AAPM IGRT Recommendations

Joint ICTP-IAEA International Workshop on the Implementation of Image Guided Radiotherapy (IGRT)
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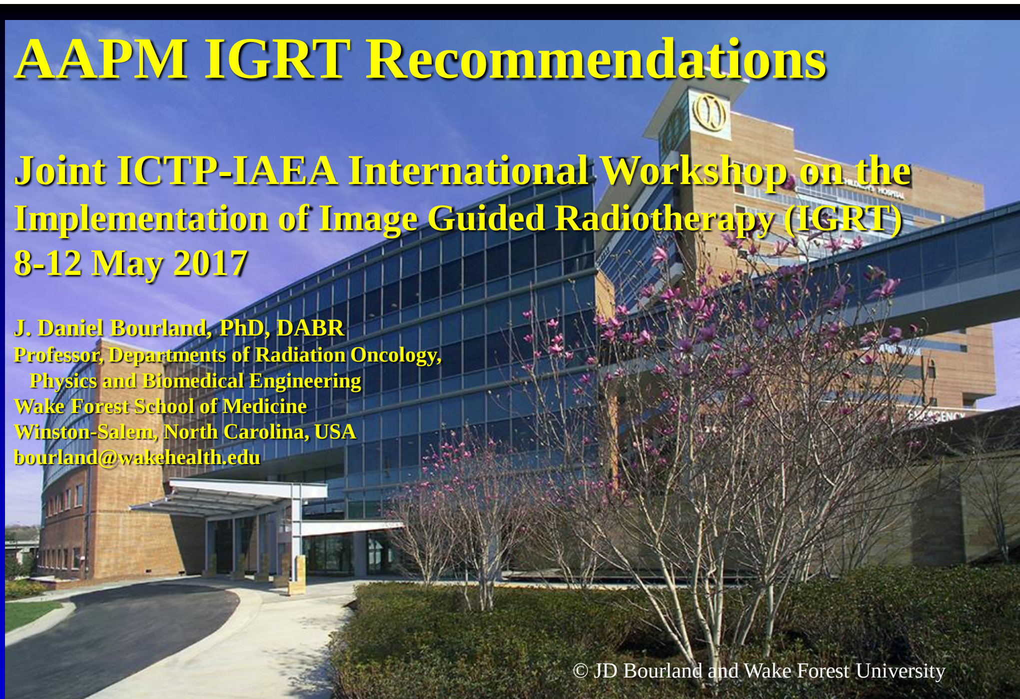

Outline

- AAPM Report 179: CT-based IGRT
  - Mechanical Quality Assurance
  - Imaging Quality Assurance
  - Dose Quality Assurance
- AAPM Practice Guideline 2.a
  - Commissioning of x-ray based IGRT
  - QA of x-ray based IGRT
- ACR-AAPM Tech Standard for IGRT
- Summary

TG-179: QA for CT-based IGRT

Quality assurance for image-guided radiation therapy utilizing CT-based technologies: A report of the AAPM TG-179

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TABLE I. Commercially available CT-based IGRT systems.

Make and model		Elekta XVI	Varian On-Board Imager	Siemens Artiste	TomoTherapy	Siemens Primatom
Imaging configuration		kV-CBCT	kV-CBCT	MV-CBCT	MVCT	kVCT-on rails
Field of view		50 × 50 × 25.6	45 × 45 × 17	40 × 40 × 27.4	40 cm	50 cm
Correction method	Translation	Automatic couch motion	Automatic couch motion	Automatic couch motion	Automatic in 2 directions	Manual couch motion
	Rotation	Optional	None	None	Optional	Optional
Geometric accuracy		Submillimeter	Submillimeter	Submillimeter	Submillimeter	Submillimeter
Dose (cGy)		0.1–3.5	0.2–2.0	3–10	0.7–3.0	0.05–1
Image acquisition and reconstruction time		2 min	1.5 min	1.5 min	5 s per slice	3 s per sec

Bissonnette JB et al. Quality assurance for image-guided radiation therapy utilizing CT-based technologies: A report of the AAPM TG-179. Medical Physics, Vol. 39, No. 4, April 2012

TABLE II. Summary of QC tests recommended for CT-based IGRT systems. Tolerances may change according to expectations, experience and performance.

Frequency	Quality metric	Quality check	Tolerance
Daily	Safety	Collision and other interlocks	Functional
		Warning lights	Functional
	System operation and accuracy	Laser/image/treatment isocentre coincidence OR	±2 mm
		Phantom localization and repositioning with couch shift	±2 mm
Monthly or upon upgrade	Geometric	Geometric calibration maps[a] OR	Replace/refresh
		kV/MV/laser alignment	±1 mm
		Couch shifts: accuracy of motions	±1 mm
	Image quality	Scale, distance, and orientation accuracy[a]	Baseline
		Uniformity, noise[a]	Baseline
		High contrast spatial resolution[a]	≤ 2 mm (or ≤ 5 lp/cm)
		Low contrast detectability[a]	Baseline
If used for dose calculation	Image quality	CT number accuracy and stability[a]	Baseline
Annual	Dose	Imaging dose	Baseline
	Imaging system performance	X-ray generator performance (kV systems only): tube potential, mA, ms accuracy, and linearity	Baseline
	Geometric	Anteroposterior, mediolateral, and craniocaudal orientations are maintained (upon upgrade from CT to IGRT system)	Accurate
	System operation	Long and short term planning of resources (disk space, manpower, etc.)	Support clinical use and current imaging policies and procedures

[a]These tests can be performed on a semiannual basis after stability has been demonstrated, 6–12 months after commissioning.

