IHE Radiology
Technical Framework Supplement

AI Results - Extensions
(AIR+)
For review and comment only.
DO NOT implement this public comment version.

Revision 1.0 – Draft for Public Comment

Date: February 28, 2022
Authors: Radiology Technical Committee
Email: radiology@ihe.net

Please verify you have the most recent version of this document. See here for Trial Implementation and Final Text versions and here for Public Comment versions.

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Foreword

This is a supplement to the IHE Radiology Technical Framework V19.0. Each supplement undergoes a process of public comment and trial implementation before being incorporated into the volumes of the Technical Frameworks.

This supplement is published on February 28, 2022 for public comment. Comments are invited and may be submitted at Radiology Public Comments. In order to be considered in development of the trial implementation version of the supplement, comments must be received by March 29, 2022.

This supplement describes changes to the existing technical framework documents.

“Boxed” instructions like the sample below indicate to the Volume Editor how to integrate the relevant section(s) into the relevant Technical Framework volume.

Amend Section X.X by the following:

Where the amendment adds text, make the added text bold underline. Where the amendment removes text, make the removed text bold strikethrough. When entire new sections are added, introduce with editor’s instructions to “add new text” or similar, which for readability are not bolded or underlined.

General information about IHE can be found at IHE.

Information about the IHE Radiology domain can be found at IHE Domains.

Information about the organization of IHE Technical Frameworks and Supplements and the process used to create them can be found at Profiles and IHE Process.

The current version of the IHE Radiology Technical Framework can be found at Radiology Technical Framework.
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Introduction to this Supplement

This supplement is a Public Comment version of an extension to the AI Results Profile.

The original AI Results Profile (published in 2020, currently in Trial Implementation status) addresses the capture, distribution, and display of medical imaging analysis results. The central use case involves communicating and displaying results generated by artificial intelligence algorithms in a structured way.

To support effective navigation and display of studies with large numbers of AI Results, this Supplement introduces Result Tree objects to encode relationships within the sets of instances. A new named option defines creation behaviors for Evidence Creators and display behaviors for Image Displays.

To support implementation and testing of AI Results, the examples in RAD TF-3: Appendix A are significantly expanded and will be matched with example binary instances. The examples span both the primitives described in the original Profile and the Result Trees introduced here.

When reviewing this supplement, reviewers may find it useful to have the AIR Profile open for reference: https://www.ihe.net/uploadedFiles/Documents/Radiology/IHE_RAD_Suppl_AIR.pdf

When this supplement reaches Trial Implementation, it will be combined into a single document with the AIR Profile.

Open Issues

<table>
<thead>
<tr>
<th></th>
<th>Q. Should the Result Tree Option simply be required for Image Displays?</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The option makes sense for Evidence Creators which might not all create result trees, but we might make required for Image Displays.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Q. Should longitudinal analysis be described and/or explicitly supported?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Assessing the same nodule over multiple studies is an interesting use case.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The current analysis package might &quot;prospectively&quot; detect, correlate and reference the prior results with the current result (which will later become &quot;prior&quot;), or a subsequent package might retrospectively find current/prior related results and create the longitudinal hierarchy.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Would anything need to be added to the Result Tree capabilities to make this work?</td>
<td></td>
</tr>
<tr>
<td>Q.</td>
<td>Are the specified negative finding encodings acceptable?</td>
<td></td>
</tr>
<tr>
<td>----</td>
<td>--------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Negative findings obviously have clinical significance. They can also affect clinical pathways and automated treatment guidelines, triggers in templates, display filters and presentation, database structure and big-data queries.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>As described in 49.4.1.6 Negative and Partial Results, there are a variety of approaches to encoding negative (and positive) findings. But implementation variability reduces interoperability.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Can the profile strengthen the recommendation in 6.5.3.2 to be a constraint on Evidence Creators, or should all Displays and Consumers be required to handle all the ways of encoding negation?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Q.</th>
<th>Should Result Tree be a new DICOM IOD (not just a new template)?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Ultimately this will be a decision of DICOM WG-6, but input is welcome)</td>
</tr>
<tr>
<td></td>
<td>It would allow a more targeted query by using the SOP Class UID as a matching key, not just the Template ID as a return key. It would also permit different constraints on the Content Item relationships without disrupting existing SR SOP Classes.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Q.</th>
<th>Are there regulatory issues with referring to a &quot;result&quot; in the profile?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Some implementers have worried the use of the word &quot;result&quot; in the specification might have implications for FDA 510k labelling, etc. There are similar concerns over the FHIR use of &quot;Observation&quot;. Is anyone aware of such issues in the U.S., Europe, Asia?</td>
</tr>
<tr>
<td></td>
<td>Q. Should details of AI execution/failure be recorded in the results?</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td>During presentation of results, Radiologists will need to be made aware of, or be able to check, details of the execution of AI(s) for the current study such as:</td>
</tr>
<tr>
<td></td>
<td>• whether an AI ran but failed (in whole or in part) and if so, why</td>
</tr>
<tr>
<td></td>
<td>• whether AI processing is still in progress (may choose to delay reading until it is)</td>
</tr>
<tr>
<td></td>
<td>• which AIs were/weren't triggered (based on execution rules/criteria)</td>
</tr>
<tr>
<td></td>
<td>AIW-I knows/tracks execution status and failures, but doesn't have an API for Image Displays to tap that information. Should there be details like that in results? E.g., a failing AI could still create a result object that notes that outcome and error code?</td>
</tr>
<tr>
<td></td>
<td>Dept admin will want to do aggregate (across all studies) management/analysis. E.g., which exams are triggering for a given AI. That might be done via an AIW-I actor.</td>
</tr>
<tr>
<td></td>
<td>Chest CAD SR contains, in TID 4101, the findings generated but also chose to include TID 4015 and 4016 to describe detections and analyses performed by listing the algorithms and the images they worked on and whether they succeeded or failed. <a href="https://dicom.nema.org/medical/dicom/current/output/chtml/part16/sect_TID_4015.html">https://dicom.nema.org/medical/dicom/current/output/chtml/part16/sect_TID_4015.html</a></td>
</tr>
<tr>
<td></td>
<td>It is likely important this information be persisted for both workflow reasons and for medicolegal reasons. But it may be appropriate to encode execution logs separately from clinical results (AIR) and the semantic relationships between results (Result Tree). Should execution be addressed here or as an extension for AIW-I?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Q. Where/when/how should we address accept/reject of results by radiologist?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>An important part of AI Workflow will involve radiologists accepting/rejecting the results generated by AI algorithms.</td>
</tr>
<tr>
<td></td>
<td>This is done both to affect the inclusion/exclusion and status of the AI generated result in the patient medical record, and to provide data for assessing the performance of the AI algorithm and potentially contribute to further training of the algorithm to improve its performance.</td>
</tr>
<tr>
<td></td>
<td>Feedback on where/when/how this should be performed and where/how the acceptance/rejection should be recorded is encouraged.</td>
</tr>
<tr>
<td></td>
<td>DICOM has &quot;approval&quot; objects that reference other objects and capture assertions or approvals about them. Acceptance/rejection could be captured in a workflow log in AIW-I or SOLE. Rejection could be implicit in the recorded findings of a radiologist being in contradiction to the AI results. New AI Result instances could be created containing the original result and the radiologists assessment of it.</td>
</tr>
</tbody>
</table>
### 8. Should the Profile address results in specialized SR Templates, not just TID 1500?

Nodes in the Result Tree template can reference any SR, not just those based on TID 1500. But since the content and structure of the specialized templates does not always conform to the encodings described in RAD TF-3 6.5, it may be difficult to standardize and express behavior requirements for Evidence Creators and Displays.

We could certainly encourage displays to support specialized templates.

### 9. What concepts should be supported for result Confidence/Certainty/Probability?

Physicians frequently mention these concepts (in broad terms) as being important for filtering, triaging, and assessing results. However, the terms are not clearly defined. Regulatory concerns further complicate the situation.

Clear semantics/models for these terms are needed so that appropriate metadata can be specified. Feedback from researchers and implementers is requested.

DICOM has a code for EV (111012, DCM, "Certainty of Finding") used in several CAD templates, that can be added to SR templates and can make additional codes.

### 10. Should direct consumption of Imaging AI Results by non-radiologists be addressed?

Use Cases exist where, for example, AI results about stroke or pulmonary embolisms are passed directly to an interventionalist, bypassing the radiologist.

Is it necessary to show this use case in AIR? Does it need to be described in AIW-I?

### 11. Should we discuss AI results that arrive after study has been reported?

This would be similar to existing PACS functions when additional images are added to a study. If the radiologist is currently reading the study, they might be alerted to these unread elements in the study. Since AIR results are all DICOM instances, that function might already trigger.

Filtered notifications (If significance=low (negative result), ignore; if significance=high (aneurysm with high probability)) could be sent to the radiologist or tech. If the report has already been delivered and read, radiologist might forward to the referring or use the addendum pathway.

Does this kind of "Evidence Consumer" behavior need to be documented? If so, in this profile or in a workflow profile?
<table>
<thead>
<tr>
<th>Q. Should a Result Tree be allowed to reference another Result Tree?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Some use cases could be handled by copying content from existing trees into new trees.</td>
</tr>
<tr>
<td>• a &quot;higher level&quot; assessment is based two &quot;lower level&quot; assessments that are already encoded with result trees. The new result tree could incorporate nodes from the lower level trees.</td>
</tr>
<tr>
<td>• the same analysis is performed by three different vendor products that each create Result Trees. Another application determines the &quot;majority&quot; opinion and subsumes the three trees into a single composite tree.</td>
</tr>
<tr>
<td>Depending on the situation, the earlier Result Tree objects could be deleted/deprecated.</td>
</tr>
<tr>
<td>One could argue that including the lower level trees by reference would be more efficient. Including by reference would add another method for creating loops which would need to be prohibited.</td>
</tr>
<tr>
<td>On a perhaps related note, should the &quot;No Purpose of Reference&quot; constraint on Rows 3,5,6 in newTID2 be retained? (It was inherited from KOS where we really wanted to avoid semantics creeping in) Relaxing the constraint could allow nodes to describe their relationships to each other in more detail. Can we sketch how this might be used beneficially?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Q. Do we need to clarify segmentation vs saliency?</th>
</tr>
</thead>
<tbody>
<tr>
<td>In AI, the word segmentation is sometimes used in a way that overlaps with saliency maps. Some recent research has also cast doubt on the usefulness of saliency maps.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Q. Should Result Tree incorporate metadata for filtering/grouping results without having to retrieve the instances?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Could include anatomy/certainty/severity/etc. for nodes. Could be a slippery slope since filtering could be based on anything. Would anatomy for the root only be useful?</td>
</tr>
<tr>
<td>Alternatively, just retrieve the root result. It may have the needed filtering details.</td>
</tr>
</tbody>
</table>

### Closed Issues

<table>
<thead>
<tr>
<th>Q. How are result primitives distinguished from other instances of the same type?</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. References in Result Trees (if present)</td>
</tr>
<tr>
<td>Parametric Maps and SRs generated as AI results look the same as Parametric Maps and SRs generated by, say, an MR scanner. A reference to those instances in a Result Tree effectively identifies them as part of a result set. One can also look at the equipment that created/contributed to the creation of the object.</td>
</tr>
<tr>
<td>Beyond that, studies are the same Bag of Stuff that they have always been.</td>
</tr>
</tbody>
</table>
IHE Technical Frameworks General Introduction

The IHE Technical Frameworks General Introduction is shared by all of the IHE domain technical frameworks. Each technical framework volume contains links to this document where appropriate.

9 Copyright Licenses

IHE technical documents refer to, and make use of, a number of standards developed and published by several standards development organizations. Please refer to the IHE Technical Frameworks General Introduction, Section 9 - Copyright Licenses for copyright license information for frequently referenced base standards. Information pertaining to the use of IHE International copyrighted materials is also available there.

10 Trademark

IHE® and the IHE logo are trademarks of the Healthcare Information Management Systems Society in the United States and trademarks of IHE Europe in the European Community. Please refer to the IHE Technical Frameworks General Introduction, Section 10 - Trademark for information on their use.
IHE Technical Frameworks General Introduction Appendices

The IHE Technical Framework General Introduction Appendices are components shared by all of the IHE domain technical frameworks. Each technical framework volume contains links to these documents where appropriate.

Update the following appendices to the General Introduction as indicated below. Note that these are not appendices to this domain’s Technical Framework (TF-1, TF-2, TF-3 or TF-4) but rather, they are appendices to the IHE Technical Frameworks General Introduction located here.

