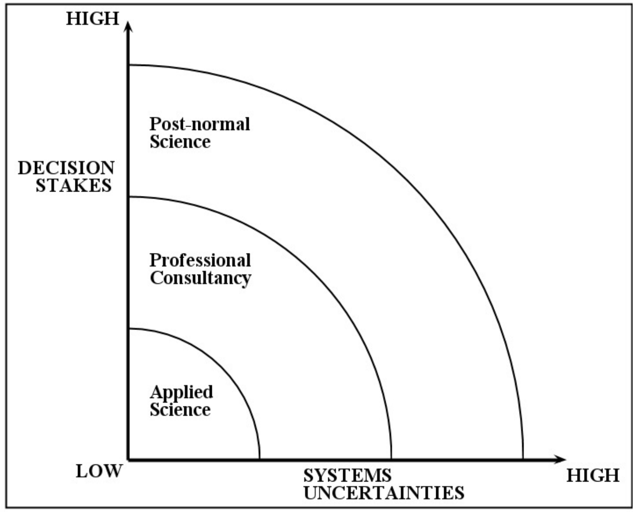
Modeling uncertainty factors in Digital Forensic Science

DFRWS EU 2025

Elénore Ryser & Mehdi Hazefi

Forensic Science

Post-normal science, oriented towards case-based research, whose object of study is the Trace through its detection, recognition, collection, examination and interpretation to understand abnormal events of public interest (e.g. crimes, security incidents).



Forensic Science International 332 (2022) 111182
Contents lists available at ScienceDirect
Forensic Science International
journal homepage: www.elsevier.com/locate/forsciint

The Sydney declaration – Revisiting the essence of forensic science through its fundamental principles

Claude Roux[a], Rebecca Bucht[b], Frank Crispino[c], Peter De Forest[d], Chris Lennard[e], Pierre Margot[f], Michelle D. Miranda[g], Niamh NicDaeid[h], Olivier Ribaux[f,*], Alastair Ross[i], Sheila Willis[h]

[a] Centre for Forensic Scie
[b] Forensic Laboratory, Fin
[c] Laboratoire de Recherch
[d] John Jay College of Crim
[e] School of Science, Weste
[f] Ecole des Sciences Crimi
[g] Farmingdale State Colle
[h] Leverhulme Research Ce
[i] Victorian Institute of Fo

ARTICLE IN

Article history:
Received 30 October 20
Received in revised form
Accepted 9 January 202
Available online 11 Janu

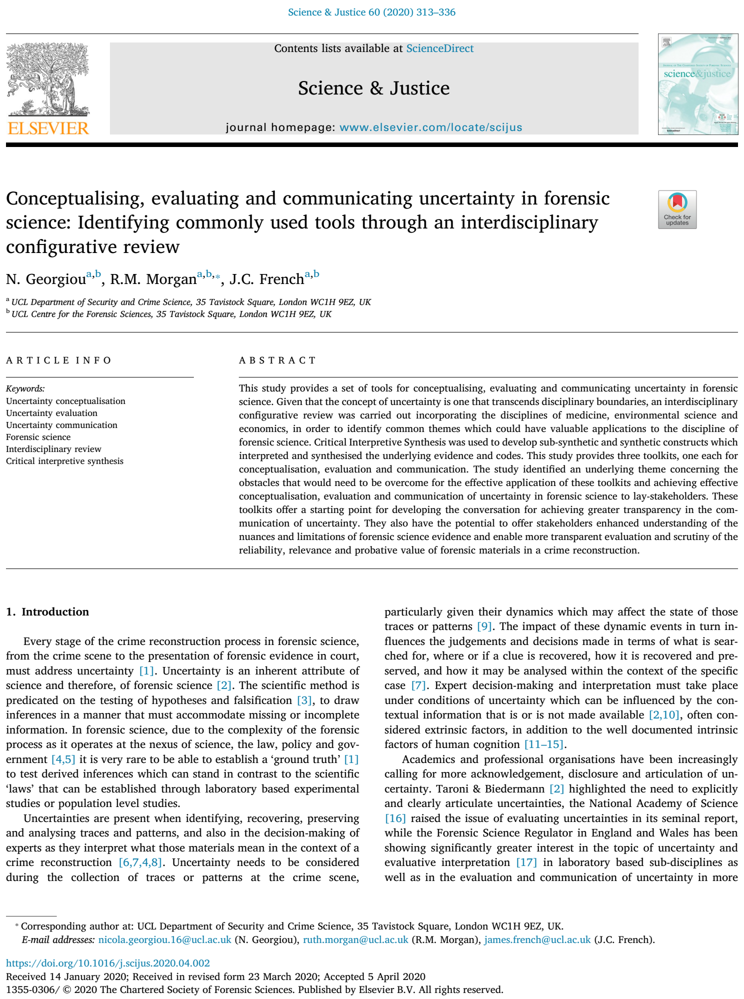
Keywords:
Trace
Principles
Signs
Clues
Context
Time asymmetry
Uncertainties
Ethics
Critical thinking
Logical reasoning

1. Introduction

Forensic science
system. This view
nificant debates ab
veloped over the l
identified and are
management [6-9],
and communicatio
posed over the yea
tractable state of cri

* Corresponding auth
E-mail address: olivi

https://doi.org/10.1016/j.