Bissonnette JB et al. Quality assurance for image-guided radiation therapy utilizing CT-based technologies: A report of the AAPM TG-179. Medical Physics, Vol. 39, No. 4, April 2012

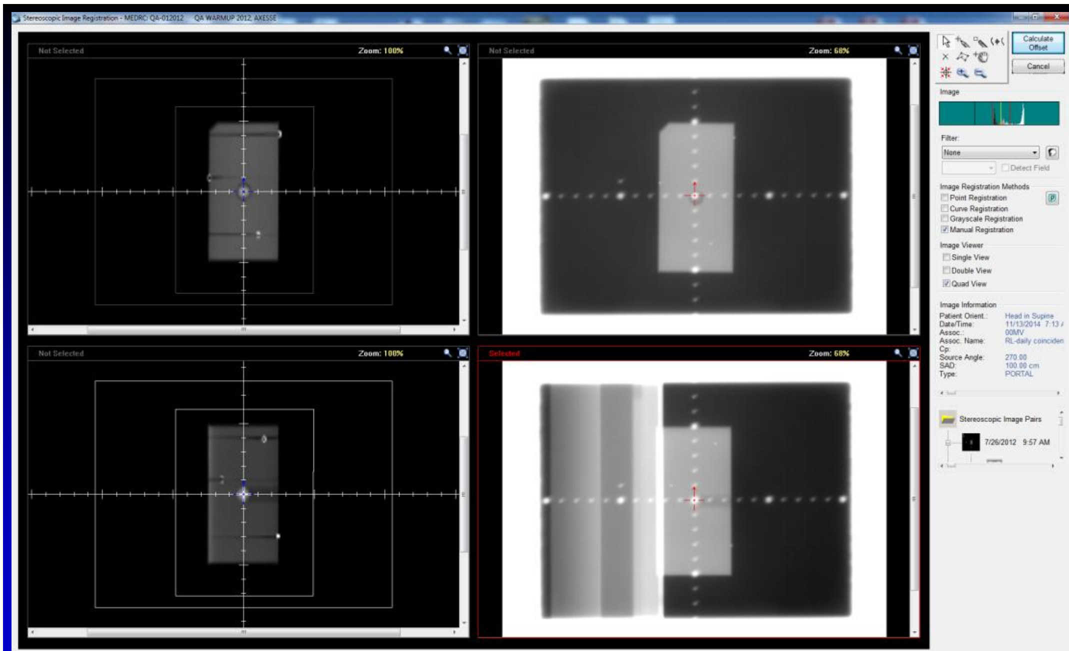
Daily Quality Assurance

Frequency	Quality Metric	Quality Check	Tolerance
Daily	Safety	Collision and Interlocks	Functional
		Warning lights	Functional
	System Operation and Accuracy	Laser/image/treatment isocenter coincidence OR	+/- 2 mm
		Phantom localization and repositioning with couch shift	+/- 2 mm

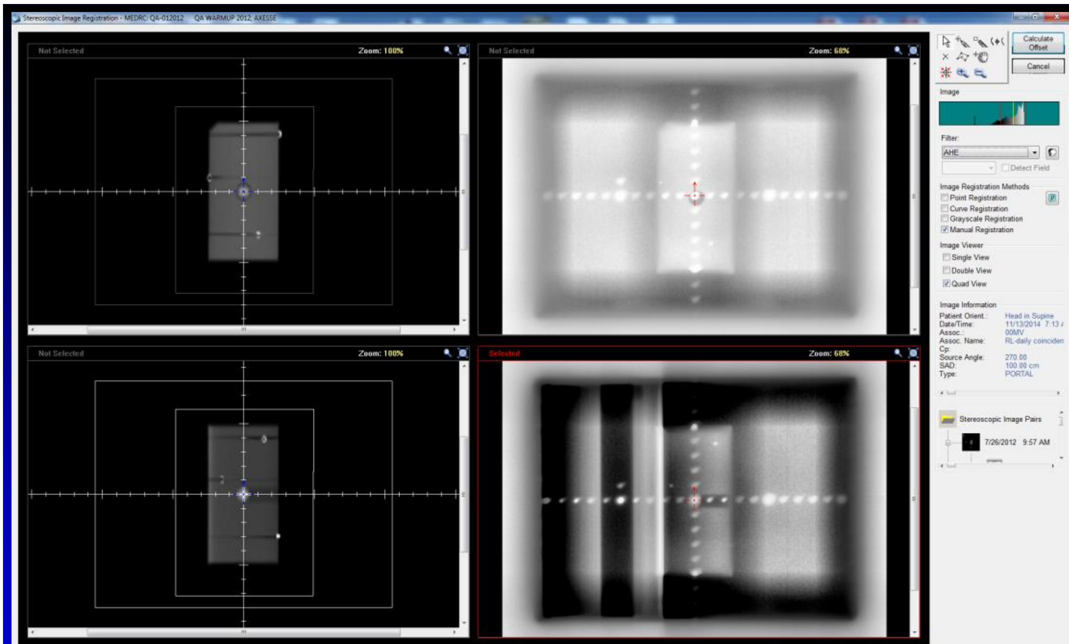
Bissonnette JB et al. Quality assurance for image-guided radiation therapy utilizing CT-based technologies: A report of the AAPM TG-179. Medical Physics, Vol. 39, No. 4, April 2012

