



P R O M E T H E E
M E T H O D S

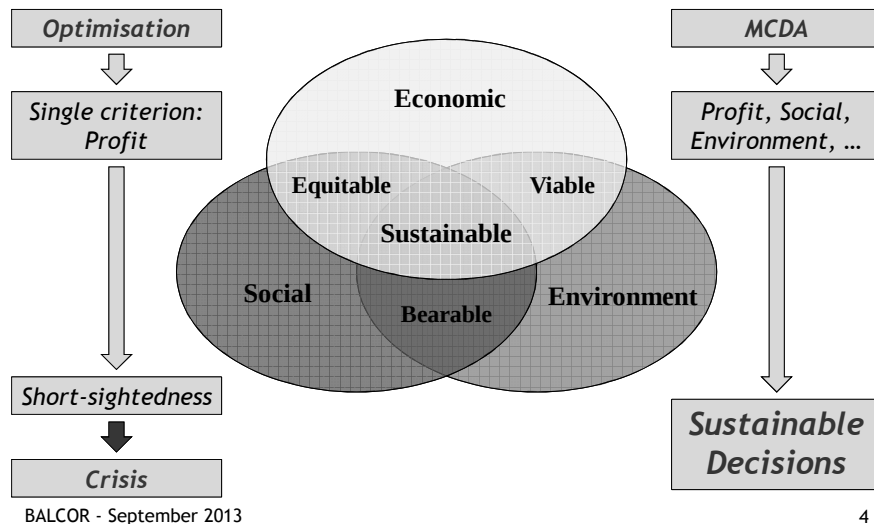
Sustainable Decisions using a Multicriteria Approach

- PROMETHEE & GAIA methods
- Visual PROMETHEE software

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<http://www.promethee-gaia.net>

MCDA vs Optimisation



Some Decision or Evaluation Problems

- Locating a new plant, a new shop, ...
- Human resources management.
- Purchasing equipment.
- Assessing the quality of suppliers.
- Evaluating projects.
- Selecting an investment strategy.

Unicriterion vs multicriteria model

- Unicriterion model:

$$\text{Optimise}\{g(a)|a \in A\}$$

- Mathematically well-stated:
 - Optimal solution,
 - Complete ranking of the actions.
- Socio-economically ill-stated:
 - Single criterion? Not realistic.
 - Notion of criterion: perception thresholds, ...

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Unicriterion vs multicriteria model

- Multicriteria model:

$$\text{Optimise}\{g_1(a), g_2(a), \dots, g_k(a)|a \in A\}$$

- Mathematically ill-stated:
 - No optimal solution,
 - No mathematical meaning.
- Socio-economically well-stated:
 - Closer to real world decision problem,
 - Search for a compromise solution.

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A simple example

The purchase of a car

Objectives:

- Economy (price),
- Usage (gas consumption),
- Performance (power),
- Space,
- Comfort.

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Visual PROMETHEE Academic - unnamed (saved)

File Edit Model Control PROMETHEE GAIA GDSS GIS Custom Assistants Snapshots

Options Help

	☒ Bertrand	☒ Price	☒ Power	☒ Consumption	☒ Habitability	☒ Comfort
Unit		k€	kW	L/100km	5-point	5-point
Cluster/Group	☒	☒	☒	☒	☒	☒
Preferences						
Min/Max		min	max	min	max	max
Weight		1,00	1,00	1,00	1,00	1,00
Preference Fm.		V shape	Linear	V shape	Level	Level
Thresholds		absolute	absolute	absolute	absolute	absolute
- Q: Indifference		n/a	5	n/a	1,0	0,5
- P: Preference		€ 15,000	30	2,0	2,5	2,5
- S: Gaussian		n/a	n/a	n/a	n/a	n/a
Statistics						
Evaluations						
☒ Tourism B	☐	€ 25,500	85	7,0	good	average
☒ Luxury 1	☐	€ 38,000	90	8,5	good	very good
☒ Tourism A	☐	€ 26,000	75	8,0	average	average
☒ Luxury 2	☐	€ 35,000	85	9,0	very good	good
☒ Economic	☐	€ 15,000	50	7,5	bad	very bad
☒ Sport	☐	€ 29,000	110	9,0	very bad	bad

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Actions: 6 (6 active) Criteria: 5 (5 active) Scenarios: 1 (1 active) Locale: Belgium (€/) Saved