Science & Justice 60 (2020) 313–336
Contents lists available at ScienceDirect
Science & Justice
journal homepage: www.elsevier.com/locate/scijus

Conceptualising, evaluating and communicating uncertainty in forensic science: Identifying commonly used tools through an interdisciplinary configurative review

N. Georgiou[a,b], R.M. Morgan[a,b,*], J.C. French[a,b]

[a] UCL Department of Security and Crime Science, 35 Tavistock Square, London WC1H 9EZ, UK
[b] UCL Centre for the Forensic Sciences, 35 Tavistock Square, London WC1H 9EZ, UK

ARTICLE INFO

Keywords:
Uncertainty conceptualisation
Uncertainty evaluation
Uncertainty communication
Forensic science
Interdisciplinary review
Critical interpretive synthesis

ABSTRACT

This study provides a set of tools for conceptualising, evaluating and communicating uncertainty in forensic science. Given that the concept of uncertainty is one that transcends disciplinary boundaries, an interdisciplinary configurative review was carried out incorporating the disciplines of medicine, environmental science and economics, in order to identify common themes which could have valuable applications to the discipline of forensic science. Critical Interpretive Synthesis was used to develop sub-synthetic and synthetic constructs which interpreted and synthesised the underlying evidence and codes. This study provides three toolkits, one each for conceptualisation, evaluation and communication. The study identified an underlying theme concerning the obstacles that would need to be overcome for the effective application of these toolkits and achieving effective conceptualisation, evaluation and communication of uncertainty in forensic science to lay-stakeholders. These toolkits offer a starting point for developing the conversation for achieving greater transparency in the communication of uncertainty. They also have the potential to offer stakeholders enhanced understanding of the nuances and limitations of forensic science evidence and enable more transparent evaluation and scrutiny of the reliability, relevance and probative value of forensic materials in a crime reconstruction.

1. Introduction

Every stage of the crime reconstruction process in forensic science, from the crime scene to the presentation of forensic evidence in court, must address uncertainty [1]. Uncertainty is an inherent attribute of science and therefore, of forensic science [2]. The scientific method is predicated on the testing of hypotheses and falsification [3], to draw inferences in a manner that must accommodate missing or incomplete information. In forensic science, due to the complexity of the forensic process as it operates at the nexus of science, the law, policy and government [4,5] it is very rare to be able to establish a 'ground truth' [1] to test derived inferences which can stand in contrast to the scientific 'laws' that can be established through laboratory based experimental studies or population level studies.

Uncertainties are present when identifying, recovering, preserving and analysing traces and patterns, and also in the decision-making of experts as they interpret what those materials mean in the context of a crime reconstruction [6,7,4,8]. Uncertainty needs to be considered during the collection of traces or patterns at the crime scene, particularly given their dynamics which may affect the state of those traces or patterns [9]. The impact of these dynamic events in turn influences the judgements and decisions made in terms of what is searched for, where or if a clue is recovered, how it is recovered and preserved, and how it may be analysed within the context of the specific case [7]. Expert decision-making and interpretation must take place under conditions of uncertainty which can be influenced by the contextual information that is or is not made available [2,10], often considered extrinsic factors, in addition to the well documented intrinsic factors of human cognition [11–15].

Academics and professional organisations have been increasingly calling for more acknowledgement, disclosure and articulation of uncertainty. Taroni & Biedermann [2] highlighted the need to explicitly and clearly articulate uncertainties, the National Academy of Science [16] raised the issue of evaluating uncertainties in its seminal report, while the Forensic Science Regulator in England and Wales has been showing significantly greater interest in the topic of uncertainty and evaluative interpretation [17] in laboratory based sub-disciplines as well as in the evaluation and communication of uncertainty in more