**Appendix A – Actors**

Add the following new or modified actors to the IHE Technical Frameworks General Introduction Appendix A:

<table>
<thead>
<tr>
<th>New (or modified) Actor Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>No new actors</td>
<td></td>
</tr>
</tbody>
</table>

**Appendix B – Transactions**

Add the following new or modified transactions to the IHE Technical Frameworks General Introduction Appendix B:

<table>
<thead>
<tr>
<th>New (or modified) Transaction Name and Number</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>No new transactions</td>
<td></td>
</tr>
</tbody>
</table>
Appendix D – Glossary

Add the following *new or modified* glossary terms to the *IHE Technical Frameworks General Introduction Appendix D*:

<table>
<thead>
<tr>
<th>New (or modified) Glossary Term</th>
<th>Definition</th>
<th>Synonyms</th>
<th>Acronym/Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>No new terms</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Modify Section 49 as shown

49 AI Results (AIR) Profile

This AI Results Profile specifies how imaging analysis results can be reliably stored, retrieved, and displayed. The motivating use case involves results generated by artificial intelligence (AI Model) algorithms, although the profile applies equally to non-AI-based analysis. The profile will refer generally to “algorithms” and “analysis results” throughout.

This profile defines content for data encoding, transactions for moving that content around, and behaviors for basic handling of the content.

49.1 AIR Actors, Transactions, and Content Modules

Figure 49.1-1: AIR Actor Diagram
49.2 AIR Actor Options

Options that may be selected for each actor in this profile, if any, are listed in the Table 49.2-1. Dependencies between options, when applicable, are specified in notes.

Table 49.2-1: AI Results – Actors and Options

<table>
<thead>
<tr>
<th>Actor</th>
<th>Option Name</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evidence Creator</td>
<td>Result Tree Option</td>
<td>RAD TF-1 49.2.1</td>
</tr>
<tr>
<td></td>
<td>No options defined</td>
<td></td>
</tr>
<tr>
<td>Image Manager / Image Archive</td>
<td>No options defined</td>
<td>--</td>
</tr>
<tr>
<td>Image Display</td>
<td>Result Tree Option</td>
<td>RAD TF-1 49.2.1</td>
</tr>
<tr>
<td></td>
<td>No options defined</td>
<td></td>
</tr>
<tr>
<td>Imaging Document Consumer</td>
<td>Result Tree Option</td>
<td>RAD TF-1 49.2.1</td>
</tr>
<tr>
<td></td>
<td>No options defined</td>
<td></td>
</tr>
</tbody>
</table>

Add Section 49.2.1 as shown

49.2.1 Result Tree Option

This option involves encoding and storing information that describes hierarchical relationships amongst a set of related AI results (as a "Result Tree" object), and later applying that information to support effective handling of the AI results in a study, such as navigation of large sets of results by a reading radiologist.

Evidence Creators that claim the Result Tree Option shall be able to create Result Tree objects as defined in RAD TF-3: 6.5.3.9 “Result Trees”.

Notes: The Evidence Creator that creates the Result Tree may be the same Evidence Creator that created the result primitives that the Result Tree references. It is also possible that some Evidence Creators simply create result primitives (without supporting the Result Tree Option) and a subsequent Evidence Creator is responsible for determining an appropriate hierarchy for the primitives created by the earlier Evidence Creators and then creating an appropriate Result Tree object (see Section 49.4.2.4).

Image Displays that claim the Result Tree Option shall be able to identify Result Tree objects as described below and be able to present Result Tree objects as defined in RAD TF-2: 4.136.4.1.3.9 “Display of Result Trees”.

Imaging Document Consumers that claim the Result Tree Option shall be able to identify Result Tree objects as described below and to process Result Tree objects; however, no specific required processing behaviors are defined.

Result Tree objects are identified by a Template Identifier (0040,DB00) value of "newTID1" in the Content Template Sequence (0040,A504) in the header of the SR. The Query Analysis Results (RAD-137) transaction, by incorporating the matching and return key requirements of Query Evidence Documents (RAD-44), already requires Responders (Image Manager / Image Archive) and Initiators (Image Display and Imaging Document Consumer) to support Template
Identifier (0040,DB00) as a return key. Using that, Initiators can locally filter the query responses received from the Responder.

It is expected that an Evidence Creator which creates a set of AI Results will implement the Result Tree Option to encode the information it has about the relationships amongst the Result Primitives that it creates. It is, however, possible and permitted for the Evidence Creator that composes the Result Tree to be separate from the Evidence Creator that composed the subordinate objects. This would depend on the Result Tree Evidence Creator having some way to determine the hierarchical relationships among the Result Primitives. A sophisticated Result Tree Evidence Creator might be able to compose Result Tree objects that span Result Primitives from multiple algorithms and/or from multiple vendors.

---

The following section headers are shown without content to remind readers of concept material available in the AIR document which they might find useful when reviewing this supplement.  
https://www.ihe.net/uploadedFiles/Documents/Radiology/IHE_RAD_Suppl_AIR.pdf

49.3 AIR Required Actor Groupings

49.4 AIR Overview

49.4.1 Concepts

49.4.1.1 Result Primitives

49.4.1.2 Result Filtering and Navigation

49.4.1.3 Result Presentation

49.4.1.4 Codesets

49.4.1.5 Confidence

49.4.1.6 Negative and Partial Results

49.4.1.7 Analysis Results vs Workflow Status

49.4.1.8 Result Approval, Retention, & Feedback

49.4.1.9 AI Algorithm Deployment
Add Section 49.4.1.10 as shown

49.4.1.10 Result Trees and Root Results

The use of multiple algorithms may produce very large collections of results for a given study.

To provide Image Displays with information to help them organize and prioritize the result “entries” listed/communicated to the operator at one time, this profile introduces a Result Tree object that communicates a basic hierarchy for a set of related results.

For example, a lung screening algorithm might produce a Result Tree object with a Lung-RADS™ score as the root result, supported by secondary results consisting of multiple detected nodule locations and assessments of the size, solidity, and margin of each detected nodule. A pneumonia algorithm might produce a Result Tree object that points to an SR finding of “pneumonia present” as the root result and reference a separate saliency map instance as the next supporting layer.

An Image Display might initially present the roots of the two Result Trees (Lung-RADS = Category 3) and (Pneumonia present) and let the radiologist “drill down”, rather than initially presenting 43 components consisting of location, size, solidity, margin, and Lung-RADS for each of 8 nodules, an overall Lung-RADS score, the pneumonia finding, and the pneumonia saliency map reference.

Support for Result Trees is indicated with the Result Tree Option (see Section 49.2.1). Result Tree encoding is defined in IHE RAD TF-3: 6.5 “Imaging Analysis Result Content”, and associated display behaviors are defined in RAD TF-2: 4.136.4.1.3.9 “Display of Result Trees”.

Add Section 49.4.2.3 as shown

49.4.2 Use Cases

…

49.4.2.3 Use Case #3: Result Trees

49.4.2.3.1 Result Trees Use Case Description

This Use Case expands on the basic Store, Retrieve & Display Use Case (see Section 49.4.2.1) by introducing Result Trees.

When large sets of results exist in a study (e.g., 40 or more primitives), presenting them to the radiologist interpreting the study has the potential to overwhelm the user and/or the reader's workflow. For example, presenting all 40 at once, or presenting them one by one in an arbitrary order, will likely be sub-optimal. The Result Tree encodes a hierarchical relationship between primitives in a set. For example, the root of the tree could be an overall Lung-RADS assessment of the patient, with subordinate assessments for each nodule which in turn each have a segmentation, a margin assessment and an opacity result.
The Result Tree is created either by the algorithm that generated the set of results or some other application that understands the structure of the results.

The Image Display uses this hierarchy to offer navigation and display functions that allow a radiologist to progressively ingest/handle/work through large result sets.

For further discussion of this concept, see Section 49.4.1.10 Result Trees and Root Results.

The simple hierarchy facilitates useful navigation and display behaviors by the Image Display, without needing to modify those implementations to incorporate specific knowledge of each algorithm or the details or internal structure of the result that each algorithm produces.

While this use case focuses on results generated by AI-based image algorithms, the mechanisms are potentially applicable to any hierarchical instance set generated by any type of conventional or AI-based algorithm.

**49.4.2.3.2 Result Trees Process Flow**

Figure 49.4.2.3.2-1 shows one Result Tree for each analysis and the Result Tree is created by the analysis algorithm itself. In this case, the Evidence Creators both support the Result Tree Option. In the figure, the selected B results are SRs retrieved using [RAD-45]. Other retrieve transactions would be used as appropriate for other types of selected results.

It is also possible results might be created that are not referenced by a Result Tree. Handling those would be left up to the Image Display and likely configured based on site policies and/or user preferences.
Figure 49.4.2.3.2-1: Result Trees Process Flow in AIR Profile

The text in Figure 49.4.2.3.2-2 was used to generate the diagram in Figure 49.4.2.3.2-1. Readers will generally find the diagram more informative. The text is included here to facilitate editing.
Figure 49.4.2.3.2-3 shows a second variant where the two assessments are performed by the first two Evidence Creators and the Result Trees are created by a third Evidence Creator (which supports the Result Tree Option). Alternatively, the third Evidence Creator might create a single Result Tree spanning both analyses if that was appropriate. Also, the third Evidence Creator is shown retrieving results from the Image Manager; alternatively, the first two Evidence Creators could send their results directly to the third Evidence Creator which would store the results together with the Result Trees to the Image Manager when ready.
The text in Figure 49.4.2.3.2-4 was used to generate the diagram in Figure 49.4.2.3.2-3. Readers will generally find the diagram more informative. The text is included here to facilitate editing.

```
**title Result Trees - separate Tree Creation**

participant Evidence Creator 1 as EC1
participant Evidence Creator 2 as EC2
participant Evidence Creator 3 as EC3
participant Image Manager/Image Archive as IM
participant Image Display as ID

EC1->+EC1: (Obtain Images)
EC1->EC1: (Generate Results A)
EC1->-IM: Store Evidence Documents [RAD-43](Results A)
EC2->+EC2: (Obtain Images)
EC2->EC2: (Generate Results B)
EC2->-IM: Store Evidence Documents [RAD-43](Result Tree)
EC3->IM: Retrieve Evidence Documents [RAD-45](Results A & B)
activate EC3
IM-->EC3: Create Result Trees A & B
EC3-->IM: Store Evidence Documents [RAD-43](Result Trees A & B)
ID-->ID: (Prepare to Review Study)

**Figure 49.4.2.3.2-4: Diagram Pseudocode for Result Trees Process Flow**
```
Volume 2 – Transactions

The following section headers are shown without content to remind readers of transaction Expected Action details available in the AIR document which they might find useful when reviewing this supplement

https://www.ihe.net/uploadedFiles/Documents/Radiology/IHE_RAD_Suppl_AIR.pdf

4.136 Display Analysis Result [RAD-136]

... 

4.136.4.1.3 Expected Actions (i.e., Display Requirements)

4.136.4.1.3.1 General Result Display Requirements

4.136.4.1.3.2 Display of Qualitative Findings

4.136.4.1.3.3 Display of Measurements

4.136.4.1.3.4 Display of Locations

4.136.4.1.3.5 Display of Regions

4.136.4.1.3.6 Display of Parametric Maps

4.136.4.1.3.7 Display of Tracking Identifiers

4.136.4.1.3.8 Display of Image References

Add Section 4.136.4.1.3.9

4.136.4.1.3.9 Display of Result Trees

Although Result Trees are not primitives in a strict sense, this section describes display requirements related to communicating the existence and content of Result Trees.

Display of Result Trees typically occurs in the course of presenting the content of a study for interpretation. The study may contain multiple Result Trees. The method for determining when to display Result Trees, or which Result Trees to display is not constrained.

For a selected Result Tree, the Display:

- shall be able to display the Concept Name and/or the Short Label of the node that is the Root Result of the Result Tree
• shall be able to display the primitive referenced by the node that is the Root Result of the Result Tree
• shall be able to indicate when Child Nodes are available for the node of a displayed result
• shall be able to display the Concept Names and/or the Short Labels of the Child Nodes when prompted by the user
• shall be able to display the primitives referenced by Child Nodes when prompted by the user

When presenting multiple peer results at the same layer, e.g., the volume and solidity assessment for each of a set of lung nodules, it is unconstrained whether they are presented together, e.g., in a table, or individually, e.g., as selected or in sequence. Implementations may want to offer multiple capabilities for use based on configuration and/or user interaction.

The following capabilities are not required for conformance, but were described by domain users as potentially useful and may be worth consideration by implementers.

• may be able to prefetch (query and retrieve) instances in the Result Tree prior to the user selecting them
• may be able to indicate to the user the number and type of supporting results available for a given displayed result
• may be able to allow the user to select a specific supporting result for a displayed result
Volume 3 – Content Modules

Modify section 6.5 as shown

6.5 Imaging Analysis Result Content

6.5.1 Scope

This IHE Radiology Content Specification defines standard encodings for the results of medical imaging data analysis. It is specifically intended to cover the output of artificial intelligence algorithms but can also address the results of more conventional analysis software and can also be used for human-generated results.

