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**The Unit Manufacturing Process
(UMP) Builder: User's Guide**

David Lechevalier
William Z. Bernstein

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Engineering Laboratory*

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National Institute of Standards and Technology
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Abstract

The ASTM E3012 Standard Guide for Characterizing Environmental Aspects of Manufacturing Processes provides guidelines for formally characterizing manufacturing processes. However, the difficulty that has arisen in the early use of the standard illustrates the need for intuitive tools for helping modeling experts to conform to the specified information model. The Unit Manufacturing Process (UMP) Builder was developed at the National Institute of Standards and Technology (NIST) to provide a visual interface for helping modeling experts to conform to the specified ASTM information model. The UMP Builder, a browser-based tool, integrates symbolic mathematical and guided textual inputs, helping to consistently record manufacturing process models for environmental sustainability into a repository. The Builder also serves as a curator by providing capabilities to explore and visualize models recorded in the Builder repository.

The UMP Builder is adapted from of an open source tool called the Configurable Data Curation System (CDCS) developed at NIST. The CDCS was originally developed to capture, share, and transform materials data, allowing users to upload an XML schema and create instances of that schema. In the UMP Builder, the schema used for creating the models is frozen. The schema follows the guidelines from the ASTM E3012 standard. The Builder also provides unique features that are specific in order to facilitate the modelling of UMPs. This user's guide aims to provide guidelines to use the UMP Builder. To obtain more information (especially on the architecture), please refer to the CDCS documentation.

Key words

ASTM E3012; Information Modeling; Smart Manufacturing; Sustainable Manufacturing; and Unit Manufacturing Processes.

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1. Introduction

The ASTM E3012 Standard Guide for Characterizing Environmental Aspects of Manufacturing Processes provides guidelines for formally characterizing manufacturing processes. However, in its current form, the standard itself is not sufficient to ensure the creation and curation of UMP models that can be shared between manufacturing enterprises. Users of the standard, specifically process modelers, require computer-supported toolkits to ease the conformance to the standard data representation. In response, the UMP Builder [1] was developed at the National Institute of Standards and Technology (NIST) to provide a visual interface for helping modeling experts to conform to the specified ASTM 3012 information model. The UMP Builder, a browser-based tool, integrates symbolic mathematical and guided textual inputs, helping to consistently record manufacturing process models for environmental sustainability into a repository [2]. This document describes the features of the Unit Manufacturing Process (UMP) Builder.

The UMP Builder was developed as part of the Smart Manufacturing Systems Design and Analysis Program [3] at NIST. The tool provides a web interface to create a model, a repository to curate the models, and an interactive visualization of the models. These features provide an initial layer of governance and verification with respect to the conformance to ASTM 3012 and are widely described in this user's guide.

The UMP Builder is adapted from of an open source tool called the Configurable Data Curation System (CDCS) developed at NIST [4]. The CDCS was originally developed to capture, share, and transform materials data, allowing users to upload an XML schema and create instances of that schema. In the UMP Builder, the schema used for creating the models is frozen. The schema follows the guidelines from the ASTM E3012 standard. The Builder also provides unique features that are specific to facilitate the modelling of UMPs. This user's guide is not intended to describe the CDCS architecture or functions but to provide guidelines to use the UMP Builder's functions that might be slightly different than the CDCS functions. To obtain more information about the CDCS architecture and technology, please contact the team in charge of the CDCS or refer to the documentation¹.

The remainder of this document presents the different UMP Builder features and how to use them.

2. User Interface

This section describes the UMP Builder user interface and its basic operations including:

- curating UMP models
- visualizing UMP models
- exploring the UMP repository
- accessing the dashboard
- administrating the UMP Builder

¹<https://www.nist.gov/itl/ssd/information-systems-group/configurable-data-curation-system-cdcs>

The home page provides the necessary access to these operations depending on the user's credentials.

2.1 Home Page

The home page provides generic information about the UMP Builder as shown in Figure 1.



Fig. 1. Home Page as an Anonymous User

As an anonymous user, you cannot access any of the feature of the tool. You first need to login or to request a new account.

2.1.1 Request a New Account

You first need to request a new account. Click on the login tab and click on the *Request an Account* button to be redirected to the required form shown in Figure 2. Provide the

necessary information. A specific policy must be followed for the password. The password:

Unit Manufacturing Process Builder

Login | Help

Home Request New Account

Request New Account

Request New Account

Use the following form to request a user account on the Unit Manufacturing Process Builder.

Username:

Password:

Confirm Password:

First Name:

Last Name:

Email Address:

Make a Request

Home | Contact Top ^

Fig. 2. Request a New Account

- must be at least 12 characters
- must contain 3 or more letters
- must contain 1 or more number
- must contain 1 or more symbol
- must contain 1 or more uppercase letter

Once requested, your account must be approved by an administrator. An email confirmation will be sent to the provided email address to confirm the request submission, and the account approval or rejection.

2.1.2 Login

To login, click on the *Login* tab at the top of the home page. You are redirected to the login page in which you can either log in or request a new account as shown in Figure 3. To login, use the credentials you have requested originally. Once logged in, the home page

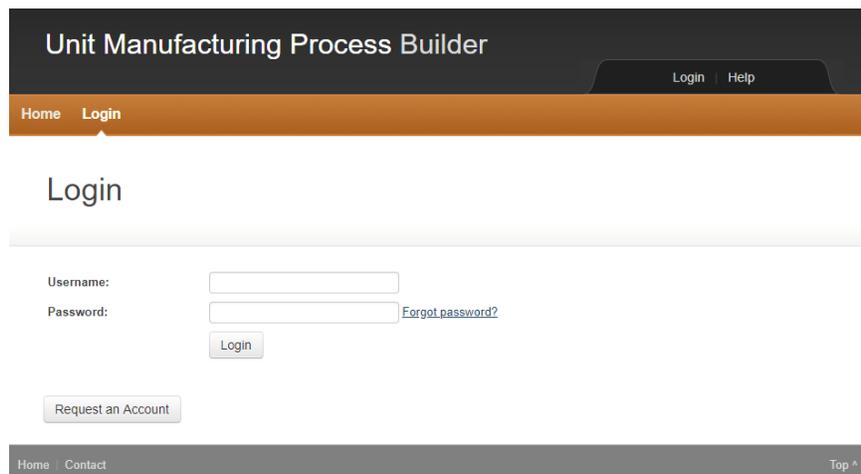


Fig. 3. Login

provides additional options, depending on the user credentials as shown in Figure 4. The available features are described in the following sections.



Fig. 4. Home Page as a Logged User

2.2 Curation

To create a new model and curate information about a UMP, you need to click on the *UMP Curation* tab in the home page. Three options are available as shown in Figure 5:

- Start a new UMP model
- Open a work-in-progress
- Upload a local UMP model

These options are described in the following sub-sections.

2.2.1 Start a New Model

When you want to start a new model in the UMP Builder, you should select the option *Start a new UMP model*. You will be provided with an empty form to start creating a new model. Before clicking on the *Start* button, you need to provide a name to your model such

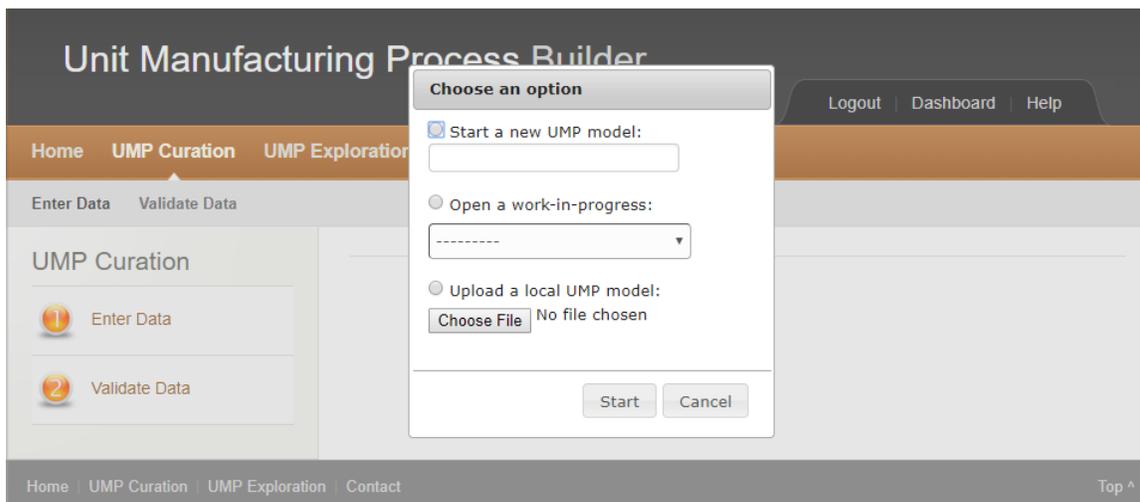


Fig. 5. UMP Curation

as “My new model” in Figure 6. Once you provided a name, you can press *Start*. You will be redirected to a new page with an empty form.

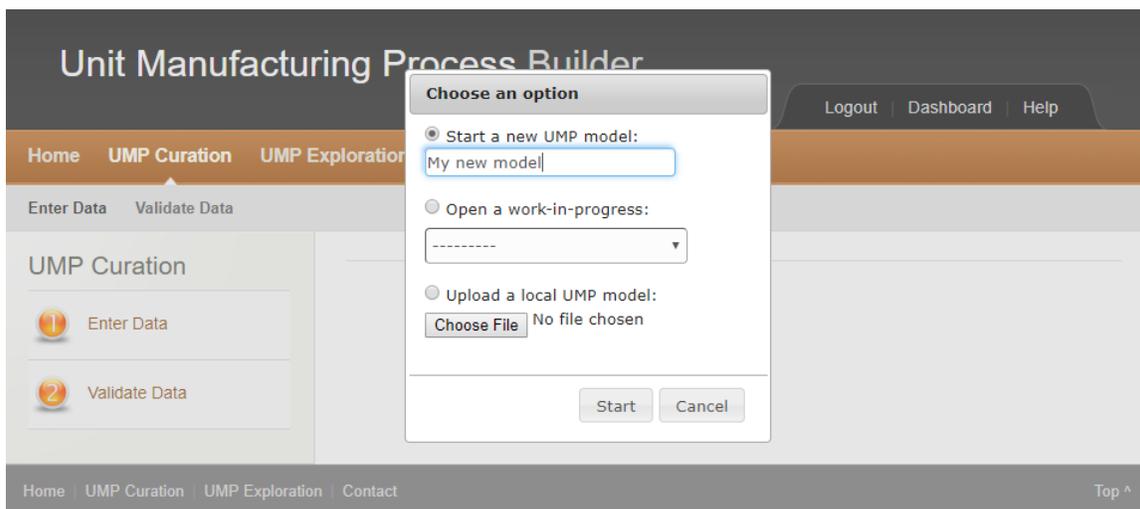


Fig. 6. Start a New Model

2.2.2 Open a Work-in-Progress

A model is periodically saved when you work on it. You also have the option to manually save progress. The option *Open a work-in-progress* allows you to reopen a model that needs additional work before being submitted to the repository. In Figure 7, you can see that “My model in progress” is available and can be reopened to provide additional information.