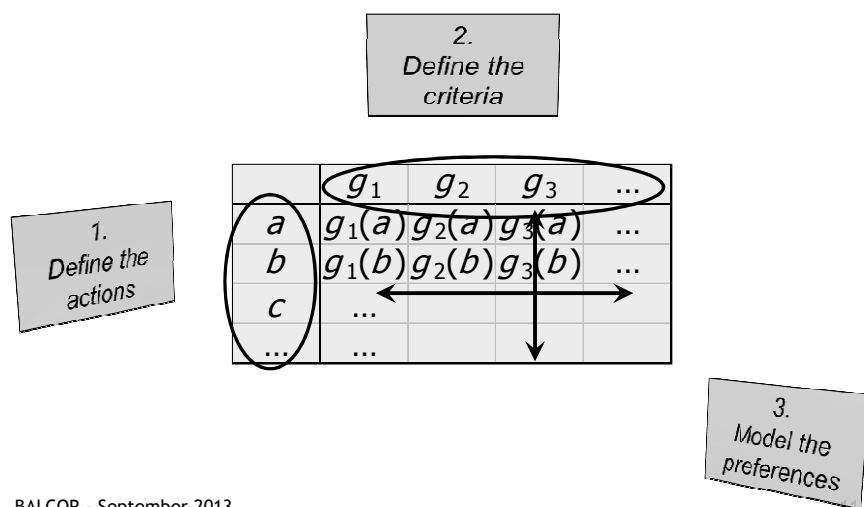
9

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Many thanks to Dr. Draženko Glavić

10

Modeling... 1... 2... 3...



Problematics

	g_1	g_2	g_3	...
a	$g_1(a)$	$g_2(a)$	$g_3(a)$	...
b	$g_1(b)$	$g_2(b)$	$g_3(b)$	...
c	...			
...	...			

Evaluations

- n actions
- k criteria

- α - choice: determine a subset of actions (the « best ones »).
- β - sorting: sort actions in predefined categories.
- γ - ranking: rank from the best to the worst action.
- δ - description: describe actions and their consequences.

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MCDA methods

- Preference modelling:
Perception of scales
Weighing of criteria
- Analysis Procedure:
Prescriptive approach: **PROMETHEE**
Ranking, Selection, Sort
Descriptive approach: **GAIA**
Description

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PROMETHEE & GAIA

- Outranking MCDA methods developed at the universities of Brussels (VUB - Prof. J.P. Brans, ULB - Prof. B. Mareschal)
- Over 470 related papers published since 1982.
- Interactive and visual software:
 - PROMCALC (1990)
 - Decision Lab (2000)
 - D-Sight (2011)
 - SmartPicker Pro (2012)
 - Visual PROMETHEE (2013)

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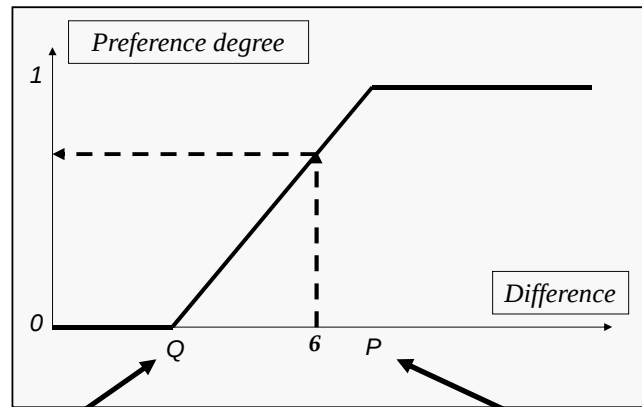
Comparison of 2 actions

	Crit. 1 (/20)	Crit. 2 (rating)	Crit. 3 (qual.)	Crit. 4 (Y/N)	...
Action 1	18	135	G	Yes	...
Action 2	9	147	<i>Difference = 6</i>		...
Action 3	15	129	VG	No	...
Action 4	12	146	VB	?	...
Action 5	7	121	G	Yes	...
...	...	...	...	...	...

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Preference function



Indifference threshold

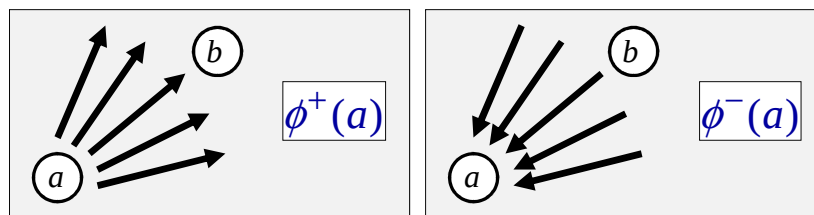
Linear

Preference threshold

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Preference flows



- Leaving flow: (strength)

$$\phi^+(a) = \frac{1}{n-1} \sum_{b \in A} \pi(a, b)$$

- Entering flow: (weakness)

$$\phi^-(a) = \frac{1}{n-1} \sum_{b \in A} \pi(b, a)$$

- Net flow:

