Commissioning Guide

The purpose of this commissioning guide is to describe the process of configuring the eRT application for clinical use. This requires modeling the actual electron treatment machines in terms of physical geometry (e.g. SAD, rotation directions and limitations, applicator sizes/names), beam parameters (e.g. treatment energies, energy spectrum, beam flatness), and other facility information/preferences (e.g. CT Curves, location/shipping address, planning defaults). As the beam modeling/commissioning steps are critical to ensuring the safety and quality of patient treatments, it is also essential that the qualified medical physicist (QMP) responsible for the facility has a sufficient understanding of the dose calculation technique used by the eRT application. As such, this guide also serves to provide this information.

Site / Facility Modeling

The first step in preparing eRT for clinical use will be to gather the data needed to create a model of the local treatment facility. This model will include the follow information:

decimal eRT Site Data Model

The following section describes the hierarchy of data used to define an Organization within the decimal eRT application.

There are three main levels for how decimal eRT stores its organization configuration data:

1. **Organization**
    1. A legal entity that provides electron radiation treatments to patient. An Organization may be a network / group or individual and the data stored at this level contains preferences and basic information that applies broadly to the entity.
    2. This is where preferences that improve organization wide standardization are stored, such as dose map colors, treatment plan report settings, and material properties.
    3. An Organization will contain 1 or more Sites.
2. **Site(s)**
    1. A site is an individual treatment facility. The site stores the shipping address, CT curves, dicom export/import settings, QA options, and a list of physicians and treatment (disease) sites.
    2. A Site contains one or more Treatment Machines.
3. **Treatment Machine**
    1. A detailed model of an electron therapy treatment machine. The majority of the configuration data, including all commissioning data, is stored within a treatment machine.
    2. The treatment machine defines all physical machine geometry, as well as the electronic machine model (e.g. name, accessory IDs).
    3. The treatment machine also stores the list of available electron treatment energies and the commissioning data necessary to ensure accurate dose calculations are achieved.

Hierarchy

A single Organization can have one or multiple [1 - n] Sites (locations where treatments occur), and a Site can have one or multiple [1 - n] Treatment Machines. This relationship is detailed in the table below:

<table>
<tr><th colspan="4">Organization Data Model</th></tr>
<tr><td rowspan="13">[1]</td><td colspan="3">Organization</td></tr>
<tr><td colspan="3">- Organization Name</td></tr>
<tr><td colspan="3">- High Level Preferences (report settings, material properties, dose colors)</td></tr>
<tr><td rowspan="12">[1 - n]</td><td colspan="2">Site</td></tr>
<tr><td colspan="2">- Facility metadata (name, shipping address)</td></tr>
<tr><td colspan="2">- Site-wide data (CT curves, dicom export/import options, list of physicians & disease sites)</td></tr>
<tr><td rowspan="10">[1 - n]</td><td>Treatment Machine</td></tr>
<tr><td>- Machine metadata (name, serial number, description)</td></tr>
<tr><td>- Machine Geometry (SAD, rotation directions, position references, tolerance tables)</td></tr>
<tr><td>- Electron Applicator List (sizes, jaw positions, IDs)</td></tr>
<tr><td>- Commissioning Data List (one entry per treatment energy)</td></tr>
<tr><td>- - Nominal Energy</td></tr>
<tr><td>- - Beam model parameters (virtual source, scattering moment)</td></tr>
<tr><td>- - PDDs (per field size and SSD)</td></tr>
<tr><td>- - Lateral profile data (per field size)</td></tr>
<tr><td>- - Photon lateral profile data (per field size)</td></tr>
</table>

Commissioning (Machine) Data

As a semi-analytical calculation model, the PBRA requires only simple measurement data results in order to fully commissioning the system. Fix Me! with more details.

Dose Calculation Engine

decimal eRT dose calculations follow the pencil beam redefinition algorithm as described in Pencil-beam redefinition algorithm for electron dose distributions that allows for electron dose calculations using beam limiting devices. It is recommended that users familiarize themselves with the PBRA as described in the above reference as it provides critical information regarding the equations used in the dose engine, how tissue heterogeneities are handled, and the value ranges for the modeling parameters. A description of the model accuracy and a set of calculation inputs and expected outputs can be found in the Acceptance Testing section of this user guide. Details on the performance of Site specific testing to verify the accuracy of dose calculations after commissioning are provided in the section below.

