

QIBA Profile:

<Title of the Profile> (<Acronym>)

Stage: A. Initial Draft

|  |  |  |
| --- | --- | --- |
| **Notation in this Template** | | |
| **Template Element** | **Appears as** | **Instructions** |
| Boilerplate text | Plain black text | Don't change.  Should appear in all profiles. |
| Example text | Plain grey text | Provides an example of content and wording appropriate to that location.  Rewrite it to your needs and change the text color back to Automatic (which will make it black). |
| Placeholder | <text in angle brackets> | Replace text and <> with your text.  Use Find/Replace for ones that appear frequently. |
| Guidance | Comment with "GUIDANCE" at the top. | Delete it when you've followed it and don't need it anymore. |

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# Change Log:

This table is a best-effort of the authors to summarize significant changes to the Profile.

|  |  |  |
| --- | --- | --- |
| **Date** | **Sections Affected** | **Summary of Change** |
| 2015.10.10 | All | Major cleanup based on comments resolved in the Process Cmte.  Also had to remove a few hundred extraneous paragraph styles. |
| 2015.10.21 | All | Approved by Process Cmte |
| 2015.11.04 | 2 (Claims)  3 (Requirements) | Incorporating the more refined form of the claim language and referenced a separate claim template.  Added Voxel Noise requirement to show example of the linkage between the requirement and the assessment procedure. |
|  |  |  |

# Open Issues:

The following issues are provided here to capture associated discussion, to focus the attention of reviewers on topics needing feedback, and to track them so they are ultimately resolved. In particular, comments on these issues are highly encouraged during the Public Comment stage.

|  |
| --- |
| **Q.**  A. |
| **Q.**  A. |

# Closed Issues:

The following issues have been considered closed by the biomarker committee. They are provided here to forestall discussion of issues that have already been raised and resolved, and to provide a record of the rationale behind the resolution.

|  |
| --- |
| **Q. Is this template open to further revisions?**  A. Yes.  This is an iterative process by nature.  Submit issues and new suggestions/ideas to the QIBA Process Cmte. |
| **Q.**  A. |

# 1. Executive Summary

The goal of a QIBA Profile is to help achieve a useful level of performance for a given biomarker.

The **Claim** (Section 2) describes the biomarker performance.  
The **Activities** (Section 3) contribute to generating the biomarker. Requirements are placed on the **Actors** that participate in those activities as necessary to achieve the Claim.   
**Assessment Procedures** (Section 4) for evaluating specific requirements are defined as needed.

This QIBA Profile (<Title of the Profile>) addresses tumor volume change which is often used as a biomarker of disease progression or response to treatment. It places requirements on Acquisition Devices, Technologists, Radiologists, Reconstruction Software and Image Analysis Tools involved in Subject Handling, Image Data Acquisition, Image Data Reconstruction, Image QA and Image Analysis.

The requirements are focused on achieving sufficient accuracy and avoiding unnecessary variability of the tumor volume measurements.

The clinical performance target is to achieve a 95% confidence interval for the tumor volume change with precision of-25% to +30%.

This document is intended to help clinicians basing decisions on this biomarker, imaging staff generating this biomarker, vendor staff developing related products, purchasers of such products and investigators designing trials with imaging endpoints.

Note that this document only states requirements to achieve the claim, not “requirements on standard of care.” Conformance to this Profile is secondary to properly caring for the patient.

QIBA Profiles addressing other imaging biomarkers using CT, MRI, PET and Ultrasound can be found at qibawiki.rsna.org.

# 2. Clinical Context and Claims

Clinical Context

Quantifying the volumes of tumors and measuring tumor longitudinal changes within subjects; i.e. evaluating growth or regression with image processing of CT scans acquired at different time points.

**Conformance to this Profile by all relevant staff and equipment supports the following claim(s):**

Claim 1: A measured increase in mass volume of 30% or more indicates that a true increase has occurred with 95% confidence.

Claim 2: For a measured change in mass volume of *X*, a 95% confidence interval for the true change is [*X*-25%, *X*+30%].