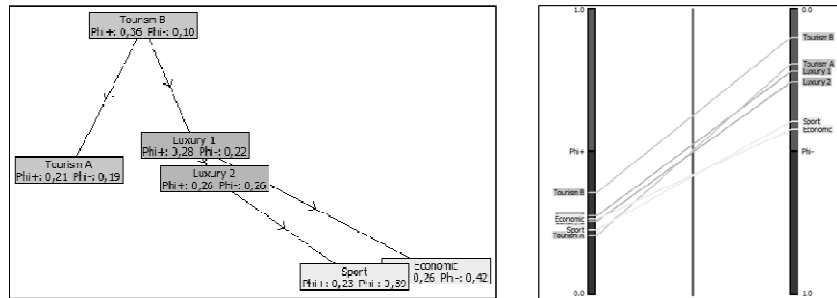
$$\phi(a) = \phi^+(a) - \phi^-(a)$$

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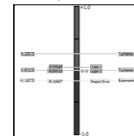
17

PROMETHEE I & II

- PROMETHEE I : partial ranking - ϕ^+, ϕ^-



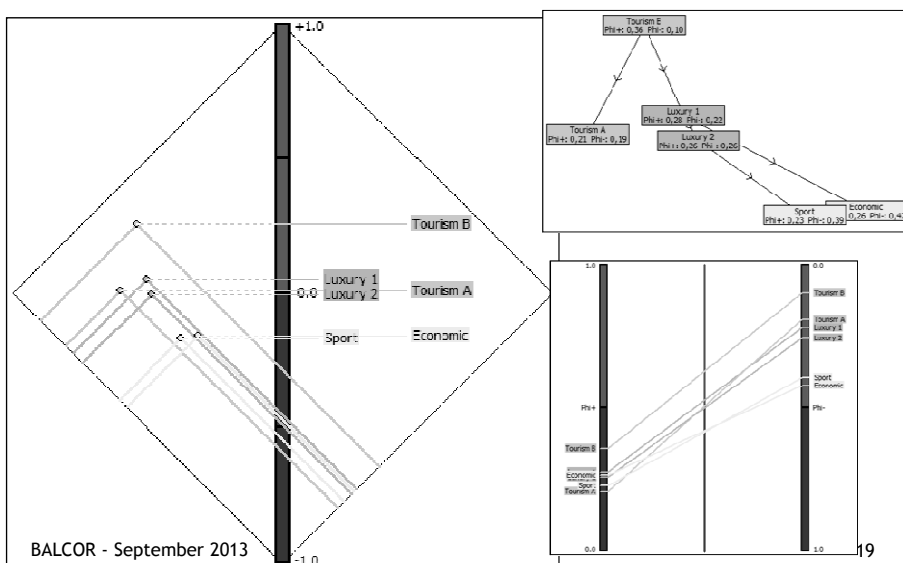
- PROMETHEE II : complete ranking - ϕ



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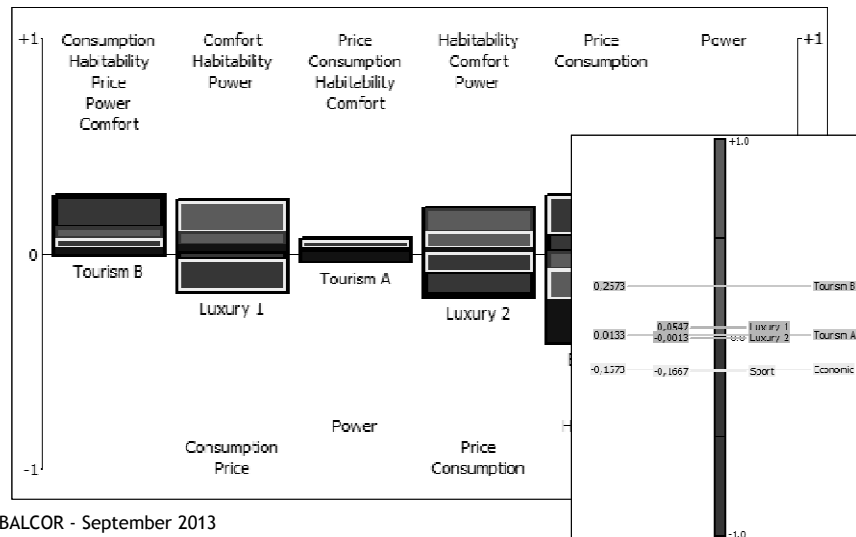
PROMETHEE Diamond



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19

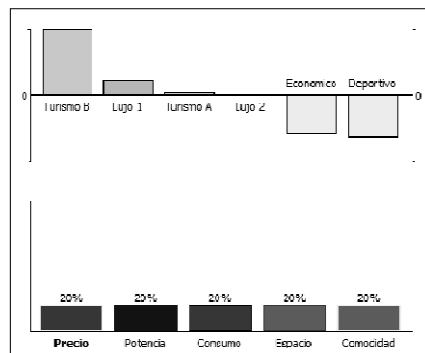
PROMETHEE Rainbow



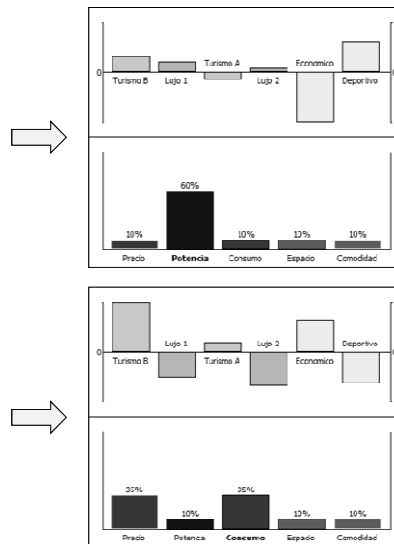
Sensitivity Analysis with PROMETHEE

- Criteria weights $\leftrightarrow$ PROMETHEE ranking.
- Interactive weight sensitivity analysis:
« Walking Weights ».
- Robustness with respect to weight values?
 - Weight stability intervals.
 - Visual weight stability intervals.

