

## SOP: 3D Reference Object Approval

Process for approving a 3D reference object minimum viable product (MVP) model for integration into the 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). 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 funded components of HuBMAP or other projects.

## Roles and Responsibilities

Different types of expertise are required to author and approve 3D reference objects and major roles are listed below. [Table 1](#) identifies the people occupying these roles.

A **Subject Matter Expert (SME)** is a person with extensive knowledge about a given topic. In the procedures addressed here, the SME ensures that 3D models are built in an anatomically correct manner. The procedures followed by the SME are designed to ensure that the 3D models are built using a process that requires minimal corrections and design iterations.

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

The **Senior Research Analyst** compiles and shares a gross-anatomical list of terms from the relevant 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 facilitate communication between the 3D Modeler and the SME(s) 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 provides 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).

The **Principal Investigator (PI)** holds final responsibility for delivering anatomically correct 3D models for use in the HuBMAP Human Reference Atlas. 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 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	<a href="mailto:kristen.browne@nih.gov">kristen.browne@nih.gov</a>
Facilitator	Andreas Bueckle	<a href="mailto:abueckle@iu.edu">abueckle@iu.edu</a>
Senior Research Analyst	Ellen Quardokus	<a href="mailto:ellenmq@iu.edu">ellenmq@iu.edu</a>
Systems Architect	Bruce W. Herr II	<a href="mailto:bherr@iu.edu">bherr@iu.edu</a>
Principal Investigator (PI)	Katy Börner	<a href="mailto:katy@iu.edu">katy@iu.edu</a>

## Workflow

### Step 1: Identifying SME(s)

- When a new organ is selected for inclusion in the HuBMAP Human Reference Atlas, 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 PI notifies the Facilitator of the selection.

## Step 2: On-boarding SMEs

- The Facilitator sends an initial email to the SME(s), pointing them to this SOP.
- The Facilitator orients each SME to the task by providing the following information:
  - 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 that the SME provide their ORCID iD(s) via this [registration form](#) for the ASCT+B Working Group.
- At this time, the Facilitator also shares videos and other demo materials about the RUI, EUI, and organ review process (outlined in the **SME Review** section below) including:
  - a. A [RUI demo](#), to be updated with every major RUI release.
  - 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. For the best experience, use either Firefox or Chrome as a browser.
  - d. Written instructions for how to use Babylon.js Sandbox can be found [here](#).

## Step 3: Gathering Requirements

- The Facilitator establishes initial contact between the SME(s) and the 3D Modeler via email. The Facilitator emphasizes that this effort is separate from the ASCT+B table effort and that time requirements will be much shorter. It is crucial to state that the gross anatomy can be separated from the ASCT+B table, which is focused on cell types and biomarkers, but that the gross anatomy should also be put into the ASCT+B table.
- 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 meeting notes are taken. The recordings and meeting notes are available from the Facilitator upon request. This initial meeting (unless deemed unnecessary by the 3D Modeler) covers the following topics:
  - 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 Senior Research Analyst prepares and shares with the SME a list of gross-anatomical terms. This list includes relevant metadata ontology IDs and labels to tag models with.
- d. The SME adds new terms or removes existing ones and approves the final version of the gross-anatomical terms list. The final authority lies with the SME. If there are multiple SMEs, the SME team is responsible for reaching consensus. The SME then shares the final list with the 3D Modeler.
- e. The 3D Modeler evaluates the list against what can be derived from 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.
- f. 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.
- g. The Facilitator is involved when either the 3D Modeller or SME(s) request it.
- h. The 3D Modeler communicates what material is needed to produce the first iteration of the model. This entails:
  - i. Clarification of the organ list - i.e. naming conventions, groupings, and if there are many, how they will be designated. The result of this effort will be reflected in the structure list as a complete listing of every object that will be created and how it will be labelled and tagged.
  - ii. Whether existing data can be used as a guide for the modeling process (such as Visible Human data)
  - iii. 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)
  - iv. Whether multiple versions of the organ are needed (e.g., left vs. right; male vs. female).
  - v. Whether the model is to be adapted from clinical data or should be designed to reflect textbook anatomy.
  - vi. Organs include sub-structures and vasculature as defined by the SME.
  - vii. The 3D Modeler and the SME decide together what data is to be used.
  - viii. 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.

## 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.

# HuBMAP

- 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 needed to review the model. The 3D Modeler makes the model available via GitHub.

## Step 5: SME Review

3D modeling and reviewing is an iterative, complex process that can be computationally expensive. Web-based technologies allow anyone with an internet connection and an updated web browser to load 3D models, inspect them from various angles, 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. Procedures for using these tools in the review process are found below.

- 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.
- 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 to the 3D model on GitHub with the SME(s).
- 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 using Firefox or Chrome. A tutorial on how to download the 3D model and then view it in Babylon can be found [here](#).
- 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(s) to discuss details.
- The 3D Modeler incorporates changes suggested by the SME(s) and then shares them back for approval.
- Completed organs are shared with SME(s) for their final approval.
- Next, the System Architect and the PI review the model and share comments with the 3D Modeler and SME(s).
- 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.

## Step 6: Publishing

The publishing process is guided by the [SOP on Using 3D Reference Objects](#).

## 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 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](#).

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**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.