TRIZ SUMMIT 2024

International Conference on TRIZ.

October 14, 2024, Moscow.

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Operation Principle Evolution with Cost-Value Analysis (OPECVA)

Затратно-ценностный анализ (ЗЦА).

October 14, 2024

From Value Analysis to Operation Principle Evolution
От функционально-стоимостного анализа (ФСА) к затратно-ценностному анализу (ЗЦА)

✓ Value Analysis Functional Approach, Cost-Value Analysis, 1947 - …

Yuri M. Sobolev

Lawrence Delos Miles

From Value Analysis to Operation Principle Evolution
От функционально-стоимостного анализа (ФСА) к затратно-ценностному анализу (ЗЦА)

- ✓ Value Analysis Functional Approach, Cost-Value Analysis, 1947 - …
  - Focus - enterprise, product, …
  - Based on the functional and/or component analysis
  - Goal - business process optimization

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From Value Analysis to Operation Principle Evolution
От ФСА к ЗЦА

	CVA	OPECVA
Focus	Enterprise, product, production process..	
Based on	Component of functional analysis	
Цель	Optimization	

	ФСА	ЗЦА
Объект	Предприятие, продукт, производственный процесс..	
Основа	Компонентный и функциональный анализ	
Цель	Оптимизация	

From Value Analysis to Operation Principle Evolution
От ФСА к ЗЦА

	CVA	OPECVA
Focus	Enterprise, product, production process..	**Any technical system**
Based on	Component of functional analysis	
Цель	Optimization	

	ФСА	ЗЦА
Объект	Предприятие, продукт, производственный процесс..	**Любая техническая система**
Основа	Компонентный и функциональный анализ	
Цель	Оптимизация	

From Value Analysis to Operation Principle Evolution
От ФСА к ЗЦА

	CVA	OPECVA
Focus	Enterprise, product, production process..	**Any technical system**
Based on	Component of functional analysis	**Operation principle analysis**
Цель	Optimization	

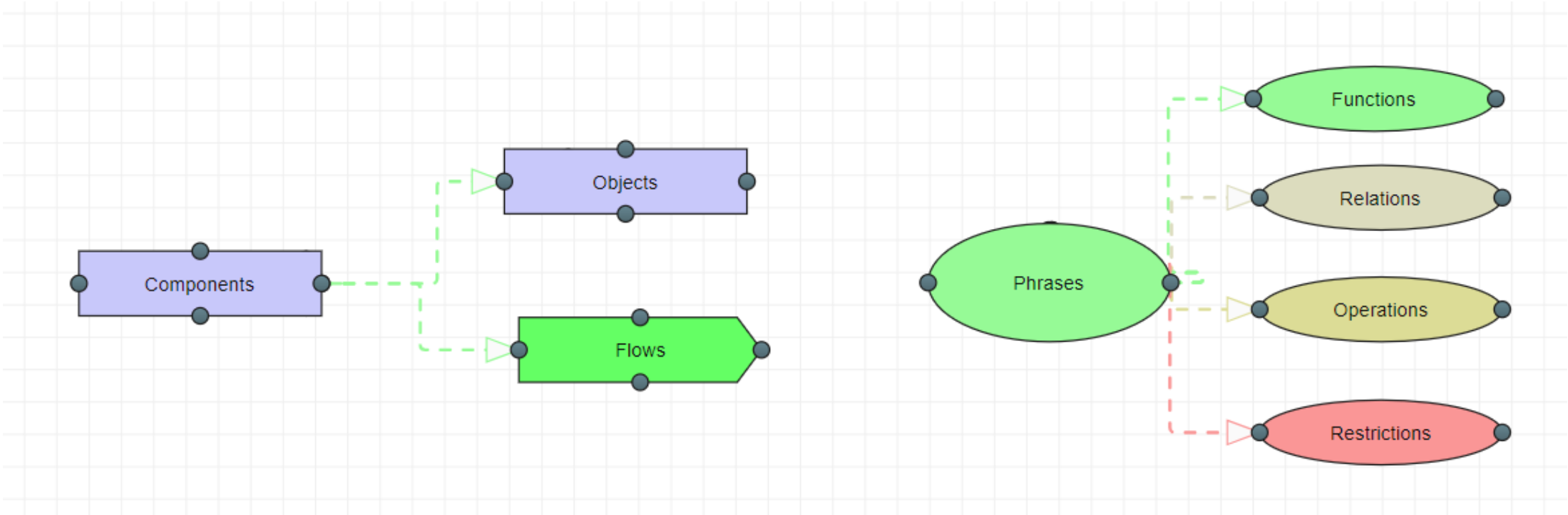
	ФСА	ЗЦА
Объект	Предприятие, продукт, производственный процесс..	**Любая техническая система**
Основа	Компонентный и функциональный анализ	**Анализ принципа действия**
Цель	Оптимизация	

From Value Analysis to Operation Principle Evolution
От ФСА к ЗЦА

	CVA	OPECVA
Focus	Enterprise, product, production process..	**Any technical system**
Based on	Component of functional analysis	**Operation principle analysis**
Цель	Optimization	**Evolution**

	ФСА	ЗЦА
Объект	Предприятие, продукт, производственный процесс..	**Любая техническая система**
Основа	Компонентный и функциональный анализ	**Анализ принципа действия**
Цель	Оптимизация	**Эволюция**

Operation Principle Analysis in CompinnoTRIZ
Анализ принципа действия



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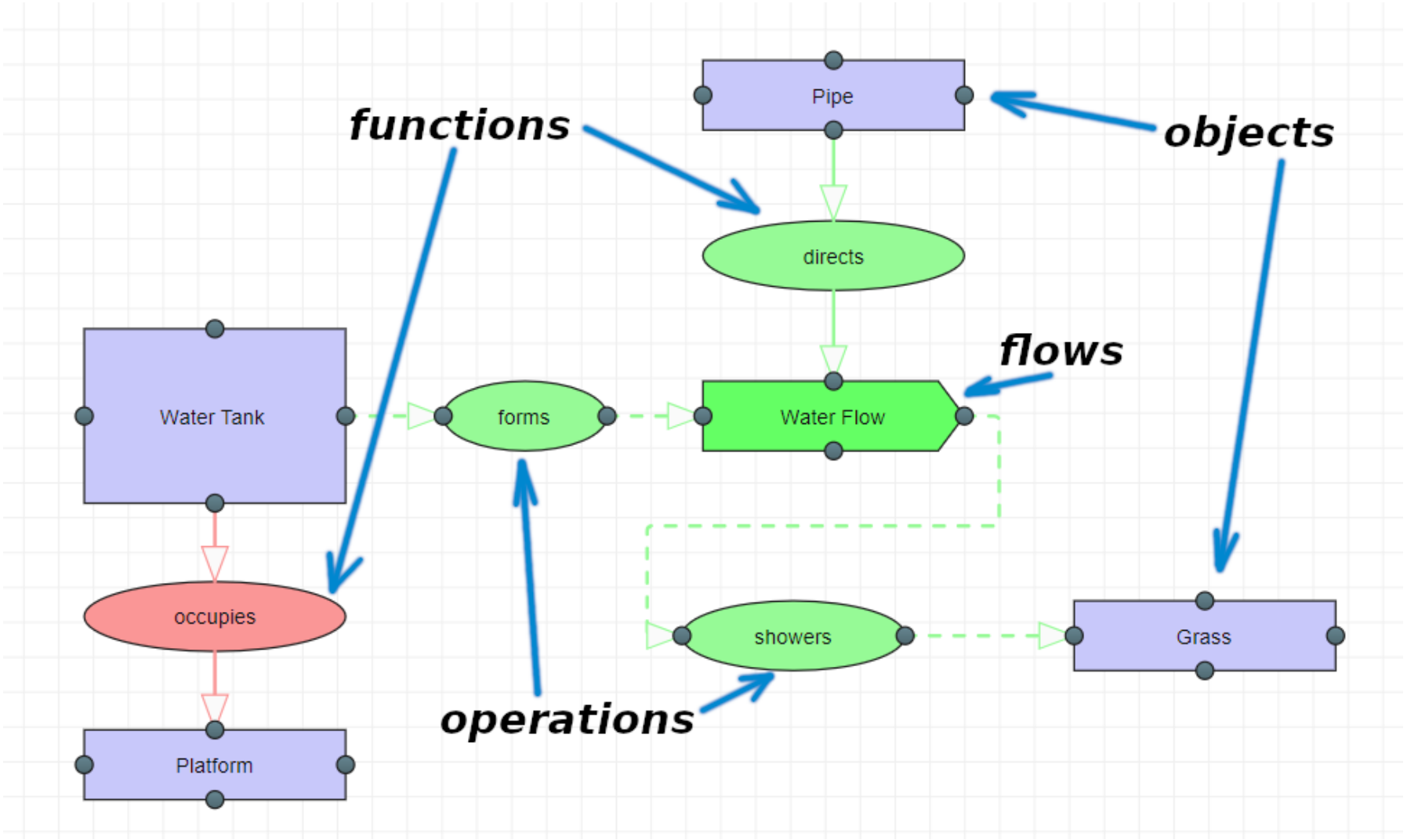
Operation Principle Analysis in CompinnoTRIZ
Анализ принципа действия



