Models, Optimality, Experts and Alternatives

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The Essence of Behavioural OR?

Models for the Non-OR Community

Models Viewed from Outside OR's Walls

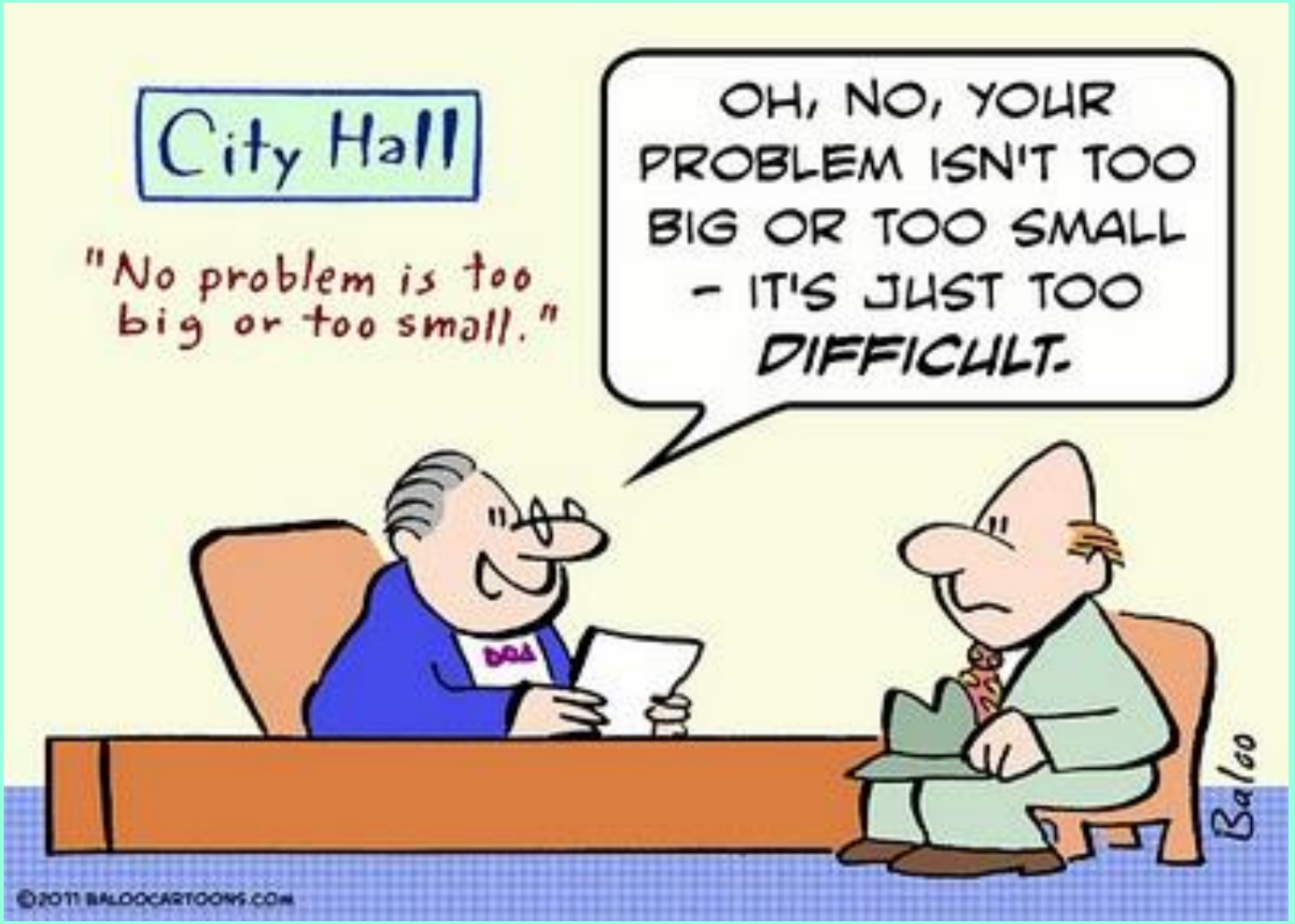
Models Viewed from Within the OR Domain

$$\text{Max} \quad Z = F(\boldsymbol{X})$$

$$\text{s.t.} \quad \boldsymbol{X} \in D$$