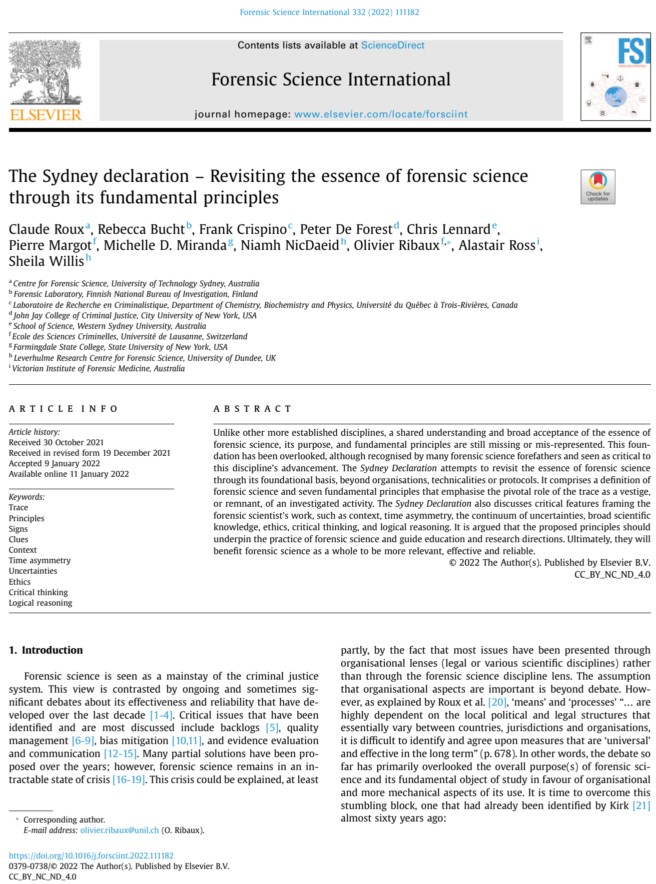
* Corresponding author at: UCL Department of Security and Crime Science, 35 Tavistock Square, London WC1H 9EZ, UK.
E-mail addresses: nicola.georgiou.16@ucl.ac.uk (N. Georgiou), ruth.morgan@ucl.ac.uk (R.M. Morgan), james.french@ucl.ac.uk (J.C. French).

https://doi.org/10.1016/j.scijus.2020.04.002
Received 14 January 2020; Received in revised form 23 March 2020; Accepted 5 April 2020

Uncertainty

"Forensic Science deals with a **continuum of uncertainties** that are present at every step of the **process that starts with the generation of traces and moves through all the steps up to the communication of the findings and value to the intended recipient** (Whether reported in written documents or in oral form such as their presentation in Court). Research is needed to identify and quantify these uncertainties with the knowledge that uncertainty will never be eliminated."

Sydney Declaration – Principle 5


Forensic Science International 332 (2022) 111182

Contents lists available at ScienceDirect

Forensic Science International

journal homepage: www.elsevier.com/locate/forsciint

The Sydney declaration – Revisiting the essence of forensic science through its fundamental principles

Claude Roux[a], Rebecca Bucht[b], Frank Crispino[c], Peter De Forest[d], Chris Lennard[e], Pierre Margot[f], Michelle D. Miranda[g], Niamh NicDaeid[h], Olivier Ribaux[f,*], Alastair Ross[i], Sheila Willis[h]

[a] Centre for Forensic Science, University of Technology Sydney, Australia
[b] Forensic Laboratory, Finnish National Bureau of Investigation, Finland
[c] Laboratoire de Recherche en Criminalistique, Department of Chemistry, Biochemistry and Physics, Université du Québec à Trois-Rivières, Canada
[d] John Jay College of Criminal Justice, City University of New York, USA
[e] School of Science, Western Sydney University, Australia
[f] Ecole des Sciences Criminelles, Université de Lausanne, Switzerland
[g] Farmingdale State College, State University of New York, USA
[h] Leverhulme Research Centre for Forensic Science, University of Dundee, UK
[i] Victorian Institute of Forensic Medicine, Australia

A R T I C L E I N F O

Article history:
Received 30 October 2021
Received in revised form 19 December 2021
Accepted 9 January 2022
Available online 11 January 2022

Keywords:
Trace
Principles
Signs
Clues
Context
Time asymmetry
Uncertainties
Ethics
Critical thinking
Logical reasoning

A B S T R A C T

Unlike other more established disciplines, a shared understanding and broad acceptance of the essence of forensic science, its purpose, and fundamental principles are still missing or mis-represented. This foundation has been overlooked, although recognised by many forensic science forefathers and seen as critical to this discipline's advancement. The *Sydney Declaration* attempts to revisit the essence of forensic science through its foundational basis, beyond organisations, technicalities or protocols. It comprises a definition of forensic science and seven fundamental principles that emphasise the pivotal role of the trace as a vestige, or remnant, of an investigated activity. The *Sydney Declaration* also discusses critical features framing the forensic scientist's work, such as context, time asymmetry, the continuum of uncertainties, broad scientific knowledge, ethics, critical thinking, and logical reasoning. It is argued that the proposed principles should underpin the practice of forensic science and guide education and research directions. Ultimately, they will benefit forensic science as a whole to be more relevant, effective and reliable.