**This claim holds when:**

* **the tumor is measurable at both timepoints (i.e., tumor margins are sufficiently conspicuous and geometrically simple enough to be recognized on all images in both scans; the tumor is unattached to other structures of equal density)**
* **the tumor longest in-plane diameter is between 10 mm (volume 0.5 cm3) and 100 mm (volume 524 cm3) at both timepoints**

Claim 3: For a measured volume of *X*, a 95% confidence interval for the true volume is *X* ± 15%.

**Discussion**

These claims are based on estimates of the within-nodule coefficient of variation (wCV) for nodules in this size range. In the claim statement the CI is expressed as Y ± 1.96 × Y × wCV. The claim assumes that the wCV is constant for nodules in the specified size range and that there is negligible bias in the measurements (i.e. bias < 5%). For estimating the critical % change, the % Repeatability Coefficient (%RC) is used: 2.77 × wCV × 100.

The -25% and +30% boundaries can be thought of as “error bars” or “noise” around the measurement of volume change. If you measure change within this range, you cannot be certain that there has really been a change. However, if a tumor changes size beyond these limits, you can be 95% confident there has been a true change in the size of the tumor, and the perceived change is not just measurement variability. Note that this does not address the biological significance of the change, just the likelihood that the measured change is real.

Clinical interpretation with respect to the magnitude of true change:   
The magnitude of the true change is defined by the measured change and the error bars (+-83%). If you measure the volume to be 200mm3 at baseline and 380mm3 at follow-up, then the measured change is a 90% increase in volume (i.e., 100x(380-200)/200). The 95% confidence interval for the true change is a 7% to 173% increase in volume. The asymmetric range in Claim 1 (-25% to +30%) is due to the way change is conventionally expressed (as a percentage of the first measurement rather than, say, a percentage of the smaller measurement) and how measurements are performed.

Clinical interpretation with respect to progression or response:  
TBA

The lower bound on the tumor longest in-plane diameter is set to limit the variability introduced when approaching the resolution of the dataset, e.g. partial volume. The upper bound is set to limit the variability introduced by more complex tumor morphology and organ involvement, and also to keep performance assessment procedures manageable.

While Claim 1 has been informed by an extensive review of the literature and expert consensus that has not yet been fully substantiated by studies that strictly conform to the specifications given here. The expectation is that during field test, data on the actual field performance will be collected and any appropriate changes made to the claim or the details of the Profile. At that point, this caveat may be removed or re-stated.

The performance values in Claim 1 reflect the likely impact of variations permitted by this Profile. The Profile permits different compliant actors (acquisition device, radiologist, image analysis tool, etc.) at the two timepoints (i.e. it is not required that the same scanner or image analysis tool be used for both exams of a patient). If one or more of the actors are the same, the implementation is still compliant with this Profile and it is expected that the measurement performance will be improved. To give a sense of the possible improvement, the following table presents expected precision for alternate scenarios, however except for the leftmost, these precision values are **not** Claims of this Profile.

**Table 1: Expected Precision for Alternate Scenarios (Informative)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Different  Acquisition Device | | | | Same  Acquisition Device | | | |
| Different  Radiologist | | Same  Radiologist | | Different  Radiologist | | Same  Radiologist | |
| Different Analysis Tool | Same Analysis Tool | Different Analysis Tool | Same Analysis Tool | Different Analysis Tool | Same Analysis Tool | Different Analysis Tool | Same Analysis Tool |
| **47%** | 46% | 33% | 32% | 38% | 36% | 13% | 11% |

Notes: 1. Precision is expressed here as the total deviation index.

2. A measured change in tumor volume that exceeds the relevant precision value in the table indicates 95% confidence in the presence of a true change.

3. A 95% confidence interval for the magnitude of the true change is given by: ± the relevant precision value.

# 3. Profile Activities

The Profile is documented in terms of “Actors” performing “Activities”. Equipment, software, staff or sites may claim conformance to this Profile as one or more of the “Actors” in the following table.

Conformant Actors shall support the listed Activities by conforming to all requirements in the referenced Section.

