

DCA

 **Elekta**

What is Elekta Unity?



65%

of all cancers occur
in the lungs, prostate,
colorectum, stomach,
liver, breast and cervix



6 out of 7

of these cancers are in difficult to
visualize soft-tissue anatomies



Integrating MR
with surgical precision
RT makes it possible
to see the target
and soft tissue
during treatment

Elekta MR-linac

Consortium collaboration



Unites
>15

pioneering sites around the world to provide evidence based introduction of MR/RT with established protocols.

200
scientists



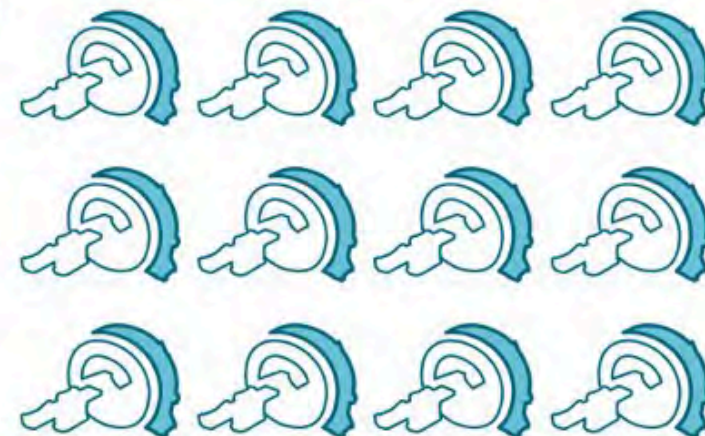
Founded by
7 world-leading
cancer centers



more than **120**
peer-reviewed
scientific papers



12 RESEARCH
DEVICES
OPERATIONAL



**NEXT GENERATION LINAC**

With state-of-the-art, 160-leaf MLC

**1.5T HIGH-FIELD
MR IMAGING**

For crystal clear target visualization

**SLIP RING TECHNOLOGY**

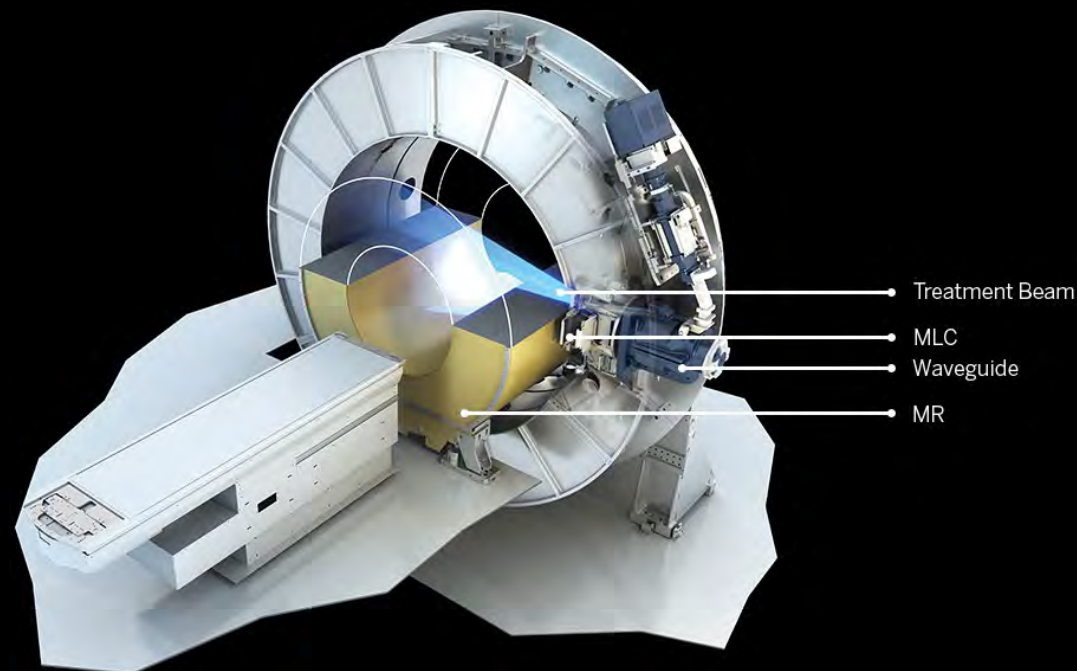
Up to 6x faster gantry rotation for continuous treatment at any angle

**INTELLIGENT SOFTWARE**

Integrated workflow for unprecedented personalization

**SHORT, WIDE BORE MAGNET**

70 cm width bore for patient comfort



Elekta MR-linac is a work in progress and not available for sale.





Health

'More cures, fewer side-effects' with pioneering radiotherapy machine



Fergus Walsh
Medical correspondent
@BBCFergusWalsh

24 September 2018

f w t e Share

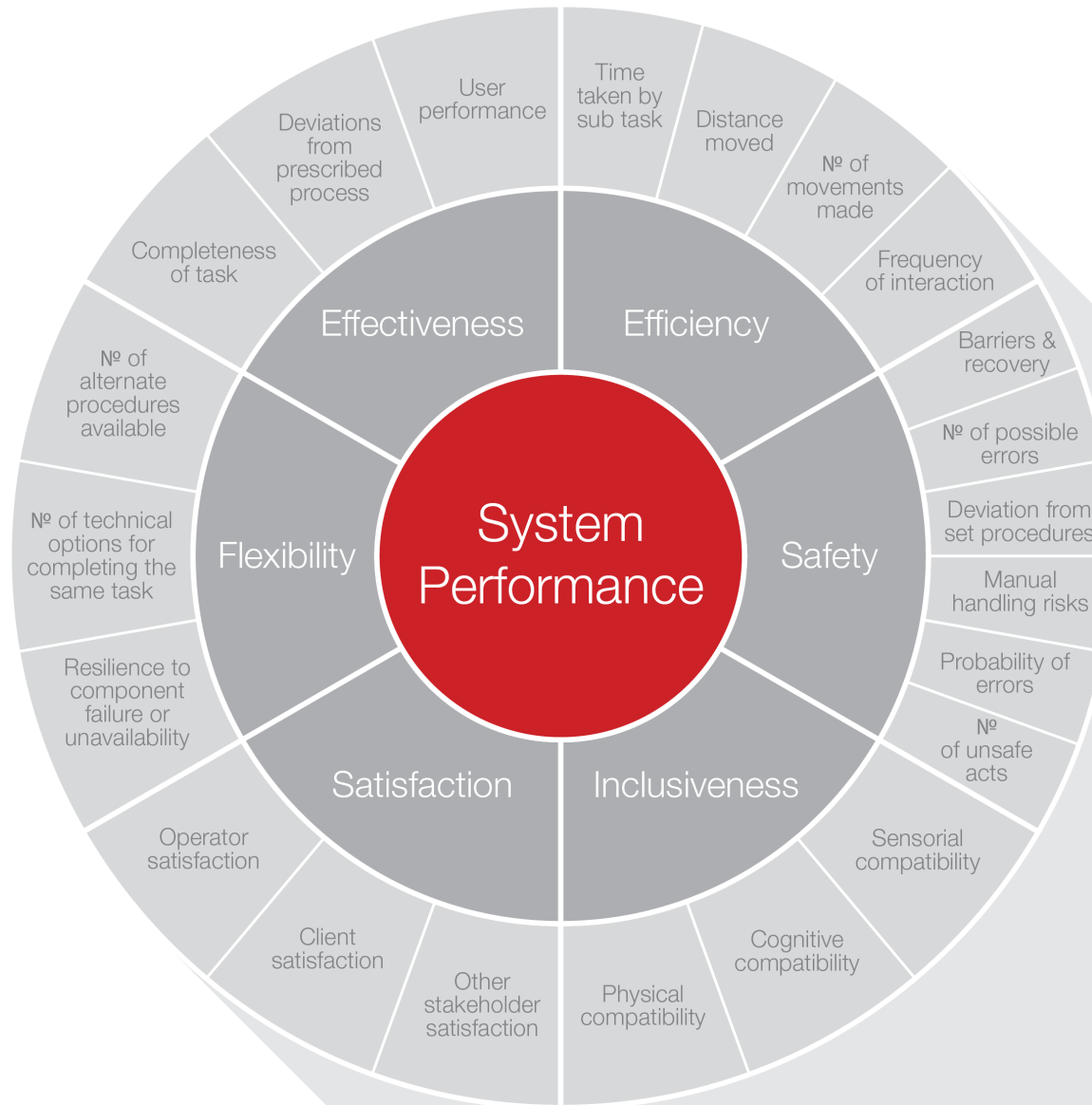


The first patient in the UK has been treated with a pioneering new radiotherapy machine.

The MR Linac simultaneously scans tumours inside the body while delivering X-ray radiation beams.

Creating a vision

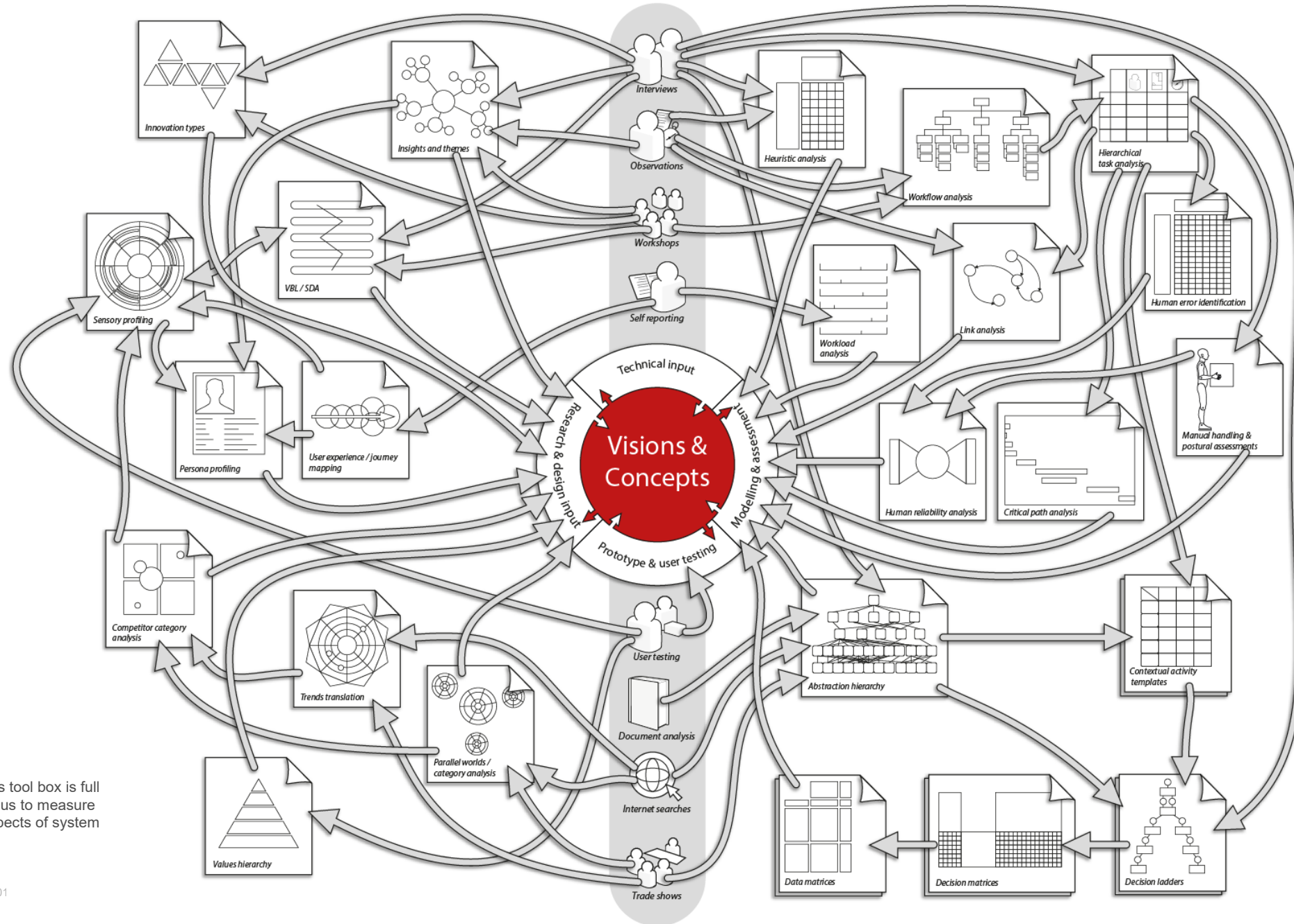
Evidence-based design



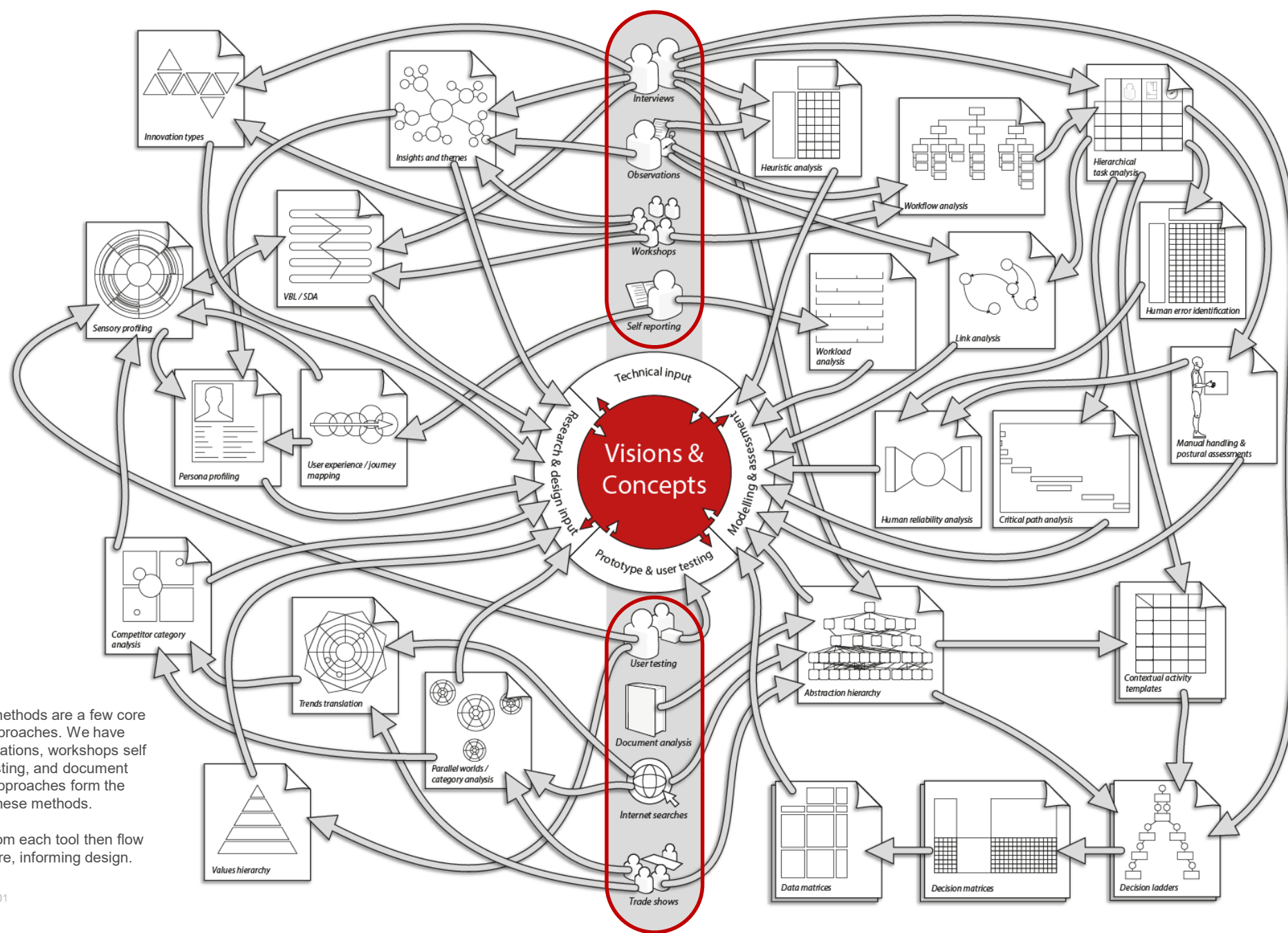
The first stage of the analysis was to define metrics of system performance.

