What to Do When Models Don't Work

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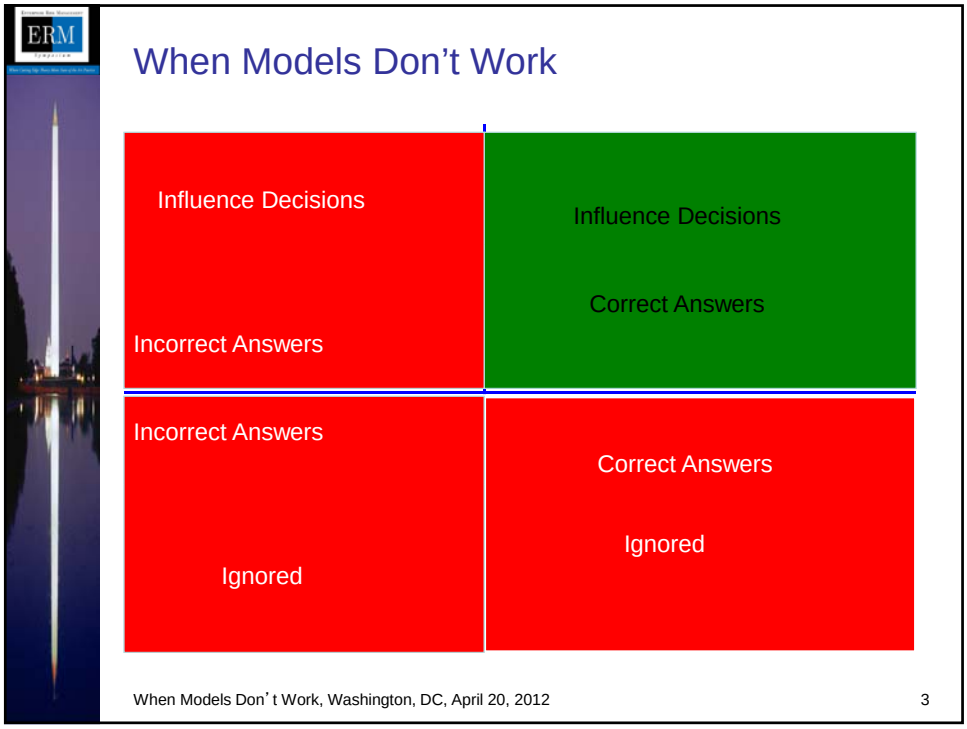
Dave Ingram, EVP, WillisRe

What to Do When Models Don't Work

Bad Risk Models have been blamed for causing or at least exacerbating the Global Financial Crisis. While statistical based models are a massive advance over single scenario best estimate models in understanding risk and volatility, they sometimes miss warning us about the problems that actually do occur because they are not inherently adaptive. The answer is not necessarily to fix the models, but to augment the models with alternate ways of thinking about risk so we know when the models need updating.

This session will review several different modes of thinking and introduce a Systems Analysis approach that can provide new insights into the complex interacting forces that lead to the outside the models problems. Participants will learn ways to evaluate and challenge the embedded assumptions that are sometimes the cause of model failures, and how to better leverage the inherent knowledge in organizations about emerging risk patterns that models don't know about yet. In addition, other modes of thinking and decision making that often drive the conclusions that conflict with both the models and with Systems Analysis will be described to provide a full meta analysis of thinking styles.


When Models Don't Work
Influence Decisions
Incorrect Answers
Influence Decisions
Correct Answers
Incorrect Answers
Ignored
Correct Answers
Ignored
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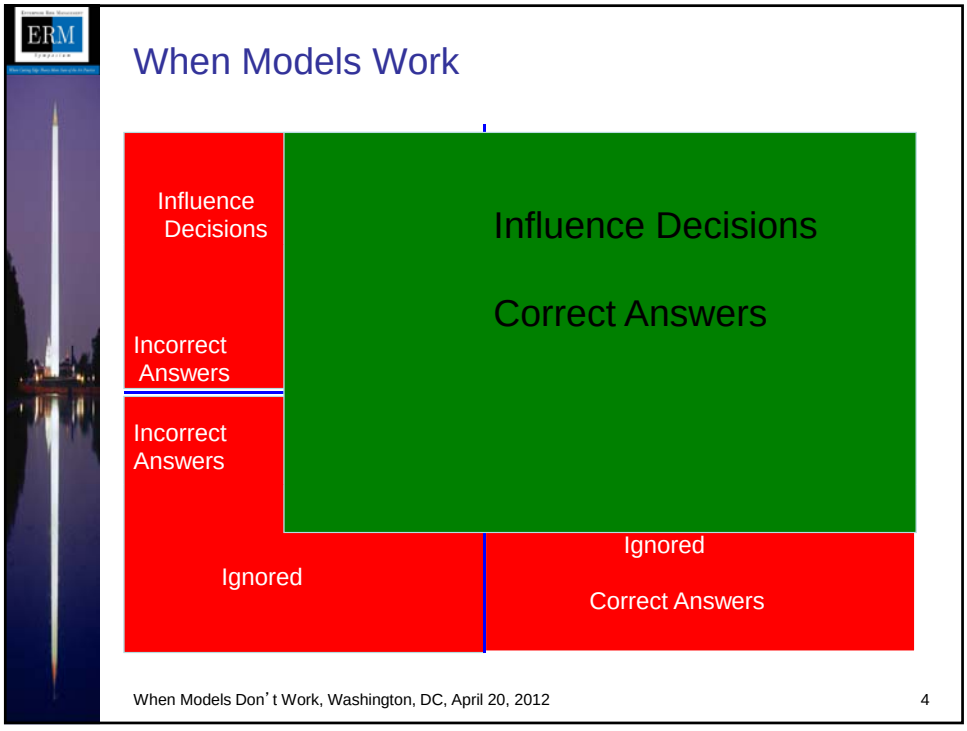
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Our Topics

1. Three modes of Thinking - Ingram
2. Systems Analysis - Cantle
3. Putting this all Together - Ingram
4. Using Systems Analysis for Emerging Risks - Cantle