1. Introduction

Forensic science is seen as a mainstay of the criminal justice system. This view is contrasted by ongoing and sometimes significant debates about its effectiveness and reliability that have developed over the last decade [1-4]. Critical issues that have been identified and are most discussed include backlogs [5], quality management [6-9], bias mitigation [10,11], and evidence evaluation and communication [12-15]. Many partial solutions have been proposed over the years; however, forensic science remains in an intractable state of crisis [16-19]. This crisis could be explained, at least partly, by the fact that most issues have been presented through organisational lenses (legal or various scientific disciplines) rather than through the forensic science discipline lens. The assumption that organisational aspects are important is beyond debate. However, as explained by Roux et al. [20], 'means' and 'processes' "… are highly dependent on the local political and legal structures that essentially vary between countries, jurisdictions and organisations, it is difficult to identify and agree upon measures that are 'universal' and effective in the long term" (p. 678). In other words, the debate so far has primarily overlooked the overall purpose(s) of forensic science and its fundamental object of study in favour of organisational and more mechanical aspects of its use. It is time to overcome this stumbling block, one that had already been identified by Kirk [21] almost sixty years ago:

* Corresponding author.
E-mail address: olivier.ribaux@unil.ch (O. Ribaux).

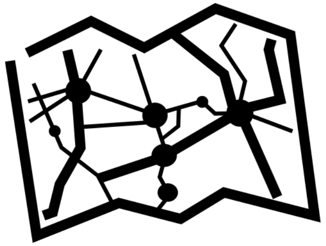
https://doi.org/10.1016/j.forsciint.2022.111182

- Start with the generation of the traces
- Goes through the whole forensic process
- Finish with the communication of the findings and value

WE NEED BASIC NUMBERS
HOW MUCH CASES WE SOLVES /YEAR?
HOW MUCH WORKHOURS /CASE
Disconnect between Academia and Practitioners
Faked data
Trustworthy Data
AI generated fake data
Organization (headless chicken)
Data Standards
Legitimacy
Complexity
No on site Triage
Privacy vs Law Enforcement
Image Analysis
picture categorization
Category images
see the big picture
Share Knowledge
Knowledge transfer?
Skilled people
collective processes
Too many standards
Lack of Standardization
Wanting Another Data Standard
gold standard vs. good enough
Open-Source AI Models & Hardware Availability
Lack of (research) data
volume & complexity
Backlogs
Waste of resources due to inefficient Process
back logs of devices
back log
Effort vs. Outcome
Deepfake Detection & AI generated material
alternative operating model
Cloud Access
Network Event Reconstruction
Network Traffic Analysis
Cell site
CCTV
Cloud data
Keeping up with changes (tools & devices)
Hiring Qualified Experts
Security Vetting
trust (co-operation/external workers)
outsourcing vs. trust
Commercial Incentives for Employees
Compare tool output?
Different tools
triage - device selection
Quality Triage Data
Open Source Education Environments
No devices
Volume
quality standards
Medical Device Forensic Data
Fake Audio Investigation
Medical Device Forensic Cooperation Industry
Medical Device Forensics Standardize Procedures
Common Struggles in Digital Forensics?
Device & Data source Evolution
Location Inference And Analysis
Recruitment + Retention
Standardisation of terms & concepts
Missing roadmap for the field
Compliance with standards
devices under investigation change
File Audio