Table 1: Actors and Required Activities

|  |  |  |
| --- | --- | --- |
| **Actor** | **Activity** | **Section** |
| Acquisition Device | Pre-delivery | 3.1. |
| Subject Handling | 3.5. |
| Image Data Acquisition | 3.6. |
| Technologist | Subject Handling | 3.5. |
| Image Data Acquisition | 3.6. |
| Image Data Reconstruction | 3.7. |
| Radiologist | Subject Handling | 3.5. |
| Image QA | 3.8. |
| Image Analysis | 3.10. |
| Reconstruction Software | Image Data Reconstruction | 3.7. |
| Image Analysis Tool | Image Analysis | 3.10. |

The requirements in this Profile do not codify a Standard of Care; they only provide guidance intended to achieve the stated Claim. Failing to conform to a “shall” in this Profile is a protocol deviation. Although deviations invalidate the Profile Claim, such deviations may be reasonable and unavoidable and the radiologist or supervising physician is expected to do so when required by the best interest of the patient or research subject. How study sponsors and others decide to handle deviations for their own purposes is entirely up to them.

The sequencing of the Activities specified in this Profile are shown in Figure 1:

<activity sequence diagram>

Figure 1: <Title of the Profile> - Activity Sequence

## 3.1. Pre-delivery

This activity describes calibrations, phantom imaging, performance assessments or validations prior to delivery of equipment to a site (e.g. performed at the factory) that are necessary to reliably meet the Profile Claim.

### 3.1.1 Discussion

### 3.1.2 Specification

| **Parameter** | **Actor** | **Requirement** |
| --- | --- | --- |
|  |  |  |
|  |  |
|  |  |  |

## 3.2. Installation

This activity describes calibrations, phantom imaging, performance assessments or validations following installation of equipment at the site that are necessary to reliably meet the Profile Claim.

### 3.2.1 Discussion

### 3.2.2 Specification

| **Parameter** | **Actor** | **Requirement** |
| --- | --- | --- |
|  |  |  |
|  |  |
|  |  |  |

## 3.3. Periodic QA

This activity describes calibrations, phantom imaging, performance assessments or validations performed periodically at the site, but not directly associated with a specific subject, that are necessary to reliably meet the Profile Claim.

### 3.3.1 Discussion

### 3.3.2 Specification

| **Parameter** | **Actor** | **Requirement** |
| --- | --- | --- |
| PET Calibration Factor | Physicist | Shall assess the current PET Calibration Factor at least quarterly.  See 4.3 Assessment Procedure: PET Calibration Factor.  Shall record the date/time of the calibration for auditing. |
| Acquisition Device | Shall be capable of performing the PET Calibration Factor assessment.  Shall record the most recent PET Calibration Factor for use in subsequent activities. |
| Qualification | Physicist | Shall be a Qualified Medical Physicist (QMP) as defined by AAPM. |
| Time sync | Physicist | Shall confirm on a weekly basis that all device clocks are synchronized to within +- 1 minute. |

## 3.4. Subject Selection

This activity describes criteria and procedures related to the selection of appropriate imaging subjects that are necessary to reliably meet the Profile Claim.

### 3.4.1 Discussion

### 3.4.2 Specification

| **Parameter** | **Actor** | **Requirement** |
| --- | --- | --- |
|  |  |  |
|  |  |
|  |  |  |

## 3.5. Subject Handling

This activity describes details of handling imaging subjects that are necessary to reliably meet the Profile Claim.

### 3.4.1 Discussion

### 3.4.2 Specification

| **Parameter** | **Actor** | **Requirement** |
| --- | --- | --- |
|  |  |  |
|  |  |
|  |  |  |

## 3.6. Image Data Acquisition

This activity describes details of the data acquisition process that are necessary to reliably meet the Profile Claim. It may also include calibrations, performance assessments or validations during acquisition (such as laying the subject on a calibrator or placing a pocket phantom next to the subject) that are necessary to reliably meet the Profile Claim.

