Causal Mapping for Auditors: Can AI Help?

Yves Genest

Portland , Ore. May 21st , 2019

CANADIAN AUDIT & ACCOUNTABILITY FOUNDATION

About the Canadian Audit and Accountability Foundation

- A premier research and education not-for-profit foundation
- We build capacity in legislative audit offices, oversight bodies, and departments and crown corporations by developing and delivering:
  - Training workshops and learning opportunities;
  - Methodology, guidance and toolkits;
  - Applied and advanced research;
  - Information sharing events and community building initiatives.

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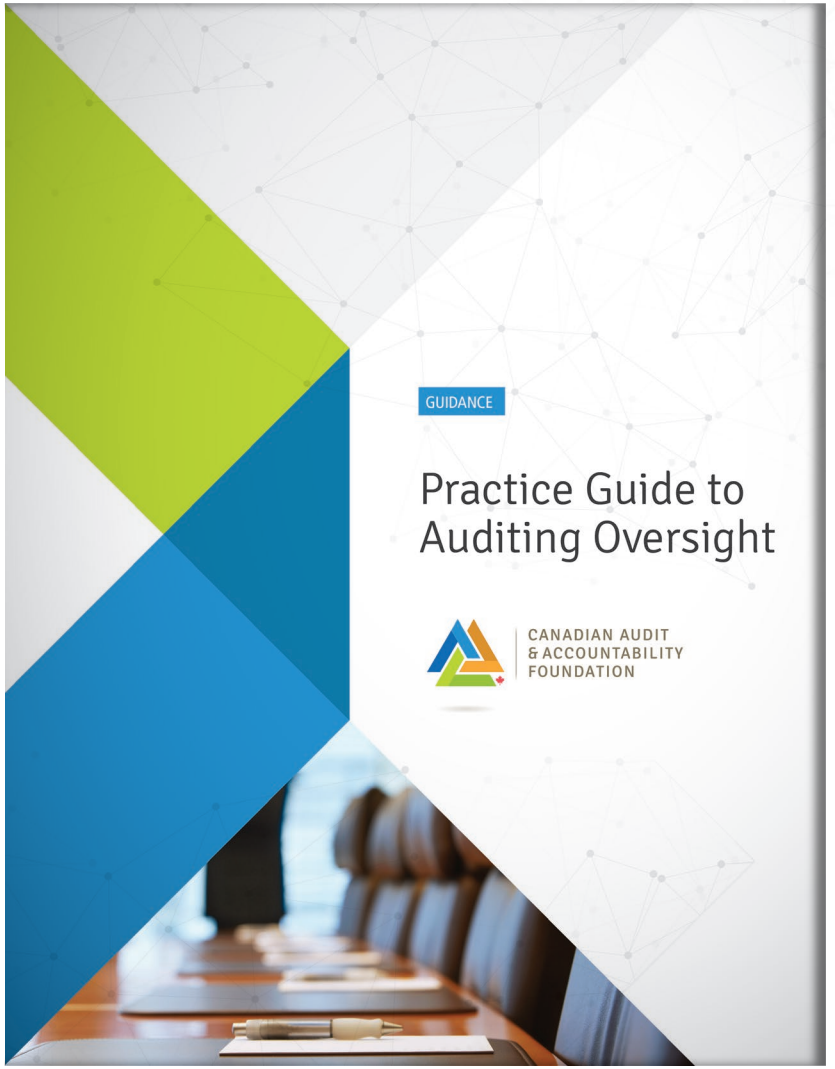
Practice Guides to Auditing …

- *… Efficiency*
- *… Oversight*
- *… Gender Equality*
- *… Oil and Gas Revenues and Financial Assurances for Site Remediation*
- *… Mining Revenues and Financial Assurances for Site Remediation*
- *… United Nations Sustainable Development Goals: Gender Equality*

Coming in 2019-2020

- *… Sampling*



WWW

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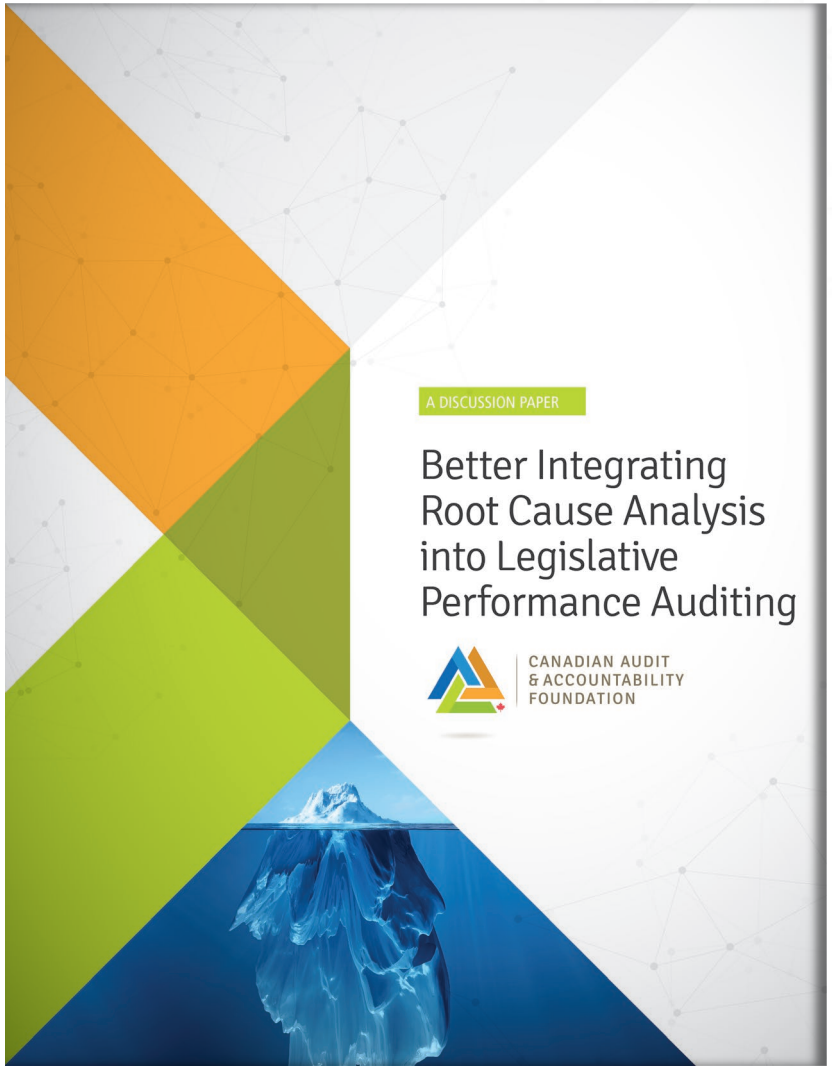
Discussion Papers

- *How to Increase the Impact of Environmental Performance Audits*
- *Better Integrating Root Causes Analysis into Legislative Performance Auditing*
- *Auditing Public-Private Partnerships*
- *Approaches to Audit Selection and Multi-Year Planning*
- *Impact of Performance Audit*

Coming in 2019-2020

- *Data Analytics*



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AUDIT NEWS

- Database containing 6,213 performance audits and other documents from 54 jurisdictions worldwide
- Search by audit institution, audit topics, management functions, and more… results in seconds