$$\boldsymbol{X} = [X_1, X_2, \ldots, X_N]$$

“Real World” OR Problems Not Straightforward



OR Expert Determines the Optimal Solution

OR Expert Announces the Model's Optimal Solution

Engineering Expertise

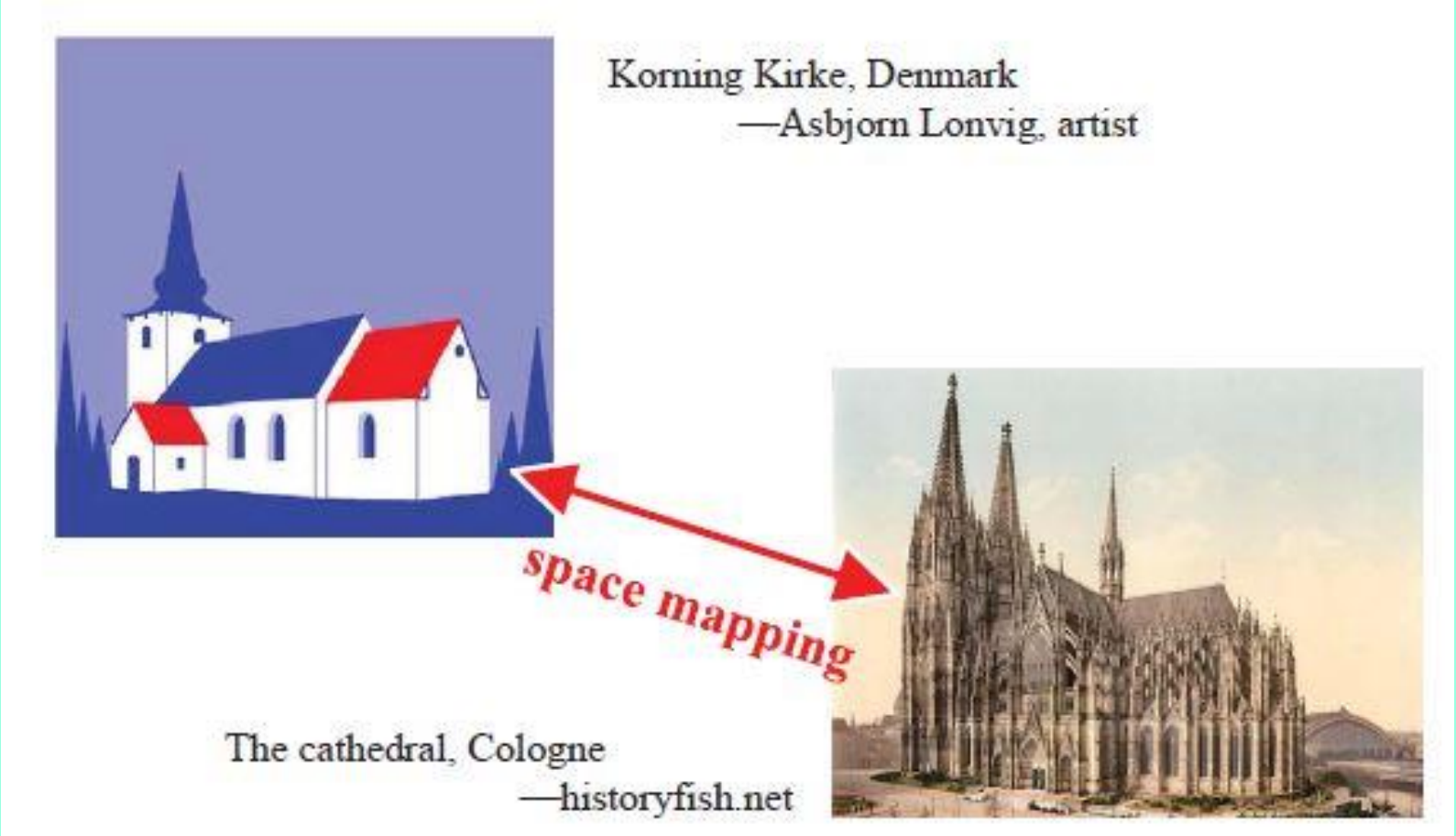
- "Have you ever wondered about the Engineer's mysterious "feel" for a problem?"

