KIM QA Instructions

You need

- **CDOG** (contact Peter Greer).

- **KIM** (Chandrima Sengupta/Paul Keall)

- **Robot** (Chandrima/Paul Keall) or **other type of moving platform**

Robot information link and instructions: https://github.com/ACRF-Image-X-Institute/6-DoF-Robotic-Motion-Phantom

KIM QA analysis codes and a sample KIM commissioning report: https://github.com/ChandrimaSengupta/KIM-QA-Analysis/tree/main/KIM-QA-Analysis-master

KIM Commissioning Requirements

- CDOG working and acquiring images

- Pelvis or Thorax phantom (depending on the trial)

- 3 fiducials inserted in the phantom

- CT scan of the phantom (ideally in 1mm slice)

- A basic plan for the phantom with kV and CBCT images

- A moving platform

KIM Commissioning Tests

- **Static tests:** The static localization accuracy tests are used to assess whether KIM can determine static positions accurately and determine the direction of static shifts correctly to ensure the KIM and patient coordinate systems are the same. The accuracy of the determination of the static phantom position was measured against the known shift and correctness of the directions of these shifts was assessed.

- **Dynamic tests:** Dynamic localization refers to the accuracy of KIM determined trajectories and was assessed against the programmed 3D prostate/liver trajectory of the HexaMotion/Robot. No gating tolerance is applied and these trajectories are completed without treatment interruption.

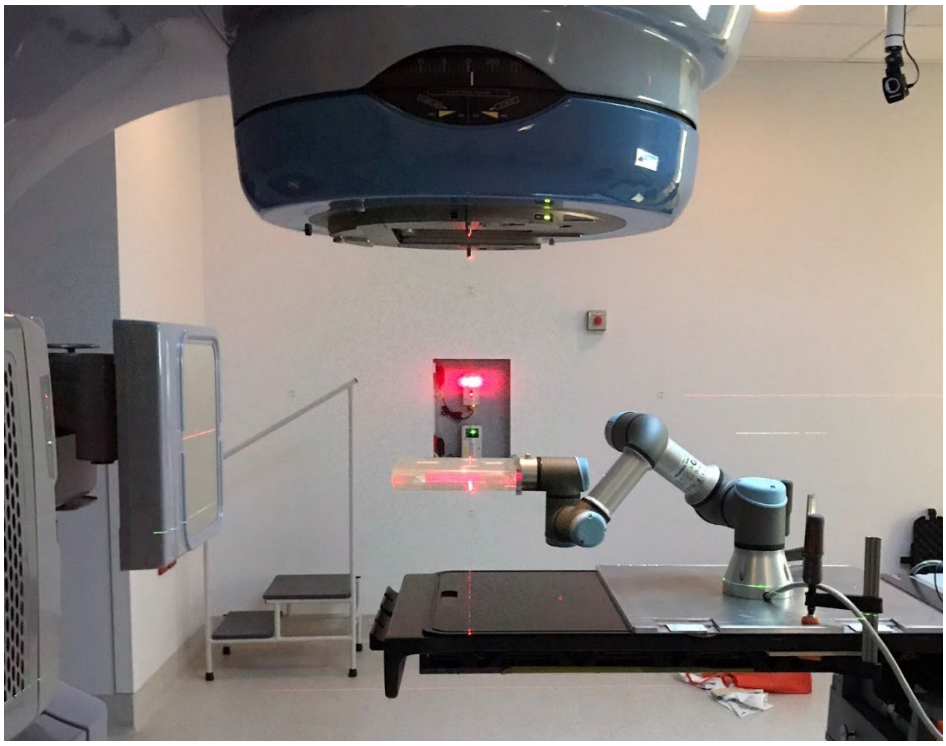
- **Treatment Interruption tests:** The treatment interruption accuracy test determines how accurately KIM can monitor the actual target motion under the clinically realistic situation where a position threshold has been exceeded during treatment and a couch shift been performed.

- **Latency test**: Verify that there is no significant latency in KIM by checking the gantry angle on the linac interface and KIM interface at any given instance.

Frequency of the KIM QA tests: KIM QA tests should be performed every month at each KIM site or after any KIM/CDOG/hardware update.

Experimental setup:

1. Place the robot on the treatment couch and mount the phantom on the robot to align the indicated black line to room lasers as shown below (Follow ‘Getting Started’ robot manual for the setup procedure).
2. Connect the robot to the laptop containing the software and launch the software. Run a trace to make sure that there is enough room for the robot to move.



Common procedures for all QA tests:

1. Position the phantom with the room laser.
2. Rotate gantry 360° to check the gantry clearance.
3. Select an appropriate plan.
4. Perform kV/kV match or MFOV CBCT -> apply 6 DoF correction

After the initial positioning is done, we will use SFOV for KIM learning and the rest of the treatment/QA.