Daily Laser/Image/Treatment Isocenter Coincidence Agreement

- Align phantom with 3 implanted gold seeds to lasers and CBCT
- Check alignment and acquire 2 orthogonal MV port films
- Use Setup Intelligence in Mosaiq to check alignment of MV ports with reference images



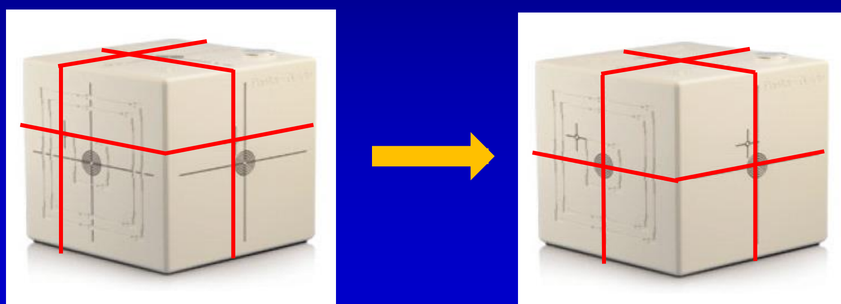
Images courtesy of Department of Radiation Oncology, Wake Forest Baptist Medical Center, Winston-Salem, NC USA



Images courtesy of Department of Radiation Oncology, Wake Forest Baptist Medical Center, Winston-Salem, NC USA

Phantom Localization and Table Shift Test

- Align Quasar phantom to known offset and CBCT
- Perform translation and check laser alignment
- Could be done Daily, typically, is performed **Weekly**
- Place small angle under 1 corner to test Hexapod rotational corrections



Monthly Quality Assurance

Frequency	Quality Metric	Quality Check	Tolerance
Monthly	Geometric	Geometric calibration map OR	Save new map
		kV / MV laser alignment	+/- 1 mm
		Couch shifts, accuracy of motions	+/- 1 mm
	Image Quality	Scale, distance, and orientation accuracy	Baseline
		Uniformity, noise	Baseline
		High contrast spatial resolution	< 2 mm, or 5 > lp/cm
		Low contrast detectability	Baseline
	If used for dose calc	CT number accuracy and stability	Baseline

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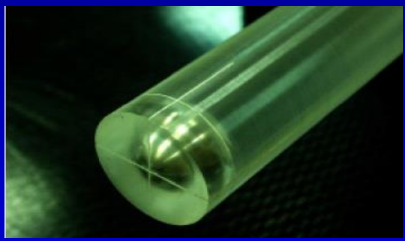
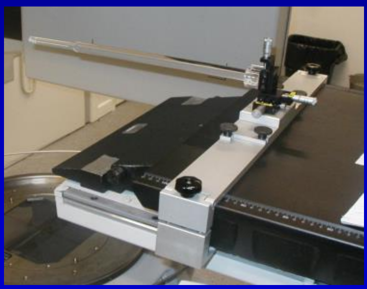
MV and kV Isocenter Coincidence

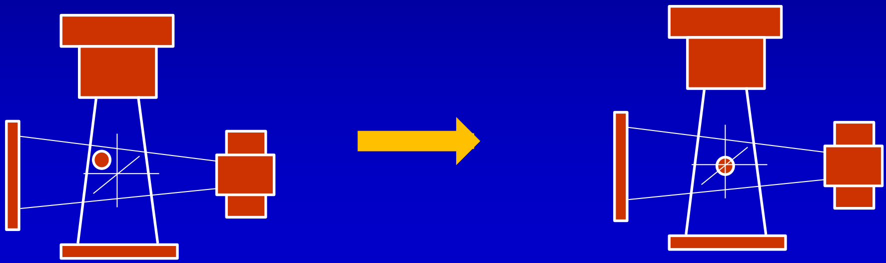
- Ball bearing test performed
- Procedure outlined in manufacturer acceptance documents
- Variation of Winston-Lutz test
- Recommend that procedure be done with physicist
- Can do in conjunction with an automated MLC calibration





MV EPID Stage

- Align ball bearing phantom (8mm) with lasers
- Acquire MV images (gantry at 0, 90, 180, 270)
- Transfer images to XVI and evaluate
- Reposition ball bearing relative to jaws
- Repeat until ball bearing is within 0.25mm of MV isocenter