  John Bandler,
  creator of Space Mapping

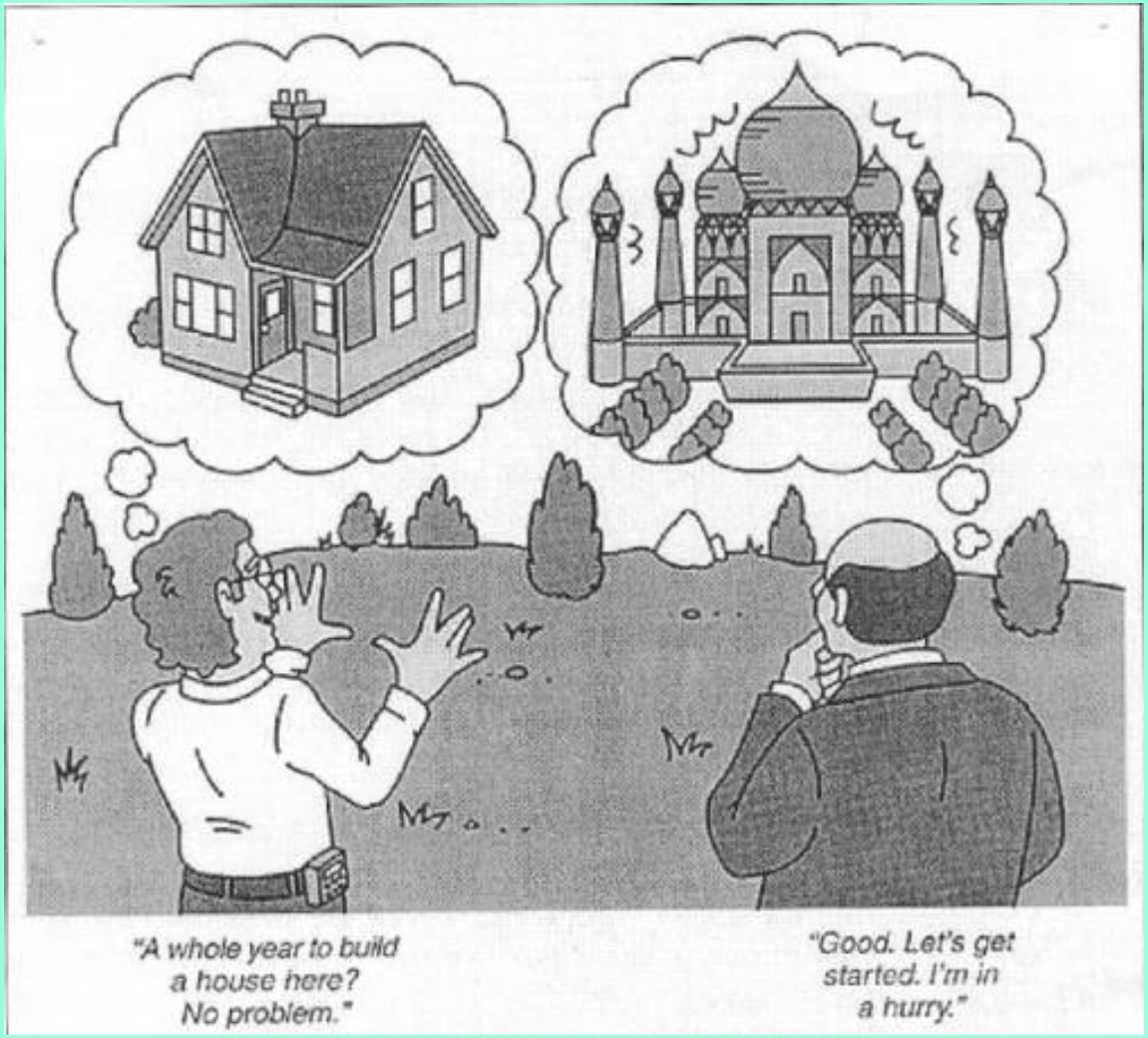
- "Let thy words be few."

  Ecclesiastes 5:2

Essence of Space Mapping (Bandler)