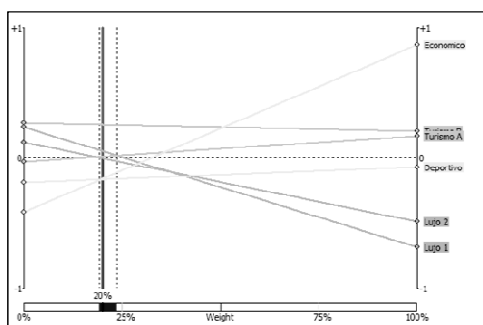
Walking Weights



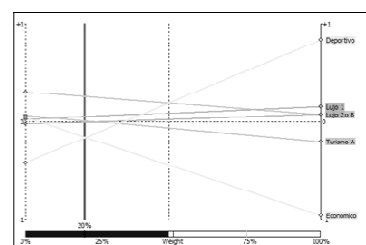
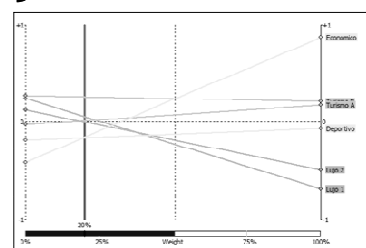
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Visual Stability Intervals



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23

GAIA

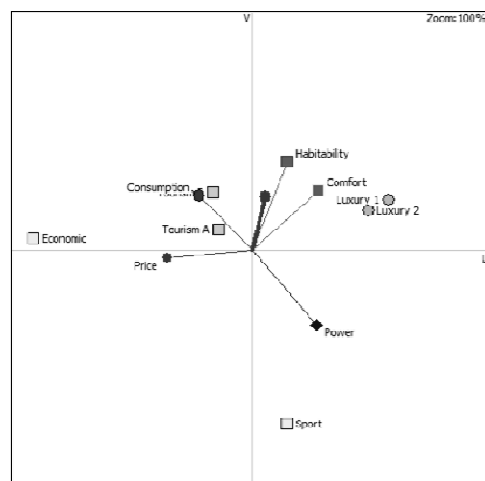
- Visual descriptive analysis.
- Better understanding:
 - Conflicting criteria.
 - Action profiles.
 - Possible compromise solutions.
- Reducing the multicriteria dimension:
 - Principal components analysis.

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GAIA

- Discover conflicts among criteria.
- Identify potential compromises.
- Help to fix priorities.

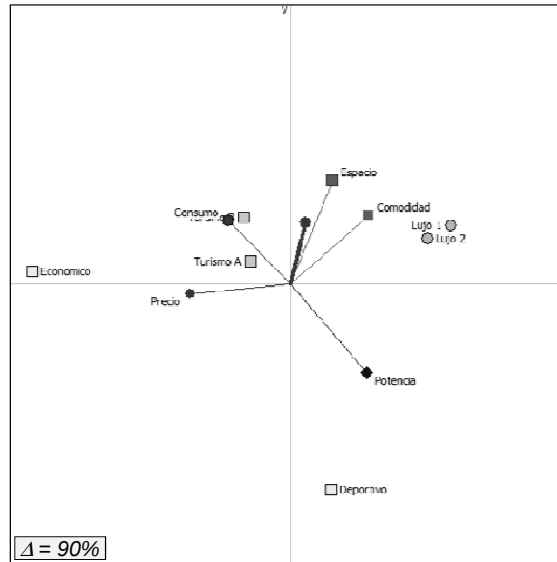


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GAIA

- *Actions:*
points
- *Criteria:*
axes



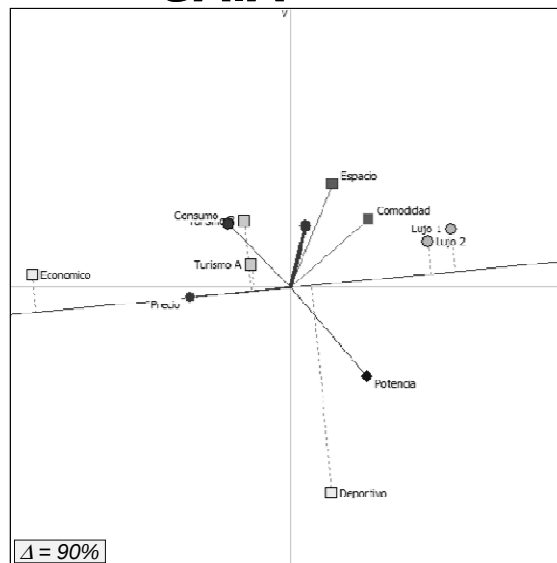
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GAIA