THREE MODES OF THINKING

Thinking

- Actuarial vs. Clinical Debate
  - Meehl
- Fast and Frugal Heuristics
  - Gigerenzer
- Natural Decision Making
  - Klein

Three Modes of Thinking

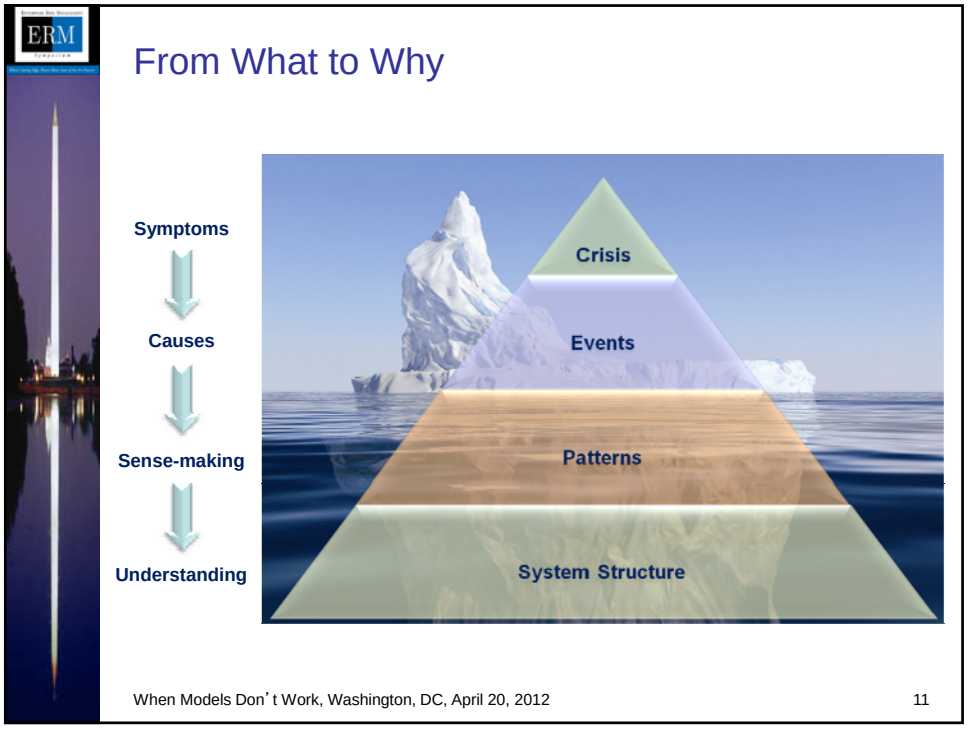
- Heuristics / NDM
- Statistics / Rational Decision Making
- Systems Analysis

SYSTEMS ANALYSIS

Unravelling the complexities of risk

When life was simple…

- Reductionist approaches can work well:
  - When things are linear
  - When things don't change too often
  - When interactions between factors are limited
- Statistical methods can work well:
  - When you are mostly interested in the range of possible outcomes
  - When you don't need to understand "why"
  - When a process repeats frequently (with broadly the same underling mechanism)
- Life is no longer simple…


From What to Why
Symptoms
Causes
Sense-making
Understanding
Crisis
Events
Patterns
System Structure
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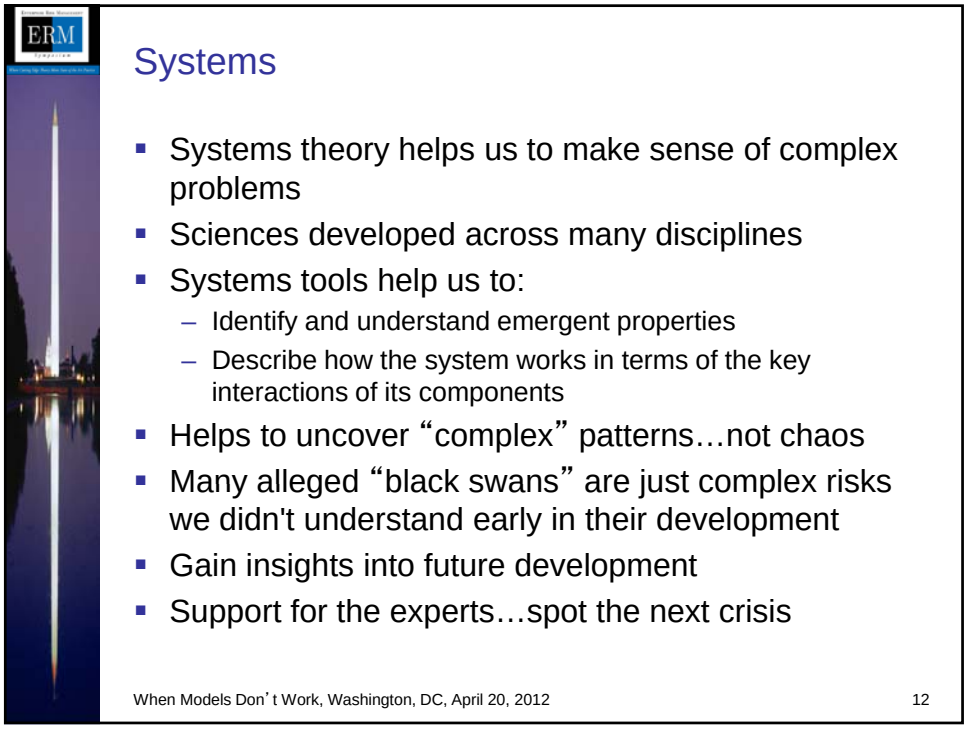
Systems
Systems theory helps us to make sense of complex problems
Sciences developed across many disciplines
Systems tools help us to:
Identify and understand emergent properties
Describe how the system works in terms of the key interactions of its components
Helps to uncover "complex" patterns…not chaos
Many alleged "black swans" are just complex risks we didn't understand early in their development
Gain insights into future development
Support for the experts…spot the next crisis
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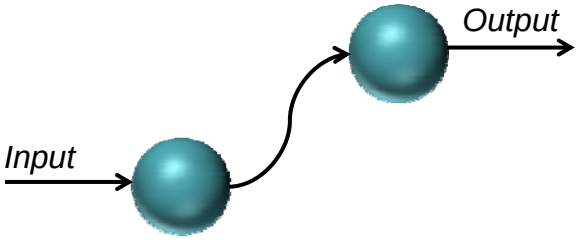
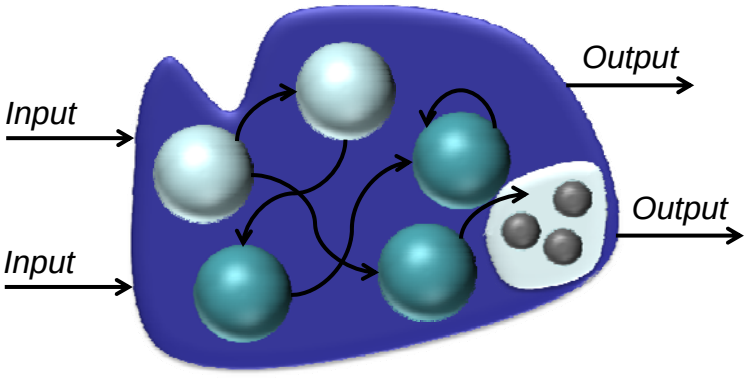
Introduction to Systems



