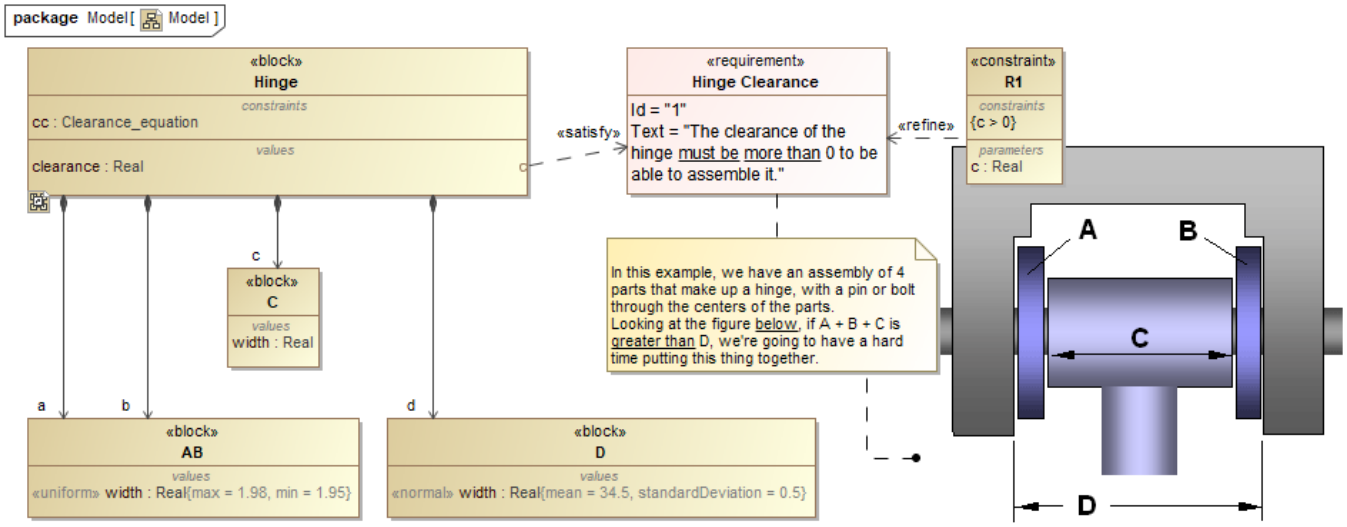
Monte Carlo simulation

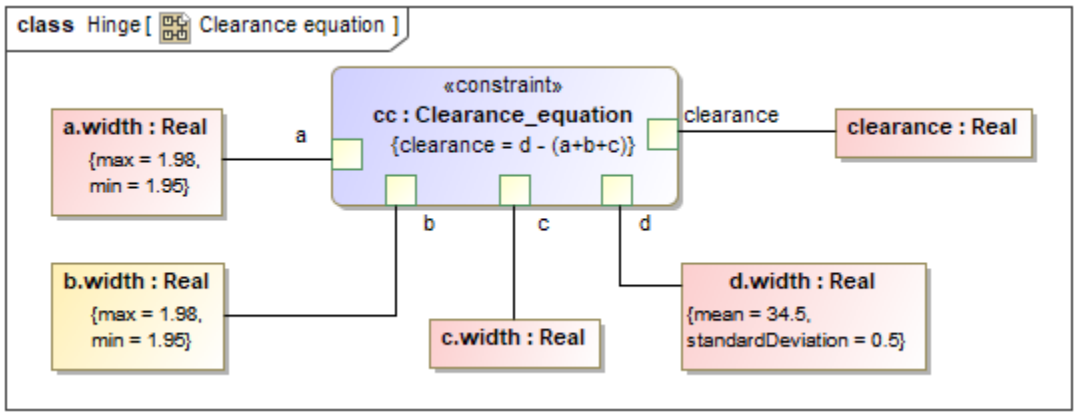
Cameo Simulation Toolkit introduces a built-in support for Monte Carlo analysis, allowing you to manage uncertainties and estimate how random variation of sensitive parameters affects the overall performance of the system being modeled. The HingeMonteCarloAnalysis sample model demonstrates the following steps.

1. Create a Block structure along with other parts in the Block Definition diagram. Apply distributions stereotypes to get a set of random inputs on value properties of the parts (e.g., the *Hinge* Block with *AB, C, and D* Blocks as parts with «uniform» and «normal» stereotypes on *width* value properties accordingly).



