A sample program for the SSOS: Material Flow Simulation

Overview

Our company SSD has developed SICLE (Simulator for Closed Life and Ecology), a Java-based software that enables users to create and simulate material circulation models.

In this instance, we are providing a Python-based sample of simulation software that visualizes material flow for Space Station OS (SSOS). While the functionality is currently limited, we hope this sample serves as a useful introduction.

Reference:

Space Station OS >Discussions > ECLSS technical discussions
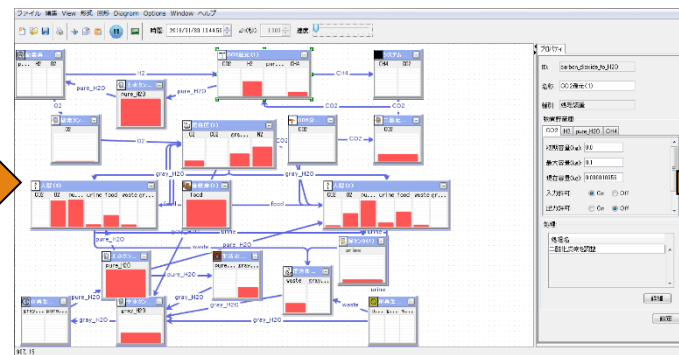
ID: diana1218, SSOS-SSD デモ.pdf

https://github.com/orgs/space-station-os/discussions/19?sort=new

About SICLE(java)

①The design interface allows users to create material circulation models by freely adding humans, devices, and tanks, each defined according to specific parameters.

②Users can set numerical values, define processing details, choose the simulation period, and run the simulation. The simulation screen tracks the fluctuations in substance levels within each device.

③Results can be analyzed in detail through CSV data and other outputs. Based on the findings, users can adjust models, values, or processing parameters and rerun the simulation.
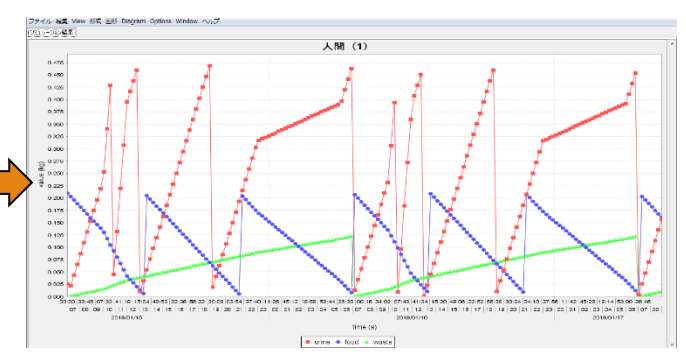
Through the simulations, users can gather valuable insights into whether a proposed model supports effective material circulation, assess device scale, tank capacities, and more.
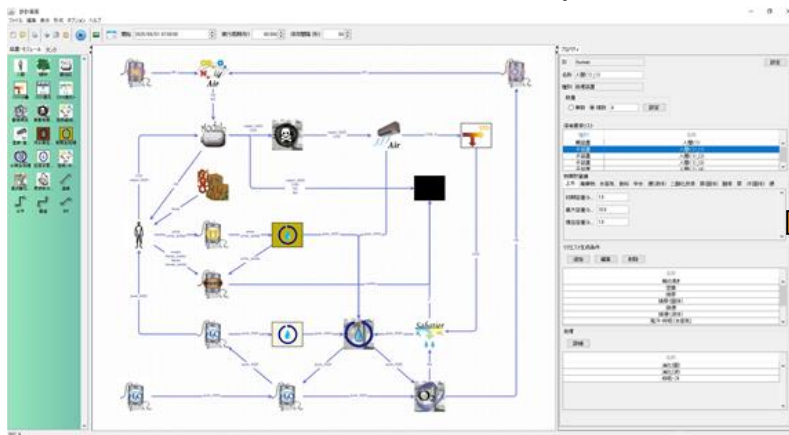
①SILCE design screen

②SILCE simulation screen

③SILCE results

Function Comparison

|	SICLE (java)	Sample model (python)
Model of material cycle	Freely creatable (Define the equipment and substances in a separate sheet.)	Fixed as described in next page (Only the contents written in code.)
Code	unpublish	publish
Model design screen	Available	Not available
Duration of simulation	Set freely	Only 30days or 100days
Output csv data	・Amount of substance within each device ・Information of input/output ・Increase/decrease of substances in each device 3 csv data The data acquisition interval can be select per minute, per hour, per day.	・Amount of substance within each device Only 1 csv data The data acquisition interval is only every hour.

