engineering laboratory

Instructional Webinar: What, how, and where to enter the RAMP Competition

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U.S. Department of Commerce

Visit challenge on-line!

https://www.challenge.gov/challenge/ramp-reusable-abstractions-of-manufacturing-processes/

Challenge.gov
Government Challenges, Your Solutions

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RAMP: Reusable Abstractions of Manufacturing Processes

National Institute of Standards and Technology

RAMP
Reusable Abstractions of Manufacturing Processes

Challenge Details

- Discussions 1
- Solutions 0
- Rules
- Submit Solution
- Challenge Followers 6

About the Challenge

Ramp up the use of manufacturing standards!

Posted By: National Institute of Standards and Technology
Category: Scientific/Engineering
Skill: Engineering
Interest: Manufacturing

Submission Dates: **9 a.m. ET, Dec 19, 2016 - 5 p.m. ET, Mar 20, 2017**

Judging Dates: **Mar 27, 2017 - Jun 08, 2017**

Winners Announced: **Jun 08, 2017**

Official Rules

In the future, manufacturing will be planned out in the virtual world. How can we do this if we don't even have models for the basic processes such as welding, drilling, and forging? Sewing, assembly, or distillation? Nope, we don't even have models for those either! At least, not the types of models really needed for our high-tech world.

Manufacturers need models to improve operations, to protect the environment, to share information, and to compose them into systems

Follow this challenge

Prizes

First Place
$1,000.00

Second Place
$750.00

Third Place
$500.00

Runners Up
$1,000.00
Up to five runners up will receive $200 each

If you have questions….

- Live participants: use the Q&A chat bar

- After the webinar, send any other questions to
  - Swee Leong, swee.leong@nist.gov
  - Bill Bernstein, wzb@nist.gov

ASTM International: Committee E60 on Sustainability

Scope:

The acquisition, promotion, and dissemination of knowledge, stimulation of research and the development of standards relating to sustainability and sustainable development.

http://www.astm.org/COMMITTEE/E60.htm

Subcommittee E60.13 on Sustainable Manufacturing

ASTM E2986-15:
Standard Guide for Evaluation of Environmental Aspects of Sustainability of Manufacturing Processes

- Designed to complement:
  - ISO 14000 (environmental management)
  - ISO 50000 (energy management)

- Provides guidelines for the collection and analysis (e.g. decision making processes) of manufacturing data

- New Appendix (up for ballot) demonstrates its use through a machining case study.

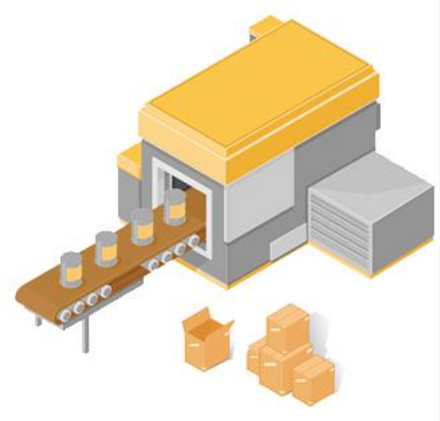
https://www.astm.org/Standards/E2986.htm

ASTM E3012-16:
Standard Guide for Characterizing Environmental Aspects of Manufacturing Processes

- Designed to complement ASTM E2986-15

- Provides guidelines for the formal characterization and representation of unit manufacturing process (UMP) models

- Fundamental foundation for the idea of a repository of reusable UMP models



https://www.astm.org/Standards/E3012.htm

Goals of ASTM E3012-16

- Consistently characterizing manufacturing process models
- Sharing and re-using manufacturing process information
- Promoting integration of tools for manufacturing-related decision-making
- Aiding environmental sustainability assessment

Goals of RAMP Competition

- Model any unit manufacturing process of interest
- Demonstrate ASTM E3012-16 on a variety of unit manufacturing processes (UMPs)
- Demonstrate the use of a **reusable** standard format leading to models suitable for system analysis, such as
  - simulation modeling or
  - as an optimization program.

The "When" - Important Dates

Submission Deadline: **March 20, 2017**

@ 5pm ET

Announcement of Finalists: **April 17,2017**

(by e-mail)

Announcement of Winners: **June 4-8, 2017**

ASME 2017 MSEC

Los Angeles, CA

The "Who"

- Can be teams or individuals
- Person accepting prize must be US citizen or permanent resident

What to submit?