Price

- *Economico:* 15 k€
- *Turismo:* 25,5-26 k€
- *Deportivo:* 29 k€
- *Lujo:* 35-38 k€



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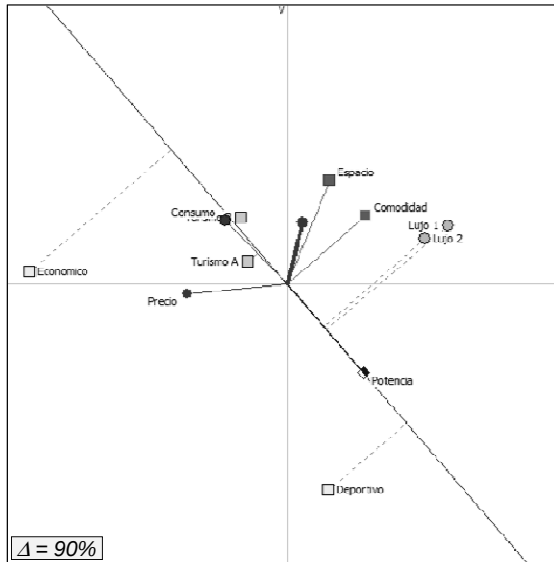
27

GAIA

Power

- Deportivo: 110 kW
- Lujo: 85-90 kW
- Turismo: 75-85 kW
- Economico: 50 kW

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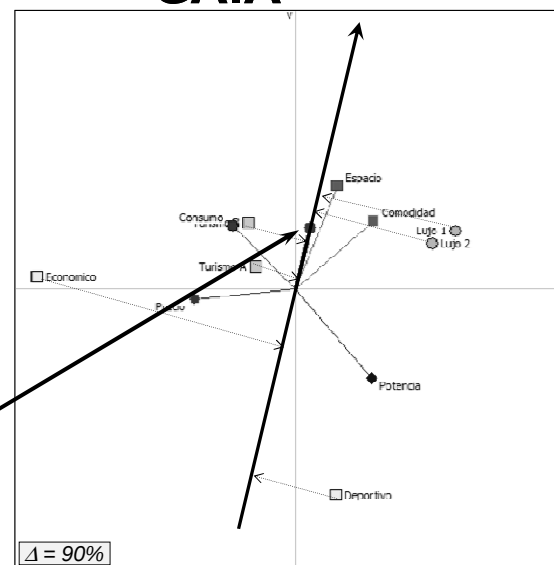
28

GAIA

PROMETHEE II !

- Turismo B : 0,26
- Lujo 1 : 0,06
- Turismo A : 0,02
- Lujo 2 : 0,00
- Economico : -0,15
- Deportivo : -0,17