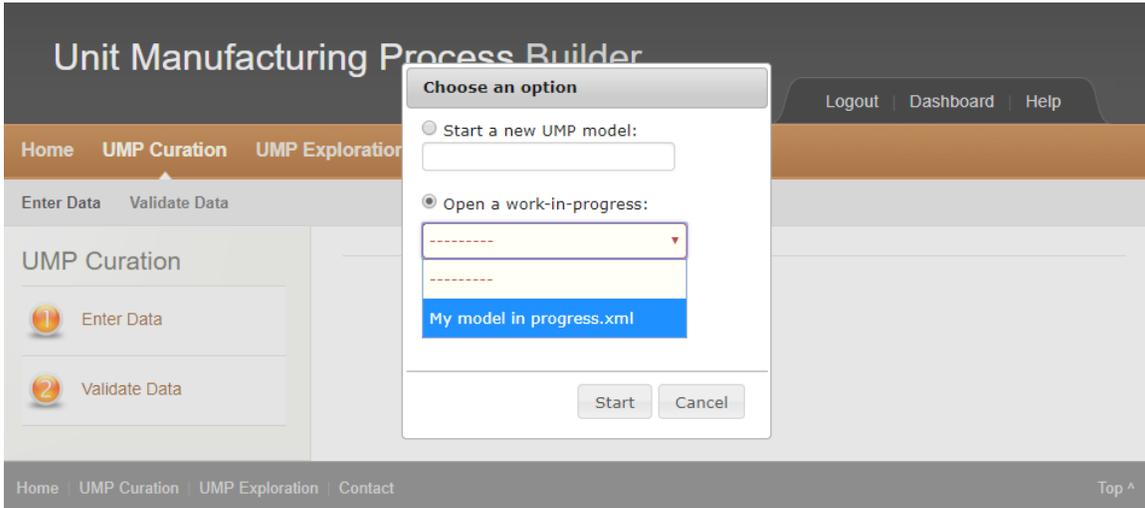


Fig. 7. Open a Work-in-Progress

2.2.3 Upload a Local UMP Model

The option *Upload a local UMP model* allows you to import a model you might have built locally with your own XML tool. The model that you import must be compliant with the schema used in the tool. The schema is available online [5]. To import your file, click on *Choose file*, select your UMP model and click *Open* in the new window shown in Figure 8, and click on start to be redirected to the new page.

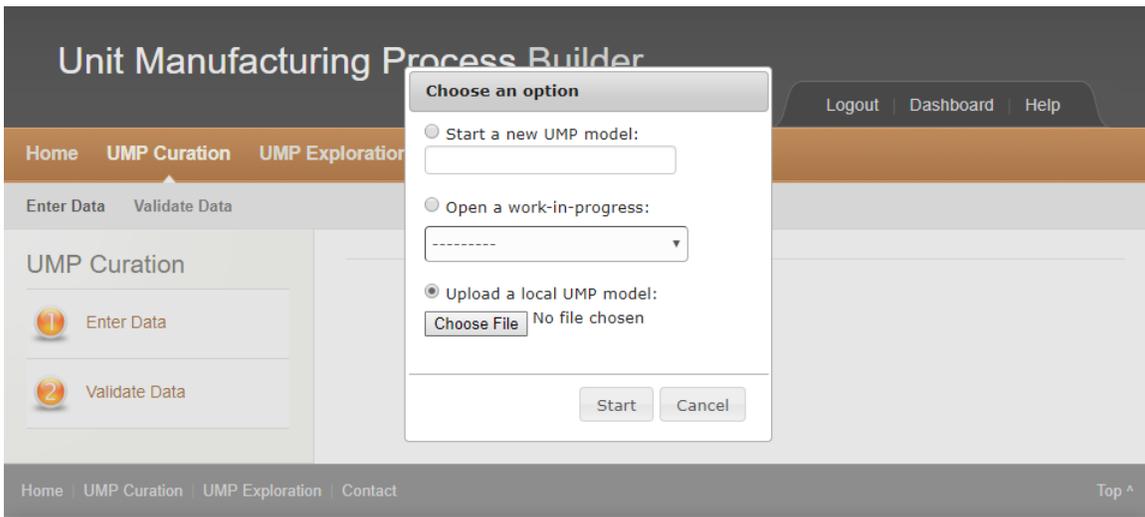


Fig. 8. Open a Local UMP Model

Once you selected one of the three options and pressed *Start*, you will be redirected to the new page that provides either an empty form (if you start a new model) or a form

pre-populated with information (if you open a work-in-progress or upload a local UMP model). The new page is described in the next section.

2.2.4 Curate the Information

The UMP Builder provides a form to create a UMP model. Shown in Figure 9, tooltips will appear when the mouse hovers over the different fields composing the form to help you understand what kind of information is expected in the different fields.

At any moment, you can either clear all the fields, save your work-in-progress (although there is an auto-save feature included), or download the current model in an XML format. The following sub-sections will describe the different fields to build a UMP model.

In this form, you can add an attribute or an element of a given type by clicking on . You can delete an attribute or an element by clicking on . You can expand or collapse an element by clicking on  or .

Please refer to the UMP schema documentation [6] to know what type of information you should provide for each field while creating an UMP model.

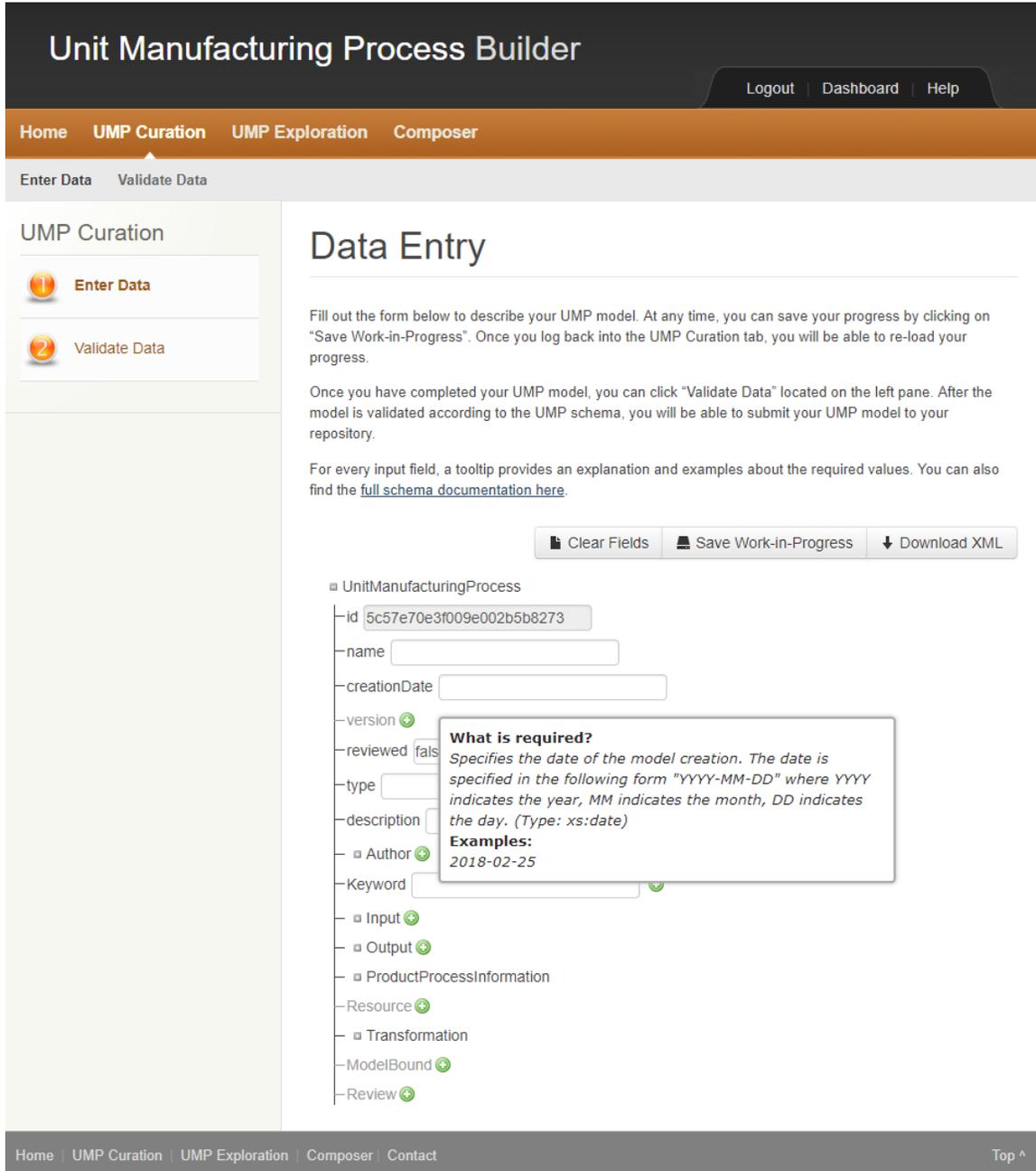


Fig. 9. Curate the Information with Tooltip Help

2.2.5 Curate the Meta-Information

The first section of the form allows you to provide model meta-information. The tooltips will provide information about the appropriate format, especially for dates. An example is provided in the Figure 10. The *id* field is automatically populated.

