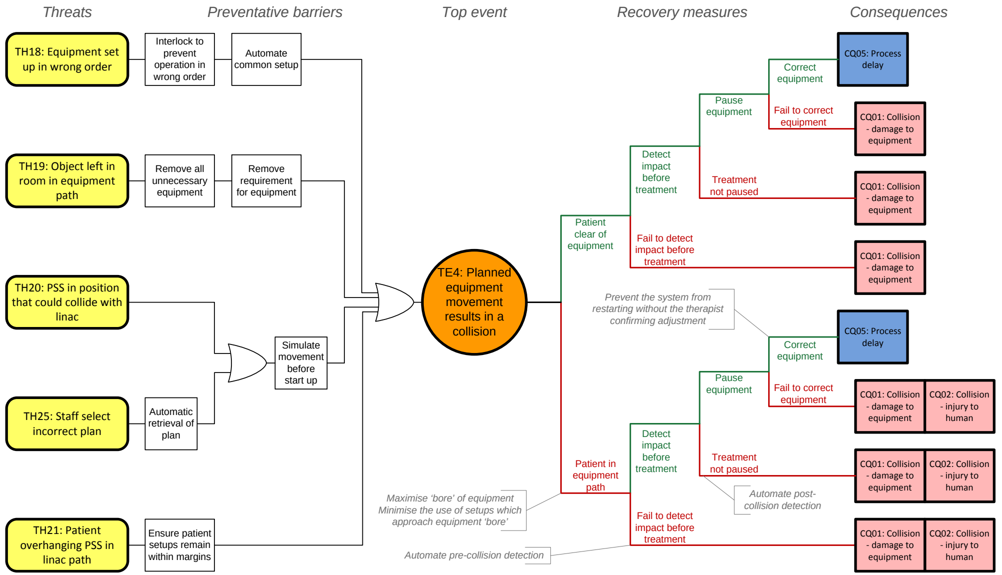


To understand error, we used a structured process for human error identification bases on TRACEr (Shorrock & Kirwan, 1999, 2002).

Each task step was considered against the keywords around the wheel.

Errors were then summarised in bowtie diagrams. These were used to create preventative barriers and recovery measures.

Given the repeatable and mechanistic nature of the task, this approach revealed some rich insights.



FRAM

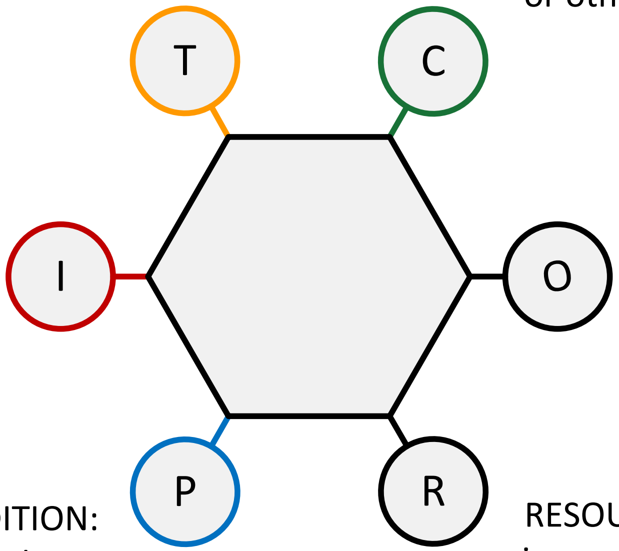
We wanted to balance this more traditional view on Error with more contemporary methods such as the Functional Resonance Analysis Method (FRAM; Hollnagel, 2012).

FRAM considers each activity based on inputs and outputs, time available control, precondition and resources

TIME available: This can be a constraint but can also be considered as a special kind of resource.

CONTROL: That which supervises or adjusts a function. Can be plans, procedures, guidelines or other functions.

INPUT: That which is used or transformed to produce the output. Constitutes the link to previous functions.



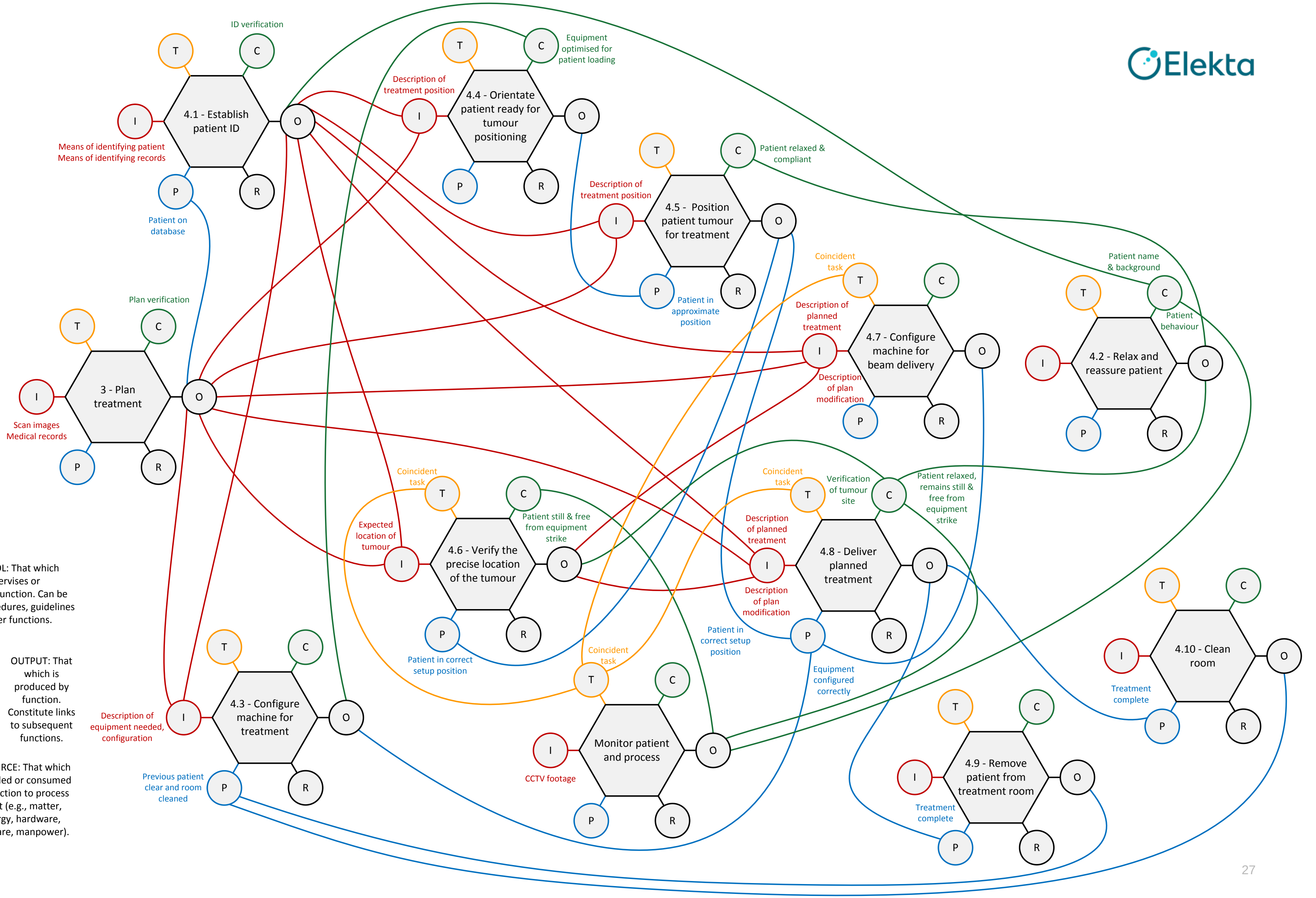
OUTPUT: That which is produced by function. Constitute links to subsequent functions.

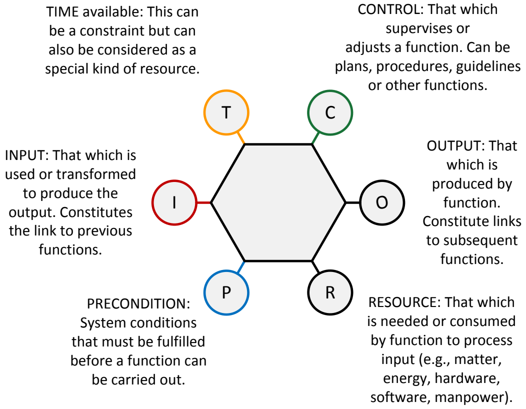
PRECONDITION: System conditions that must be fulfilled before a function can be carried out.