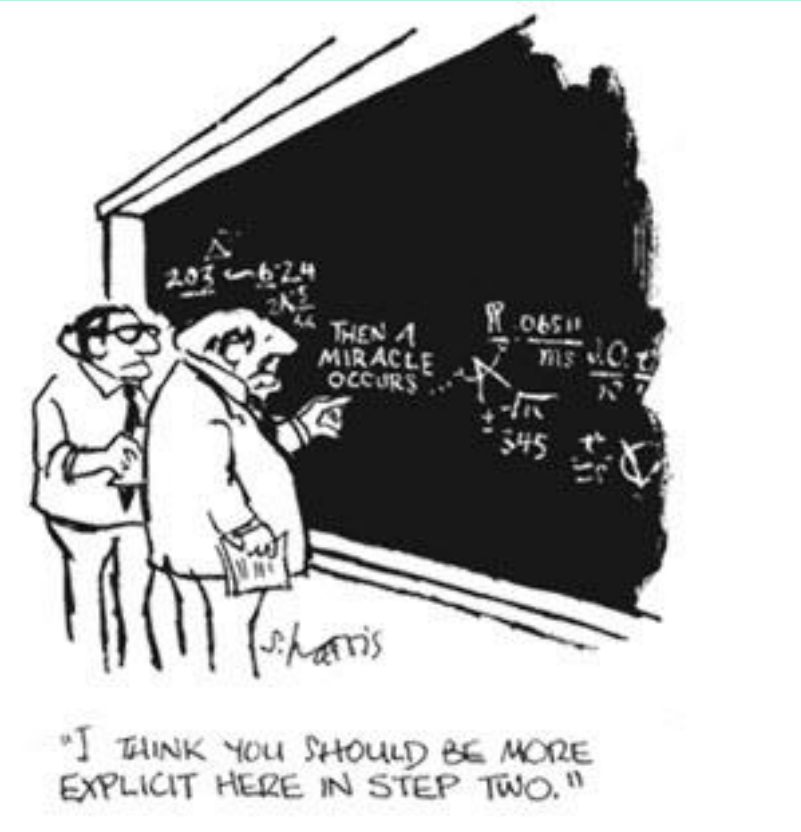


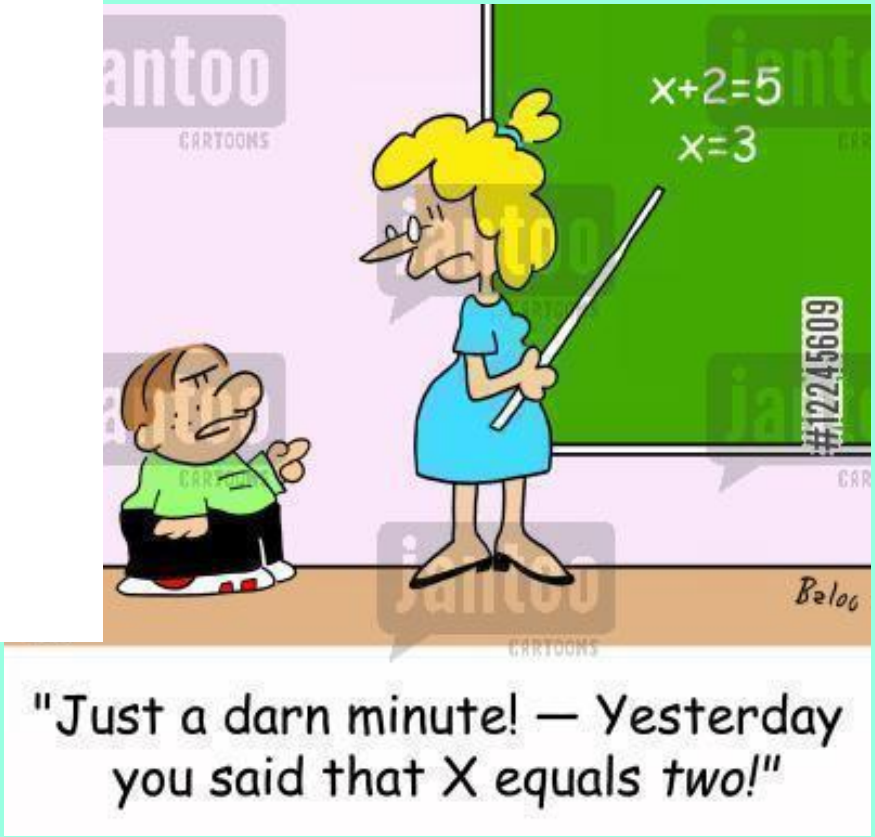
"*All models are wrong but some are useful*" (Box)



"*Science may be described as the art of systematic over-simplification*" (Popper)

"If you think you understand X that's a sure sign you don't understand X"





A Certain Hubris Exists Within Experts

“Ordinary Models” Can be Manipulated

Louisa Peacock
Columnist, Daily Telegraph

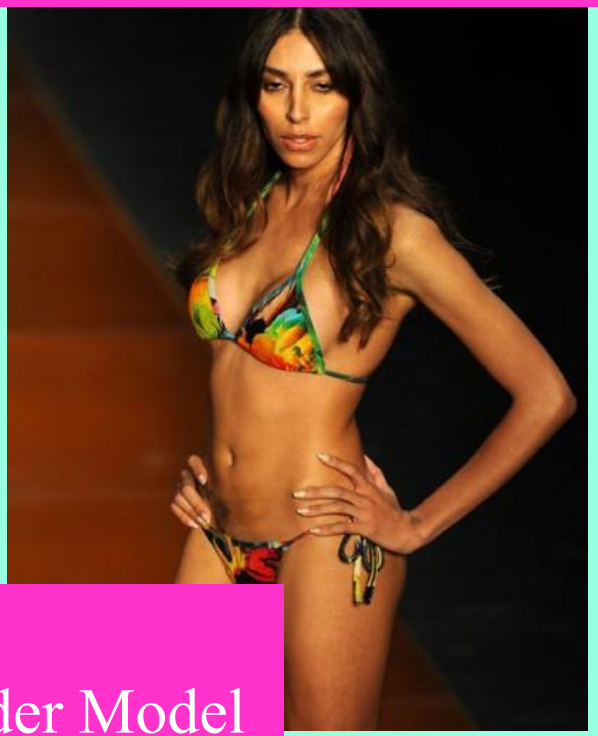
Perfect Models are Idealized Abstractions

Even Expert Modellers View Models "Incorrectly"