The specification abstracts imaging analysis results as being composed from a set of primitives. Creators of such results are required, in Section 6.5.3, to be able to encode each primitive using specified DICOM IODs. When the results of a given analysis involve multiple primitives, the primitives may be encoded individually in separate instances of the specified IOD, but in many cases it will make sense to encode multiple primitives together in the same instance; e.g., multiple related measurements in a single SR instance.

The set of primitives is comprised of the following:

Qualitative Findings

This primitive is a coded concept name paired with a coded or text value. This structure is common in SR instances. A qualitative finding may or may not reference a specific location or region.

Algorithms might use this for results like flagging presence/absence of a particular finding, categorizing structures in an image, staging pathologies, etc.

Examples of SR Concept-Value encoding include:

- (RDE436, RADELEMENT, "Presence of pulmonary embolism") = (272519000, SCT, "Absent")
- (129715009, SCT, "Breast composition") = (129719003, SCT, "Extremely Dense")

See RAD TF-1: 49.4.1.4 for a discussion of codesets for concepts and values.

Notes:
1. Whether “Score” findings are qualitative or measurements depends on the semantics. Scores that are rankings using discrete categorizations with specific criteria, like a BI-RADS Score, would be considered qualitative findings and use coded values, while scores that are numerical values on a continuum, like a pain score from 1-10, would be considered numerical measurement values, sometimes with no units.

2. Methods of encoding negative findings is an area of ongoing investigation. Additional guidance will be provided when it becomes available. See also RAD TF-1: 49.4.1.6.
Measurements

This primitive is a structure containing a coded concept paired with one or more numerical values and associated details like measurement units, etc. This structure is common in SR instances. A measurement may or may not be based on a specific location or region. Algorithms might use this for results like measured tumor sizes, blood flow rates, etc.

Examples include:

- (81827009, SCT, "Diameter") = "26.43","mm"; where (363698007, SCT, “Finding Site”) = (54247002, SCT, "Ascending Aorta")
- (410668003, SCT, “Length") = "52","mm"; where (121071, DCM, “Finding”) = (27925004, SCT, "Nodule") and (363698007, SCT, “Finding Site") = (23451007, SCT, "Adrenal Gland")
- (285285000, SCT, "Cobb Angle") = "18.4","deg"; where (363698007, SCT, “Finding Site") = (122495006, SCT, "Thoracic spine")

Note: Other details about the Cobb Angle measurement, like the specific vertebra selected to derive the Cobb Angle and whether the top or bottom surface was chosen, might be encoded as additional subordinate results.

Locations

This primitive is a spatial location, in the form of coordinates for a point or a line. The coordinates are typically expressed in an imaging coordinate system in the frame of reference of an imaging dataset. The coordinates may be within a single “slice” (2D) or within an imaged volume (3D).

Algorithms might use this for results like the location of a tumor or calcification, a spatial fiducial point, or the tip of a needle or tube.

Regions

The primitive is a planar or volumetric region of an imaging dataset.

Algorithms might use this for results like classifying the type of tissue in different pixels/voxels, or defining the boundary of a particular organ, or encoding a bounding box showing the rough location or extent of an intracranial bleed, or encoding an arbitrary region within which a metric like average density has been calculated. Semantically, a single region can consist of multiple discontiguous parts.

Parametric Maps

This primitive is a set of 2D (or 3D) pixels (or voxels) that are image-like but the values encode a "parameter" such as a physical quantity or quantitative model parameter.

Algorithms might use this for results such as visual explanations (e.g., a “saliency map”, showing which parts of a source image influenced the algorithms decision), or quantitative analysis (showing calculated values like brain perfusion, apparent diffusion coefficients (ADC), or the parameters of a dynamic contrast model.)
Note: Tissue classifications may be more appropriately handled as segmentations. Similarly, a probabilistic classification (showing for each pixel the probability it contains malignant cells, or the probability the voxel is part of a hemorrhage) is best encoded as a segmentation, using the FRACTIONAL Segmentation Type.

**Tracking Identifiers**

This primitive is an identification of a persistent entity in the form of a unique identifier.

Algorithms might use unique identifiers to designate the same lesion or tumor in a specific patient in each of a longitudinal set of studies over time. A display might use the corresponding human-readable identifier to communicate this to a user. Longitudinal analysis and evaluation of change are facilitated when the same Tracking Identifier is associated with other primitives like location coordinates, measurements, or qualitative findings (like tumor stage or therapeutic response).

**Image References**

This primitive is a reference to one or more image instances, in the form of an instance UID. When there is a need to be more specific for a multi-frame instance, the reference may include frame information.

Algorithms are also expected to commonly reference the “input” image that was analyzed, however that is expected to be part of the result metadata, rather than the result “payload”.

When a study contains multiple related primitives, a Result Tree may be used to encode a hierarchical relationship between the primitives.

**Result Tree**

This content is an acyclic directed graph that identifies one referenced result primitive as the root of the tree, and references other primitives as directly supporting the root. Further result primitives can be referenced below those supporting results, and so on.

The tree is intended to allow displays and other result consumers to be able to present a potentially large set of result primitives in a rational fashion without needing to understand the nature of all the potential sets of results that various algorithms could generate.

The tree might be encoded by the software that created the set of results, or by another piece of software sophisticated enough to work out an appropriate hierarchy.

**6.5.2 Referenced Standards**

The DICOM Standard PS3 is available at: http://dicomstandard.org/current

- **DICOM PS3.3: A.35.1 Basic Text SR IOD**
- **DICOM PS3.3: A.35.4 Key Object Selection Document IOD**
- **DICOM PS3.3: A.35.13 Comprehensive 3D SR IOD**
- **DICOM PS3.16: TID 1500 Measurement Report**
DICOM PS3.3: A.51 Segmentation IOD
DICOM PS3.3: A.75 Parametric Map IOD

6.5.3 Analysis Result Encodings

Creators of imaging analysis results shall be capable of encoding them as described in this section. The general requirements in Section 6.5.3.1 apply to the encoding of all of the primitives described in the subsequent sections.

The encodings make use of the following SOP Classes:

- Comprehensive 3D SR Storage (1.2.840.10008.5.1.4.1.1.88.34)
- Segmentation Storage (1.2.840.10008.5.1.4.1.1.66.4)
- Parametric Map Storage (1.2.840.10008.5.1.4.1.1.30)
- Key Object Selection Document Storage (1.2.840.10008.5.1.4.1.1.88.59)

The correspondence between Primitives and the IODs used for encoding is summarized in Table 6.5.3-1.

Table 6.5.3-1: Primitives & Encoding IODs

<table>
<thead>
<tr>
<th>SR IOD (TID 1500)</th>
<th>Segmentation IOD</th>
<th>Parametric Map IOD</th>
<th>Key Object Selection Document IOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qualitative Findings</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measurements</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Locations</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regions</td>
<td>X, X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tracking Identifiers</td>
<td>X, X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parametric Maps</td>
<td>X, X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Image References</td>
<td>X, X</td>
<td>X, X</td>
<td>X</td>
</tr>
</tbody>
</table>

Notes: 1. For extensive specific guidance on topics such as encoding planar measurements and finding-related coordinates in SR, it is strongly recommended that readers refer to: Clunie, D., DICOM SR for communicating planar annotations, An Imaging Data Commons (IDC) White Paper, 2019

2. The use of the word “image” in this section is intended to mean both a single-frame image IOD and a specific frame of a multi-frame image IOD.
6.5.3.1 General Result Encoding Requirements

The Creator is expected to populate much of the contextual metadata (e.g., patient demographics, patient identifiers and issuers, study accession number, etc.) in the result instances based on those values in the medical imaging data being processed, and/or the UPS Workitem (if the Creator is being driven by the AI Workflow for Imaging Profile).

Per DICOM, the attributes of the General Equipment Module describe the overall equipment that created the result instance (i.e., the Creator as a whole, not individual subcomponents or algorithms).

The Creator shall describe each algorithm that was used to generate the results in the Contributing Equipment Sequence (0018,A001). Multiple items may be included. The Creator shall encode the following details in the Contributing Equipment Sequence:

- Purpose of Reference Code Sequence (0040,A170) shall be (Newcode1, 99CP2064, "Processing Algorithm")
- Manufacturer (0008,0070)
- Manufacturer’s Model Name (0008,1090)
- Software Versions (0018,1020)
- Device UID (0018,1002)

Note: For algorithms that include a human operator, the identity of the user can be encoded in the Operators’ Name (0008,1070) attribute or the Operator Identification Sequence (0008,1072).

Each time an AI Model is modified, for example by training, it would be appropriate to update the Device UID.

In SR instances, when an algorithm is identified in the SR Tree (typically in TID 4019 and/or TID 1004) it will also be identified in the Contributing Equipment Sequence (0018,A001). The content items, if present, shall contain the same value as the corresponding attribute shown in Table 6.5.3.1-1.

Table 6.5.3.1-1: Corresponding Algorithm Identification Attributes and Content Items

<table>
<thead>
<tr>
<th>Contributing Equipment Sequence Attribute</th>
<th>Device Observer Content Item (TID 1004)</th>
<th>Algorithm Identification Content Item (TID 4019)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer (0008,0070)</td>
<td>(121014, DCM, “Device Observer Manufacturer”)</td>
<td></td>
</tr>
<tr>
<td>Manufacturer’s Model Name (0008,1090)</td>
<td>(121015, DCM, “Device Observer Model Name”)</td>
<td>(111001, DCM, “Algorithm Name”)</td>
</tr>
<tr>
<td>Software Versions (0018,1020)</td>
<td>(111003, DCM, “Algorithm Version”)</td>
<td></td>
</tr>
<tr>
<td>Device UID (0018,1002)</td>
<td>(121012, DCM, “Device Observer UID”)</td>
<td></td>
</tr>
</tbody>
</table>
The Author Observer Sequence (0040,A078) is not usually included in machine generated reports in which that information is the same as in the General Equipment Module (i.e., the authoring device is also the recording device).

**DICOM SR Guidance**

Content Date (0008,0023) and Content Time (0008,0033) are defined to be the date and time that the document content creation started. In the context of analysis results, these may be considered to be the date and time that the analysis that generated the result(s) started executing. They are distinct from the Instance Creation Date (0008,0012) and Instance Creation Time (0008,0013), if present which may be some time later.

As an inherent part of the SR Content Tree encoding, each Content Item may have an Observation UID (0040,A171). Observation UIDs may be used to reference specific findings from another instance, but otherwise they are usually absent.

**The Creator shall, when it creates multiple primitives inside a single SR Instance, populate the Observation UID (0040,A171) of the corresponding Content Item for each primitive, i.e.:**

- For Qualitative Findings, the corresponding finding Content Item (which may or may not have a Concept Name of (121071, DCM, "Finding"))
- For Measurements, the corresponding NUM Content Item
- For Locations, the corresponding SCOORD or SCOORD3D Content Item
- For planar contour-based Regions, the corresponding SCOORD or SCOORD3D Content Item
- For volumetric contour-based Regions, each of the corresponding SCOORD or SCOORD3D Content Items (using the same Observation UID, which represents the observation of the composite volume).
- For Tracking Identifiers, the corresponding Tracking Identifier or Tracking Unique Identifier Content Item. If both are present, populate the Observation UID of one, not both.

**Notes:**
1. A Tracking Unique Identifier uniquely identifies the entity that is the subject of an observation (e.g., this patient’s aortic valve, or a specific lesion), while an Observation UID uniquely identifies the observation itself (e.g., a diameter measurement of that entity taken today at 2pm). So, a number of observations of the same entity will all have different Observation UIDs but the same Tracking Unique Identifier.
2. DICOM has published Supplement 219 (JSON Representation of DICOM Structured Reports) as a Frozen Draft for Trial Use and Comment. ([ftp://medical.nema.org/medical/dicom/supps/Frozen/sup219_fz_JSONSR.pdf](ftp://medical.nema.org/medical/dicom/supps/Frozen/sup219_fz_JSONSR.pdf)) It specifies a simplified JSON representation of the content of a DICOM Structured Reporting instance. The intention is to allow developers to encode image-derived results, in particular, measurements and annotations that might be generated by artificial intelligence (AI), machine learning (ML) and quantitative imaging (QI). The approach is applicable to both export of AI/ML results and also to encoding of truth data for AI/ML training, testing, and validation. Implementers are encouraged to experiment with the encoding and provide feedback.
Frame of Reference (FoR) Guidance

DICOM instances that encode spatial information typically include a Frame of Reference UID (0020,0052) that identifies the origin and coordinate system of coordinates in the instance (without specifically defining that origin and coordinate system). When two instances share the same Frame of Reference UID, coordinates in the two instances are nominally in the same coordinate space.