RESOURCE: That which is needed or consumed by function to process input (e.g., matter, energy, hardware, software, manpower).

FRAM

The diagram shows the interrelationships between treatment phases as identified in the HTA.





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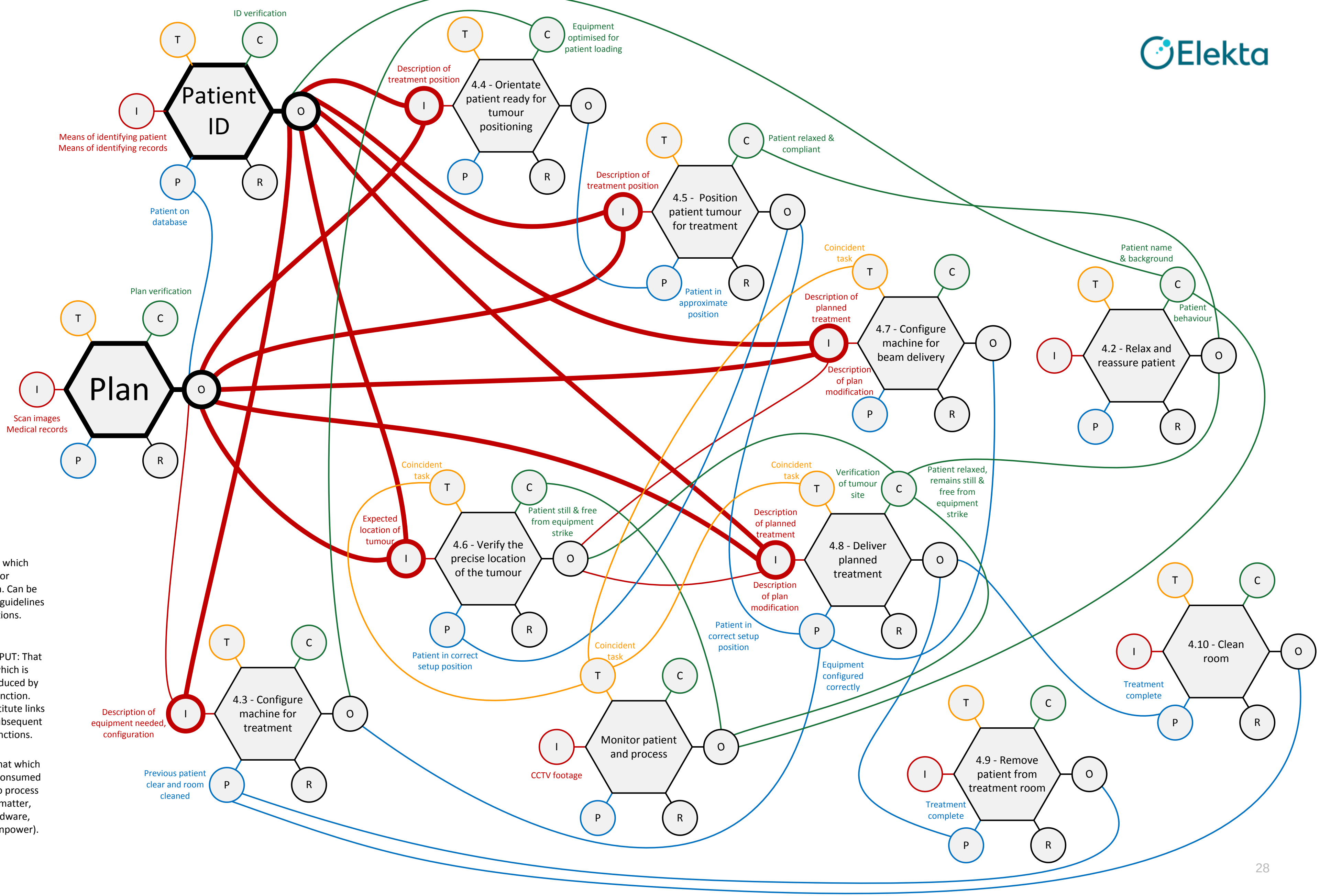
FRAM

The outputs from the patient ID and the planning process are critical.

Verification is key.



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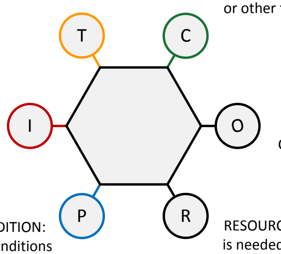

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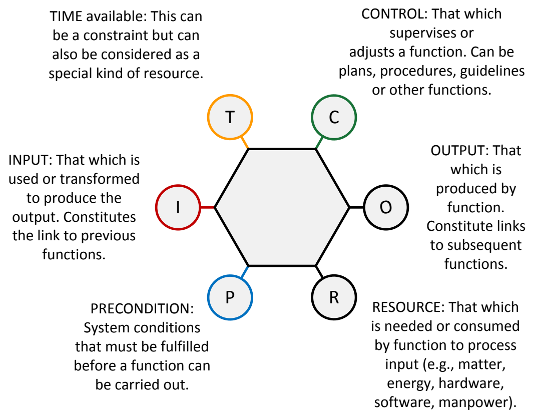
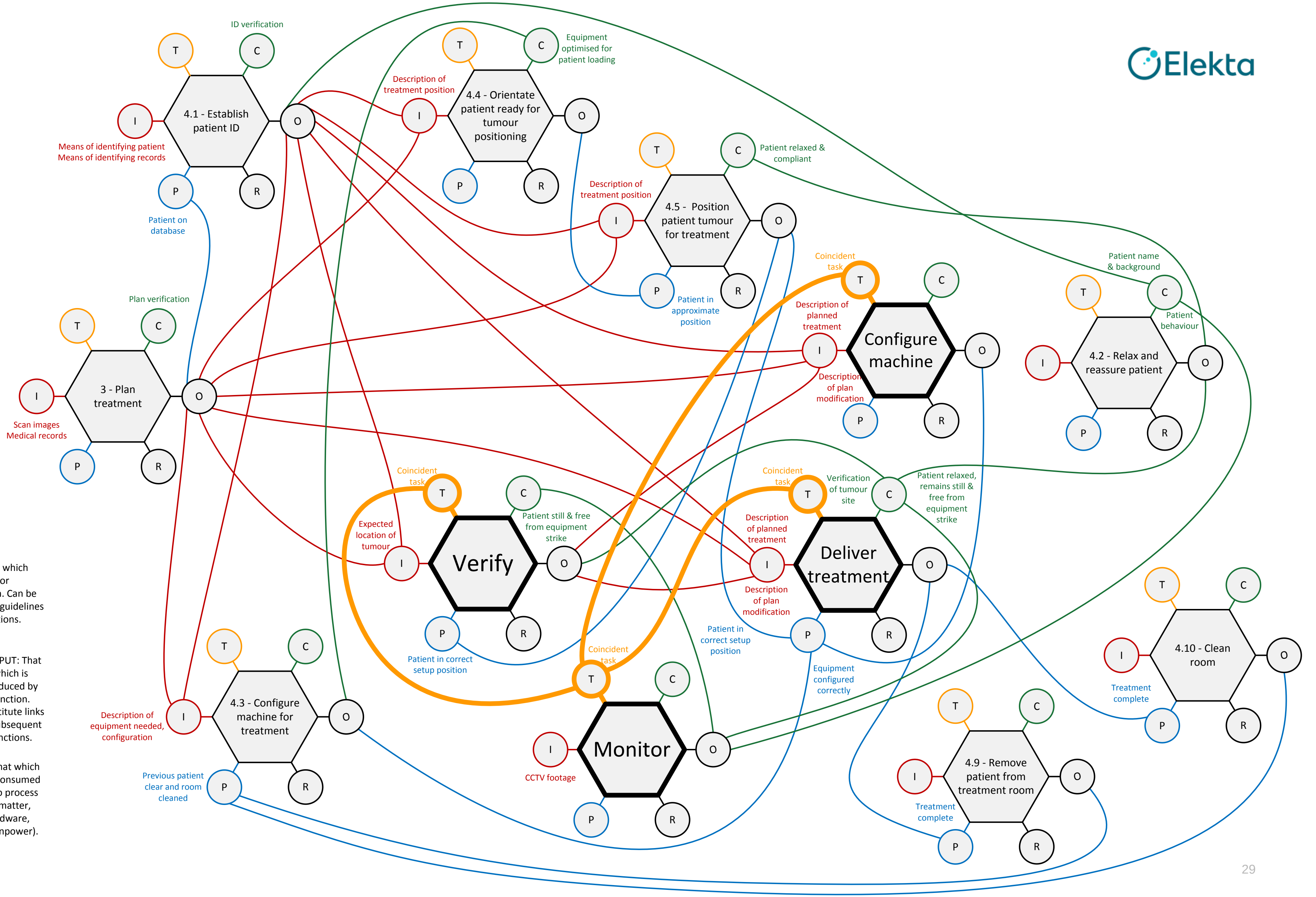
FRAM

Monitoring from the control room is a coincident task.