Models Do Not Always Reflect the Ideal Portrayed

Roberta Close
(Male) Transgender Model

Lea T
(Male) Transgender Model



Candis Cayne
(Male) Transgender Model

Claudia Charriez
(Male) Transgender Model

Models Do Not Always Reflect the Ideal Portrayed

Andrej Pejić
Male Transgender Model

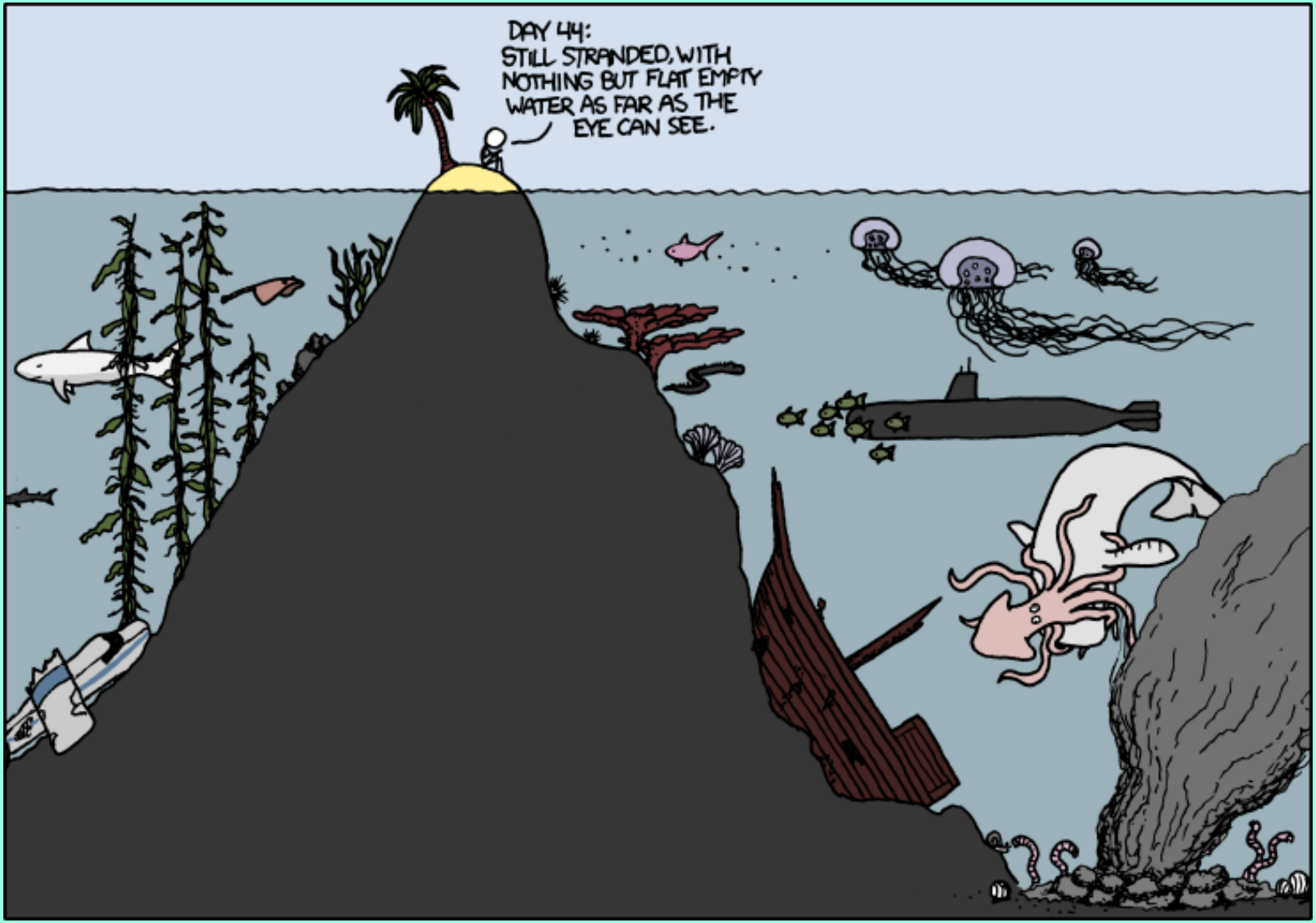
Jenna (Walter) Talackova
Miss Universe Canada

Because Models Are Abstractions

Heather Cassils
Female Model

My Torso with a Different Head Photoshopped Onto the Picture ☺

Bounded Rationality of Experts (H. Simon)



The Way We Think, Leads Us Astray (Kahneman, Tversky)

- Expert Modellers are not always rational
- Irrational aberrations are not temporary & are not due to emotions
- Expert modellers are ignorant of their own ignorance
- "Rationality was f**ked"