13

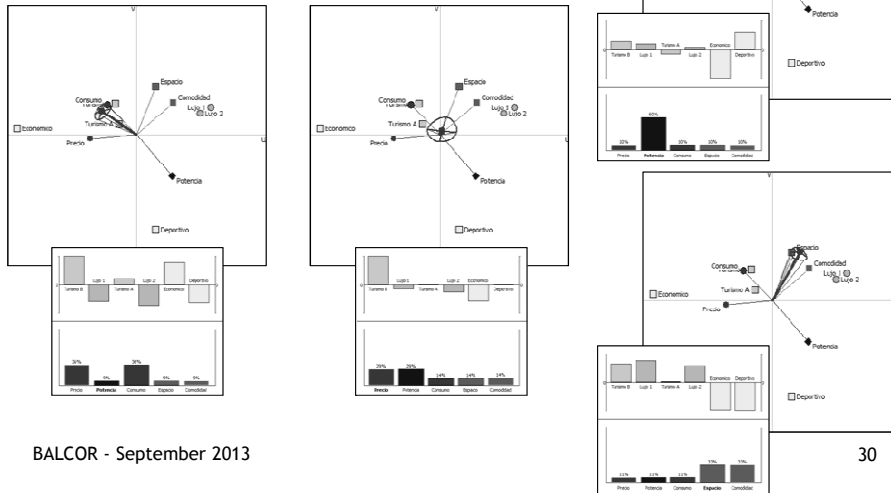


29

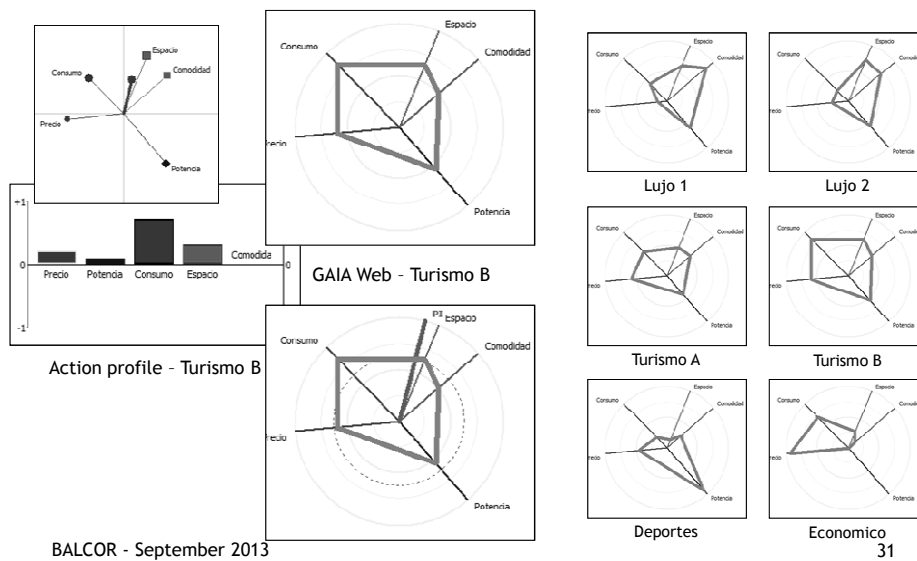
GAIA-Brain

20 years old

35 years old



GAIA Webs



Further...

- PROMETHEE Sort:
 - Using reference actions.
- Multi-scenarios model:
 - GDSS Group Decision extensions of PROMETHEE and GAIA.
- GIS Google Maps integration:
 - For geo-localized actions.
- Performance Analysis:
 - Input/Output analysis

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PROMap

- *Google Maps* integration:



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Further developments

- Imperfect information:
 - Uncertainty (probabilistic evaluations, ...)
 - Imprecision (fuzzy numbers, ...)
- Enhanced GAIA analysis:
 - GAIA-stick,
 - Custom GAIA plane.
- Dynamic extension.

Visual PROMETHEE WWW.PROMETHEE-GAIA.NET



- Visual PROMETHEE software (9 languages):
 - Free Academic Edition
 - Business Edition
- <http://biblio.promethee-gaia.net> :
 - Over 470 published references.
- Visual PROMETHEE Manual (PDF or ebook)
- Services: Training, Coaching, Free seminars
- <http://blog.promethee-gaia.net>
- <http://faq.promethee-gaia.net>
- LinkedIn group, Tweeter, ...

Single- and Multi-decision maker decision problems

- Single-decision maker :
 - Single stakeholder (decision maker).
 - Single evaluation table and preference structure.
- Multi-decision maker:
 - Multiple stakeholders (including decision maker(s)).
 - Multiple evaluation tables and preference structures.
 - Looking for a consensus solution.

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Multi-scenarios model

- Scenarios:
 - Points of view,
 - Hypotheses, ...
- Evaluations:
 - 'Objective' criteria: common evaluations.
 - 'Subjective' criteria: specific evaluations for each scenario.
- Specific preference structures :
 - Weights, preference thresholds.

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Multi-scenarios model

- Adaptation of PROMETHEE:
 - Individual rankings.
 - Global (group) rankings taking into account a possible weighing of the scenarios.
- Adaptation of GAIA:
 - Three distinct analyses.

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A simple example: Plant location

- Actions: 5 potential sites
- Criteria:
 - g_1 : Cost (investment)
 - g_2 : Cost (operations)
 - g_3 : Employment
 - g_4 : Transportation
 - g_5 : Environmental impact
 - g_6 : Social impact

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Example 2

- Four stakeholders (“decision makers”):
 - Industrial (actual decision maker),
 - Political authorities (regional),
 - Environmental protection groups,
 - Workers unions (social).
- Four multicriteria tables.

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The screenshot displays the Visual PROMETHEE Academic software interface, showing four separate multicriteria tables for different stakeholders: Industrial, Political, Environmental, and Social. Each table is a window within the main application, showing criteria, preferences, and evaluations for various sites.

Industrial scenario

Criteria	Investment	Operations	Employment	Transportation	Environ. Imp.	Social Imp.
Unit	MS	MS	workers	5-point	impact	impact
Cluster/Group						
Preferences						
Min/Max	min	min	min	max	min	min
Weight	25,00	15,00	20,00	20,00	10,00	10,00
Preference Fm.	Linear	Linear	Linear	Level	Level	Level
Thresholds	percentage	percentage	percentage	absolute	absolute	absolute
+Q: Indifference	0,05	0,05	0,05	0,5	0,5	0,5
+P: Preference	0,25	0,25	3,1	1,5	1,5	1,5
-S: Gaussian	n/a	n/a	n/a	n/a	n/a	n/a
Evaluations						
Site 1	€ 74	€ 12	175	average	high	low
Site 2	€ 86	€ 9	170	good	low	very low
Site 3	€ 89	€ 7	145	very low	very low	moderate