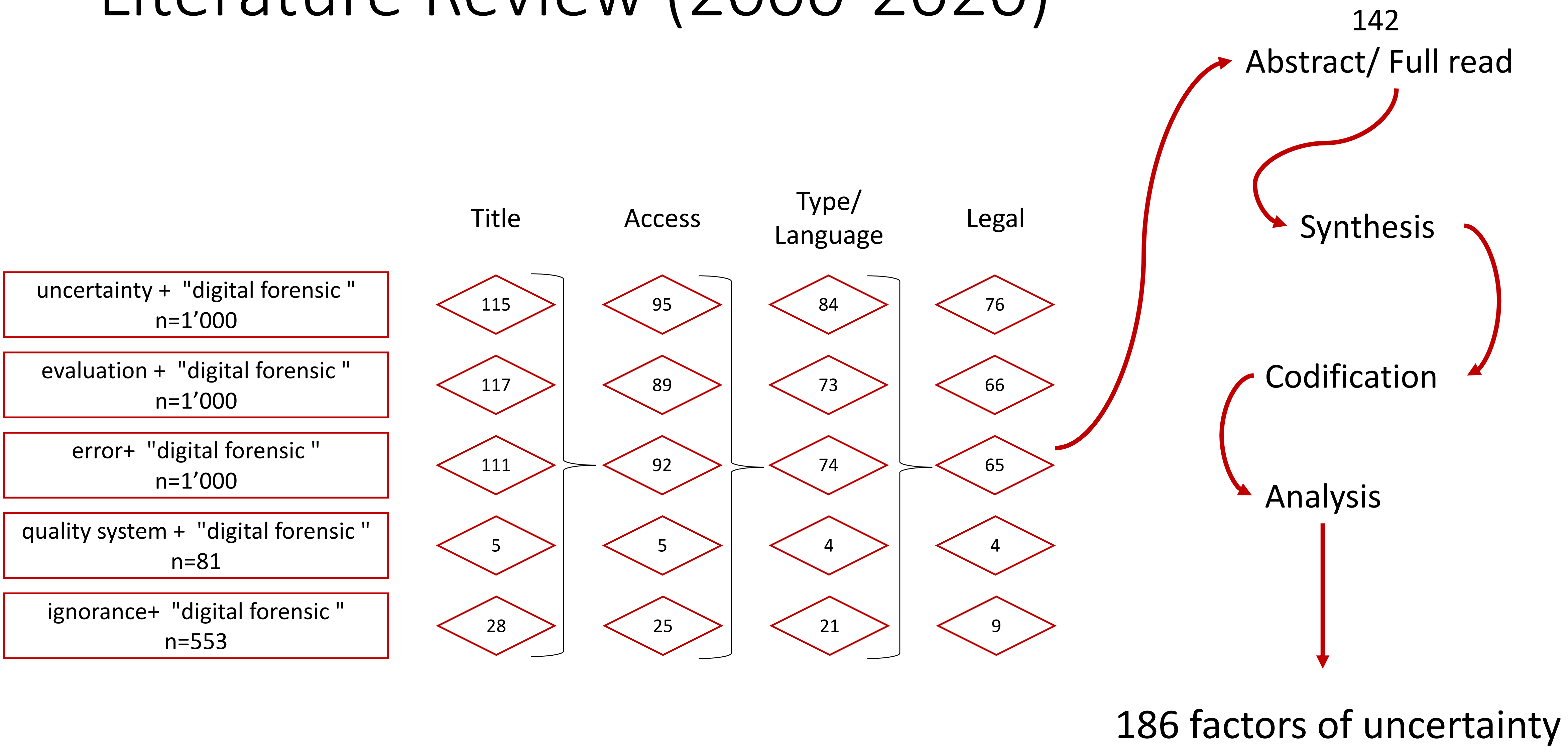
Research objectives

Enhance the understanding of sources and factors of uncertainty that may influence the outcomes of a digital forensic science analysis.



Provide an overview of the methods and tools used in digital forensic science to evaluate and communicate uncertainty.

Literature Review (2000-2020)



