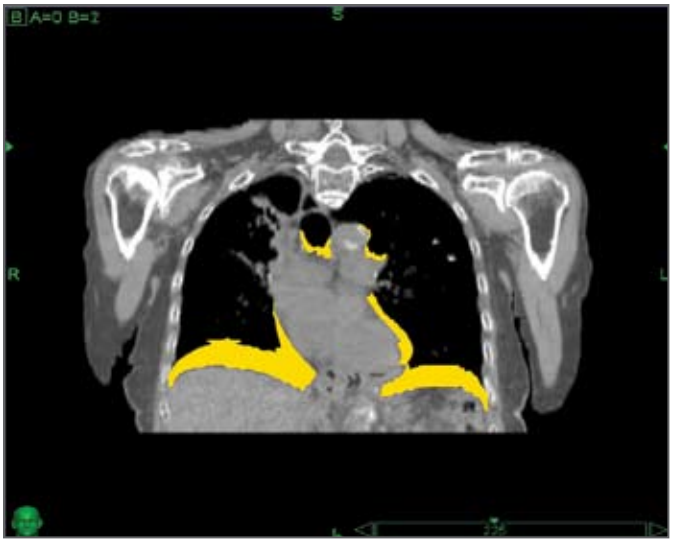
# 4D Treatment Optimization and Planning System

**The CyberKnife® Robotic Radiosurgery System, when used with the Synchrony® Respiratory Tracking System, has the unique ability to dynamically track and accurately deliver 4-dimensional (4D) radiosurgery when treating targets that move with respiration. Clinical confidence in the accuracy of the dose delivered in a 4D treatment is enhanced when the plan is generated using the 4D Treatment Optimization and Planning feature of the MultiPlan® Treatment Planning System.**

### Incorporate uncertainties into the planning process

4D changes in anatomy during imaging introduce uncertainties into the planning process. Some planning systems use techniques such as breath-hold imaging to account for these uncertainties. Unfortunately, use of imaging workarounds often leads to the use of planning workarounds – such as delineation of large target margins to account for intrafraction motion.

Rather than work around the uncertainties caused by respiration, the 4D Treatment Optimization and Planning System incorporates these uncertainties into the optimization and planning process. The resulting dose calculation considers the intra-fraction motion of not only the treatment target but all surrounding critical structures as well.



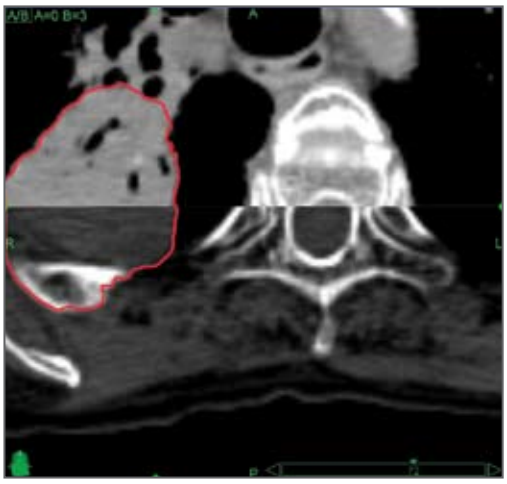
Changes in patient anatomy (highlighted area) can be seen by viewing the same 3DCT slice at different phases of the breathing cycle.

### The basic principle

The primary input into the 4D Treatment Optimization and Planning System is a sequence of 3DCT image series acquired over consecutive phases of a patient's normal breathing cycle – or a 4DCT. Once the 4DCT is imported, the next step in the 4D planning process is to align the sequence of image series on the treatment target so that they represent a 'beam's eye view' of the Synchrony treatment.

Because the image series are aligned on the target, the changes in form and position of the normal tissues that surround the target are clearly and easily visualized. These changes in form and position are converted into a deformation model, which is then used in the planning optimization process. By considering the deformation model in the 4D planning process, the effects of respiratory motion on the dose distribution are built into to the resulting treatment plan.

Intrafraction motion is not a limiting factor when a treatment plan is generated using the 4D Treatment Optimization and Planning System. This is demonstrated by the decrease in target margins needed and lower doses to critical structures outside the treatment target.

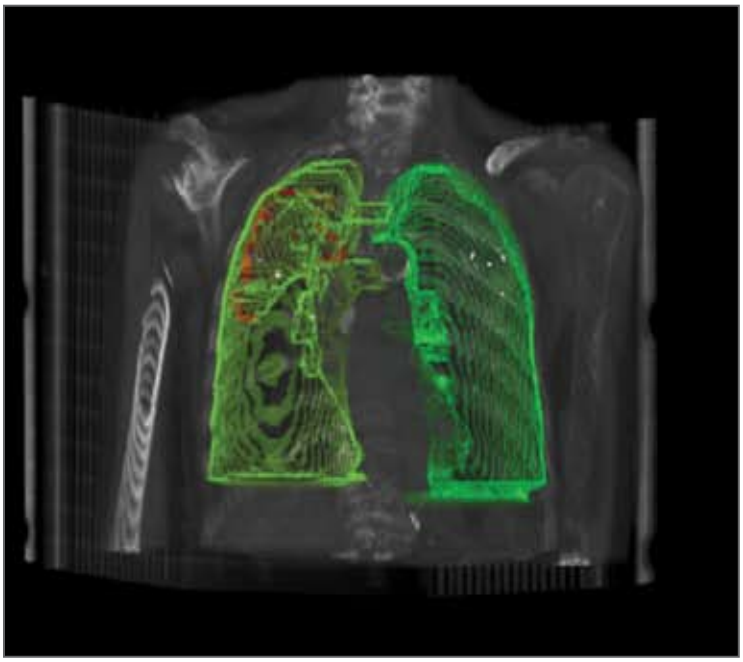


Aligning the target identified in each phase of the breathing cycle results in a target-centric beam's eye view. The split view shows that the target (red contour) is aligned and shows the deformation of other anatomy such as the spinal canal.

## Clinical Applications

Use the 4D Treatment Optimization and Planning System to generate treatment plans for anatomic areas that move or deform during respiration. Common applications include lung, liver and pancreas.

When a 4D treatment plan is delivered using the Synchrony® Respiration Tracking System, uncertainties introduced by respiratory motion are virtually eliminated.



View an animation of the effects of deformation on a 3D rendering of the patient anatomy.

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CyberKnife®

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*Unrivaled Conformality and Dose Gradient*

*Unparalleled Healthy Tissue Preservation*

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