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New Products

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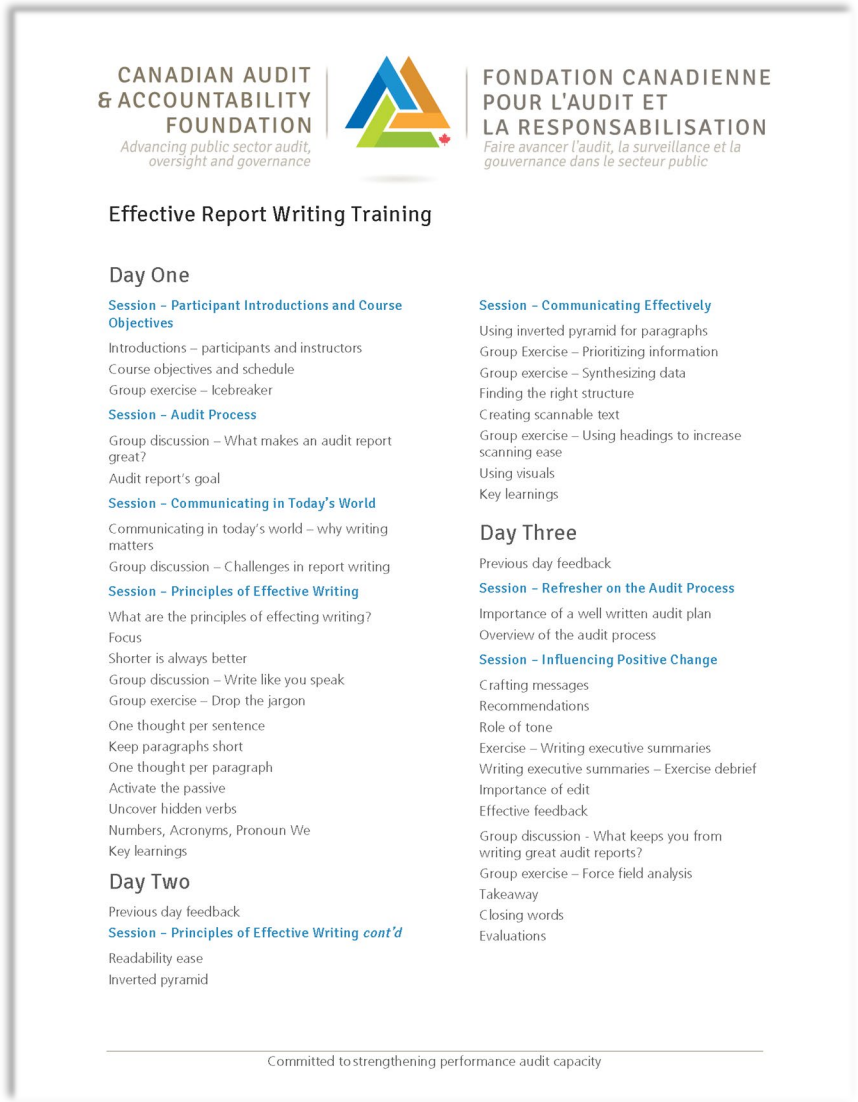

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Advancing public sector audit, oversight and governance

FONDATION CANADIENNE POUR L'AUDIT ET LA RESPONSABILISATION
Faire avancer l'audit, la surveillance et la gouvernance dans le secteur public

Effective Report Writing Training

Day One

Session – Participant Introductions and Course Objectives
Introductions – participants and instructors
Course objectives and schedule
Group exercise – Icebreaker

Session – Audit Process
Group discussion – What makes an audit report great?
Audit report's goal

Session – Communicating in Today's World
Communicating in today's world – why writing matters
Group discussion – Challenges in report writing

Session – Principles of Effective Writing
What are the principles of effecting writing?
Focus
Shorter is always better
Group discussion – Write like you speak
Group exercise – Drop the jargon
One thought per sentence
Keep paragraphs short
One thought per paragraph
Activate the passive
Uncover hidden verbs
Numbers, Acronyms, Pronoun We
Key learnings

Day Two

Previous day feedback
Session – Principles of Effective Writing *cont'd*
Readability ease
Inverted pyramid

Session – Communicating Effectively
Using inverted pyramid for paragraphs
Group Exercise – Prioritizing information
Group exercise – Synthesizing data
Finding the right structure
Creating scannable text
Group exercise – Using headings to increase scanning ease
Using visuals
Key learnings

Day Three

Previous day feedback
Session – Refresher on the Audit Process
Importance of a well written audit plan
Overview of the audit process
Session – Influencing Positive Change
Crafting messages
Recommendations
Role of tone
Exercise – Writing executive summaries
Writing executive summaries – Exercise debrief
Importance of edit
Effective feedback
Group discussion - What keeps you from writing great audit reports?
Group exercise – Force field analysis
Takeaway
Closing words
Evaluations

Committed to strengthening performance audit capacity

Our suite of classroom training workshops…

- *Fundamentals of Performance Audit*
- *Advanced Performance Audit*
- *Evidence Collection and Analysis*
- *Effective Report Writing*

Coming in 2018-2019

- *Root Cause Analysis*
- *Auditing Gender Equality*

Webinars…

- *Oversight in the Public Sector – A Webinar on Auditing Board Oversight (English and French)*
- *Auditing P3s*

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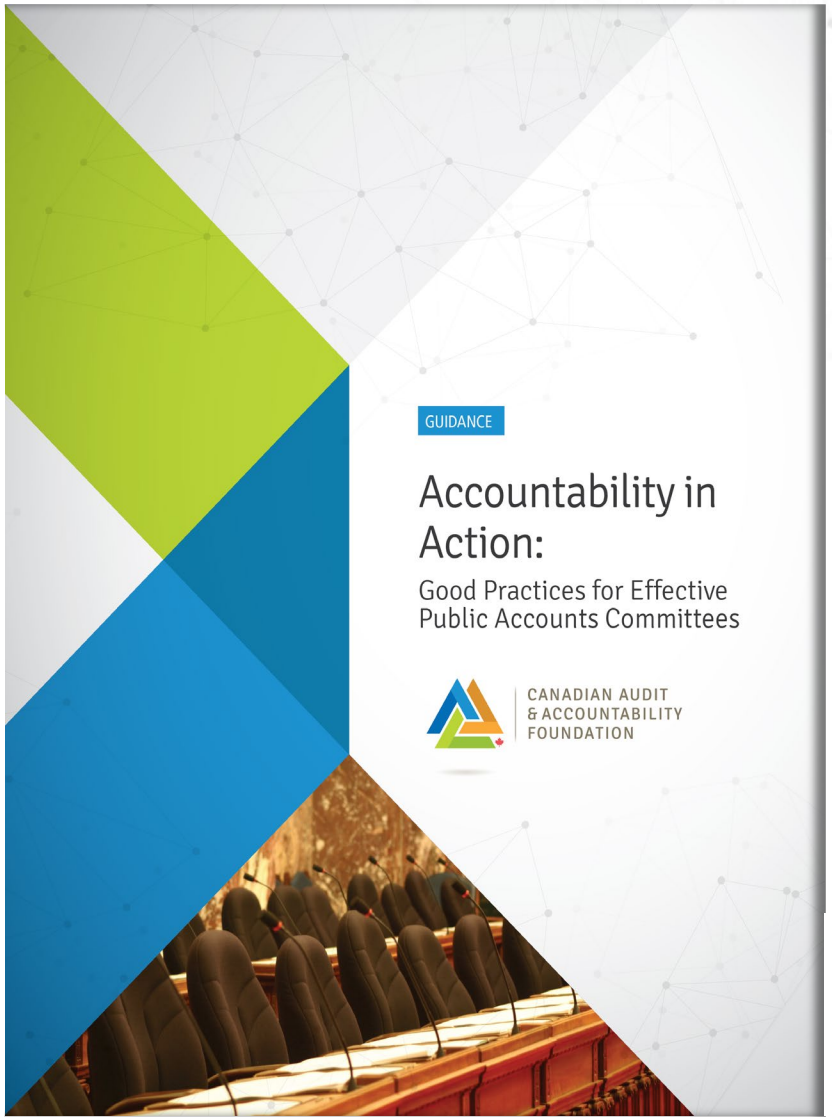
Oversight Research

- *Accountability in Action: Good Practices for Effective Public Accounts Committees*
- *Building and Sustaining Effective Auditor General–Public Accounts Committee Relationships*
- *Sharing International Practices – A Profile of the legislative oversight committee in Scotland*
- *Parliamentary Oversight – Committees and Relationships*
  - *A Guide to Strengthening Public Accounts Committees*
  - *Attributes of an Effective Public Accounts Committee*
  - *Guide for Witnesses*
  - *Guidance on Reporting and Follow-up*
  - *Preparation for Hearings & Frequently Asked Questions*



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Oversight Training for Members of Public Accounts Committees

- What is the role of a Public Accounts Committee?
- Reading and understanding audit documents.
- Cross-Jurisdictional comparison of best practices
  - ❖ Planning
  - ❖ Hearings
  - ❖ Constructive Partisanship
  - ❖ PAC- AG relations
- Developing Effective Questions
- Effective Follow-up on recommendations
- Self-Assessment

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A rich history of developing capacity for performance auditors *(2016-2017 and since 1980)*

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What We Will Cover Today

- What is root cause analysis and how is it relevant and useful to auditors
- Introducing an exploration of the development of a technical solution to causal mapping
- Further improvements and ideas

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What is Root Cause Analysis?

- Root cause analysis is an approach to understanding why something happened or how a situation developed, whether it is an industrial accident, a defective product, or a program deficiency.
- It can also be used to drive efficiency, eliminate waste, or improve business processes.
- Root cause analysis is not a single methodology; rather, it encompasses a body of qualitative and quantitative tools and techniques.
- It is applied in a wide range of settings, such as accident investigation, risk analysis, business process improvement, change management, and quality control.

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Root Cause Analysis in Public Sector Auditing – Common Audit Findings

- Lack of compliance with rules or policies,
- Results not being achieved as intended
- Risks not being evaluated and managed
- Strategies not being developed or followed
- Activities and actions of key players are poorly coordinated or their roles are not clear
- Missing data or information to measure program results or to support decisions
- Inefficient or wasteful processes.