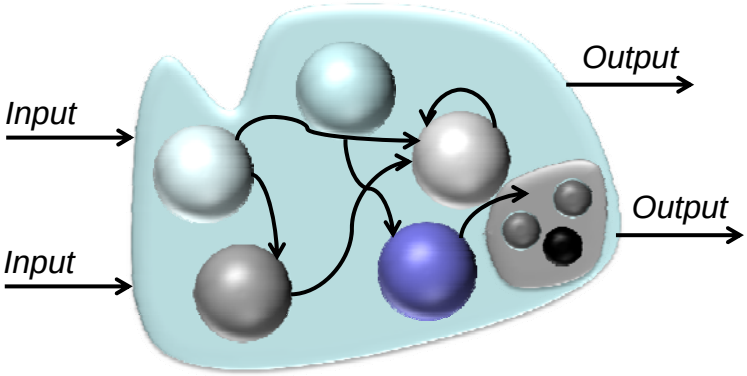
A set of components interconnected for a purpose

Introduction to Systems



Complex System – Feedback, subsystems, etc.

Introduction to Systems



Complex Adaptive System – Structure changes

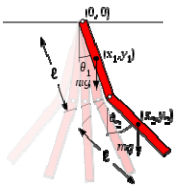
Complex Adaptive System Characteristics

- Has a purpose
- Emergence – the whole has properties not held by sub components
- Self Organisation – structure and hierarchy but few leverage points
- Interacting feedback loops – causing highly non-linear behaviour
- Counter-intuitive and non-intended consequences
- Has tipping point or critical complexity limit before collapse
- Evolves and history is important
- Cause and symptom separated in time and space

Complexity from simple rules

Centres of mass:

$$x_1 = \frac{\ell}{2}\sin\theta_1,$$
$$y_1 = -\frac{\ell}{2}\cos\theta_1$$
$$x_2 = \ell\left(\sin\theta_1 + \frac{1}{2}\sin\theta_2\right),$$
$$y_2 = -\ell\left(\cos\theta_1 + \frac{1}{2}\cos\theta_2\right).$$



Equations of motion (where L denotes the Lagrangian, KE-PE)

$$\dot{\theta}_1 = \frac{6}{m\ell^2}\frac{2p_{\theta_1} - 3\cos(\theta_1-\theta_2)p_{\theta_2}}{16 - 9\cos^2(\theta_1-\theta_2)}$$
$$\dot{\theta}_2 = \frac{6}{m\ell^2}\frac{8p_{\theta_2} - 3\cos(\theta_1-\theta_2)p_{\theta_1}}{16 - 9\cos^2(\theta_1-\theta_2)}.$$
$$\dot{p}_{\theta_1} = \frac{\partial L}{\partial\theta_1} = -\frac{1}{2}m\ell^2\left[\dot{\theta}_1\dot{\theta}_2\sin(\theta_1-\theta_2) + 3\frac{g}{\ell}\sin\theta_1\right]$$
$$\dot{p}_{\theta_2} = \frac{\partial L}{\partial\theta_2} = -\frac{1}{2}m\ell^2\left[-\dot{\theta}_1\dot{\theta}_2\sin(\theta_1-\theta_2) + \frac{g}{\ell}\sin\theta_2\right]$$

Source: http://en.wikipedia.org/wiki/Double_pendulum

Unintended consequences

- People "understand" bits of risk, not the whole thing

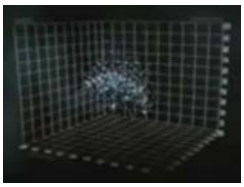
Self-Organisation and Emergence

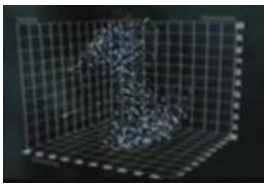


Modeling complexity need not be complex:

These highly complex behaviors can be reproduced quite accurately with 4 simple, interacting rules

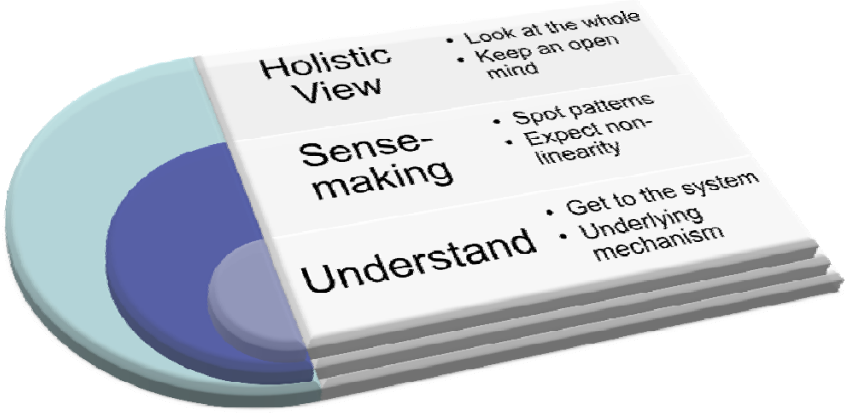
1. Only aware of nearest neighbor... 2. Line up... 3. Attracted/small distance apart... 4. Danger!...Get out of the way



