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# SOP: 3D Reference Object Approval

Process for approving a 3D reference object minimum viable product (MVP) models for integration into EUI and RUI tools

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# Introduction

The procedures outlined in this document describe how 3D reference objects are reviewed, refined, and approved by subject matter experts (SMEs), and thus describe our quality assurance/quality control for these 3D objects. Models appear in the [CCF Portal 3D Reference Object Library](#) on the [CCF Portal](#) and are used in the [Registration User Interface](#) (RUI) and [Exploration User Interface](#) (EUI).

This document is intended for subject matter experts (SMEs), many of whom are organ experts from other funded components of HuBMAP.

# Roles and Responsibilities

Below, please find definitions for each role in the procedures outlined here. [Table 1](#) identifies the people occupying these roles.

**Subject Matter Expert(s) or SME(s)** is a person with extensive knowledge about a given topic. Here, SMEs lend us their expertise to ensure that 3D models are built not only factually correctly but also in a manner that requires minimal correction and design iterations.

The **3D Modeler** builds 3D models, negotiates and implements suggested changes with SMEs, and uploads the models for usage in HuBMAP services and user interfaces.

**Senior Research Analyst** compiles and shares a gross-anatomical list of terms from the ASCT+B table.

The **Facilitator** is the 3D Modeler's main contact in the MC-IU team. They provide the information and resources the 3D Modeler needs and facilitates communication between the 3D Modeler and the SMEs throughout the process of building an organ. The 3D Modeler and the Facilitator meet weekly.

The **Systems Architect** uses the 3D objects in the Registration User Interface (RUI) and Exploration User Interface (EUI). The Systems Architect offers their technical expertise in the areas of 3D model storage options and the integration of the 3D models into the HuBMAP ecosystem (e.g., how structures should be labeled to work well with existing ontology schemas).

**Principal Investigator (PI)** is responsible for delivering anatomically correct 3D models for use in the HuBMAP Atlas construction effort. The PI approves budgets associated with the 3D reference object modeling process, sets high-level goals and associated deadlines, attends meetings, and reviews notes and recordings from relevant meetings between the Facilitator and other key personnel as outlined in this SOP as needed.

**Table 1.** Roles, names, and email addresses of key personnel.

| Role | Name | Email |
|---|---|---|
| Subject Matter Expert (SME) | Depends on organ | |
| 3D Modeler | Kristen Browne | kristen.browne@nih.gov |
| Facilitator | Andreas Bueckle | abueckle@iu.edu |
| Senior Research Analyst (Anatomical structures) | Ellen Quardokus | ellenmq@iu.edu |
| Systems Architect | Bruce W. Herrr II | bherr@iu.edu |
| Principal Investigator (PI) | Katy Börner | katy@iu.edu |

# Workflow

## Step 1: Identify SME(s)

- When a new organ is selected for inclusion in the MC-IU UIs, the PI identifies 1-3 SMEs

a. Selection is made from experts researching the organ within HuBMAP
   b. Experts outside HuBMAP are invited as needed to construct and review the organ.
- The Facilitator is notified of the selection by the PI.

## Step 2: On-boarding SMEs

- The Facilitator sends an initial email to SME, pointing them to this SOP.
- The Facilitator orients the SME to the task:
   a. An overview of the roles outlined in this SOP, who occupies these roles, and why they are needed
   b. The scope of MC-IU's UIs for HuBMAP, e.g., the RUI and EUI
   c. How the 3D reference organ models are used in these UIs
   d. That SME input is essential for the successful implementation and inclusion of 3D models in the MC-IU UIs
   e. How the 3D model review process works, see below
- The Facilitator requests the ORCID(s) from the SME(s).
- At this time, the Facilitator also shares videos and other demo materials about the RUI, EUI, and organ review process (see Tools and Organ Review section below). Specifically, they share as needed:
   a. A RUI demo, to be updated with every major RUI release:
      https://www.youtube.com/watch?v=zT3DDQ7Ju-k&feature=youtu.be
   b. An EUI demo, to be updated with every major RUI release (same link as RUI but later in the video)
   c. A demo of how to use Babylon.js Sandbox: https://youtu.be/RIF-N8gqUdY

## Step 3: Gathering Requirements

- The Facilitator establishes initial contact between the SME and the 3D Modeler via email. The 3D Modeler may request a call to answer organ-specific questions, establish a specific work mode, or review existing and prior work that could help build the 3D model. All calls are recorded and meetings notes are taken. The recordings and meeting notes are available from the Facilitator upon request. This initial meeting (if deemed necessary by the 3D Modeler) covers the following material:
   a. The Facilitator provides a brief overview of how the organs will be used
   b. The SME confirms that they have understood this SOP, and asks any remaining questions
   c. The 3D Modeler communicates what material is needed to produce the first iteration of the model. This entails:
      i. Whether existing data can be used as a guide for the modeling process (such as Visible Human data)
      ii. Whether an existing 3D model can be used (e.g., an existing knee model or a model from a different species as for lymph node)

       iii.      Whether multiple versions of the organ are needed (e.g., left vs. right; male vs. female).

       iv.      Whether the model is to be adapted from clinical data or should be designed to reflect textbook anatomy.

       v.      Organs include sub-structures and vasculature as defined by the SME.

       vi.      The 3D Modeler and the SME decide together what data is to be used.

       vii.      If needed, the PI can specify requirements for the data to be included (e.g., to exploit synergies with other efforts such as the Allen Brain Atlas) or help obtain a dataset that can be used for the modeling process.