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Operation Principle Analysis in CompinnoTRIZ
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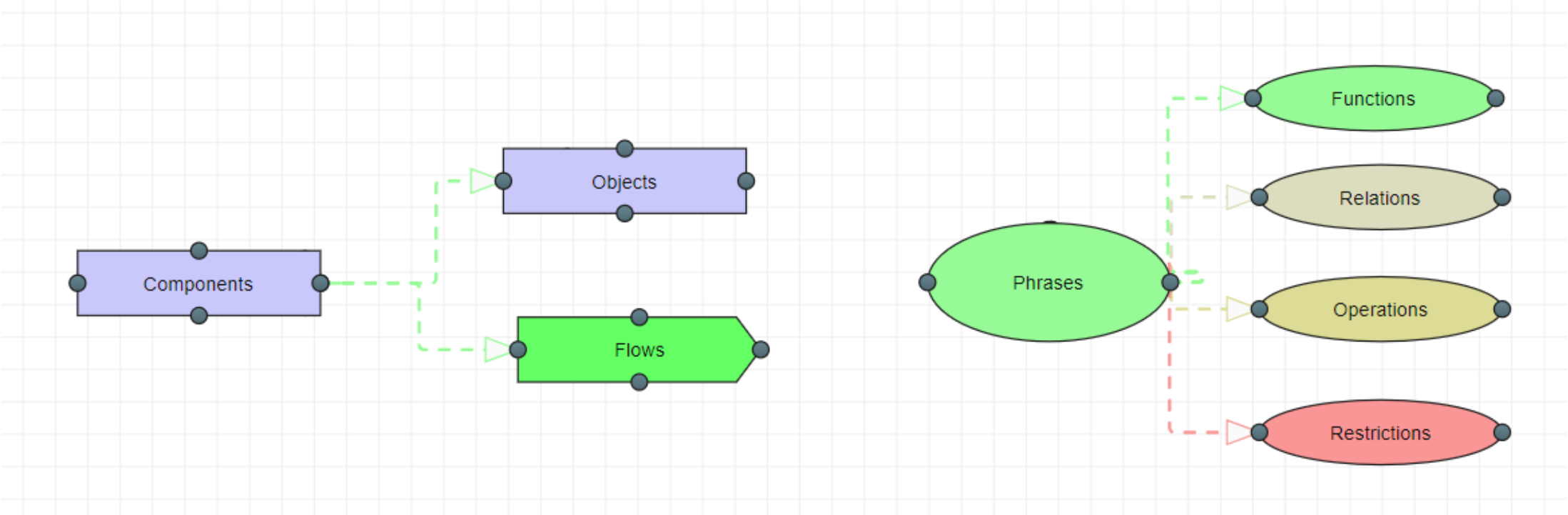

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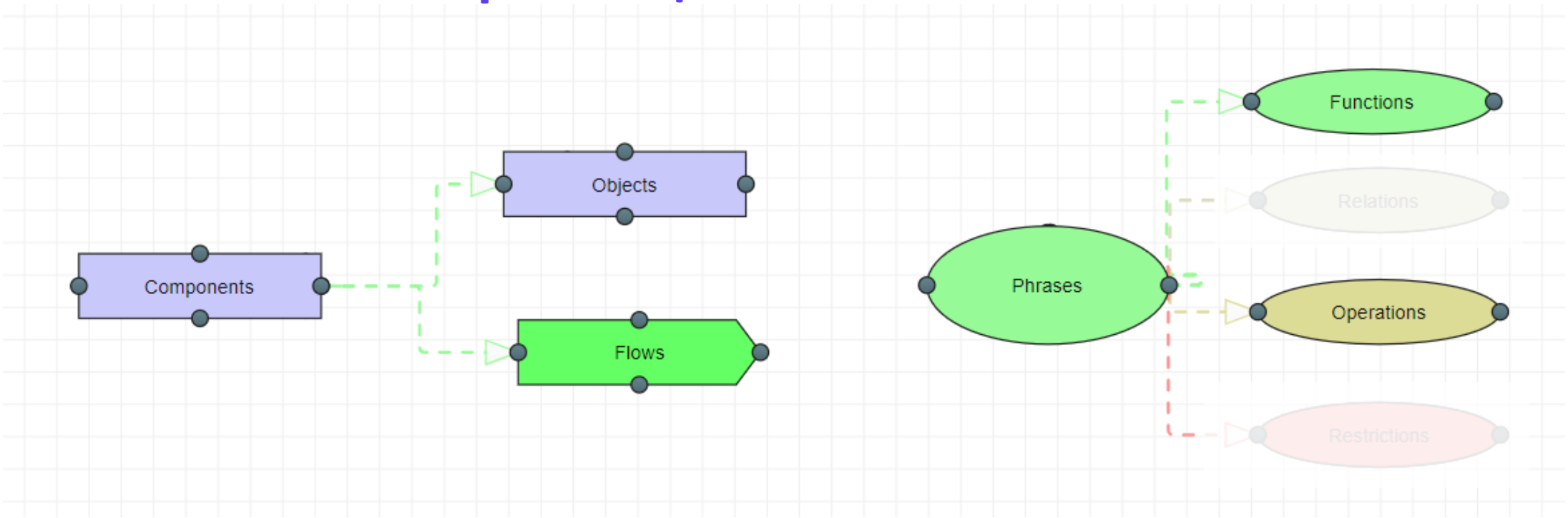
Operation Principle Evolution with Cost-Value Analysis
Затратно-ценностный анализ



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OPECVA Methodology

✓ Определить критерии ценности (Define value criteria)

Meat grinder

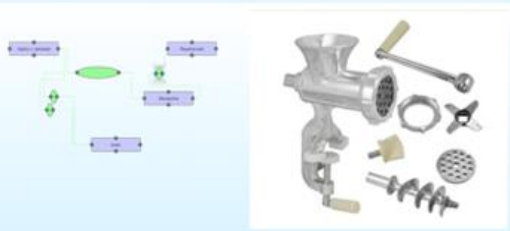
Back

Value criteria | Objects | Functions | Processes/Streams

Direct assessment | Unit of mea | Weight | +

Name	Pairwise comparisons	Unit of measurement	Weight of the criterion	
Value	1		10	
Beauty	1		1	

Refresh



OPECVA Methodology

✓ Ввести затраты на объекты (Input object costs)

Meat grinder

Back

Value criteria | Objects | Functions | Processes/Streams

List of loop objects

- Meat
- Meat grinder

Unit of cost measurement: thousand rubles — Save

Objects for analysis	Costs (thousand rubles)	Costs (share)
Screw	25	0.010
screw	125	0.049
Housing with clamp	1000	0.392
Knife	450	0.176
Knife grill	250	0.098
Pen	150	0.059
Screw	550	0.216

Save

Refresh

OPECVA Methodology. Objects

✓ Для каждого критерия ввести ценность объекта (Input object values for each criterium)

Beauty

Result ?

Screw	1. equally, identically, indifferently	screw
Screw	1/5. fundamentally worse, much less important	Housing with clamp
Screw	1/3. worse, less important	Knife
Screw	1/4. significantly worse, significantly less important	Knife grill
Screw	1/5. fundamentally worse, much less important	Pen
Screw	1. equally, identically, indifferently	Screw
screw	1/5. fundamentally worse, much less important	Housing with clamp
screw	1/3. worse, less important	Knife
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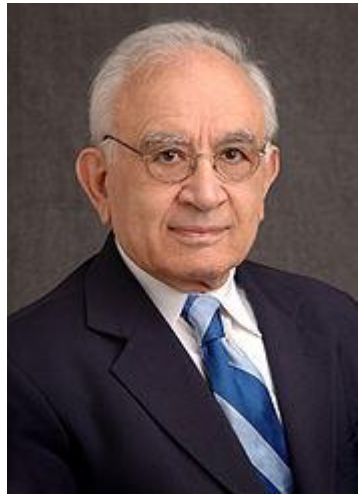
screw	1/5. fundamentally worse, much less important	Pen
screw	1. equally, identically, indifferently	Screw
Housing with clamp	1. equally, identically, indifferently	Knife
Housing with clamp	1. equally, identically, indifferently	Knife grill
Housing with clamp	1. equally, identically, indifferently	Pen
Housing with clamp	5. fundamentally better, more important	Screw
Knife	1. equally, identically, indifferently	Knife grill
Knife	1/2. a little worse, a little less important	Pen
Knife	3. better, more important	Screw
Knife grill	1. equally, identically, indifferently	Pen
Knife grill	4. significantly better, more important	Screw
Pen	5. fundamentally better, more important	Screw