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, safety, inclusiveness, satisfaction, flexibility and effectiveness.



The human factors tool box is full of tools that allow us to measure these different aspects of system performance.



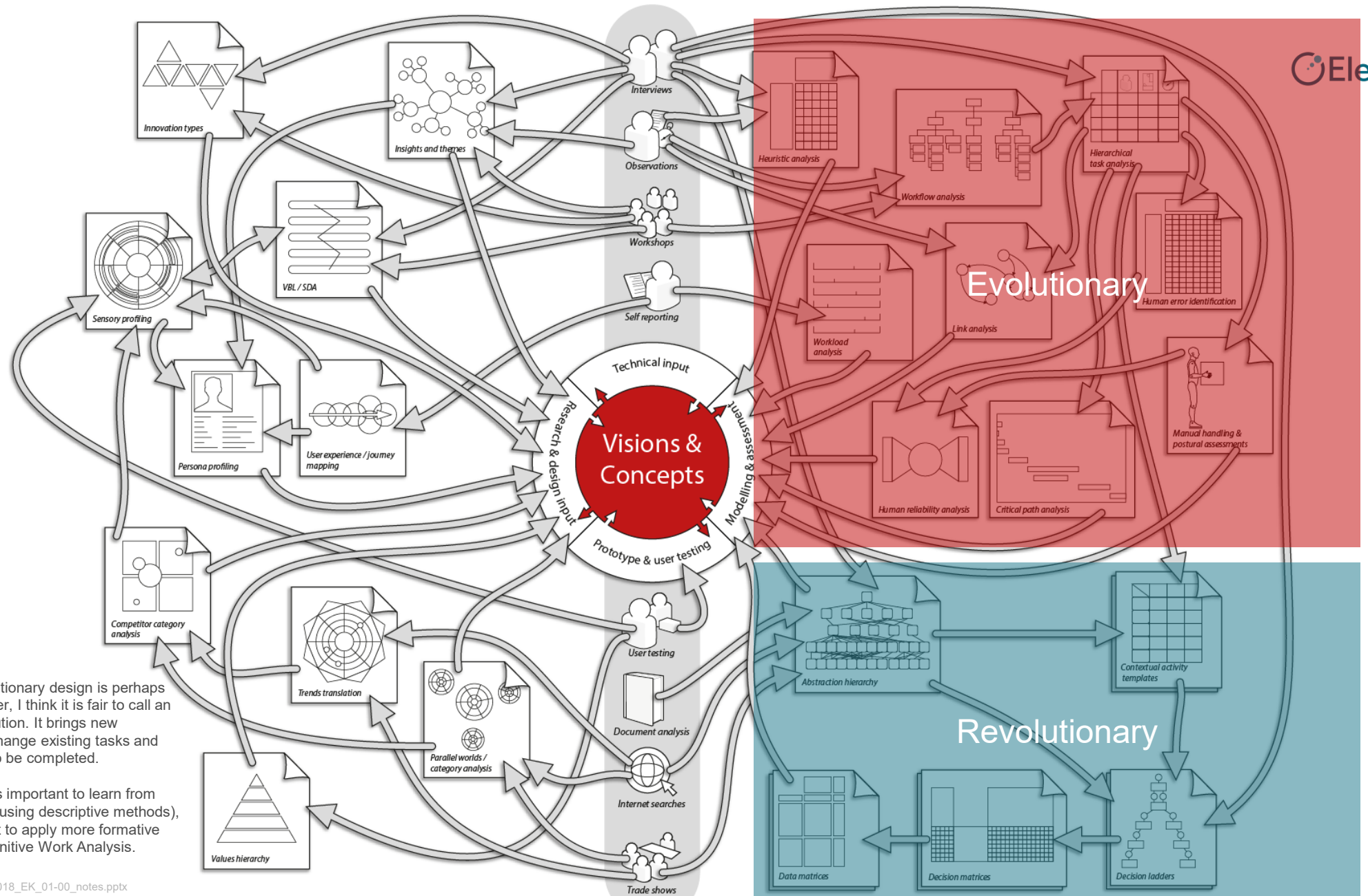
Central to these methods are a few core data collection approaches. We have interviews, observations, workshops self reporting, user testing, and document analysis. These approaches form the back-bone of all these methods.

Insights gained from each tool then flow back into the centre, informing design.

Thus, the goal is to develop designs that are:

*Inspired by
Informed by
Evaluated against*

An evidence base from Human Factors methods



The phrase revolutionary design is perhaps overused. However, I think it is fair to call an MR-Linac a revolution. It brings new capabilities that change existing tasks and allow new tasks to be completed.

As such, while it is important to learn from existing systems (using descriptive methods), it is also important to apply more formative tools such as Cognitive Work Analysis.

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 treatment 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.

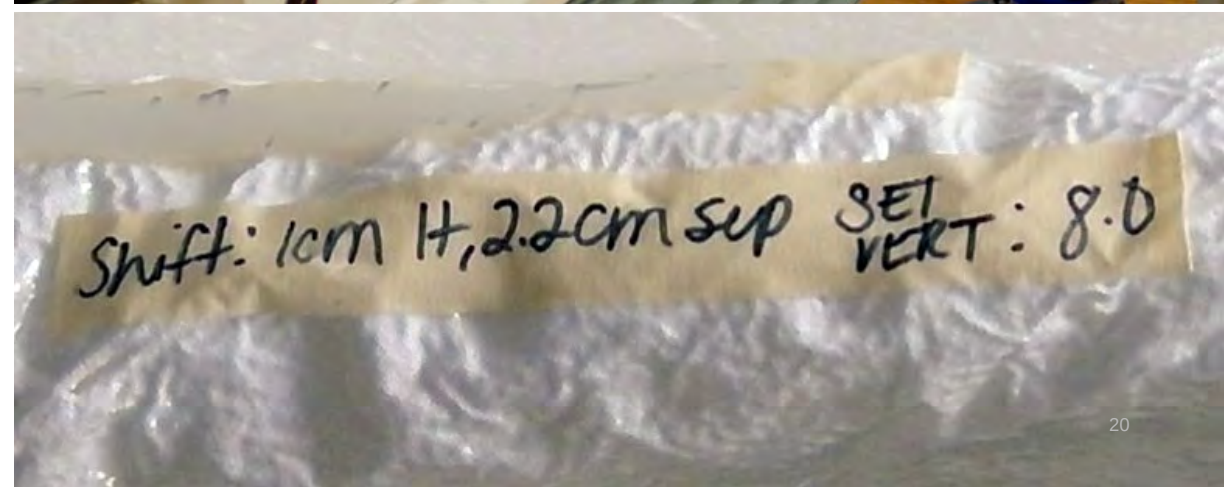
Latent needs

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

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
devices, help patient

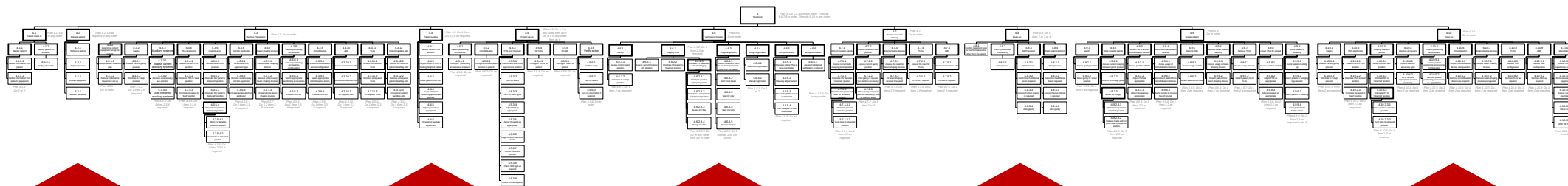
4.9

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

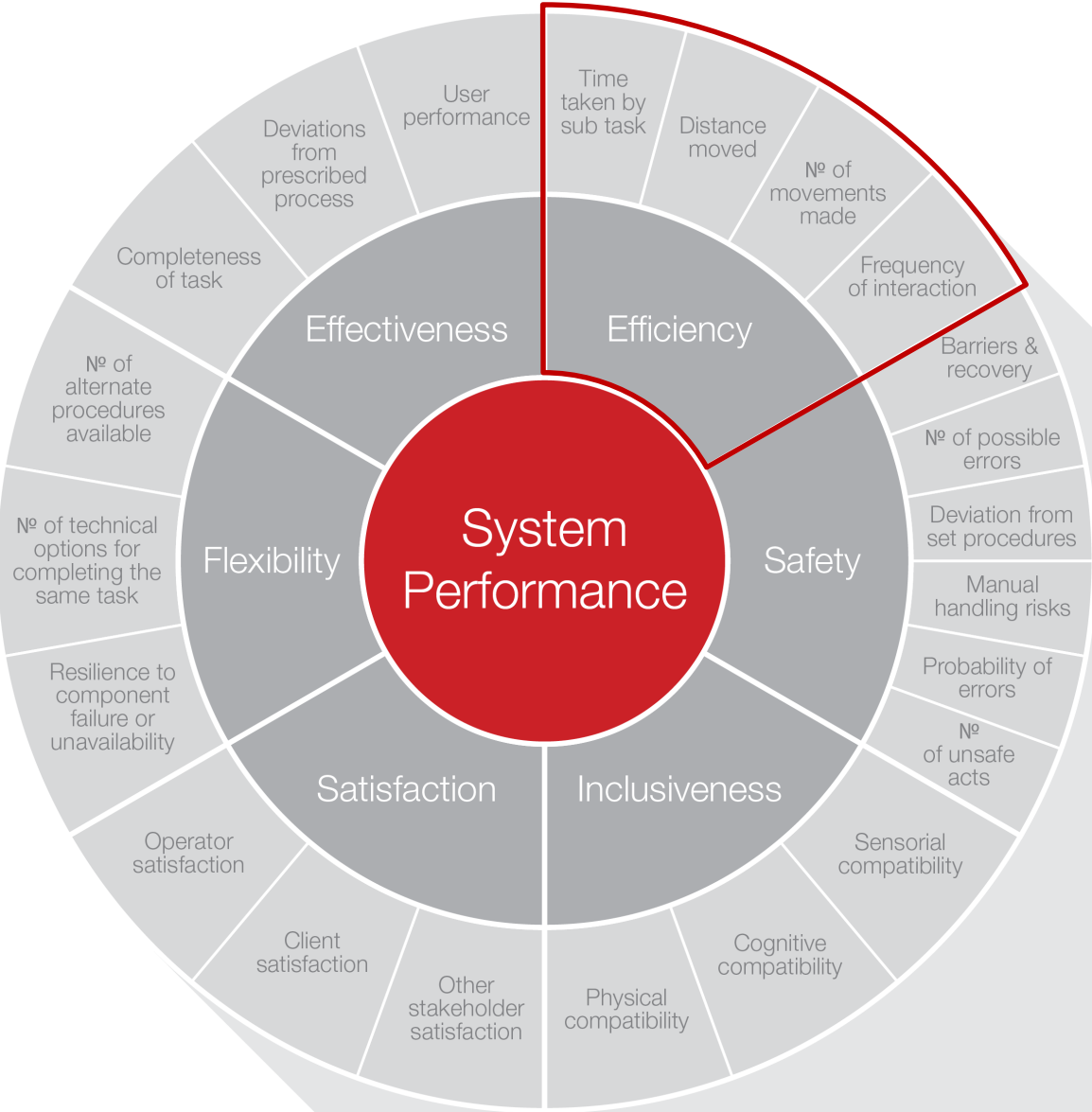
Beam on

Treat patient

4.10

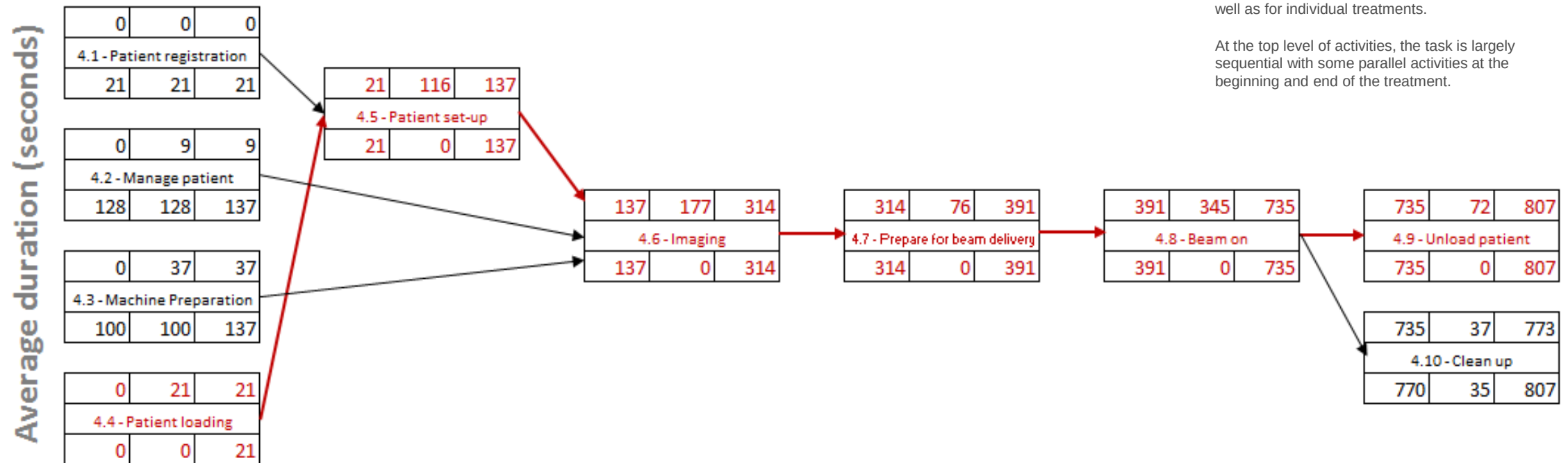
Clean up

Wipe down machine,
reset ready for next
patient



Critical path analysis (PERT charts)