Richard Thaler

Salem Hypothesis for Engineers

- People who *claim* science expertise, whilst advocating creationism, tend to be formally trained as **engineers**
- Correlation between **engineering** and **creationist beliefs**
- *Crank magnetism* condition
  - people attracted to multiple crank ideas at the same time
- Usually includes climate change denial and crackpot beliefs

Modelling-to-Generate-**Alternatives**

- When is constructing good alternatives **ever** ***undesirable***?
- MGA motivation is to produce alternatives that are:

  (i) near-optimal wrt known modelled objective(s)

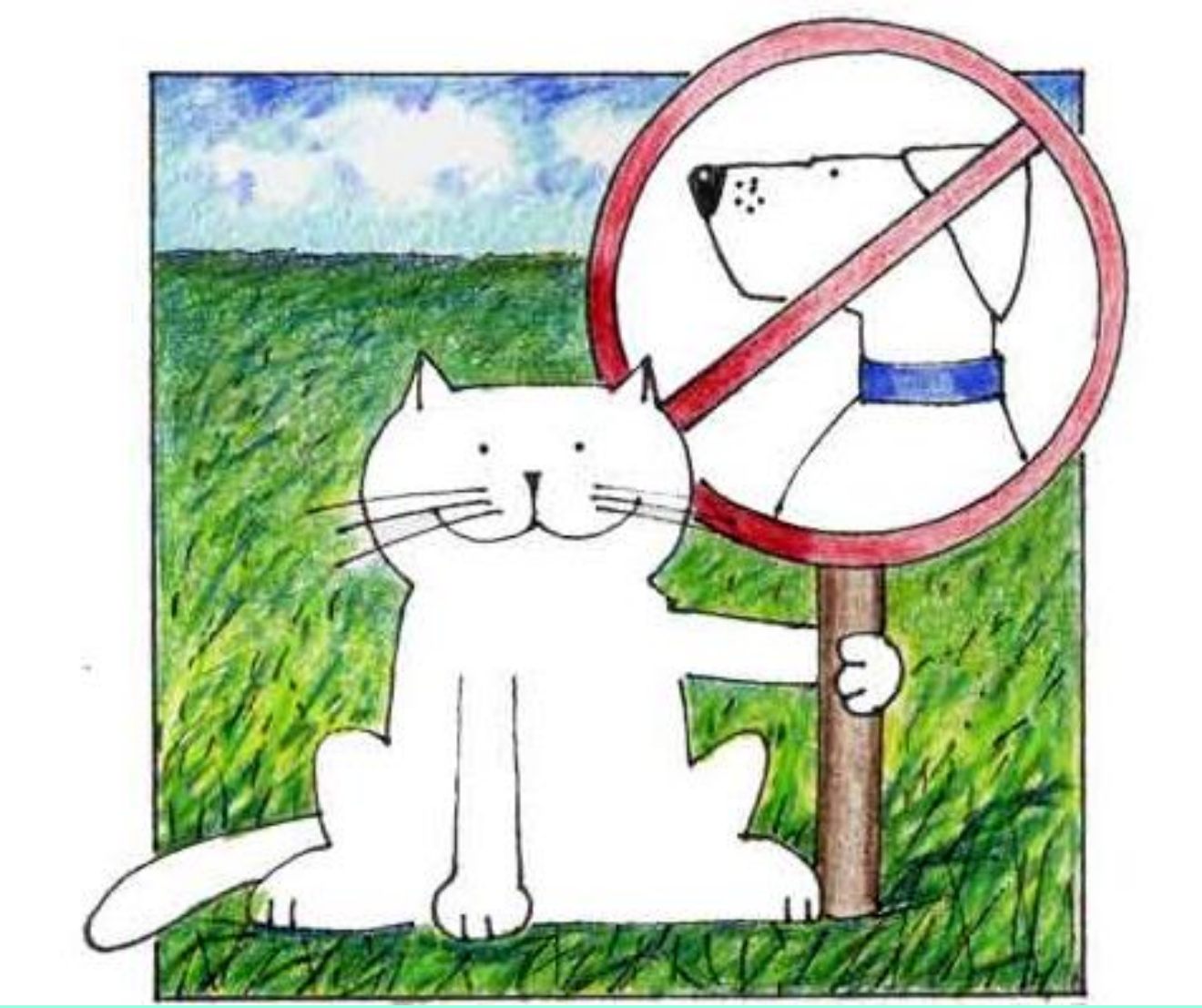
  (ii) fundamentally "different" in system structure

- MGA systematically generates these alternatives
- "Good" alternatives provide fundamentally distinct perspectives