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The Argument in Favor of Undertaking Root Cause Analysis

- Develop audit recommendations aimed at correcting the underlying causes of the reported finding or deficiency.
- Design lasting solutions so as to avoid repetition, report after report, of the same audit finding.
- Other potential benefits include:
  - providing insight and explanation for audit findings
  - assessing whether recommendations are necessary or relevant prior to reporting
  - helping the auditee appreciate that the auditors understand the situation, and
  - contributing to more effective use of government resources in addressing identified weaknesses.

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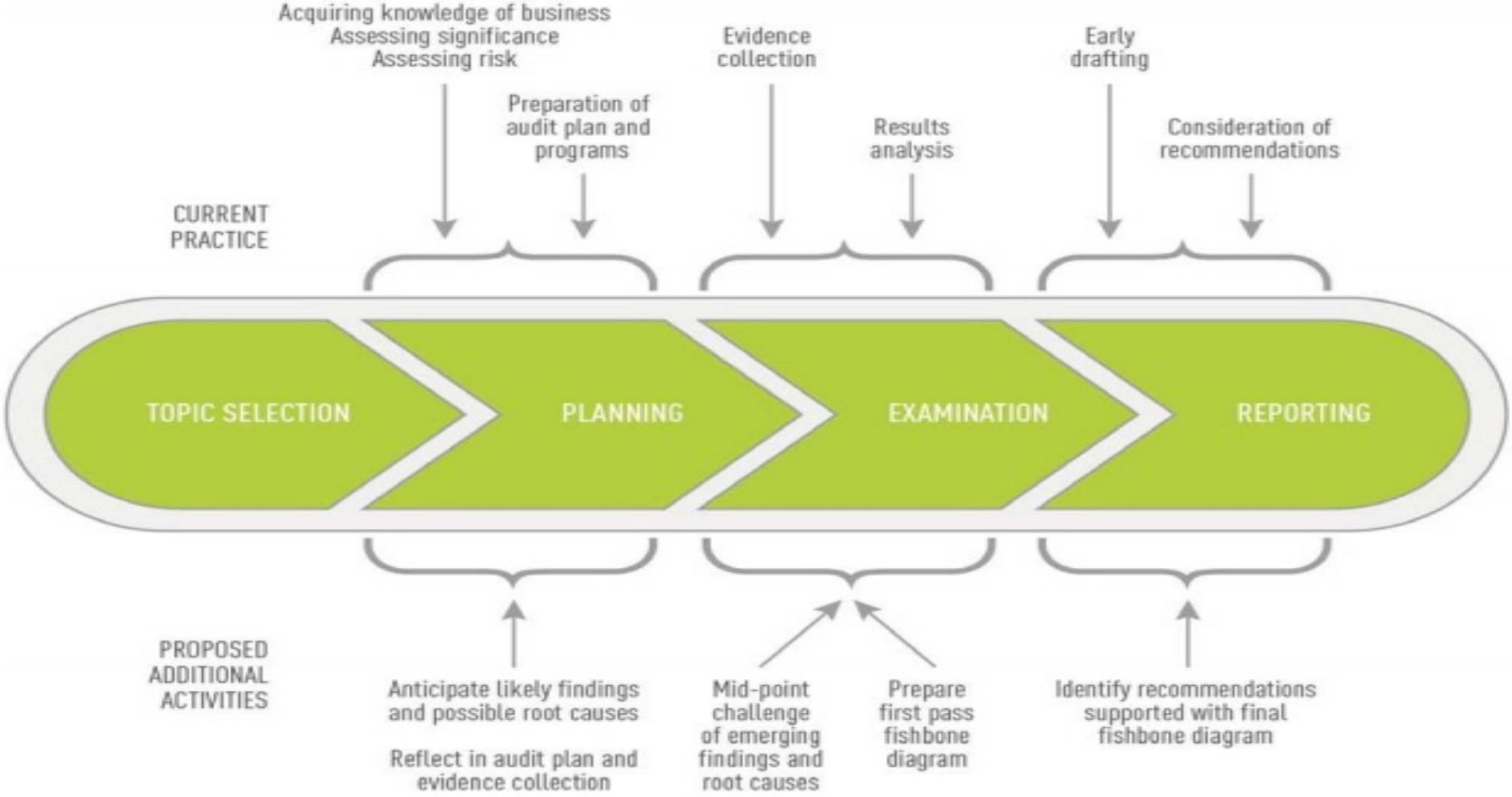
RCA and the Audit Process



The Burning Question of Why?

- Often the types of audit findings (that we just discussed) are symptoms or manifestations of much deeper, more systemic factors.
- Analyzing the underlying—or root—causes of observed deficiencies helps to delve below the surface, beyond the symptom, to answer these “why?” questions.

The “Five Whys” Technique

- Invented in the 1930s and made popular in the 1970s by the Toyota Production System, the Five Whys is a technique often used in cause analysis.
- As the name implies, this technique involves asking the question “Why?” five times about a given event, problem, or significant performance audit finding.
- The theory suggests that the answer to the fifth “Why?” is usually pretty close to the root cause. (It could take fewer than or more than five). The Five Whys technique helps to separate the symptoms from the causes of a problem.

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The “Five Whys” Technique - Example

- **Significant Finding**: the fleet of vehicles did not meet the availability target
- ***Why?*** The vehicles were often not available due to mechanical problems
  - ***Why?*** Not enough technicians are on site to do all the necessary maintenance and repairs
    - ***Why?*** Too few technicians have completed the training program in recent years.
      - ***Why?*** Not enough instructors to provide the required training
        - ***Why?*** Many instructors retired the same year and there was no succession plan or recruitment strategy
- **Recommendation** (*aimed at symptom*): The entity should ensure that the fleet of vehicles meets availability targets.
- **Recommendation** (*aimed at cause*): the entity should establish a succession plan and recruitment strategy for instructors and technicians to support maintenance activities

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Part Art / Part Science – Professional Judgement Required

- Findings and causes can be “exchangeable” in the sense that what is considered a root cause in one audit could be considered a significant finding in another audit, depending on the specific objective and criteria.
- For example, in one audit, “weak governance processes” could be the cause of a significant finding related to a “lack of planning.” In another audit, a “lack of planning” could be the cause for a significant finding related to “late and over-budget project delivery.”

Part Art / Part Science – Professional Judgement Required

- For any given significant finding, there could be multiple and interrelated causes, particularly in audits addressing complex topics involving several entities or sectors. This could complicate the task of determining attribution to specific causes.
- In a public sector environment, the causes of significant audit findings may be traced back to the merits of policy, the absence or adequacy of legislation, a lack of political prioritization, or the adequacy of resources. It would be up to each audit office to determine whether, and how, to report on such root causes.

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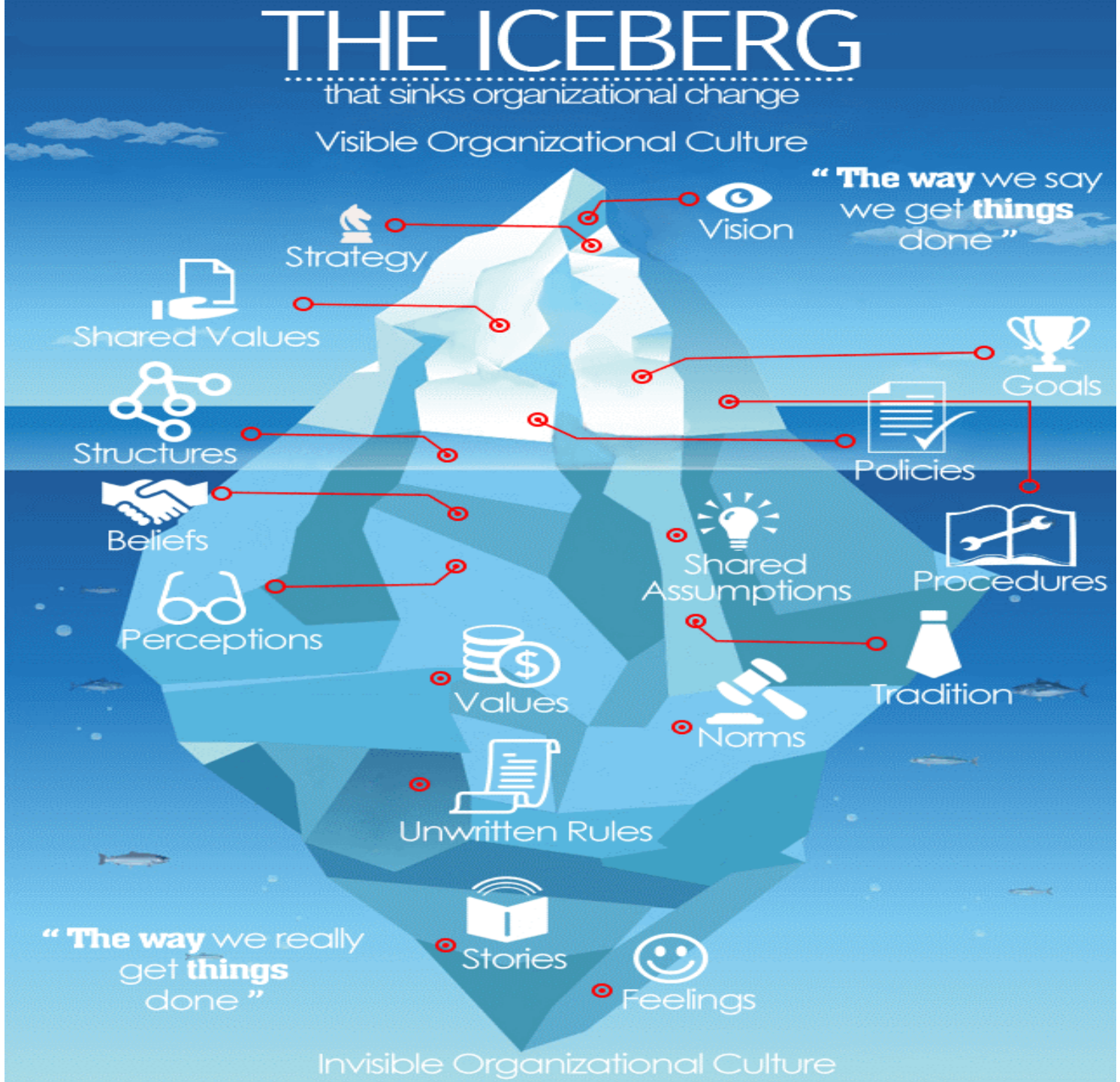