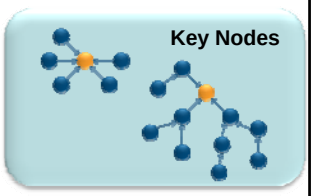


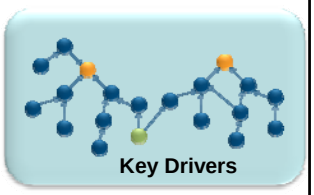
Source: Strogatz, Synchrony

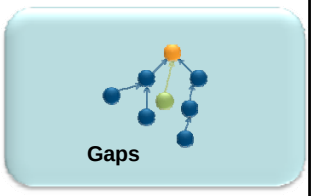
Systems Thinking In Practice



Understanding The System







Rapidly elicit highly detailed description of risk profile and implicit dynamics

Looking Through Different Lenses

- Using metrics designed to describe complex non-linear patterns, you can see signs of trouble building up and begin to form theories about the dynamics
- You can actually measure how much information something contains:

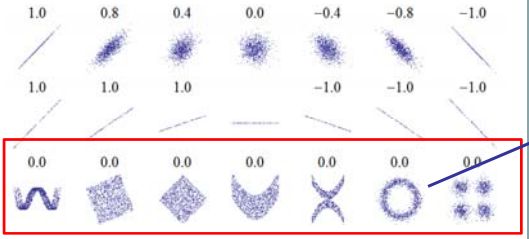
$$I(x) = -\log p(x)$$

- If something is surprising it will tell you a lot
- Looking at your management information in this way can yield insights about the early development of unusual behaviors

Connectivity

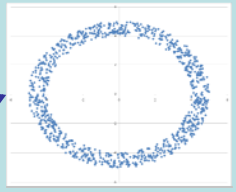
- Typical correlation measures cannot spot non-linear dependency
- Mutual information sharing can

Different levels of correlation



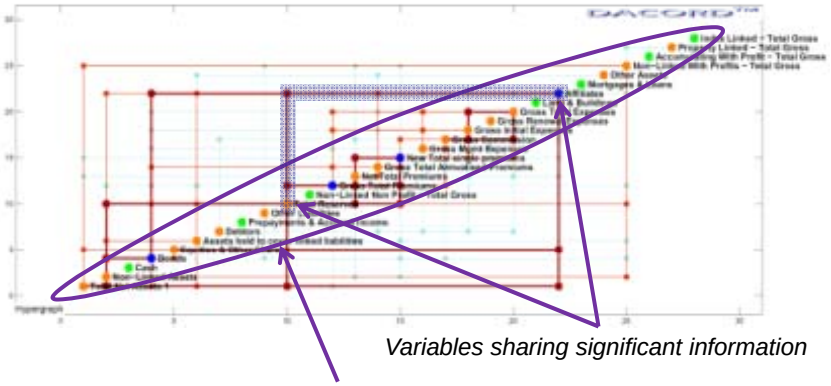
Example
Θ ~ U[0,2π]
R ~ U[4, 5]
X = R cos Θ
Y = R sin Θ

Sample of 1000



Correlation = 0.0
Mutual Info = 1.0

Non-linear dependence

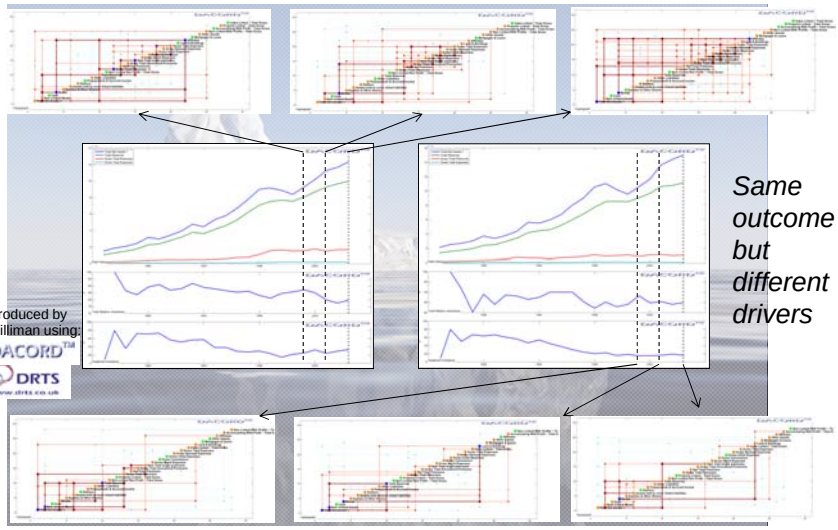


Variables sharing significant information

Variables of system performance

Looking beneath the surface

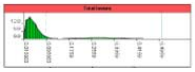
This company's performance seems complex, involving many variables



Same outcome but different drivers

This company's performance seems less "complex"