Political

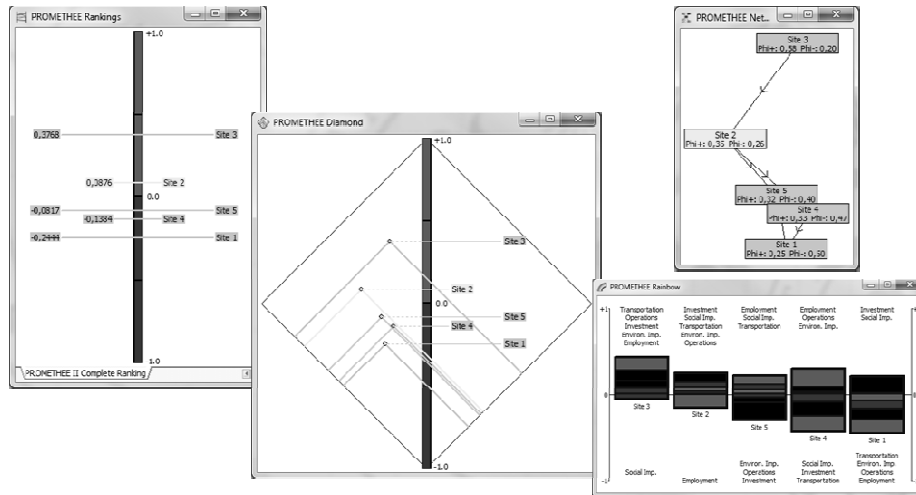
Environmental

Social

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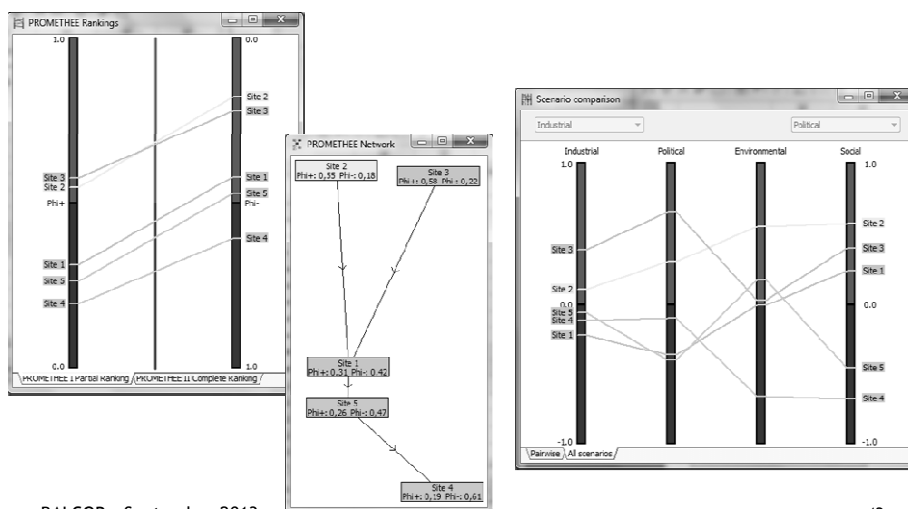
PROMETHEE Rankings Industrial scenario



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42

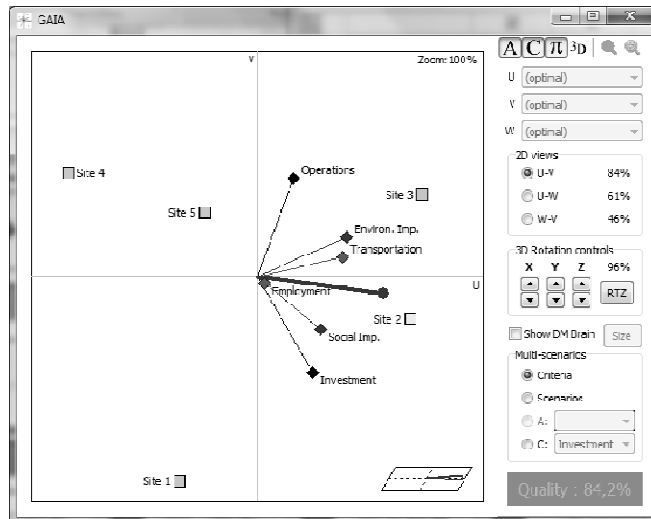
Group Ranking « Consensus »