The screenshot shows the 'Unit Manufacturing Process Builder' web application. The main header is dark grey with the title 'Unit Manufacturing Process Builder' and navigation links for 'Logout', 'Dashboard', and 'Help'. Below this is an orange navigation bar with 'Home', 'UMP Curation', and 'UMP Exploration'. Underneath, a grey bar contains 'Enter Data' and 'Validate Data'. The left sidebar is titled 'UMP Curation' and has two buttons: 'Enter Data' (with a red exclamation mark icon) and 'Validate Data' (with a yellow checkmark icon). The main content area is titled 'Data Entry' and contains instructions: 'Fill out the form below to describe your UMP model. At any time, you can save your progress by clicking on "Save Work-in-Progress". Once you log back into the UMP Curation tab, you will be able to re-load your progress.' It also states: 'Once you have completed your UMP model, you can click "Validate Data" located on the left pane. After the model is validated according to the UMP schema, you will be able to submit your UMP model to your repository.' A note says: 'For every input field, a tooltip provides an explanation and examples about the required values. You can also find the [full schema documentation here](#).' Below the text are three buttons: 'Clear Fields', 'Save Work-in-Progress', and 'Download XML'. The form is for a 'UnitManufacturingProcess' and includes the following fields: 'id' (5c19075af39cba002b0ce4de), 'name' (Milling model), 'creationDate' (12/18/2018), 'version' (with a green plus icon), 'reviewed' (false), 'type' (Milling), 'description' (This is my milling model), 'Author' (with a green plus icon) containing 'FirstName' (David), 'LastName' (Lechevalier), 'Organization' (Engisis LLC), and 'Email' (with a green plus icon). There are two 'Keyword' fields: 'milling' and 'demonstration', each with a green plus icon and a red X icon. Below these are expandable sections for 'Input', 'Output', 'ProductProcessInformation', 'Resource', 'Transformation', 'ModelBound', and 'Review', each with a green plus icon. The footer is dark grey with 'Home | UMP Curation | UMP Exploration | Contact' on the left and 'Top ^' on the right.

Fig. 10. Curate the Meta-information

2.2.6 Curate the Inputs and the Outputs

The second and third sections of the form enables the creation of inputs and outputs. Inputs and outputs follow the same schema. An example of an *Input* called “Electricity” is shown in Figure 11. In a UMP model, *Symbols* and *Bounds* are always represented in a specific format called Mathematical Markup Language (MathML) [7]. To facilitate the representation of the information in this format, we used the trial version of a tool called MathType².

Fig. 11. Curate an Input

Figure 12 shows how the MathType interface looks like. The only requirement to properly add information in the MathML formats is to check the button  when you add a variable name and unchecked it when you anything else. The variable name is then boxed in blue.

²<http://www.wiris.com/en/mathtype>

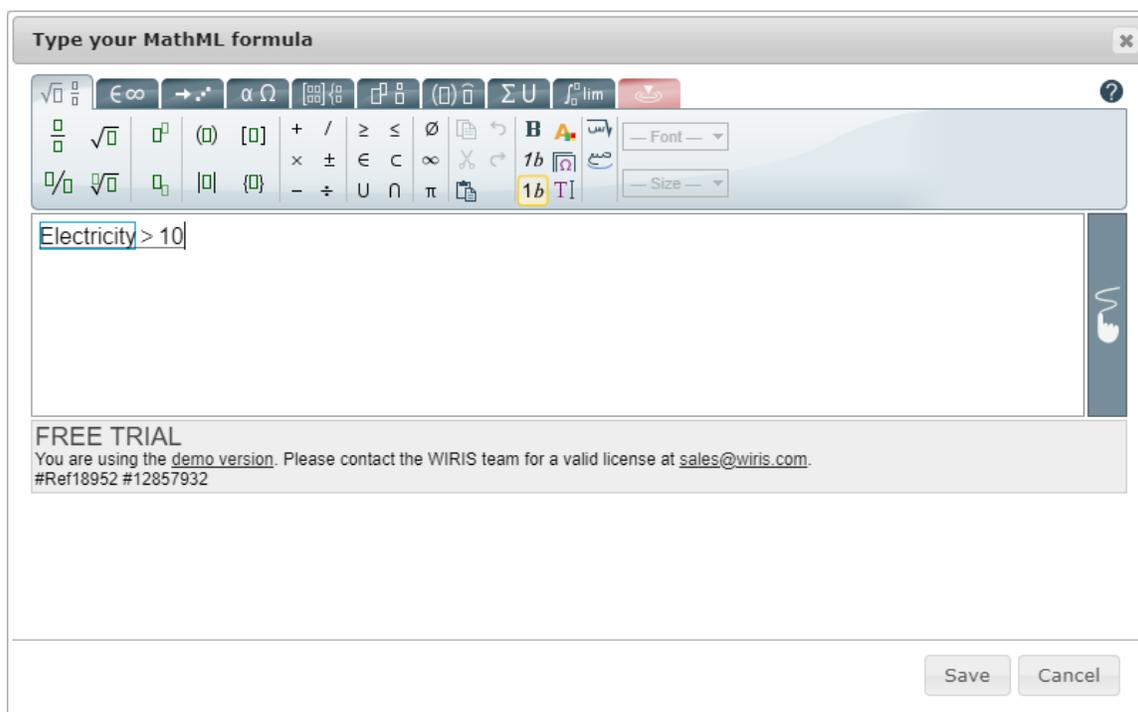


Fig. 12. MathType Interface

2.2.7 Curate the Product and Process Information

ProductandProcessInformation is the fourth section of the form and currently includes 5 sub sections:

- *ControlParameter*
- *FixedParameter*
- *IntermediateVariable*
- *MetricofInterest*
- *SupportingInformation*

ControlParameter, *IntermediateVariable* and *MetricofInterest* follow the same schema. *FixedParameter* includes an additional element called *Value*. Like the inputs and outputs, *ControlParameter*, *FixedParameter*, *IntermediateVariable* and *MetricofInterest* includes *Symbols* and *Bounds* in the MathML format. The MathType interface is also provided to include the necessary values. Figure 13 shows an example for a *ControlParameter* called “Depth of cut”.

2.2.8 Curate the Resources

Resource is the fifth section of the form. Several resources can be included in the model. An example of a *Resource* called “Operator” is shown in Figure 14.

Fig. 13. Curate a Control Parameter

Fig. 14. Curate a Resource

2.2.9 Curate the Transformations

Transformation is the sixth section of the form and currently includes sub-sections:

- *Equation*
- *PMMLModel*
- *FeasibilityConstraint*
- *Description*

Equation, and *FeasibilityConstraint* follow the same schema. *PMMLModel* follows its own schema. Finally, *Description* provides a field to record information in a text format about the transformation represented in the model. *Equation*, and *FeasibilityConstraint* include a MathML representation. The MathType interface is also provided to include the necessary values. Figure 15 shows an example for an *Equation* called “Feed rate”.

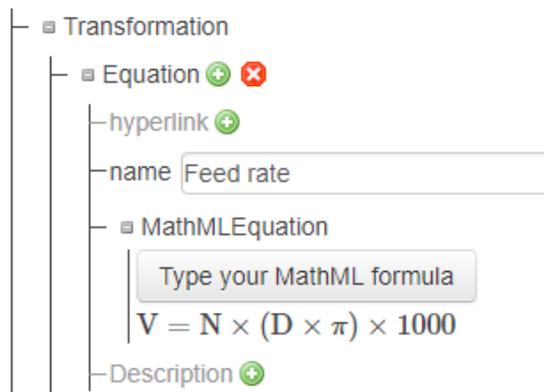


Fig. 15. Curate an Equation

A *PMMLModel* element is slightly different and provides the possibility to include a data-driven model in an PMML format³ instead of a MathML format. The field containing the data-driven model is automatically verifying that proper XML is added as shown in Figure 16.

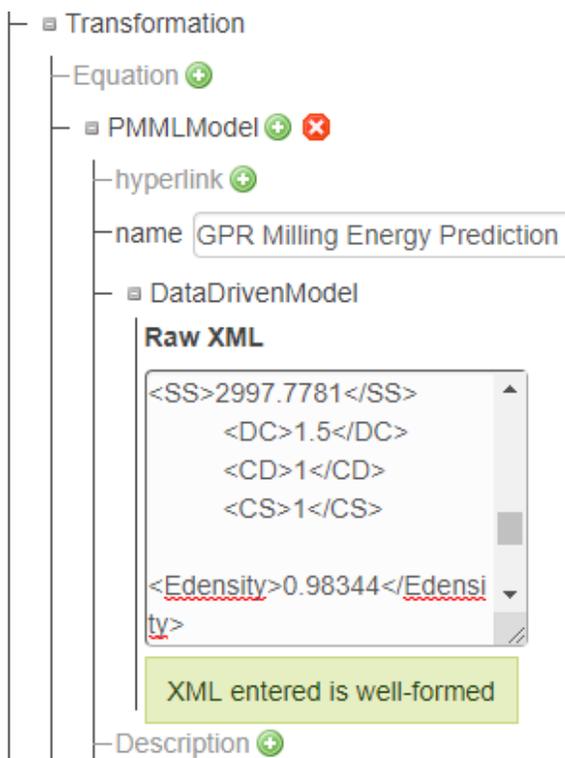


Fig. 16. Curate a PMML Model

³<http://dmg.org/pmml/v4-3/GeneralStructure.html>

2.2.10 Curate the Model Bounds

A model can be valid under specific conditions. The section *ModelBound* enables the recording of these conditions. An example of model bound equation is provided in Figure 17. The equation is represented in the MathML format using the MathType interface.

The screenshot shows a form for curating model bounds. It features a tree-like structure with expandable sections. The 'ModelBound' section is expanded, showing 'UseBoundDescription' (with a green plus icon), 'UseBoundEquation' (with green plus and red minus icons), and 'MathMLEquation' (with a green plus icon). Below 'MathMLEquation' is a text input field containing 'T > 0'. The 'Description' field contains 'When temperature is above 0°F' and has a red minus icon.

Fig. 17. Curate a Model Bound

2.2.11 Curate the Reviews

The last section of the forms is the *Review* section that enables recordings of external feedbacks about a model. An example of a *Review* is provided in Figure 18.

The screenshot shows a form for curating reviews. It features a tree-like structure with expandable sections. The 'Review' section is expanded, showing 'creationDate' (2019-02-04), 'Reviewer' (with sub-fields for 'FirstName' (David), 'LastName' (Lechevalier), and 'Organization' (Engisis LLC)), 'Email' (with a green plus icon), and 'Feedback' (This model is pretty accurate!).