Software to be sell. While SSD have extensive expertise with SICLE (Java).Please understand that sample model (python) has very limited functionality as it is a sample intended for SSOS.

About sample model in python

[Configuration]
・Crew (Human)：1
・Module (Human tank)：1
・Oxygen tank：1
・Pure water tank small：1
・Carbon dioxide separator：1
・Carbon dioxide to water system (Carbon Dioxide To H2O)：1
・Sabatier 2 system (Sabatier Separator)：1
・Oxygen recovery processor：1
・Water recycling processor：1
・Outside：1

NOTE: SSD is aware that the present model is insufficient as a general model of material circulation in space. The purpose of this model it's to provide a simple circulation for humans were oxygen, and water are also implemented as a sample for SSOS.
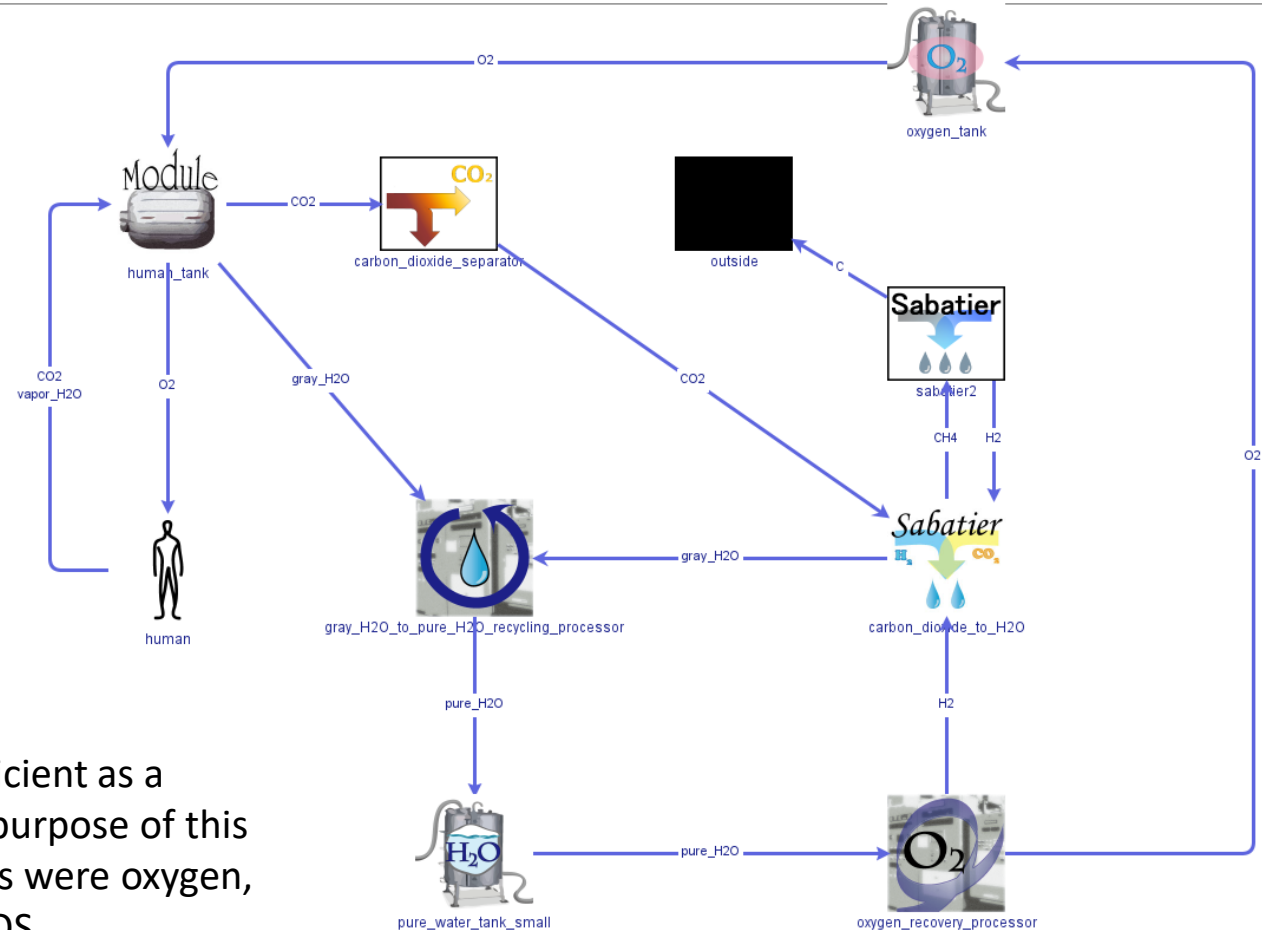
Detail of sample model① initial value/maximum value