Alternatives Needed When **Not Everyone Agrees**

Alternatives Also Needed When **Everyone Does Agree**

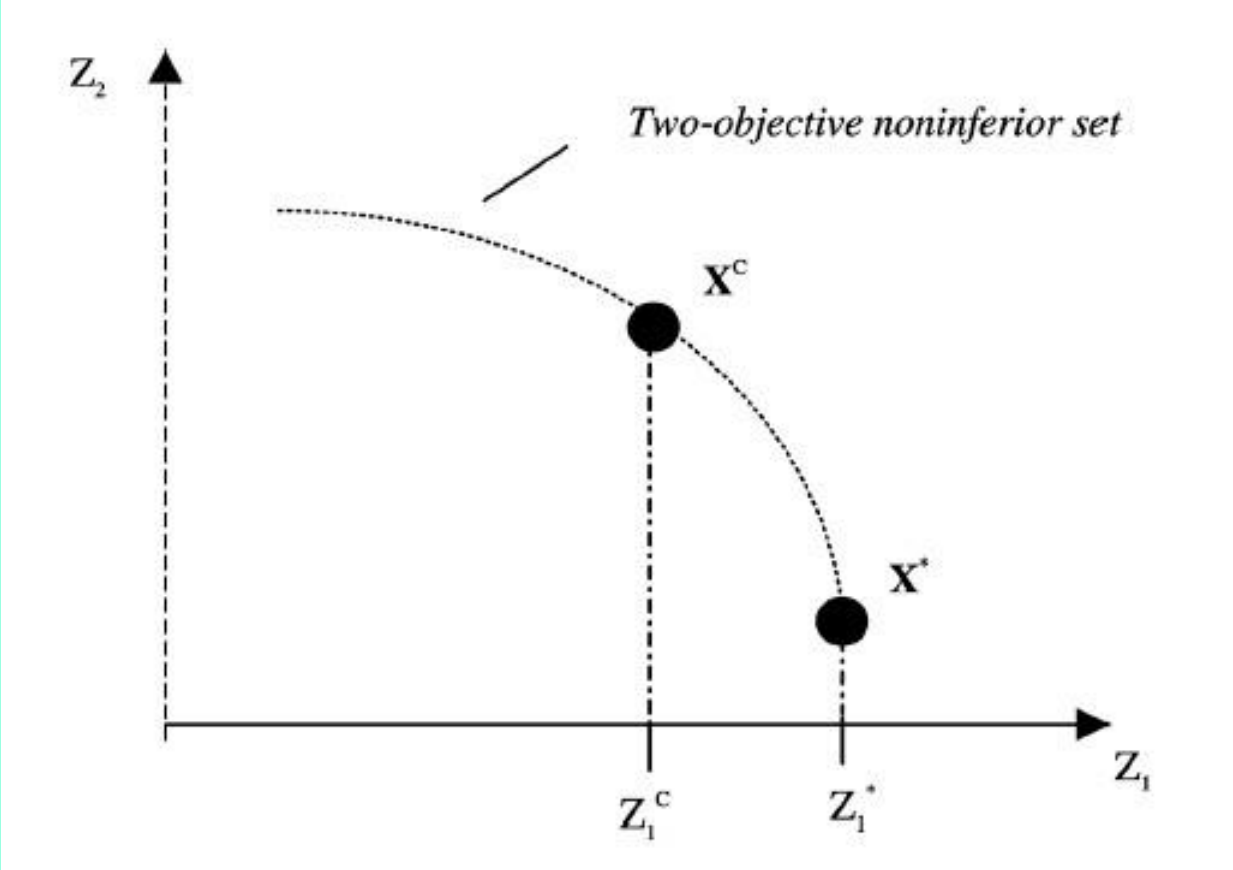
Fundamentally Opposing Perspectives May Still Exist



Powerful Stakeholder Views May Not Be Known

Unknown or "Hidden" Agendas in Two-Objective Space

- Z_1 is the modelled objective with optimal solution X^*
- Z_2 is an unmodelled objective not captured within the model
- X^c is an inferior "compromise" solution in $Z1$ solution space



Modelling to Generate Alternatives (MGA)

- X^* is optimal with objective $Z^* = F(X^*)$

- Maximally different alternative to X* is

$$\text{Max } \Delta = \Sigma_i \; | X_i - X_i^* |$$

$$\text{s.t. } X \varepsilon D$$

$$\text{Target Constraint } | F(X) - Z^* | \leq T$$

- Δ is some appropriate difference function
  T is a target specified in relation to Z^*