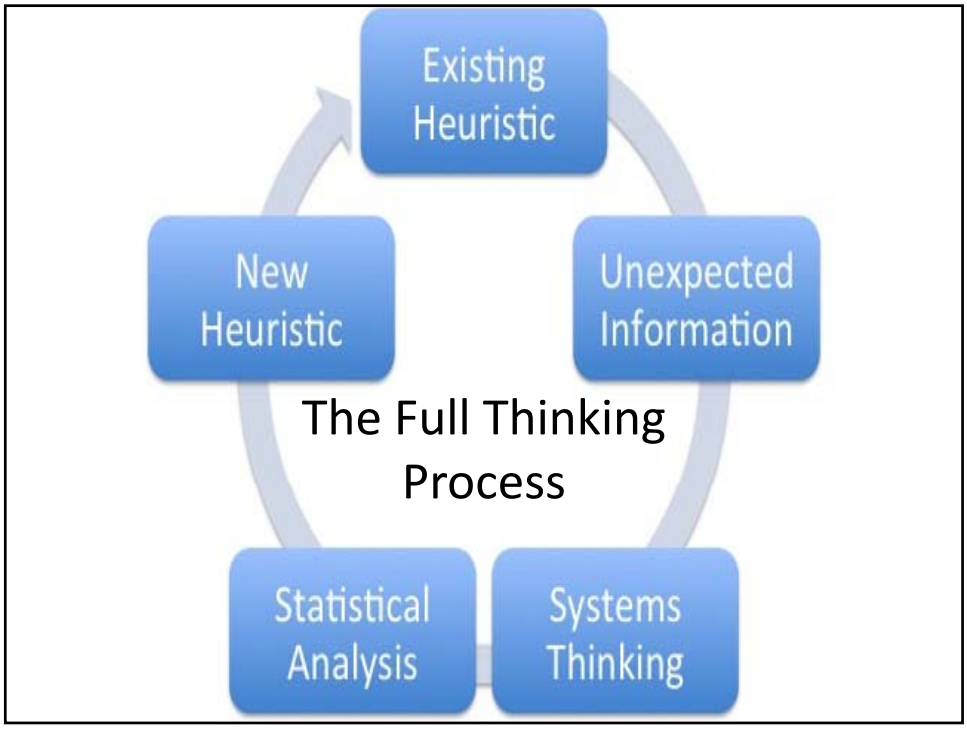
Putting the "Systems" into "Modeling"



- Outcome estimated directly by "experts"
- Requires them to pre-process a lot of knowledge
- Assumptions being made are unseen

- Dynamics made transparent
- Outcome derived from understanding of system structure

PULLING THIS ALL TOGETHER

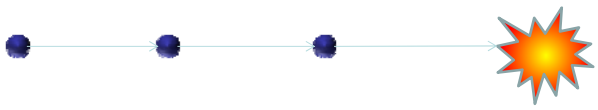


EMERGING RISK

Seeing the wood for the trees

Emerging Risk

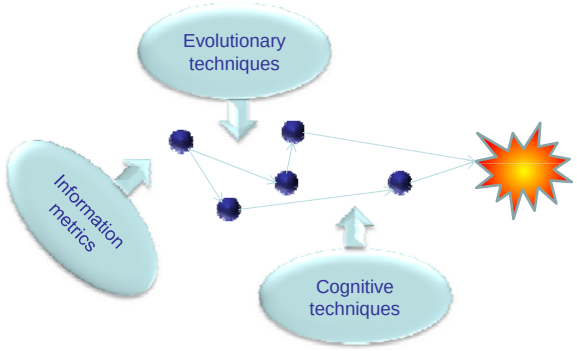
- Simple risks are easy(ish) to spot early



Linear relationships make it easy to see how one thing leads to another

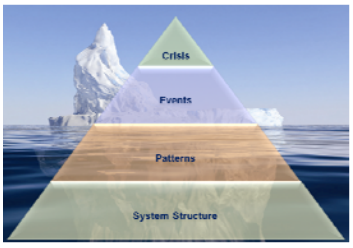
Emerging Risk

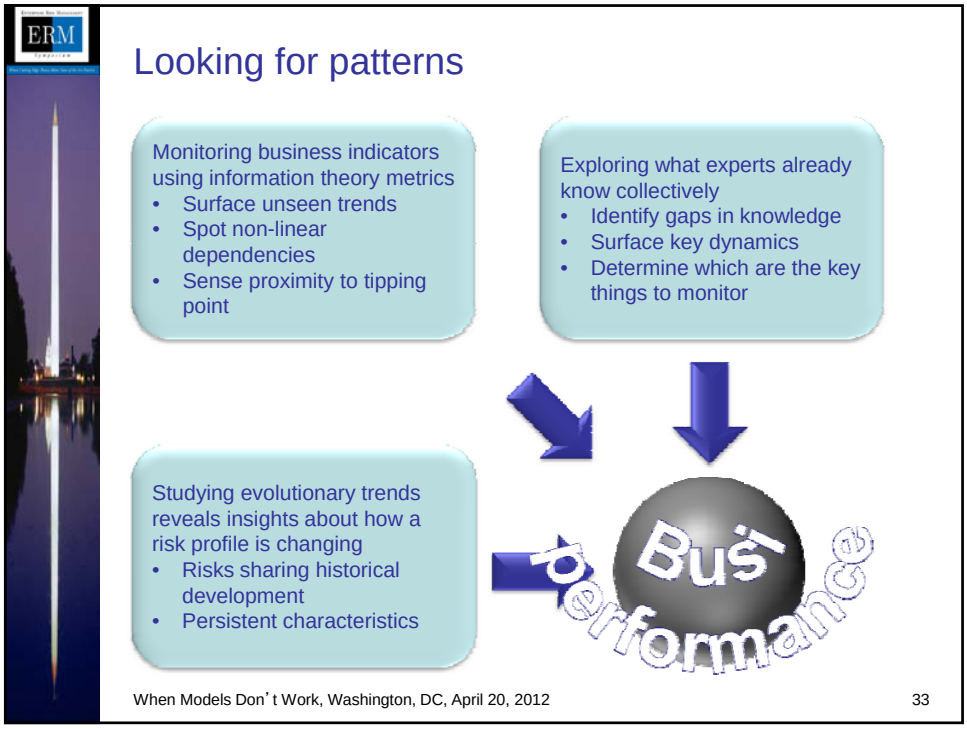
- Complex risks more difficult
  - Visible factors may not yet be obviously linked to risk outcomes
  - Adaptation makes it hard to adjust monitoring to maintain focus



Applying Systems to Emerging Risk

- Need to understand the system mechanism
- How does your company produce risk?
- Need to know the interacting factors and their dynamics