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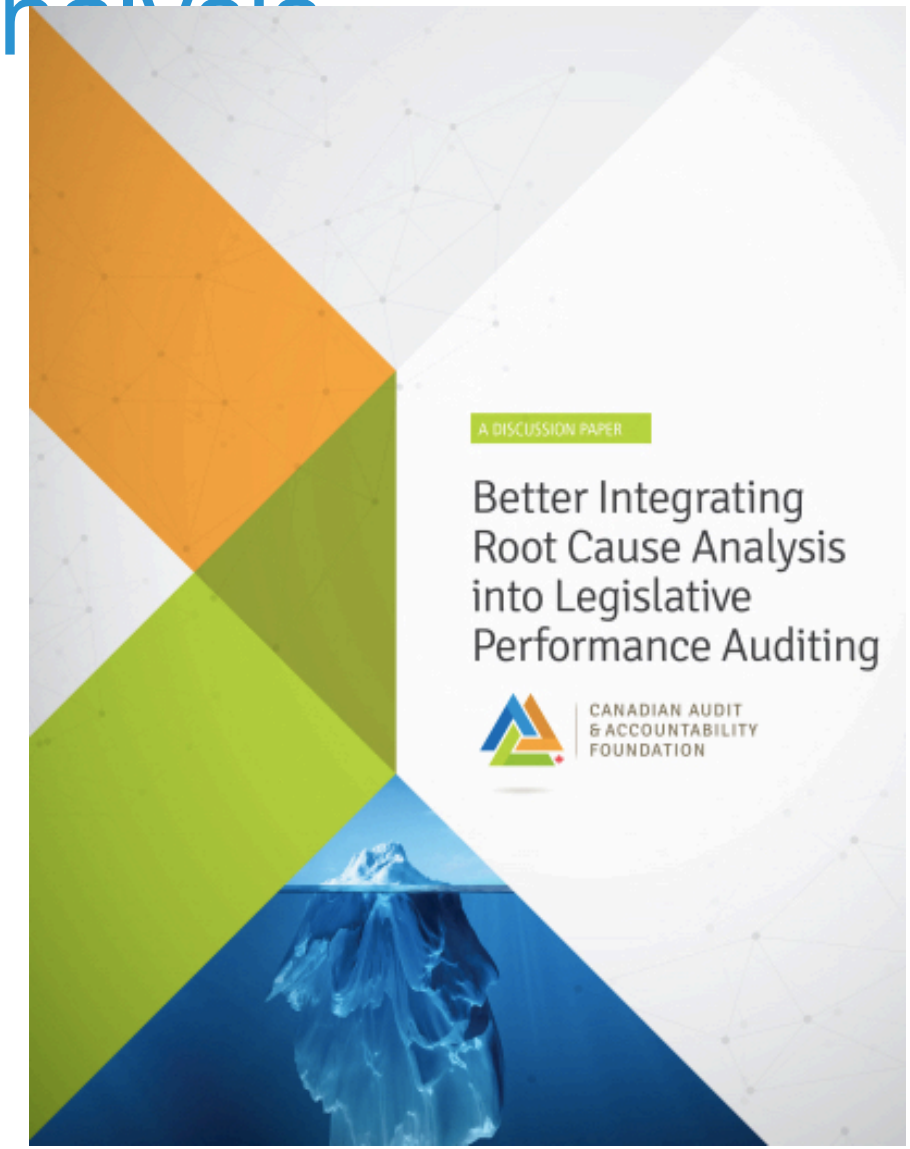
CAAF Discussion Paper on Root Cause Analysis



BETTER INTEGRATING ROOT CAUSE ANALYSIS IN AUDITS

Available for free on our website

www.caaf-fcar.ca

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Financial loss – known vs unknown

What we see & know
~$200B annually

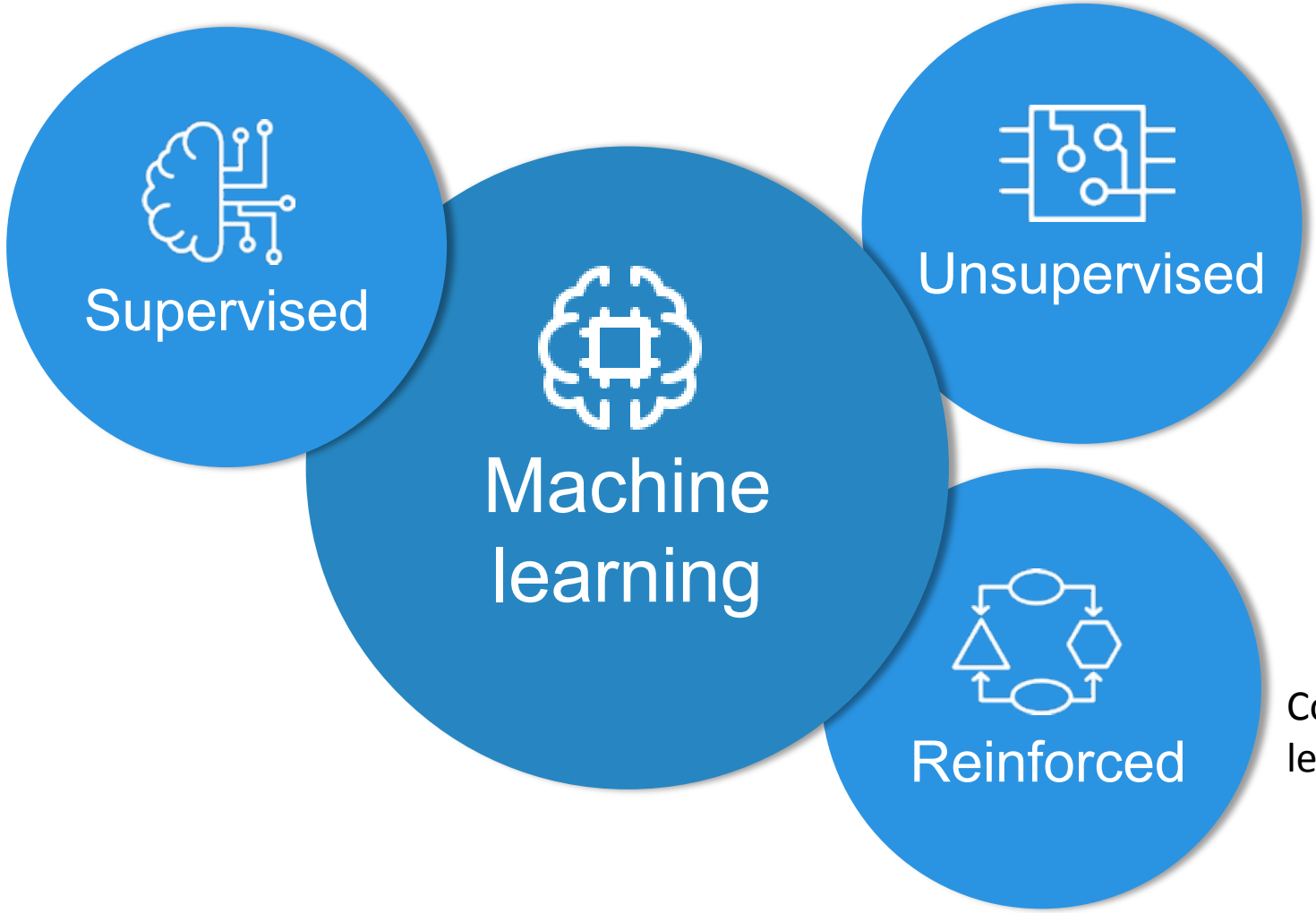
Financial loss due to human error or by intent is surging **~$4T** annually

"To place this in context, the 2017 estimated Gross World Product was USD $79.6 trillion. A total global fraud loss of nearly USD $4 trillion represents 5% of the Gross World Product"

Source: Association of Certified Fraud Examiners, Institute of Internal Auditors

What is Machine Learning?

