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Hands-on session on Influence Charts

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Iceberg Can Be Towed To Supply Fresh Water For Drought Areas: How?

Towing Icebergs (movie)[1]

[1] E&T Magazine May 2011

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The cost of desalinating seawater using conventional technology in the Persian Gulf is high (around 0.1€/m^3) and requires extensive amounts of oil. Some time ago scientists suggested that it could well prove both practically feasible and less expensive to tow icebergs from the Antarctic, a distance of about 9,600km. Although some of the ice would undoubtedly melt in transit, it was thought that a significant proportion of the iceberg would remain intact upon arrival in the Gulf. Bear in mind that since water expands upon freezing, $1m^3$of ice produces only $0.85m^3$ of water.

A study was carried out to evaluate the practical problems associated with such a proposal and to quantify the factors that were likely to influence the economics of such a venture. One factor was the difference in rental costs and capacities of towing vessels. Note that each vessel has a maximum iceberg it can tow (measured in cubic meters). The Towing Vessel Data are summarised in Table 1.

Table 1: Towing Vessel Data

Ship Size	**Small**	**Medium**	**Large**
Daily rental (€)	400	600	800
Maximum load (m^3)	500,000	1,000,000	10,000,000

It was found that the melting rate of the iceberg depends on both the towing speed and the distance from the South Pole. The data in Table 2 represents the rate at which a hypothetical spherical iceberg shrinks in radius over a day at the given distance from the Pole and at the given towing speed.

Table 2: Melting Rates (meter/day)

	Distance from Pole (km)			
	1,000	**2,000**	**3,000**	$\geq$ **4,000**
Speed				
1 km/hr	0.06	0.12	0.18	0.24
3 km/hr	0.08	0.16	0.24	0.32
5 km/hr	0.10	0.20	0.30	0.40

Finally, fuel cost was found to depend on the towing speed and the (current) size of the iceberg. These costs are presented in Table 3.

Table 3: Fuel Costs (€/m^3)

	Current Volume (m^3)		
	100,000	**1,000,000**	**10,000,000**
Speed			
1 km/hr	8.4	10.5	12.6
3 km/hr	10.8	13.5	16.2
5 km/hr	13.2	16.5	19.8

Determine whether it is economically feasible to produce water from icebergs in the Persian Gulf, and if it is, determine the best means to do so.

[2] in Management Science: The Art of Modeling with Spreadsheets, 3e, S.G. Powell and K.R. Baker. pp479; Source: Cross, M. and A.O. Moscardini, 1985. Learning the Art of Mathematical Modeling. Ellis Horward Limited, West Sussex.

A "Problem" versus a "Mess"

- A mess is a morass of unsettling symptoms, causes, data, pressures, shortfalls, opportunities, etc. . .
- A problem is a clear situation that is capable of resolution.
- Identifying a problem in a mess is the first step in the creative problem-solving process.

Characteristics of Well-Structured Problems

- The objectives of the analysis are clear.
- The assumptions that must be made are obvious.
- All the necessary data are readily available.
- The logical structure behind the analysis is well understood.

Example: algebra problems are typically well-structured problems.

Characteristics of Ill-Structured Problems

- The objectives of the analysis are unclear.
- The assumptions that must be made are unclear.
- It is unclear what data are needed and available.
- The logical structure behind the analysis is unclear.

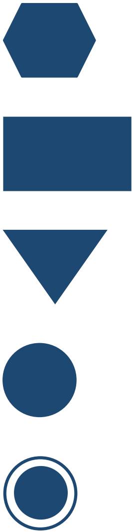
Example: Icebergs Can Be Towed To Supply Fresh Water For Drought Areas?