1. Graphical Representation
2. Transformation Function(s)
3. Description of Nomenclature
4. Description of Information Sources
5. README Section
6. Written Narrative

1) Graphical Representation

Product/Process Information

- Equipment and material specifications
- Process Specifications
  - Setup-operation-teardown instructions
  - Control Programs and process control
- Product and engineering specifications
  - Part geometries
- Production plans
- Quality plans
  - KPI’s and quality plans
- PLM and sustainability plans
- Safety documentation

Input

- Energy
- Material & consumables
- Outside factors
- Disturbance

Transformation

- Energy
- Material
- Information

Output

- Product
- By-Product
- Waste
  - Solid, liquid, emission
  - Thermal, noise
- Feedback

Resources

- Equipment
- Tooling
- Fixtures
- Human
- Software

Figure based on ASTM E3012-16. Standard available for competition participants.

1) Graphical Representation - Example

Product & Process Information

Job Information

Part Description:	Heat Sink Test Part
Geometry:	Complex, see CAD file (file.stp)
Material:	Al6061
Operations:	Mill thicknesses, bosses and counter bores, deburr, mill chamfers, radii, mill fins
Required Tools:	End mills, chamfer mills, rounding mills

Variable definitions for transformation equations (short list)

U_p – Specific Cutting Energy (W/mm³)
V_i – volume of input (mm³)
V – Cutting Speed (m/min)
t_{a_o} – Approach and Overtravel time (sec)
t_r – Retract time (sec)
t_h – Handling Time (sec)
t_i – Milling Idle time (sec)
p_i – Milling Idle power (kW)
e_i – Milling Idle Energy (kJ)
e_c – Energy Consumed per cycle (kJ/cycle)
t_c – Total time per cycle (sec)
p_m – Milling Power (kW)
e_m – Milling Energy (kJ)
f_t – Feed per tooth (mm/tooth)
VRR – Volume Material Removal Rate (mm³/min)
L_c – Extent of the first contact (mm)
t_m – Milling Time (sec/cut)
E – Total energy consumed (kWh/cycle)
C – Total cost for energy ($)
CO_2 – Total CO_2 for energy (kg)
t_t – Total time for all cycles (sec)
$Yield$ – Items produced in all cycles (qty)

Inputs

Electrical energy, kWh
Workpiece material
(e.g. aluminum, steel)

Transformation Equations

$f_t = f_r/(N * n_t)$
$VRR = w_m * d * f_r$
For centered milling:
$L_c = D/2$
For peripheral milling:
$t_m = 60 * \frac{l_m + L_c}{f_r}$
$L_c = \sqrt{d * (D - d)}$
For face milling:
$t_m = 60 * \frac{l_m + 2 * L_c}{f_r}$
$L_c = \sqrt{w_m * (D - w_m)}$

$V = N * D * 1000\pi$
$p_i = p_s + p_c + p_a$
$t_c = t_l + t_c + t_u + t_i$
$V_i = l_m * w_m * h_m * n_c$
$t_{a\_o} = 60 * \frac{d_a + d_o}{f_r}$
$p_m = \frac{VRR * U_p}{1000}$
$t_h = t_{a\_o} + t_r$
$t_i = t_h + t_m$

$e_m = p_m * t_m$
$e_i = p_i + t_i$
$e_c = e_m + e_i + e_b$
$t_t = t_c * n_c$
$Yield = n_c$
$C = E * C_{kwh}$
$CO2 = E * CO2_{kwh}$
$E = e_c * n_c * 2.78e^{-4}$

Outputs

Finished part, qty
Waste
Heat, BTU
Material, kg

Resources

Operator:	John Doe
Machine:	GF Agile HP600U
Fixture Details:	Mill Clearance, Drill, Ream and Tap Mounting Holes Orientation, Origin → (0.100,0.720,0.168)
Software:	See MasterCam for fixture and tooling specifics

Tool List:
(1) 1/4" Dia. 2 Flute Stubby Fullerton E.M.
(2) 3/16" Dia. 2 Flute Stubby Fullerton E.M.
(3) 3" Face Mill
(4) 1/2" Dia. 2 Flute Stubby Fullerton E.M.
(5) 1/4" x 45° Chamfer Mill
(6) 1/4" 2 Flute E.M. With .020" x 45° Chamfers
(7) 1/4" x .093" Corner Rounding E.M.