Fig. 18. Curate a Review

2.2.12 Validate and Submit the Model

Once you curated all the information, you can validate your model by clicking on the *Validate data* link on the left. This will automatically validate the information against the schema and redirect you to the visualization page if the model is correct. If the model is incorrect or values are missing, you will be notified by an error message.

You can interactively visualize your model before submitting it to the repository. Information about the visualization features are provided in Section 2.4. When you are ready to

submit the model, click on the *Submit to repository* button at the top of the page. A message will confirm the submission and you will be redirected to the home page. Figure 19 shows how the visualization page looks like when the model is ready for submission.

The screenshot displays the 'Unit Manufacturing Process Builder' interface. The main header includes 'Unit Manufacturing Process Builder' and navigation links for 'Logout', 'Dashboard', and 'Help'. Below this is a secondary navigation bar with 'Home', 'UMP Curation', 'UMP Exploration', and 'Composer'. The 'Validate Data' section is active, showing a sidebar with 'UMP Curation' options: 'Enter Data' and 'Validate Data'. The main content area features a 'Validate Data' title and a descriptive paragraph. Below the text are buttons for 'Tree view', 'Export current view as image', 'Expand all', 'Download XML', and 'Submit to repository'. A tree view on the left lists 'UnitManufacturingProcess', 'Authors', 'Keywords', 'Model Bounds', and 'Reviews'. The central diagram illustrates the process flow: 'Inputs' (Aluminum, Cutting fluid, Electrical energy) feed into 'Transformations' (Equations, PMML Models, Feasibility Constraints), which produce 'Outputs' (Finished part, Metal chips, Waste cutting fluid). 'Resources' (Operator, Tool list, Agie Charmilles HPM600U Brochure) also feed into the 'Transformations'. A 'Product And Process Information' box (Control Parameters, Fixed Parameters, Intermediate Variables, Metric of Interest, Supporting Information) is positioned above the flow. A 'Full list of transformations' link is at the bottom of the diagram area. The footer contains 'Home | UMP Curation | UMP Exploration | Composer | Contact' and a 'Top ^' link.

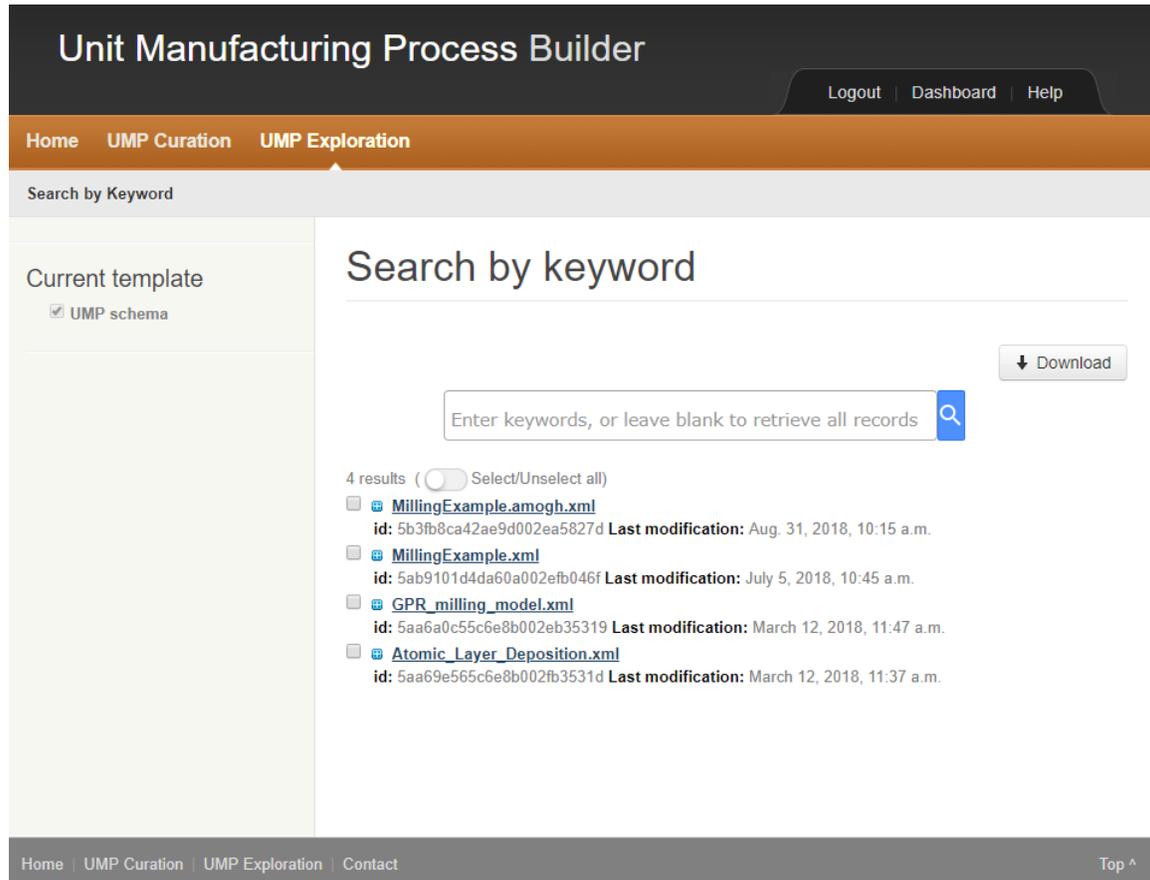
Fig. 19. Model Ready to Be Submitted

2.3 Exploration

To explore the UMP repository and discover the available UMP models, you need to click on the *UMP Exploration* tab from the home page.

2.3.1 List of the Available Models

This will redirect you to a page that provides a list of all the available models as shown in Figure 20.



The screenshot displays the 'Unit Manufacturing Process Builder' web application. The header includes 'Logout', 'Dashboard', and 'Help' links. The main navigation bar shows 'Home', 'UMP Curation', and 'UMP Exploration'. A search bar is present with the text 'Search by Keyword'. On the left, a sidebar shows 'Current template' with a checked 'UMP schema' option. The main content area is titled 'Search by keyword' and features a search input field with the placeholder text 'Enter keywords, or leave blank to retrieve all records' and a magnifying glass icon. A 'Download' button is located to the right of the search field. Below the search field, there are 4 results, each with a checkbox, a file name, an ID, and a last modification date. The results are:

- [MillingExample.amogh.xml](#)
id: 5b3fb8ca42ae9d002ea5827d Last modification: Aug. 31, 2018, 10:15 a.m.
- [MillingExample.xml](#)
id: 5ab9101d4da60a002efb046f Last modification: July 5, 2018, 10:45 a.m.
- [GPR_milling_model.xml](#)
id: 5aa6a0c55c6e8b002eb35319 Last modification: March 12, 2018, 11:47 a.m.
- [Atomic_Layer_Deposition.xml](#)
id: 5aa69e565c6e8b002fb3531d Last modification: March 12, 2018, 11:37 a.m.

The footer contains 'Home | UMP Curation | UMP Exploration | Contact' and a 'Top ^' link.

Fig. 20. List of Available Models

2.3.2 Keyword Search through the Model List

If you look for specific models, you can enter keywords in the input field and click on the magnifying glass button. The UMP Builder will then look for models including this keyword and refresh the list with the models matching this request. An example with the keyword “GPR” is provided in Figure 21.

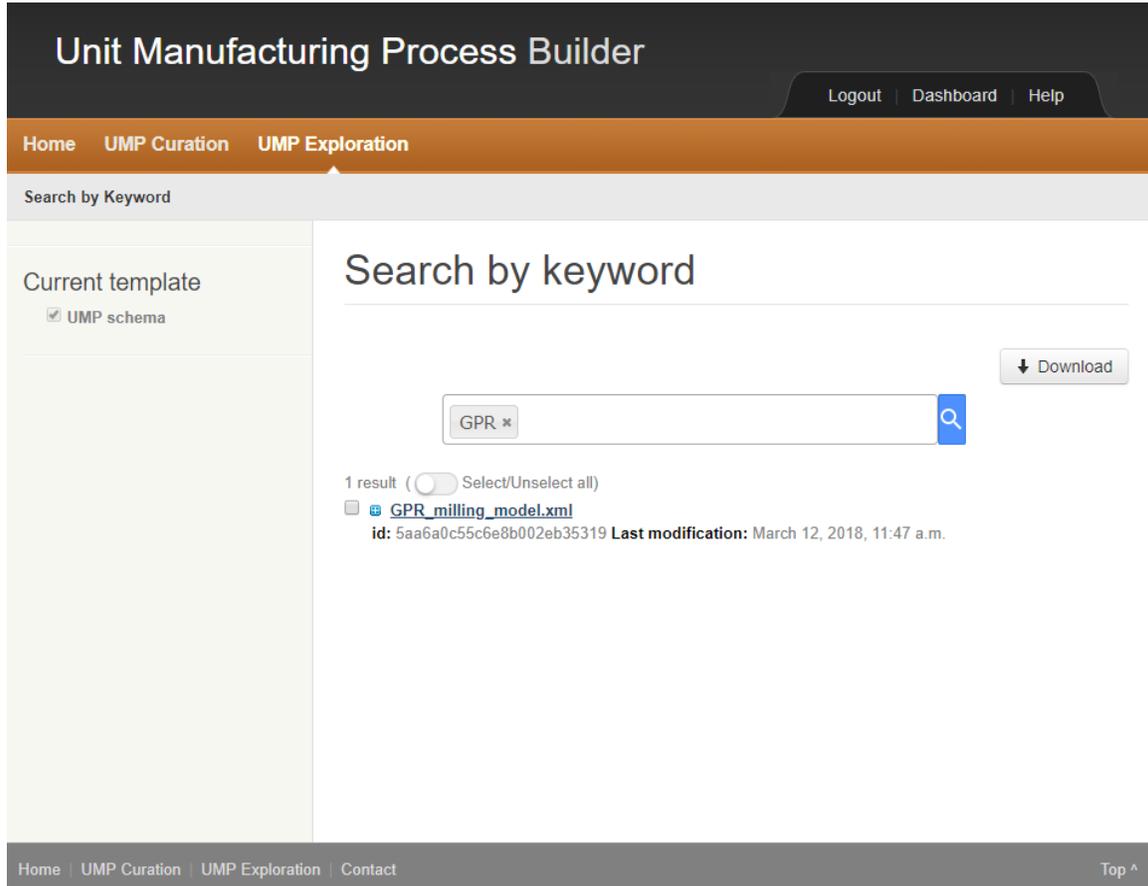


Fig. 21. Result of a Keyword Search

2.4 Visualization

After the validation of your model, or when you select a model from the validation page, you are redirected to the visualization page. This page provides an interactive visualization of the UMP model as shown in Figure 22. The graphical representation is similar to the graphical representation proposed in the ASTM E3012 standard.