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43

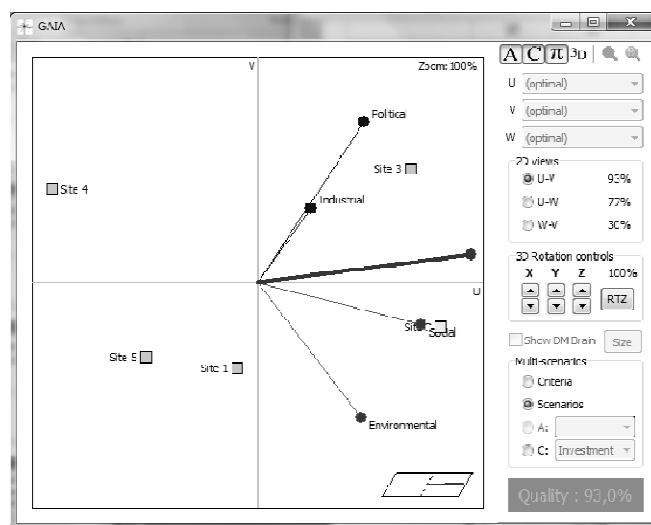
GDSS-GAIA: Criteria



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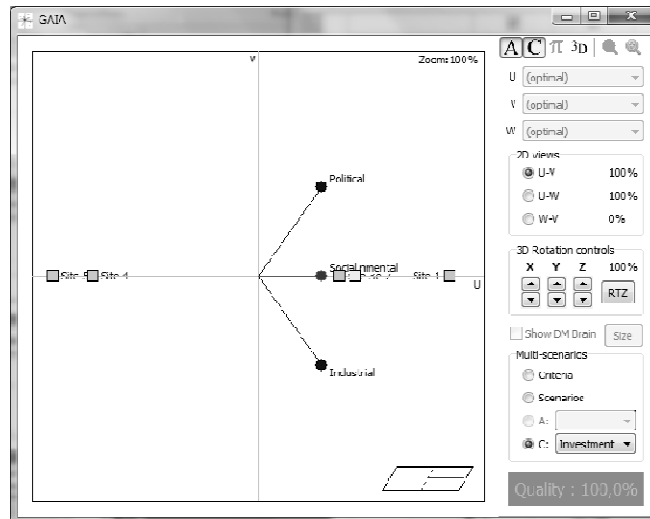
GDSS-GAIA: Scenarios



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45

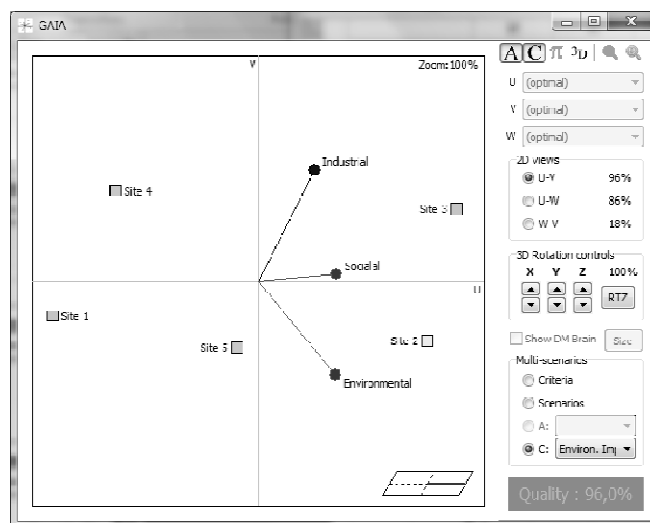
GDSS-GAIA: Single Criterion



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46

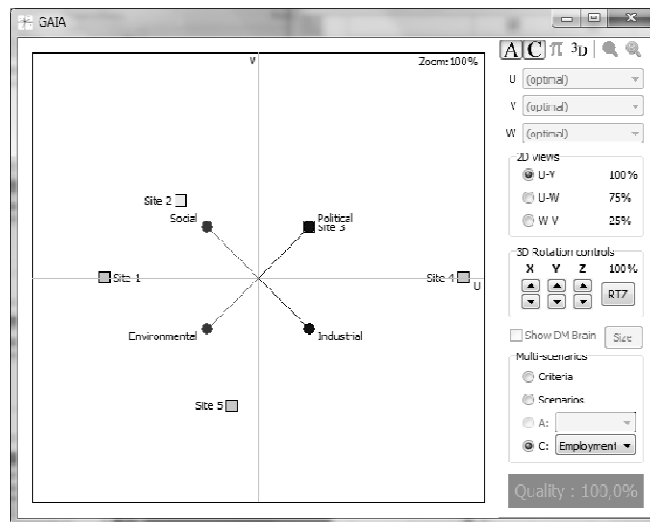
GDSS-GAIA: Single Criterion



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47

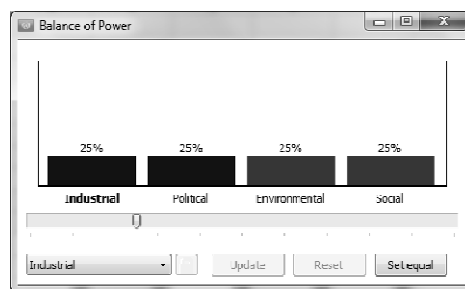
GDSS-GAIA: Single Criterion



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Sensitivity Analysis



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49