

Standardized Exchange of Information Between Geometry and Physics-based Modeling

Utilizing Selected Data-driven Model Structures

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• Extraction of Parameters from Geometric Models

- Machine Learning
- Extraction of Parameters from Machine Learning
- Conclusion and Future Work



https://thumbs.dreamstime.com/b/d-business-man-presenting-concept-agenda-white-background-36110030.jpg



Agenda

- Aim and Research questions
- Method

• Theory

- Proposed Methodology
- Geometric Models





Introduction

- OpenSCALING project
- Data-driven approach to the design and analysis of aircraft fuel system
- Open standards are utilized





Aim and Research questions



The aim of this research is evaluating data transfer applications used in aircraft fuel system simulations to improve the interoperability between geometric data and simulation tools.

- **RQ1:** How can tool-independent standards be leveraged to enhance interoperability between system simulation and geometric modeling in a data transfer process, specifically regarding accuracy?
- **RQ2:** Which methods can be used to improve traceability and ensure better tracking of data lineage between geometric models and dynamic simulations?

Design Research Method

- Criteria Effectiveness of the overall research
- *DS1* Analyze the problem
- PS1 Identify and develop potential methods
- DS2 Evaluate the methods



Theory

Standardized data exchange

•FMI

• Packaging of single simulations models within a FMU

•SSP • Packaging of multipl

 Packaging of multiple simulation models including associated parameters at any system level

•SSP Traceability

• Utilized to improve traceability for simulation models

• SRMD



FMI – Functional Mock-up Interface FMU – Functional Mock-up Unit SSP – System Structure and Parameterization SSD – System Structure Description SSM – System Structure Mapping SRMD – Simulation Resource meta-data





To optimize the workflow, the amount of instances has been reduced from ${\sim}70\;000$ to 1200

Geometric Models







External



Split Function
Acceleration vector:





Extracting Parameters to ML: Approach 1 – CSV () SAAB file

 n_x ; n_y ; n_z ; VolumeFuel; CoGx; CoGy; CoGz; D; VolumeRef = 1,20950459778775; Tank_Center_x = 6347,791; Tank_Center_y = 0; Tank_Center_z = 11812,5;

0.7198;0.4625;0.51767;0.314593515374361;6496.89447419825;764.916040203295;11969.8248629192;268.278244746772; 0.55609;-0.20008;-0.80668;0.947462510173661;6392.49057184007;-157.217108181353;11740.1953573125;223.721568557405; -0.35137;-0.32021;-0.87977;7.26726128306146E-04;5845.7642769445;-543.2955905502;11419.0368454143;-680.278533447127; -0.78183;0.10827;-0.61402;0.488036754533416;6086.59792130807;133.278499235304;11682.3467224237;-78.2785311349407; 0.94399;-0.32726;0.042159;1.1124674831112;6384.8576723017;-66.1194080745504;11807.5061768598;-533.721601341242; ...

Extracting Parameters to ML: Approach 2 – UDF Template



UDF Template and extracted parameters



Naming conventions



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Extracting Parameters to ML - SSP 1.0



XML

-►

- v<parameter name="nx" type="Double"> <value>-0.11698</value> <unit>Unit Not Applicable</unit> <comment>Comment goes here</comment>
- </parameter> v<parameter name="ny" type="Double"> <value>-0.32139</value> <unit>Unit Not Applicable</unit> <comment>Comment goes here</comment>
- </parameter> v<parameter name="nz" type="Double"> <value>-0.93969</value> <unit>Unit Not Applicable</unit> <comment>Comment goes here</comment>
- </parameter> v<parameter name="Volume" type="Double"</pre> <value>0.179472569829558</value>
- <unit>[m3]</unit> <comment>Comment goes here</comment> </parameter>

- v<parameter name="D" type="Double">v<parameter name="D" type="Double"</p> <value>69.4440974669554</value> <unit>[mm]</unit> <comment>Comment goes here</comment> </parameter>
- v<parameter name="point x" type="Double</pre> <value>404.062</value> <unit>[mm]</unit> <comment>Comment goes here</comment>
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- <comment>Comment goes here</comment> </parameter>
- v<parameter name="CoGy" type="Double"> <value>269.548914170239</value> <unit>[mm]</unit> <comment>Comment goes here</comment>
- </parameter> v<parameter name="CoGz" type="Double">
- <value>174.909160902707</value> <unit>[mm]</unit> <comment>Comment goes here</comment>
- </parameter>

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 - <unit>Unit Not Applicable</unit> <comment>Comment goes here</comment>