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



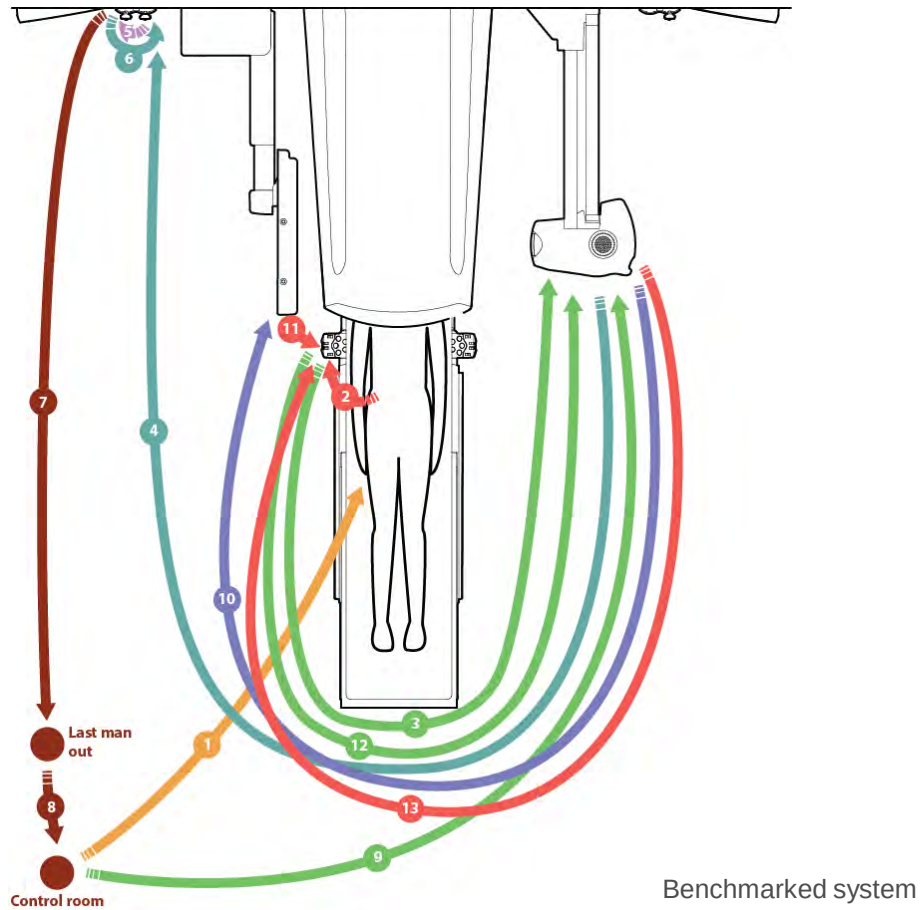
Data from the HTA could be explored in PERT (Program Evaluation Review Technique) charts to identify the critical path.

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

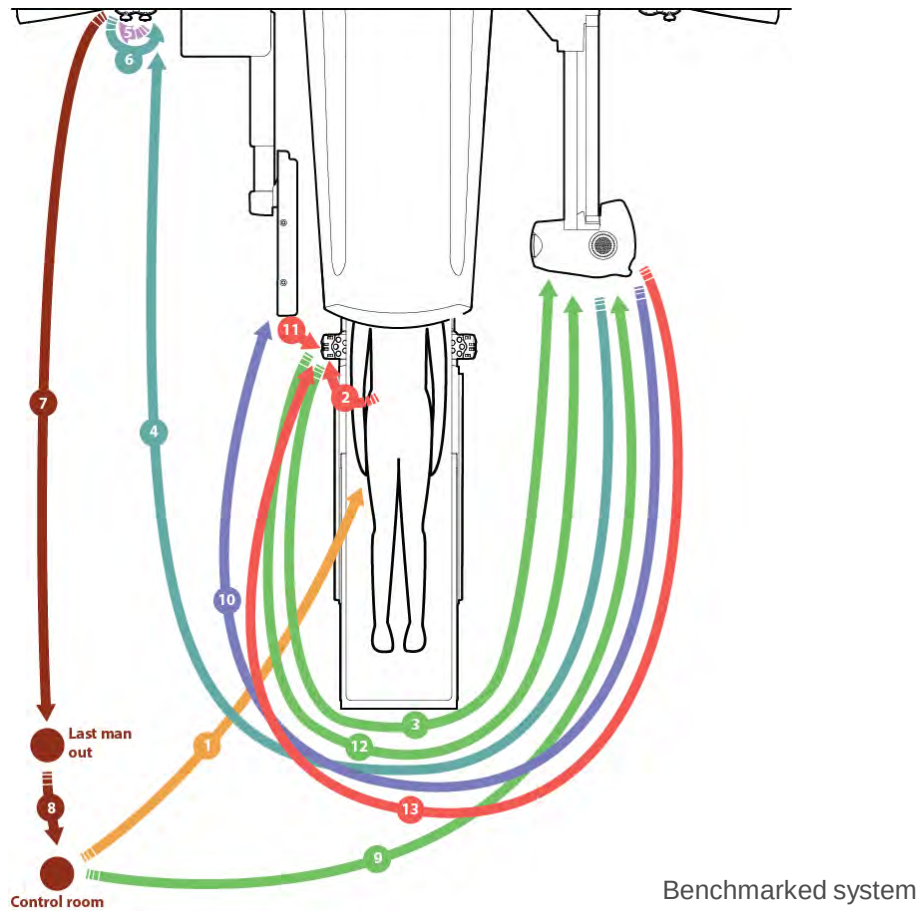


Likewise, we expanded on the HTA using Link analysis diagrams.

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

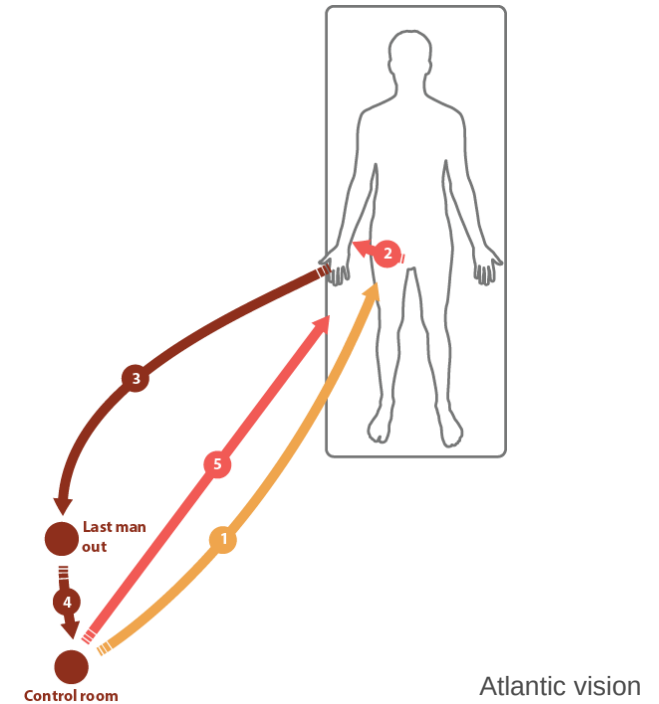
Each of the numbered arrows indicated a movement made by the radiotherapist. A total of 13 moves are required in a typical treatment. Much of this stems from a requirement to manually interact with elements of the machine (e.g. deploy and retract imaging panels), or move to control locations.

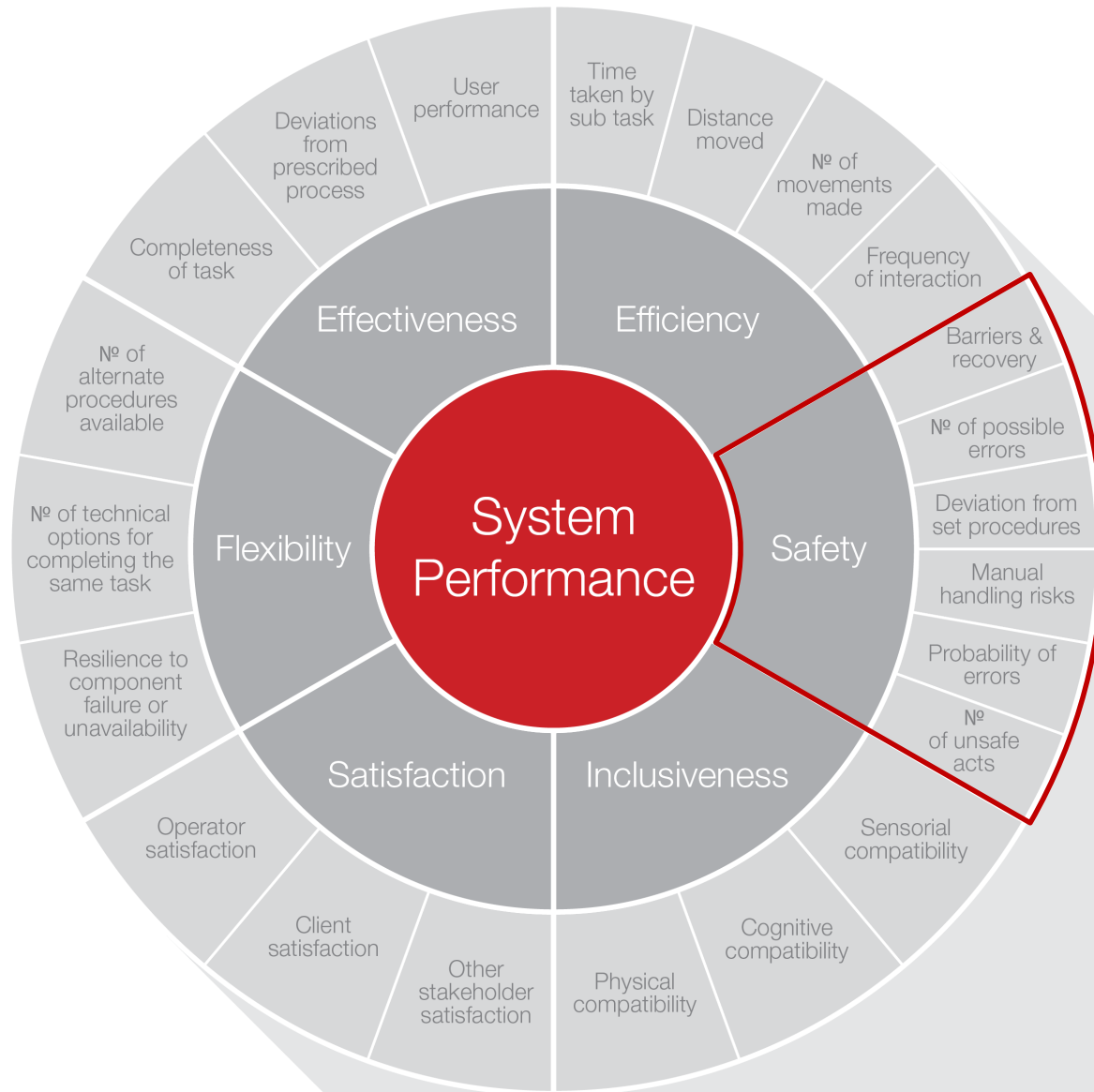
Link analysis

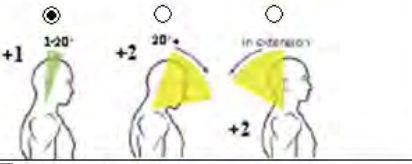
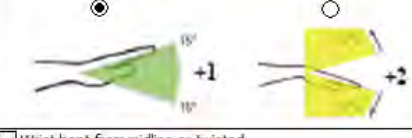


The diagram on the right shows how this has been simplified for the Atlantic vision, for the same task we were able to reduce the number of movements from 13 to 5.

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





1: Neck Position  ☐ Neck twisted ☒ Neck side bending	6: Upper Arm Position  ☒ Shoulder is raised ☐ Upper arm is abducted ☐ Arm is supported or leaning																		
2: Locate Trunk Position  ☐ Trunk twisted ☒ Trunk side bending (combined maximum of +1)	Step 7: Lower Arm Position 																		
3: Legs Bilateral: +1 (0-20°), +2 (20-45°), +3 (45-60°), +4 (60-75°) Unilateral: +1 (0-20°), +2 (20-45°), +3 (45-60°), +4 (60-75°) ☐ Trunk twisted ☒ Trunk side bending (combined maximum of +1)	Step 8: Wrist Position  ☐ Wrist bent from midline or twisted																		
4: Add Force/Load Score ☒ If Load < 5kgs: +1 ☐ If Load is 5 to 10kgs: +0 ☐ If load > 10kg: +1 ☐ Rapid shock or build up of force	Step 9: Activity Score ☐ 1 or more body parts are held longer than a minute (static) ☒ Repeated small range actions (more than 4x per minute) ☐ Action causes rapid large change in posture																		
5: Add Coupling Score ☒ Good: Well fitted handles and mid range power grip ☐ Fair: Acceptable but not ideal hold or coupling acceptable with another body part ☐ Poor: Hand hold not acceptable but possible ☐ Unacceptable: No handles, awkward, unsafe	<table border="1"> <thead> <tr> <th>Score</th> <th>Risk Level</th> <th>Action</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>Negligible</td> <td>None necessary</td> </tr> <tr> <td>2-3</td> <td>Low</td> <td>May be necessary</td> </tr> <tr> <td>4-7</td> <td>Medium</td> <td>Necessary</td> </tr> <tr> <td>8-10</td> <td>High</td> <td>Necessary soon</td> </tr> <tr> <td>11-15</td> <td>Very High</td> <td>Necessary now</td> </tr> </tbody> </table>	Score	Risk Level	Action	1	Negligible	None necessary	2-3	Low	May be necessary	4-7	Medium	Necessary	8-10	High	Necessary soon	11-15	Very High	Necessary now
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Manual handling assessments were also conducted across the treatment activity.