Saati Pairwise Comparison Method
Метод попарного сравнения Саати

$$\omega_i \quad i \in \{1..n\}$$

$$\sum_{i=1}^{n} \omega_i = 1$$



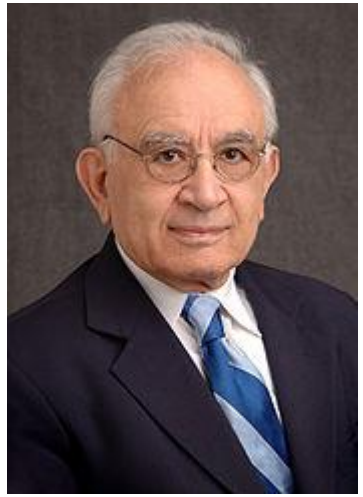
Thomas L. Saaty

Saati Pairwise Comparison Method
Метод попарного сравнения Саати

$$\omega_i \quad i \in \{1..n\}$$

$$\sum_{i=1}^{n} \omega_i = 1$$

$$\begin{pmatrix} \frac{\omega_1}{\omega_1} & \cdots & \frac{\omega_1}{\omega_n} \\ & \cdots & \\ \frac{\omega_n}{\omega_1} & \cdots & \frac{\omega_n}{\omega_n} \end{pmatrix}$$



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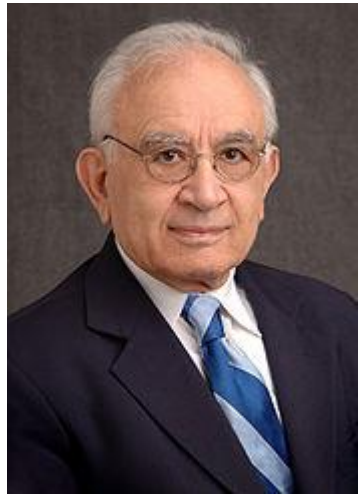
$$\frac{\omega_i}{\omega_j}\frac{\omega_j}{\omega_k} = \frac{\omega_i}{\omega_k}$$



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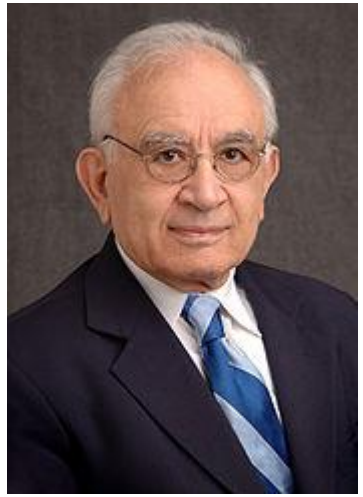

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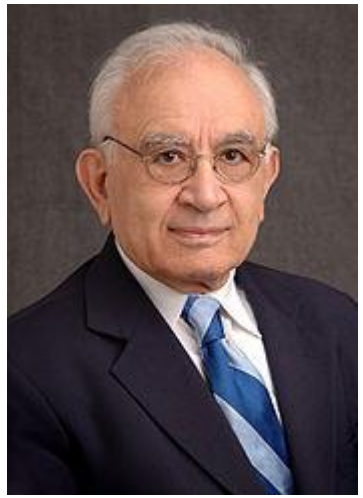
$$\frac{\omega_i}{\omega_j}\frac{\omega_j}{\omega_k} = \frac{\omega_i}{\omega_k} \qquad A_{ij}A_{jk} = A_{ik}$$

Saati Pairwise Comparison Method
Метод попарного сравнения Саати

$$\omega_i \quad i \in \{1..n\}$$

$$\sum_{i=1}^{n} \omega_i = 1$$

$$\begin{pmatrix} \frac{\omega_1}{\omega_1} & \cdots & \frac{\omega_1}{\omega_n} \\ & \cdots & \\ \frac{\omega_n}{\omega_1} & \cdots & \frac{\omega_n}{\omega_n} \end{pmatrix}$$



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Saati Pairwise Comparison Method
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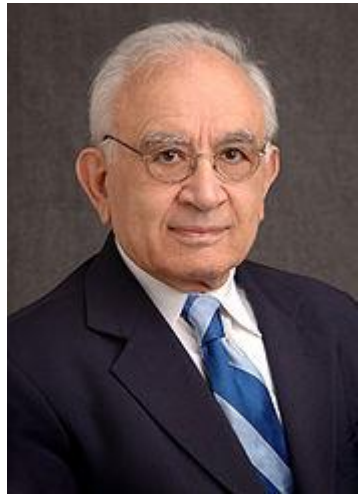
$$A_{ij}A_{jk} \neq A_{ik}$$

$$\begin{pmatrix} \frac{\omega_1}{\omega_1} & \cdots & \frac{\omega_1}{\omega_n} \\ & \cdots & \\ \frac{\omega_n}{\omega_1} & \cdots & \frac{\omega_n}{\omega_n} \end{pmatrix}$$



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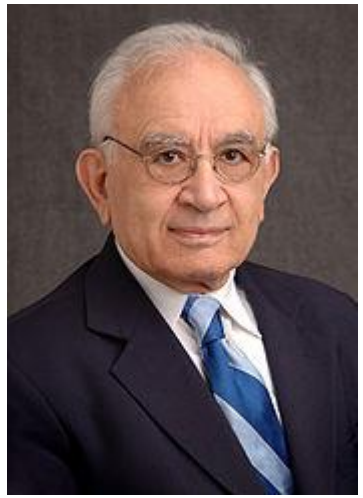
$$\begin{pmatrix} \frac{\omega_1}{\omega_1} & \cdots & \frac{\omega_1}{\omega_n} \\ & \cdots & \\ \frac{\omega_n}{\omega_1} & \cdots & \frac{\omega_n}{\omega_n} \end{pmatrix}$$

$$\frac{\lambda_{max} - n}{n} \leq 0.2$$



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OPECVA Methodology. Objects

- ✓ Для каждого критерия ввести ценность объекта (Input object values for each criterium)

Beauty

Result ?

Screw	1. equally, identically, indifferently	screw
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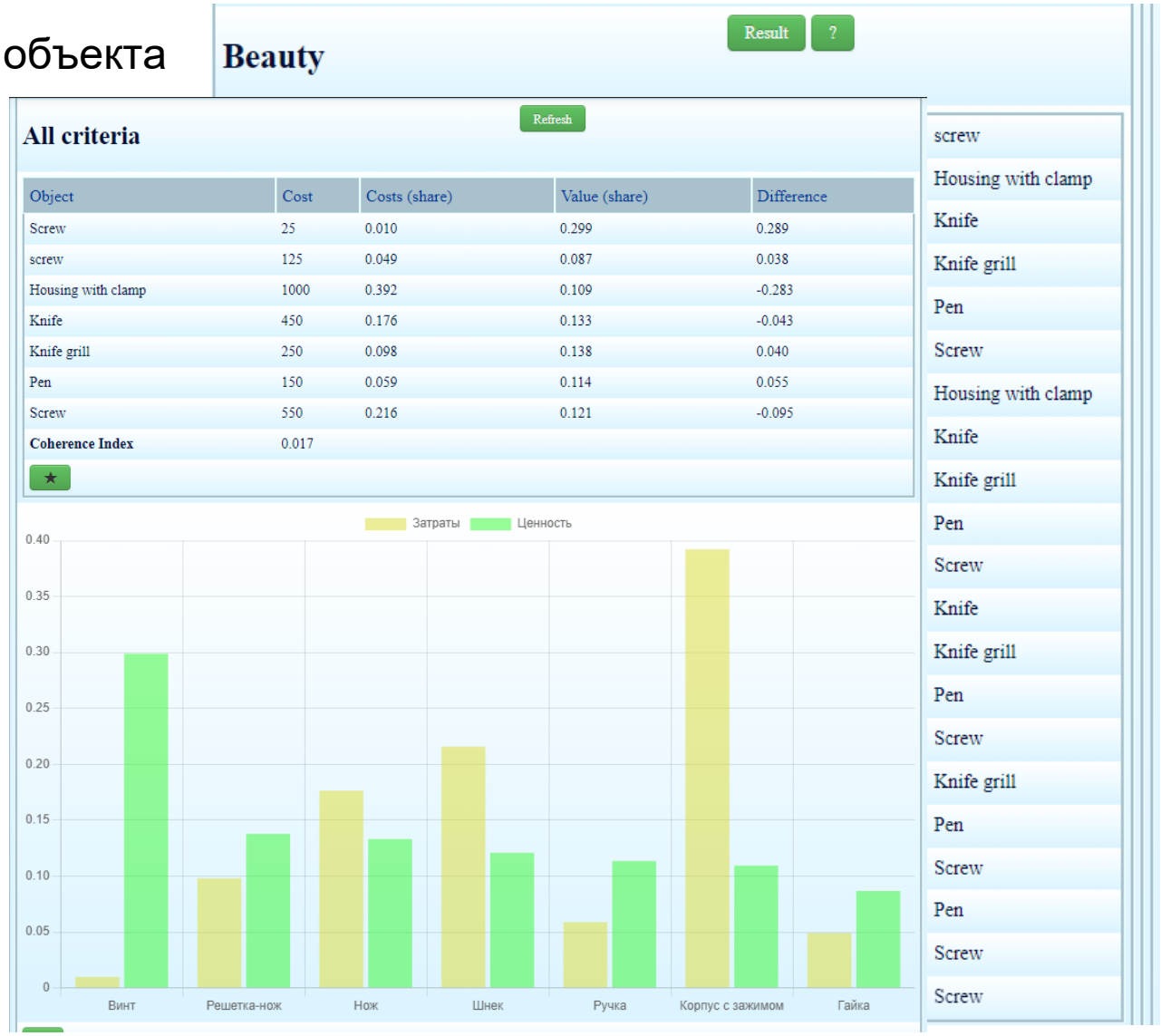
Housing with clamp	5. fundamentally better, more important	Screw
Knife	1. equally, identically, indifferently	Knife grill
Knife	1/2. a little worse, a little less important	Pen
Knife	3. better, more important	Screw
Knife grill	1. equally, identically, indifferently	Pen
Knife grill	4. significantly better, more important	Screw
Pen	5. fundamentally better, more important	Screw