</parameter>

- ▼<parameter name="ny" type="Double"> <value>-0.32139</value>
 - <unit>Unit Not Applicable</unit>
- <comment>Comment goes here</comment>
- </parameter>
- ▼<parameter name="nz" type="Double"> <value>-0.93969</value>
 - <unit>Unit Not Applicable</unit>
 - <comment>Comment goes here</comment>
- </parameter>
- ▼<parameter name="Volume" type="Double"> <value>0.179472569829558</value> <unit>[m3]</unit>
- <comment>Comment goes here</comment> </parameter>

- SSV
- <ssv:Parameter name="part 'Tank for analysis'.geometricalSet 'instantiatedGeometry'.geometricalSet 'accVec 1'.parameterSet 'accVec 1 3'.parameter 'nx'"> <ssv:Real unit="Unit Not Applicable" value="-0.11698"/> </ssv:Parameter>
- <ssy:Parameter name="part 'Tank for analysis'.geometricalSet 'instantiatedGeometry'.geometricalSet 'accVec 1'.parameterSet 'accVec 1 3'.parameter 'ny'"> <ssv:Real unit="Unit Not Applicable" value="-0.32139"/>
- </ssv:Parameter>
- <ssv:Parameter name="part_'Tank for analysis'.geometricalSet_'instantiatedGeometry'.geometricalSet_'accVec_1'.parameterSet_'accVec_1_3'.parameter_'nz'"> <ssv:Real unit="Unit Not Applicable" value="-0.93969"/>
- </ssv:Parameter>
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- </ssv:Parameter>
- <ssv:Parameter name="part_'Tank for analysis'.geometricalSet_'instantiatedGeometry'.geometricalSet_'accVec_1'.parameterSet_'accVec_1_3'.parameter_'point_y'"> <ssv:Real unit="[m]" value="0.311159"/>
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- </ssy:Parameter>
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- </ssv:Parameter>
- <ssv:Parameter name="part_'Tank for analysis'.geometricalSet_'instantiatedGeometry'.geometricalSet_'accVec_1'.parameterSet_'accVec_1.3'.parameter_'CoGz'"> <ssv:Real unit="[m]" value="0.174909160902707"/>

Proposed Methodology





VBA – Visual Basic for Applications ML – Machine Learning

Machine Learning

- Python in Pycharm Linux environment
- PySSP Standard

• A Python library that allows for the creation, reading and editing of SSV, SSM and SSB files. In addition, it allows for the reading of SSP, FMU and SSD files.

- Radial Basis Functions:
 - Input parameters: *n_x, n_y, n_z* and *volume of fuel*
 - Output parameters: GCx, GCy, GCz and D (4 separate functions)

• Number of centers (*n*), Weights (*W*) and Prescaler (σ) are saved for each output parameter

• The PySSP standard have been further developed to support SSV files in both SSP 1.0 and SSP 2.0 formats





https://i0.wp.com/junilearning.com/wpcontent/uploads/2020/06/python-programminglanguage.webp?fit=800%2C800&ssl=1

FMI – Functional Mock-up Interface

- FMU Functional Mock-up Unit
- SSP System Structure and Parameterization
- SSD System Structure Description
- SSM System Structure Mapping
- SRMD Simulation Resource meta-data

Extracting Parameters from ML

SSP 1.0 Format



SSP 2.0 Format

xml version='1.0' encoding='utf-8'?		xml version='10' encoding='utf-8'?							
<ssv:parameterset xmlns:ssv="</td"><td>Metadata</td><td><pre>// Security ParameterSat vmlne/secu-</pre></td></ssv:parameterset>	Metadata	<pre>// Security ParameterSat vmlne/secu-</pre>							
"http://sspstandard.org/SSP1/SystemStructureParameterValues" version="1.0"	Motadata	"http://sepetandard.org/SSD2/SystemStructureDarameterValues" version="2.0"							
name="D_Fuel_Tank_1_1" generationTool="pyssp_standard" generationDateAndTime=	=	netp.//sspstalidaid.org/5512/SystemStructurer arameter values version = 2.0							
"2025-01-23T13:14:28.583104">		name= D_ruer_rank_1_r generation root= pyssp_standard generationDateAnd rune=							
<ssv:parameters></ssv:parameters>		2025-01-29112:48:34.381107 >							
<ssv:parameter name="VolumeRef"></ssv:parameter>		<ssv:l'arameters></ssv:l'arameters>							
<ssv:real unit="m<sup>3</sup>" value="1.20950459778775"></ssv:real>		<ssv:parameter name="VolumeRef"></ssv:parameter>							
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		<ssv:integer value="255"></ssv:integer>							
<ssy:parameter name="weight_0"></ssy:parameter>	romotoro	Arrays							
<ssy:real unit="" value="-0.08593060185474588"></ssy:real>	lameters	<ssv:parameter name="CentersD"></ssv:parameter>							
		<ssv:real unit="" value="[0.9931943598680439, -0.8382422608317056,]"></ssv:real>							
<ssy:parameter name="weight_1"></ssy:parameter>									
<ssv:real unit="" value="-0.02910161179473955"></ssv:real>		<ssy:parameter name="PrescalerD"></ssy:parameter>							
		<ssy:real unit="" value="[0.0263047042718215, 0.10026821582423856]"></ssy:real>							
<ssy:parameter name="weight 2"></ssy:parameter>									
<ssy:real unit="" value="-0.04456052861465783"></ssy:real>		<ssy-parameter name="WeightsD"></ssy-parameter>							
		<ssy:beal unit="" value="[-0.0894165236805315 _0.04270625074786133]"></ssy:beal>							
<ssy:parameter name="weight 3"></ssy:parameter>		<pre></pre>							
<pre><ssv:beal unit="" value="-0.7697661191752928"></ssv:beal></pre>									
		<ssv: units="" xmins:ssc="nttp://ssp-standard.org/5512/SystemStructureCommon"></ssv:>							
<ssy:units xmlns:ssc="http://ssp-standard.org/SSP1/SystemStructureCommon"></ssy:units>		<ssc:unit name="m"></ssc:unit>							
<ssc:unit name="m"></ssc:unit>		<ssc:baseunit m="1"></ssc:baseunit>							
<ssc:baseunit m="1"></ssc:baseunit>	Linita								
	Units	$\langle ssc:Unit name="m^3" \rangle$							
$\langle ssc: Unit name="m^{3"} \rangle$		<ssc:baseunit m="3"></ssc:baseunit>							
<ssc:baseunit m="3"></ssc:baseunit>									