### 3.6.1 Discussion

### 3.6.2 Specification

| **Parameter** | **Actor** | **Requirement** | **DICOM Tag** |
| --- | --- | --- | --- |
|  |  |  |  |
|  |  |  |
|  |  |  |  |

## 3.7. Image Data Reconstruction

This activity describes criteria and procedures related to producing images from the acquired data that are necessary to reliably meet the Profile Claim.

### 3.7.1 Discussion

### 3.7.2 SPECIFICATION

| **Parameter** | **Actor** | **Requirement** |
| --- | --- | --- |
|  |  |  |
|  |  |
|  |  |  |

## 3.8. Image QA

This activity describes criteria and evaluations of the images that are necessary to reliably meet the Profile Claim.

### 3.8.1 Discussion

**Tumor Size** can affect the accuracy of measurements. Both theoretical considerations and the groundwork projects done by QIBA indicate that for tumors that are small, errors in measurement represent a greater percentage of the measured size. For tumors that are smaller than the limits defined in this profile, please see the profile produced by the QIBA Small Nodule group for more information on imaging recommendations and performance claims. For tumors that are extremely large, the limitations on measurement are based less on imaging physics and more on anatomy. Such tumors are likely to cross anatomical boundaries and abut structures that make consistent segmentation difficult.

**Tumor Margin Conspicuity** refers to the clarity with which the boundary of the tumor can be discerned from the surroundings. Conspicuity can directly impact the ability to segment the tumor to properly determine its volume. Conspicuity problems can derive from poor contrast enhancement, from the inherent texture, homogeneity or structure of the tumor, or from attachment of the tumor to other structures.

### 3.8.2 SPECIFICATION

| **Parameter** | **Actor** | **Requirement** |
| --- | --- | --- |
| Tumor Size | Radiologist | Shall confirm (now or during measurement) that tumor longest in-plane diameter is between 10 mm and 100 mm.  (For a spherical tumor this would roughly correspond to a volume between 0.5 cm3 and 524 cm3.) |
| Tumor Margin Conspicuity | Radiologist | Shall confirm the tumor margins are sufficiently conspicuous and unattached to other structures of equal density to distinguish the volume of the tumor. |

## 3.9. Image Distribution

This activity describes criteria and procedures related to distributing images that are necessary to reliably meet the Profile Claim.

### 3.9.1 Discussion

### 3.9.2 Specification

| **Parameter** | **Actor** | **Requirement** |
| --- | --- | --- |
|  |  |  |
|  |  |
|  |  |  |

## 3.10. Image Analysis

This activity describes criteria and procedures related to producing measurements from the images that are necessary to reliably meet the Profile Claim.

### 3.10.1 Discussion

### 3.10.2 Specification

| **Parameter** | **Actor** | **Requirement** |
| --- | --- | --- |
|  |  |  |
|  |  |
|  |  |  |

## 3.11. Image Interpretation

This activity describes criteria and procedures related to clinically interpreting the measurements and images that are necessary to reliably meet the Profile Claim.

### 3.11.1 Discussion

### 3.11.2 Specification

| **Parameter** | **Actor** | **Requirement** |
| --- | --- | --- |
|  |  |  |
|  |  |
|  |  |  |

# 4. Assessment Procedures

To conform to this Profile, participating staff and equipment (“Actors”) shall support each activity assigned to them in Table 1.

To support an activity, the actor shall conform to the requirements (indicated by “shall language”) listed in the specifications table of the activity subsection in Section 3.

Although most of the requirements described in Section 3 can be assessed for conformance by direct observation, some of the performance-oriented requirements cannot, in which case the requirement will reference an assessment procedure in a subsection here in Section 4.

Formal claims of conformance by the organization responsible for an Actor shall be in the form of a published QIBA Conformance Statement. Vendors publishing a QIBA Conformance Statement shall provide a set of “Model-specific Parameters” (as shown in Appendix D) describing how their product was configured to achieve conformance. Vendors shall also provide access or describe the characteristics of the test set used for conformance testing.