2.4.1 Meta-Information

The graphical representation first includes all the meta-information of the UMP, the authors, the keywords, the model bounds and the possible reviews. Each section is expandable by clicking on the name of the section.

2.4.2 Main Information

The five boxes include the information about the inputs, product and process information, resources, transformations and outputs of the model. Each box is expandable by clicking on

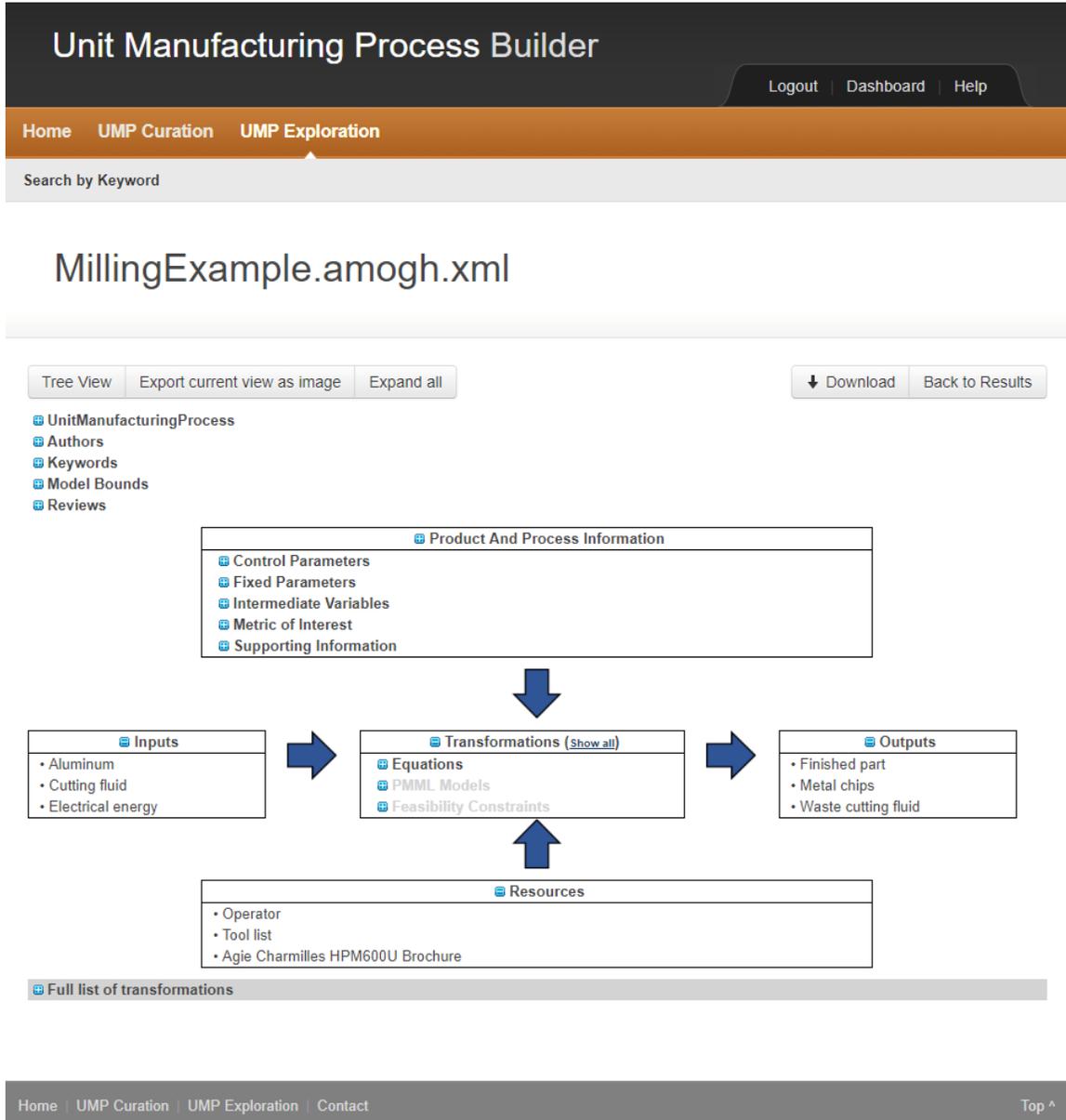


Fig. 22. Visualization Page

the name of the sub-sections of the boxes. When you click on elements inside the boxes, a pop-up appears and provides any additional information about the given element as shown in Figure 23.

2.4.3 Full List of Transformations

At the bottom of the graphical representation, you can obtain the list of all equations included as transformations in the model.

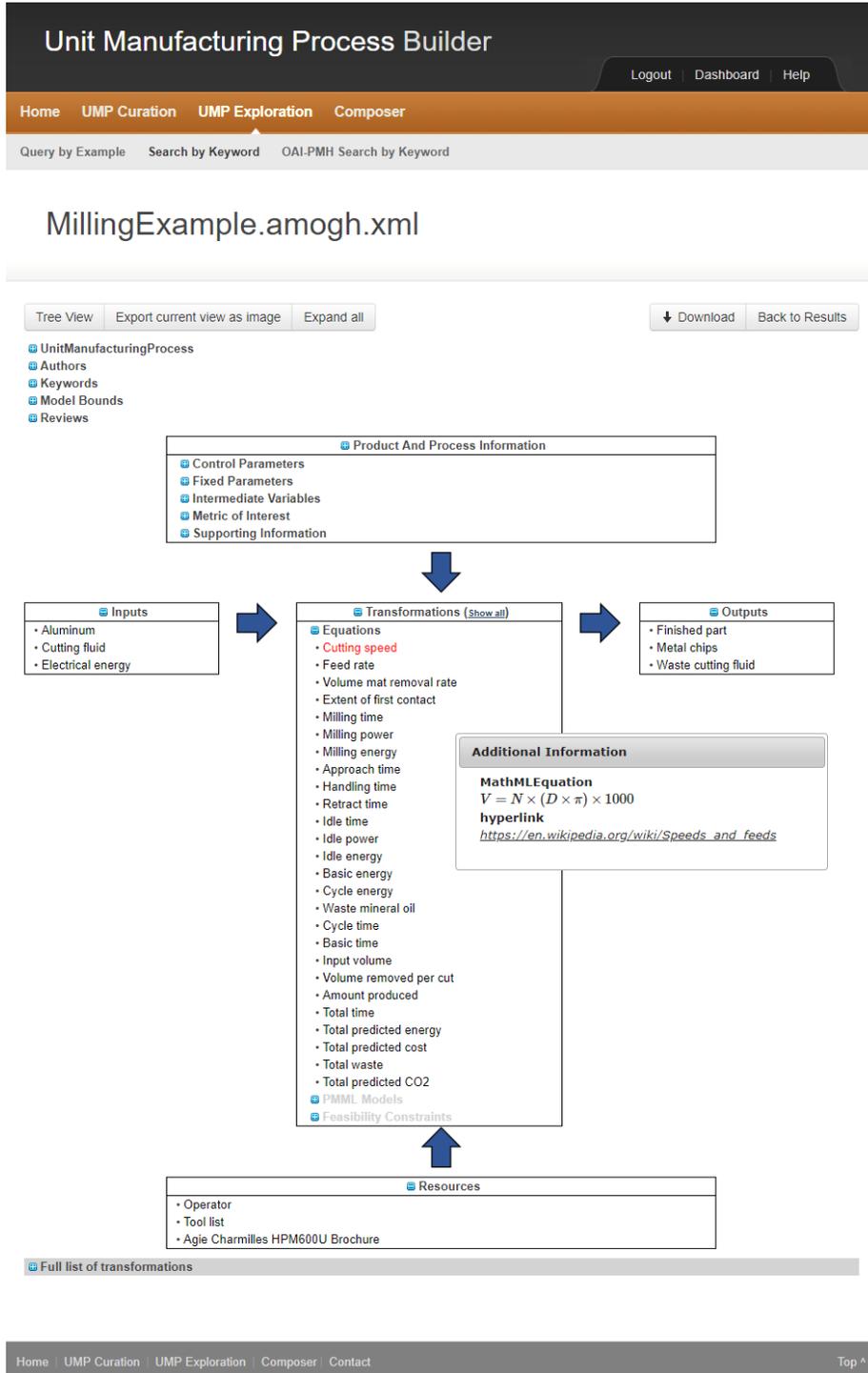


Fig. 23. Additional Information

2.4.4 Additional Features

The page provides capabilities to visualize the model in a tree view, export the current state of the view as an image, expand all the sections of the representation, and download the model in an xml format by clicking on the buttons on the top of the graphical representation.

2.5 Dashboard

The dashboard allows you to edit your profile, change your password, and see the list of submitted models and work-in-progress. To reach the dashboard, press the *Dashboard* tab from any page.

2.5.1 My Profile

When you click on the tab, you are redirected to the *My Profile* section of the dashboard where you can edit your profile and change your password as shown in Figure 24.