Verification of Dose Calculation Accuracy

Following installation or commissioning of the Software, the user shall verify the accuracy of calculated dose distributions within the clinical environment prior to clinical use. These procedures confirm correct system configuration and data integrity and do not replace institutional commissioning requirements.

User Qualifications

Testing shall be performed by a Qualified Medical Physicist.

Test Overview

The user shall compare eRT-calculated dose results against independently measured or previously validated reference data under representative clinical conditions.

Testing should include beam configurations spanning the intended clinical use range.

Recommended Test Conditions

The verification procedure should include, as applicable:

- homogeneous phantom geometry
- representative beam energies and modalities
- clinically relevant field sizes
- central-axis and off-axis dose evaluation
- depth-dose and lateral profile comparisons
- heterogeneity test cases where applicable

Procedure

1. Configure the Software using clinically commissioned beam data.
2. Create test plans using defined phantom geometries.
3. Calculate dose distributions using default clinical calculation settings.
4. Export calculated dose data or evaluate within the Software.
5. Compare calculated results against:
    1. measured dosimetric data, or
    2. validated reference datasets.

Evaluation Methods

Comparison methods may include:

- point dose comparison
- percent depth dose (PDD) analysis
- profile comparison
- gamma index analysis or equivalent quantitative metric

Acceptance Criteria

Acceptance tolerances shall be defined by the clinical institution in accordance with applicable professional guidelines (e.g., AAPM recommendations).

Typical tolerances used in clinical practice include:

- ±3% dose difference in high-dose regions;
- distance-to-agreement criteria consistent with institutional standards.

Documentation

The user shall document:

- test configurations
- comparison results
- acceptance criteria used
- final approval for clinical use

Documentation should be retained according to institutional quality management procedures.

Reverification

Accuracy verification should be repeated following:

- Software updates affecting calculation algorithms
- changes to beam configuration data
- hardware or operating system changes that may affect performance

Other Mathematical Considerations

Interpolation

Interpolation processes are necessary within many contexts for an application such as eRT. Specifically, users should be aware of the following contexts where interpolation is used:

1. Dose Calculation (internal)
2. MU Determination

3. Dose Result Displays
4. Dose Volume Histograms (DVHs)
5. Dose Exporting
6. The Dose Profile tool

In all such cases, eRT will use a linear interpolation approach whenever data falls within the range of the provided minimum and maximum values. Note, for 2D or 3D calculations, this refers to bi-linear or tri-linear interpolation as appropriate.

The following is an overview of the use of interpolation throughout the treatment planning process.

Since users provide commissioning data for all electron energies utilized at their site, there is no interpolation across energies. However, data is provided at discrete field sizes and SSD positions that may not exactly match the commissioning data. This is the first use of interpolation, whereby user supplied PDDs are interpolated to the appropriate field size and SSD for the beam at hand. This interpolation uses a combination of electron beam theory and user provided data to generate a PDD that accurately reflects the intermediate beam conditions (see Fix Me! interpolation reference for details). The off-axis-ratios and other beam parameters are linearly interpolated as needed. Following the PDD determination, the PBRA then computes dose on a beam-aligned, divergent grid. The next interpolation occurs to transfer the dose data from this beam aligned grid onto a patient-aligned, equally spaced grid. This uses standard trilinear interpolation. Dose within this patient-aligned grid is displayed on-screen within the eRT application. This same dose is also used for DVH computations and all other dose statistics provided by the eRT application. DVH and all volume-based dose statistics are computed using the dose at the center of each voxel in this dose grid, but volumes are computed by accounting for the actual portion of the voxel contained within the structure/region at hand. The dose from this patient-aligned dose grid is directed exported by the eRT application such that no further interpolation is needed.

Extrapolation

As described in the above section, eRT will not extrapolate data other than by extending the first/last data value as appropriate (this is in essence, a zero-order extrapolation).