Human expert feeds the computer



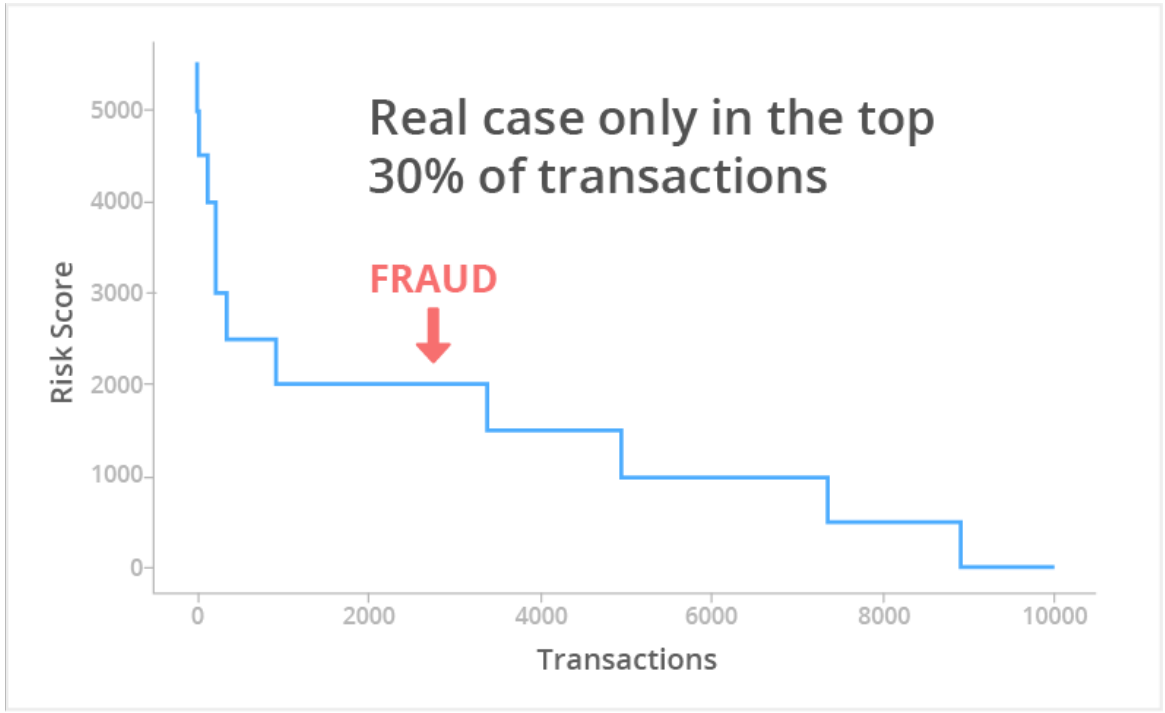
No expert input, computer identifies patterns in data

Computer continuously learns from the environment

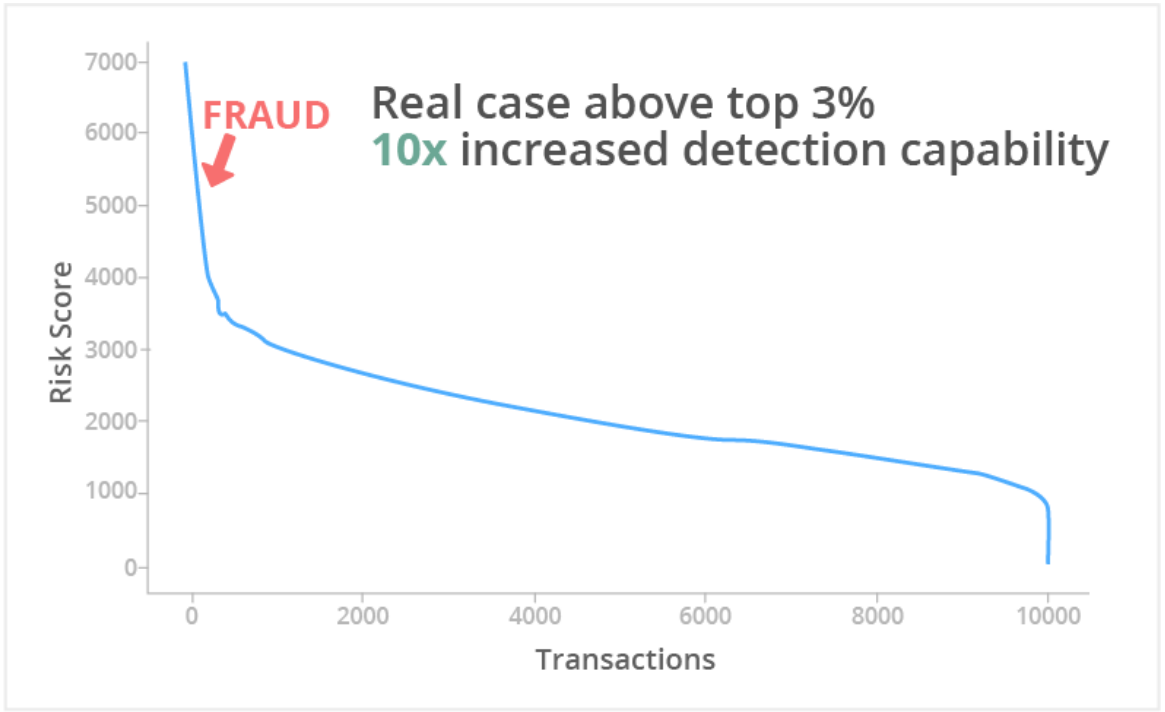
MindBridge

Comparison: Old rules versus machine learning

Rules alone: Ranked Risk Score



Machine learning: Ranked Risk Score



MindBridge

What is Deep Learning and NLP?

- Deep Learning is a type of machine learning that is based on data representations (instead of traditional task based algorithms)
- Inspired by the patterns used by biological systems
- Natural Language Processing (NLP) is a field of AI concerned with interactions between machines and human (natural) languages
- Early definition defined by Alan Turing and his “Turing Test” criteria
- Later advanced by Noam Chomsky as part of his linguistics work

How Can a Computer Read English?

London is the capital and most populous city of England and the United Kingdom. Standing on the River Thames in the south east of the island of Great Britain, London has been a major settlement for two millennia. It was founded by the Romans, who named it Londinium. London's ancient core, the City of London, largely retains its 1.12-square-mile (2.9 km2) medieval boundaries.

Source: https://medium.com/@ageitgey/natural-language-processing-is-fun-9a0bff37854e

Building the NLP Pipeline

- Sentence segmentation
- Word tokenization
- Predicting parts of speech
- Text lemmatization (pony vs. ponies)
- Identifying stop words (noise)
- Dependency parsing (how words relate to each other)
- Named entity recognition
- Coreference resolution (dealing with pronouns)

Word Embedding → Adjacency Matrix

"The cat in the hat":

	the	**cat**	**in**	**hat**
the	-	1	1	1
cat	1	-	1	0
in	1	1	-	0
hat	1	0	0	-

Convolution Technology for Text

“Great green dragons are attacking the poor peasant village.”