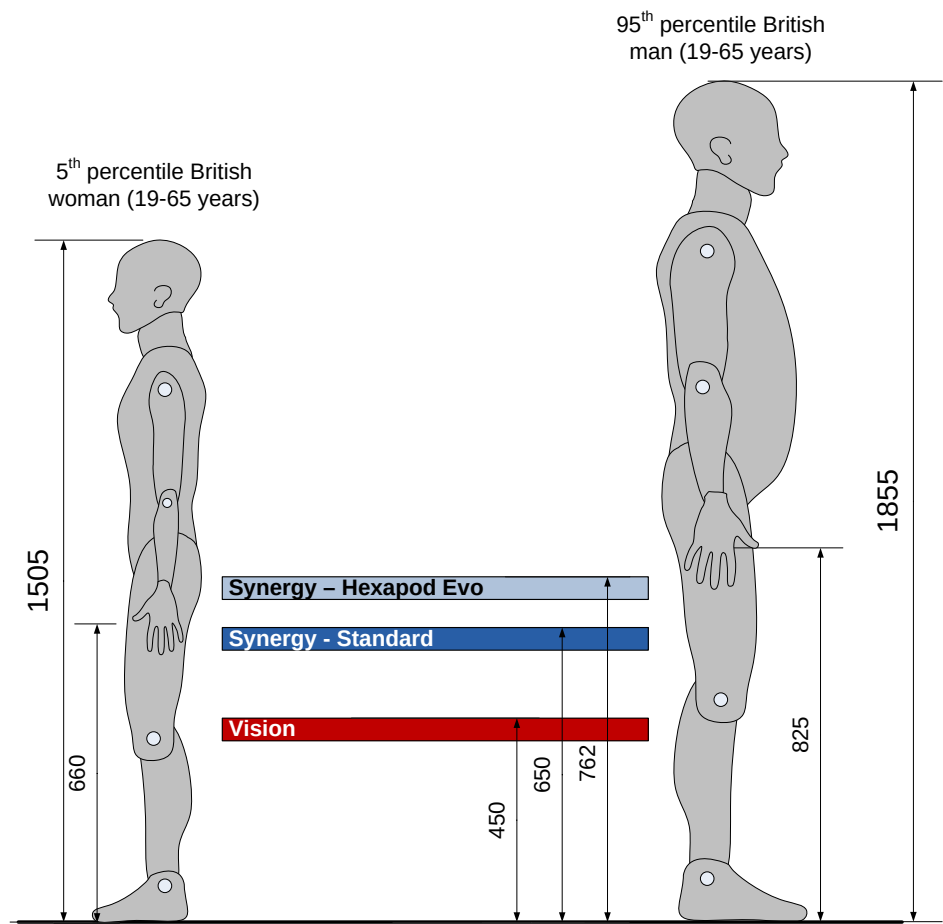
Each task step in the HTA was coded to indicate if manual handling was involved. These tasks were then filtered (using the HSE filter). REBA (Hignett, 2000) was used to assess those of higher risk.

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.

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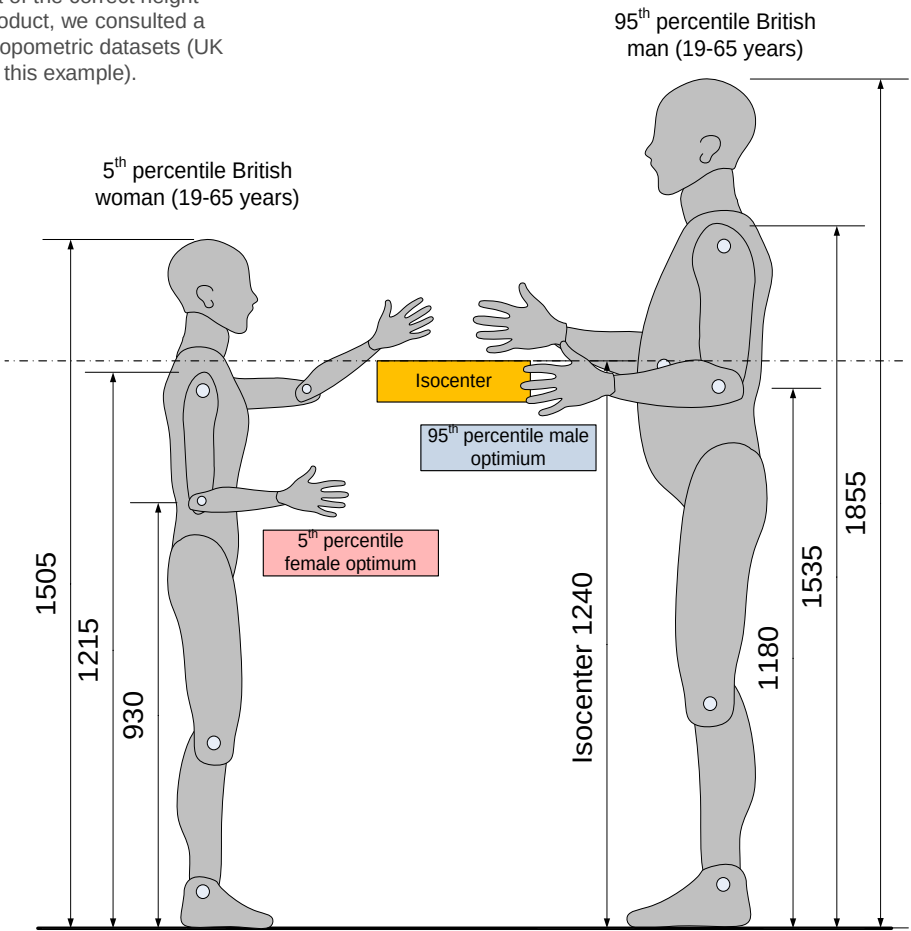
By reducing the height of the table for setup, the risk to the operators can be greatly reduced – as shown on the example on the right

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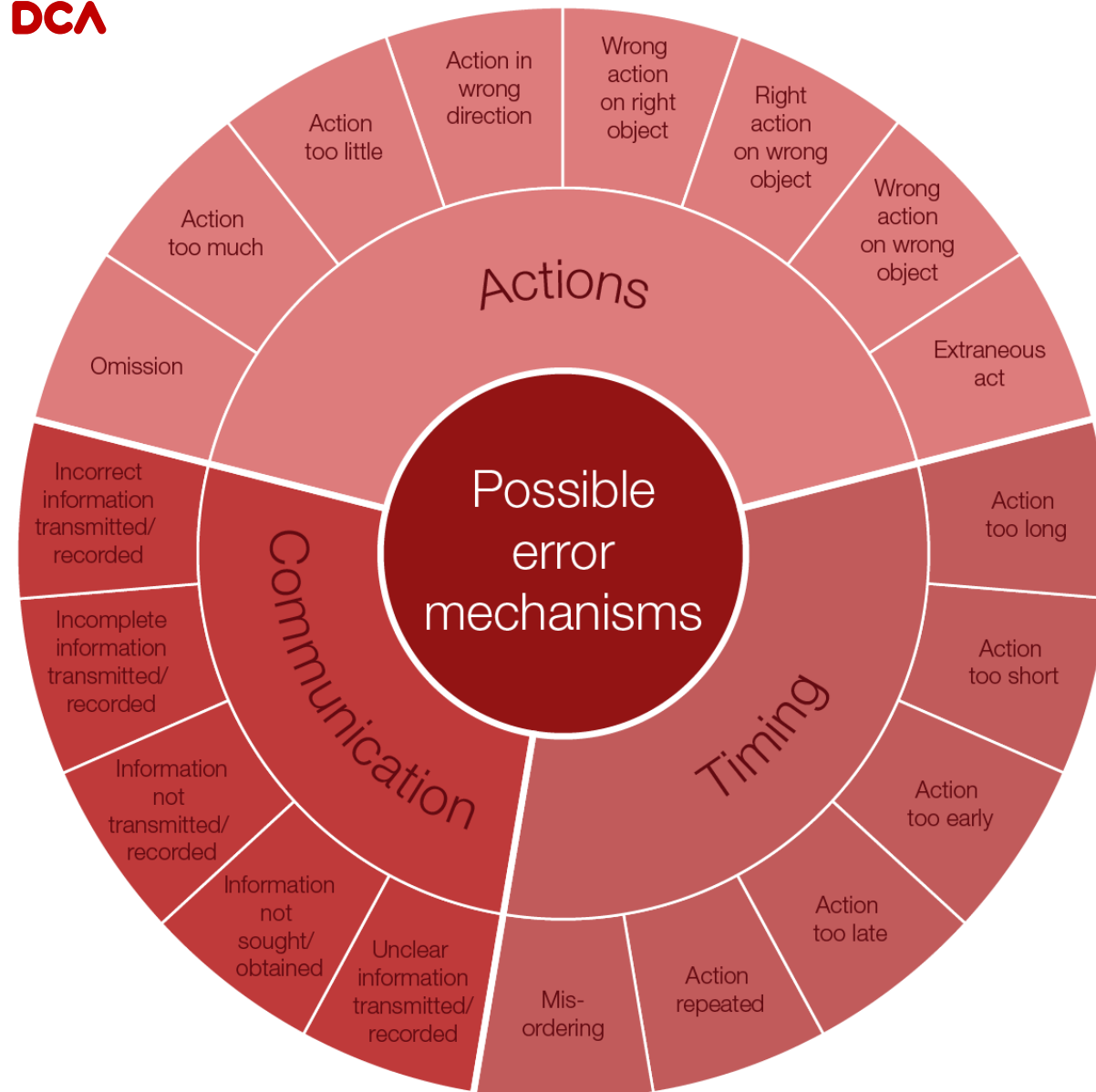


All dimensions in mm, based upon Pheasant & Haslegrave (2006) Table 10.1, without shoes

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).



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

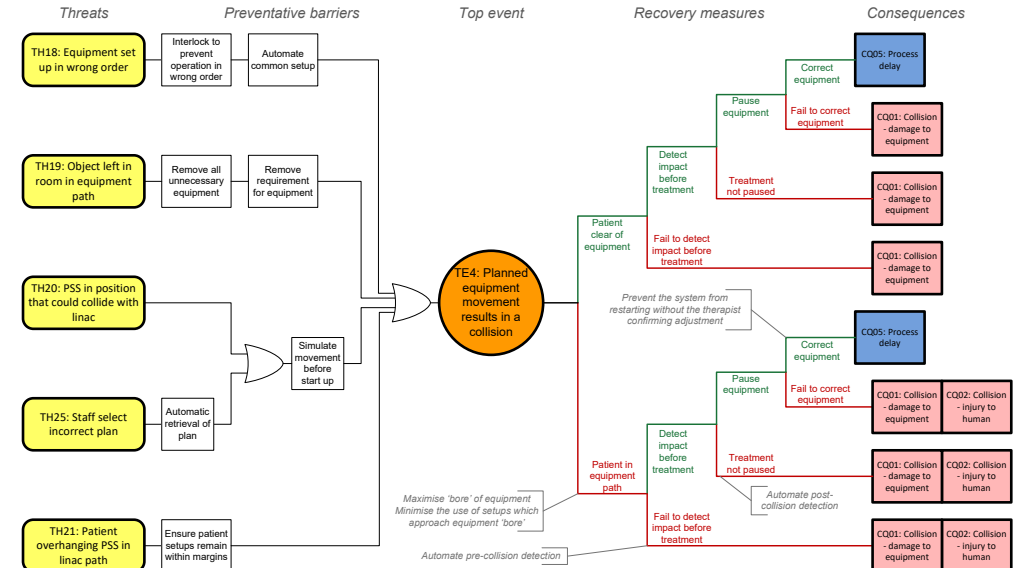


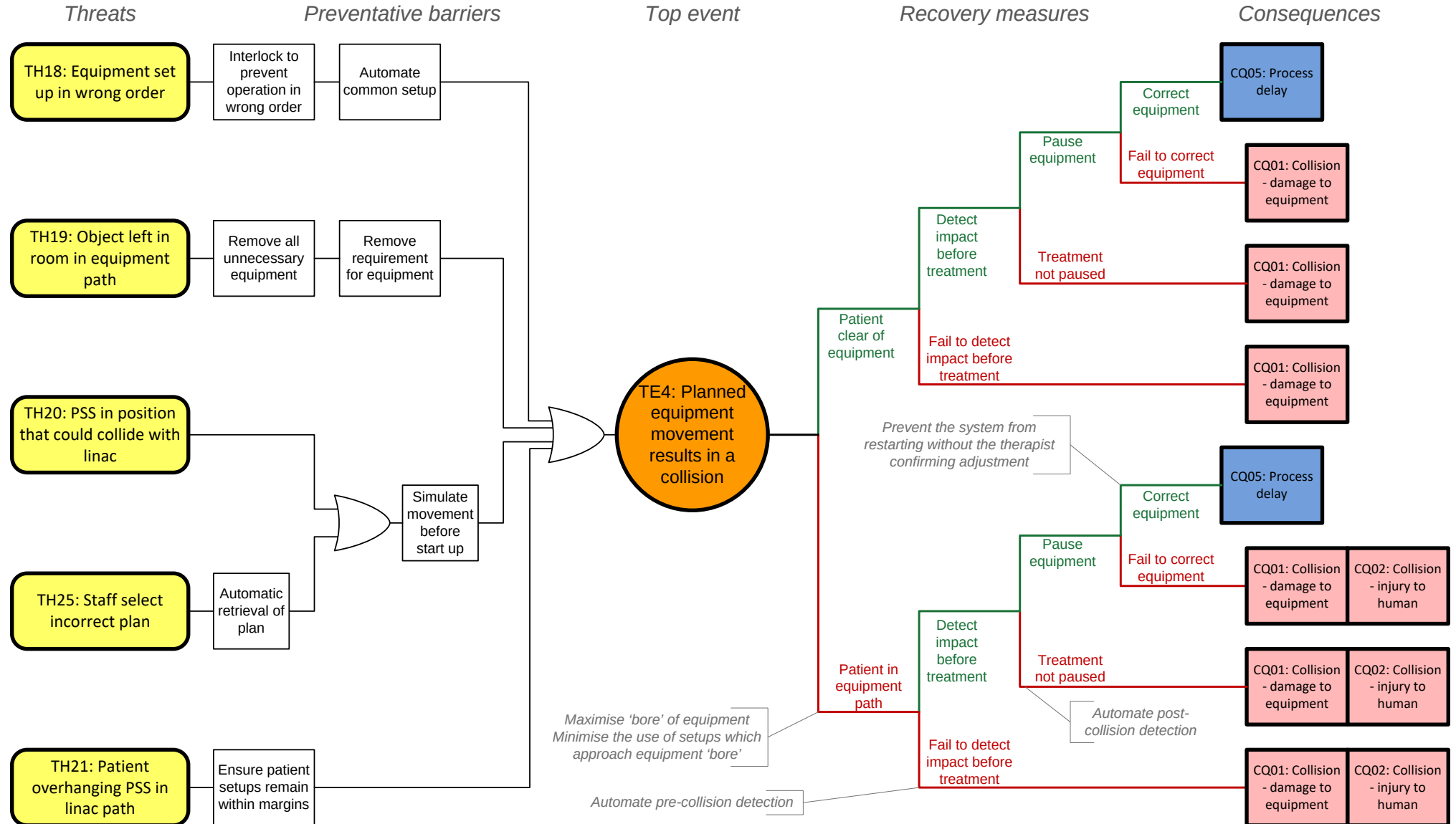
To understand error, we used a structured process for human error identification based on TRACER (Shorrock & Kirwan, 1999, 2002).