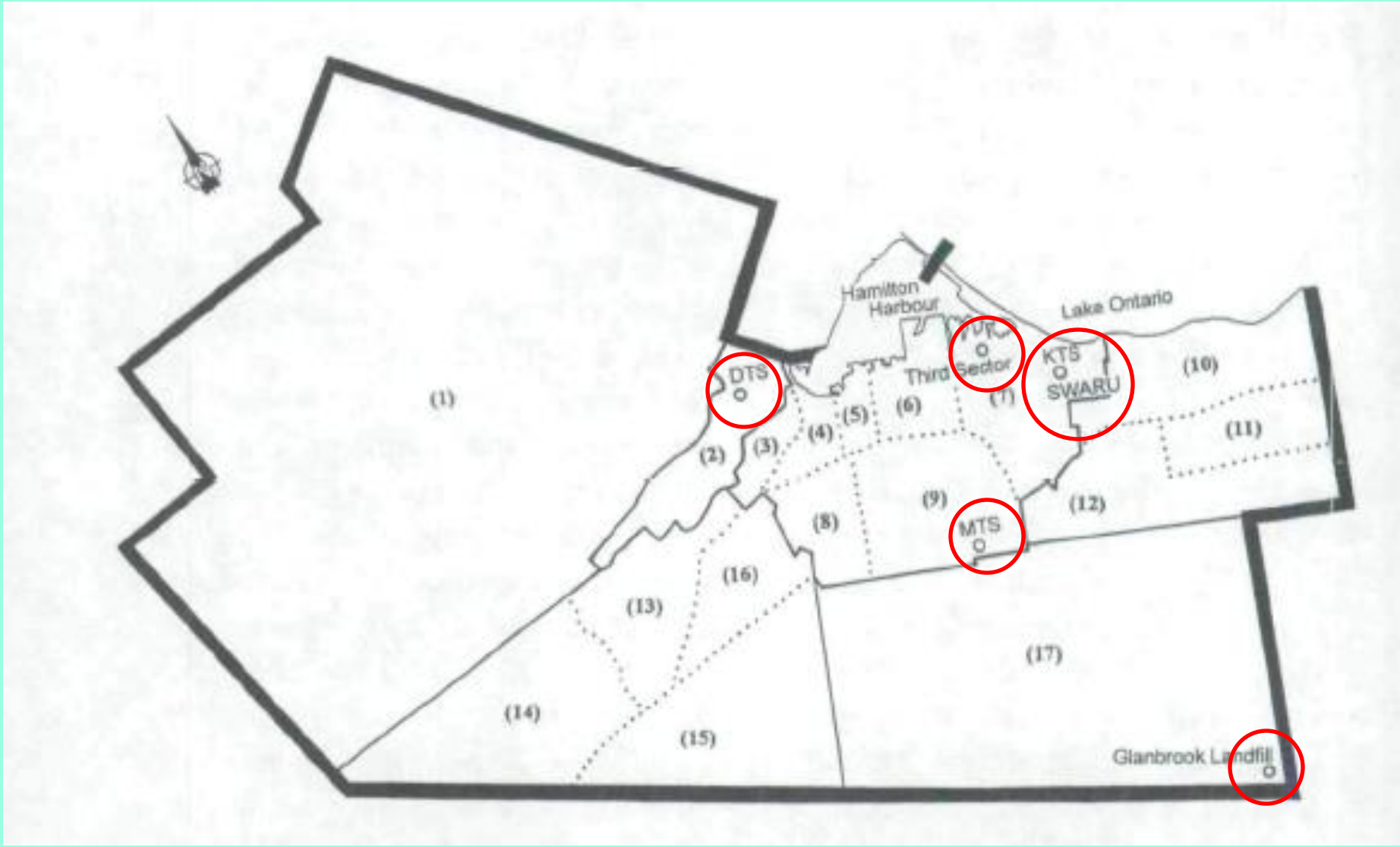
“Hard” OR View to Generating Alternatives

"This really is an innovative approach, but I'm afraid we can't consider it. It's never been done before."

CASE: Municipal Solid Waste Planning in Hamilton-Wentworth

- Industrial centre of Canada, 1100 sq. kms
- 6 towns and cities, 17 districts
- 500,000 residents
- 300,000 tonnes of MSW/year
- 1 landfill, 1 waste-to-energy incinerator
- 3 transfer stations
- Recycling & Composting Programs
- Hazardous waste facility
- Annual Budget $22 million

CASE: Layout of Hamilton-Wentworth Waste Management Facilities



Annual MSW Performance Costs ($ Millions) Found for 4 Maximally Different Alternatives for (i) Existing System Structure (Scenario 1), (ii) Incinerator at Maximum (Scenario 2), and (iii) Incinerator at Any Level (Scenario 3)

Scenario Considered	SOLUTION ALTERNATIVE			
	Overall "Optimal" Solution	Best 2% Solution	Best 5% Solution	Best 8% Solution
SCENARIO 1	20.6	20.9	21.4	22.2
SCENARIO 2	22.1	22.4	23.1	23.8
SCENARIO 3	18.7	18.9	19.5	20.0

Conclusion

- **All** "real world" MODELS are an abstraction of reality
- OR requires the OPTIMALITY of an abstraction
- OR EXPERTS facilitate model optimization
- Generating real ALTERNATIVES always beneficial