OPECVA Methodology. Objects

✓ Для каждого критерия ввести ценность объекта
(Input object values for each criterium)

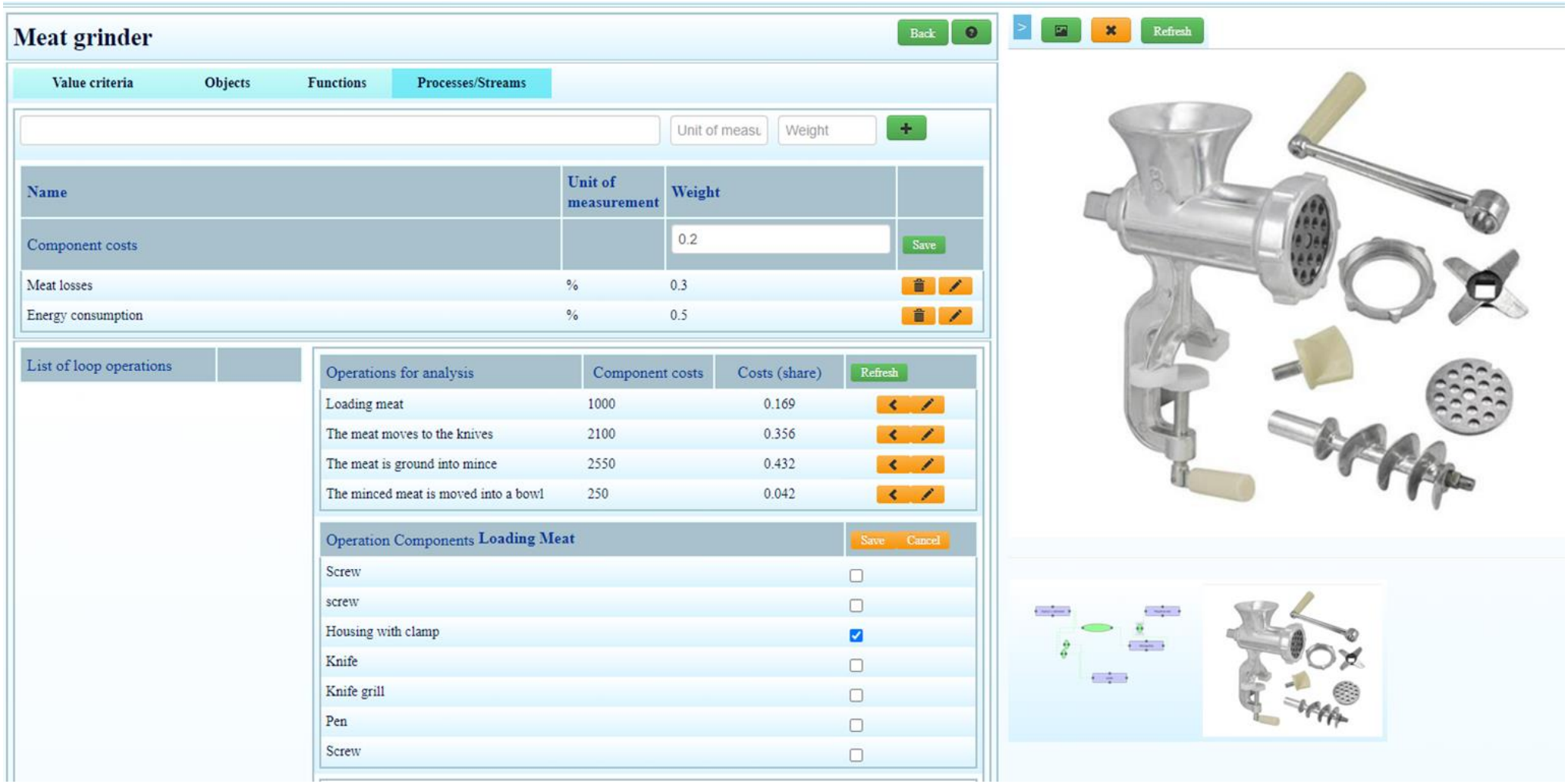


OPECVA Methodology. Functions

✓ Ввести ценность функций по каждому критерию (Input function values for each criterium)

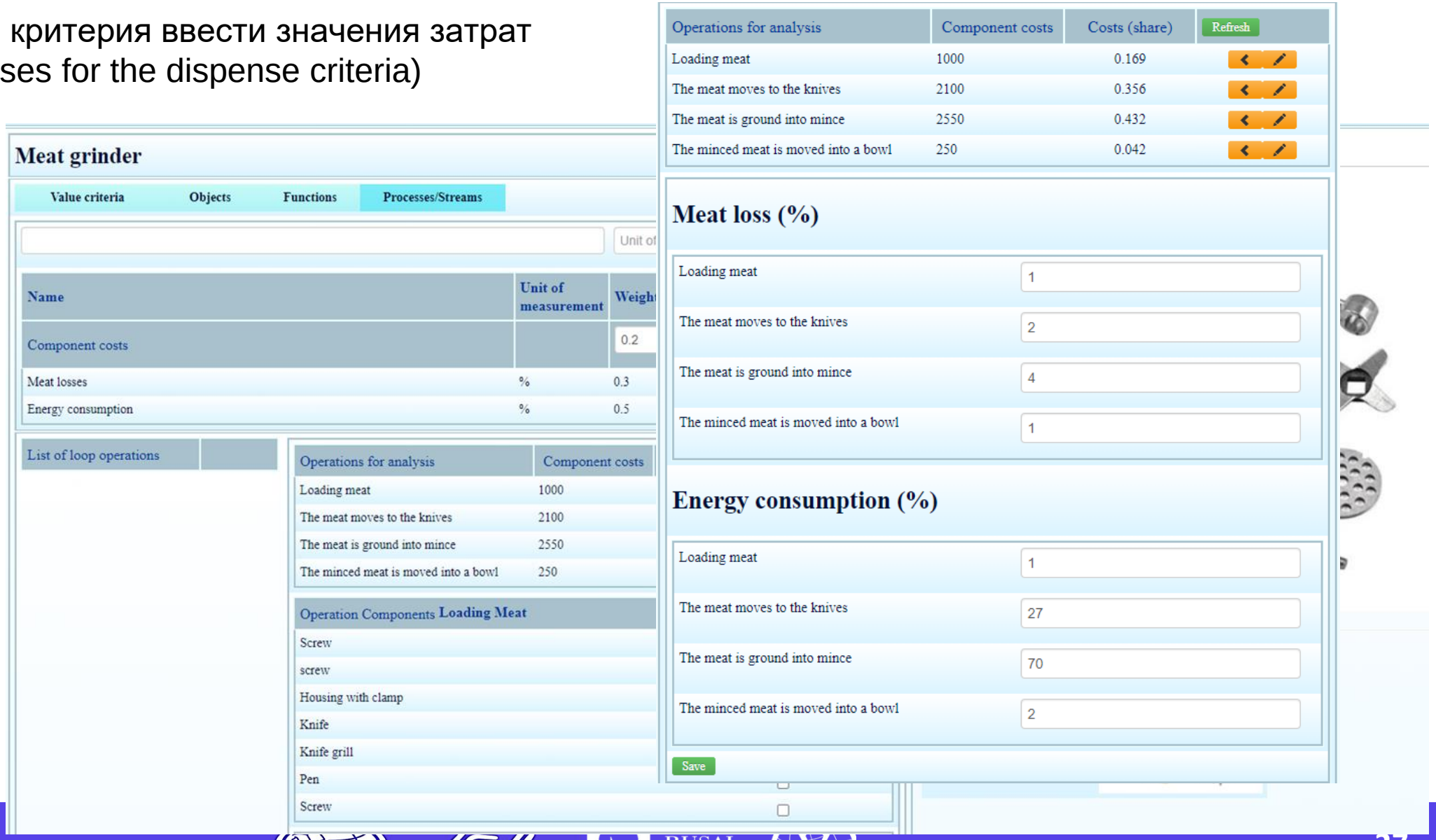
OPECVA Methodology. Processes

✓ Определить критерии затрат (Define dispense criteria)