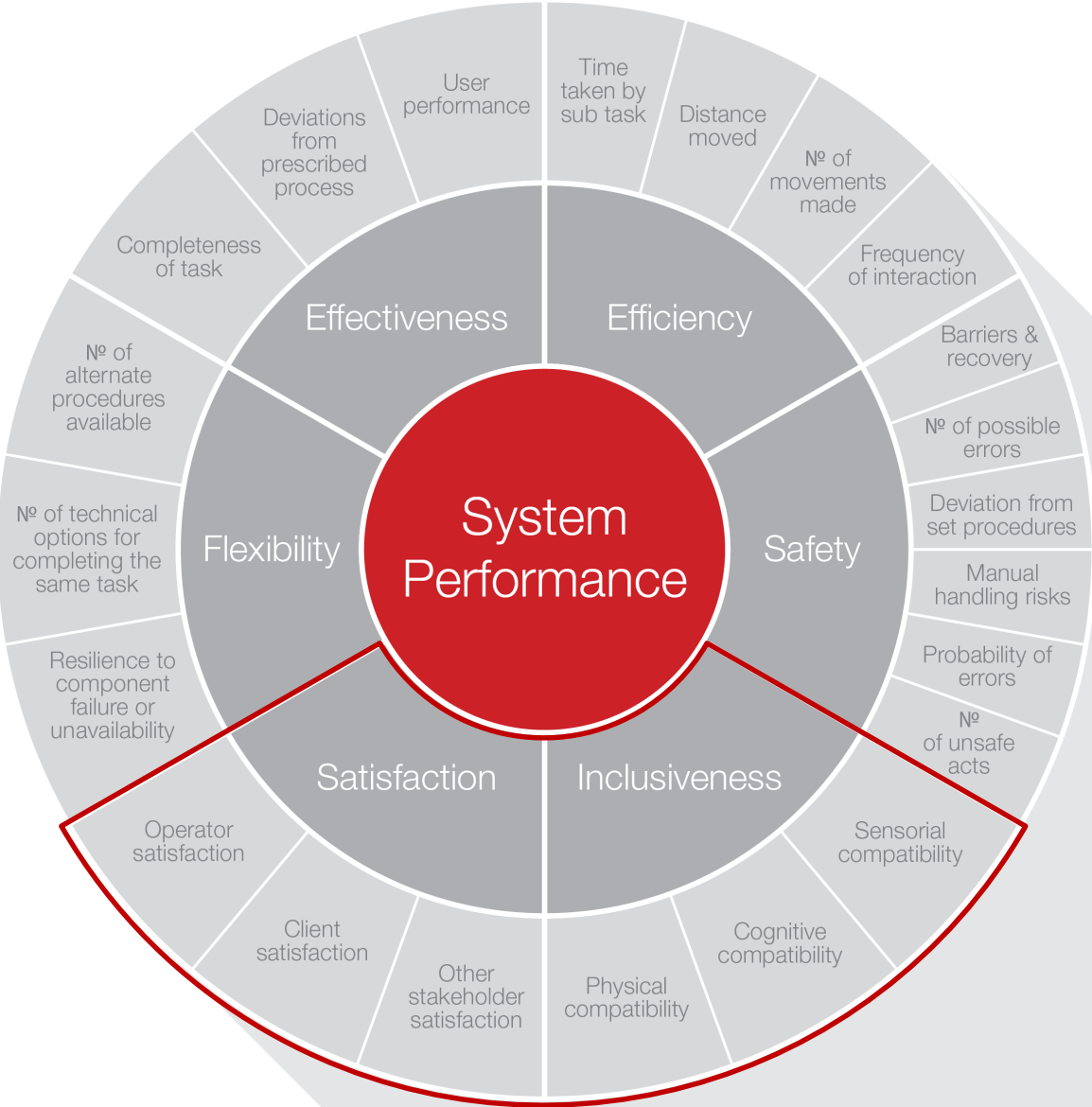
Each task step was considered against the keywords around the wheel.

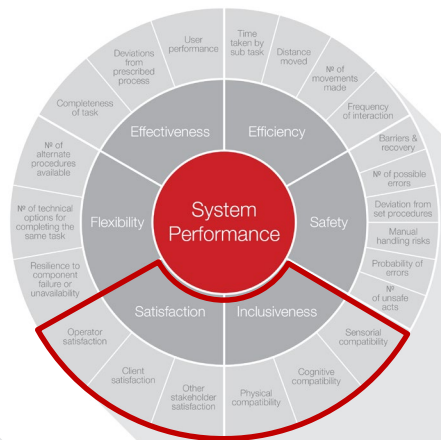
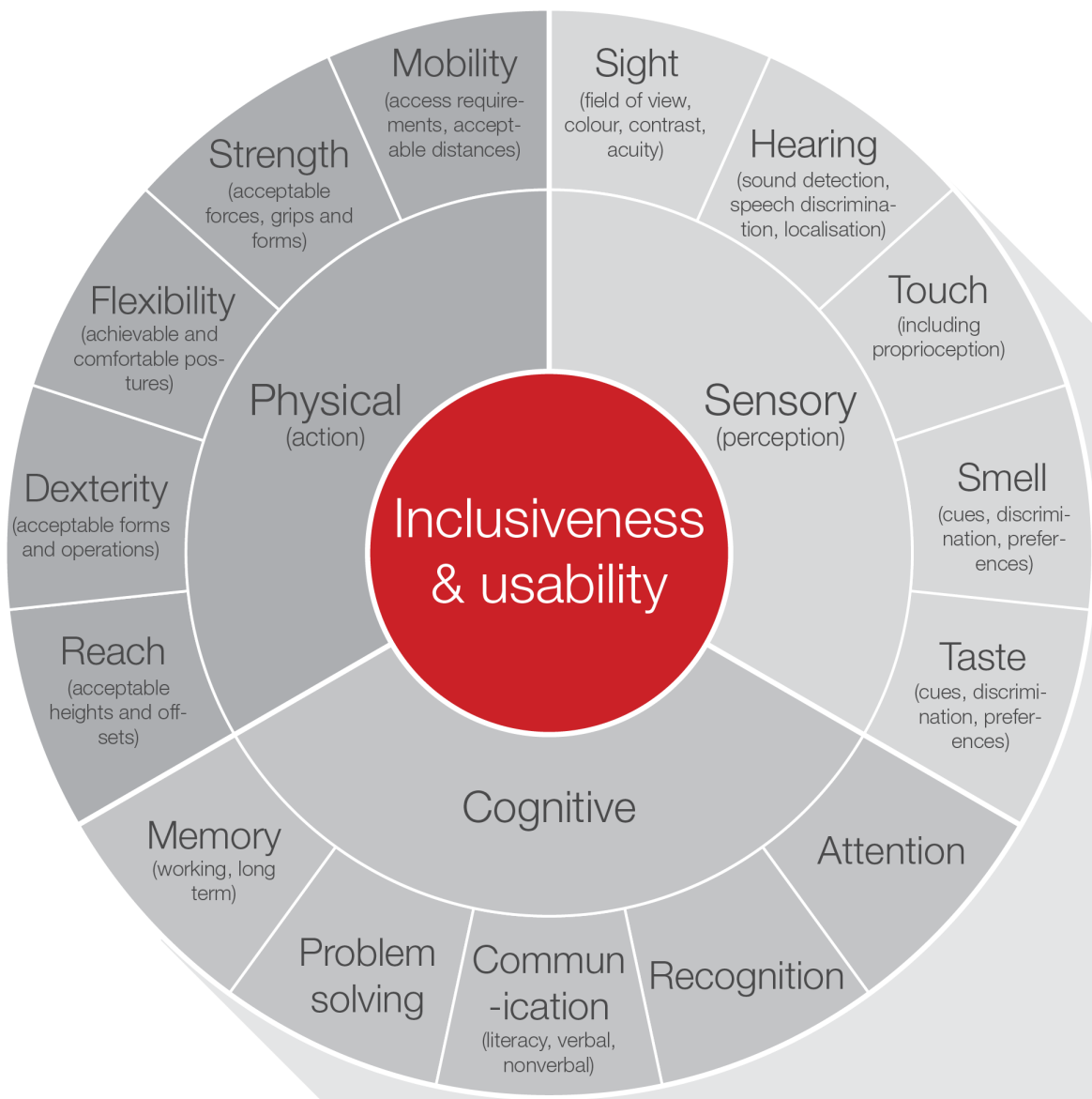
Errors were then summarised in bowtie diagrams. These were used to create preventative barriers and recovery measures.

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





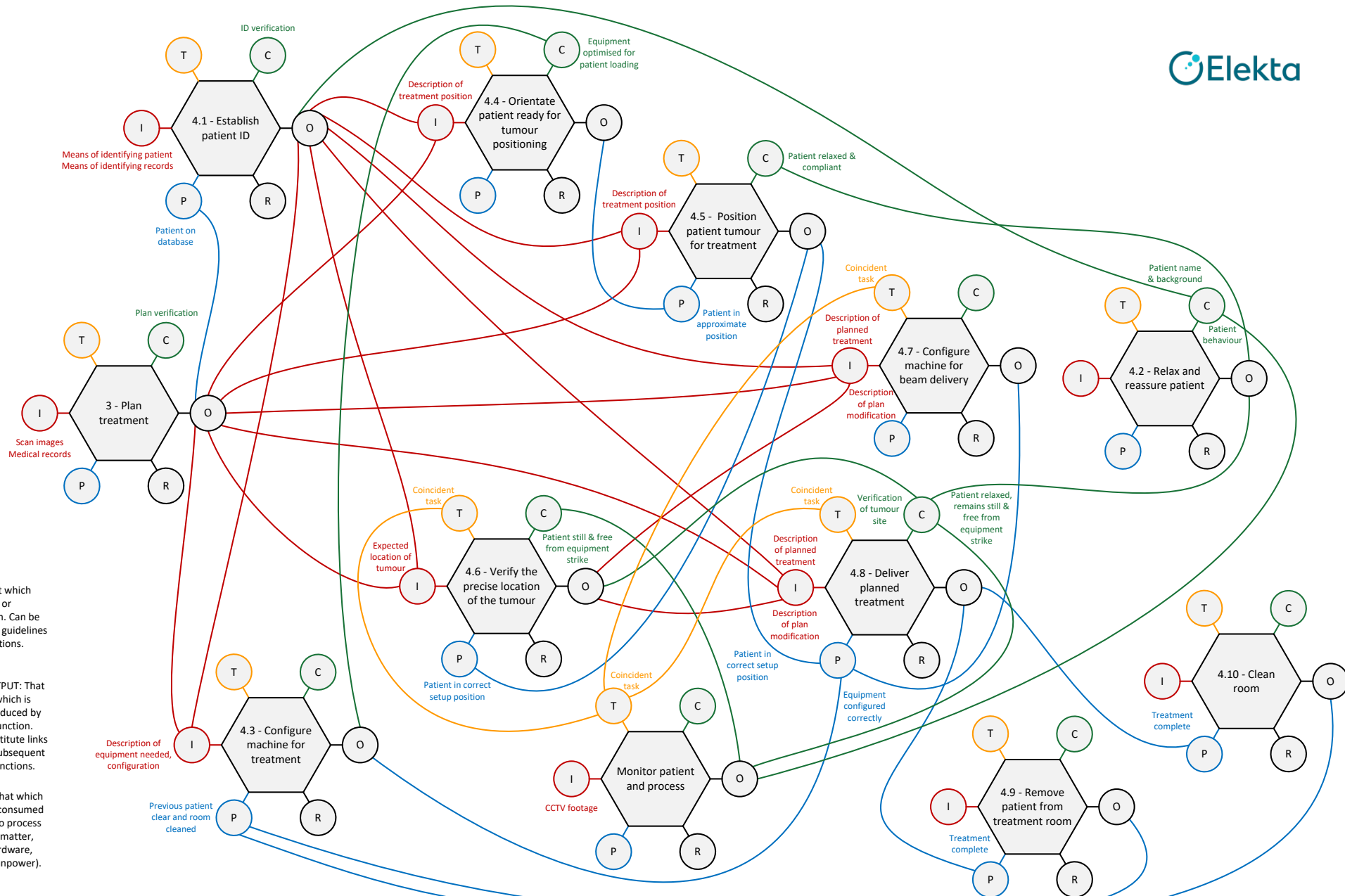






FRAM

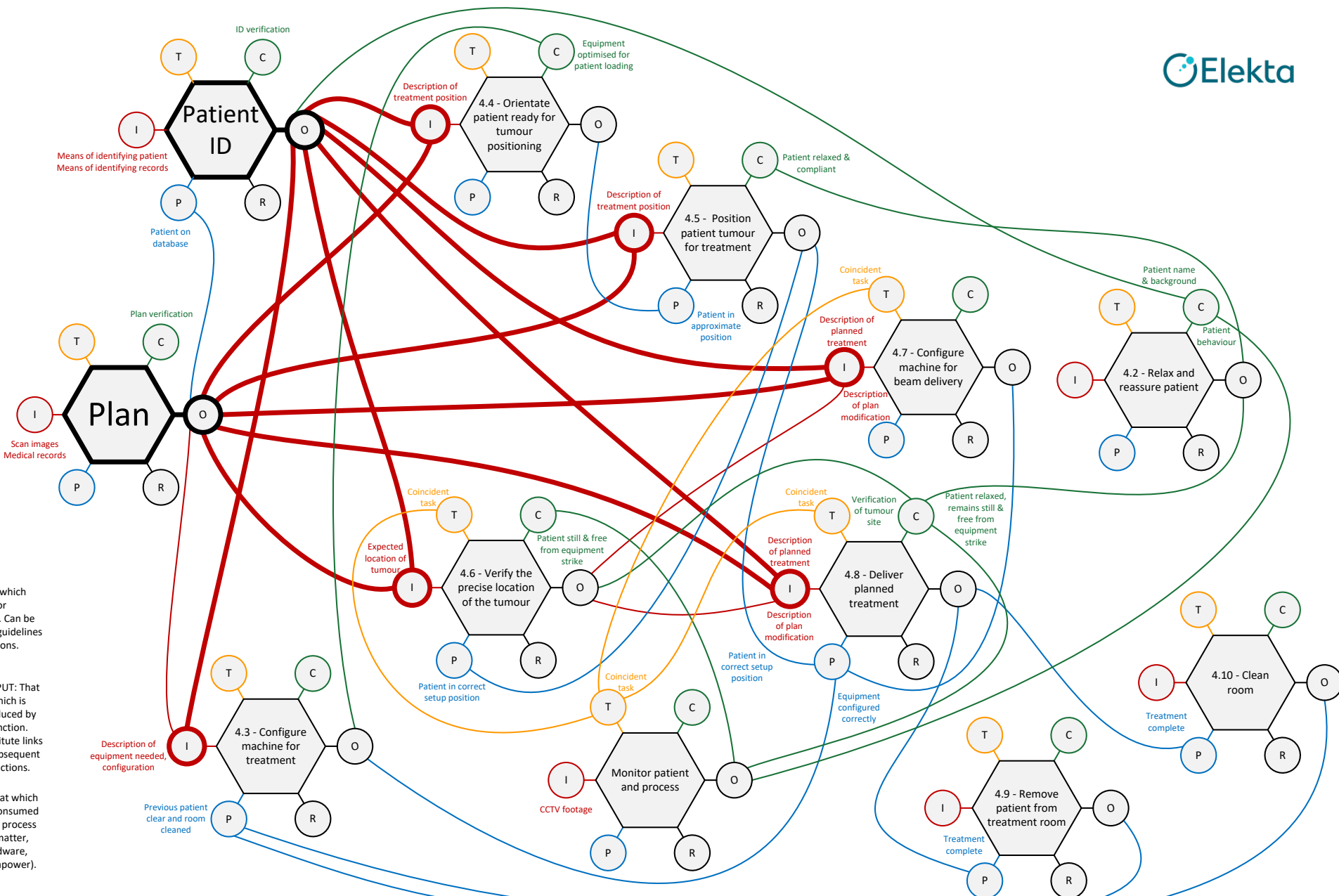
The diagram shows the interrelationships between treatment phases as identified in the HTA



