

Commissioning Guide

Overview

The decimal ElectronRT (eRT) app is designed to allow users to accurately compute the delivered dose to a patient undergoing electron beam therapy. However, the accuracy of such calculations is highly dependent upon the proper initialization and maintenance of the system commissioning data. This document is intended to serve as a guide to aid users in performing these critical commissioning processes. Commissioning and acceptance should only be completed by a Qualified Medical Physicist (QMP) and any such QMP performing these processes should read this entire Commissioning Guide, the complete eRT Instructions For Use, and sign the appropriate acknowledgement of responsibility. Additionally, such QMP should be appropriately educated and licensed to perform such tasks as per their local laws and regulations.

The commissioning process 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 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.

Commissioning Approach

For clinical users, .decimal staff will assist in the preparation of the eRT commissioning data files, using user provided measurement data files. Users must attest to the accuracy and completeness of any provided measurement data and .decimal recommends an independent 3rd party is used to review such data for accuracy. Clinical users will be provided a list of measurement data necessary to complete the eRT commissioning process, or alternatively, for users that already have a commissioned electron TPS, a list of data to export from their existing system. From this data, .decimal staff will create the eRT commissioning data files as described below.

Commissioning Data Structure

Two types of data are used by this application for commissioning purposes: 1) data entered manually into eRT through the software user interface and 2) pre-prepared data files imported into the software. Manually entered data is typically used for administrative level information, such as machine name & type, and machine geometric parameters, such as the physical SAD, rotation directions, and reference positions. For details on the manually entered data, refer to the [Organization Settings page found here](#). Imported data files are typically used when measured data is involved, such as for CT (HU) to stopping

power curves, percent depth dose data, beam in-plane profile data, and output factors for absolute dose calibration. For details on the CT Curves data files, please click [here](#); for all other commissioning data files, continue reading below.

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:

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

Commissioning (Machine) Data

As a semi-analytical calculation model, the PBRA requires only simple measurement data results in order to fully commission the system. The following information is included in the eRT Machine Data files for each electron treatment energy:

- Percent depth dose curves for the full range of field sizes desired for clinical use (at the reference SSD)
- Off-Axis-Ratios for the electron portion of the dose at a specified depth
- Photon dose profiles at a depth of 2cm beyond the practical range of the electrons



Check on this

- The physical (nominal) and virtual SAD value



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- The beam effective scattering angle (σ -theta-x)
- The beam drift (distance from the block surface to the isocenter plane)
- (Optional) Percent depth dose curves at an extended SSD

It is worth noting that many of these values will be derived (computed) from other direct measurement data and the eRT customer service team will guide each facility in collecting the necessary data such that these commissioning files can be constructed.

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 eRT 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

*Example datasets or test cases may be provided separately to assist verification upon request.

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:

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

Documentation

At a minimum, 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  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).

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