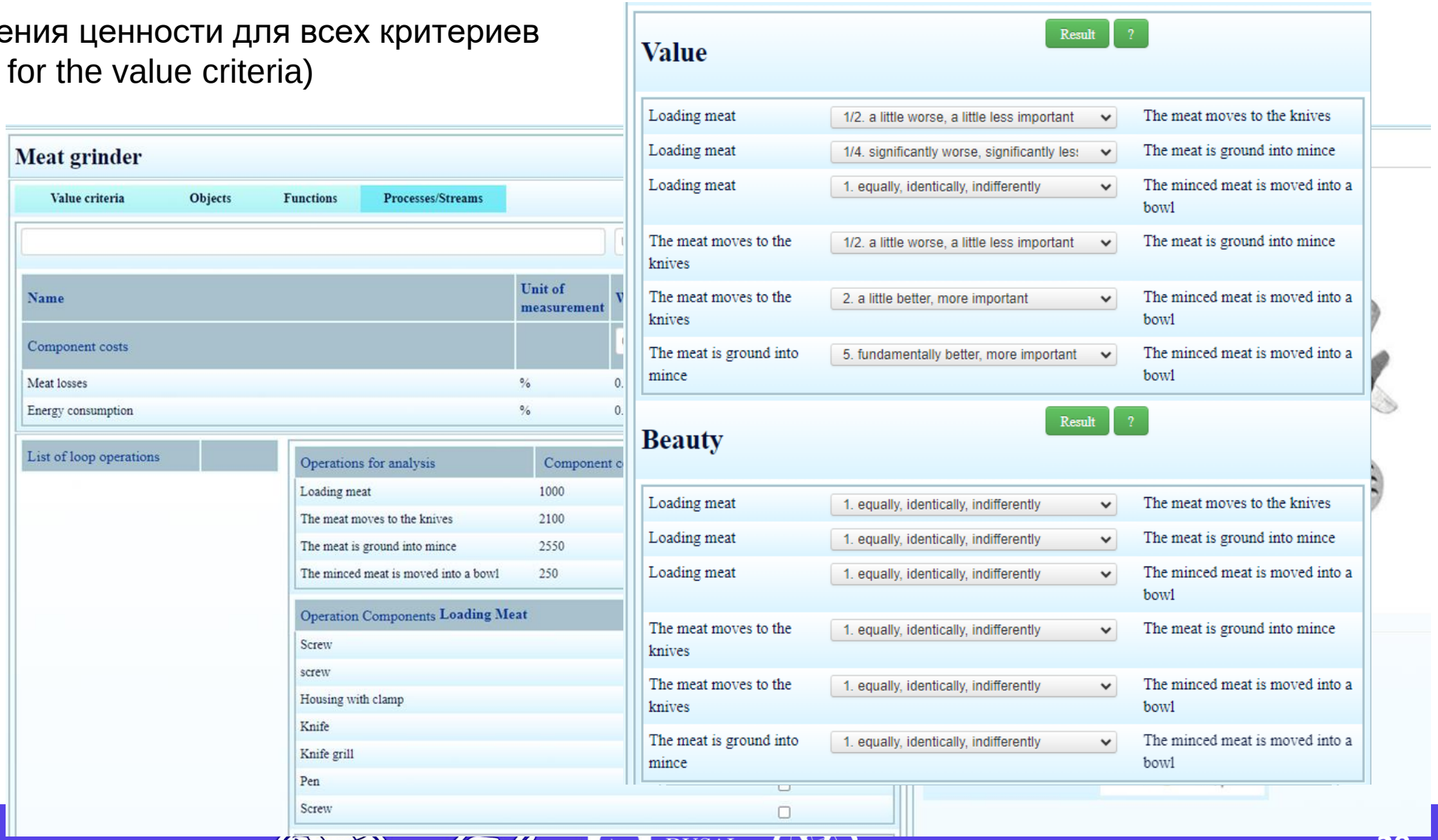
OPECVA Methodology. Processes

✓ Для каждого критерия ввести значения затрат (Input dispenses for the dispense criteria)



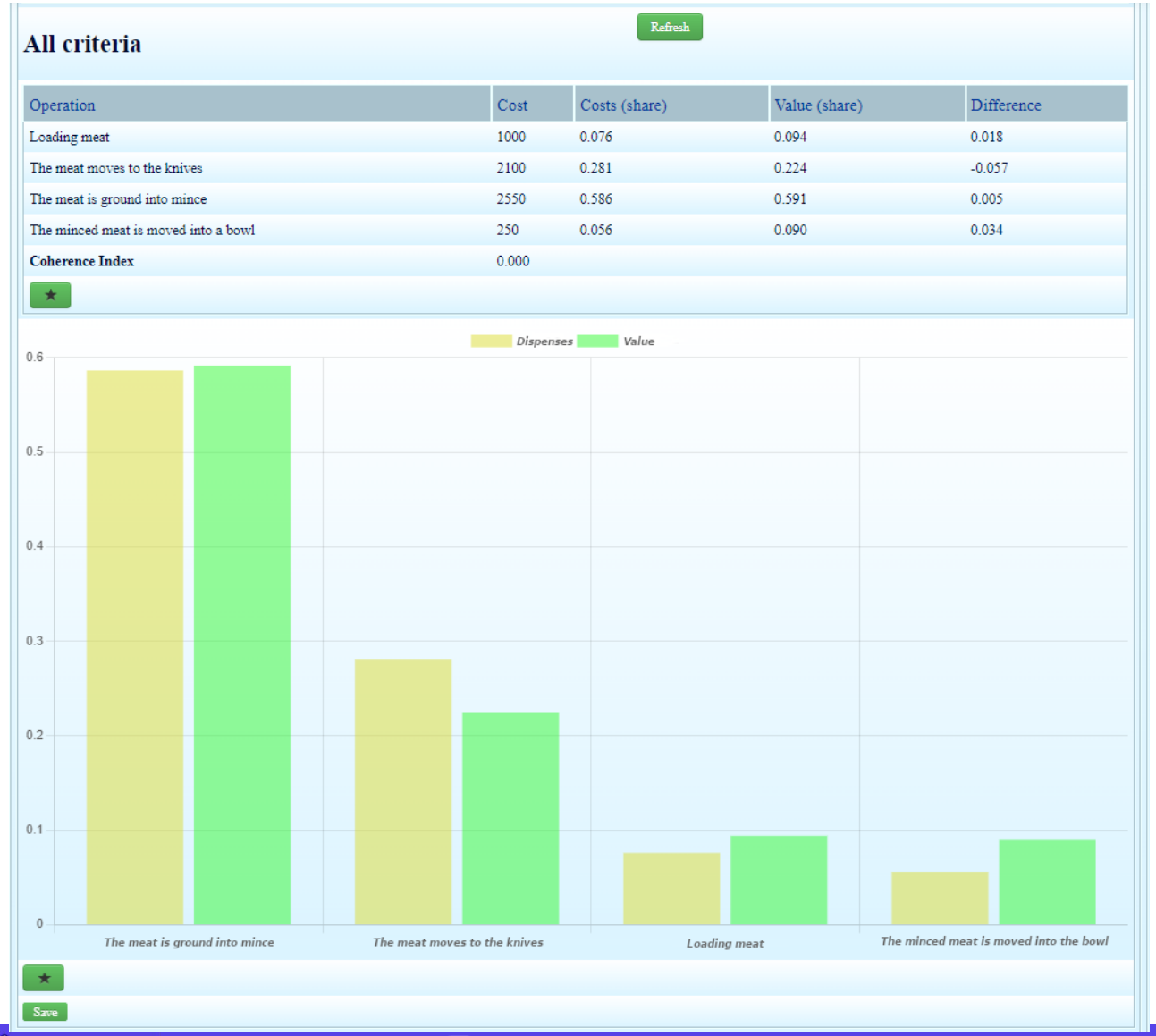
OPECVA Methodology. Processes

✓ Ввести значения ценности для всех критериев
(Input values for the value criteria)



OPECVA Methodology. Processes

✓ Интерпретировать результат
(Interpret the result)



CVA Recommendations

- The CVA serves as a basis for selecting those objects, functions and processes for which the relative costs are higher than the relative value
- The CVA generates recommendations to set targets for convolution, cost reduction or value adding for:
  - System objects
  - System functions
  - Processes in the system

Рекомендации в ЗЦА

- На основе ЗЦА отбираются те объекты, функции и процессы, для которых относительные затраты выше относительной ценности
- В ЗЦА формируются рекомендации по постановке задач на свертывание, снижение затрат или повышение ценности для:
  - Объектов системы
  - Функций системы
  - Процессов в системе