Some form of automation may improve performance.





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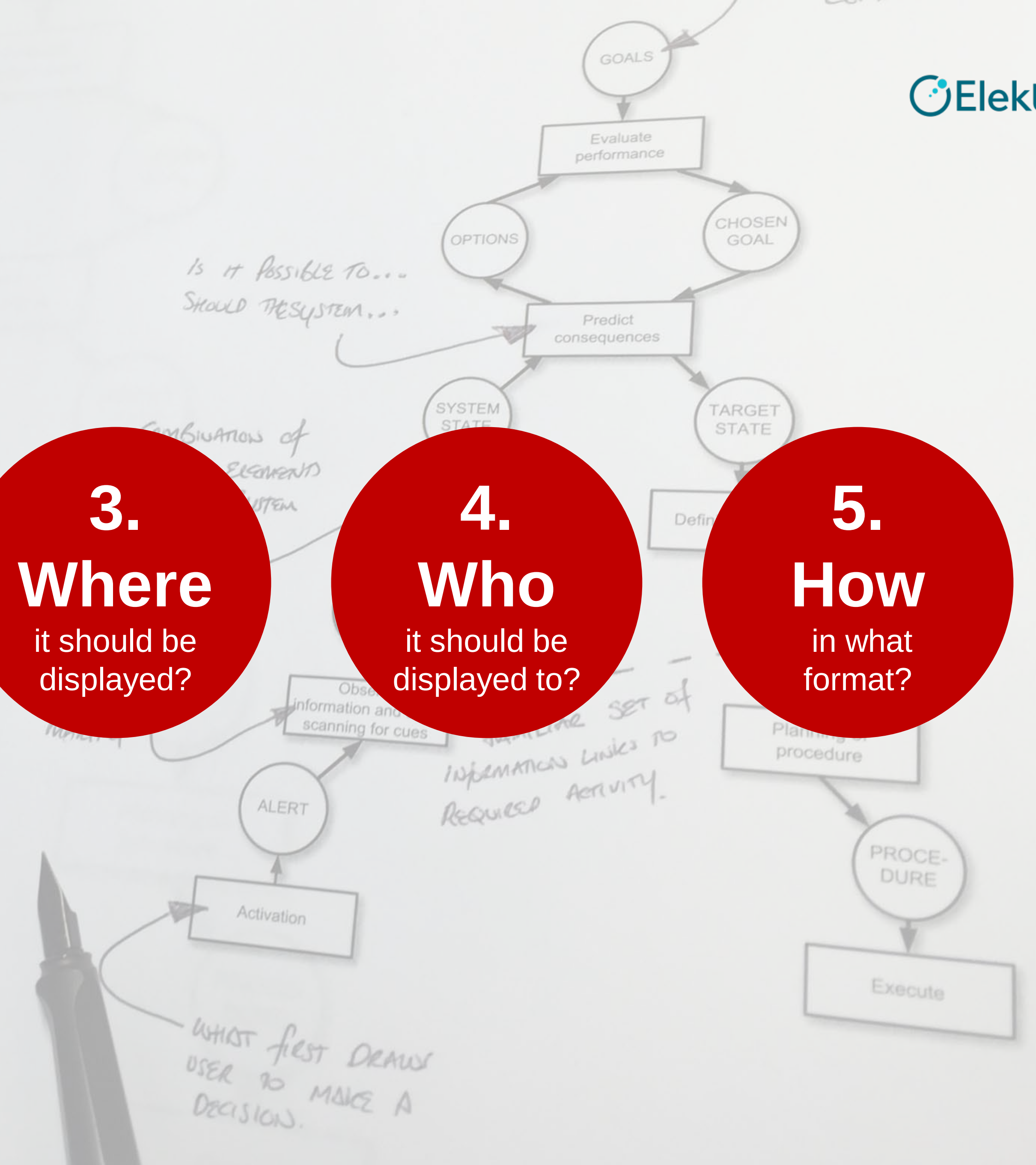
Information emerged as a key theme for this project. Thus, the aim is to generate models to establish, what information is required, when and where it needs to be displayed, who to, and in what format.



1. What information is required?

2. When it needs to be displayed?

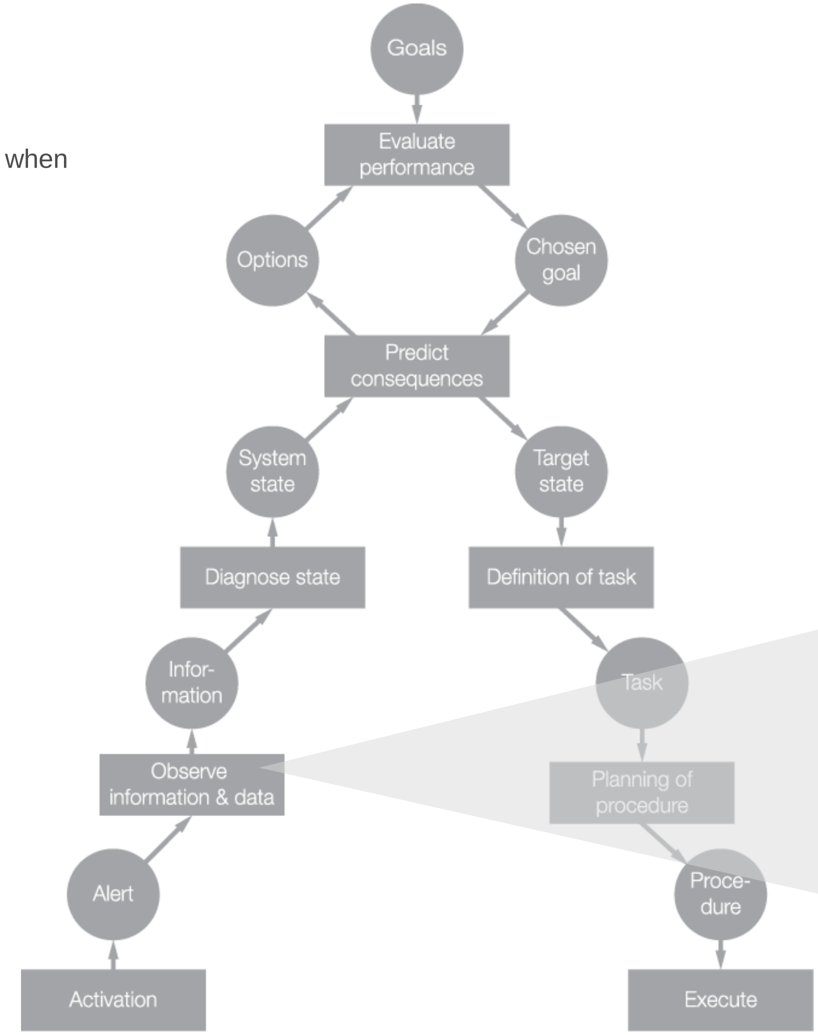
3. Where it should be displayed?

4. Who it should be displayed to?

5. How in what format?

Decision ladders

36 information elements could be of use when setting up the patient



064 Who is the patient?
032 Does the patient have special medical needs?
042 Does the patient have any special cultural religious needs?
066 Is the patient a child?
067 What is the cancer type?
068 How should the patient be positioned (posture)?
008 What is the weight (size)of the patient?
009 What is the height of the patient?
015 Does the patient have physical needs?
016 Does the patient have mental needs?
069 Is the patient comfortable?
070 Is the patient relaxed?
071 Is the patient cooperative?
072 Is the patient sensitive to modesty?
052 What are the patients set up instructions?
055 What equipment is already out?
057 How many staff are available?
058 Is technical support available?
060 Where is the PSS table?
073 What are the PSS table limits?
061 Where is the hexapod?
074 What are the hexapod limits?
062 Where is the gantry?
063 Which imaging panels are deployed?
065 Where is the patient in relation to the PSS?
075 What auxiliary equipment is in the room?
053 Does the patient have personalised immobilisation devices?
054 Does the patient have personalised accessories?
076 What immobilisation aids are required?
077 What immobilisation aids are in place?
078 Which set up aids are required?
079 Which set up aids are in place?
080 Which head applicator is required?
081 Which head applicator is in place?
082 What is the equipment’s movement path?
051 Are the room and equipment clean?