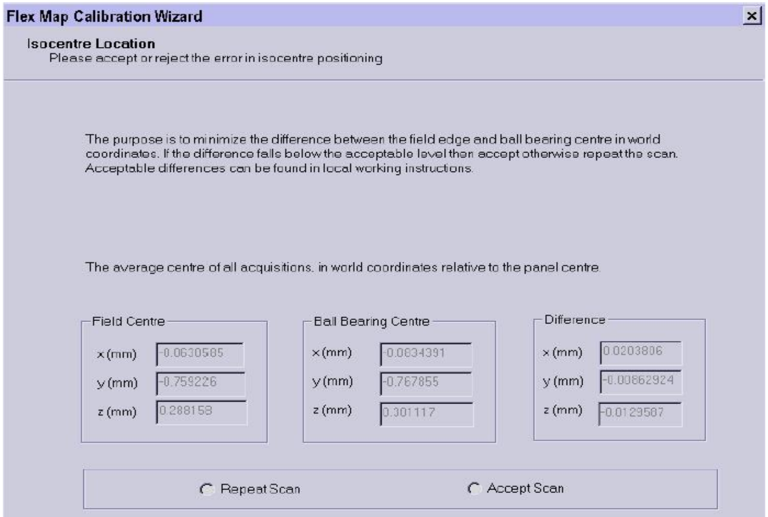
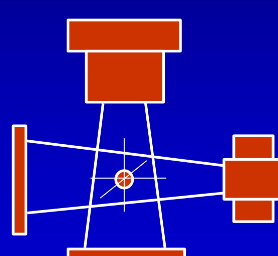


Figure 2.1 A screen dump from the full flexmap calibration wizard in the XVI software. The "Field Centre" column is calculated from the collimated MeV beams taken at eight specific positions. It shows the average position of the MeV beam isocenters. The "Ball Bearing Centre" column shows the average position of the dense ball for those eight beam positions. Subtracting the ball bearing column from the field center column results in the "Difference" column, which shows the position difference between the beam isocenter and the center of the dense ball.

http://lup.lub.lu.se/luur/download?func=downloadFile&recordOId=2156983&fileOId=2157374

kV CBCT Stage

- Acquire CBCT scan
- Determine position of ball bearing in each projection
- Plot position as a function of gantry angle to determine head sag (flex map)
- Flex maps must be generated for all acquisition modes (CW and CCW)
- Acquire CBCT scan
- Compare to reference set
- Discrepancy is variation between isocenters



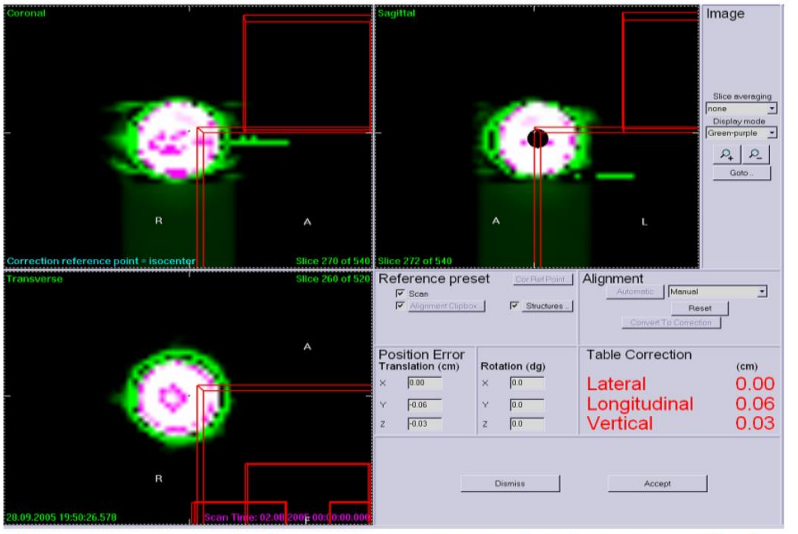
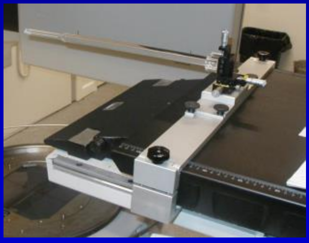


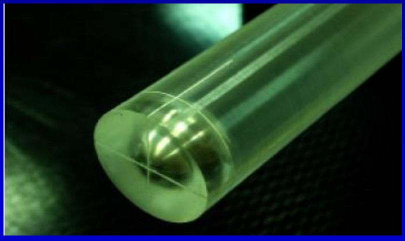
Figure 2.2 The correction window in the XVI software. The images show the shift of the ball compared to the isocenter. The green area is the acquired volumetric image and the purple area is from the dummy ball placed at isocenter (plan). A manual matching has been performed by moving the plan in coincidence with the green acquired image prior to the screenshot. The red lines on the right side in each view are to illustrate the view directions in the software and they have nothing to do with the matching.

Renstrom, Master of Science Thesis, 2005
http://lup.lub.lu.se/luur/download?func=downloadFile&recordOId=2156983&fileOId=2157374

MV Isocenter Stability

- Ball bearing image with gantry, collimator, table rotations
- Winston-Lutz test
- Isocenter variation should be within 1 mm
- Note: go into room and look





Annual Quality Assurance

Frequency	Quality Metric	Quality Check	Tolerance
Annual	Dose	Imaging dose	Baseline
	Image System Performance	X-ray generator (kV systems) kV, mA, exposure time, linearity	Baseline
	Geometric	Anteroposterior, mediolateral, and craniocaudal orientations are maintained	Accurate designations
	System Operation	Long and short term resource planning (disk space, effort, etc.)	In support of clinical use

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Image Quality

- CT Imaging Quality Assurance
  - AAPM Report 74
  - AAPM Report 142
- Typical Tests
  - Scale and distance accuracy
  - Low contrast resolution
  - Spatial Resolution
  - Uniformity and noise

E. E. Klein, J. Hanley, J. Bayouth, F. F. Yin, W. Simon, S. Dresser, C. Serago, F. Aguirre, L. Ma, B. Arjomandy, C. Liu, C. Sandin, and T. Holmes, "Task Group 142 report: Quality assurance of medical accelerators," Med. Phys. **36**, 4197–4212 (2009).