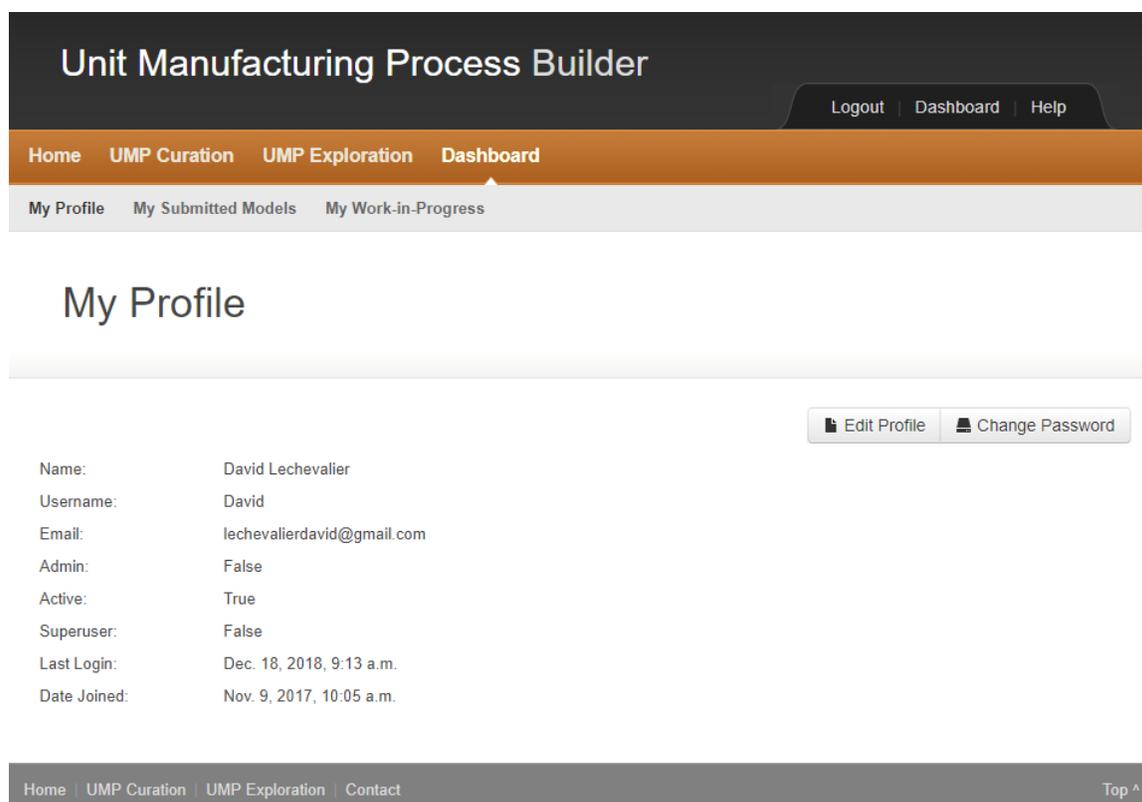


Fig. 24. Profile Page

2.5.2 My Submitted Models

You can also consult the models you have submitted by clicking on the *My Submitted Models* tab. Figure 25 shows the page displayed to consult the models. You can decide to view a submitted model, change the model name, modify the model, delete the model or change the ownership of the model by clicking on the appropriate buttons.

The screenshot shows the 'Unit Manufacturing Process Builder' interface. At the top, there is a navigation bar with 'Logout', 'Dashboard', and 'Help' links. Below this is a secondary navigation bar with 'Home', 'UMP Curation', 'UMP Exploration', and 'Dashboard' tabs. A third navigation bar shows 'My Profile', 'My Submitted Models', and 'My Work-in-Progress' tabs. The main content area is titled 'My submitted models' and contains a table with the following data:

Resource name	Published	Last Publication date	Actions
MillingExample	Yes	Aug. 31, 2018, 10:15 a.m.	View Delete Change name Change Owner Edit

At the bottom of the page, there is a footer navigation bar with 'Home', 'UMP Curation', 'UMP Exploration', and 'Contact' links, and a 'Top ^' link on the right.

Fig. 25. Submitted Models Page

2.5.3 My Work-in-Progress

Your work-in-progress are available by clicking on the *My Work-in-Progress* tab. You can decide to view a work-in-progress, change the name, continue working on the model, delete the work-in-progress or change the ownership of the work-in-progress by clicking on the appropriate buttons. Figure 26 show the page that displays the different options.

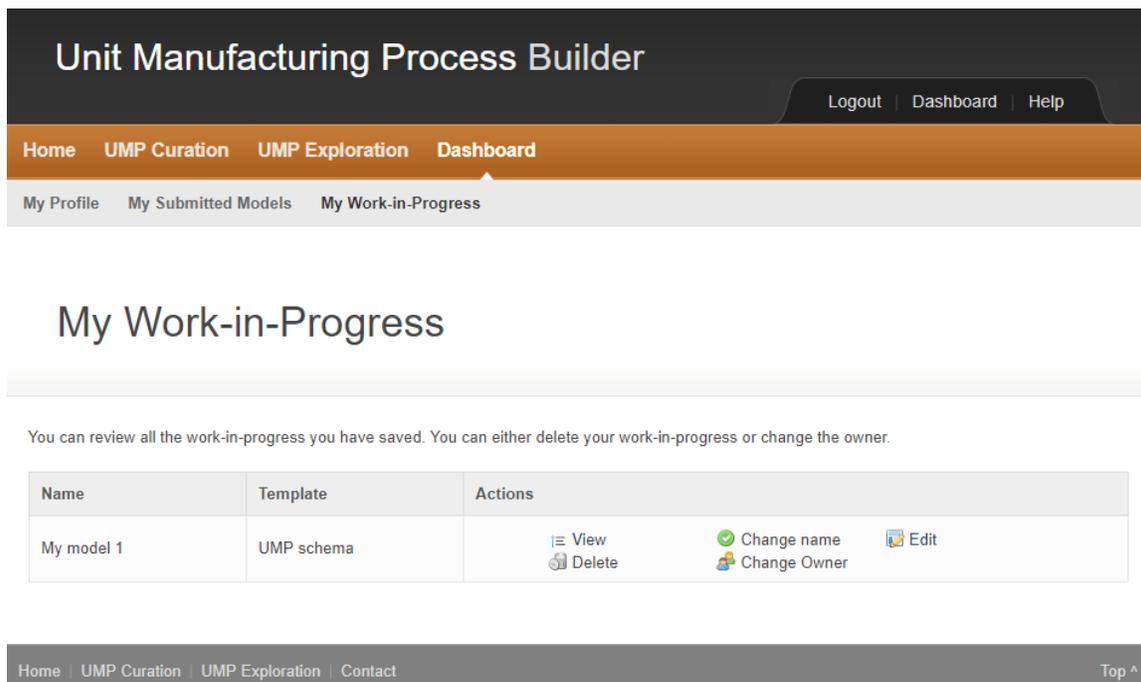


Fig. 26. Work-in-Progress Page

2.6 Administration

If you have been providing administration credentials, you have access to the administration section. To reach this section, you need to click on the *Administration* tab located at the bottom of the home page. You will be redirected to the *User Management* section of the administration page as shown in Figure 27.

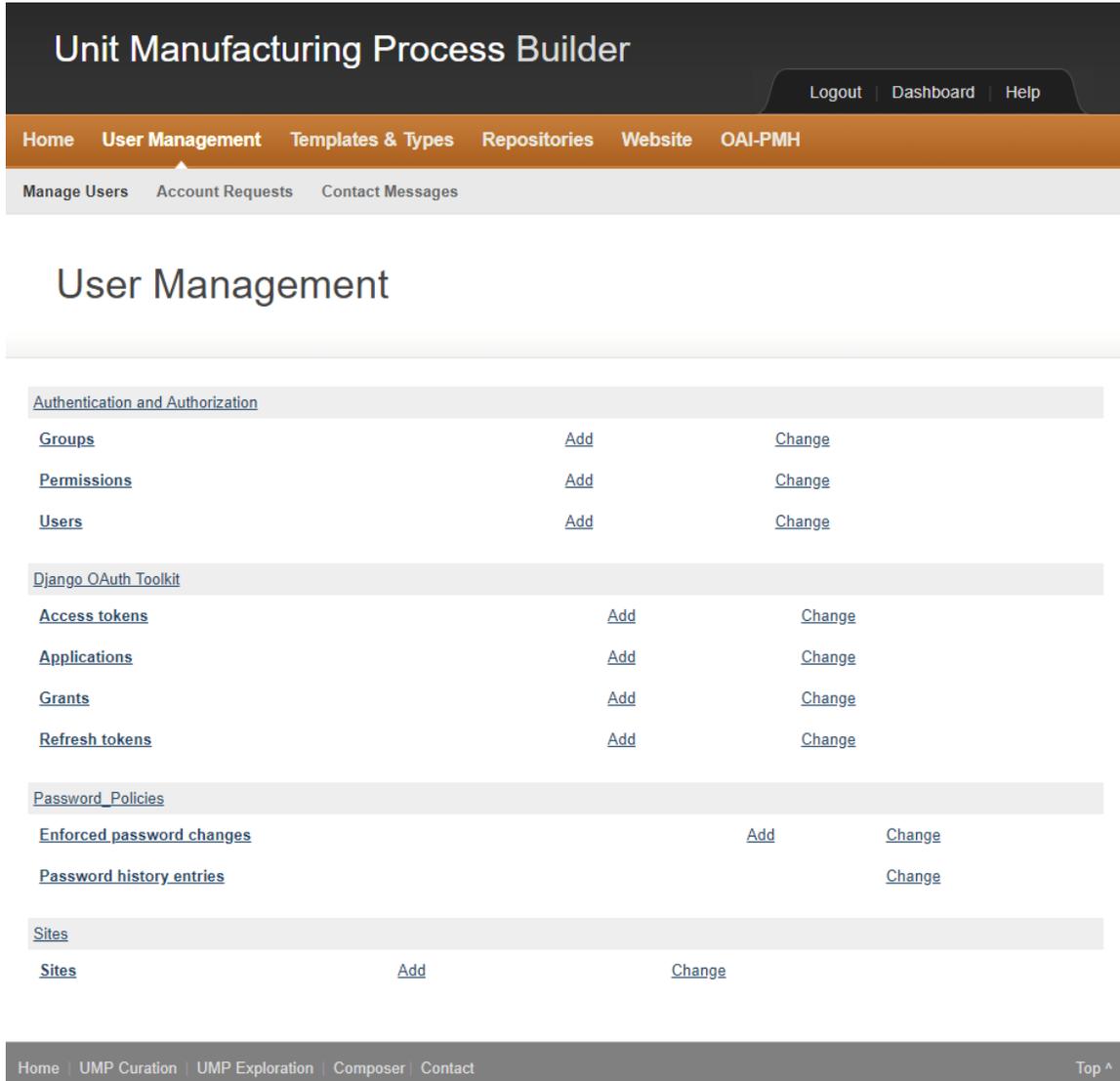


Fig. 27. User Management Page

2.6.1 Manage Users

You can manage the users and modify their permissions by clicking on the *Change* link for *Users*. You will be redirected to the list of users shown in Figure 28 and you can click on the users you wish to modify.

Once you have selected the user to change, you are redirected to page to make the necessary modification on the user name, personal info, permissions as shown in Figure 29.