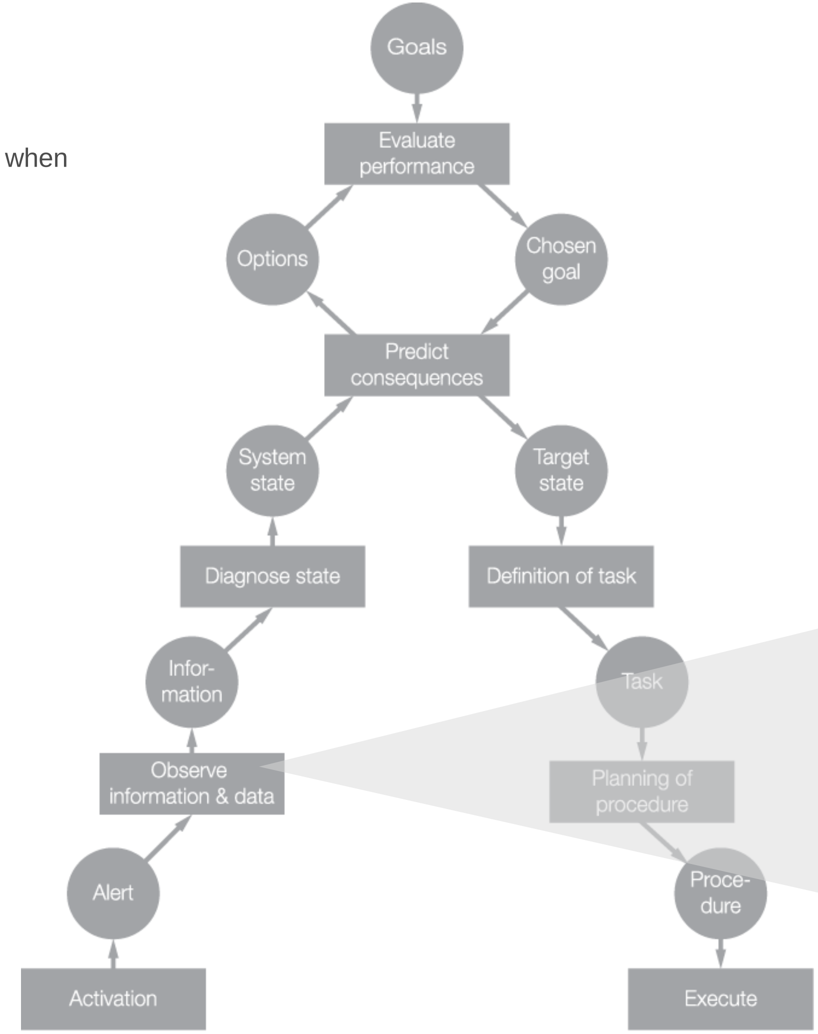
We also turned to Rasmussen's decision ladders to help define system information requirements.

In this example, we found that there were 36 information elements that could be of use when setting up a patient.

Decision ladders

36 information elements could be of use when setting up the patient

16 exist in the physical environment



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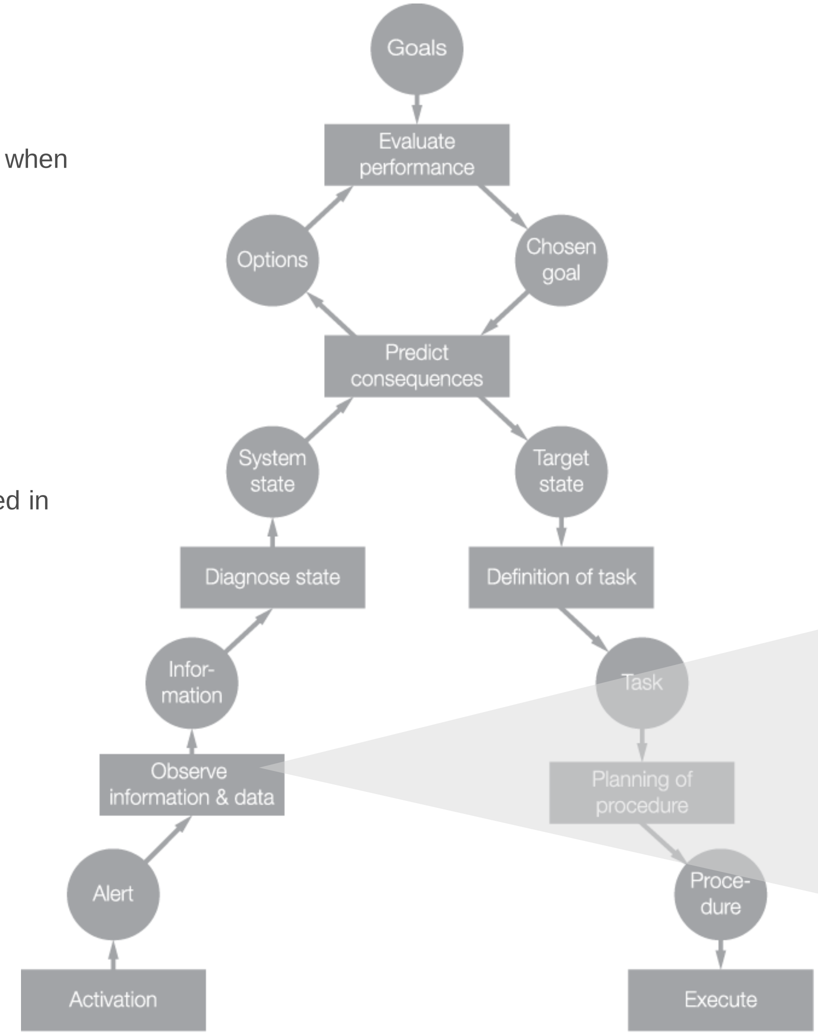
Of those, we found that 16 were readily available in the physical environment, things like the size of the patient or the position of the equipment.

Decision ladders

36 information elements could be of use when setting up the patient

16 exist in the physical environment

10 are supported by information displayed in the control room



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And we found 10 were already present on digital displays.

This understanding of what information was required, where and when was critical to improving the design.

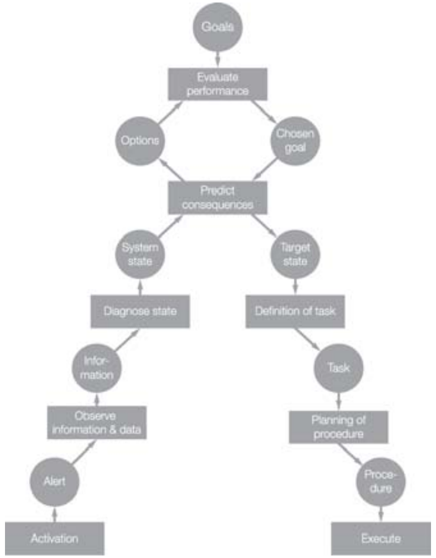
Design

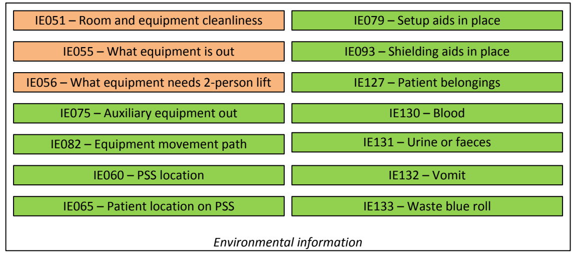
Treatment room information

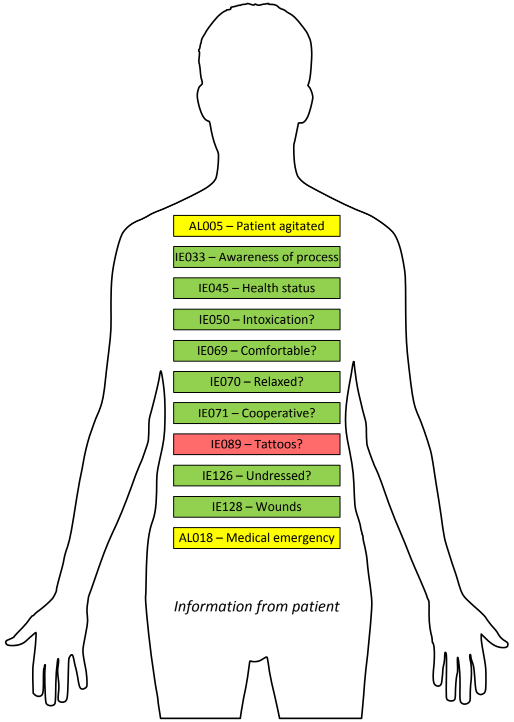
The first stage of redesigning the information displays for the vision was to plot this information out and define what was needed (green), and what could be needed (orange), for a range of situations.