Image Quality

- CatPhan (done annually)
  - Image uniformity
  - Low contrast
  - High resolution
- Image quality checks for uniformity, heterogeneity, CT number accuracy, resolution, artifacts

Now You Are a CT Physicist!

AAPM REPORT NO. 74

QUALITY CONTROL
IN DIAGNOSTIC RADIOLOGY

Report of Task Group #12
Diagnostic X-ray Imaging Committee

July 2002

Published for the
American Association of Physicists in Medicine
by Medical Physics Publishing

But Wait, Even TG142 Has Imaging QA!

TABLE VI. Imaging.

E. E. Klein, J. Hanley, J. Bayouth, F. F. Yin, W. Simon, S. Dresser, C. Serago, F. Aguirre, L. Ma, B. Arjomandy, C. Liu, C. Sandin, and T. Holmes, "Task Group 142 report: Quality assurance of medical accelerators," Med. Phys. **36**, 4197–4212 (2009).

Procedure	Application-type tolerance	
	non-SRS/SBRT	SRS/SBRT
Daily[a]		
Planar kV and MV (EPID) imaging		
Collision interlocks	Functional	Functional
Positioning/repositioning	≤2 mm	≤1 mm
Imaging and treatment coordinate coincidence (single gantry angle)	≤2 mm	≤1 mm
Cone-beam CT (kV and MV)		
Collision interlocks	Functional	Functional
Imaging and treatment coordinate coincidence	≤2 mm	≤1 mm
Positioning/repositioning	≤1 mm	≤1 mm
Monthly		
Planar MV imaging (EPID)		
Imaging and treatment coordinate coincidence (four cardinal angles)	≤2 mm	≤1 mm
Scaling[b]	≤2 mm	≤2 mm
Spatial resolution	Baseline[c]	Baseline
Contrast	Baseline	Baseline
Uniformity and noise	Baseline	Baseline

TABLE VI. Imaging.

E. E. Klein, J. Hanley, J. Bayouth, F. F. Yin, W. Simon, S. Dresser, C. Serago, F. Aguirre, L. Ma, B. Arjomandy, C. Liu, C. Sandin, and T. Holmes, "Task Group 142 report: Quality assurance of medical accelerators," Med. Phys. **36**, 4197–4212 (2009).

Procedure	Application-type tolerance	
	non-SRS/SBRT	SRS/SBRT
Planar kV imaging[d]		
Imaging and treatment coordinate coincidence (four cardinal angles)	≤2 mm	≤1 mm
Scaling	≤2 mm	≤1 mm
Spatial resolution	Baseline	Baseline
Contrast	Baseline	Baseline
Uniformity and noise	Baseline	Baseline
Cone-beam CT (kV and MV)		
Geometric distortion	≤2 mm	≤1 mm
Spatial resolution	Baseline	Baseline
Contrast	Baseline	Baseline
HU constancy	Baseline	Baseline
Uniformity and noise	Baseline	Baseline
Annual (A)		
Planar MV imaging (EPID)		
Full range of travel SDD	±5 mm	±5 mm
Imaging dose[e]	Baseline	Baseline
Planar kV imaging		
Beam quality/energy	Baseline	Baseline
Imaging dose	Baseline	Baseline
Cone-beam CT (kV and MV)		
Imaging dose	Baseline	Baseline

Image Dose

- Previously discussed – assess dosimetric aspects of defined imaging protocols

Accuracy of CT Numbers

- If IGRT technique is used for re-computation of dose, and for general purposes, the CT numbers must be 1) determined and set accordingly, and 2) measured routine to insure stability.
- Typical approach: electron density phantom, differing imaging parameters according to defined imaging protocols.

Physics Effort for QA Procedures

TABLE III. Estimated human resources required for image guidance using CT-based IGRT technologies. Estimates are obtained from the collected experiences of the task group members. More time is required when performing commissioning and quality control testing of 2D functions on some platforms.

Activity	Responsibility	Time	Notes
Acceptance testing and commissioning	Physicists	2.5 days	
Education	Physicists	2 days	First install only
	Therapists	2 days	First install only
	Dosimetrists	2 days	First install only
Operation	Therapists	5 mins/patient	Each treatment with IGRT; includes image acquisition and evaluation
	Dosimetrists	10 min/patient	Data transfers to imaging platform
Review of images	Physicians	5 min/scan	0 when performed by therapists
Daily quality control tests	Therapists	10 min	
Monthly quality control tests	Physicists	1–2 h	
Annual quality control tests	Physicists	2–4 h	
Continued clinical support	Physicists	0.05 full-time equivalent position	Ad hoc activity