The Block Definition diagram of the Hinge model with distributed value properties applied.

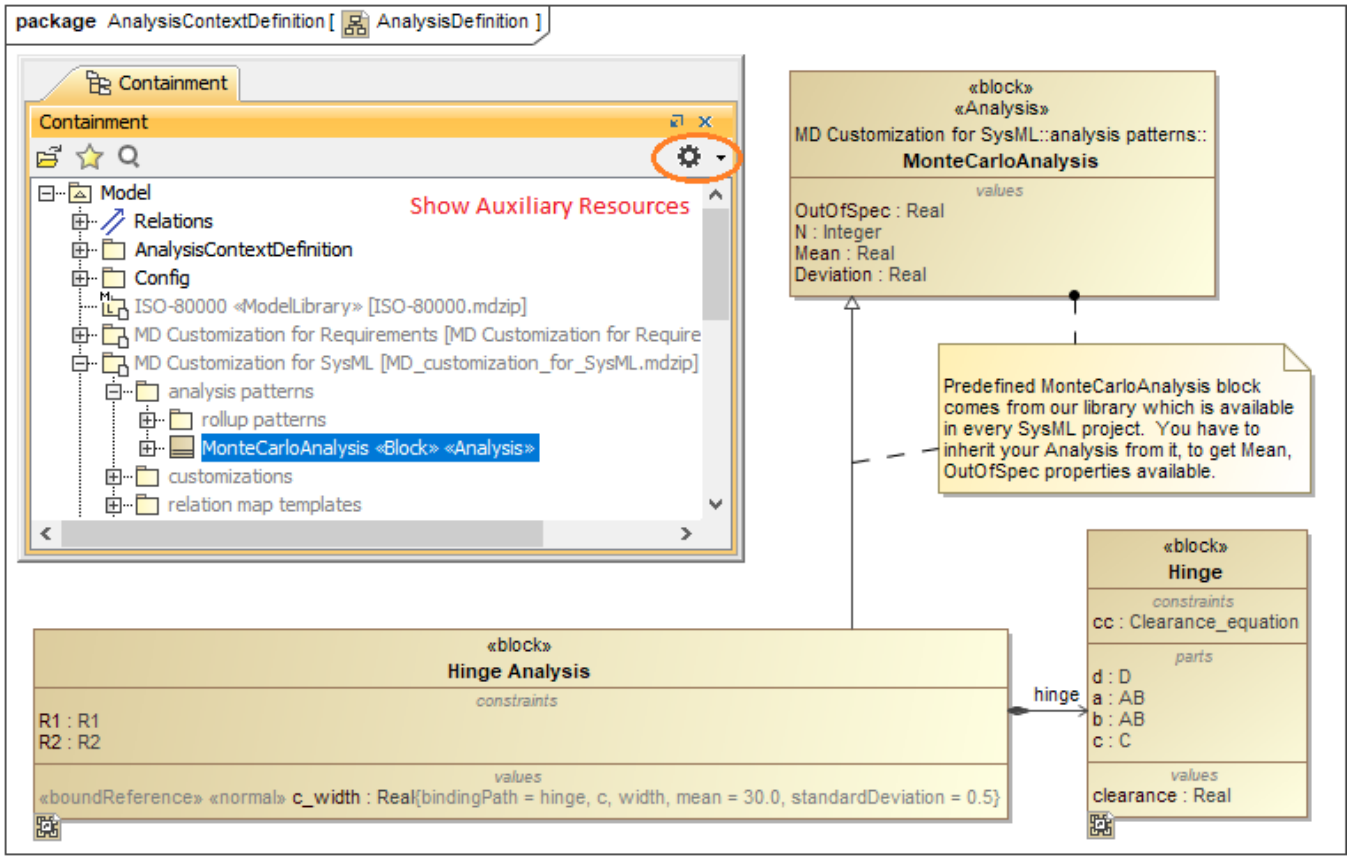
2. Create a Constraint Block of those value properties in the Parametric diagram according to the requirement (e.g., *clearance = d – (a + b + c)*).



The Parametric diagram of the Hinge model.