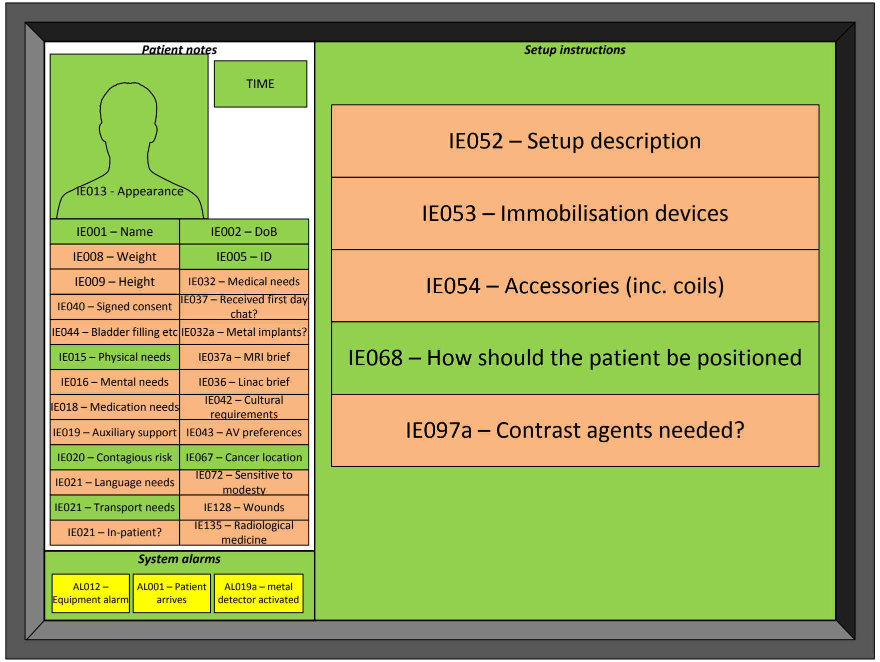
This shows an example for the treatment room information. This is clustered by information on the patient, in the environment. and on some form of display (digital or paper).

The example is for the patient loading stage. This diagram was modified for each stage.

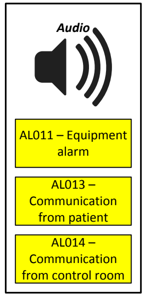








System generated information requirements

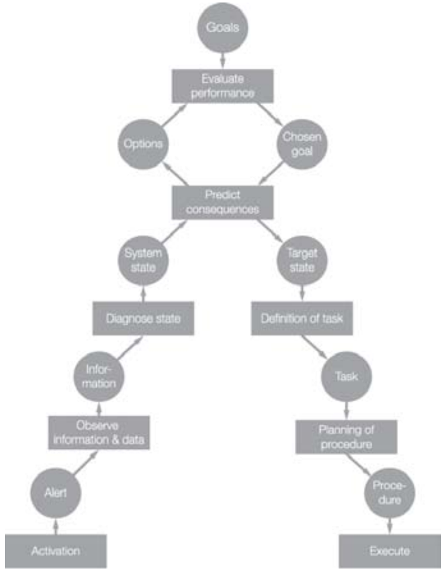


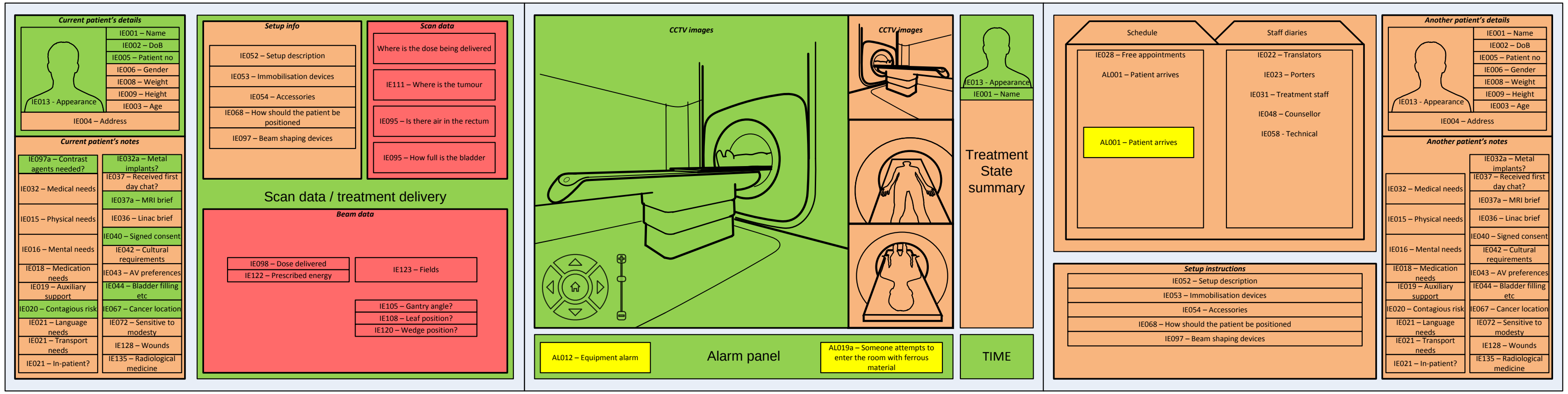
Green – Typically required at the current stage
Amber – Could be required at the current stage (may be hidden)
Red – Not required at then current stage
Yellow – Alerts to be displayed as required

4.4 Patient loading

Control room information

We performed the same task for the vision's control room displays. As before, a different diagram was produced for each stage of the treatment process. A split is shown highlighting the different information requirements for the two radiotherapists. One delivering the treatment and the second, verifying the treatment, liaising with other staff, manning the schedule and managing the patients.





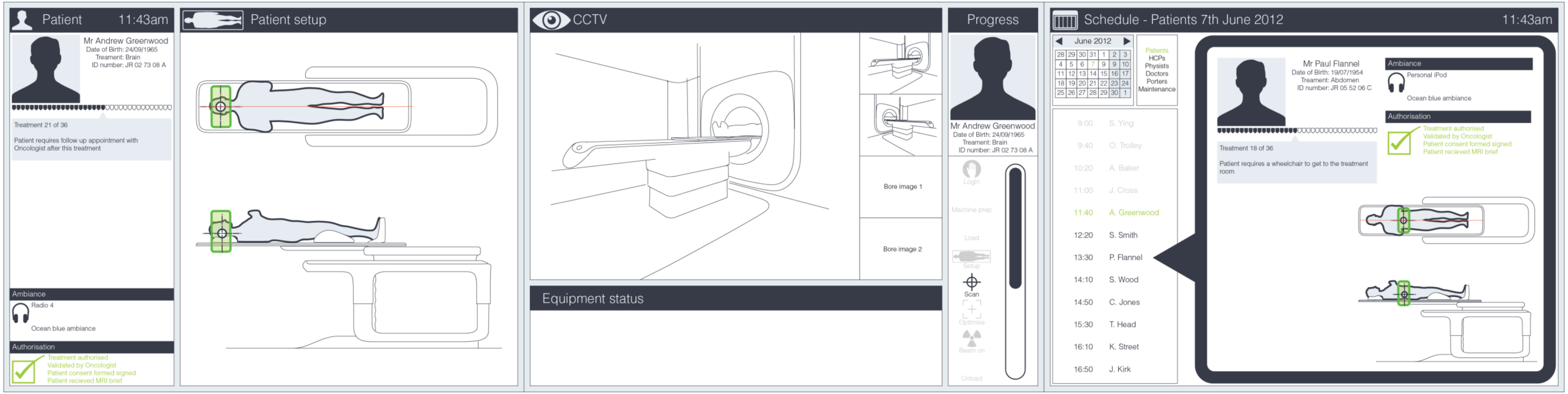
Main user – running machine

Second user – verification, liaison, scheduling, patient management

Green – Typically required at the current stage
Amber – Could be required at the current stage (may be hidden)
Red – Not required at the current stage
Yellow – Alerts to be displayed as required

Basic wireframes were then created for each treatment stage.