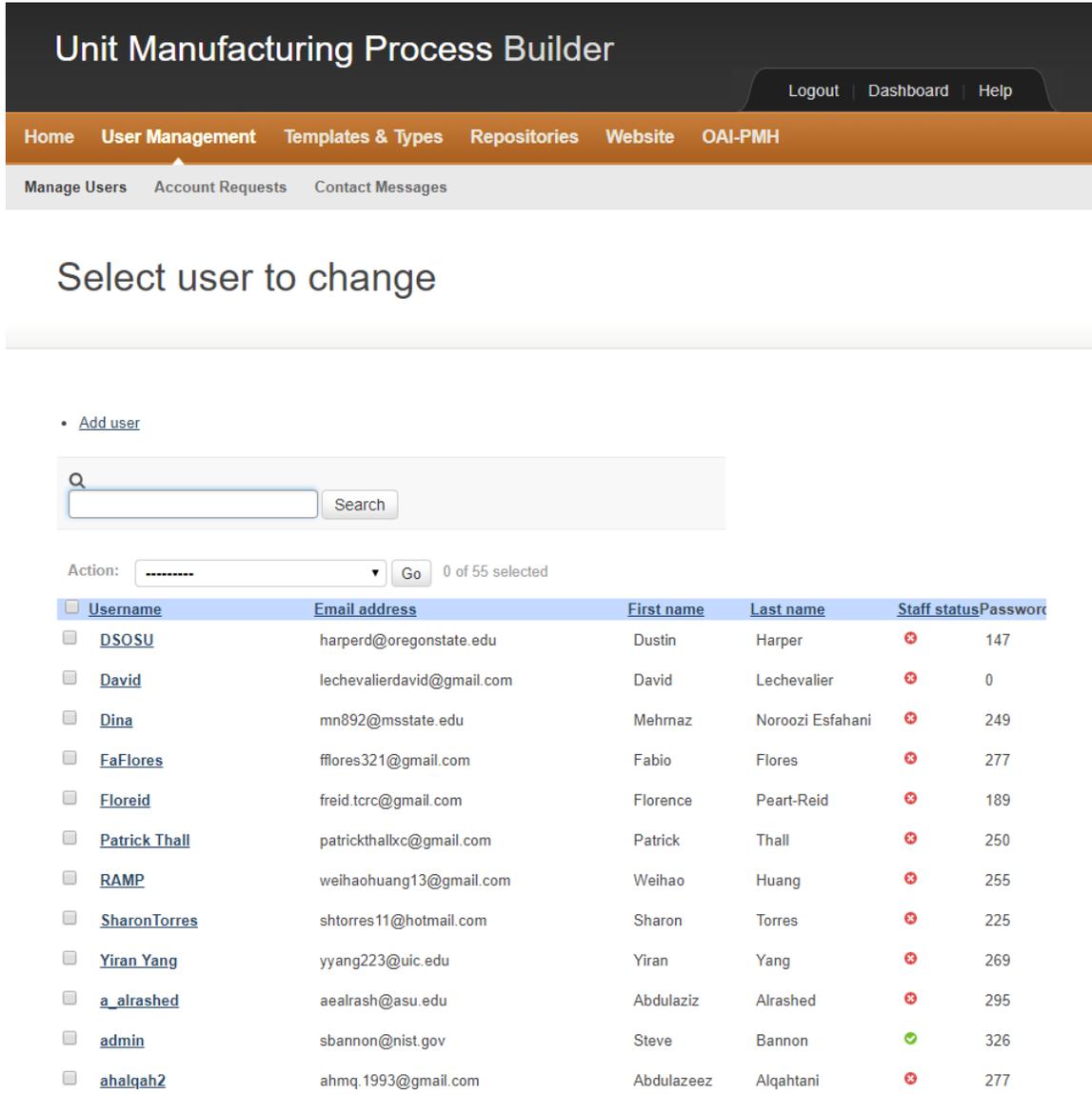


Fig. 28. User List

2.6.2 Manage Groups

Similarly, you can modify or create a new group by clicking the *add* or *change* link for *Groups*. Groups are used to automatically assign a set of permissions. If you click on the *change* link, you can then select the group to modify as shown in Figure 30.

You will be redirected to the page to select which permissions to provide to the group you are creating or modifying as shown in Figure 31.

These are the two main features you should manage in the *Manage Users* section.

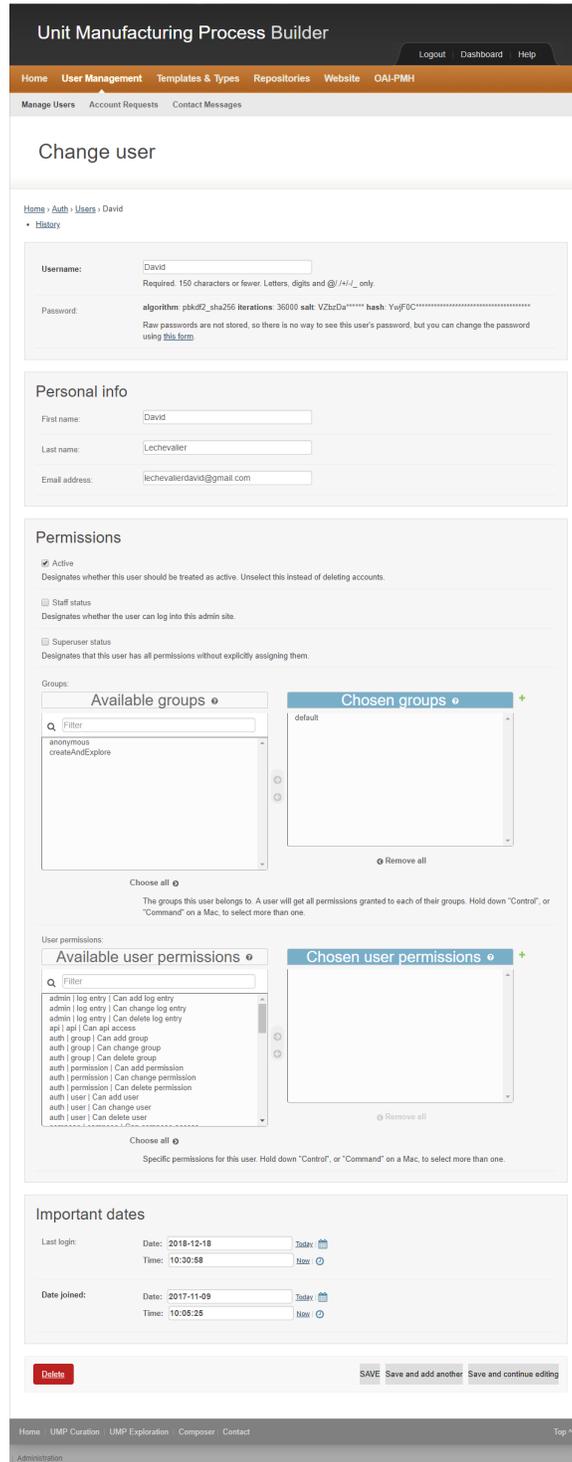


Fig. 29. User Modification

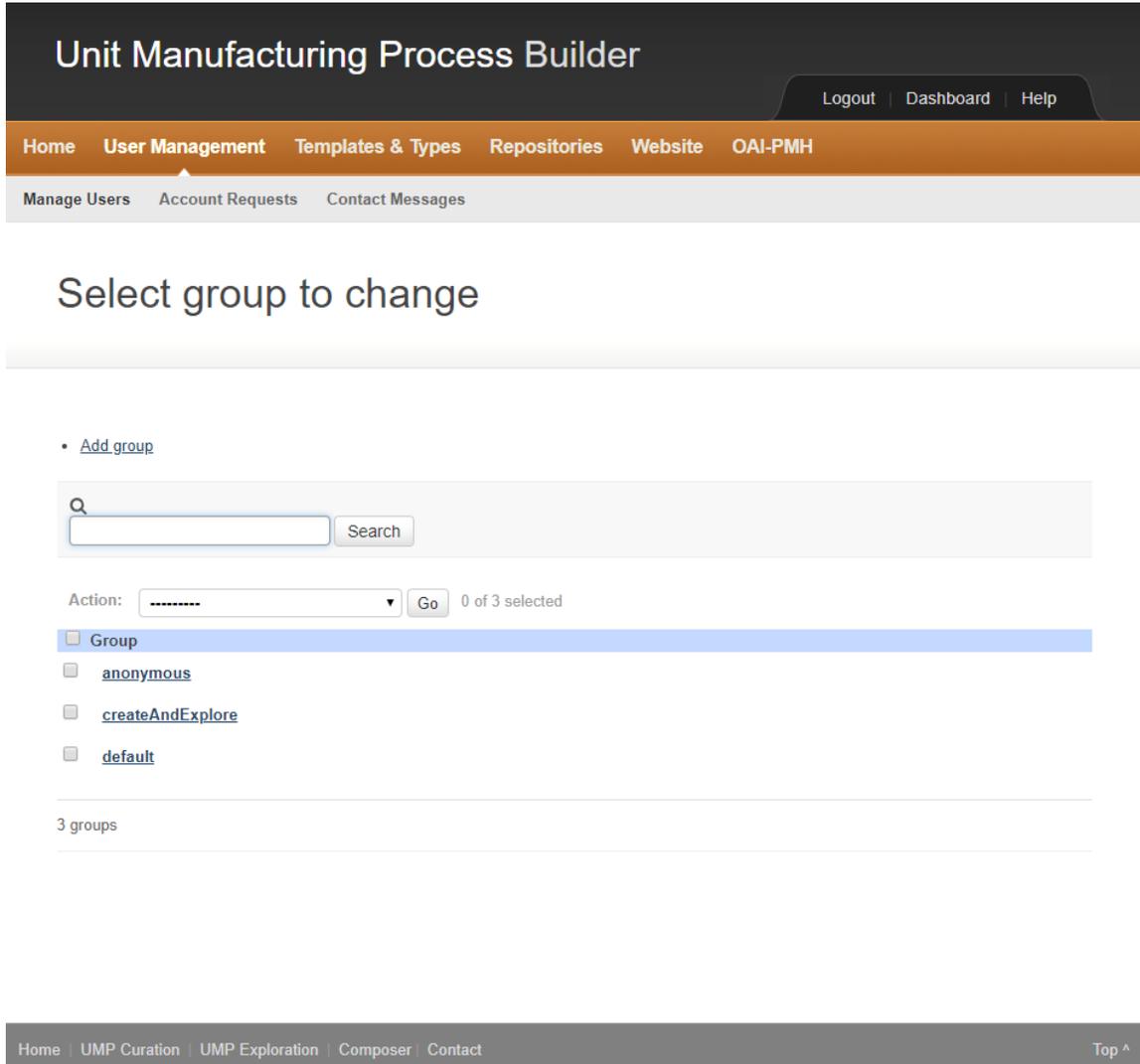


Fig. 30. Group List

2.6.3 Account Requests

To consult the pending account requests, you can click on the *Account Request* tab. Figure 32 shows how the requests are displayed. You are able to *Accept* or *Deny* the requests pending for approval. The user who requested the account is notified of your decision by email.