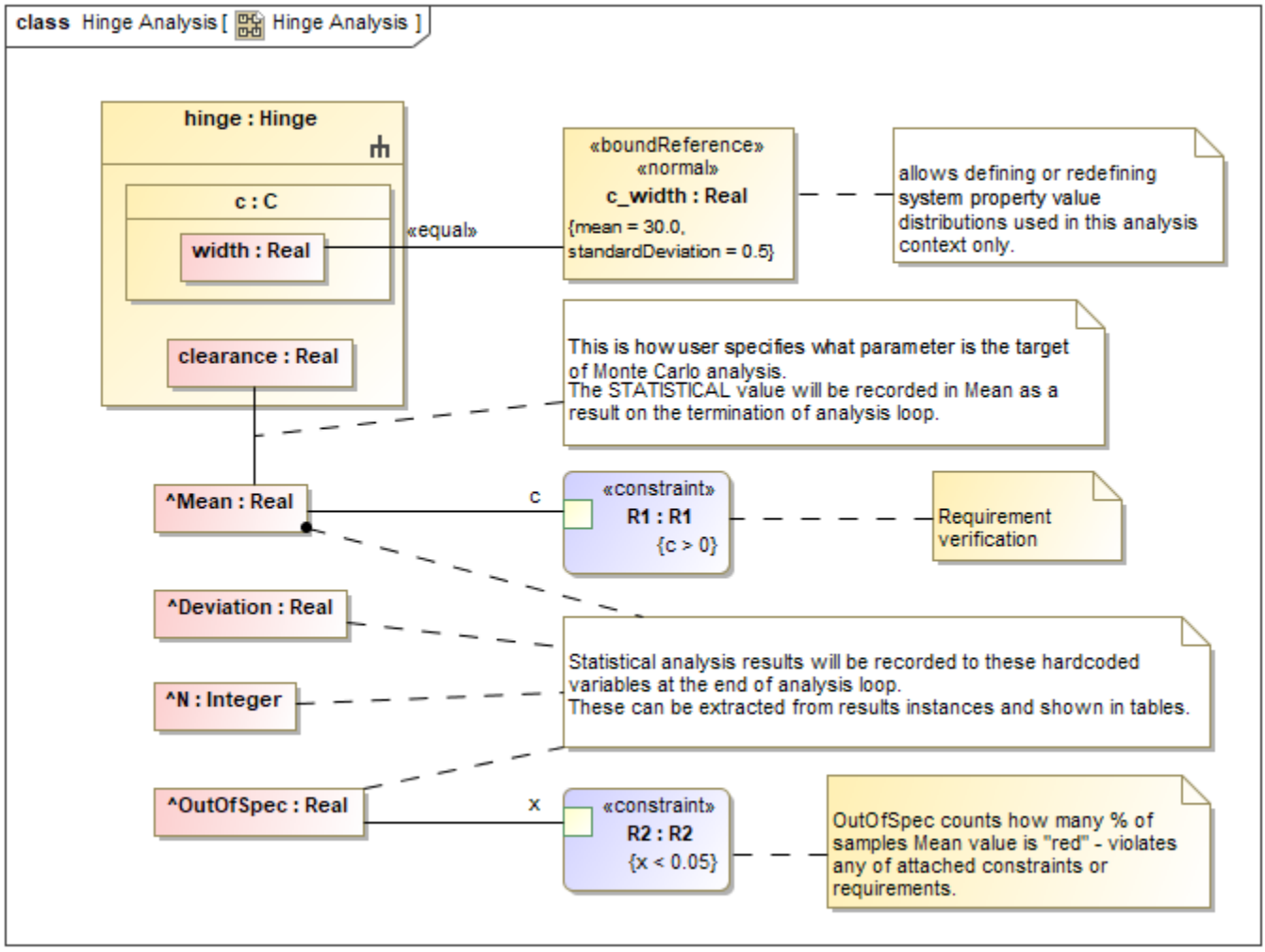
3. Create another Block Definition diagram to include an analysis context definition. In the Containment tree pane, click  and select **Show Auxiliary Resources**. Drag the predefined *MonteCarloAnalysis* Block from the **MD Customization for SysML** library (available in every SysML project) into the Block Definition diagram.

4. Inherit your analysis context definition (e.g., the *Hinge Analysis* Block from *MonteCarloAnalysis* Block) to get *N*, *Mean*, *Deviation*, and *OutOfSpec* properties. Finally, you must set the *Hinge* Block as part of the *Hinge Analysis* Block.