Demonstration of the Saaty's Pairwise Comparison Method on the Example of a Vortex Bench

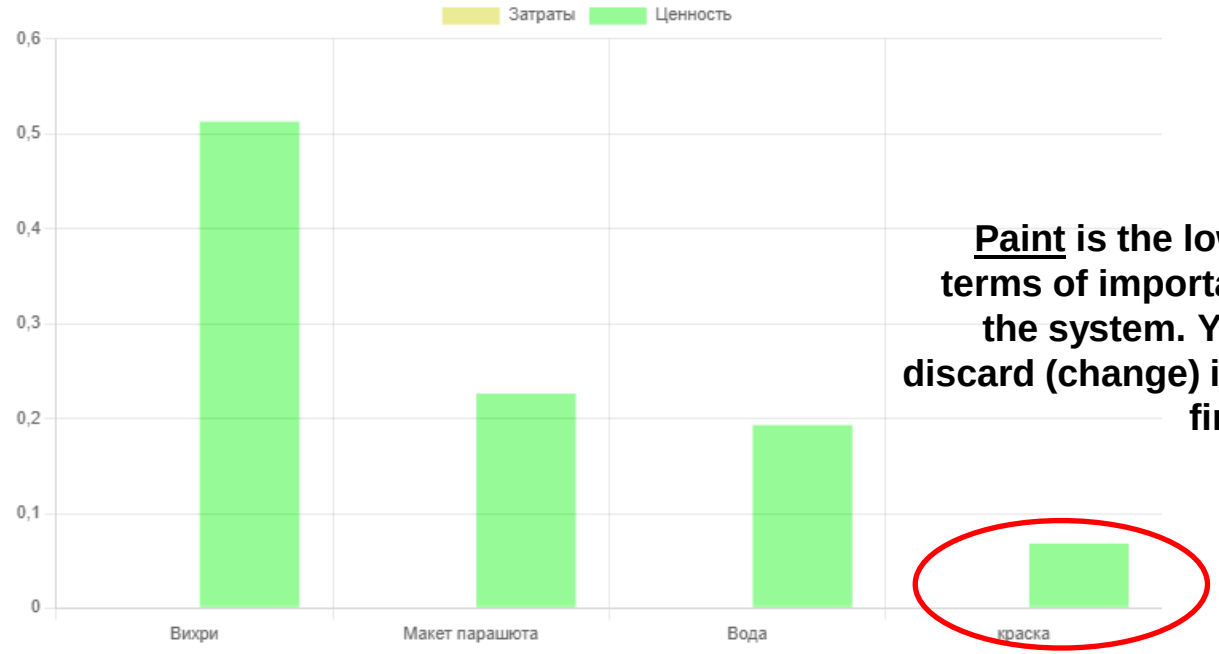
To examine vortex formation, a model of a parachute (tower, etc.) is placed in a glass tube through which water is pumped. Observation is done visually.

It is the paint that causes the problem: it runs out quickly and distorts the shape of the mock-up parachute.

List of bench objects: Vortexes, Water, Paint, Mock-up parachute.

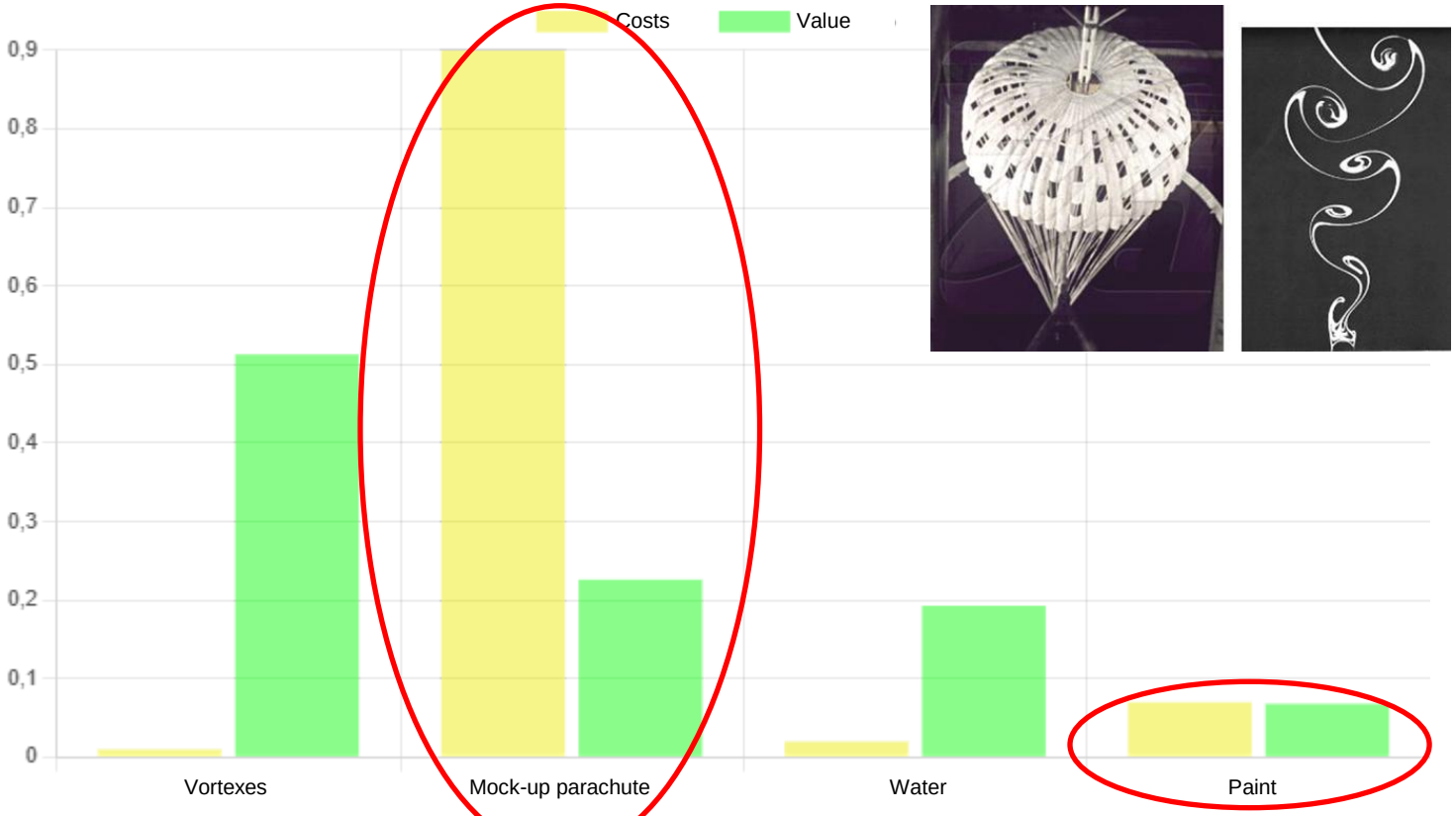
Comparison of functional importance by Saati pairwise comparison.

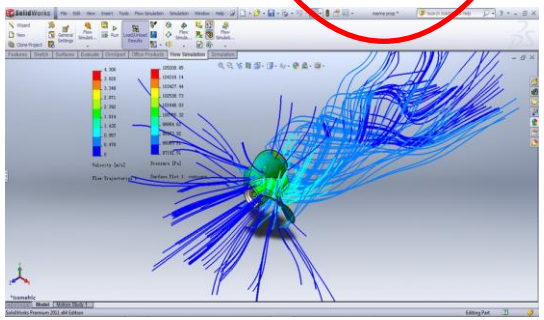
Vortexes	3. Better, more important Paint
Vortexes	2. Slightly better, more important Water
Vortexes	2. Slightly better, more important Mock-up parachute
Paint	1/2. Slightly worse, slightly less important Water
Paint	1/3. Worse, less important Mock-up parachute
Water	1. Equally, alike, indifferently Mock-up parachute



<u>Paint</u> is the lowest in terms of importance in the system. You can discard (change) it in the first turn