装置/タンク	最大容量/初期値	物質 (kg)							
		O2	CO2	vapor_H2O	gray_H2O	CH4	H2	pure_H2O	C
クルー(Human)	Capacity	5	5	10					
	start_value	5	0	0					
モジュール(Module)	Capacity	10	10	10	10				
	start_value	10	0	0	0				
酸素タンク(oxygen_tank)	Capacity	150							
	start_value	100							
上水タンク(pure_water_tank_small)	Capacity							500	
	start_value							50	
CO2吸着装置(carbon_dioxide_separator)	Capacity		10						
	start_value		0						
サバチエ第一反応装置(carbon_dioxide_to_H2O)	Capacity		10		10	10	10		
	start_value		0		0	0	0		
サバチエ第二反応装置(sabatier2)	Capacity					10	10		10
	start_value					0	0		0
酸素製造装置(oxygen_recovery_processor)	Capacity	10					10	10	
	start_value	0					0	10	
水再生装置(gray_H2O_to_pure_H2O_recycling_processor)	Capacity				50			10	
	start_value				0			0	
システム外(outside)	Capacity	Infinity	Infinity	Infinity	Infinity	Infinity			Infinity
	start_value	0	0	0	0	0			0

Example:
Oxygen tank
Initial O2 value
：100kg
Maximum O2 value
：150kg

Detail of sample model② processing

装置/タンク	物質 (kg/day)							
	O2	CO2	vapor_H2O	gray_H2O	CH4	H2	pure_H2O	C
クルー(Human)	-0.895	1.085	2.946					
モジュール(Module)			-2.946	2.946				
酸素タンク(oxygen_tank)								
上水タンク(pure_water_tank_small)								
CO2吸着装置(carbon_dioxide_separator)		-0.5425						
サバチエ第一反応装置(carbon_dioxide_to_H2O)		-1.1		0.9	0.4	-0.2		
サバチエ第二反応装置(sabatier2)					-0.4	0.1		0.3
水再生装置(gray_H2O_to_pure_H2O_recycling_processor)				-3			3	
酸素製造装置(oxygen_recovery_processor)	0.8					0.1	-0.9	
システム外(outside)								
SUM	-0.095	-0.5575	0	0.846	0	0	2.1	0.3

Example:
crew
Consumption of O2: 0.895kg/day, Emission of CO2: 1.085kg/day, Emission of Vapor_H2O: 2.946kg/day

Detail of sample model③ rationale of the figures

About ① (initial value/maximum value)
We conducted simulations and adjusted to the appropriate values.

About ② (processing)
　Crew：Refer to *1
　Module: 100% conversion to crew's vapor water to gray water.
　Carbon dioxide separator :50% absorption of carbon dioxide.
　Sabatier Reaction No. 1: The ratio of molar mass was matched from the chemical formula.
　Sabatier Reaction No. 2: The ratio of molar mass was matched from the chemical formula.
　Water Recycling Device: 100% conversion of gray water to pure water.
　Oxygen Production Processor: The ratio of molar mass was matched from the chemical formula.

*1: Life Support Baseline Values and Assumptions Document, NASA/TP-2015-218570, Rev2
　　　Table 3-31 Summary of Nominal Human Metabolic Interface Values

Results and Future

[Results]
A sample program in Python was developed for simulating material cycles.

Verifications were consistent by comparing the results with those from the SICLE Java version.
Thus, our work is now complete.

[Future]
Non

Extras :
-Developing Python-based simulation software that allows for freely creating models like SICLE in java will require additional development costs.

-We believe it would be beneficial to explore the potential use of the Space Station OS for private utilization of the ISS, alongside our simulation technology, including considerations related to funding.

Contact

・We will answer any questions about the submitted sample program in Python on GitHub.

・If you have any questions about the Java version of SICLE or are interested in a trial version, please contact us via the website URL. On this page, we will answer all your questions.

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