ERM
Looking for patterns
Monitoring business indicators using information theory metrics
• Surface unseen trends
• Spot non-linear dependencies
• Sense proximity to tipping point
Exploring what experts already know collectively
• Identify gaps in knowledge
• Surface key dynamics
• Determine which are the key things to monitor
Studying evolutionary trends reveals insights about how a risk profile is changing
• Risks sharing historical development
• Persistent characteristics
Bust
Performance
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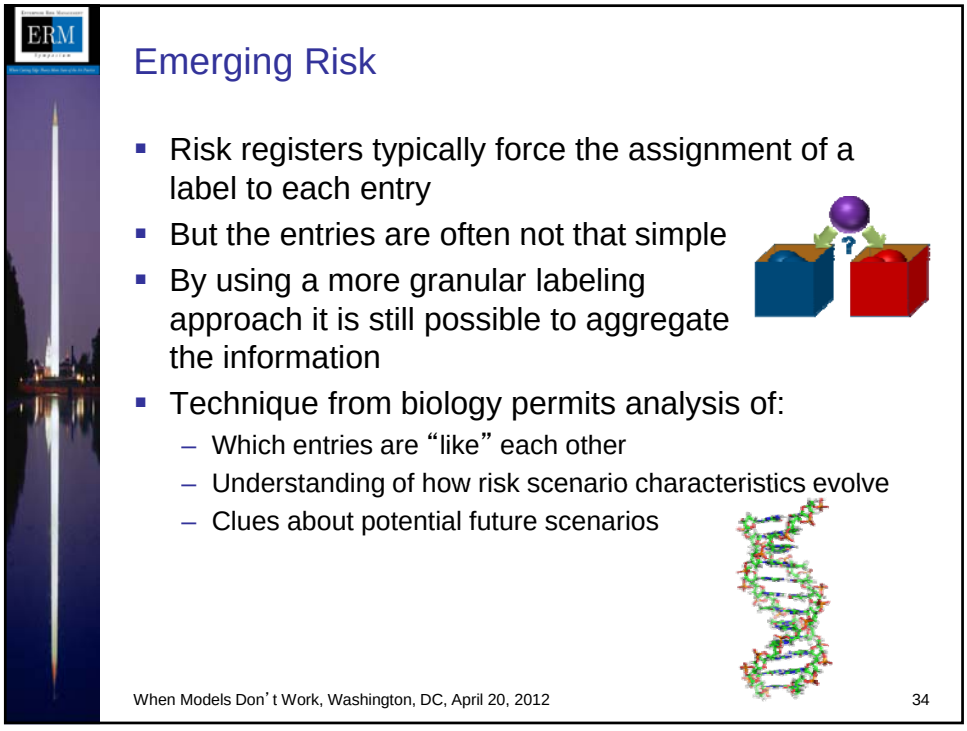
ERM
Emerging Risk
▪ Risk registers typically force the assignment of a label to each entry
▪ But the entries are often not that simple
▪ By using a more granular labeling approach it is still possible to aggregate the information
▪ Technique from biology permits analysis of:
– Which entries are "like" each other
– Understanding of how risk scenario characteristics evolve
– Clues about potential future scenarios
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An overview of Evolutionary Risk Approach

- Enterprise risk as an evolutionary process
- How can we model the risk evolution process
- What insight can evolution of risks provide
  - A rigorous classification system with relationships
  - A guide to emerging, dynamic and systemic risks
  - A unique organizational risk lineage

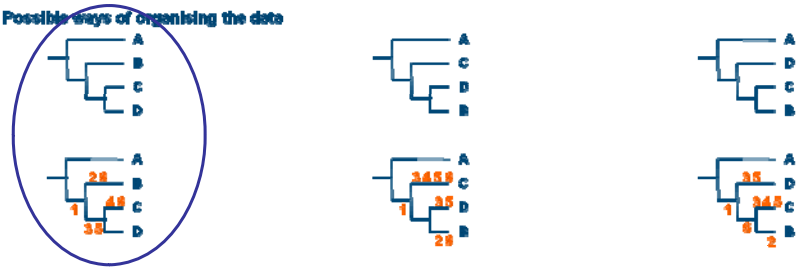
Overview of Cladistics and Phylogeny

- This methodology identifies small groups of highly related risks which share a common ancestor
- The evolutionary history of each of these groups can then be accurately traced
- Then their relation to other groups investigated
- By understanding the phylogeny of the risks we can:
  - Determine where evolution is most prolific
  - Detail path dependency and co-evolution of risk
  - Identify the most active characteristics to manage
  - Create focused scenarios for emerging risk modelling

Cladistic approach

Scenario	Characteristics					
	1	2	3	4	5	6
A	N	N	N	N	N	N
B	Y	Y	N	N	N	Y
C	Y	N	Y	Y	Y	Y
D	Y	N	Y	N	Y	N