3-wide window:

“Great green dragons”

“Dragons are attacking”

“Attacking the poor”

“Poor peasant village”

5-wide window:

“Great green dragons are attacking”

“attacking the poor peasant village”

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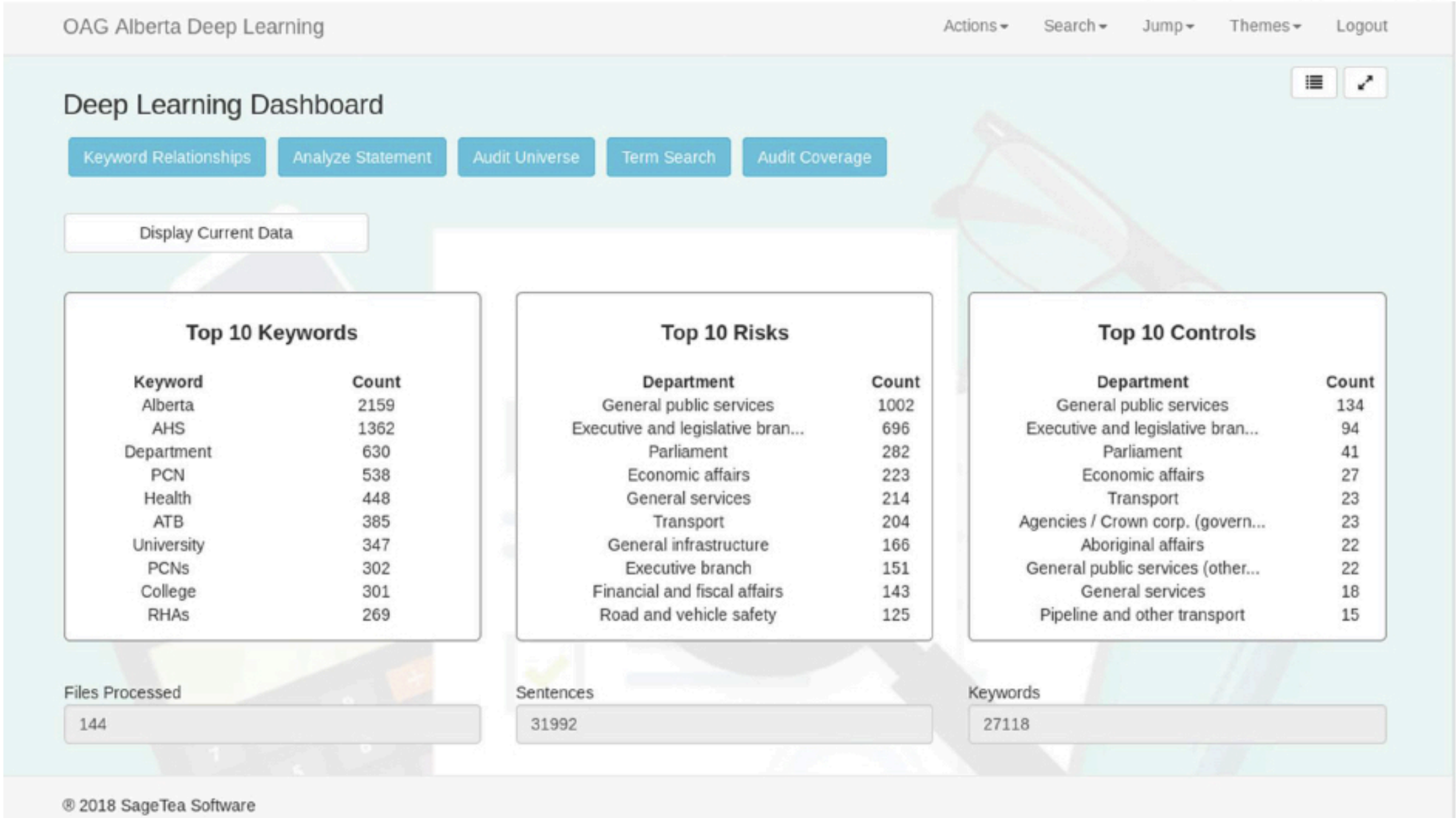
Main Categories of Possible Root-Causes

- Governance-related
  - Authority
  - Process and Planning
  - Oversight and performance reports
- Operations-related
  - People
  - Assets
  - Delivery
  - Culture

The Deep Learning Dashboard

- “Trained” by Canadian Federal Government Auditors
- Identifies risks and controls and connects them with the audit universe
- Maps key sentences and keywords relationships
- Based on open-source technology



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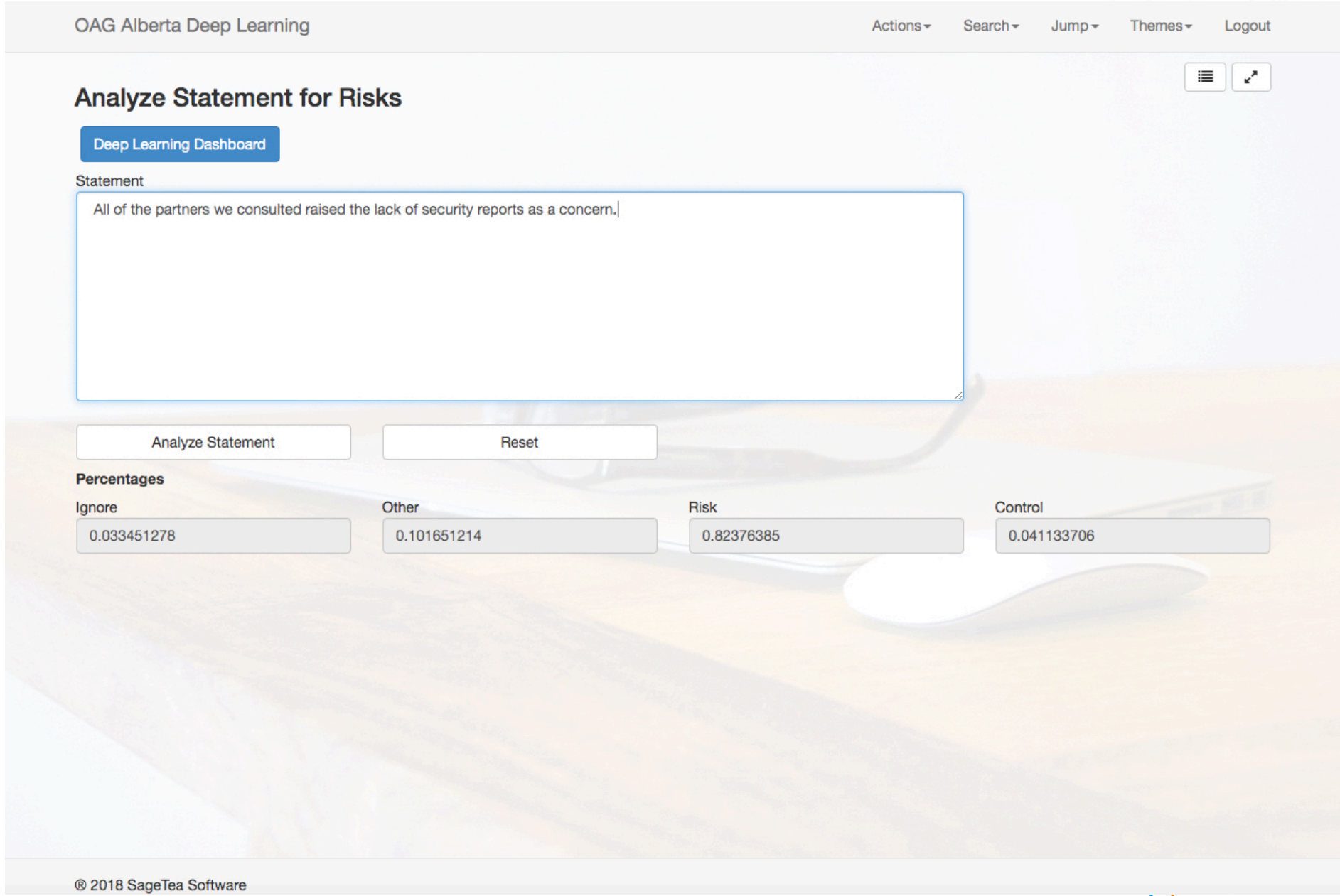

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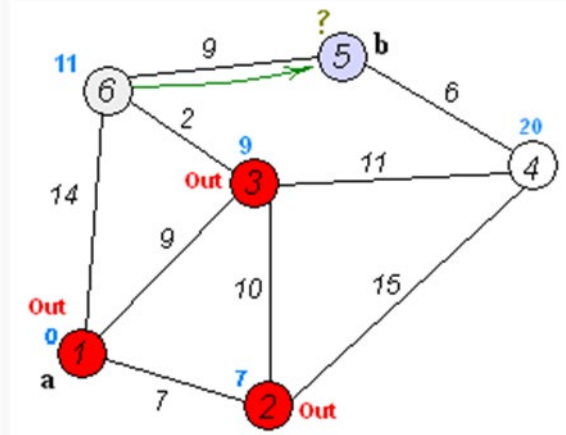
How Our Technical Solution Works

Dijkstra's algorithm



Dijkstra's algorithm to find the shortest path between *a* and *b*. It picks the unvisited vertex with the lowest distance, calculates the distance through it to each unvisited neighbor, and updates the neighbor's distance if smaller. Mark visited (set to red) when done with neighbors.