Inheriting the Hinge Analysis Block from the predefined MonteCarloAnalysis Block and setting the Hinge Block as part of the Hinge Analysis Block.

5. Specify a parameter target, e.g., the *clearance* value property, of the Monte Carlo analysis in another Parametric diagram. Statistical values will be recorded in the Mean as a result of termination of the analysis loop. You must create Constraint Blocks and connect them to the *requirement verification* (*R1*) and the *OutOfSpec* property (*R2*) respectively.



Specifying the requirement verification (R1) and OutOfSpec property (R2) of the Monte Carlo analysis in another Parametric diagram.

6. Create a Simulation Configuration diagram, add a «SimulationConfig» to the diagram, and set the following tags:

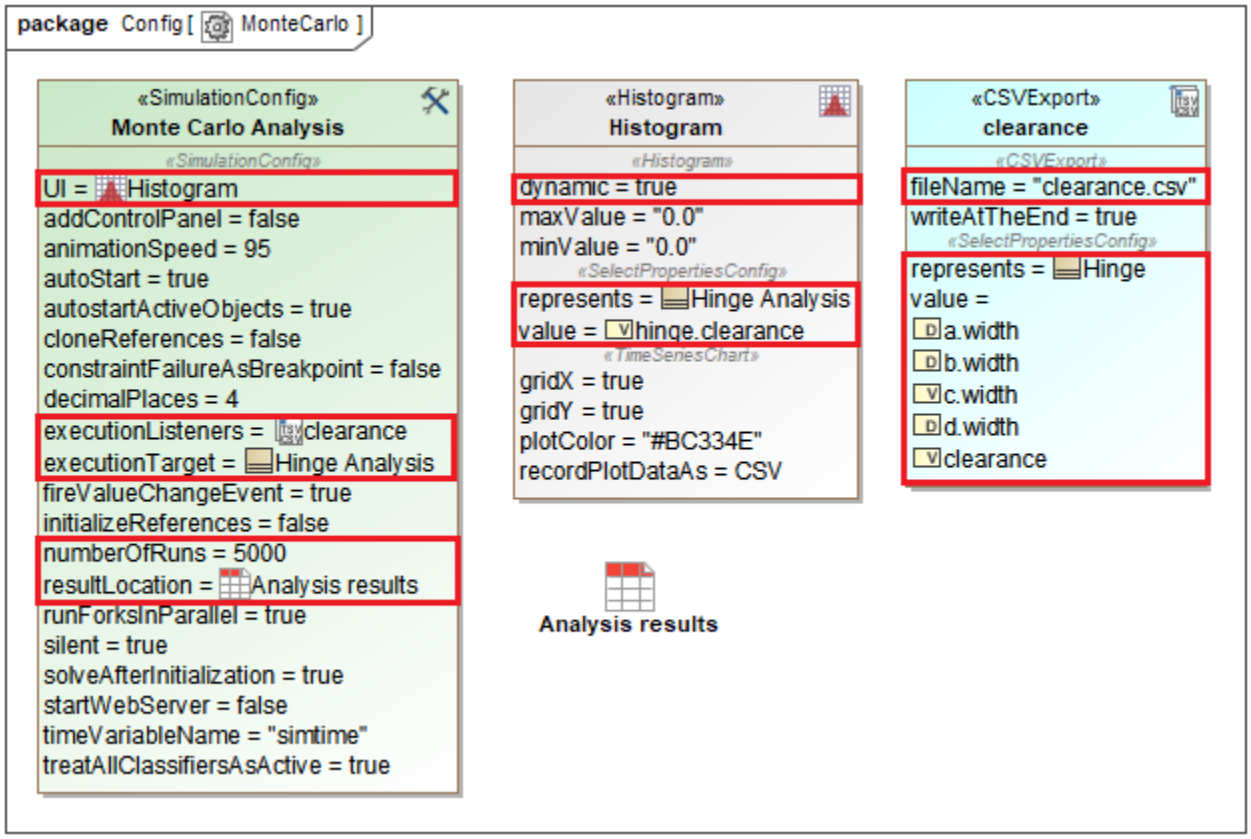
- *executionTarget*: *Hinge Analysis* Block.
- *numberOfRuns*: the number of runs, e.g., 5000.
- *resultLocation*: an Instance table, e.g., *Analysis results*.
- *silent*: true (for the optimum performance of the Monte Carlo simulation).