ate (environment)	Inherent uncertainty Presence of anti-forensics events Unpredictability of living systems Rapid pace of technological change Limited/malfunctioning hardware Unsafe environment Complexity of system Complexity of environment Variability of phenomena Unpredictability of phenomena Complexity of phenomena Non-transparent / unaccessible systems Time relativity	Variability of phenomena Complexity of system Scientific/technological progress Unpredictability of phenomena Indeterminacy of future events/outcomes Fundamental Continuous nature of phenomena Unpredictability of living systems Complexity of phenomena Unpredictable behaviour of actors	Innate
Data	Accessibility (Data) Admissibility Biased (Data) Complex (Data) Complex life cycle (Data) Comprehensiveness (Data) Contamination (Data) Contradictive (Data) Credibility (data) Fidelity (data) Frangibility (Data) Imprecise (Data) Inaccurate/imprecise (Data) Incomplete/imperfect (Data) Inherent uncertainty (Data) Insufficient (Data) Integrity (data) Interpretive (data) Irrelevant (Data) Loss (Data) Past event inaccurate descriptor (Data) Processed (Data) Quality (Data) Structure (Data) Tampered (Data) traces not mutually independent Unknown / Not studied (Data) Unreliable (Data) Unrepresentative of entire population (Data) Variable (Data) Volatile (Data) Volume (Data) Vulnerable (Data)	Unreliable/Lack of validation Irrelevant Volume Not applicable Insufficient Incomplete/imperfect Availability Variable Structure Non-discriminatory Revised Vague Unexpected Multi-causal Complex Lack of unanimity Past patterns inaccurate descriptors Contradictory Unrepresentative of entire populatio Inaccurate/imprecise Poor Biaised Unclear	
Méthodologique	Heavely dependent on tools Difficult to find the most investigatively-useful information Multi interaction of variables on the experiment	Model Inputs (methodological)	
Semantic	Problem definition (expert-client)		
nnate (process)	Back-casting Bounded expert knowledge (context) Legaly bounded expert Case-specific dependence Complexity of the questions Complex and diverse domain Measuring variable in a live system External influences Scientists are multiple times removed from the Event under scrutiny	Layers of interpretation to the proble Measuring variables in real time Bounded expert knowledge Back-casting	
Knowledge	Academic limitations & Research skills (Expert) Unrepresentative of real population Limited applicability of the experiments Difficult to establish/unknown ground truth Lack of reference / experimental datasets Lack of knowledge exchange Weak Scientific Basis Lack of scientific knowledge Lack of common knowledge Lack of understanding of phenomena Limited / poor academic literature Lack of study on error rates lack of reproductibility studies Lack of empirical studies / research Dissemination of erroneous knowledge Unreliable knowledge Disregarding fundamentals	Academic limitations (expert) Weak scientific basis Absent/Incomplete/inadequate unde Imperfect/Incomplete/Lack of comm Equally valid frames of knowledge Progress in knowledge	
Methodology	Disponibility/trust in literature Lack of / variable / poor peer-review methods Lack of methods & models Lack of resources and data sets for testing Lack of agreement on best practice Lack of clear & up-to-date standardized procedures and principles Quality (Work) Methodological & Technical errors Procedure & Results Reproductibility Methodology & techniques variability Confidence in Method & Tools & Techniques (expert) Requirements and Testing of Techniques, Tools & Methods Methodology validation & verification Relayability of DF process (Methodology) Difficulty/Impossibility in establishing ground truth Appropriate use of appropriate equipment/tools Misinterpretation of Data & Tools outputs (expert) Clarity of the method used Lack of documentation Lack of scientific rigor Lack of search for contradictory facts Bias from the reference material Lack of information about what a normal behavior is Transfer of theory to practice Problems associating data Unsure of the interpretation of findings Leaving the more complex forensic questions unanswered Method of evaluation of hypotheses Assigning weights or signification to the observations/events Lack of approaches to deal, measure and define uncertainties Collaboration with other experts or investigation team Poor quality management Management of work environment Inadequate case management Work environment & Accessibility to tools	Model (parameters, codes, misspecif Precision of analytical instrument Data storage and management Variability in weighing of informatior Choice of relevant literature/evidenc Collaboration/Disagreement (expert) Confidence in analytical instruments	
Tools	Tool design error Algorithm implementation error Logic errors of software tools (unpredictable output) Erroneous tool output Inconsistency and ambiguity in the display of results Poor algorithm (tool) Misusage of tools Reliability of Tools & Methods Accuracy & precision of tools & methods Limitation of Tools & Methods Tool, Techniques & Method Reproductibility		Tools
Semantic	Low level of harmonisation / consensus Restricted opportunity to develop the knowledge Small personal continuity in research Problem definition (semantics)		
	Cognitive bias & Human-related error Skills (Expert) Training (Expert) Knowledge (Expert) Experience (Expert)	Personal lack of knowledge (expert) Complicated decision-making (expert) Quality of expert (expert) Heuristics (expert) Philosophical (expert)	

20 most frequently identified codes

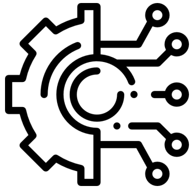
Codes	n/142	Codes	n/142
M - Confidence in Method, Tools & Techniques	46	M - Lack of clear & up-to-date standardized procedures and principles	30
E - Cognitive bias & Human-related error	41	E - Skills (Expert)	30
D - Loss (Data)	40	D - Unreliable (Data)	28
I - Rapid pace of technological change	37	Inaccurate/imprecise (Data)	26
D - Tampered (Data)	36	E - Knowledge	26
D - Variable (Data)	36	E - Knowledge of the limitation of tools & techniques	26
M - Misinterpretation of Data & Tools outputs	34	E - Subjectivity	25
I - Variability of phenomena	34	T - Accuracy & precision of tools & methods	24
D - Volume (Data)	34	P - Difficulty of assigning probabilities (expert)	23
M - Requirements and Testing of Techniques, Tools & Methods	32	K - Weak Scientific Basis	23

Comparative with Georgiou (2020)

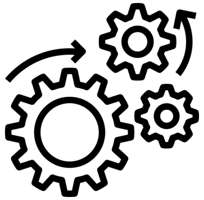
=> Reflects the academic point of view

Methodology

Document the presence of uncertainty through the **triangulation of three studies**.