FRAM

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

Verification is key



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**

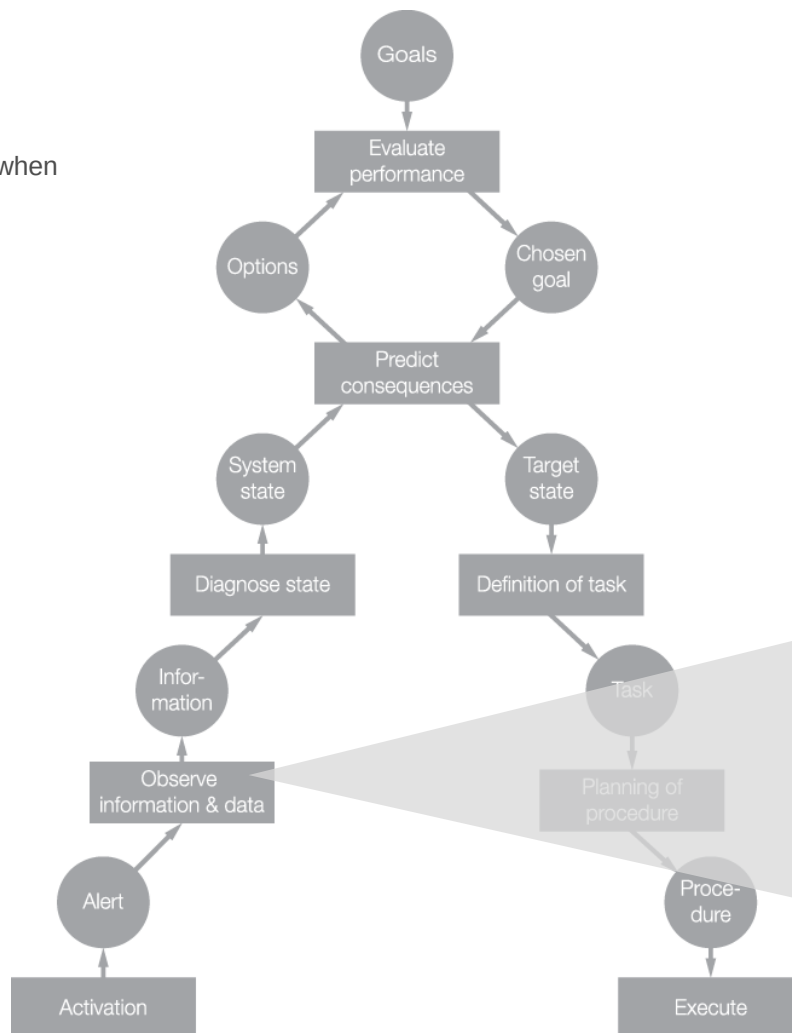
it should be
displayed to?

5.**How**

in what
format?

Decision ladders

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



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.

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?

Design

Treatment room information

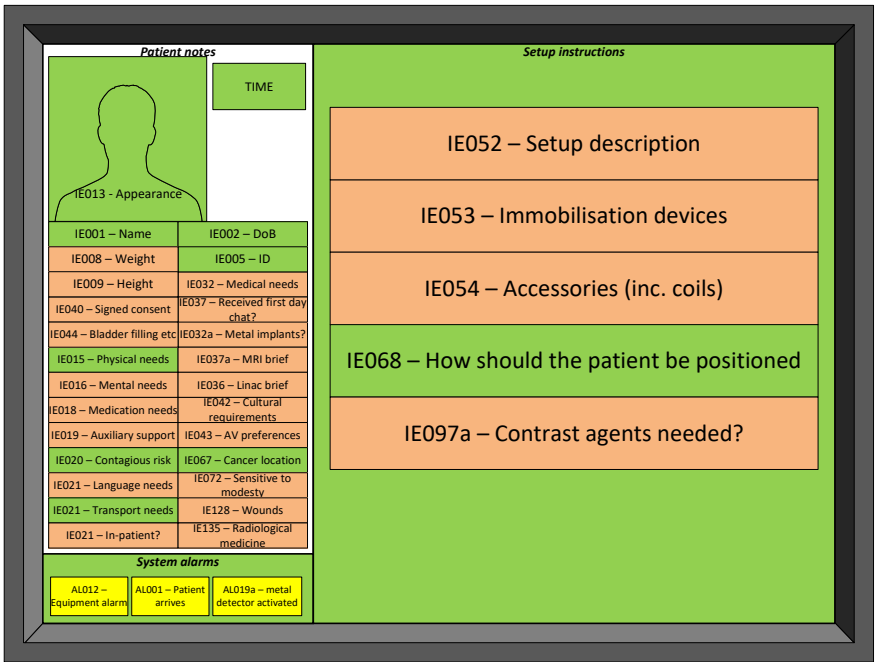
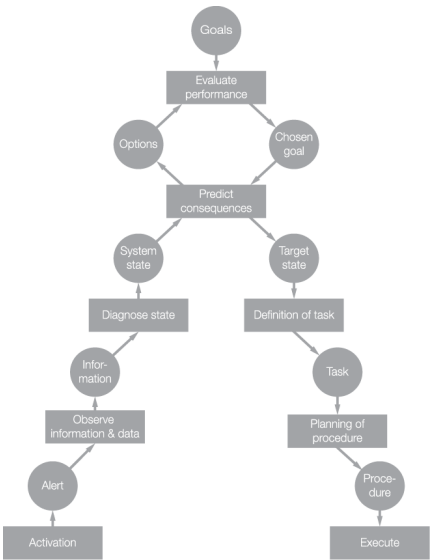
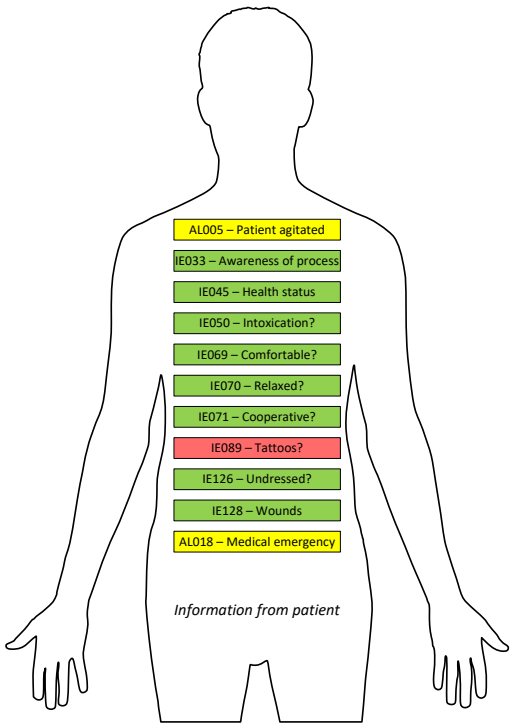
The first stage of redesigning the information displays was to plot this information out and define what was needed (green), and what could be needed (orange), for a range of situations.

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.

IE051 – Room and equipment cleanliness	IE079 – Setup aids in place
IE055 – What equipment is out	IE093 – Shielding aids in place
IE056 – What equipment needs 2-person lift	IE127 – Patient belongings
IE075 – Auxiliary equipment out	IE130 – Blood
IE082 – Equipment movement path	IE131 – Urine or faeces
IE060 – PSS location	IE132 – Vomit
IE065 – Patient location on PSS	IE133 – Waste blue roll

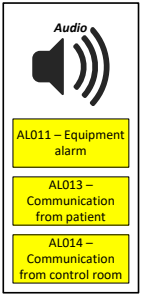
Environmental information



System generated information requirements

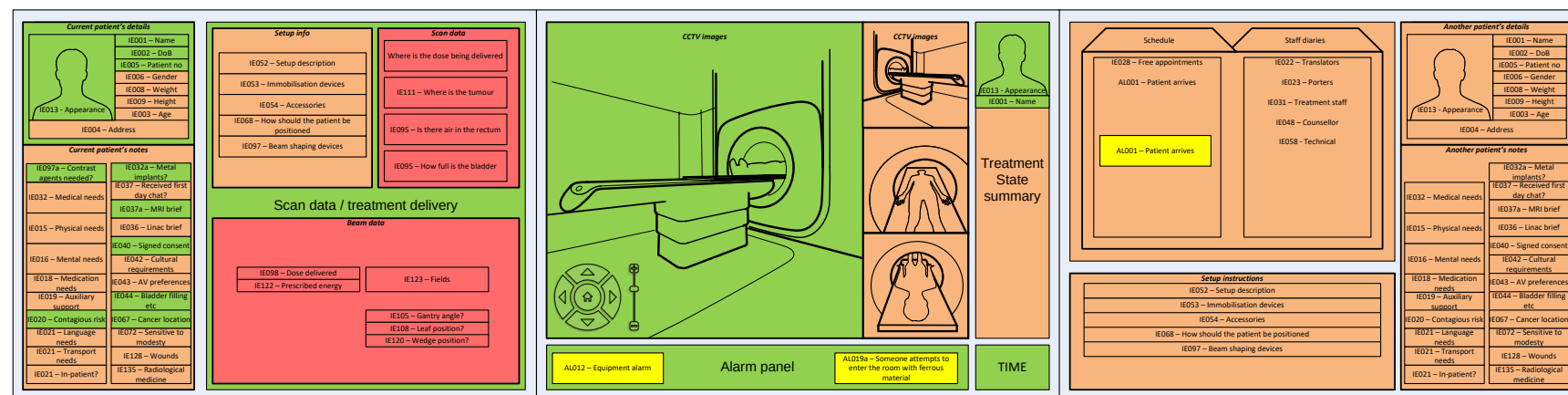
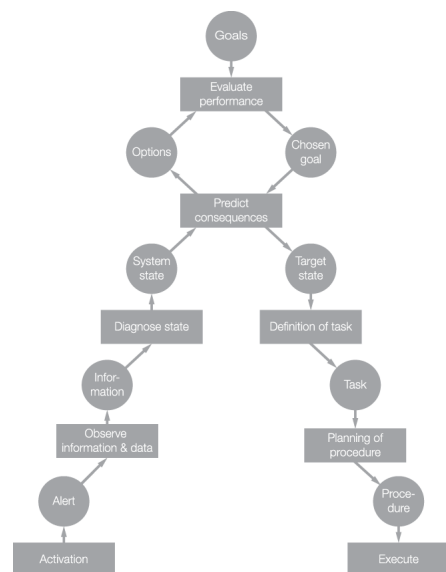
Green – Typically required at the current stage
Amber – Could be required at the current stage (may be hidden)
Red – Not required at then current stage
Yellow – Alerts to be displayed as required

4.4 Patient loading



Control room information

We performed the same task for the 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.



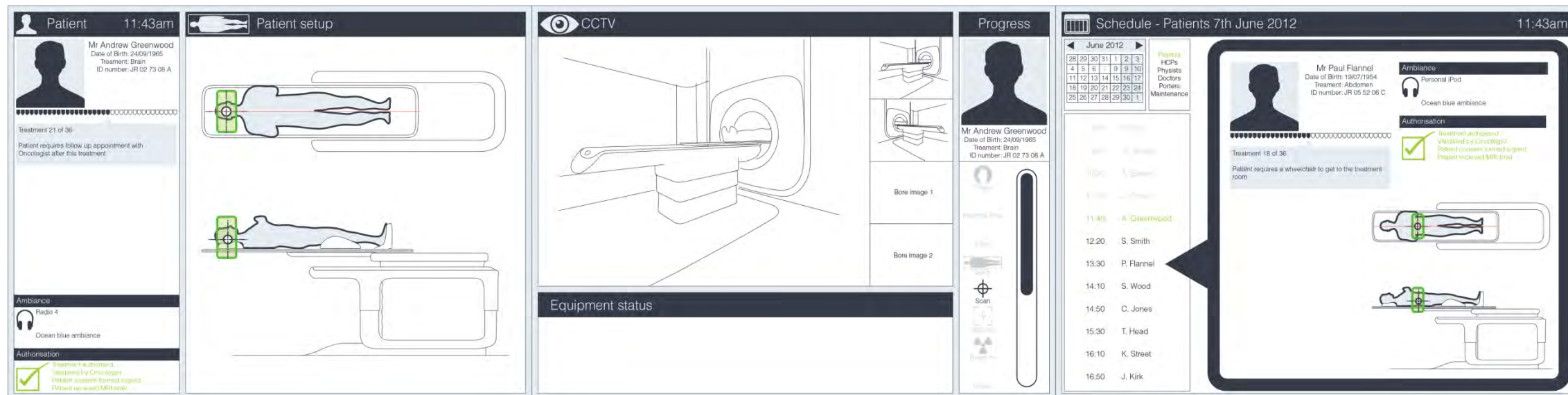
Main user – running machine

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

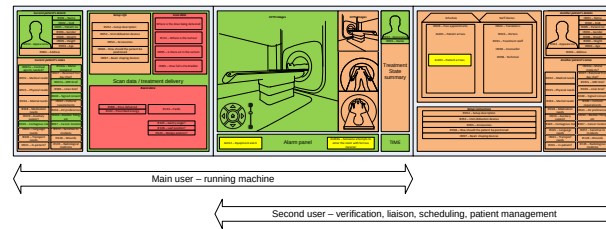
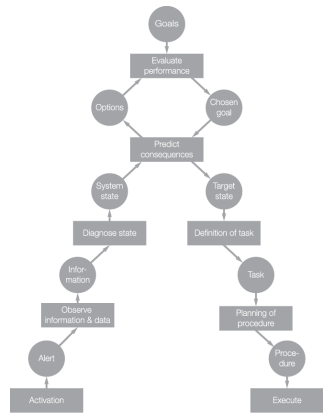
Basic wireframes were then created for each treatment stage.