Note

- For a model that has Behaviors (Classifier Behavior and/or Part Property with Behaviors), see the *autoStart* tag in SimulationConfig.
- If *numberOfRuns* of any table (*executionTarget*) is more than 1, it will be ignored in the Monte Carlo simulation. The table, however, will be run only once.
- If *silent* is set to false, the simulation will run with animation and idle time for each iteration, which is not practical for the Monte Carlo simulation.

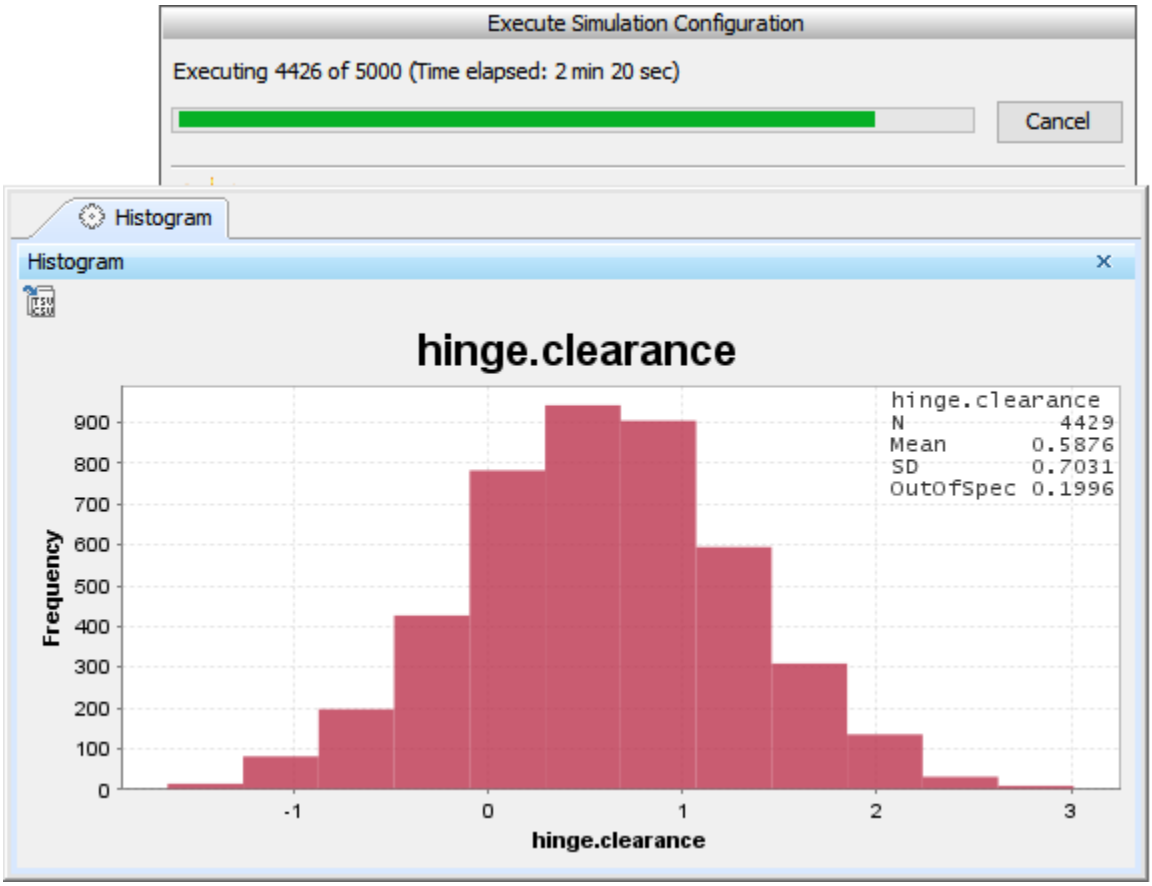
7. Drag a *Histogram* control from the **Simulation** toolbar to the Simulation Configuration diagram. You can use the histogram as a local user interface. Set the *represents* and *value* tags to the *Hinge Analysis* Block and to the *clearance* value property respectively. Set the *dynamic* tag to **true** to view the histogram that dynamically updates those statistical values (setting to **false** will open the histogram at the end of executions). You can also record the values of every iteration using the *CSV Export* control by setting the *represents* and *value* tags to the *Hinge* Block and other related value properties, e.g., *a .width*, to be in the exported CSV file.