1) Graphical Representation - Example

Product & Process Information

Job Information

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$L_c = \sqrt{d * (D - d)}$
For face milling:
$t_m = 60 * \frac{l_m + 2 * L_c}{f_r}$
$L_c = \sqrt{w_m * (D - w_m)}$

$V = N * D * 1000\pi$
$p_i = p_s + p_c + p_a$
$t_c = t_l + t_c + t_u + t_i$
$V_i = l_m * w_m * h_m * n_c$
$t_{a\_o} = 60 * \frac{d_a + d_o}{f_r}$
$p_m = \frac{VRR * U_p}{1000}$
$t_h = t_{a\_o} + t_r$
$t_i = t_h + t_m$

$e_m = p_m * t_m$
$e_i = p_i + t_i$
$e_c = e_m + e_i + e_b$
$t_t = t_c * n_c$
$Yield = n_c$
$C = E * C_{kwh}$
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2) Transformation Function(s)

Include equations that compute metrics from control parameters in any readable mathematical format, such as

- MS Word,
- LaTeX,
- ASCII text,
- JSONiq
- Matlab

Submissions only acceptable in PDFs

3) Description of Nomenclature

- Include all variable names and types in the structured form (like a table)

Name	Meaning	Type	Unit
machine	Name of the machine	Parameter	
material_type	Work piece Type (material)	Parameter	
material_length	Work piece length	Parameter	mm
material_width	Work piece width	Parameter	mm
material_height	Work piece height	Parameter	mm
millType	Milling Type	Parameter	
centered	Tool cornered or centered (yes or no)	Parameter	
D	Diameter of the cutter	Parameter	mm
N	Spindle Speed	Variable	rpm
f_r	Feed Rate	Variable	mm/min
n_t	Number of tooth	Parameter	integer unit
depth	Depth of cut	Parameter	mm

… …   … …   … …   … …

4) Description of Information Sources

- Sources used to define UMP models, such as existing literature, case studies, and textbooks.

MODEL SOURCE
UMP Name: Milling
Source Name: Unit Process Life Cycle Inventory Dr. Devi Kalla, Dr. Janet Twomey, and Dr. Michael Overcash 08/19/2009
Where on the web: http://cratel.wichita.edu/uplci/milling/
@date: 07/26/2016
@author: Mohan Krishnamoorthy, Alex Brodsky

5) README Section

- Nature and location of files, i.e. folder structure
- Might include a URL to your submission's video
- Source code files are optional but can be included if you feel that they will better clarify your work.
- PDF only. We will not run the code.

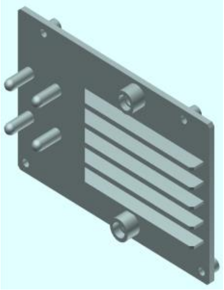
6) Written Narrative (750 words max)

- **Validation:** explain how the model is validated.
  - Examples include: case study, literature review, traditional cross-validation techniques, or others

- **Novelty of UMP analysis: show off your ideas!**
  - Knowledge/understanding of UMP modeling
  - Standards supporting reusable models
  - Techniques for development & validation of UMP models

Summary: Information for UMP & its instantiation

Product/Process Information



Material Properties
Type: Aluminum 6061
Brinell hardness: 30-150
Specific cutting energy Up: 0.98 W/(s*mm^3)
Cutting speed: 120-140 m/min
Feed per tooth: 0.28-0.56 mm/tooth
Density: 2712 kg/m^3

Machine Instructions (G-code)
N1418 T3
N1419 G91 G28 Z0 M06
N1420 T1 M01
G90 G10 L2 P#501 X[#510]
N1421 M8
... ...

Inputs

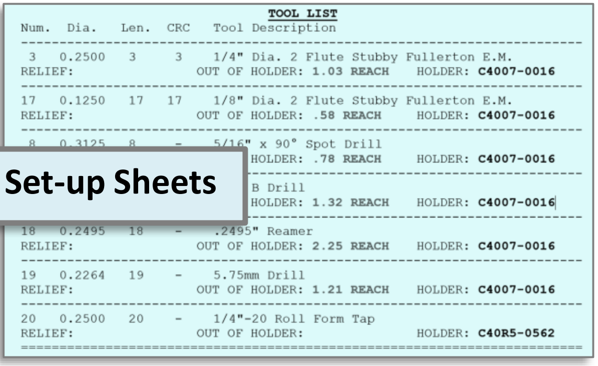
Transformations

http://cratel.wichita.edu/uplci/milling/

http://cratel.wichita.edu/uplci/drilling-2/

Outputs

Resources



```
                         TOOL LIST
Num.  Dia.    Len.  CRC   Tool Description
--------------------------------------------------------------------
 3   0.2500   3     3    1/4" Dia. 2 Flute Stubby Fullerton E.M.
RELIEF:                OUT OF HOLDER: 1.03 REACH    HOLDER: C4007-0016
--------------------------------------------------------------------
17   0.1250   17   17    1/8" Dia. 2 Flute Stubby Fullerton E.M.
RELIEF:                OUT OF HOLDER: .58 REACH     HOLDER: C4007-0016
--------------------------------------------------------------------
 8   0.3125   8     -    5/16" x 90° Spot Drill
                          HOLDER: .78 REACH         HOLDER: C4007-0016
--------------------------------------------------------------------
                          B Drill
                          HOLDER: 1.32 REACH        HOLDER: C4007-0016
--------------------------------------------------------------------
18   0.2495   18    -    .2495" Reamer
RELIEF:                OUT OF HOLDER: 2.25 REACH    HOLDER: C4007-0016
--------------------------------------------------------------------
19   0.2264   19    -    5.75mm Drill
RELIEF:                OUT OF HOLDER: 1.21 REACH    HOLDER: C4007-0016
--------------------------------------------------------------------
20   0.2500   20    -    1/4"-20 Roll Form Tap
RELIEF:                OUT OF HOLDER:               HOLDER: C40R5-0562
====================================================================
```