Creators are strongly encouraged to use shared Frame of Reference UIDs whenever appropriate to avoid placing the burden on downstream systems of performing otherwise unnecessary registrations and transformations. Since the coordinate systems are typically patient-relative, any change of the patient position or use of a different device would result in a new Frame of Reference UID.

Note: Some DICOM Image IODs (like CR images or Ultrasound images) do not necessarily contain a Frame of Reference UID. If DICOM Segmentation IODs are created for such images, the segmentation pixels are required by DICOM to correspond directly to the pixels of the segmented image. In that situation, the segmentation and the image are implicitly in the same Frame of Reference, and if the DICOM Segmentation IOD declares a Frame of Reference UID, the image may then be assumed to be in the same Frame of Reference.

6.5.3.2 Qualitative Findings

Qualitative findings shall be encoded in an instance of the DICOM Comprehensive 3D SR SOP Class using TID 1500 (Measurement Report) as the root template.

- [http://dicom.nema.org/medical/dicom/current/output/chtml/part16/chapter_A.html#sect_TID_1500](http://dicom.nema.org/medical/dicom/current/output/chtml/part16/chapter_A.html#sect_TID_1500)

The value for Procedure Reported (121058, DCM, "Procedure reported") shall describe the imaging procedure analyzed, not the algorithm used.

Depending on whether the qualitative findings refer to a planar region of an image, a volume, or does not refer to any imaging, the root template will contain, respectively, TID 1410 (Planar ROI Measurement and Qualitative Evaluations), TID 1411 (Volumetric ROI Measurement and Qualitative Evaluations), or TID 1501 (Measurement and Qualitative Evaluations). The CONTAINER for (C0034375, UMLS, "Qualitative Evaluations") in TID 1500 shall not be used, as those can be encoded in TID 1501.

- [http://dicom.nema.org/medical/dicom/current/output/chtml/part16/chapter_A.html#sect_TID_1410](http://dicom.nema.org/medical/dicom/current/output/chtml/part16/chapter_A.html#sect_TID_1410)
- [http://dicom.nema.org/medical/dicom/current/output/chtml/part16/chapter_A.html#sect_TID_1411](http://dicom.nema.org/medical/dicom/current/output/chtml/part16/chapter_A.html#sect_TID_1411)
- [http://dicom.nema.org/medical/dicom/current/output/chtml/part16/chapter_A.html#sect_TID_1501](http://dicom.nema.org/medical/dicom/current/output/chtml/part16/chapter_A.html#sect_TID_1501)

Notes: 1. A qualitative finding that refers to an entire image may be encoded using TID 1501 with an IMAGE reference without spatial coordinates. See also DICOM CP 1999.

2. TID 1411 supports encoding a simple ellipsoid Volume Surface, or a set of isocontours, that may be used to define a bounding region around an entity such as a tumor without precisely delineating its surface. In such cases a (130400, DCM, "Geometric purpose of region") = (75958009, SCT, "Bounded by") modifier is appropriate.
3. Details about the patient condition that represent the context of other observations rather than being observations themselves are best encoded as Observation Context rather than analysis results.

Image references for qualitative evaluations in TID 1410 (Row 6 or 8) and 1411 (Row 6, 11, or 12) are mandated by DICOM for the ROIs that are the basis of the qualitative finding(s).

Image references, if any, for qualitative evaluations in TID 1501 are encoded in Rows 10b-10e. See DICOM CP 1999.

If multiple qualitative findings apply to the same entity (see Section 6.5.3.7 “Tracking Identifiers”), those findings may be encoded in a single invocation of TID 1501, TID 1410, or TID 1411.

A single SR instance may contain multiple invocations of multiple sub-templates (TID 1501, TID 1410, and TID 1411).

**Implementations are encouraged to consider encoding simple negative findings using a negative finding concept. For example:**

\[(373572006, \text{SCT}, \text{"Clinical finding absent"}) = (23360400, \text{SCT}, \text{"Pneumonia"})\]

TID 1501, TID 1410, and TID 1411 are extensible, permitting \[(373572006, \text{SCT}, \text{"Clinical finding absent"})\] to be used in places where \[(121071, \text{DCM}, \text{"Finding"})\] appears. See also RAD TF-1:49.4.6 Negative and Partial Findings.

Implementations are encouraged to consider encoding anatomical locations for qualitative findings using the Finding Site concept. This can be useful to help organize and database the findings. For example:

\[(121071, \text{DCM}, \text{"Finding"}) = (55584005, \text{SCT}, \text{"Embolism"})\]
\[(363698007, \text{SCT}, \text{"Finding Site"}) = (39607008, \text{SCT}, \text{"Lung"})\]

While it is also possible to use

\[(121071, \text{DCM}, \text{"Finding"}) = (59282003, \text{SCT}, \text{"Pulmonary embolism"})\],

the Finding Site gives greater flexibility, such as,

\[(121071, \text{DCM}, \text{"Finding"}) = (55584005, \text{SCT}, \text{"Embolism"})\]
\[(363698007, \text{SCT}, \text{"Finding Site"}) = (45653009, \text{SCT}, \text{"Upper lobe of lung"})\]

or for an intracranial hemorrhage,

\[(121071, \text{DCM}, \text{"Finding"}) = (50960005, \text{SCT}, \text{"Hemorrhage"})\]
\[(363698007, \text{SCT}, \text{"Finding Site"}) = (78277001, \text{SCT}, \text{"Temporal Lobe"})\]
\[(272741003, \text{SCT}, \text{"Laterality"}) = (7771000, \text{SCT}, \text{"Left"})\]

See also the related discussion at the end of the following Section 6.5.3.3 “Measurements”.
Add Section 6.5.3.9 as shown

6.5.3.9 Result Trees

Result Trees shall be encoded in an instance of the DICOM Basic Text SR Storage SOP Class using TID newTID1 (Result Tree) as the root template.

TID newTID1 (Result Tree) organizes result primitives by establishing one result as the root of the tree, and allowing each result to reference one or more subordinate results.

The selection of the root result and organization of the nodes in the tree is left to the system creating the Result Tree. While results that are direct children are usually those from which the parent result was derived or on which it depends, that is not required to be the case. The hierarchy is a way for the creating system to encode choices that can drive the display system. Ultimately, the tree suggests a pattern of progressive disclosure that is expected to be:
- helpful to a person trying to explore and understand a set of related results
- something a basic viewer can readily traverse and present

Proposed Additions to DICOM PS 3.16

TID newTID1 Result Tree

The Result Tree Template organizes results into a hierarchical tree. One result/finding is designated as the root/primary and may reference a set of other results/findings that are directly subordinate to, or elaborate on, the root result/finding. Referenced results, in turn, may each reference a set of other results.

The tree shall be a directed acyclic graph. The tree shall not reference other trees (i.e., other instances based on TID newTID1). It is permitted for a given result to be referenced from multiple Result Trees or from multiple nodes in a single Result Tree.

The Template can only be instantiated at the root node and cannot be included in other Templates.

The Template is not extensible; that is, no other Content Items may be added to this Template, or to the Templates that are included, recursively.

Type: Non-Extensible
Order: Significant
Root: Yes
Table TID newTID1: Result Tree

<table>
<thead>
<tr>
<th>NL</th>
<th>Rel with Parent</th>
<th>VT</th>
<th>Concept Name</th>
<th>VM</th>
<th>Req Type</th>
<th>Condition</th>
<th>Value Set Constraint</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>CONTAINER</td>
<td>BCID newCID0 &quot;Result Tree Titles&quot;</td>
<td>1</td>
<td>M</td>
<td>Root node</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>&gt; HAS CONCEPT MOD</td>
<td>INCLUDE</td>
<td>DTID 1204 “Language of Content Item and Descendants”</td>
<td>1</td>
<td>U</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>&gt; HAS OBS CONTEXT</td>
<td>INCLUDE</td>
<td>DTID 1002 “Observer Context”</td>
<td>1-n</td>
<td>U</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>&gt; CONTAINS</td>
<td>INCLUDE</td>
<td>DTID newTID2 &quot;Result Tree Node&quot;</td>
<td>1</td>
<td>M</td>
<td>$Concept = EV (newCode2, DCM, &quot;Root Result&quot;)</td>
<td></td>
</tr>
</tbody>
</table>

Content Item Descriptions

Row 1 The Title may be displayed in selection lists and, as such, is expected to describe the nature of the content of the tree. Beyond newCID0, additional codes may be drawn from the RadElement Set codes at radelement.org. Private codes may also be used. Consider describing the type of assessment that generated the result set.

Row 3 The Observer Context describes the observer that determined the referenced instances comprise a Result Tree. This observer may or may not be the system that generated the instances referenced in the tree.

TID newTID2 Result Tree Node

The Tree Node Template references a Result in a Result Tree and optionally includes a subordinate layer of nodes. The referenced Result may have been encoded in one of several types of instance.

Table TID newTID2: Parameters

<table>
<thead>
<tr>
<th>Parameter Name</th>
<th>Parameter Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Concept</td>
<td>Coded term or Context Group indicating the nature of the content referenced by the node.</td>
</tr>
</tbody>
</table>

Type: Non-Extensible
Order: Non-Significant
Root: No
<table>
<thead>
<tr>
<th></th>
<th>NL</th>
<th>Rel with Parent</th>
<th>VT</th>
<th>Concept Name</th>
<th>VM</th>
<th>Req Type</th>
<th>Condition</th>
<th>Value Set Constraint</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CONTAINS</td>
<td>TEXT</td>
<td>EV (125309, DCM, &quot;Short Label&quot;)</td>
<td>1</td>
<td>U</td>
<td></td>
<td>DCID 6034 &quot;Intended Use of CAD Output&quot;</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>CONTAINS</td>
<td>CODE</td>
<td>EV (111056, DCM, &quot;Rendering Intent&quot;)</td>
<td>1</td>
<td>U</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>CONTAINS</td>
<td>COMPOSITE</td>
<td>$Concept</td>
<td>1</td>
<td>MC</td>
<td>IFF Rows 5 and 6 are absent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>CONTAINS</td>
<td>UIDREF</td>
<td>EV (newCode7, DCM, &quot;Referenced Observation UID&quot;)</td>
<td>1</td>
<td>MC</td>
<td>IFF the Result Tree Node does not represent all content items in the instance referenced by Row 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>CONTAINS</td>
<td>IMAGE</td>
<td>$Concept</td>
<td>1</td>
<td>MC</td>
<td>IFF Rows 3 and 6 are absent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>CONTAINS</td>
<td>WAVEFORM</td>
<td>$Concept</td>
<td>1</td>
<td>MC</td>
<td>IFF Rows 3 and 5 are absent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>CONTAINS</td>
<td>CONTAINER</td>
<td>EV (newCode3, DCM, &quot;Child Node&quot;)</td>
<td>1-n</td>
<td>U</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>CONTAINS</td>
<td>INCLUDE</td>
<td>DTID newTID2 &quot;Result Tree Node&quot;</td>
<td>1</td>
<td>M</td>
<td></td>
<td>$Concept = BCID newCID1 &quot;Result Tree Nodes&quot;</td>
<td></td>
</tr>
</tbody>
</table>

### Content Item Descriptions

**Row 1**: This may be used to identify the content referenced by the node, for example to facilitate browsing or selection. Short Labels are not standardized and may omit details; thus, it is not recommended to use them for purposes such as matching.

**Row 2**: The values in the CID only represent recommendations from the producer of the Content Item. Receiving devices may opt to display data marked "Not for Presentation" and not display data marked "Presentation Required" based on user interactions and/or configuration settings.

**Row 3, 5, 6**: Purpose of reference shall not be present.

**Row 4**: This row permits referencing a specific Content Item of interest within a Structured Report instance referenced in Row 3.