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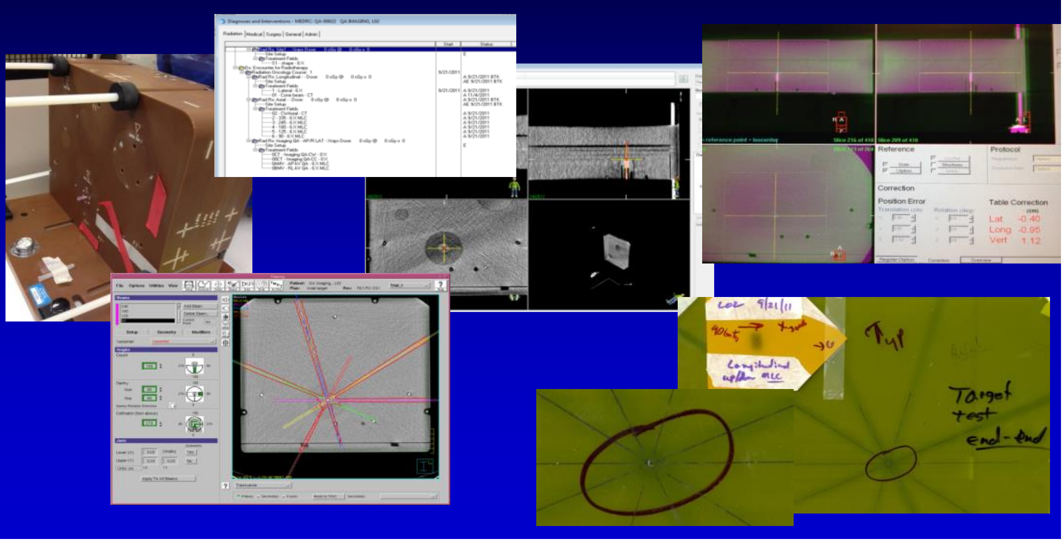
End-to-End Test

Verify the fidelity and accuracy of the “system”



AAPM Practice Guideline 2.a

JOURNAL OF APPLIED CLINICAL MEDICAL PHYSICS, VOLUME 15, NUMBER 1, 2014

AAPM Medical Physics Practice Guideline 2.a: Commissioning and quality assurance of X-ray–based image-guided radiotherapy systems

Task Group Authors: Jonas D. Fontenot, Hassaan Alkhatib, Jeffrey A. Garrett, Andrew R Jensen, Steven P. McCullough, Arthur J. Olch, Brent C. Parker, Ching-Chong Jack Yang, Lynne A. Fairobent, AAPM Staff

a. Goals and Rationale

This document is part of a series of medical physics practice guidelines commissioned by the American Association of Physicists in Medicine (AAPM) intended to succinctly state the minimum acceptable standards for various aspects of clinical medical physics.

- Gantry-mounted two-dimensional MV imaging systems
- Gantry-mounted three-dimensional MV imaging systems
- Gantry-mounted two-dimensional kV imaging systems
- Gantry-mounted three-dimensional kV imaging systems
- Room-mounted two-dimensional kV imaging systems
- Room-mounted three-dimensional kV imaging systems

Staffing: AAPM Practice Guideline 2.a

a. Medical Physicist — The qualified medical physicist (QMP) **must** be competent to practice independently in the subfield of therapeutic radiological physics. The individual **must** be certified either by the American Board of Radiology, American Board of Medical Physicists, or the Canadian College of Medical Physicists. Responsibilities of the qualified medical physicist in an IGRT program include:

- Acceptance testing and commissioning
- Implementing and managing a quality assurance program
- Developing and implementing standard operating procedures (including imaging protocols and repositioning thresholds)

The QMP may be assisted by medical physics residents or medical physicist assistants with these responsibilities provided 1) these individuals have been appropriately trained to perform the assigned tasks, and 2) the QMP provides general supervision of all work performed.

Staffing: AAPM Practice Guideline 2.a

b. Radiation Oncologist — The radiation oncologist **should** meet qualifications outlined in the ACR-ASTRO practice guideline for clinical use of IGRT.[10] In short, the responsibilities of the radiation oncologist in an IGRT program include:

- Specifying patient positioning procedures
- Specifying imaging modalities and frequencies
- Identifying registration targets and repositioning thresholds
- Conducting timely review of clinical IGRT images
- Conducting regular reviews of the IGRT program
- Implementing and managing a quality assurance program
- Developing and implementing standard operating procedures (including imaging protocols and repositioning thresholds)

c. Medical Dosimetrist — The medical dosimetrist **should** meet the qualifications outlined in the *Scope of Practice of a Medical Dosimetrist* approved by the Board of Directors of the American Association of Medical Dosimetrists.[11] Responsibilities of the medical dosimetrist or treatment planner in an IGRT program include:

- Creating and transferring to the OIS all patient-specific data necessary for IGRT implementation

Staffing: AAPM Practice Guideline 2.a

d. Radiation Therapist — The radiation therapist **should** meet the qualifications outlined in *Radiation Therapy Practice Standards* issued by the American Society of Radiologic Technologists.[12] Responsibilities of the radiation therapist in an IGRT program include:

- Understanding the use of positioning devices in IGRT
- Preparing the IGRT system for acquisition of patient-specific positioning verification images
- Implementing the IGRT treatment protocol under the supervision of the radiation oncologist and medical physicist
- Acquiring positioning verification images for review by the radiation oncologist
- Assisting in periodic review of the stability of the IGRT system (e.g., daily QA)

e. Information Technologist — It is important that each facility identify an individual that is responsible for providing and maintaining resources necessary for storing, archiving and retrieving images generated during IGRT. This may be accomplished by a dedicated Information Specialist or duties assigned to another team member.