Set-up Sheets

UPLCI Database
http://cratel.wichita.edu/uplci/

NIST SMS Testbed
http://smstestbed.nist.gov

Brodsky, A., Krishnamoorthy, M., Bernstein, W.Z. and Nachawati, M.O., 2016. A system and architecture for reusable abstractions of manufacturing processes. In *Proc. of the 2016 IEEE Conference on Big Data*. DOI: 10.1109/BigData.2016.7840823

Review Criteria for Selecting Finalists

- **Completeness:** Submission follows the guidelines and includes all necessary components.
- **Complexity:** Model reflects the complexities of the manufacturing process, especially those which influence sustainability indicators such as energy and material consumption.
- **Clarity:** Model is clear in describing the process and the process-related information.
- **Accuracy:** Submission accurately models the process as shown through validation.
- **Novelty:** Approach taken develops new techniques to advance model reusability or reliability.

Awards and travel stipends

- First Place Prize: $1,000
- Second Place Prize: $750
- Third Place Prize: $500
- Runners Up Prizes (up to five): $200 each

All finalists and other participants can also apply for a travel stipend to Los Angeles of up to $1500

MSEC Workshop URL: https://www.nist.gov/news-events/events/2017/06/workshop-formalizing-manufacturing-processes-structured-sustainability

Live Judging Criteria

- **Complexity – 10%:** Model reflects complexities of the manufacturing process, especially those which influence eco-indicators, e.g. energy/material consumption.
- **Clarity – 10%:** Model is clear in describing the process and the process-related information.
- **Accuracy – 35%:** Submission accurately models the process as shown through validation.
- **Novelty – 35%:** Approach taken develops new techniques to advance model reusability or reliability.
- **Presentation – 10%:** Quality and content conveyed in a brief in-person presentation at 2017 MSEC.

engineering laboratory

Reusable Abstractions of Manufacturing Processes

Pause to check Q&A board...

https://www.challenge.gov/challenge/ramp-reusable-abstractions-of-manufacturing-processes/

National Institute of Standards and Technology
U.S. Department of Commerce

engineering laboratory

Demo: Using JSONiq to formally represent UMP transformation functions

Mohan Krishnamoorthy,

George Mason University

National Institute of Standards and Technology
U.S. Department of Commerce

Recall our graphical representation

Product & Process Information

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For face milling:

$t_m = 60 * \frac{l_m + 2 * L_c}{f_r}$

$L_c = \sqrt{w_m * (D - w_m)}$

$V = N * D * 1000\pi$

$p_i = p_s + p_c + p_a$

$t_c = t_l + t_c + t_u + t_i$

$V_i = l_m * w_m * h_m * n_c$

$t_{a\_o} = 60 * \frac{d_a + d_o}{f_r}$

$p_m = \frac{VRR * U_p}{1000}$

$t_h = t_{a\_o} + t_r$

$t_i = t_h + t_m$

$e_m = p_m * t_m$

$e_i = p_i + t_i$

$e_c = e_m + e_i + e_b$

$t_t = t_c * n_c$

$Yield = n_c$

$C = E * C_{kwh}$

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JSON Structure

- Lightweight data-interchange format
- An open standard like XML
- Represent hierarchical and heterogeneous data
- Example JSON Object:

```
{
    "scalar": value,
    "JSON Object": {…},
    "JSON Array": […],
    …
}
```

JSONiq – the JSON query language

- Query and functional programming language
- Analogous to SQL
- Write transformation equations as executable code
- Lends to reusable models

Atom – a “hackable” text editor

- Code and text editor
- Fully Customizable
- Provides many packages and plugins
- Easy to setup and use
- Intuitive Interface

Demo time!

Atom Studio & Zorba Resources

- Detailed Instructions (Go here first!): http://mason.gmu.edu/~mnachawa/resources/jsoniq-environment.html
- Zorba XQuery/JSONiq Processor
  - (http://www.zorba.io/download)
- Atom Studio
  - (https://atom.io/)
- Atom Binding to Zorba
  - (linter, language-jsoniq, atom-runner)