CVA of Objects for the Vortex Research Bench

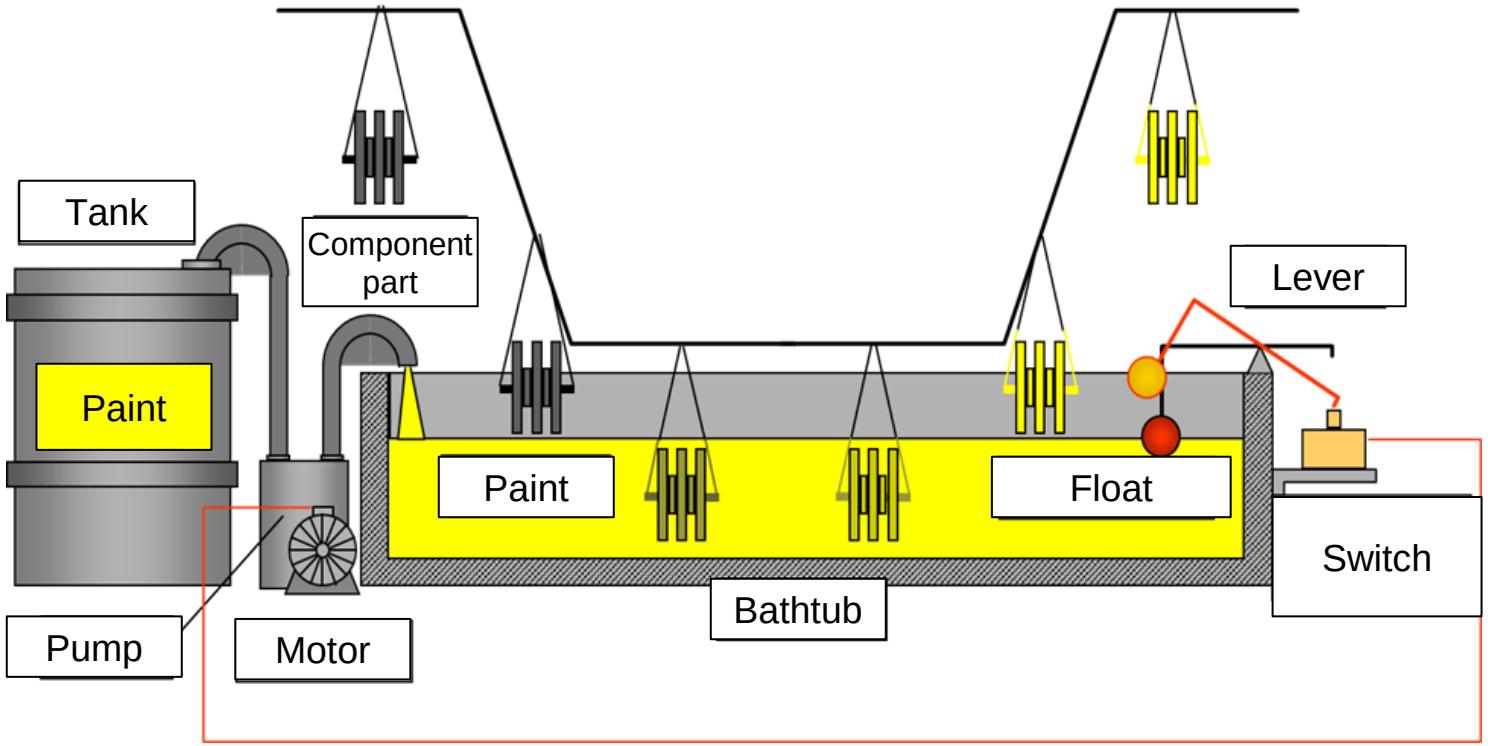




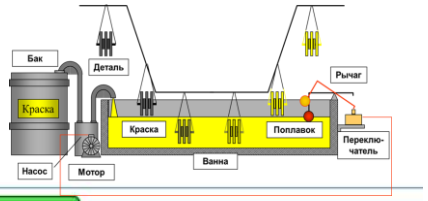
- Analysing the dissonance between value and costs shows that we not only need to consider convolution of paint, but also that of the mock-up (relative costs are higher than relative value).
- Properties of parachute systems can now be analysed in software packages

CVA of Objects and Structures.
Example. System for Feeding Parts into the Painting Bathtub.

System components: Bathtub, Tank, Pump, Motor, Switch, Lever, Float.
Problems: (1) Due to paint sticking to the float, the paint level control is poor; (2) High costs for the whole system.
Task: set convolution problems using CVA approaches for objects and structures



Pairwise comparison of objects.



Результат

Ценность

Ванна	2. немного лучше, важнее	Бак
Ванна	3. лучше, важнее	Насос
Ванна	4. значительно лучше, важнее	Мотор
Ванна	4. значительно лучше, важнее	Переключатель
Ванна	4. значительно лучше, важнее	Рычаг
Ванна	4. значительно лучше, важнее	Поплавок
Бак	3. лучше, важнее	Насос
Бак	3. лучше, важнее	Мотор
Бак	3. лучше, важнее	Переключатель
Бак	3. лучше, важнее	Рычаг
Бак	3. лучше, важнее	Поплавок
Насос	2. немного лучше, важнее	Мотор
Насос	2. немного лучше, важнее	Переключатель
Насос	2. немного лучше, важнее	Рычаг
Насос	2. немного лучше, важнее	Поплавок
Мотор	2. немного лучше, важнее	Переключатель
Мотор	2. немного лучше, важнее	Рычаг
Мотор	2. немного лучше, важнее	Поплавок
Переключатель	2. немного лучше, важнее	Рычаг
Переключатель	2. немного лучше, важнее	Поплавок
Рычаг	2. немного лучше, важнее	Поплавок

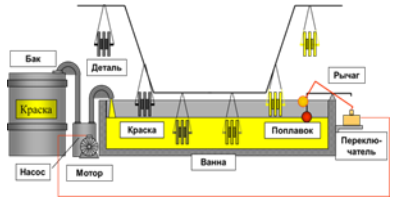
Result

Value

Bath	2. a little better, more important	Tank
Bath	3. better, more important	Pump
Bath	4. much better, more Important	The motor
Bath	4. much better, more Important	Switch
Bath	4. much better, more Important	Lever
Bath	4. much better, more Important	Poplovok
Tank	3. better, more important	Pump
Tank	3. better, more important	The motor
Tank	3. better, more important	Switch
Tank	3. better, more important	Lever
Tank	3. better, more important	Poplovok
Pump	2. a little better, more important	The motor
Pump	2. a little better, more important	Switch
Pump	2. a little better, more important	Lever
Pump	2. a little better, more important	Poplovok
The motor	2. a little better, more important	Switch
The motor	2. a little better, more important	Lever
The motor	2. a little better, more important	Poplovok
Switch	2. a little better, more important	Lever
Switch	2. a little better, more important	Poplovok
Lever	2. a little better, more important	Poplovok

Save

CVA of the objects of the system for feeding component parts into the painting bathtub



Object	Cost (RUB '000)	Costs (share)	Value (%)	Value (share)	Difference
Tank	2	0.050	25,600	0.256	0.206
Bathtub	14	0.350	42,500	0.425	0.075
Float	2	0.050	3,000	0.030	–0.020
Lever	2	0.050	4,200	0.042	–0.008
Switch	2	0.050	5,700	0.057	0.007
Pump	6	0.150	11,200	0.112	–0.038
Motor	12	0.300	7,800	0.078	–0.222

CVA: without functions but with costs and different values

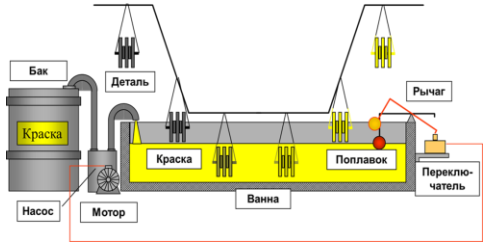
	Costs per year (RUB ' 000)	**Normalised costs %**	Income for the year (RUB mln)	**Normalised income %**	**Difference**
Business Unit 1	14	28.0%	90	29.7%	1.7%
Business Unit 2	11	22.0%	70	23.1%	1.1%
Business Unit 3	10	20.0%	140	46.2%	26.2%
Business Unit 4	10	20.0%	0	0.0%	–20.0%
Business Unit 5	5	10.0%	3	1.0%	–9.0%
	50	100.0%	303	100.0%	

CVA table for a company of 5 business units. The difference between normalised cost and normalised income (value) shows whether to set targets for improving or convolution of business units 4 and 5.

	Costs per year (RUB ' 000)	Normalised costs %	Income for the year (RUB mln)	Forecast of income in 3 years	Normalised value %	Difference
Influence coefficients:			*0.6*	*0.4*		
Business Unit 1	14	28.0%	90	190	28.3%	0.3%
Business Unit 2	11	22.0%	70	150	22.2%	0.2%
Business Unit 3	10	20.0%	140	80	25.2%	5.2%
Business Unit 4	10	20.0%	0	270	23.5%	3.5%
Business Unit 5	5	10.0%	3	5	0.8%	–9.2%
	50	100.0%	303	695	100.0%	

CVA table for a company of 5 business units considering two value criteria: ‘Income for the year’ (with an influence weight of 0.6 on the business unit's value) and ‘Forecast of income in 3 years' (with an influence weight of 0.4 on the business unit's value). In this case, only Business Unit 5 remains problematic.

CVA of Functions. Example. System for Feeding Parts into the Painting Bathtub.