2.6.4 Contact Messages

A user can send contact messages that available by clicking on the *Contact Messages* tab. The list of messages is displayed, and you can then answer to the user by email.

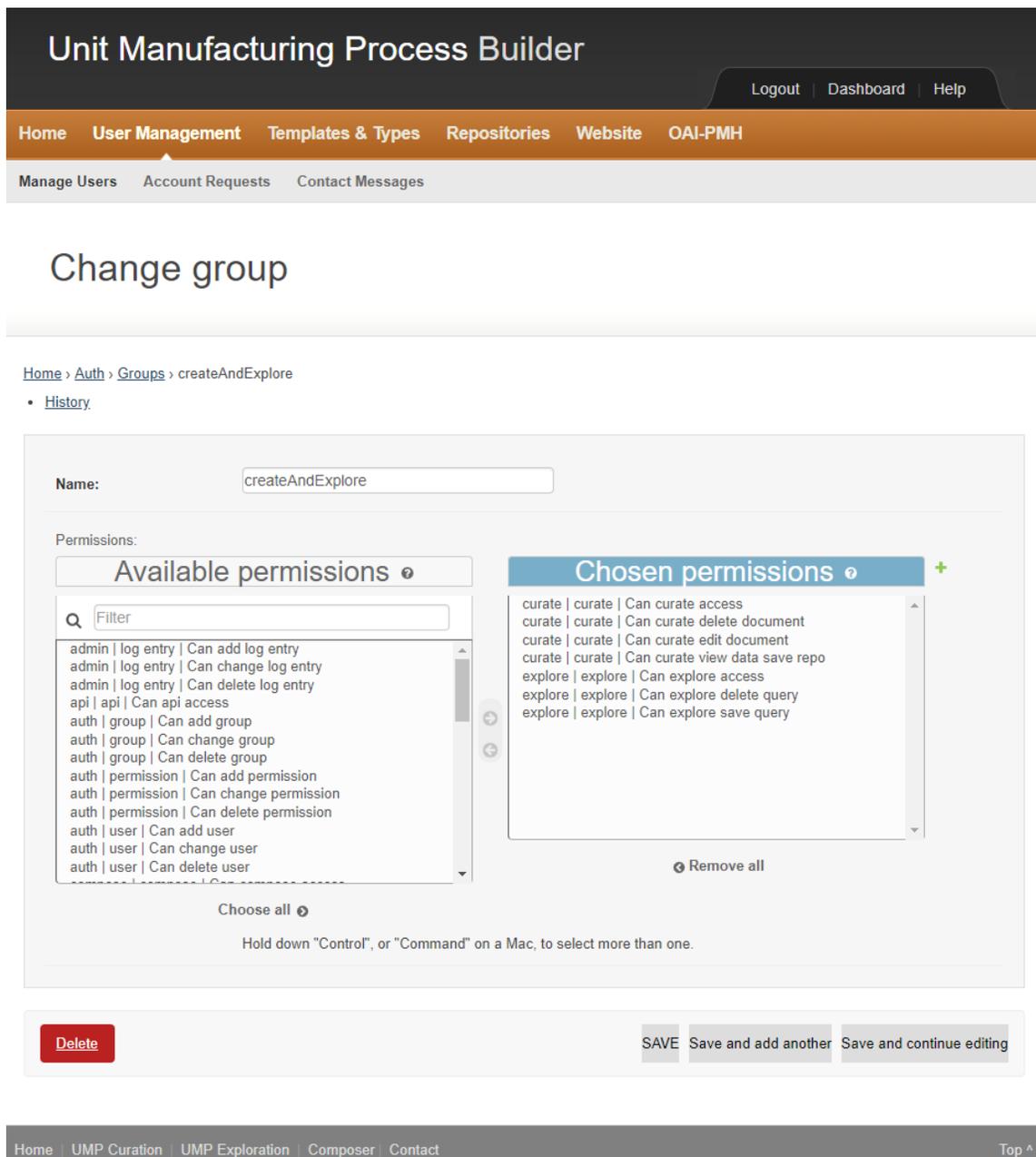


Fig. 31. Group Modification

3. Summary

In summary, this document described the features and functionality of the UMP Builder for curating and visualizing and querying unit manufacturing process (UMP) models. UMP models are captured in an XML format that is compliant to the ASTM E3012 standard.

The UMP Builder provides features to curate the UMP models into a repository. The

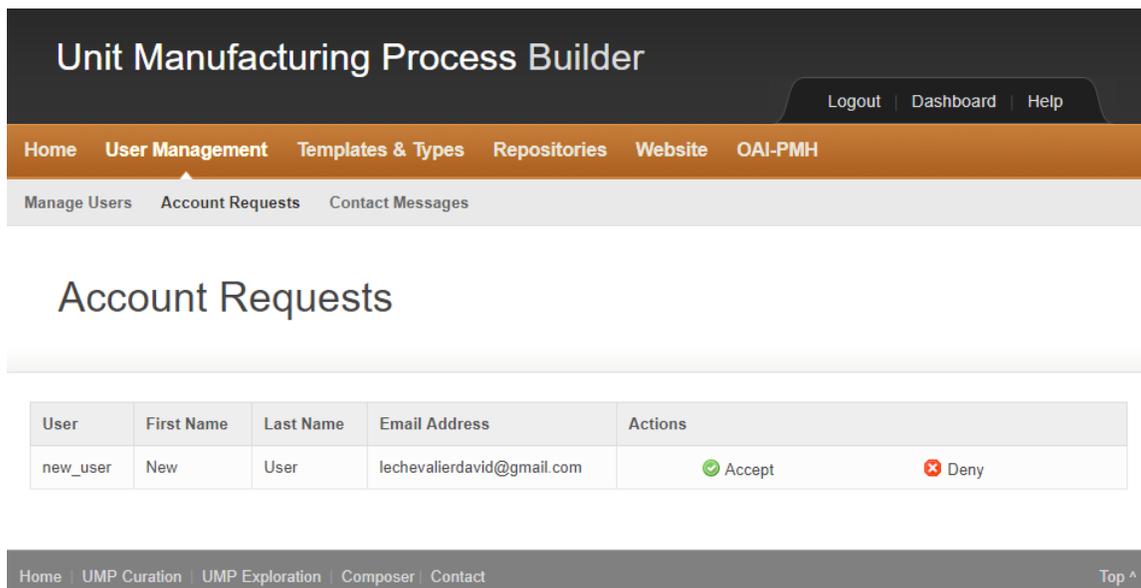


Fig. 32. Account Request List

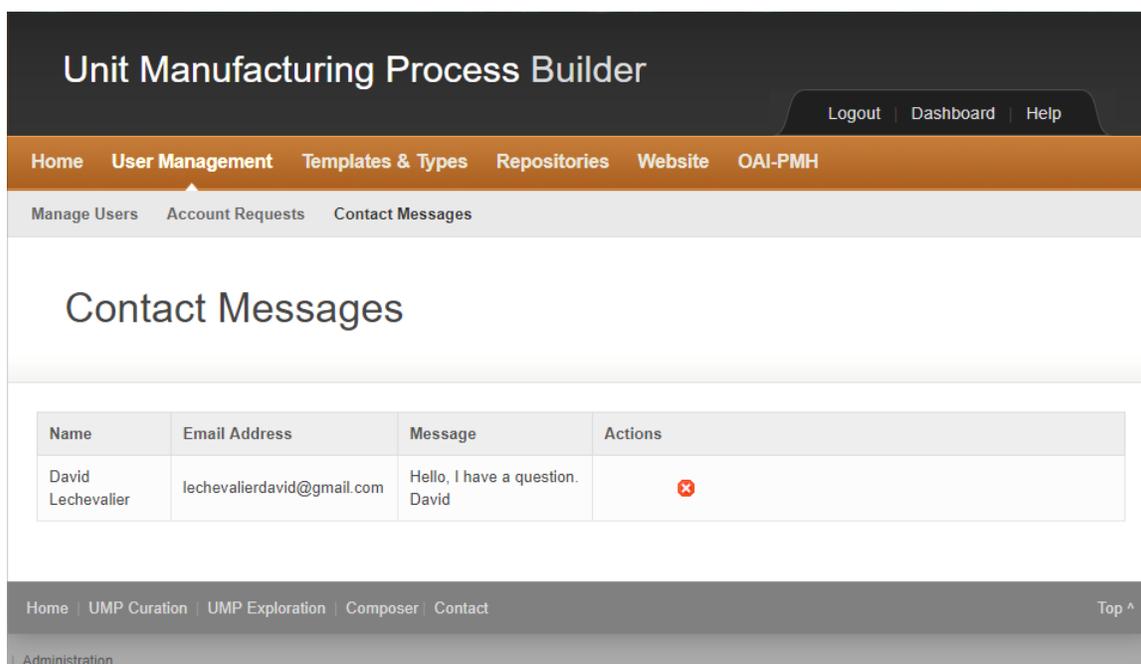


Fig. 33. Contact Messages

tool also provides query capabilities in order to retrieve existing models. Interactive visualizations of the models are available in order to go through all the information collected in a model. The document describes how to build your model section by section, how to submit the models to the repository, and how to visualize models that are recorded in the repos-

itory. This work is an on-going process in order to facilitate the digitalization of UMPs. Defining a robust schema to represent the UMP is key to enabling this digitalization. A robust application is necessary to increase the adoption of such a process in the manufacturing area and will be the subject of future work and collaboration with partners involved in this area of research.

Disclaimer

Certain commercial products may have been identified in this paper. These products were used only for demonstration purposes. This use does not imply approval or endorsement by NIST, nor does it imply that these products are necessarily the best for the purpose.

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