**Row 5, 6**: The Referenced Frame Number (0008,1160) attribute of the IMAGE Content Item permits referencing one or more frames in the referenced Image Instance when appropriate, for example when the Result Tree Node does not include all the frames in the image instance. Similarly, the Referenced Segment Number (0062,000B) attribute may be used when the Result Tree does not include all the segments in the segmentation instance.
CID newcid0 Result Tree Titles

Resources: HTML | FHIR JSON | FHIR XML | IHE SVS XML
Type: Extensible
Version: yyyymmdd
UID: 1.2.840.10008.6.1.zzcid0

Table CID newcid0: Result Tree Titles

<table>
<thead>
<tr>
<th>Coding Scheme Designator</th>
<th>Code Value</th>
<th>Code Meaning</th>
<th>UMLS Concept Unique ID</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Result Tree</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Abdominal Aortic Aneurysm Assessment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cardiomegaly Assessment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coronary Plaque Assessment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>COVID-19 Assessment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Endotracheal Tube Assessment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pleural Effusion Assessment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pneumonia Assessment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pneumothorax Assessment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pulmonary Embolism Assessment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pulmonary Nodule Assessment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rib Fracture Assessment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Scoliosis Assessment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vertebra Assessment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>…</td>
<td></td>
</tr>
</tbody>
</table>

CID newcid1 Result Tree Nodes

Resources: HTML | FHIR JSON | FHIR XML | IHE SVS XML
Type: Extensible
Version: yyyymmdd
UID: 1.2.840.10008.6.1.zzcid1

Table CID newcid1: Result Tree Nodes

<table>
<thead>
<tr>
<th>Coding Scheme Designator</th>
<th>Code Value</th>
<th>Code Meaning</th>
<th>SNOMED-RT ID</th>
<th>UMLS Concept Unique ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCM</td>
<td>newCode2</td>
<td>Root Result</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCM</td>
<td></td>
<td>Nodule Assessment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCM</td>
<td></td>
<td>Segmentation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCM</td>
<td></td>
<td>Saliency Map</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coding Scheme Designator</td>
<td>Code Value</td>
<td>Code Meaning</td>
<td>SNOMED-RT ID</td>
<td>UMLS Concept Unique ID</td>
</tr>
<tr>
<td>--------------------------</td>
<td>------------</td>
<td>--------------</td>
<td>--------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>DCM</td>
<td></td>
<td>Projection Image</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>...</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table D-1: DICOM Controlled Terminology Definitions

<table>
<thead>
<tr>
<th>Code Value</th>
<th>Code Meaning</th>
<th>Definition</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>newCode2</td>
<td>Root Result</td>
<td>A result that is at the root of a result tree.</td>
<td></td>
</tr>
<tr>
<td>newCode3</td>
<td>Child Node</td>
<td>A node in a tree that is a direct child of the current node.</td>
<td></td>
</tr>
<tr>
<td>newCode7</td>
<td>Referenced Observation UID</td>
<td>The value of Observation UID for a specific Content Item in a Structured Report Instance.</td>
<td></td>
</tr>
</tbody>
</table>
Appendices to Volume 3

Modify Appendix A in Volume 3 as shown.

Appendix A – Example Analysis Result Encodings

These examples were prepared in support of the AI Results (AIR) Profile. See Section 6.5.3 Imaging Analysis Result Content for the encoding specifications.

This appendix contains a limited set of illustrative examples, due in part to the maintenance overhead for IHE Profile documents. Additional examples may be available as part of the implementation materials associated with this profile on the IHE website or in IHE Connectathons.

A.1 Common Header Attributes

All the IODs used for Imaging Analysis Result Content (see Section 6.5.3) include a number of common DICOM modules describing the Patient, Study, Series, etc. with which the analysis result is associated. Table A.1-1 provides an example of values for the attributes of such modules. Depending on the specific IOD, values such as SOP Class UID (0008,0016) and Modality (0008,0060) would differ and some additional required attributes would be expected.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Tag</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOP Class UID</td>
<td>(0008,0016)</td>
<td>1.2.840.10008.5.1.4.1.1.88.34</td>
</tr>
<tr>
<td>SOP Instance UID</td>
<td>(0008,0018)</td>
<td>1.2.3.4.5.6.7.300</td>
</tr>
<tr>
<td>Study Date</td>
<td>(0008,0020)</td>
<td>20191029</td>
</tr>
<tr>
<td>Content Date</td>
<td>(0008,0023)</td>
<td>20191029</td>
</tr>
<tr>
<td>Study Time</td>
<td>(0008,0030)</td>
<td>154500</td>
</tr>
<tr>
<td>Content Time</td>
<td>(0008,0033)</td>
<td>155210</td>
</tr>
<tr>
<td>Accession Number</td>
<td>(0008,0050)</td>
<td>123456</td>
</tr>
<tr>
<td>Modality</td>
<td>(0008,0060)</td>
<td>SR</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>(0008,0070)</td>
<td>Aperture Labs</td>
</tr>
<tr>
<td>Referring Physician's Name</td>
<td>(0008,0090)</td>
<td>Johnson^Cave^^Dr.^M.D.</td>
</tr>
<tr>
<td>Manufacturer's Model Name</td>
<td>(0008,1090)</td>
<td>AI Portal Platform</td>
</tr>
<tr>
<td>Patient's Name</td>
<td>(0010,0010)</td>
<td>Person^Chell^^^</td>
</tr>
<tr>
<td>Patient's ID</td>
<td>(0010,0020)</td>
<td>000001498</td>
</tr>
<tr>
<td>Issuer of Patient ID</td>
<td>(0010,0021)</td>
<td>Mercy Hospital</td>
</tr>
</tbody>
</table>
A.2 Qualitative Finding

As described in Section 6.5.3, qualitative findings are encoded in DICOM SR objects using TID 1500 as the root template.

The example in Table A.2-1 represents the SR Content Tree inside the DICOM SR object. The header of the DICOM SR object would look like the example in Table A.1-1.

Notes: 1. The Image Library container was left empty since there is only a single source image which is considered to be reasonably well described by the imaging procedure.
2. The algorithm has also generated a saliency map image for the embolism finding. The saliency image is referenced using the Visual Explanation concept.

Table A.2-1: Qualitative Finding SR Content Example

<table>
<thead>
<tr>
<th>Node</th>
<th>Code Meaning of Concept Name</th>
<th>Value</th>
<th>TID</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Imaging Measurement Report</td>
<td></td>
<td>TID 1500</td>
</tr>
<tr>
<td>1.1</td>
<td>Language of Content Item and Descendants</td>
<td>(en-US, RFC5646, &quot;American English&quot;)</td>
<td>TID 1204</td>
</tr>
<tr>
<td>1.2</td>
<td>Observer Type</td>
<td>(121007, DCM, &quot;Device&quot;)</td>
<td>TID 1001</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>TID 1002</td>
</tr>
<tr>
<td>1.3</td>
<td>Device Observer UID</td>
<td>1.2.8.7.6.5.78765234</td>
<td>TID 1004</td>
</tr>
<tr>
<td>1.4</td>
<td>Device Observer Manufacturer</td>
<td>Acme Algorithmics</td>
<td>TID 1004</td>
</tr>
</tbody>
</table>
### Node | Code Meaning of Concept Name | Value | TID
---|---|---|---
1.5 | Device Observer Model Name | PneumoScan | TID 1004
1.36 | Procedure Reported | (43778-0, LN, “Portable XR Chest AP supine”) | TID 1500
1.47 | Image Library | | TID 1500
1.58 | Imaging Measurements | | TID 1500
1.58.1 | Algorithm Name | PneumoScan | TID 1419
1.58.2 | Algorithm Version | 3.1.202006 | TID 1419
1.58.3 | Measurement Group | | TID 1501
1.58.3.1 | Tracking Identifier | Pneumo2394958 | TID 1501
1.58.3.2 | Tracking Unique Identifier | 1.2.276.0.7230010.384756 | TID 1501
1.58.3.3 | Finding | (55584005, SCT, "Emboli") | TID 1501
1.58.3.4 | Finding Site | (45653009, SCT, "Upper lobe of lung") | TID 1501
1.58.3.4.1 | Laterality | (24028007, SCT, "Right") | TID 1501
1.58.3.5 | Source Image | 1.2.840.10008.5.1.4.1.1.1.1 (Digital X-Ray Image Storage - For Processing SOP Class) 1.2.3.4.5.6.7.8001 (SOP Instance of XR Chest AP Image) | TID 1501
1.58.3.6 | Visual Explanation | 1.2.840.10008.5.1.4.1.1.30 (Parametric Map Storage SOP Class) 1.2.3.4.5.6.7.9001 (SOP Instance of corresponding saliency map) | TID 1501

**Add new Example sections to Appendix A as shown**

### A.3 CT Chest Result Set

This is an example of a set of results generated by a variety of assessment algorithms operating on a CT Chest Study.

Some of the example SR Content includes Observation UID (0040,A171) as required in RAD TF-3:6.5.3.1. For simplicity, Observation UID is shown in the tables as a child node of the SR Content Item to which it applies, even though it is actually an attribute in the representation of that Content Item as described in DICOM PS3.3 Section C.17.3.

### A.3.1 CT Chest Pneumothorax Assessment Result Set

This is an example of a set of results generated by a pneumothorax assessment algorithm operating on a CT Chest Study.
The result set includes the Result Tree, the Root Result (pneumothorax is present), and a contour-based volumetric segmentation representing the estimated extent of the pneumothorax. The Root Result and Segmentation are shown here together in the same SR instance and their Observation UIDs are included in the Result Tree. Alternatively, the volumetric segmentation could have been encoded in a separate instance which could either have been DICOM Segmentation instance or an SR instance like that shown.

A.3.1.1 Result Tree

As described in Section 6.5.3 Analysis Result Encodings, Result Trees are encoded in DICOM SR objects using TID newTID1 as the root template.

The example in Table A.3.1.1-1 represents the SR Content Tree inside the DICOM SR object. The header of the DICOM SR object would look something like the example in Table A.1-1.

<table>
<thead>
<tr>
<th>Node</th>
<th>Code Meaning of Concept Name</th>
<th>Value</th>
<th>TID</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pneumothorax Assessment</td>
<td></td>
<td>newTID1</td>
</tr>
<tr>
<td>1.1</td>
<td>Language of Content Item and Descendants</td>
<td>(en-US, RFC5646, &quot;American English&quot;)</td>
<td>TID 1204</td>
</tr>
<tr>
<td>1.2</td>
<td>Observer Type</td>
<td>(121007, DCM, &quot;Device&quot;)</td>
<td>TID 1001, 1002</td>
</tr>
<tr>
<td>1.3</td>
<td>Device Observer UID</td>
<td>1.2.8.7.6.5.787651234</td>
<td>TID 1004</td>
</tr>
<tr>
<td>1.4</td>
<td>Device Observer Manufacturer</td>
<td>Aperture Labs</td>
<td>TID 1004</td>
</tr>
<tr>
<td>1.5</td>
<td>Device Observer Model Name</td>
<td>AI 3D Pneumothorax</td>
<td>TID 1004</td>
</tr>
<tr>
<td>1.6</td>
<td>Root Result</td>
<td>COMPOSITE See A.3.3.2</td>
<td>newTID2</td>
</tr>
<tr>
<td>1.7</td>
<td>Referenced Observation UID</td>
<td>1.2.3.4.5.6.7.8.3121.0.1</td>
<td>newTID2</td>
</tr>
<tr>
<td>1.8</td>
<td>Child Node</td>
<td></td>
<td>newTID2</td>
</tr>
<tr>
<td>1.8.1</td>
<td>Segmentation</td>
<td>COMPOSITE See A.3.3.2</td>
<td>newTID2</td>
</tr>
<tr>
<td>1.8.2</td>
<td>Referenced Observation UID</td>
<td>1.2.3.4.5.6.7.8.3121.0.2</td>
<td>newTID2</td>
</tr>
</tbody>
</table>

A.3.1.2 Root Result & Segmentation

As described in Section 6.5.3 Analysis Result Encodings, qualitative findings are encoded in DICOM SR objects using TID 1500 as the root template and contour-based segmentations may also be encoded in DICOM SR objects using TID 1500 as the root template.

The example in Table A.3.3.2-1 represents the SR Content Tree inside the DICOM SR object. The header of the DICOM SR object would look something like the example in Table A.1-1.

The Tracking Identifiers in nodes 1.8.3.1 and 1.8.3.2 identify this specific occurrence of pneumothorax in this patient. Although this is the first encounter, the identifiers are included so
that a subsequent detection that is able to determine that it is a subsequent encounter with the same occurrence of pneumothorax could indicate that by using the same identifiers. This could support, for example, size comparisons. If no identifiers are included in the first occurrence, there is nothing for the second occurrence to use. This is an example of using Tracking Identifiers to track a condition, rather than, for example, a region of tissue.