Possible ways of organising the data



Most parsimonious solution

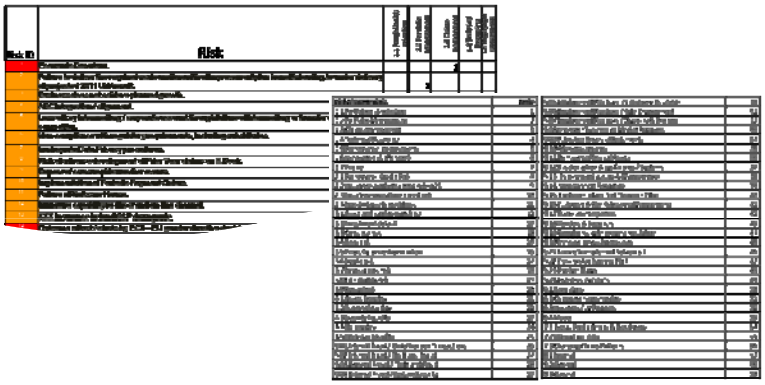
Leverages Existing Information

- Typical risk register asks for single classifier

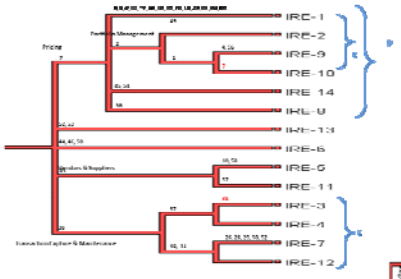
Risk Characteristic	Code
1.1 Portfolio risk selection	1
1.2 Portfolio Management	2
1.3 Claims management	3
1.4 Technical Reserving	4
1.5 Reinsurance arrangements	5
1.6 Longevity risk: Pricing	6
1.7 Pricing	7
2.1 Reinsurance Credit risk	8
2.2 Insurance underwriting credit risk	9
2.3 Insurance operations credit risk	10
2.4 Investment assets credit risk	11
3.1 Asset and liability matching	12
3.2 Investment default	13
3.3 Currency risk	14
3.4 Basis risk	15
3.5 Property price depreciation	16
3.6 Liquidity risk	17
3.7 Interest rate risk	18
3.8 Commodity risk	19
3.9 Spread risk	20
4.1 Assets liquidity	21
4.2 Funding liquidity	22
4.3 Liability liquidity	23
4.4 FX liquidity	24
4.5 Intra-day liquidity	25
5.01 Internal fraud / Unauthorised Transactions	26
5.02 Internal fraud / Theft and Fraud	27
5.03 External Fraud / Theft and Fraud	28
5.04 External Fraud / System Security	29
5.05 Employment Practices / Employee Relations	30
5.06 Employment Practices / Safe Environment	31
5.07 Employment Practices / Diversity & Discrim.	32
5.08 Improper Business or Market Practices	33
5.09 Published Financial Statements	34
5.10 Advisory activities	35
5.11 Damage to Physical Assets	36
5.12 Disruption & system failures / Systems	37
5.13 Transaction Capture & Maintenance	38
5.14 Monitoring & Reporting	39
5.15 Customer Intake and Documentation	40
5.16 Customer & Client Account Management	41
5.17 Trade counterparties	42
5.18 Vendors & Suppliers	43
5.19 Compliance with existing regulation	44
5.20 Increase in regulatory costs	45
5.21 Failure to implement Solvency II	46
5.22 Over-water Funding MCR	47
5.23 Product Flaws	48
5.24 Expenses overruns	49
6.1 Regulations	50
6.2 Corporate responsibility	51
6.3 Investors / IV Partners	52
6.4 Media	53
7.1 Legal, Political Tax & Regulatory	54
7.2 Macro-Economic	55
7.3 Changing Claims Patterns	56
8.1 Internal	57
8.2 External	58
8.3 General	59

Leverages Existing Information

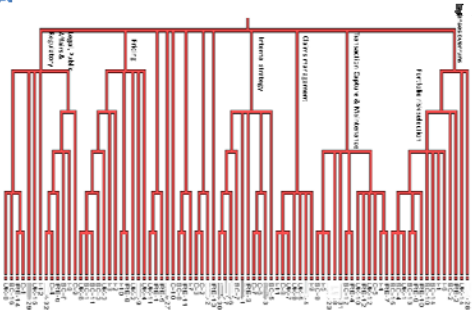
- The technique builds on (enhanced) risk register info
- Simply extend range of characteristic classifiers



Evolutionary Risk Profile

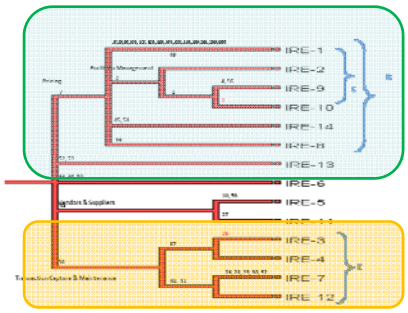


We can identify risks which share similarities, common evolutionary paths and identify clues about future development



Risks can be studied for a part of the company, or the whole

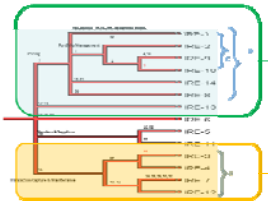
Evolutionary Risk Profile



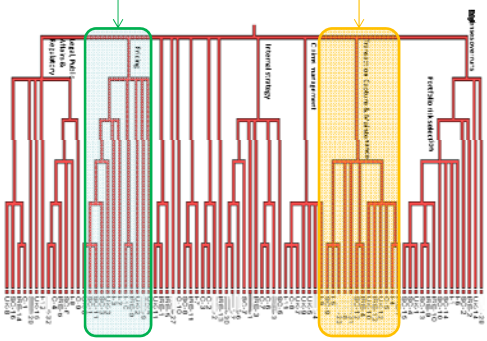
All of these relate to pricing

All of these relate to servicing

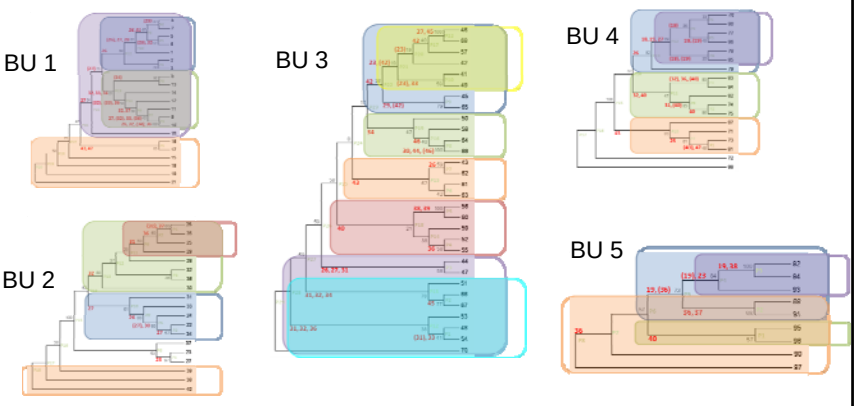
Evolutionary Risk Profile



We can see that these themes are common across the group but other themes such as strategy, legal and expense are potentially bigger issues



Risk Profile

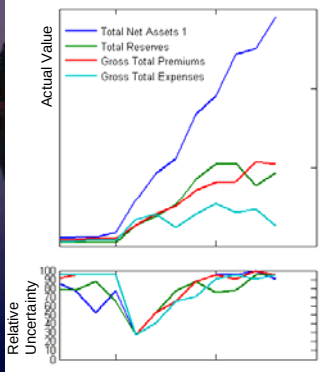


Interpreting Evolutionary Properties

- Look at tree shape
  - areas of cascading bifurcation are likely areas for more evolution and therefore emerging risks
- Identify branches that have the most characters/adaptation
  - They are more likely to adapt again
- Find characters that evolve most frequently
  - Is there a character or pattern that is responsible?
- Are any risks/branches losing characters, ask why?
  - Risks should generally increase in complexity
- Are there any characters gained in sequence/coevolution?
  - Understand this pattern as a possible clue to new risks

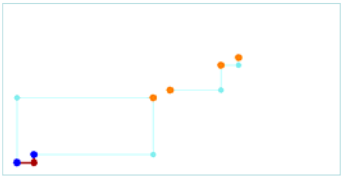
Complexity Analysis

- Monitoring performance measures you can see if they make sense or not. This company's growth seems to start making less sense after a while. Why?