Commissioning and QA: AAPM PG 2.a

TABLE 1. Recommended minimum practices for commissioning and QA of an IGRT system.

Acceptance Testing and Commissioning	
Procedure	
Customer acceptance procedures	
TPS integration	
OIS integration	
Establish routine QA baselines	
QA documentation	
Routine Quality Assurance	
Procedure	*Tolerance*
Daily	
Safety/interlocks	*Functional*
Imaging-treatment isocenter coincidence (SRS only)	1 mm
Positioning/repositioning (SRS only)	1 mm
Imaging-treatment isocenter coincidence (SBRT only)	2 mm
Positioning/repositioning (SBRT only)	2 mm
Weekly	
Imaging-treatment isocenter coincidence (non-SRS/SBRT)	2 mm
Positioning/repositioning (non-SRS/SBRT)	2 mm
Semi-annually	
Image scaling	2 mm
Annually	
Imaging dose	
2D MV	± 1 cGy of baseline value
2D kV (static imaging mode)	± 3 mGy of baseline value
2D kV (fluoroscopy mode)	± 1 cGy/min of baseline value
All 3D imaging modes	± 1 cGy of baseline value
Image quality	
2D (spatial resolution, contrast)	Baseline value
3D (uniformity, spatial resolution, contrast)	
Upgrade/Repair/Service	
Verify / Reestablish QA baselines (as appropriate)	

SRS = stereotactic radiosurgery; SBRT = stereotactic body radiation therapy.

Commissioning and QA: AAPM PG 2.a

Procedures Described

- Customer acceptance procedures
- TPS configuration and connectivity
- OIS integration and connectivity
- Routine QA baselines
- IGRT QA program documentation

- Safety and interlocks
- Image contrast
- Spatial resolution
- Image scale
- Image uniformity
- Imaging-treatment isocenter coincidence
- Table positioning, repositioning
- Image dose

ACR-AAPM Technical Standard
Medical Physics and IGRT

Revised 2014 (Resolution 36)*

ACR–AAPM TECHNICAL STANDARD FOR MEDICAL PHYSICS PERFORMANCE MONITORING OF IMAGE-GUIDED RADIATION THERAPY (IGRT)

The Qualified Medical Physicist is responsible for the technical aspects of IGRT. Those responsibilities should be clearly defined and should include the following:

1. Acceptance testing and commissioning of the IGRT system, thereby assuring its mechanical, software, and geometric precision and accuracy, as well as image quality verification and documentation. This includes:
   a. Communication with the treatment planning system
   b. Communication with the treatment delivery system
   c. Evaluation of adequate image quality and imaging dose
   d. Testing of image registration software and translation to patient shift coordinates
   e. Communication of patient data between storage, retrieval, and display devices

2. Implementation and management of a QA program for the IGRT system to monitor and assure each of the following:
   a. The geometric relationship between the image guidance system and the treatment delivery system.
   b. The proper functioning of the registration software that compares planning image datasets to IGRT datasets.

3. Together with the radiation oncologist, development, implementation and documentation of standard operating procedures (SOPs) for the use of IGRT (including how, when, and who the IGRT procedures should be done for each patient treatment protocol).

ACR-AAPM Technical Standard
Medical Physics and IGRT

A. Equipment Performance and Integration

An image-guidance system consists of components to acquire images (radiation sources, detectors, and their mechanical assemblies), measure position (image alignment tools), and perform adjustments (interfaces and equipment for position adjustment). Each of these components requires validation prior to implementation as well as routine checks to ensure safe and effective utilization.

1. Image quality
   Image quality is typically characterized by physical measurements such as contrast, resolution, and noise. It can also be evaluated by its impact on the performance of a person or alignment system that uses the images (eg, via a receiver operation characteristic curve). It is important that consistent measurement methods and phantoms are used for image quality evaluation, and that the methods are ultimately tied to the ability to use these images in practices. AAPM TG-142 and TG-179 provide recommendations for best and minimum QA practices, respectively [8,9].

2. Mechanical integrity
   Whether room-mounted and rigid or gantry-mounted and moving, imaging equipment must be able to maintain a known relationship to the treatment coordinate system. The configuration and its stability should be established and monitored (eg, checking of flex maps for centering projections as a function of angle in a gantry mounted system). AAPM TG-142 and TG-226 provide recommendations for best and minimum QA practices, respectively [8,10].

3. Registration software
   IGRT equipment has both manual and automated alignment tools. These tools have advantages and limitations, should be understood by evaluation prior to patient imaging. Accuracy and reproducibility of alignment results should be tested using images similar to those expected to be acquired in a clinic. AAPM TG-142 and TG-226 provide recommendations for best and minimum QA practices, respectively [8,10].

ACR-AAPM Technical Standard
Medical Physics and IGRT

4. Motion-management system
Use of motion management in IGRT may be done by multiple methods. Each of these methods requires its own evaluation for accuracy and effectiveness. Appropriate QA testing of each methodology should be done prior to its incorporation into the IGRT process. AAPM TG-76 and AAPM TG-142 contain useful recommended guidelines for QA and implementation of respiratory motion management [8,11].