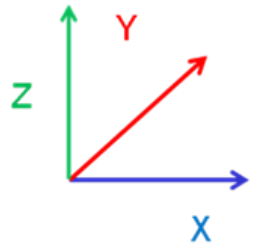
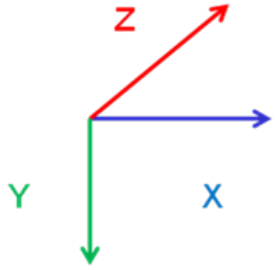
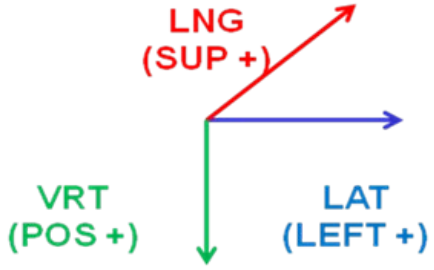
1. Static localization form

Date	
Physicist	
Linac	
KIM software version	
Initial couch position	VRT: LNG: LAT:

Direction (5mm)	**Robot position (mm)**			**Comments**
	X	Y	Z	
Initial	0.0	0.0	0.0	
+5mm Sup	0.0	5.0	0.0	
-5mm Sup	0.0	-5.0	0.0	
+5mm Left	5.0	0.0	0.0	
-5mm Left	-5.0	0.0	0.0	
+5mm Ant	0.0	0.0	5.0	
-5mm Ant	0.0	0.0	-5.0	

Notes:

KIM/Robot and Varian coordinate systems

Poulsen for KIM / IEC /Robot	Varian Eclipse TPS / DICOM	Varian Couch Coordinates
		

Process:

Acquire pre-treatment arc and treatment arc with KIM for Initial position, Superior, Inferior, Left, Right, Anterior and Posterior directions.

1. Start KIM. For KIM learning arc, use a SFOV.
2. Acquire a single kV image. Check if the red crosses are inside the green squares for each marker. If not, then restart the KIM software and load the correct patient file. If yes, complete the rest of the CBCT.
3. Once the learning arc is completed, start the treatment arc.
4. Complete two treatment arcs for Initial position, Superior, Inferior, Left, Right, Anterior and Posterior directions.

Criteria:

Mean and SD of difference between programmed and detected amplitude of motion is < 1mm and 2 mm respectively.

2. Dynamic localization form

Date	
Physicist	
Linac	
KIM software version	
Initial couch position	VRT: LNG: LAT:

Trajectory		**Comments**
Stable		
Continuous		
Persistent Excursion		
Transient Excursion		
High-frequency Excursion		
Erratic Behaviour		

Use the relevant traces for your trial:

https://github.com/ChandrimaSengupta/KIM-QA-Analysis/tree/main/KIM-QA-Analysis-master/Robot%20traces

Dynamic localization procedure

Need:

- Robot
- Phantom
- Scheduled arc plan
- Liver/prostate trajectories

Process:

Acquire pre-treatment arc and treatment arc with KIM for all the motion trajectories.

1. Start KIM. For KIM learning arc, use a SFOV.
2. Once the learning arc is completed, start a treatment arc.
3. Run all the traces.Tip: Start the robot first, once the robot moves, start CDOG acquisition.

Criteria:

Mean and SD of difference between programmed and detected motion is <1 mm and < 2 mm respectively.

3. Treatment interruption form

Date	
Physicist	
Linac	
KIM software version	
Trajectories folder	
Initial couch position	VRT: LNG: LAT:

Trajectory	Acquired?	Couch position	VRT (cm)	LNG (cm)	LAT (cm)
Large SI AP Breath hold		1			
		2			
		3			
		4			
Transient breath hold		1			
		2			
		3			
		4			
		1			
		2			
		3			
		4			
		1			
		2			
		3			
		4			
		5			

Notes:

Treatment interruption procedure

Need:

- Robot
- Phantom
- Scheduled arc plan
- Liver trajectories
- Activate remote couch shifts.

Process:

Acquire pretreatment arc and treatment arc with KIM for all the motion trajectories.

1. Start KIM. For KIM learning arc, use a SFOV.
2. Once the learning arc is completed, start the treatment arc.
3. Run the traces. If KIM indicates to stop the beam -> Terminate the beam -> Open Couch Move Assistant -> Enter the couch shift from KIM -> Check the final couch positions from KIM and in the linac match -> Press ‘Send’.
4. Start the treatmnet arc and make sure KIM picks up the markers correctly and the relevant directions are shifted close to zero.

Criteria:

1. KIM software does not crash during the entire procedure
2. Mean and SD of difference between programmed and detected amplitude of motion is < 1 mm and <2 mm respectively.