## 4.1. Assessment Procedure: Voxel Noise

This procedure can be used by a vendor or an imaging site to assess the voxel noise of reconstructed images. Voxel noise is assessed in terms of the standard deviation of pixel values when imaging a material with uniform density.

The assessor shall first warm up the scanner’s x-ray tube and perform calibration scans (often called air-calibration scans) according to scanner manufacturer recommendations. The assessor shall then scan a phantom of uniform density, such as the ACR CT Accreditation Program (CTAP) Phantom’s module 3, which is a 20 cm diameter cylinder of water equivalent material. The phantom shall be placed at the isocenter of the scanner. The acquisition protocol and reconstruction parameters shall conform to this Profile (See Section 3.6.2 and 3.7.2). The same protocol and parameters shall be used when performing the assessments in 4.1 and 4.2.

When the scan is performed, the assessor shall select a single representative slice from the uniformity portion of the phantom. An approximately circular region of interest (ROI) of at least 400 mm2 shall be placed near the center of the phantom.

The assessor shall record the values reported for the ROI mean and standard deviation.

The procedure described above is provided as a reference method. Sites or vendors may submit to QIBA a proposed alternative method (such as using the water phantom portion of a manufacturer’s QA phantom) and evidence that the results produced by the proposed method are equivalent to this reference method. Upon review and approval by QIBA, the alternative method will also become an accepted assessment procedure in this Profile.

The test procedure described here is based on the use of conventional filtered backprojection reconstruction methods; extreme care must be taken when iterative reconstruction methods are used as their use may invalidate some of the assumptions inherent in this method.

## 4.2. Assessment Procedure: <Parameter Y>

## 4.3. Assessment Procedure: PET Calibration Factor

This procedure can be used by a vendor, physicist or an imaging site to assess the PET Calibration Factor of an acquisition device. PET Calibration Factor is assessed in terms of compensating value that needs to be applied to get the image voxel values produced by the acquisition device to match the known activity in kBq/mL of scanned phantom. The units of the PET Calibration factor are kBq/mL divided by the arbitrary units used by the acquisition device to record image voxel values.

The assessor shall scan a phantom of uniform …

# References

# Appendices

## Appendix A: Acknowledgements and Attributions

## Appendix B: Background Information

## Appendix C: Conventions and Definitions

## Appendix D: Model-specific Instructions and Parameters

For acquisition modalities, reconstruction software and software analysis tools, profile conformance requires meeting the activity specifications above in Sections 2, 3 and 4.

This Appendix provides, as an informative tool, some specific acquisition parameters, reconstruction parameters and analysis software parameters that are expected to be compatible with meeting the profile requirements. Just using these parameters without meeting the requirements specified in the profile is not sufficient to achieve conformance. Conversely, it is possible to use different compatible parameters and still achieve conformance.

Sites using models listed here are encouraged to consider using these parameters for both simplicity and consistency. Sites using models not listed here may be able to devise their own settings that result in data meeting the requirements.

**IMPORTANT: The presence of a product model/version in these tables does not imply it has demonstrated conformance with the QIBA Profile. Refer to the QIBA Conformance Statement for the product.**

Table D.1 Model-specific Parameters for Acquisition Devices

| Acquisition Device | Settings Compatible with Conformance |
| --- | --- |
| Acme Medical  CT Lights  V3.14 | *Submitted by: Gotham University Hospital* |
| |  |  | | --- | --- | | kVp | 120 | | Number of Data Channels (N) | 64 | | Width of Each Data Channel (T, in mm) | 0.625 | | Gantry Rotation Time in seconds | 1.0 | | mA | 120 | | Pitch | 0.984 | | Scan FoV | Large Body (500mm) | |

Table D.2 Model-specific Parameters for Reconstruction Software

| Reconstruction Software | Settings Compatible with Conformance |
| --- | --- |
| Acme Medical  CT WS  V3.14 | |  |  | | --- | --- | | Reconstructed Slice Width, mm | 1.25 | | Reconstruction Interval | 1.0mm | | Display FOV, mm | 350 | | Recon kernel | STD | |