5. Imaging dose
Imaging parameters and associated doses for different IGRT applications should also be carefully assessed as defined by AAPM TG-75 [12]. It is important to clearly understand the imaging dose to the whole imaging volume for each IGRT procedure, especially when it applies to motion imaging. Note that the imaging volume is much larger than the treatment volume [12].

6. System integration
There are many commercially available QA phantoms for testing IGRT systems, and an appropriate phantom should be considered essential for IGRT implementation. These phantoms and various test devices often come with a description of the recommended test procedure. It is essential that users verify the appropriateness of the test equipment to ensure the accuracy and precision of the different IGRT systems in their clinic.

ACR-AAPM Technical Standard
Medical Physics and IGRT

End-to-end Test

The following list describes elements of a typical end-to-end test that can be used to evaluate an IGRT system:

a. A solid phantom that includes a number of high-contrast markers and line patterns can be used to verify the performance of the IGRT system. A motion simulator may be used in conjunction with the phantom to evaluate motion-management strategies.
b. The procedure should start with a CT simulation process that scans the phantom to locate the position of the markers (or targets and critical organs).
c. The treatment planning system is used to target each marker with at least 2 small treatment fields that are orthogonal or near orthogonal.
d. The phantom is positioned within the coordinate frame of the delivery system in accordance with the previously generated treatment plan. Setup deviations from planned treatment are introduced by displacing the phantom with translations of known magnitude. Rotational errors can also be introduced to test the correction process when a patient support system with 6 degrees of freedom is available.
e. After phantom imaging and image registration, the calculated translational and/or rotational displacements are applied in accordance with the clinical procedure for error corrections. Positioning errors are commonly corrected by treatment couch displacements controlled remotely from the delivery system console. Verification images should be taken after positioning to validate the intended shifts.
f. An independent imaging system (eg, electronic imager or film) is then used to demonstrate that the markers appear with the small treatment fields at the predicted position.
g. The record of the IGRT procedure registered in the radiation oncology information system should be inspected to confirm accurate reporting on the session in terms of applied displacements and timeline.

ACR-AAPM Technical Standard
Medical Physics and IGRT

B. Correction Strategies

Use of image guidance involves determining a strategy for selecting when to measure, which method to use (eg, laser, x-ray, CT), and how to act on a measurement. Included in these decisions are selection of appropriate staff qualifications and training. It is critical that implementation and maintenance of IGRT be supported by a rigorous program of documentation and training [2].

C. Patient Dose

Imaging dose assessment is an important component for IGRT QA as recommended in AAPM TG-75 [12]. IGRT methods using ionizing radiation will deliver an absorbed radiation dose to the patient that can in some situations be a significant portion of the prescribed dose for treatment. Furthermore, x-ray imaging irradiates a significantly larger region than the treatment volume, and therefore doses to critical structures may be larger than intended. Management of the IGRT doses requires radiation physics expertise because 1) the method of measuring dose depends on the imaging geometry (eg, 2-D or 3-D, fan beam or cone beam) and 2) comparing generalized diagnostic imaging metrics, such as air kerma or CT dose index, to individualized therapeutic absorbed doses is nontrivial.

ACR-AAPM Technical Standard
Medical Physics and IGRT

4. Motion-management system
   Use of motion management in IGRT may be done by multiple methods. Each of these methods requires its own evaluation for accuracy and effectiveness. Appropriate QA testing of each methodology should be done prior to its incorporation into the IGRT process. AAPM TG-76 and AAPM TG-142 contain useful recommended guidelines for QA and implementation of respiratory motion management [8,11].

5. Imaging dose
   Imaging parameters and associated doses for different IGRT applications should also be carefully assessed as defined by AAPM TG-75 [12]. It is important to clearly understand the imaging dose to the whole imaging volume for each IGRT procedure, especially when it applies to motion imaging. Note that the imaging volume is much larger than the treatment volume [12].

6. System integration
   There are many commercially available QA phantoms for testing IGRT systems, and an appropriate phantom should be considered essential for IGRT implementation. These phantoms and various test devices often come with a description of the recommended test procedure. It is essential that users verify the appropriateness of the test equipment to ensure the accuracy and precision of the different IGRT systems in their clinic.

Summary

- CT-based IGRT devices are imaging devices
- Quality assurance should proceed based on the specific CT technology
- Quality assurance comprises: Mechanicals, Interlocks/Safety, Image Quality and Fidelity, Image Dose, Communications/Data Transfer with/to Other Systems
- Physics effort and instrumentation are required

Summary

Key AAPM and Other Guidance Documents

- AAPM Task Group 179. Quality assurance for image-guided radiation therapy utilizing CT-based technologies. 2012
- AAPM Task Group 75. Murphy MJ, Balter J, Balter S, et al. The management of imaging dose during image-guided radiotherapy: report of the AAPM Task Group 75. Med Phys. 2007;34(10):4041-4063.
- AAPM Task Group 104. The role of in-room kV X-Ray imaging for patient setup and target localization. 2009
- AAPM Task Group 142. Quality assurance of medical accelerators. Klein et al. Med. Phys. 36(9): 4197-4212. 2009
- ACR–AAPM Technical Standard for Medical Physics Performance Monitoring of Image-guided radiation therapy (IGRT). Revised 2014 (Resolution 36)
- ACR-ASTRO Practice Parameter for Image-Guided Radiation Therapy (IGRT). Revised 2014 (CSC/BOC)