Table A.3.1.2-1: Root Result SR Content Example

<table>
<thead>
<tr>
<th>Node</th>
<th>Code Meaning of Concept Name</th>
<th>Value</th>
<th>TID</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Imaging Measurement Report</td>
<td></td>
<td>TID 1500</td>
</tr>
<tr>
<td>1.1</td>
<td>Language of Content Item and Descendants</td>
<td>(en-US, RFC5646, &quot;American English&quot;)</td>
<td>TID 1204</td>
</tr>
<tr>
<td>1.2</td>
<td>Observer Type</td>
<td>(121007, DCM, &quot;Device&quot;)</td>
<td>TID 1001</td>
</tr>
<tr>
<td>1.3</td>
<td>Device Observer UID</td>
<td>1.2.8.7.6.5.78765234</td>
<td>TID 1004</td>
</tr>
<tr>
<td>1.4</td>
<td>Device Observer Manufacturer</td>
<td>Aperture Labs</td>
<td>TID 1004</td>
</tr>
<tr>
<td>1.5</td>
<td>Device Observer Model Name</td>
<td>AI 3D Pneumothorax</td>
<td>TID 1004</td>
</tr>
<tr>
<td>1.6</td>
<td>Procedure Reported</td>
<td>(29252-4, LN, &quot;CT Chest WO contrast&quot;)</td>
<td>TID 1500</td>
</tr>
<tr>
<td>1.7</td>
<td>Image Library</td>
<td></td>
<td>TID 1500</td>
</tr>
<tr>
<td>1.8</td>
<td>Imaging Measurements</td>
<td></td>
<td>TID 1500</td>
</tr>
<tr>
<td>1.8.1</td>
<td>Algorithm Name</td>
<td>AI 3D Pneumothorax</td>
<td>TID 4019</td>
</tr>
<tr>
<td>1.8.2</td>
<td>Algorithm Version</td>
<td>1.5.8b</td>
<td>TID 4019</td>
</tr>
<tr>
<td>1.8.3</td>
<td>Measurement Group</td>
<td></td>
<td>TID 1501</td>
</tr>
<tr>
<td>1.8.3.1</td>
<td>Tracking Identifier</td>
<td>Pneumothorax2394958</td>
<td>TID 1501</td>
</tr>
<tr>
<td>1.8.3.2</td>
<td>Tracking Unique Identifier</td>
<td>1.2.276.0.7230010.384756</td>
<td>TID 1501</td>
</tr>
<tr>
<td>1.8.3.3</td>
<td>Finding</td>
<td>(36118008, SCT, &quot;Pneumothorax&quot;)</td>
<td>TID 1501</td>
</tr>
<tr>
<td>1.8.3.3.-</td>
<td>Observation UID</td>
<td>1.2.3.4.5.6.7.8.3121.0.1</td>
<td>SR IOD</td>
</tr>
<tr>
<td>1.8.3.4</td>
<td>Finding Site</td>
<td>(39607008, SCT, &quot;Lung&quot;)</td>
<td>TID 1501</td>
</tr>
<tr>
<td>1.8.3.4.1</td>
<td>Laterality</td>
<td>(7771000, SCT, &quot;Left&quot;)</td>
<td>TID 1501</td>
</tr>
<tr>
<td>1.8.3.5</td>
<td>Geometric purpose of region</td>
<td>(111041, DCM, &quot;Outline&quot;)</td>
<td>Extension</td>
</tr>
<tr>
<td>1.8.3.6</td>
<td>Image Region</td>
<td>SCOORD Contour a</td>
<td>TID 1501</td>
</tr>
<tr>
<td>1.8.3.6.-</td>
<td>Observation UID</td>
<td>1.2.3.4.5.6.7.8.3121.0.2</td>
<td>SR IOD</td>
</tr>
<tr>
<td>1.8.3.6.1</td>
<td></td>
<td>1.2.840.10008.5.1.4.1.1.2 (CT Image SOP Class)</td>
<td>TID 1501</td>
</tr>
<tr>
<td>1.8.3.7</td>
<td>Image Region</td>
<td>SCOORD Contour b</td>
<td>TID 1501</td>
</tr>
<tr>
<td>1.8.3.7.-</td>
<td>Observation UID</td>
<td>1.2.3.4.5.6.7.8.3121.0.2</td>
<td>SR IOD</td>
</tr>
<tr>
<td>1.8.3.7.1</td>
<td></td>
<td>1.2.840.10008.5.1.4.1.1.2 (CT Image SOP Class)</td>
<td>TID 1501</td>
</tr>
</tbody>
</table>
A.3.2 CT Chest Pneumonia Assessment Result Set

This is an example of a set of results generated by a pneumonia assessment algorithm operating on a CT Chest Study.

The result set includes the Result Tree, the Root Result (pneumonia is absent), a saliency map showing the image regions the AI associated with the pneumonia finding, and a "Projection" image with which the saliency map can be blended for presentation.

A.3.2.1 Result Tree

As described in Section 6.5.3 Analysis Result Encodings, Result Trees are encoded in DICOM SR objects using TID newTID1 as the root template.

The example in Table A.3.2.1-1 represents the SR Content Tree inside the DICOM SR object. The header of the DICOM SR object would look something like the example in Table A.1-1.

Table A.3.2.1-1: Result Tree SR Content Example

<table>
<thead>
<tr>
<th>Node</th>
<th>Code Meaning of Concept Name</th>
<th>Value</th>
<th>TID</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pneumonia Assessment</td>
<td></td>
<td>newTID1</td>
</tr>
<tr>
<td>1.1</td>
<td>Language of Content Item and Descendants</td>
<td>(en-US, RFC5646, &quot;American English&quot;)</td>
<td>TID 1204</td>
</tr>
<tr>
<td>1.2</td>
<td>Observer Type</td>
<td>(121007, DCM, &quot;Device&quot;)</td>
<td>TID 1001  TID 1002</td>
</tr>
<tr>
<td>1.3</td>
<td>Device Observer UID</td>
<td>1.2.8.7.6.5.787652341</td>
<td>TID 1004</td>
</tr>
<tr>
<td>1.4</td>
<td>Device Observer Manufacturer</td>
<td>Acme Algorithmics</td>
<td>TID 1004</td>
</tr>
<tr>
<td>1.5</td>
<td>Device Observer Model Name</td>
<td>PneumoScan CT</td>
<td>TID 1004</td>
</tr>
<tr>
<td>1.6</td>
<td>Root Result</td>
<td>COMPOSITE See A.3.2.2</td>
<td>newTID2</td>
</tr>
<tr>
<td>1.7</td>
<td>Child Node</td>
<td></td>
<td>newTID2</td>
</tr>
<tr>
<td>1.7.1</td>
<td>Saliency Map</td>
<td>IMAGE See A.3.2.3</td>
<td>newTID2</td>
</tr>
<tr>
<td>1.7.2</td>
<td>Child Node</td>
<td></td>
<td>newTID2</td>
</tr>
<tr>
<td>1.7.2.1</td>
<td>Projection Image</td>
<td>IMAGE See A.3.2.4</td>
<td>newTID2</td>
</tr>
</tbody>
</table>

A.3.2.2 Root Result

As described in Section 6.5.3 Analysis Result Encodings, qualitative findings are encoded in DICOM SR objects using TID 1500 as the root template.
The example in Table A.3.2.2-1 represents the SR Content Tree inside the DICOM SR object. The header of the DICOM SR object would look something like the example in Table A.1-1.

<table>
<thead>
<tr>
<th>Node</th>
<th>Code Meaning of Concept Name</th>
<th>Value</th>
<th>TID</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Imaging Measurement Report</td>
<td></td>
<td>TID 1500</td>
</tr>
<tr>
<td>1.1</td>
<td>Language of Content Item and Descendants</td>
<td>(en-US, RFC5646, &quot;American English&quot;)</td>
<td>TID 1204</td>
</tr>
<tr>
<td>1.2</td>
<td>Observer Type</td>
<td>(121007, DCM, &quot;Device&quot;)</td>
<td>TID 1001</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>TID 1002</td>
</tr>
<tr>
<td>1.3</td>
<td>Device Observer UID</td>
<td>1.2.8.7.6.5.787652341</td>
<td>TID 1004</td>
</tr>
<tr>
<td>1.4</td>
<td>Device Observer Manufacturer</td>
<td>Acme Algorithmics</td>
<td>TID 1004</td>
</tr>
<tr>
<td>1.5</td>
<td>Device Observer Model Name</td>
<td>PneumoScan CT</td>
<td>TID 1004</td>
</tr>
<tr>
<td>1.6</td>
<td>Procedure Reported</td>
<td>(29252-4, LN, &quot;CT Chest WO contrast&quot;)</td>
<td>TID 1500</td>
</tr>
<tr>
<td>1.4</td>
<td>Image Library</td>
<td></td>
<td>TID 1500</td>
</tr>
<tr>
<td>1.5</td>
<td>Imaging Measurements</td>
<td></td>
<td>TID 1500</td>
</tr>
<tr>
<td>1.5.1</td>
<td>Algorithm Name</td>
<td>PneumoScan CT</td>
<td>TID 4019</td>
</tr>
<tr>
<td>1.5.2</td>
<td>Algorithm Version</td>
<td>3.1.202008</td>
<td>TID 4019</td>
</tr>
<tr>
<td>1.5.3</td>
<td>Measurement Group</td>
<td></td>
<td>TID 1501</td>
</tr>
<tr>
<td>1.5.3.1</td>
<td>(373572006, SCT, &quot;Clinical finding absent&quot;)</td>
<td>(23360400, SCT, &quot;Pneumonia&quot;)</td>
<td>TID 1501</td>
</tr>
<tr>
<td>1.5.2.1</td>
<td>Finding Site</td>
<td>(39607008, SCT, &quot;Lung&quot;)</td>
<td>TID 1501</td>
</tr>
<tr>
<td>1.5.2.2.1</td>
<td>Laterality</td>
<td>(51440002, SCT, &quot;Bilateral&quot;)</td>
<td>TID 1501</td>
</tr>
<tr>
<td>1.5.3.3</td>
<td>Source Image</td>
<td>1.2.840.10008.5.1.4.1.1.2 (CT Image Storage SOP Class)</td>
<td>TID 1501</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.2.3.4.5.6.7.8.3121.1.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.2.3.4.5.6.7.8.3121.1.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>etc.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(SOP Instances of CT Chest Images)</td>
<td></td>
</tr>
<tr>
<td>1.5.3.4</td>
<td>Visual Explanation</td>
<td>1.2.840.10008.5.1.4.1.1.30 (Parametric Map Storage SOP Class)</td>
<td>TID 1501</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.2.3.4.5.6.7.8.3223.1.1 (SOP Instance of corresponding saliency map)</td>
<td></td>
</tr>
</tbody>
</table>
A.3.2.3 Saliency Image

As described in Section 6.5.3 Analysis Result Encodings, saliency images are encoded as an instance of the DICOM Parametric Map IOD.

The example in Table A.3.2.3-1 represents key header attributes of the Parametric Map instance. Common Header attributes would appear similar to that shown in Table A.1-1.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Tag</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOP Class UID</td>
<td>(0008,0016)</td>
<td>1.2.840.10008.5.1.4.1.1.30</td>
</tr>
<tr>
<td>SOP Instance UID</td>
<td>(0008,0018)</td>
<td>1.2.3.4.5.6.7.8.3223.1.1</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modality</td>
<td>(0008,0060)</td>
<td>CT</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contributing Equipment Sequence</td>
<td>(0018,A001)</td>
<td></td>
</tr>
<tr>
<td>&gt;Purpose of Reference Code Sequence</td>
<td>(0040,A170)</td>
<td>(Newcode1, 99CP2064, &quot;Processing Algorithm&quot;)</td>
</tr>
<tr>
<td>&gt;Manufacturer</td>
<td>(0008,0070)</td>
<td>Acme Algorithmics</td>
</tr>
<tr>
<td>&gt;Manufacturer’s Model Name</td>
<td>(0008,1090)</td>
<td>PneumoScan CT</td>
</tr>
<tr>
<td>&gt;Software Versions</td>
<td>(0018,1020)</td>
<td>3.1.202006</td>
</tr>
<tr>
<td>&gt;Device UID</td>
<td>(0018,1002)</td>
<td>1.2.8.7.6.5.78765234.1</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A.3.2.4 "Projection" Image

The "Projection" image is a planar view of the chest that corresponds spatially with the saliency image. It available for blending with the saliency image to provide an anatomical reference for the saliency data. The projection image is derived from the transverse CT images, for example using a MIP algorithm, and is encoded as a DICOM CT Image object (which is used for transverse, coronal, sagittal and oblique images).

The example in Table A.3.2.4-1 represents key header attributes of the CT Image instance. Common Header attributes would appear similar to that shown in Table A.1-1.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Tag</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOP Class UID</td>
<td>(0008,0016)</td>
<td>1.2.840.10008.5.1.4.1.1.2</td>
</tr>
<tr>
<td>SOP Instance UID</td>
<td>(0008,0018)</td>
<td>1.2.3.4.5.6.7.9.3241.1.1</td>
</tr>
</tbody>
</table>
A.3.3 CT Chest Lung Nodule Assessment Result Set

This example result set might be generated by a comprehensive lung nodule assessment algorithm.

The result set includes the Result Tree, the Root Result (overall Lung-RADS™ assessment), and a set of nodule results, each consisting of a centroid location, an individual Lung-RADS nodule score, a segmentation, a calculated volume, a solidity assessment and a margin assessment.

The nodule segmentations are shown here in individual Segmentation instances as they might be produced by an algorithm that segments a single nodule based on a seed location from a detection algorithm. Alternatively, the segmentations might have been in a single Segmentation instance with different Segment IDs used by the Result tree. Each nodule is represented by an individual SR which contains multiple observations for that nodule. The Root Result (an overall patient assessment) is shown in a separate SR as if it were generated by a third algorithm.