8. Drag the *Histogram* and *CSV Export* controls to the «SimulationConfig». *UI* and *executionListeners* tags will be updated with the names of the *Histogram* control as *Histogram* and *CSVExport* controls as *clearance*.



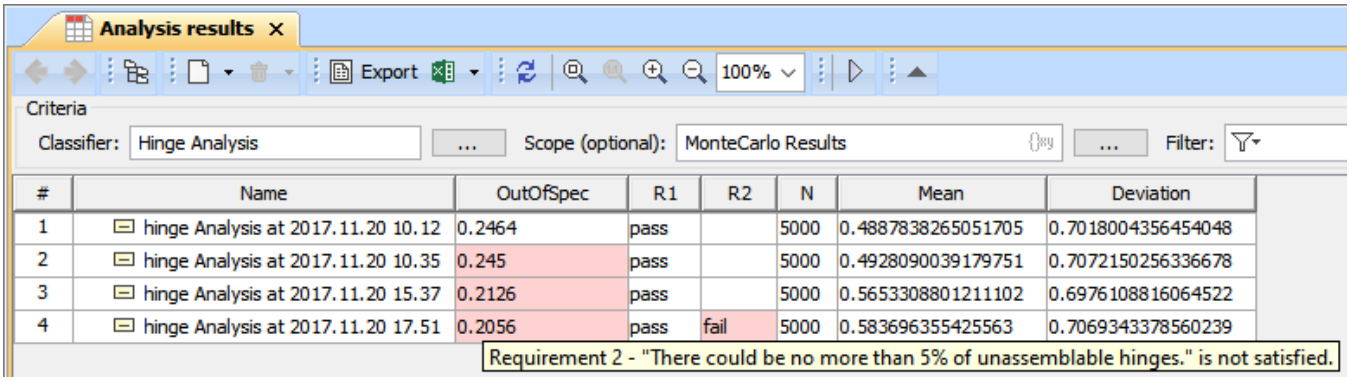
«SimulationConfig» setting with numberOfRuns, Histogram, CSV Export, and Instance Table.

9. Run «SimulationConfig». The histogram will dynamically show the estimated distribution of the values of the analysis context definition of *hinge.clearance* during the simulation at the top right of the histogram. The simulation progress bar is shown and allows the user to cancel the simulation.



The histogram dynamically shows statistical results during the simulation.

10. Analysis results will be recorded in the **Instance** table along with verification status. You can also see the detail of the constraint failure in the tooltip when hovering the mouse over any highlighted red values. The value properties with distributions stereotypes applied are exported to the **clearance.CSV** file.



Analysis results are recorded in the Instance table with verification status.

	A	B	C	D	E	F
1	time(ms)	a.width	b.width	c.width	d.width	clearance
2	0	1.9699	1.9527	29.7489	34.1094	0.438
3	0	1.9719	1.9589	30.1333	34.3102	0.2462
4	0	1.9793	1.9689	29.5465	34.9699	1.4751
5	0	1.9607	1.9623	31.0178	35.0214	0.0807
6	0	1.9783	1.9779	30.2774	35.2926	1.0591
7	0	1.953	1.9504	28.786	34.5033	1.8138
8	0	1.9794	1.9584	29.6696	34.3921	0.7848
9	0	1.966	1.9579	30.4552	34.4694	0.0903
10	0	1.9517	1.965	30.2331	34.6525	0.5027
11	0	1.9654	1.9678	30.4735	34.7705	0.3638
12	0	1.9719	1.9655	29.8754	34.7032	0.8903
13	0	1.9782	1.9779	29.3136	35.0491	1.7795
14	0	1.971	1.965	29.5043	34.9351	1.4948
15	0	1.9561	1.9783	29.3873	34.0719	0.7502
16	0	1.9538	1.9629	29.9016	34.4221	0.6039
17	0	1.9795	1.956	30.1975	34.5067	0.3736
18	0	1.9608	1.9632	29.7818	34.5114	0.8055
19	0	1.961	1.9762	29.4141	34.683	1.3316
20	0	1.9797	1.9608	30.5296	35.7698	1.2997

Analysis results are exported to the clearance.CSV file.