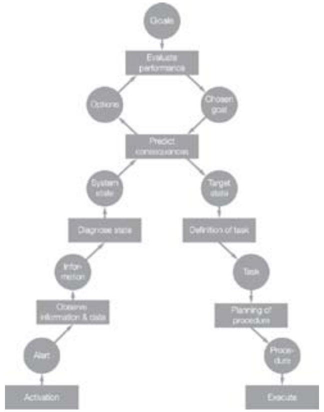
The example shows an early wireframe of the information for the control room split across three screens.

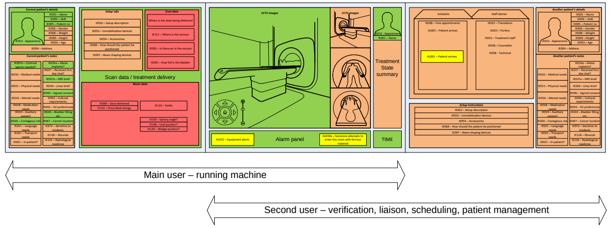


DCA

This shows the vision concept worked up to a higher resolution.

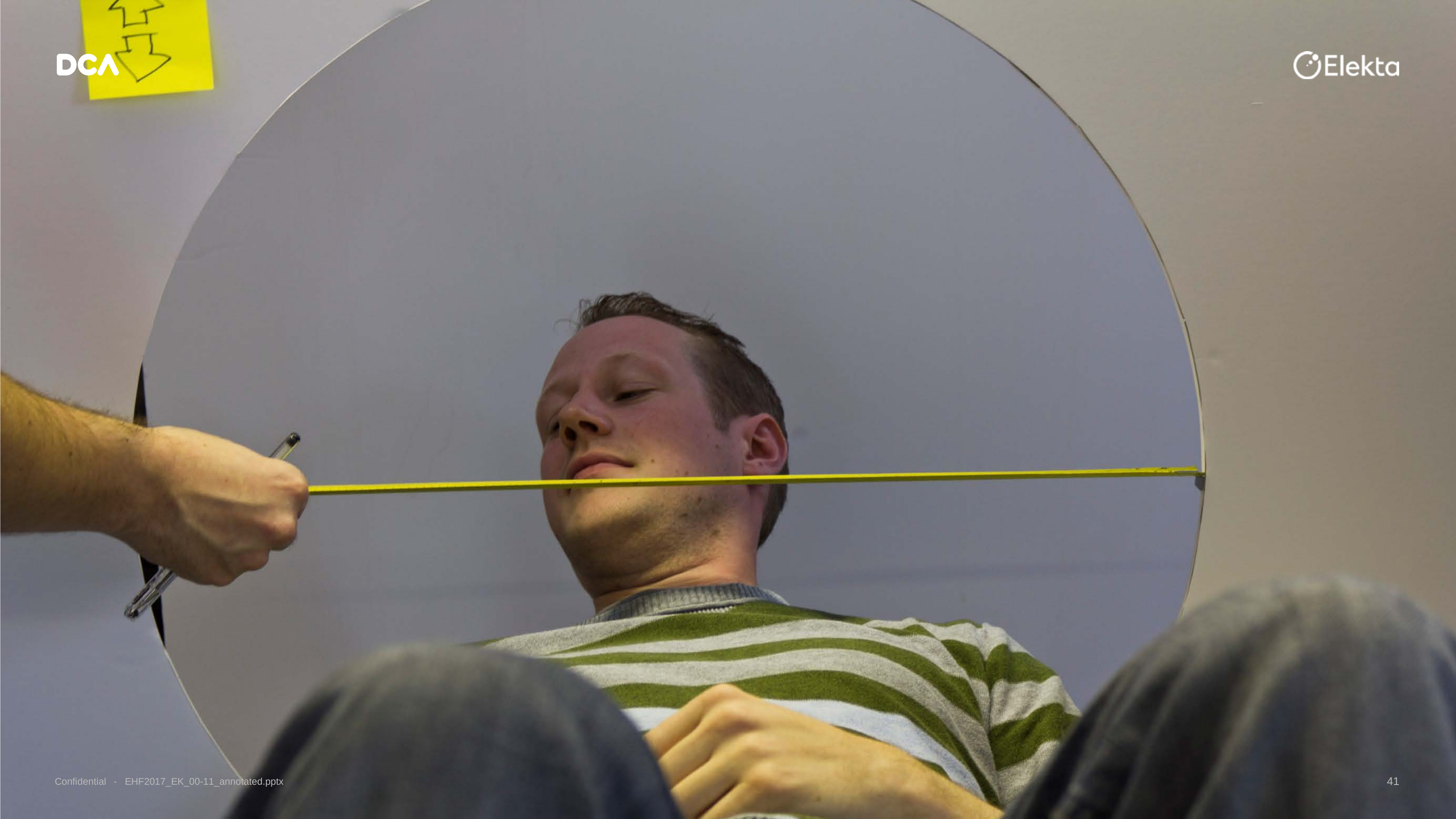
Thus, we had a very structured and auditable process moving from analysis using decision ladders, through specification, to wireframes and embodiment.