Class	Search algorithm
Data structure	Graph
Worst-case performance	$O(\|E\| + \|V\| \log \|V\|)$

+

Deep Learning of a Provincial Audit Reports on Risks & Controls

=

RCA

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How Dijkstra's Algorithm Works

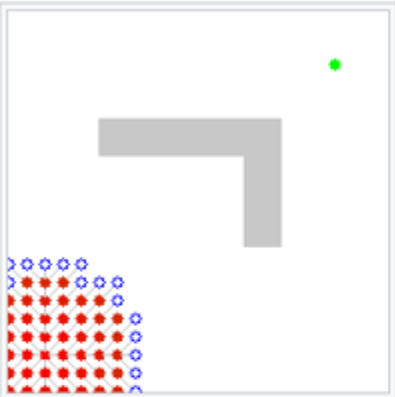
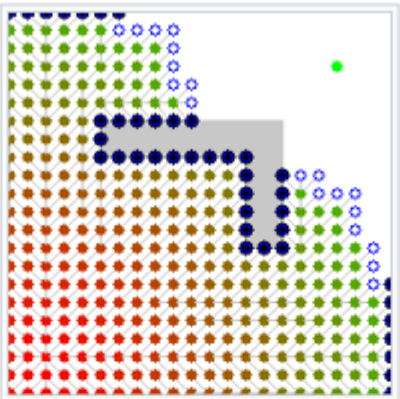


Illustration of Dijkstra's algorithm finding a path from a start node (lower left, red) to a goal node (upper right, green) in a robot motion planning problem. Open nodes represent the "tentative" set (aka set of "unvisited" nodes). Filled nodes are visited ones, with color representing the distance: the greener, the closer. Nodes in all the different directions are explored uniformly, appearing more-or-less as a circular wavefront as Dijkstra's algorithm uses a heuristic identically equal to 0.



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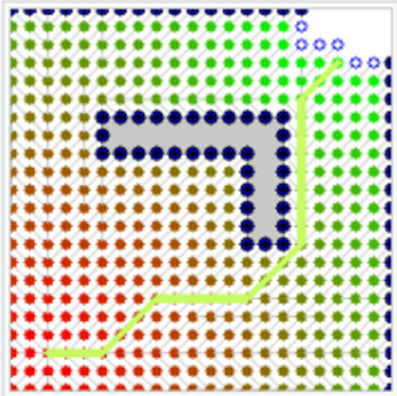

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In operation, Dijkstra's Algorithm behaves like an expanding wave front, which moves outwards until it finds the target (shown as the green dot). Once the target is detected Dijkstra's Algorithm completes and has found the shortest path from the origin to the target.

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How We Use Dijkstra with Deep Learning

1. Performing a Root Cause Analysis (RCA) is essentially a graph traversal problem once you have established the nodes and edges. We do this using **Dijkstra's Algorithm and Deep Learning**.
2. In this case, the **graph nodes** are the statements about risks, controls or other types of statements and the edges are the known relationships between them
3. The edges of the graphs are the relationships between the statements as defined through deep learning. The values on these **edges** are **probabilities** – generated through **Deep Learning**. These define parameters such as the likelihood that one statement is a source of risk to another.

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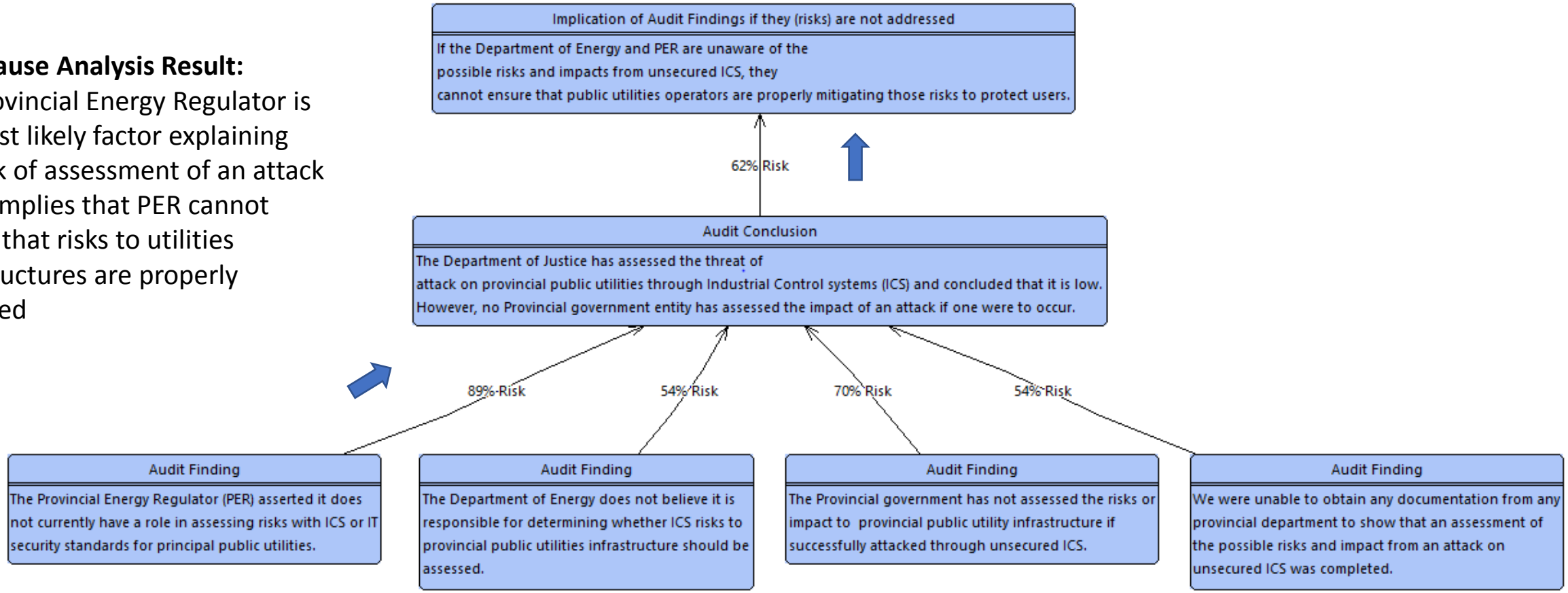
Features of this application of Dijkstra to RCA

- The standard assumption in Dijkstra's Algorithm is there is a known "start" and an "end" find the shortest path between two nodes.
- For RCA, we do not know the final root cause.
- To achieve this, we define conditional filters which tell Dijkstra's Algorithm how to know when it should stop. (Ultimately the root cause of something can go all the way to the origin of the universe and the "big bang".)
- Realistically, what we want to achieve is a sufficient depth of Root Cause Analysis for Audit purposes. This also provides a framework for dynamic filters which serve as "lenses" through which an auditor can analyze the root causes.
- We therefore apply the **"Five Ways" technique** to provide "lense" for the algorithm to focus on in this application.

References:
Edsger W. Dijkstra @ 1956 (Published Dijkstra's Algorithm in 1959
Related Diagrams from Wikipedia

Summary of our Results

Root Cause Analysis Result:
The Provincial Energy Regulator is the most likely factor explaining the lack of assessment of an attack which implies that PER cannot ensure that risks to utilities infrastructures are properly mitigated



References:
Edsger W. Dijkstra @ 1956 (Published Dijkstra's Algorithm in 1959
Related Diagrams from Wikipedia

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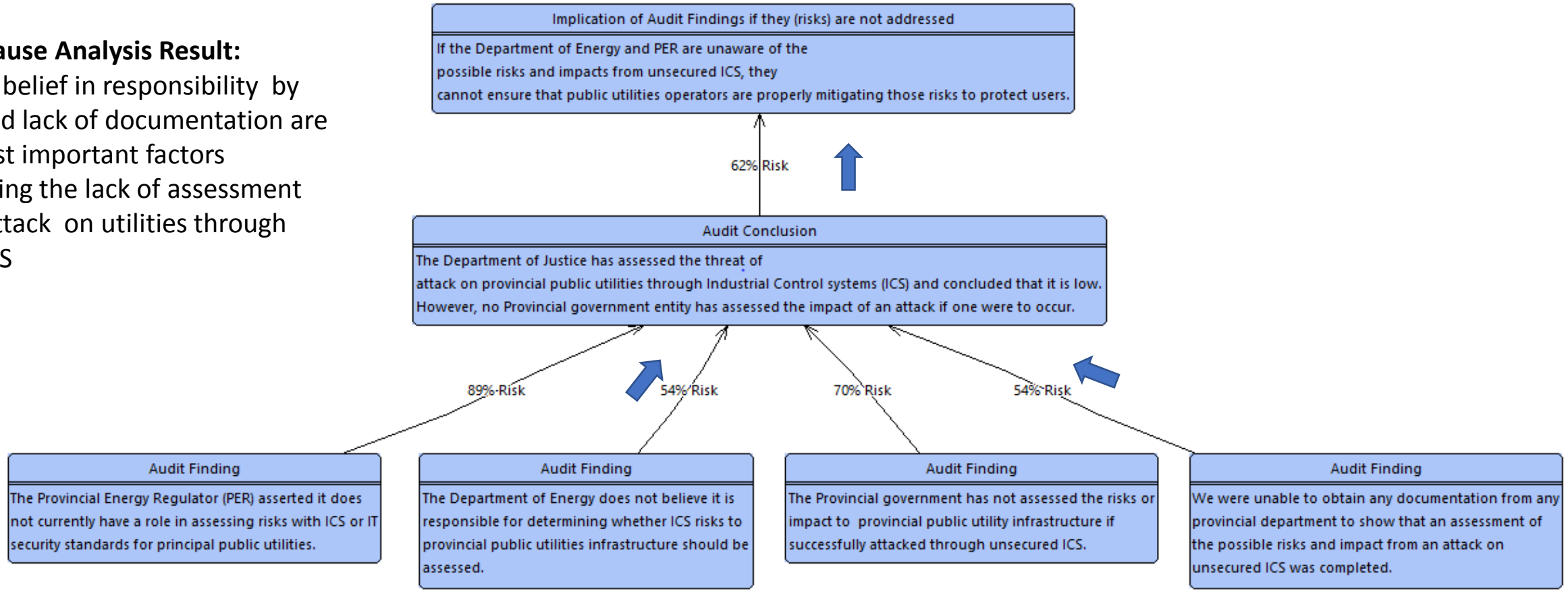
Summary of our Results