- The Senior Research Analyst prepares and shares a gross-anatomical list of terms from the ASCT+B table, see ASCT-B Table_Construction SOP and CCF portal.
- The SME  then adds new terms or removes existing ones and approves the final version of the list. The SME typically  consults with ASCT+B table authors. The final authority lies with the SME. If there are multiple SMEs, the SME team has to come to a consensus. The final list is shared with the 3D Modeler.
- The 3D Modeler then evaluates the list against what can be found in existing data (Visible Human data or other). They also provide a time and cost estimate for model design which is used to help prioritize organ model design.
- The SME reviews the edited list and evaluates whether any additional  spatial references or landmarks are required in order to be able to register or explore tissue blocks.
- The Facilitator is involved when either the3D Modeller or SME(s) request it.

## Step 4: Organ Construction

Once requirements from the PI and SME have been captured, modeling work begins. The Modeler produces 3D reference objects from Visible Human or other data identified by SMEs or the PI using standard industry tools such as Autodesk Maya, ZBrush, and Blender.

- The 3D Modeler builds a first version of the model.
- The 3D Modeler informs the Facilitator about their progress and any roadblocks encountered, either in their weekly meeting or via email.
- The Facilitator involves the PI to make decisions about content or if the SME is unresponsive.
- The 3D Modeler shares a draft of the model with the SME, the Facilitator, and the PI as needed. The Facilitator enables this demo by making sure every party has access to the model and Tools that can be used to review the model. The 3D Modeler makes the model available via GitHub.

## Step 5: Tools & Review

3D modeling and reviewing is an iterative, complex process that can be computationally expensive. Luckily, there now exist various web-based technologies that allow anyone with an internet connection and an updated web browser to load 3D models, inspect them from various angles,

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read through the hierarchy of substructures with the 3D object, and even adjust the lighting and other scene-related settings to ensure that all potential problems can be identified.

- During the review process, meetings should be a last resort in order to use time efficiently. Emails and annotated screenshots are the preferred means of communication.
- In order to review 3D models, the 3D Modeler uploads a review version of the given mode to the GitHub repository used for staging.
- The 3D Modeler shares a direct link of the 3D model on GitHub with the SMEs.
- The SME downloads the GLB version of the model to their computer.
- The SME uses Babylon.js Sandbox to view the 3D model in their browser. A tutorial on how to download the 3D model and then view it in Babylon can be found here: https://youtu.be/RIF-N8gqUdY
- The SME provides feedback on the model to the 3D Modeler via email. Annotated screenshots work well in communicating suggested changes. These changes can relate to the accurate positioning and shape of structures, the naming, and the relationship between the structures and substructures.
- If needed, the 3D Modeler arranges a meeting with the SME to discuss details.
- The 3D Modeler incorporates changes suggested by the SME and then shares them back for approval.
- Completed organs are shared with SMEs for their final approval.
- Progress and final approvals are tracked by the Facilitator with input from the 3D Modeler and the PI in a document that is available on request.

# References and Definitions

The below references and definitions were used in writing this Standard Operating Procedure. When available, definitions were taken from the HuBMAP Dictionary, and aligned with standard terminologies used in relevant fields.

## References

- 3D Model Viewer: https://sandbox.babylonjs.com/
- 3D models are stored on GitHub: https://github.com/hubmapconsortium/ccf-3d-reference-object-library
- 3D models are featured on the CCF Portal: https://hubmapconsortium.github.io/ccf/pages/ccf-3d-reference-library.html

## Glossary

**3D model**: A 3D model is a digital object, consisting of vertices and edges, who, when taken together, can form a potentially endless variety of primitive (e.g., cubes, spheres, cones) and

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complex shapes (such as organs). 3D models come in many formats with various capabilities and limitations (OBJ, FBX, GLB, see below). We use GLB and FBX as output formats.

**ASCT+B Tables:** see HuBMAP Glossary.

**Common Coordinate Framework (CCF):** see HuBMAP Glossary.

**Exploration User Interface (EUI)**: see HuBMAP Glossary.

**FBX file format:** 3D file format specification, see https://code.blender.org/2013/08/fbx-binary-file-format-specification/

**GitHub:** an online service for version control and code-sharing

**GLB file format:** 3D file format specification, see https://docs.fileformat.com/3d/glb/

**OBJ file format:** 3D file format specification, see https://www.cs.cmu.edu/~mbz/personal/graphics/obj.html

**Registration User Interface (RUI)**: see HuBMAP Glossary.

**Standard Operating Procedures (SOPs)**: Describe team member responsibilities and outline procedures, which must be followed to support the reproducibility of scientific research.

**Visible Human (VH):** The Visible Human Male and Visible Human datasets are provided by the National Library of Medicine. Add additional information about this data set, e.g., CT scans, gathered for what purpose.