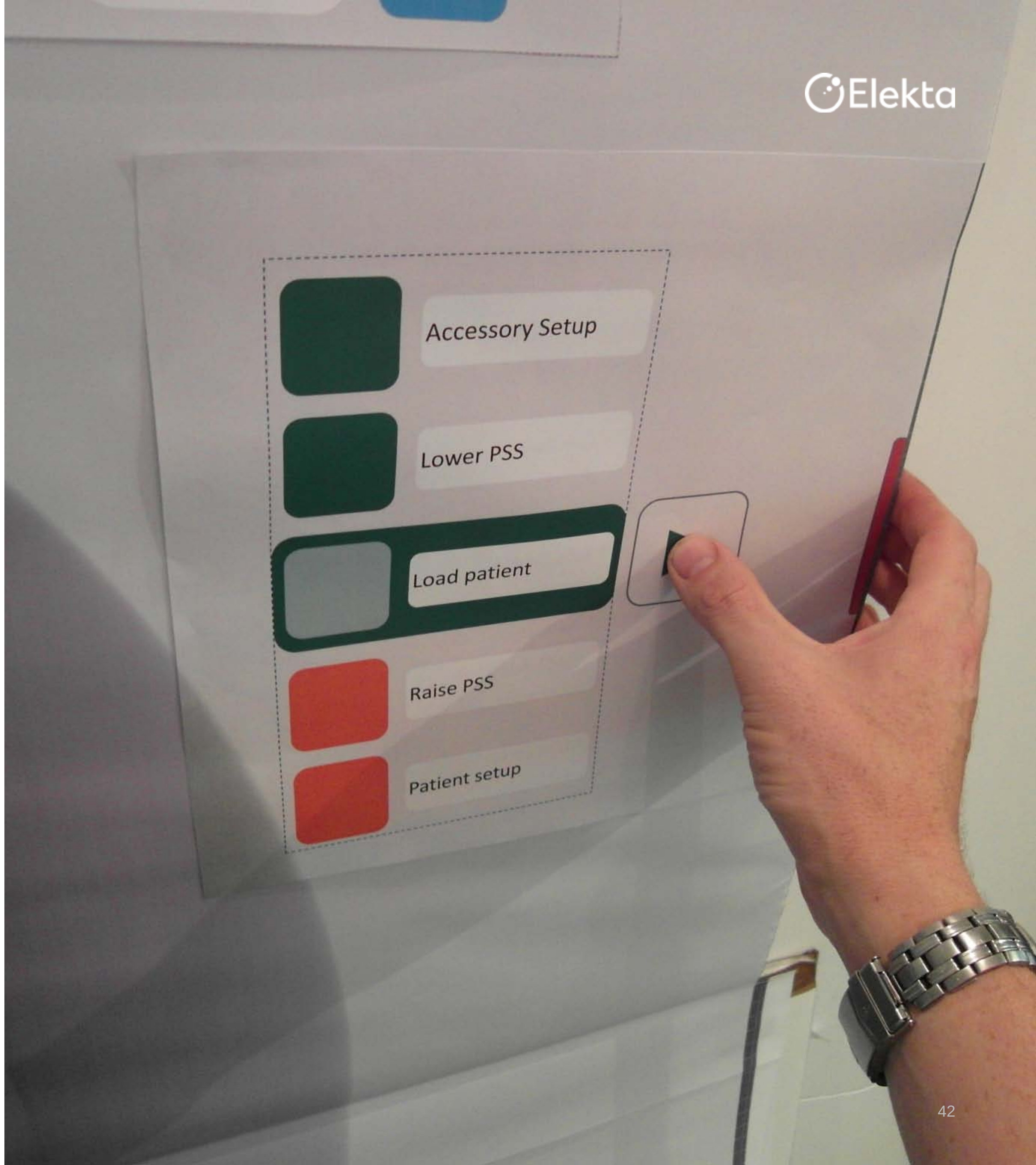




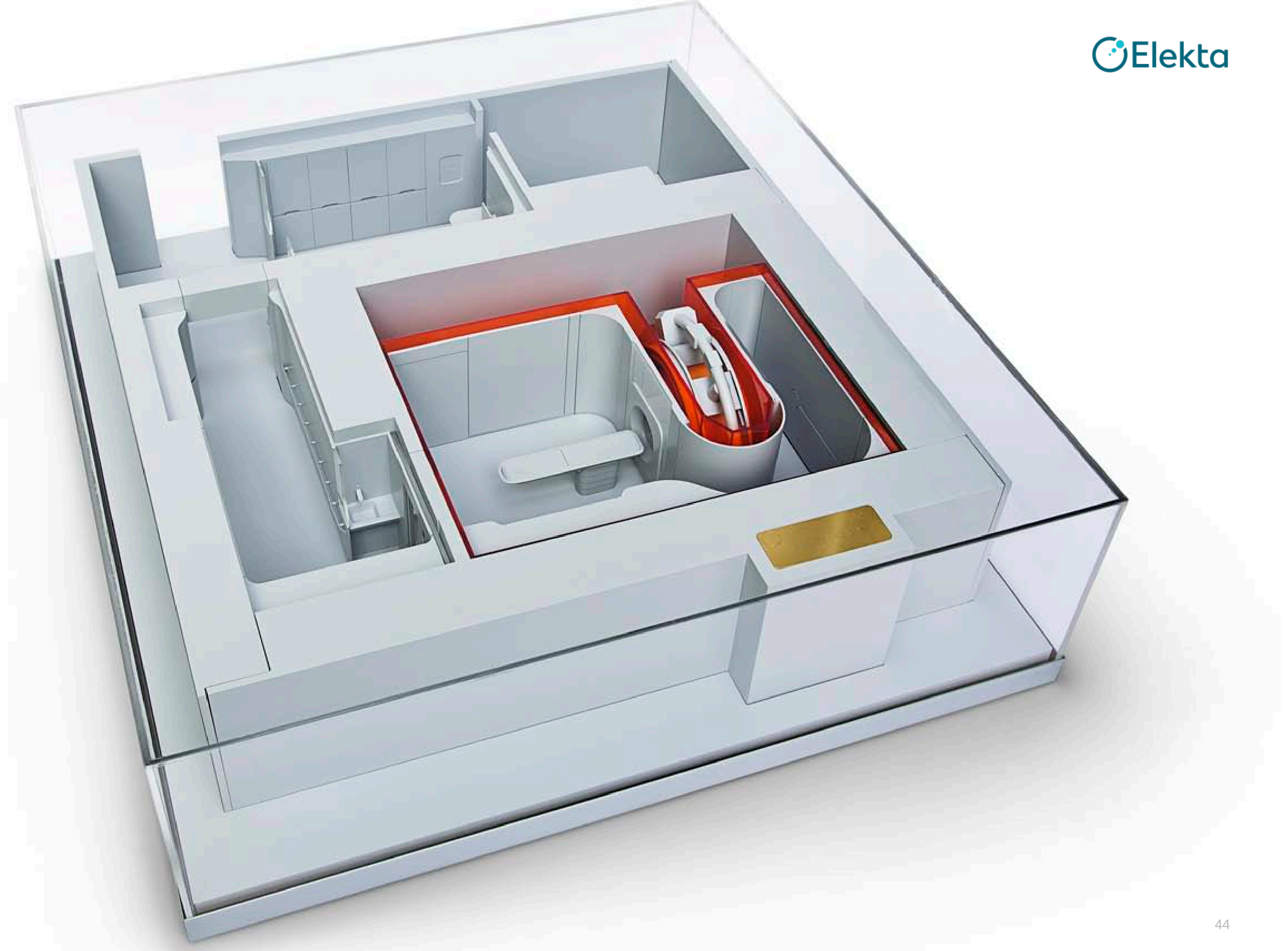
Prototyping

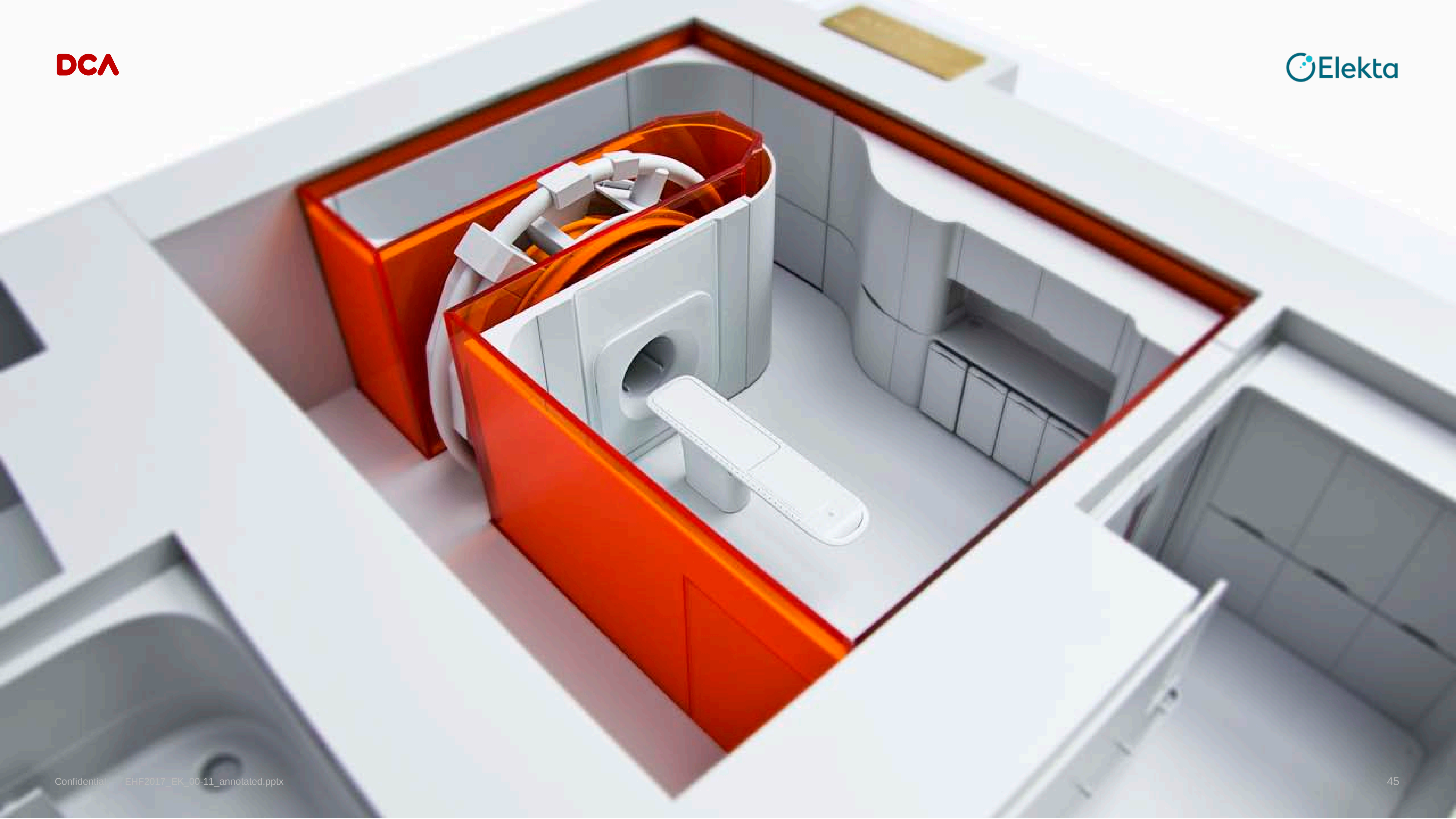
The vision was also supported by physical prototypes looking at patient experience and access to controls.




Accessory Setup
Lower PSS
Load patient
Raise PSS
Patient setup

The room environment was optimised based on radiological protection, control of magnetic fields, access, and patient experience.