Root Cause Analysis Result:
Lack of belief in responsibility by DOE and lack of documentation are the least important factors explaining the lack of assessment of an attack on utilities through their ICS



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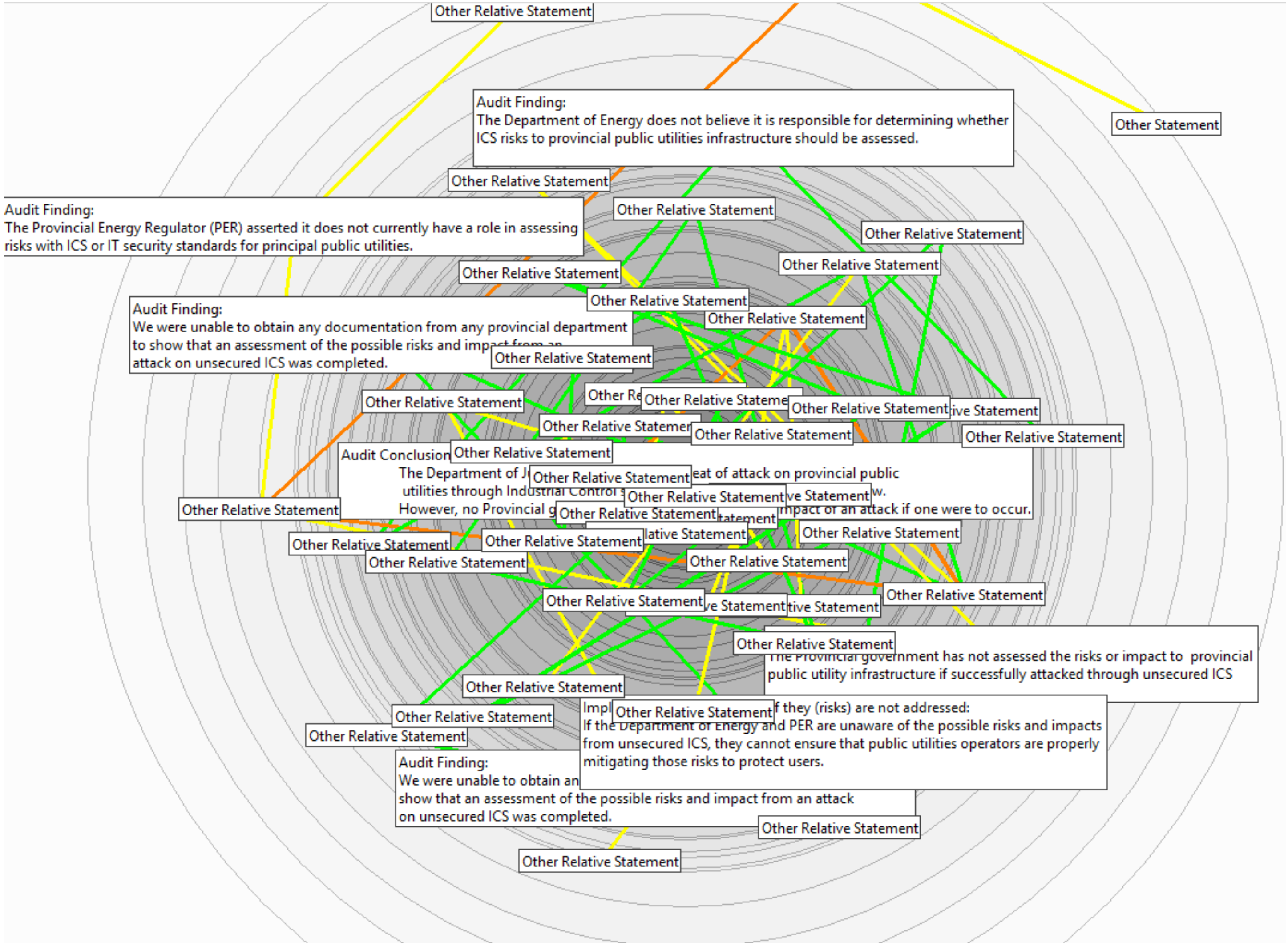
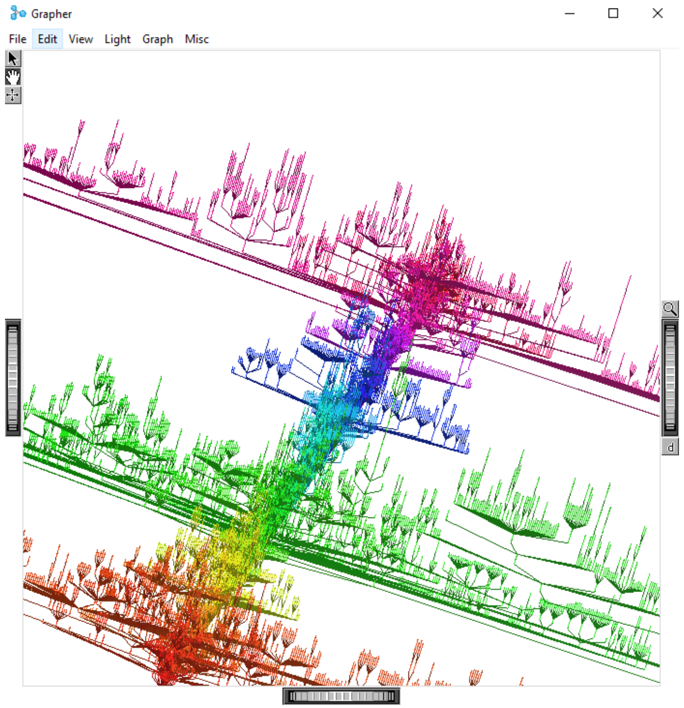


Left: We model risk as a relative distance from the findings providing the weight functions needed for RCA. Bottom: SAGETEAUX OpenGL 3D Rendering.



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Deep Learning Server: dl1.sageteasoftware.com | Port: | Username: | Password:

Set Default | Get All Statements | Get Entity List

Initialize Language Model

Import File | Import Directory | ☐ Recurse Subdirectories | ☐ Import Natural Language | Perform Root Cause Analysis

Import File Data | Set File IDs | Add Statements | Set Predictions | Get Audit Tree Totals

Working Directory: c:\SageTea\OAG

Processing File: c:\SageTea\OAG\2016OctoberReport-58-61.pdf

FILE IMPORT COUNT: 1

Directory: c:\SageTea\OAG
Import sub-directories: false

Audit Plan RCA Tool – Free Trial Offer

How it works:

1. Download a copy of Text to Software from this link: https://sageteasoftware.com/download/windows/SageTeaTextToSoftware.exe
2. Install the software on any Windows PC, Windows 10 is recommended
3. Send an email to david.long@sagetea.ai to request your free SageTea Cloud with our latest Audit Plan software. Audit Plan is a web application designed for auditors and works with Text to Software.
4. We will setup your new Text to Software tool with a profile and access to the cloud
5. You use Text to Software's Deep Learning Dashboard to add and process your audit documents using AI
6. You login to your new cloud and see the results

SageTea Software

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Conclusion

- Dijkstra's Algorithm is a standard method that is common in devices such as GPSs.
- We applied it to RCA as a simple method to performing Root Cause Analysis.
- Deep Learning was used to generate the graph nodes as statements with risks represented as probabilities.
- AI is a potentially powerful tool but close collaboration between auditors and Ai experts is required
- Software development is a long and risky journey

Lemay.ai

SageTea Software

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