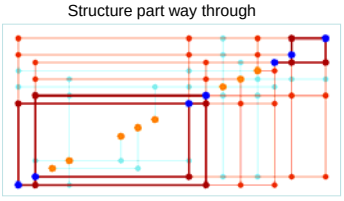


Complexity of performance increases dramatically which suggests that headline growth is not robust

Structure at start of growth

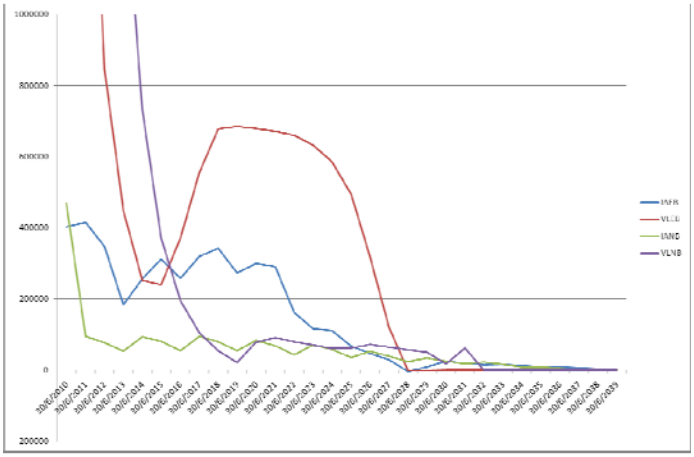


Structure part way through



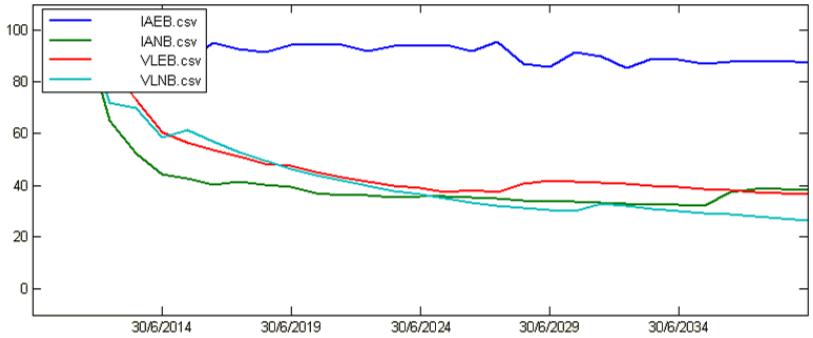
Complexity Analysis

- Which projection looks unusual?



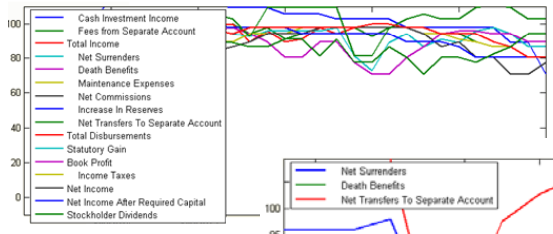
Complexity Analysis

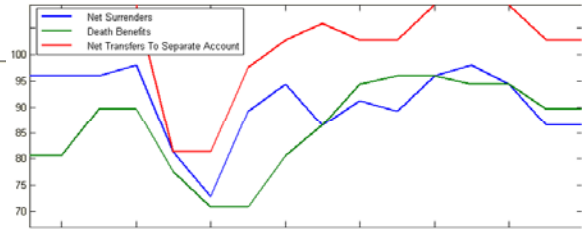
- The uncertainty of IAEB remains very high. Why?



Complexity Analysis

- We look at the components of IAEB's profit...



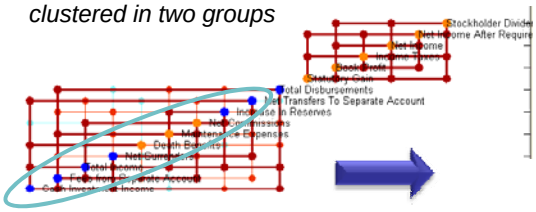


- We find that some follow a different trend – increasing uncertainty

Complexity Analysis

- We can look at how the variables are connected to explore further

Variables initially clustered in two groups



These variables no longer driving the performance

We later see an increased connection of "disbursements" to profit

Combining the perspectives

- The evolutionary analysis prompts questions:
  - Why does this characteristic show up a lot?
  - Why does this one often combine with that one?
  - Why does this business unit have very different characteristics to that one?
- The analysis of performance data prompts questions:
  - Why are these indicators linked to performance right now?
  - Why are these NOT linked to performance right now?
  - Why has the level of uncertainty in performance risen?
- The cognitive analysis prompts questions:
  - How could this dynamic cycle start?
  - How could an example of this area of the map occur?
  - Are we seeing examples of these triggers?

Summary

- Systems approach helps to study the complexity before making simplifications
- Helps to triangulate multiple insights (data, experts, etc.)
- Helps to incorporate adaptation and non-linearity
- Think of companies as a collection of people not machines
- Culture matters – you can't grow sunflowers in the shade
- Keep an open mind – ask real questions
- Focus on outcomes not just the "how"

Conclusions

- Models don't Work when the modelers fail to use systems thinking to make sure that the statistical models are looking at the right things
- Models are ineffective when the modelers do not realize that most people use Heuristics and Natural Decision Making to actually make their decisions

Questions?

Thank You

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