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



This shows the concept
worked up to a higher
resolution.



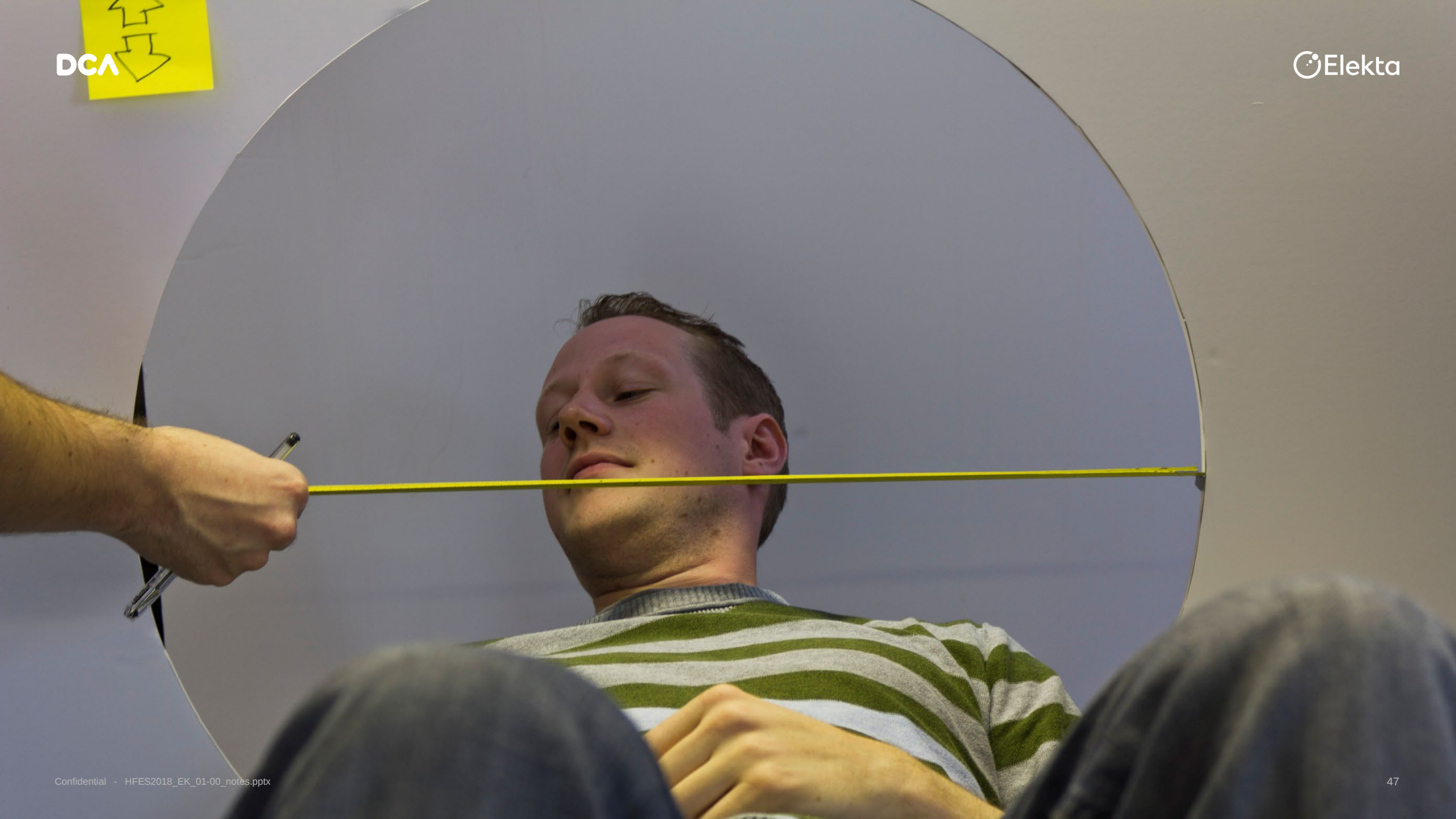


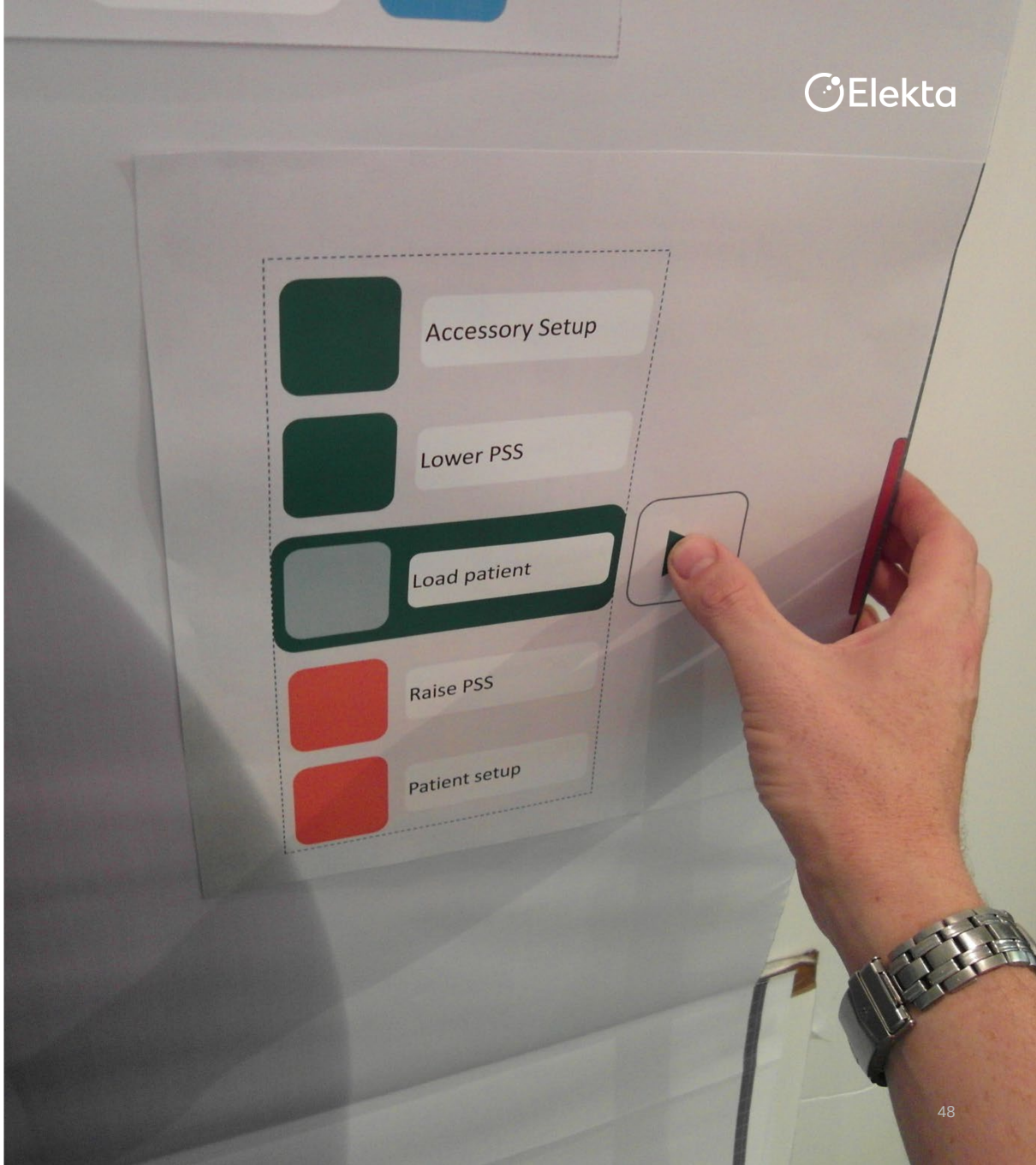
Thus, we had a very structured and auditable process moving from analysis using decision ladders, through specification, to wireframes and embodiment.

Prototyping



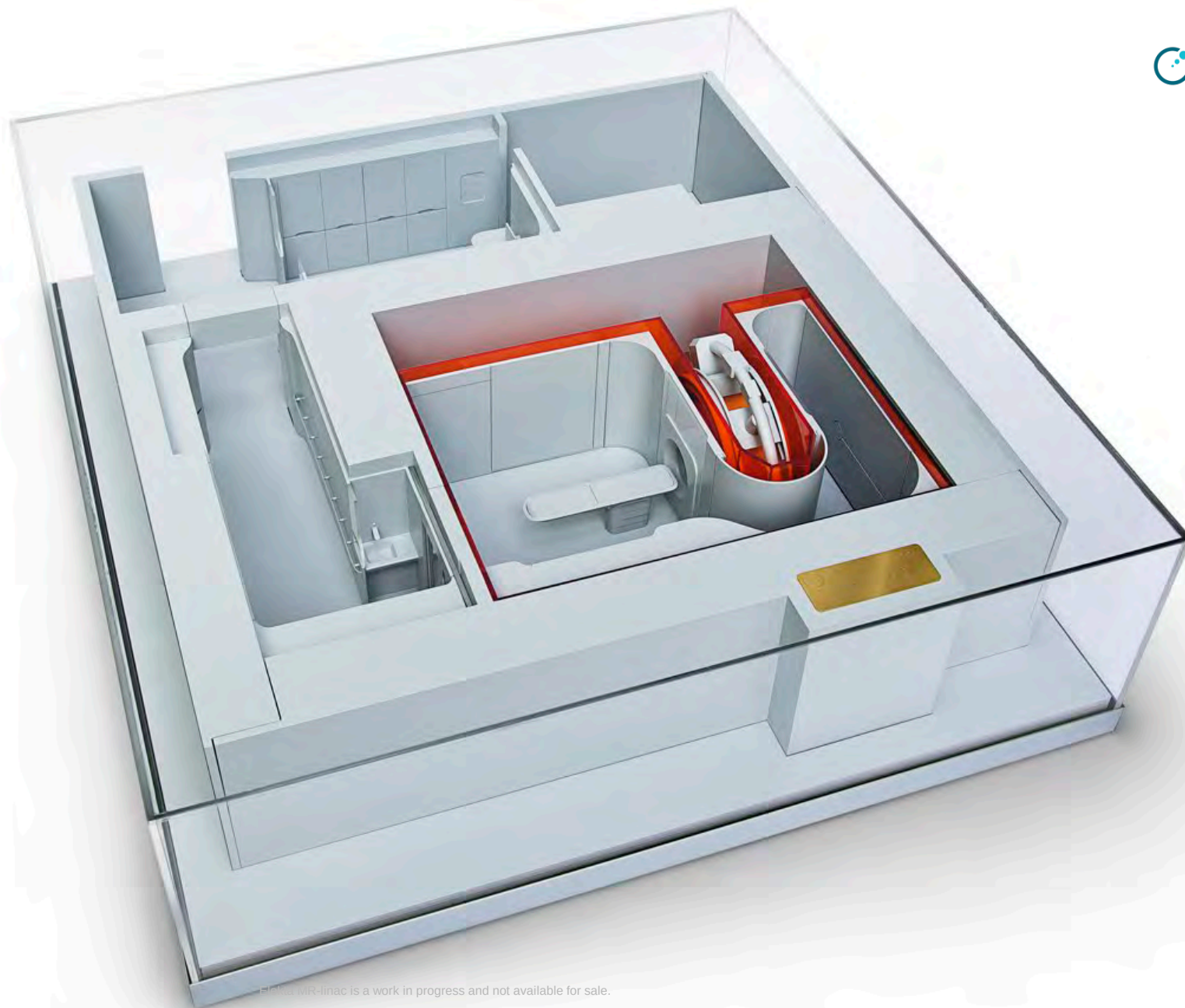
The vision was also supported by physical prototypes looking at patient experience and access to controls.