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Import SSV in SSP 1.0 Format into Dymola

Open → Import SSP → SSV Files → Select SSV file to import

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Open Open	+	Load Ctrl+Shift+O Load an existing Modelica file and show its contents without changing current directory.		Select All	Line Re	ectangle	Ellipse	Polygon	Text Bitm	itmap 🗼	Arrange	- Annotation		Split Chec Model		Attribute:	5	3 Find	Find Connectior	Diagram Filter	Create L	Create Local State	
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Print Print	•	Import SEP																					
Save Log		Import an SSP the model and	, creating a top-level pa d all FMUs.	ackage containing																			
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FMI – Functional Mock-up Interface

- FMU Functional Mock-up Unit
- SSP System Structure and Parameterization
- SSD System Structure Description
- SSM System Structure Mapping
- SRMD Simulation Resource meta-data

Computer	Name	▲ Size Type	Date Mod *
	D_Fuel_Tank_1_2.ssv	277KiB XML document	1/31/25 7
ludsa	D_Fuel_Tank_1_1.ssv	262KiB XML document	1/31/25 7
	D_Cube.ssv	266KiB XML document	1/31/25 7
	CGz_Fuel_Tank_3.ssv	277KiB XML document	1/31/25 7
	CGz_Fuel_Tank_2_2.ssv	275KiB XML document	1/31/25 7
	CGz_Fuel_Tank_2_1.ssv	278KiB XML document	1/31/25 7
	💿 CGz_Fuel_Tank_1_2.ssv	286KiB XML document	1/31/25 7
	CGz_Fuel_Tank_1_1.ssv	263KiB XML document	1/31/25 7
	CGz_Cube.ssv	268KiB XML document	1/31/25 7
	💿 CGy_Fuel_Tank_3.ssv	277KiB XML document	1/31/25 7
	💿 CGy_Fuel_Tank_2_2.ssv	275KiB XML document	1/31/25 7
	CGy_Fuel_Tank_2_1.ssv	271KiB XML document	1/31/25 7
	CGy_Fuel_Tank_1_2.ssv	277KiB XML document	1/31/25 7
	CGy_Fuel_Tank_1_1.ssv	263KiB XML document	1/31/25 7
	CGv Cube.ssv	268KiB_XML document	1/31/25 7*
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Files of type:	SSV Files (*.ssv)	•	e <u>C</u> ancel

Conclusion and Future Work

SAAB

- SSP standard
 - Enhances interoperability between different simulation tools (e.g., Modelica, Simulink, FMUs), making it easier to combine fuel system simulations with other physical models (thermal, structural, etc.)
 - Traceability
- SSP 2.0 Format
 - Easier to Read & Manage: Instead of having many separate entries, a single, structured entry is recieved
 - Reduces File Size & Redundancy: Instead of defining multiple similar parameters, they are stored in one array
 - Faster Data Processing: a single read operation can load all values instead of looping through multiple individual entries
- In the future, SSP 2.0 could enable standardization across industries and lead to seamless cross-platform engineering simulations, which means companies can share & reuse simulation models across different tools without compatibility issues

COMPANY Rhermal Fluid Library (work in Progress) Your Name | Document Identification | Issue 1 FMI – Functional Mock-up Interface FMU – Functional Mock-up Unit SSP – System Structure and Parameterization SSD – System Structure Description

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