A.3.3.1 Result Tree

As described in Section 6.5.3 Analysis Result Encodings, Result Trees are encoded in DICOM SR objects using TID newTID1 as the root template.

The example in Table A.3.3.1-1 represents the SR Content Tree inside the DICOM SR object. The header of the DICOM SR object would look like the example in Table A.1-1.

<table>
<thead>
<tr>
<th>Node</th>
<th>Code Meaning of Concept Name</th>
<th>Value</th>
<th>TID</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lung Nodule Assessment</td>
<td></td>
<td>newTID1</td>
</tr>
<tr>
<td>1.1</td>
<td>Language of Content Item and Descendants</td>
<td>(en-US, RFC5646, &quot;American English&quot;)</td>
<td>TID 1204</td>
</tr>
<tr>
<td>Node</td>
<td>Code Meaning of Concept Name</td>
<td>Value</td>
<td>TID</td>
</tr>
<tr>
<td>------</td>
<td>-----------------------------</td>
<td>-------</td>
<td>-----</td>
</tr>
<tr>
<td>1.2</td>
<td>Observer Type</td>
<td>(121007, DCM, &quot;Device&quot;)</td>
<td>TID 1001, TID 1002</td>
</tr>
<tr>
<td>1.3</td>
<td>Device Observer UID</td>
<td>1.2.8.7.6.5.79765234x</td>
<td>TID 1004</td>
</tr>
<tr>
<td>1.4</td>
<td>Device Observer Manufacturer</td>
<td>Acme Algorithmics</td>
<td>TID 1004</td>
</tr>
<tr>
<td>1.5</td>
<td>Device Observer Model Name</td>
<td>Lung Sum</td>
<td>TID 1004</td>
</tr>
<tr>
<td>1.6</td>
<td>Root Result</td>
<td>COMPOSITE See A.3.3.2</td>
<td>newTID2</td>
</tr>
<tr>
<td>1.7</td>
<td>Short Label</td>
<td>&quot;Overall Lung-RADS 4A&quot;</td>
<td>newTID2</td>
</tr>
<tr>
<td>1.8</td>
<td>Child Node</td>
<td>newTID2</td>
<td></td>
</tr>
<tr>
<td>1.8.1</td>
<td>Nodule 1</td>
<td>COMPOSITE See A.3.3.3</td>
<td>newTID2</td>
</tr>
<tr>
<td>1.8.1.1</td>
<td>Referenced Observation UID</td>
<td>1.2.3.4.5.6.7.8.3331.1.1</td>
<td>newTID2</td>
</tr>
<tr>
<td>1.8.2</td>
<td>Short Label</td>
<td>&quot;Nodule Lung-RADS 3&quot;</td>
<td>newTID2</td>
</tr>
<tr>
<td>1.8.3</td>
<td>Child Node</td>
<td>newTID2</td>
<td></td>
</tr>
<tr>
<td>1.8.3.1</td>
<td>Density</td>
<td>COMPOSITE See A.3.3.3</td>
<td>newTID2</td>
</tr>
<tr>
<td>1.8.3.1.1</td>
<td>Referenced Observation UID</td>
<td>1.2.3.4.5.6.7.8.3331.1.2</td>
<td>newTID2</td>
</tr>
<tr>
<td>1.8.4</td>
<td>Child Node</td>
<td>newTID2</td>
<td></td>
</tr>
<tr>
<td>1.8.4.1</td>
<td>Margin</td>
<td>COMPOSITE See A.3.3.3</td>
<td>newTID2</td>
</tr>
<tr>
<td>1.8.4.1.1</td>
<td>Referenced Observation UID</td>
<td>1.2.3.4.5.6.7.8.3331.1.3</td>
<td>newTID2</td>
</tr>
<tr>
<td>1.8.5</td>
<td>Child Node</td>
<td>newTID2</td>
<td></td>
</tr>
<tr>
<td>1.8.5.1</td>
<td>Shape</td>
<td>COMPOSITE See A.3.3.3</td>
<td>newTID2</td>
</tr>
<tr>
<td>1.8.5.1.1</td>
<td>Referenced Observation UID</td>
<td>1.2.3.4.5.6.7.8.3331.1.4</td>
<td>newTID2</td>
</tr>
<tr>
<td>1.8.6</td>
<td>Child Node</td>
<td>newTID2</td>
<td></td>
</tr>
<tr>
<td>1.8.6.1</td>
<td>Diameter</td>
<td>COMPOSITE See A.3.3.3</td>
<td>newTID2</td>
</tr>
<tr>
<td>1.8.6.1.1</td>
<td>Referenced Observation UID</td>
<td>1.2.3.4.5.6.7.8.3331.1.7</td>
<td>newTID2</td>
</tr>
<tr>
<td>1.8.6.2</td>
<td>Child Node</td>
<td>newTID2</td>
<td></td>
</tr>
<tr>
<td>1.8.6.2.1</td>
<td>Long Axis</td>
<td>COMPOSITE See A.3.3.3</td>
<td>newTID2</td>
</tr>
<tr>
<td>1.8.6.2.1.1</td>
<td>Referenced Observation UID</td>
<td>1.2.3.4.5.6.7.8.3331.1.5</td>
<td>newTID2</td>
</tr>
<tr>
<td>1.8.6.3</td>
<td>Child Node</td>
<td>newTID2</td>
<td></td>
</tr>
<tr>
<td>1.8.6.3.1</td>
<td>Short Axis</td>
<td>COMPOSITE See A.3.3.3</td>
<td>newTID2</td>
</tr>
<tr>
<td>1.8.6.3.1.1</td>
<td>Referenced Observation UID</td>
<td>1.2.3.4.5.6.7.8.3331.1.6</td>
<td>newTID2</td>
</tr>
<tr>
<td>1.8.7</td>
<td>Child Node</td>
<td>newTID2</td>
<td></td>
</tr>
<tr>
<td>1.8.7.1</td>
<td>Volume</td>
<td>COMPOSITE See A.3.3.3</td>
<td>newTID2</td>
</tr>
</tbody>
</table>
Node | Code Meaning of Concept Name | Value | TID
--- | --- | --- | ---
1.8.7.1.1 | Referenced Observation UID | 1.2.3.4.5.6.7.8.3331.2.1 | newTID2
1.8.7.2 | Child Node | | newTID2
1.8.7.2.1 | Segmentation | IMAGE See A.3.3.4 | newTID2
1.8.7.2.1.- | Referenced Segment Number | 1 | SR IOD
1.8.7.3 | Child Node | | newTID2
1.8.7.3.1 | Location | COMPOSITE See A.3.3.3 | newTID2
1.8.7.3.1.1 | Referenced Observation UID | 1.2.3.4.5.6.7.8.3331.3.1 | newTID2
1.9 | Child Node | | newTID2
1.9.1 | Nodule 2 | COMPOSITE Similar to A.3.3.3 | newTID2
1.9.1.1 | Referenced Observation UID | 1.2.3.4.5.6.7.8.3331.1.1 | newTID2
1.9.2 | Short Label "Nodule Lung-RADS 4A" | "Nodule Lung-RADS 4A" | newTID2
1.9.3 | Child Node | | newTID2

Note: The above tree presents each nodule first as a Lung-RADS score, then it's characteristics, and finally as a segmentation. Radiologists at a given site might prefer the tree be constructed with a different nesting to present nodules first as a segmentation region, then the characteristics and finally a proposed Lung-RADS score. The software that composes the Result Tree object might permit configuration to construct trees that match such local preferences.

A.3.3.2 Root Result

As described in Section 6.5.3 Analysis Result Encodings, qualitative findings are encoded in DICOM SR objects using TID 1500 as the root template.

The example in Table A.3.3.2-1 represents the SR Content Tree inside the DICOM SR object. The header of the DICOM SR object would look something like the example in Table A.1-1.

Table A.3.3.2-1: Root Result SR Content Example

<table>
<thead>
<tr>
<th>Node</th>
<th>Code Meaning of Concept Name</th>
<th>Value</th>
<th>TID</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Imaging Measurement Report</td>
<td></td>
<td>TID 1500</td>
</tr>
<tr>
<td>1.1</td>
<td>Language of Content Item and Descendants</td>
<td>(en-US, RFC5646, &quot;American English&quot;)</td>
<td>TID 1204</td>
</tr>
<tr>
<td>1.2</td>
<td>Observer Type</td>
<td>(121007, DCM, &quot;Device&quot;)</td>
<td>TID 1001, TID 1002</td>
</tr>
<tr>
<td>1.3</td>
<td>Device Observer UID</td>
<td>1.2.8.7.6.5.7976523321</td>
<td>TID 1004</td>
</tr>
<tr>
<td>1.4</td>
<td>Device Observer Manufacturer</td>
<td>Acme Algorithmics</td>
<td>TID 1004</td>
</tr>
<tr>
<td>1.5</td>
<td>Device Observer Model Name</td>
<td>Lung CT Server</td>
<td>TID 1004</td>
</tr>
</tbody>
</table>
### A.3.3.3 Nodule 1

As described in Section 6.5.3 Analysis Result Encodings, qualitative findings are encoded in DICOM SR objects using TID 1500 as the root template.

The example in Table A.3.3.3-1 represents the SR Content Tree inside the DICOM SR object. The header of the DICOM SR object would look something like the example in Table A.1-1.

<table>
<thead>
<tr>
<th>Node</th>
<th>Code Meaning of Concept Name</th>
<th>Value</th>
<th>TID</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.6</td>
<td>Procedure Reported</td>
<td>(29252-4, LN, &quot;CT Chest WO contrast&quot;)</td>
<td>TID 1500</td>
</tr>
<tr>
<td>1.7</td>
<td>Image Library</td>
<td></td>
<td>TID 1500</td>
</tr>
<tr>
<td>1.8</td>
<td>Imaging Measurements</td>
<td></td>
<td>TID 1500</td>
</tr>
<tr>
<td>1.8.1</td>
<td>Algorithm Name</td>
<td>Lungfish</td>
<td>TID 4019</td>
</tr>
<tr>
<td>1.8.2</td>
<td>Algorithm Version</td>
<td>1.6</td>
<td>TID 4019</td>
</tr>
<tr>
<td>1.8.3</td>
<td>Measurement Group</td>
<td></td>
<td>TID 1501</td>
</tr>
<tr>
<td>1.8.3.1</td>
<td>Finding</td>
<td>(RID50139, RADLEX, &quot;Lung-RADS 4A&quot;)</td>
<td>TID 1501</td>
</tr>
<tr>
<td>1.8.3.2</td>
<td>Finding Site</td>
<td>(39607008, SCT, &quot;Lung&quot;)</td>
<td>TID 1501</td>
</tr>
<tr>
<td>1.8.3.2.1</td>
<td>Laterality</td>
<td>(51440002, SCT, &quot;Bilateral&quot;)</td>
<td>TID 1501</td>
</tr>
<tr>
<td>1.8.3.3</td>
<td>Source Image</td>
<td>1.2.840.10008.5.1.4.1.1.2 (CT Image Storage SOP Class) 1.2.3.4.5.6.7.8.322.1 1.2.3.4.5.6.7.8.322.2 etc. (SOP Instances of CT Chest Images)</td>
<td>TID 1501</td>
</tr>
</tbody>
</table>