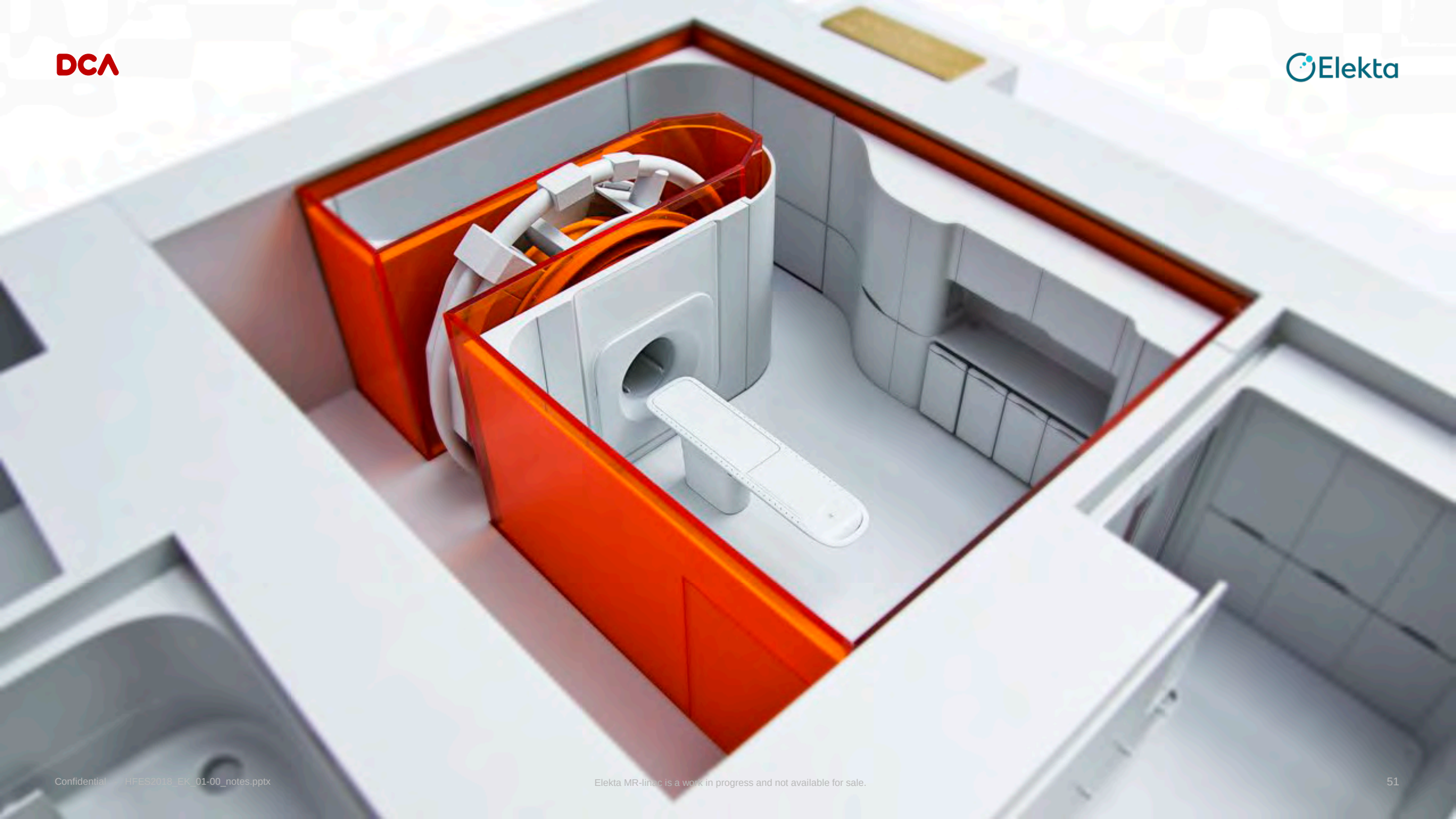






The room environment was optimised based on radiological protection, control of magnetic fields, access, and patient experience.





Atlantic vision

The Atlantic vision was presented as an animation following a patient experience.

This shows the view in to the control room and corridor to the treatment room.



Two separate staff workstation were proposed, one for each role. The desks are height adjustable to allow for the option to stand.

A large 'virtual window' provides a clear view of the treatment room.





Biometric login confirms the correct patient is entering the treatment room.

Information is provided about the progress of the treatment and selected music and lighting schemes.

DCA

Elekta

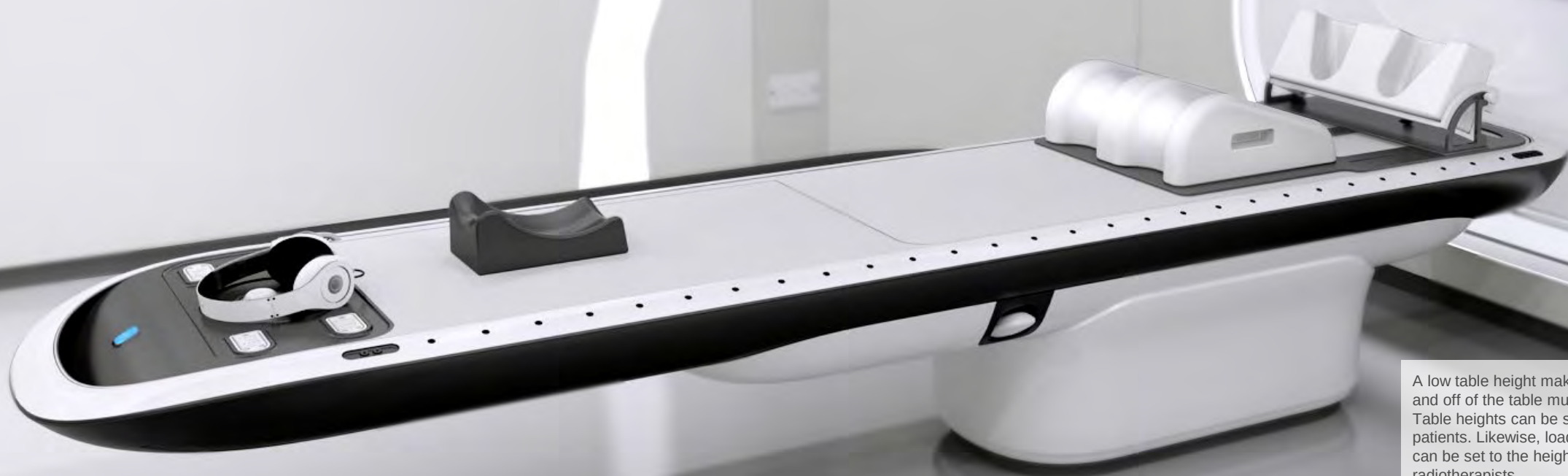




Rooms lighting is customisable.

DCA

Elekta



A low table height makes getting on and off of the table much easier. Table heights can be set for individual patients. Likewise, loading heights can be set to the height of the radiotherapists.

From vision to reality



Sara Jones 45yr

Radiation Oncologist

The design was developed based on a number of personas.

"I want to spend more time face to face with my patients instead of managing complicated computer systems"

Facts about Sara

Experience as a Radiation Oncologist: 10 years

Technical skills: Medium ●●●○○

Specialization: M.D., Radiation Oncology, Head & Neck

Works at: University Hospital with

Part of team or group:

- Radiation Oncologist Lead for the hospital's Head & Neck Tumor Advisory Board and a part of the Head & Neck multidisciplinary team
- Team lead Head & Neck national cancer guideline group

Work goals:

- Exercise best practice and evidence based Radiation

One day with Sara

In her daily work Sara is mostly on the run. She appreciates being able to carry out easier tasks while on the move. However, she prefers to sit down at her desk occasionally to focus on more complicated cases. She has a desk of her own at the doctors' office where she can work peacefully, but she doesn't mind using the workstations in the planning room or doing simpler tasks when logged in from her private laptop at home.



Mary Rogers 27yr

Medical Dosimetrist/Planner

"I take pride in helping my team deliver great care by making sure that I create the best treatment plan for each patient."

Facts about Mary

Experience as a
Dosimetrist/Planner:

3 years

Technical skills:

Medium



Specialization:

Medical Dosimetrist/Planner

Part of team or group:

- VMAT (Volumetric Modulated Arc Therapy planning) team
- AAMD (American Association of Medical Dosimetrist) member

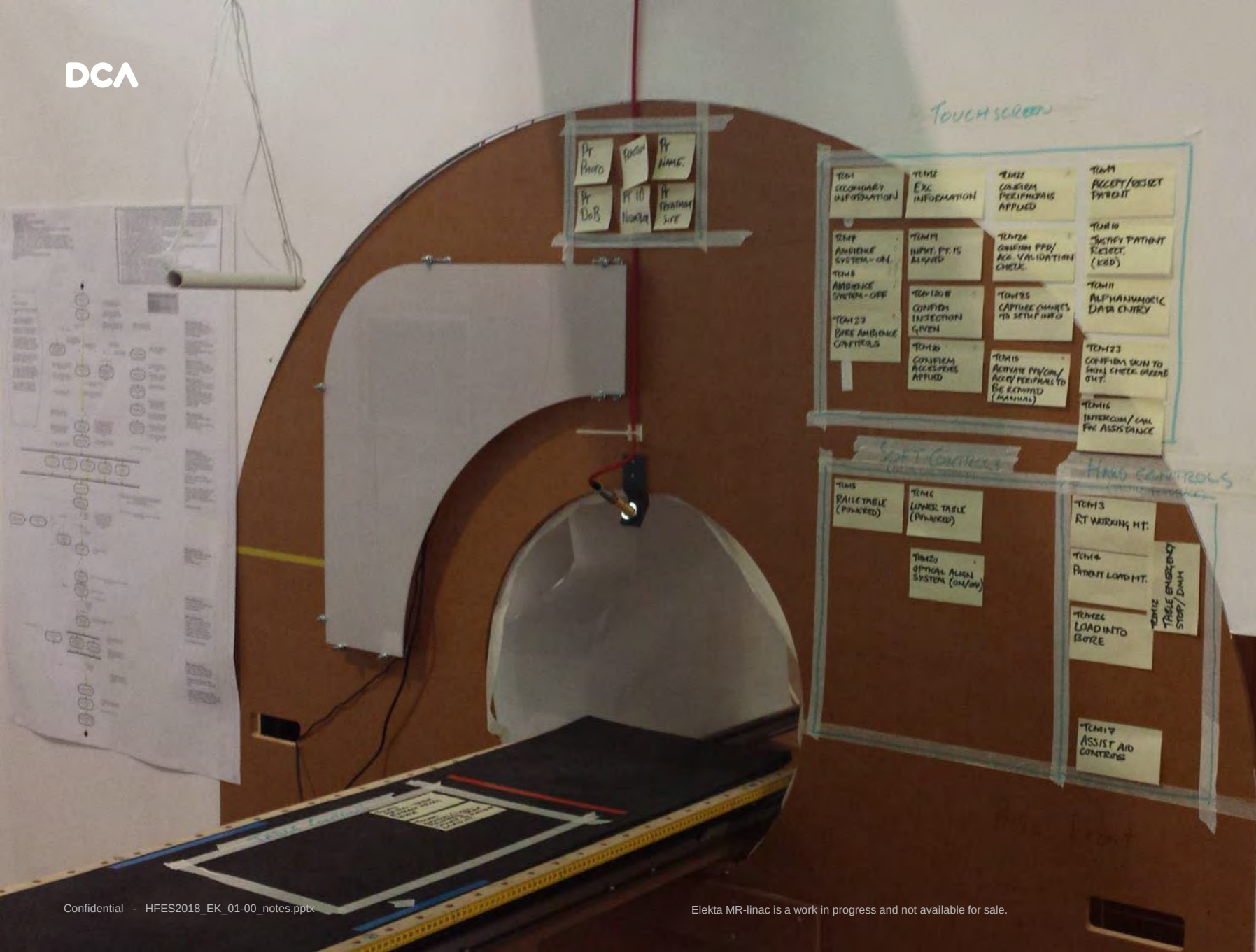
One day with Mary

Mary works as a medical dosimetrist at a university hospital. There are five dosimetrists and one trainee in her group. The dosimetrists, physicists, and radiation oncologist working on planning tasks share a large planning room. They have a shared task list showing patients that are ready for segmentation, delineation, treatment planning or plan QA. Most days, Mary logs into her workstation in the planning room and into the systems she needs during the day: the treatment planning system, the medical record system, and the hospital internet where she can reach treatment guidelines, hospital email, and take care of administrative



Elekta took responsibility for developing a production product informed by the vision.

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



Information requirements were validated with clinical specialists.



And tested in simulated use workflows





Johnson, Tony



MRN: 6012111234

Oct 16, 1962 | 52 yr

Conformal Prostate

185* Prostate

Site: Prostate

Phone: 123-456-7890

Technique: IMRT

Add: 100 Mathilda Pl

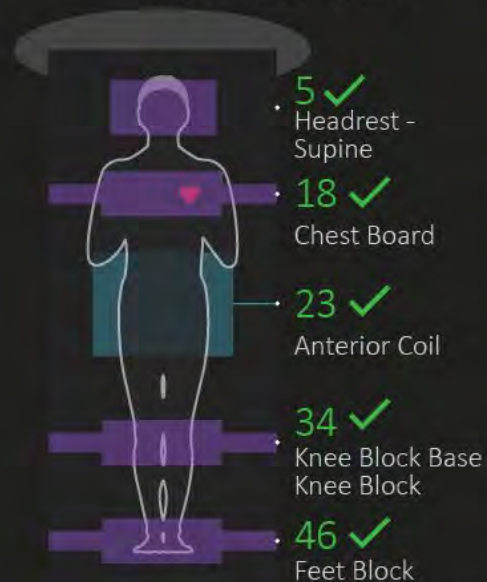
Fraction: 4/25

Sunnyvale CA

Attending: Susan H.

94086

Head First Supine



Setup Instructions:

Pacemaker...

Allergies...

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua.

Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute



Confirm Time-Out

Confirm Patient Setup

Setup Patient

Goal

Perform patient timeout.
Prepare PPD and contrast for setup.
Immunize patient Tony for treatment.
Load patient into treatment position.

Trigger

Patient enters Treatment Room

Actors

Patient Tony
Radiation Therapists
Anne and Steve;



Location

Treatment Room



VolunteerA, Jo

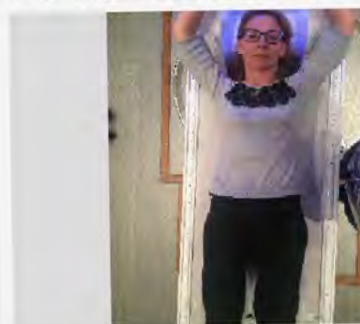
88881

1/12/1980

Site: Lt Lung

Attending: Susan H.

Phone: 123-456-7890 Add: 100 Mathilda Pl, Sunnyvale CA 94086



Displaying 2 out of 3 setup photos

Setup Notes:

CT references=SSN (suprasternal notch),
Arms above head,
Handgrip

Table Position

Set: 20.5 cm

Actual: 20.5 cm

Head First Supine

Headrest - Supine

Wing Step 3

Knee Step 34.5

Feet Step 44.5

Reference Mark 12

Coil Frame 16

Anterior Coil

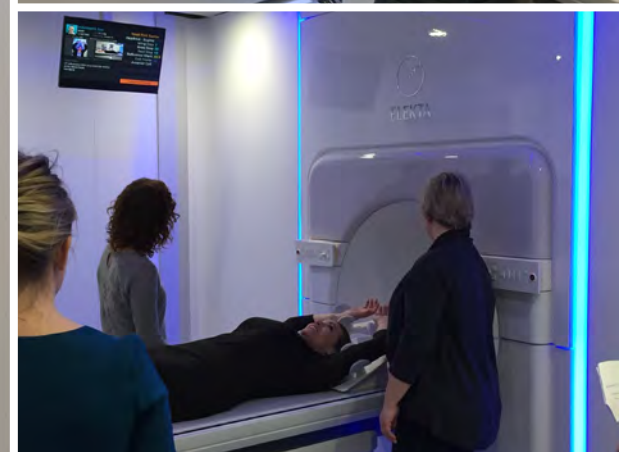
Table Ready

DCA



Testing was conducted throughout the development process.

Elekta







NEC

600003 - ElektaMR
Patient ID
Patient Name
Field ID
Table Longitudinal
Radiation Type
Energy
Technique
Prescribed MU
Backup MU
Beam Timer
Dose Rate
Segment
Total MU
Exit
Preparatory
Field Incomplete
All Interlocks On
71



DCA

 **Elekta**