- Goals of the analysis:
  To assess if it is economically feasible to produce water from icebergs in the Persian Gulf and if it is, to determine the best means to do so.
- Assumptions:
  - Icebergs are available for free;
  - The speed of the towing vessels is constant;
  - The icebergs are spherical.
- Data needed:
  - Desalinating cost;
  - Distance from the pole;
  - Shrink rate (ice-water volume conversion);
  - Rental costs of towing vessels;
  - Capacities of towing vessels;
  - Melting rates;
  - Fuel cost.

- Offer the modeller a bridge between an ill-structured problem and a formal model.
- Identify the main elements of a model.
- Delineate the boundaries of a model.
- Are recommended for early stages of any problem formulation task.

Building Blocks for Influence Charts

Outputs	(hexagons)
Decisions	(rectangles)
Inputs	(triangles)
Intermediate variables	(circles)
Random variables	(double circles)



Building Influence Charts

- Influence Charts are built from right to left.
- Start with the outcome measure.
- Decompose the outcome measure into independent variables that directly determine it.
- Repeat the decomposition for each variable in turn.
- Identify input data and decisions as they arise.
- Each variable should appear only once.
- Highlight special types of elements with special symbols.

Icebergs for Kuwait – Influence Chart

Rental cost

Boat

Total cost

Number of Days

Speed

Water cost

Fuel cost

Water volume at arrival

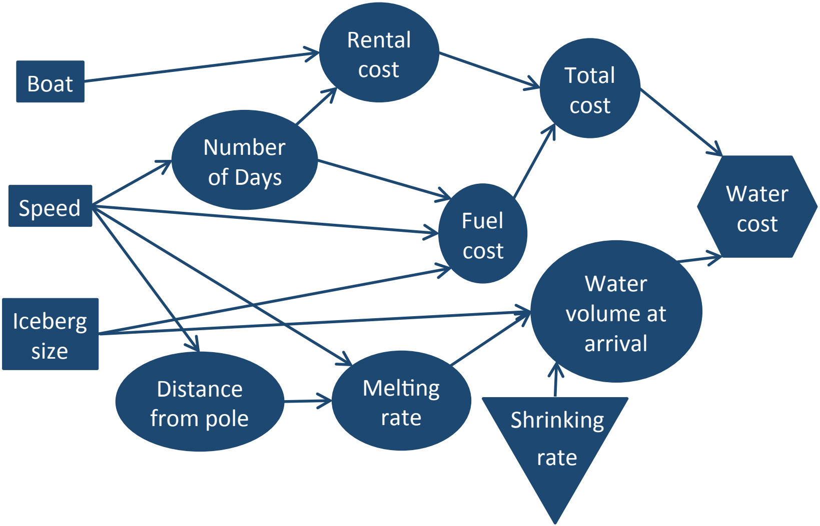
Iceberg size

Distance from pole

Melting rate

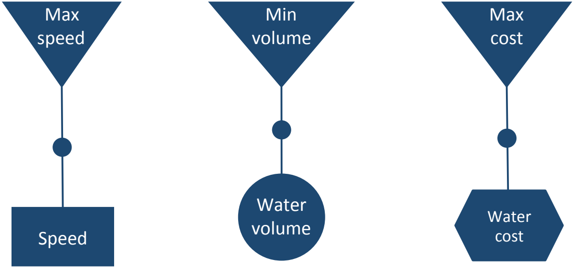
Shrinking rate

Icebergs for Kuwait – Influence Chart



Building Blocks for Influence Charts (extensions)

Dependencies that are lower or upper bounds on the decisions, variables or outcomes.



The most common error in building Influence Charts is . . .

. . . to draw an arrow from the output back to the decisions, trying to represent that the outcome will be used to determine the best decision.

An influence chart, however, is a description of how we will calculate outcomes for a set of decisions and other parameters, it is not intended to be used to find the best decision!

Influence Charts (wrap-up)

- The goal is to develop the problem structure.
- To show outputs and how they are calculated from inputs.
- Influence Charts ignore all available numerical data.
- There is no one correct Influence Chart because Influence Charts rely on modelling assumptions.
- Modelling assumptions should be recorded as they are made.