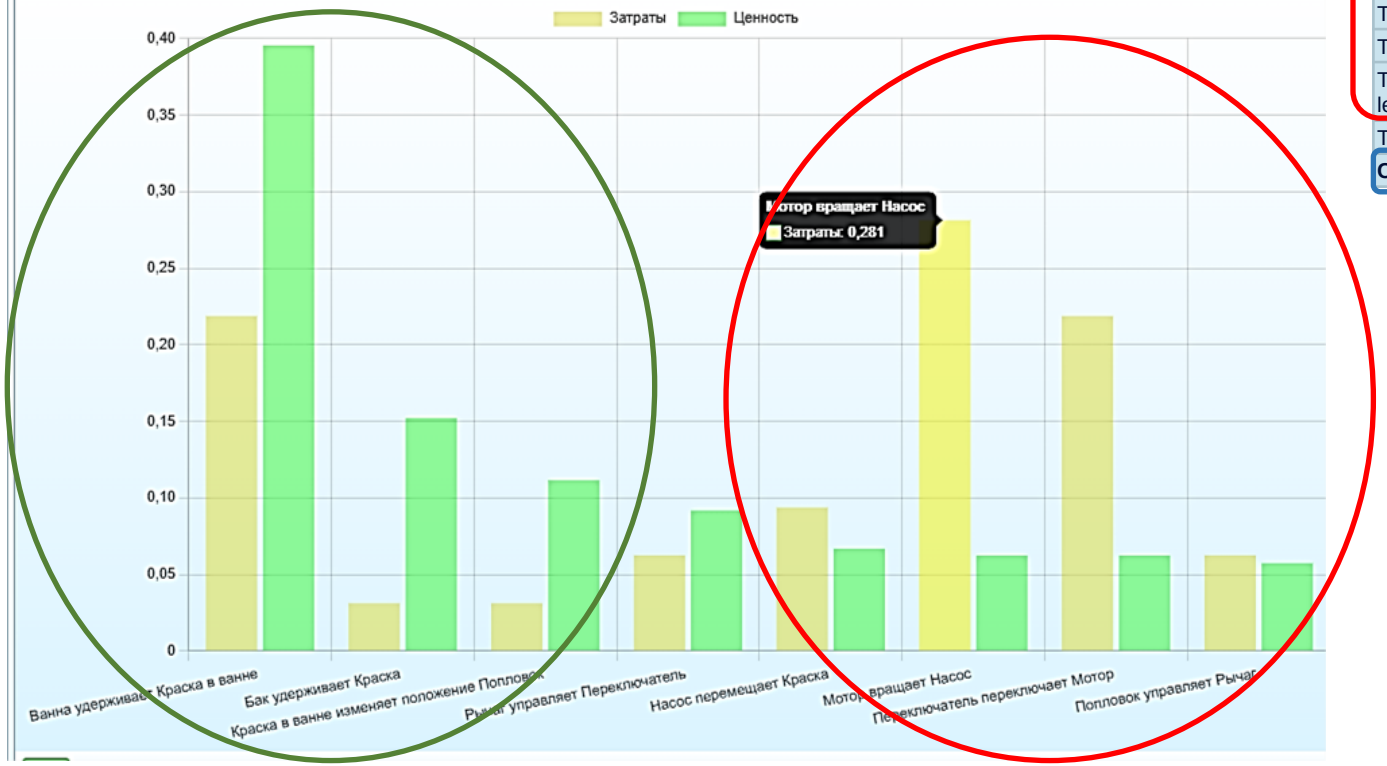


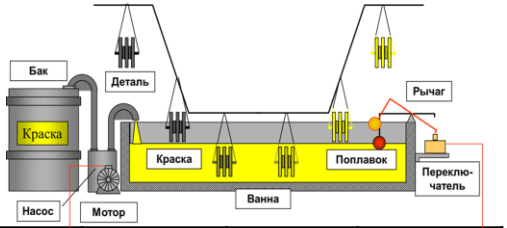
Function	Components	Costs of function components	Normalised costs (%)	Value (%)	Difference
1. The tank holds the Paint	Tank	2	3.1%	17.3%	14.2%
2. The bathtub holds the Paint in the bathtub	Bathtub	14	21.9%	53.7%	20.6%
3. The Paint in the bathtub changes the position of the Float	Float	2	3.1%	11.5%	22.5%
The Motor turns the Pump	Motor, Pump	18	28.1%	7.3%	–16.9%
The Pump transports the Paint	Pump	6	9.4%	8.4%	–1.6%
The Switch toggles the Motor	Switch, Motor	14	21.9%	5.5%	–16.2%
The Float controls the Lever	Float, Lever	4	6.3%	7.3%	–2.1%
The Lever operates the Switch	Lever, Switch	4	6.3%	6.3%	–3.2%
		64	100.0%	100.0%	

- Processes, relationships, harmful functions and functions that do not involve any of the components of the system under consideration should be excluded from the list to be analysed.
- The table marks in red the functions that should be convolved or improved in the first turn

CVA functions in Compinno-TRIZ

Функция	Затраты (тыс. руб.)	Совокупные затраты (доля)	Ценность	Ценность (доля)	Разница
Бак удерживает Краска	2	0.031	0.327	0.152	0.121
Ванна удерживает Краска в ванне	14	0.219	0.851	0.395	0.177
Краска в ванне изменяет положение Поплавок	2	0.031	0.240	0.112	0.080
Мотор вращает Насос	18	0.281	0.134	0.062	-0.219
Насос перемещает Краска	6	0.094	0.144	0.067	-0.027
Переключатель переключает Мотор	14	0.219	0.134	0.062	-0.156
Поплавок управляет Рычаг	4	0.063	0.124	0.057	-0.005
Рычаг управляет Переключатель	4	0.063	0.198	0.092	0.029
Индекс согласованности	0.139				





Value					
Function	Costs (RUB '000)	Total Costs (Share)	Value	Value (share)	Difference
The tank holds the paint	2	0.031	0.327	0.152	0.121
Bathtub holds Paint in bathtub	14	0.219	0.851	0.395	0.177
Paint in the bathtub changes the position of the floats	2	0.031	0.240	0.112	0.080
The motor rotates the pump	18	0.281	0.134	0.062	–0.219
The pump moves the paint	6	0.094	0.144	0.067	–0.027
The switch switches the motor	14	0.219	0.134	0.062	–0.156
The float is controlled by a lever.	4	0.063	0.124	0.057	–0.005
The lever controls the switch	4	0.063	0.198	0.092	0.029
Coherence Index	0.139				

Analysis of dissonance of characteristics and CVA

- System Characteristics Dissonance Analysis is a method of analysing interrelated different characteristics of the one and the same system or one and the same characteristics of different systems in order to highlight problem situations and to set tasks.
- Dissonance in TRIZ is a disruption of coherence (harmony) in the interrelated characteristics of one or more similar systems.
- The System Characteristics Dissonance Analysis enables the identification of possible contradictions in the development of systems based on the comparison of interrelated characteristics of systems that disrupt the expected or desired relationships between these characteristics.
- CVA is a special case of analysing the dissonance of system characteristics, which uses value and cost characteristics as characteristics

Анализ диссонанса характеристик и ЗЦА

- Анализ диссонанса характеристик системы — это метод анализа связанных между собой разных характеристик одной системы или одной и той же характеристики разных систем для выделения проблемных ситуаций и постановки задач.
- Диссонанс в ТРИЗ — это нарушение согласованности (гармонии) в связанных между собой характеристиках одной или нескольких схожих систем.
- Анализ диссонанса характеристик систем позволяет выявить возможные противоречия в развитии систем на основе сравнения связанных между собой характеристик систем, нарушающих ожидаемые или желаемые связи между этими характеристиками.
- ЗЦА – это частный случай анализа диссонанса характеристик системы, в котором в качестве характеристик используются характеристики ценности и затрат

Conclusions

- Cost-Value Analysis is designed to set problems based on finding dissonance between values and costs of objects, functions and processes in the system and is a complement to the analysis of the principle of system operation: component and functional analysis, process and flow analysis
- The tasks set during CVA allow to move from an AS IS system model to an AS IT SHOULD BE system model
- CVA of objects can be performed on the basis of component analysis of the system without functional analysis
- On the one hand, CVA is a generalisation of Activity Based Costing, and on the other hand, it is a special case of System Characteristics Dissonance Analysis
- The CVA methodology was implemented in the Compinno-TRIZ web application https://triz-compinno.tech/

Выводы

- Затратно-ценностный анализ предназначен для постановки задач на основе нахождения диссонанса между ценностями и затратами объектов, функций и процессов в системе и является дополнением анализа принципа действия системы: компонентного и функционального анализа, анализа процессов и потоков
- Поставленные в ходе ЗЦА задачи позволяют переходить от модели системы КАК ЕСТЬ к моделям системы КАК НАДО
- ЗЦА-объектов может быть проведен на основе компонентного анализа системы без проведения функционального анализа
- ЗЦА является с одной стороны обобщением функционально-стоимостного анализа, а с другой – частным случаем анализа диссонанса характеристик системы
- Методика ЗЦА реализована в программном комплексе Compinno-TRIZ https://triz-compinno.tech/

TRIZ SUMMIT 2024

Q&A

SESSION

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Спасибо!

Thank you!