### Table A.3.3.3-1: Nodule 1 SR Content Example

<table>
<thead>
<tr>
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<td>1.1</td>
<td>Language of Content Item and Descendants</td>
<td>(en-US, RFC5646, &quot;American English&quot;)</td>
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<tr>
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<td>Observer Type</td>
<td>(121007, DCM, &quot;Device&quot;)</td>
<td>TID 1001 TID 1002</td>
</tr>
<tr>
<td>1.3</td>
<td>Device Observer UID</td>
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<td>TID 1004</td>
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<tr>
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<td>Device Observer Manufacturer</td>
<td>Acme Algorithmics</td>
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<tr>
<td>1.7</td>
<td>Image Library</td>
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<tr>
<td>Node</td>
<td>Code Meaning of Concept Name</td>
<td>Value</td>
<td>TID</td>
</tr>
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<td>------------------------------</td>
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</tr>
<tr>
<td>1.8</td>
<td>Imaging Measurements</td>
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<td>Measurement Group</td>
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</tr>
<tr>
<td>1.8.3.1</td>
<td>Tracking Identifier</td>
<td>Nodule 1</td>
<td>TID 1501</td>
</tr>
<tr>
<td>1.8.3.2</td>
<td>Tracking Unique Identifier</td>
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<td>1.8.3.3</td>
<td>Finding</td>
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<td>Finding Site</td>
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<td>TID 1501</td>
</tr>
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<td>1.8.3.5</td>
<td>Laterality</td>
<td>(7771000, SCT, “Left”)</td>
<td>TID 1501</td>
</tr>
<tr>
<td>1.8.3.6</td>
<td>Source Image</td>
<td>1.2.840.10008.5.1.4.1.1.2 (CT Image Storage SOP Class)</td>
<td>TID 1501</td>
</tr>
<tr>
<td></td>
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<td>1.2.3.4.5.6.7.8.322.21</td>
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</tr>
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<td></td>
<td>(SOP Instances of CT Chest Images)</td>
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<td>(RID50134, RADLEX, &quot;Lung-RADS Assessment&quot;)</td>
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</tr>
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<td>1.8.3.8</td>
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<td>(82280004, SCT, &quot;Smooth&quot;)</td>
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<td>Tracking Identifier</td>
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<td>TID 1411</td>
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<td>TID 1411</td>
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<tr>
<td>1.8.4.3</td>
<td>Geometric Purpose of Region</td>
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</tr>
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<td>1.8.4.4</td>
<td>Referenced Segment</td>
<td>IMAGE</td>
<td>TID 1411</td>
</tr>
<tr>
<td>1.8.4.4.1</td>
<td>Referenced Segment Number</td>
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<td>SR IOD</td>
</tr>
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<td>1.2.3.4.5.6.7.8.322.24</td>
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<td>1.2.3.4.5.6.7.8.322.25</td>
<td></td>
</tr>
<tr>
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<td>(SOP Instances of CT Chest Images)</td>
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</tr>
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<td>1.8.4.6</td>
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<td>SR IOD</td>
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<td>Measurement Group</td>
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<td>Tracking Unique Identifier</td>
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<td>Geometric Purpose of Region</td>
<td>(111010, DCM, &quot;Center&quot;)</td>
<td>TID 1410</td>
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<td>Image Region</td>
<td>SCOORD Point</td>
<td>TID 1410</td>
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</tr>
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<td></td>
<td></td>
<td>1.2.3.4.5.6.7.8.322.23 (CT SOP Instance a)</td>
<td></td>
</tr>
</tbody>
</table>
A.3.3.4 Segmentation 1

As described in Section 6.5.3 Analysis Result Encodings, volumetric segmentations may be encoded as an instance of the DICOM Segmentation IOD.

The example in Table A.3.3.4-1 represents key header attributes of the Segmentation instance. Common Header attributes would appear similar to that shown in Table A.1-1.

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<td>(0008,0060)</td>
<td>CT</td>
</tr>
<tr>
<td>Contributing Equipment</td>
<td>(0018,A001)</td>
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</tr>
<tr>
<td>Purpose of Reference Code</td>
<td>(0040,A170)</td>
<td>(Newcode1, 99CP2064, &quot;Processing Algorithm&quot;)</td>
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<td>Manufacturer</td>
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<td>Acme Algorithmics</td>
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<td>Manufacturer’s Model Name</td>
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<td>Nodule Spotter</td>
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<td>(0018,1020)</td>
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<td>(0018,1002)</td>
<td>1.2.8.7.6.5.787653341.0</td>
</tr>
</tbody>
</table>

A.3.4 CT Chest Abdominal Aortic Aneurysm Assessment Result Set

This is an example of a set of results generated by an abdominal aortic aneurysm assessment algorithm operating on a CT Chest Study.

The result set includes the Result Tree, the Root Result (abdominal aortic aneurysm is present), a triage classification, and a 3D location where the aneurysm was detected.

... 

Reviewers are encouraged to suggest additional examples that would be instructive.
Appendix L – Analysis Result Filtering and Navigation (Informative)

As AI adoption increases, a given study may be subjected to many analyses, potentially from different vendors, leading to many AI-generated results.

Consider a chest CT that is acquired and evaluated by algorithms that produce a collection of results, including findings or observations about:

- Cracked ribs,
- Pneumothorax,
- Pneumonia,
- Scoliosis,
- Aortic aneurysms,
- Coronary plaque, and
- Lung lesions

Further, some results may consist of multiple components; e.g.,

- A lung lesion result might include a finding that a lung nodule is present, a location for the nodule, a segmentation of its boundary, measurements of its dimensions and volume, an overall nodule classification as benign/suspicious/malignant/etc., a Key Object Selection indicating the image slice most representative of the nodule, etc.
- A cracked rib result might include a finding on recency; is it recently cracked, or an older injury.

RadElement commonly groups multiple related elements into “element sets”

The software used to review imaging studies (studies which will now include all these analyses, both conventional and AI-based) will need to address the challenge of helping the radiologist be aware of the available information and review it as appropriate, while simultaneously avoiding the addition of extra time and tangible steps that are anathema in the imaging interpretation process.

Note: The display of individual result primitives is directly addressed by this profile in the form of baseline requirements in [RAD-136]. Specific result discovery or navigation behaviors by the Image Display are left to product design and not addressed by this profile; however, the profile indirectly addresses the related tasks of filtering and navigating the
available results by trying to ensure sufficient relevant metadata is available in the result objects. A “zero-click
interface” would certainly be appealing, but this profile does not attempt to design one.

The following “Hypothetical Behavior” sections are intended to facilitate discussion of possible use cases and mechanisms that would help imaging clinicians. If those discussions identify certain key metadata needed to support such mechanisms, that may result in Change Proposals with requirements, constraints, or recommendations for Evidence Creators or Image Displays. These hypothetical behaviors are not requirements in this profile.

**L.1 Hypothetical Behavior: Result “Display Protocols”**

One could imagine an Image Display allowing users to configure rules and behaviors that controlled what results were initially displayed and how they were presented. This is analogous to conventional hanging protocols which use rules to control what images are presented and how they are organized on the available displays.

A presumption in this display protocol discussion is that none of the results in the study would be inaccessible to the imaging clinician, rather some results would be automatically prioritized, arranged and presented, while others might require interactions by the imaging clinician to access. Based on experience in mammography CAD, where the rate of false positives presented a significant challenge, some forms of result filtering will be necessary to make the display of results usable when more than a few are present in a study.

Some conceivable factors that might be incorporated into rules might include:

- Whether the result is “normal” or “abnormal” (e.g., might not initially display results that are normal or unremarkable)
  - Normal/abnormal may be treated as a continuum using a score or degree of severity
  - Value ranges for normal/abnormal will sometimes be locally defined
- The algorithm “confidence”, perhaps in terms of the sensitivity/specificity of the algorithm, or the positive/negative predictive value, or in terms of some generated metric (e.g., might not display results that do not exceed a certain threshold, and/or might highlight results with a particularly high confidence). Note that “confidence” is easier said than estimated. See RAD TF-1: 49.4.1.5.
- The change or consistency of the current result when compared to prior results. (e.g., might highlight or display results that represent a change from the prior situation; a new lesion vs one that was previously present; a mass that has increased or decreased in size vs one that has not changed size)
- The criticality of an abnormal result (e.g., might display a result with high criticality, perhaps even if it was below the normal confidence threshold). The IHE Results Distribution Profile highlights the RADLEX codes for observation categories (from most to least severe, where the top 3 are differentiated by the rough time frame in which action should be taken):
  - RID49480^Category 1 Emergent Actionable Finding^RadLex
• RID49481^Category 2 Urgent Actionable Finding^RadLex
• RID49482^Category 3 Noncritical Actionable Finding^RadLex
• RID50261^Non-actionable^RadLex
• RID13173^Normal^RadLex (synonym “Unremarkable”)

- Whether the result has been reviewed/verified/approved by a human (e.g., might display results a resident has “approved/verified/confirmed”, perhaps even if it was below the normal confidence threshold).

- The relationship between the type or anatomical location of the results and the indications, reason for study or anatomical focus of the imaging procedure (e.g., might suppress cardiac results that are normal when viewing a lung study but displayed them in a cardiac study, or might provide an organ-based summary of findings)

- The algorithm make/model/version used (e.g., an imaging clinician might be evaluating a particular algorithm and want to see the results of that algorithm for all studies during the period of evaluation; or an imaging clinician might not have confidence in a particular algorithm and not want those results “cluttering” the display)

- Whether the result is a “root result” (see the following Hypothetical Behavior: Root Results, Layers of Detail, Result Summarization) or a subordinate finding (e.g., might display the root result that pneumothorax is present or a lesion was detected, but suppress the segmentation showing the lesion or pneumothorax location unless requested).

- Whether the algorithm completed successfully (e.g., algorithms that failed or only partially completed might still generate results useful for evaluating its performance, or simply knowing that it was run; results created with a failure status would not normally be displayed). Based on experience in mammography CAD, the following states might be considered:
  - Successfully processed
  - Partially processed; incomplete
  - Processing failed; unsupported data (e.g., wrong body part or modality)
  - Processing failed; modality model not validated
  - Processing failed; low confidence

- The relative date/time of multiple results (e.g., current results might be presented next to prior results, and/or differentiated from a current result from re-processing a prior image)
  - Note that the date/time of the results reflects when they were created, as distinct from the date/time of the images from which the results were generated
  - Multiple findings might also be present in the study for the same Concept when different algorithms make a determination, say, on whether pneumonia is present, or the same algorithm is run with different parameters.
• The approval status of the algorithm (e.g., during normal clinical reading might not initially display the results of a research algorithm that is not yet FDA approved). The approval status of the algorithm might not be encoded directly in the result but rather the Algorithm Identification coded into the result might be used to consult a database or configuration table that records the status for each algorithm locally in use.

• The approved paradigm of the algorithm (e.g., might not initially display the results of an algorithm approved for use as a “second reader” since that would invalidate its intended mode of use, or).

• The type of reader (e.g., might not initially display some types of results to Emergency Room readers, or residents)

• The nature of the current review (e.g., might present the “worst” case of several conflicting results when performing triage, while normal reading workflow might prioritize differently or might present both results).

• Known details about the patient (e.g., might not highlight a pneumothorax result for a patient known to have chest tube in place unless the pneumothorax size exceeds a certain threshold)

• Relationships between results (e.g., for a primary finding that a tumor is present, the related results that show the segmented surface of the tumor, and the numerical measurements of the dimensions and volume might be displayed together, or the primary finding might be displayed with an indicator that there are secondary/supporting results that can also be displayed. In addition to direct references between results, relationships can also be inferred by results sharing the same Tracking Identifier, the same Finding Site, or the same Frame of Reference)

• Results that correspond to fields in the current report template (e.g., findings that will automatically “flow through” to populate elements of the report based on the current configuration would be displayed or highlighted to make sure the radiologist is fully aware. To a certain extent, the report template encodes a certain focus of interest. More specifically, a report template that is tuned to the needs of a particular specialist (cardiologist, pulmonologist, neurosurgeon, family doctor, etc.) may focus on findings relevant to their interests. A study of coronary artery calcification might not highlight an abdominal aortic aneurysm of less than 3cm. As more analysis is performed, the ratio of observations that do not appear in the report might exceed the observations that do.)

Rules might also control how results are grouped or formatted on the display, for example grouping abnormal findings together, or grouping cardiac results separately from lung results, or grouping results that came as a set from a particular algorithm.

An additional complexity is that a study might contain conflicting results. Consider a general chest X-Ray algorithm that evaluates 6 conditions, which determined that cracked ribs were absent, and another special purpose algorithm (which might be considered to be more sophisticated) which determined that two cracked ribs were present. What if the findings were
reversed, with the more specialized model indicating no fractures and the less specialized model indicating fractures were present? Perhaps the result with the higher confidence would be displayed with an indication that conflicting results are present.

SR instances from different Evidence Creators will be in different series which may provide additional clues for the Image Display.

**L.2 Hypothetical Behavior: Root Results, Layers of Detail**

It seems likely that displays might leverage component hierarchy by first presenting a summary “root” result or key value to an imaging clinician and offer the ability to explore additional layers of detail as needed, for example allowing the imaging clinician to expose the segmentation that underlies a volume measurement. This exploration might be done to gain greater confidence in the root result, or to comprehend more details and nuances of the finding(s).

In another example, a lung screening algorithm might record a LungRADS™ score as a root result, supported by secondary results consisting of multiple detected nodule locations and assessments of the size, solidity, and margin of each detected nodule. Another algorithm might record an SR finding of “pneumonia present” as a root result with a reference to a separate saliency map instance. An Image Display might then initially present the two root results (LungRADS = Category 3) and (Pneumonia present) and offer “drill down”, rather than initially presenting 43 components consisting of location, size, solidity, margin, and LungRADS for each of 8 nodules, an overall LungRADS score, the pneumonia finding, and the pneumonia saliency map reference.

Root results would likely capture the hierarchy within a set of results that were generated together. If multiple applications were run on a study, each would likely generate its own root result. More advanced logic or analysis software might prioritize all results for a given study.

An effective root result mechanism should allow a display to use a simple query filter to get the first-order set of “summary findings”. The references in each of those root results provide a logical next layer of detail. Ideally, some displays will develop much more sophisticated analysis and logic, or more advanced configurations, and more advanced navigation and display, while the root results would provide a first simple step up from the flat list of findings.