The vision

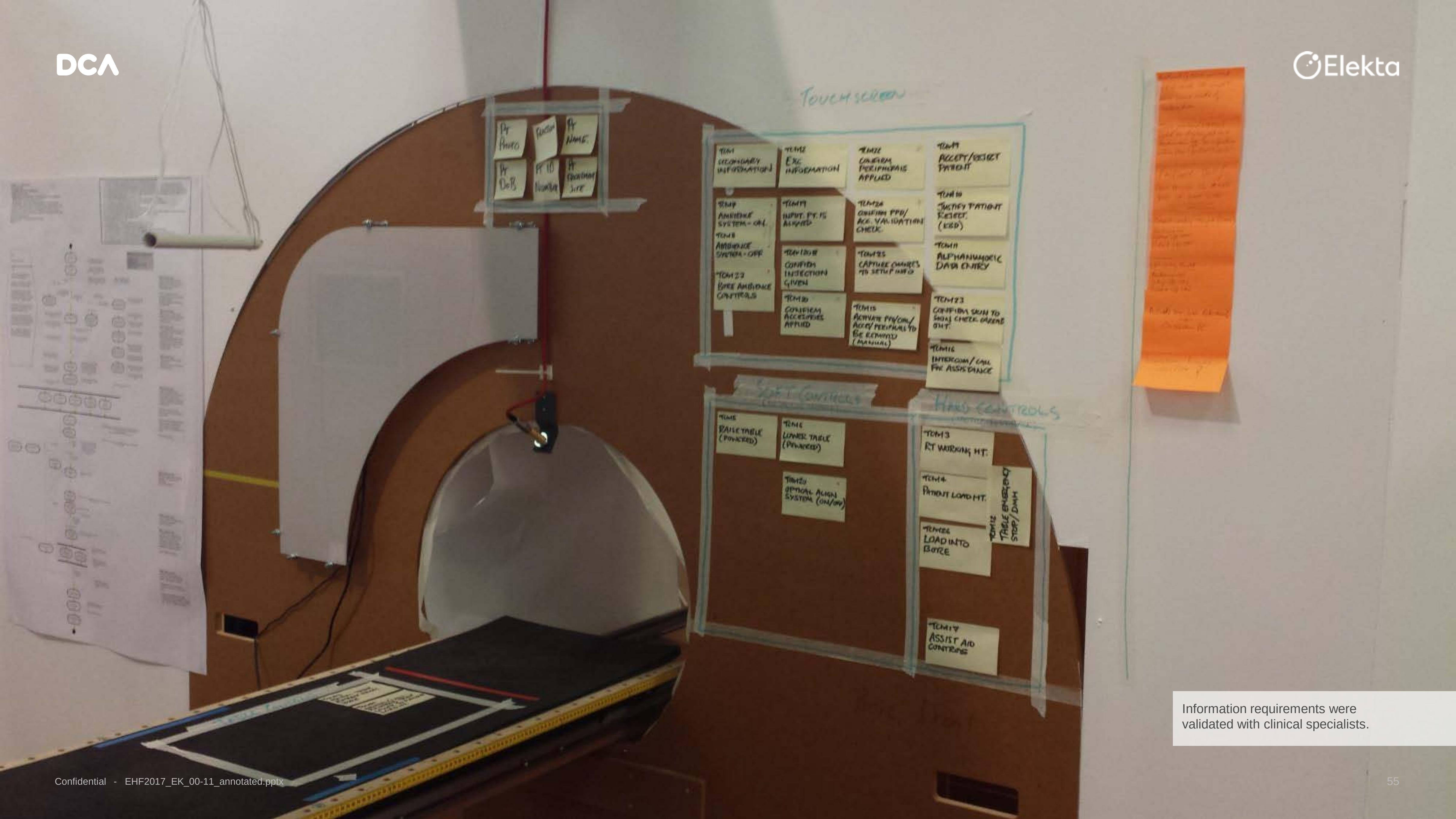

Welcome
Mr Andrew Greenwood
Date of Birth: 07 / 01 / 1963
ID number: EK153756A
Weight: 85kg
Treatment 16 of 36
Continue


DCA
Elekta

From vision to reality

Elekta progressed development of a production product informed and inspired by the vision.

The design was refined in an iterative way. Full size prototypes were build to evaluate the design against known workflows.



Information requirements were validated with clinical specialists.

And tested in simulated use workflows


DCA
Elekta

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Elekta

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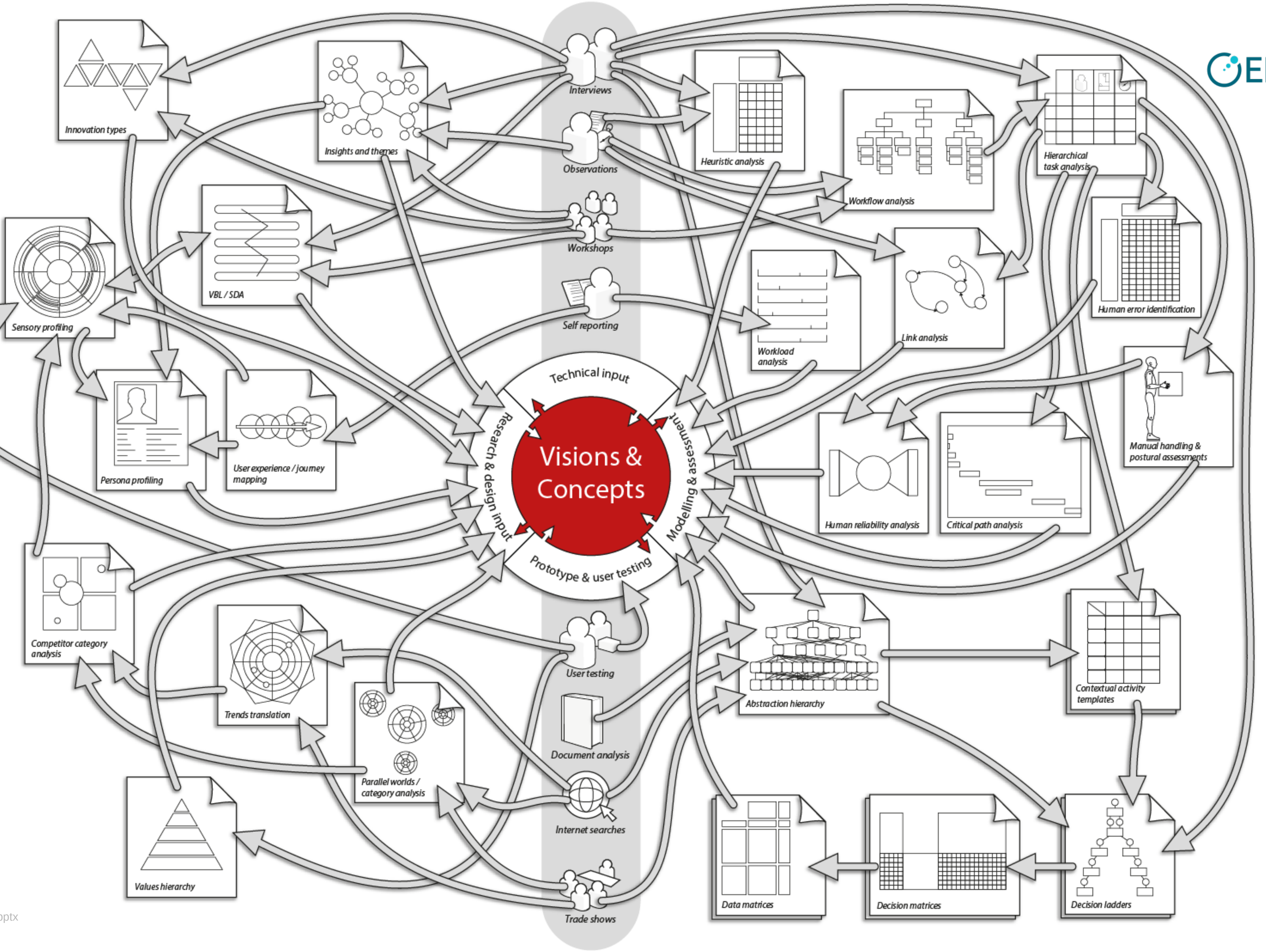
Elekta



Apologies for the brevity and the lack of detail in this presentation, we would have liked to have spent longer discussing each tool we used; however, the aim of the presentation is to highlight that many HF tools can be brought to bear on the same design challenge. We found huge value in comparing the outputs of these methods. Thus, the known weaknesses of more traditional approach could be offset by more conventional ones.

Hopefully, this case study is also an interesting example of design and the application and translation of research into a tangible output.

DCA Elekta