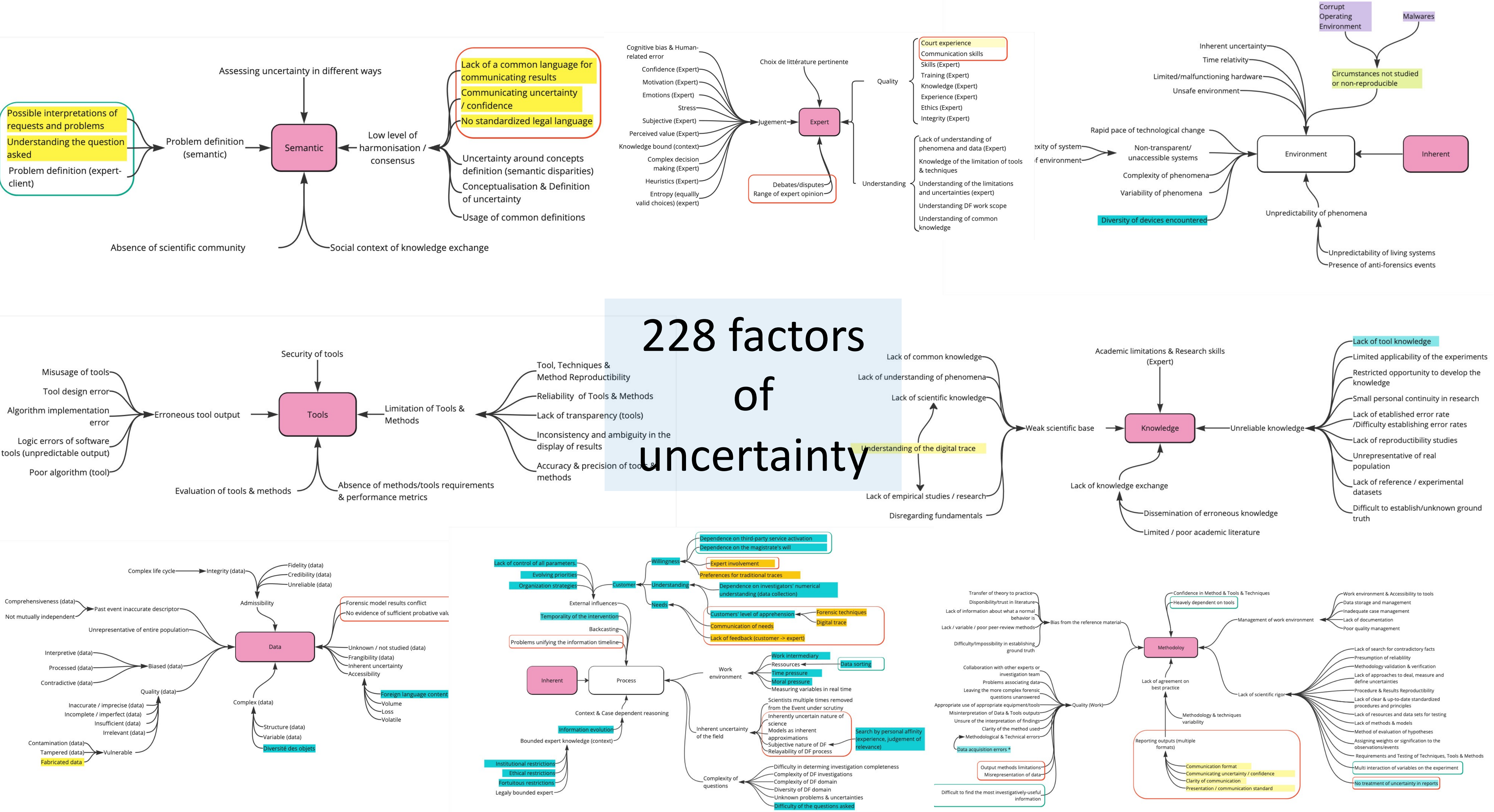


Intrinsic uncertainty factors related to the Trace. → Geolocation metadata



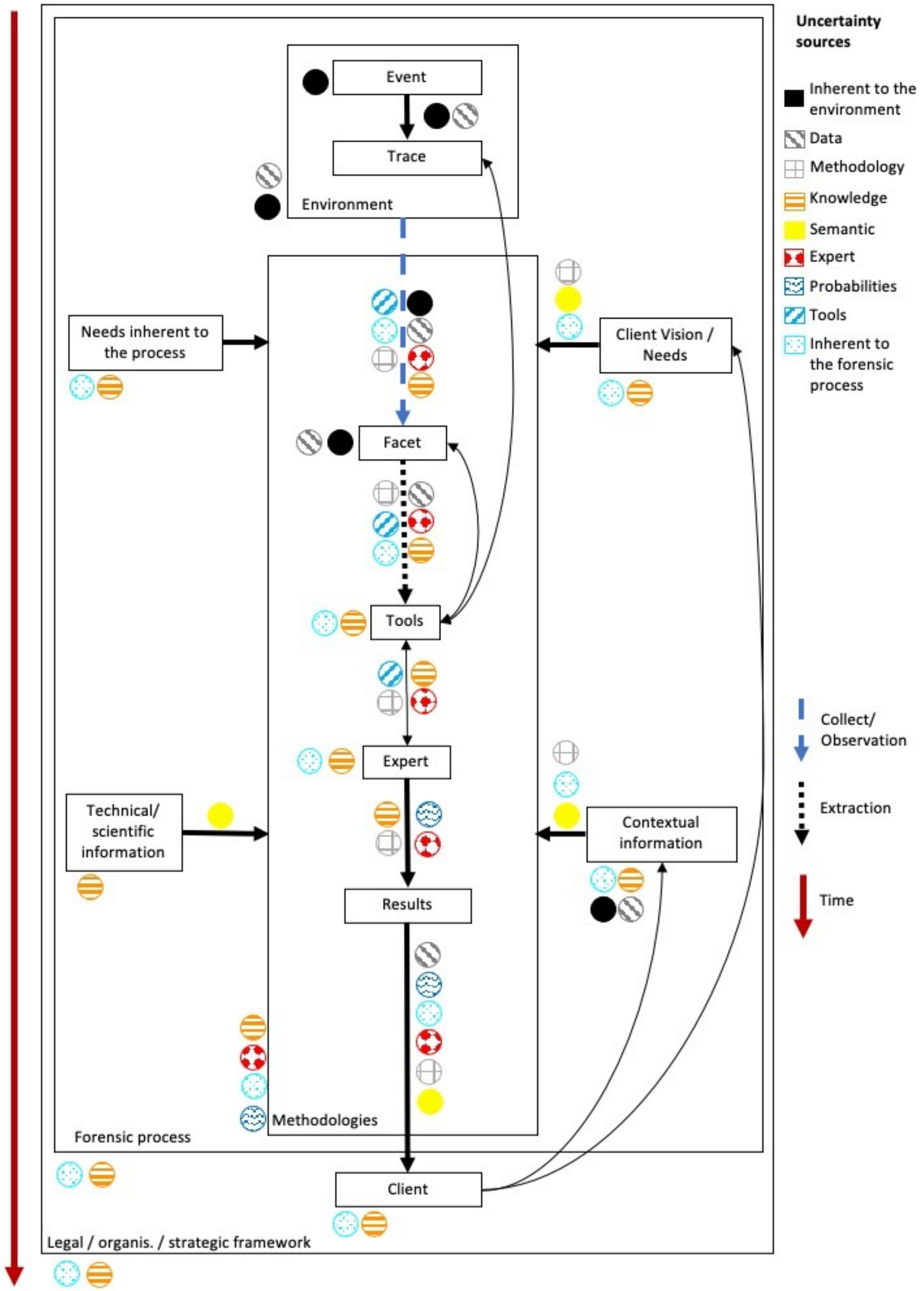
Operationalisation of the digital forensic science process → Field study in a police environment

Communication of results → Interprofessional questionnaire


228 factors of uncertainty
Assessing uncertainty in different ways
Possible interpretations of requests and problems
Understanding the question asked
Problem definition (expert-client)
Problem definition (semantic)
Semantic
Low level of harmonisation / consensus
Lack of a common language for communicating results
Communicating uncertainty / confidence
No standardized legal language
Uncertainty around concepts definition (semantic disparities)
Conceptualisation & Definition of uncertainty
Usage of common definitions
Absence of scientific community
Social context of knowledge exchange
Cognitive bias & Human-related error
Confidence (Expert)
Motivation (Expert)
Emotions (Expert)
Stress
Subjective (Expert)
Perceived value (Expert)
Knowledge bound (context)
Complex decision making (Expert)
Heuristics (Expert)
Entropy (equallly valid choices) (expert)
Jugement
Choix de littérature pertinente
Expert
Debates/disputes
Range of expert opinion
Quality
Court experience
Communication skills
Skills (Expert)
Training (Expert)
Knowledge (Expert)
Experience (Expert)
Ethics (Expert)
Integrity (Expert)
Understanding
Lack of understanding of phenomena and data (Expert)
Knowledge of the limitation of tools & techniques
Understanding of the limitations and uncertainties (expert)
Understanding DF work scope
Understanding of common knowledge
Corrupt Operating Environment
Malwares
Circumstances not studied or non-reproducible
Inherent uncertainty
Time relativity
Limited/malfunctioning hardware
Unsafe environment
Rapid pace of technological change
exity of system
f environment
Non-transparent/ unaccessible systems
Complexity of phenomena
Variability of phenomena
Diversity of devices encountered
Environment
Inherent
Unpredictability of phenomena
Unpredictability of living systems
Presence of anti-forensics events
Security of tools
Misusage of tools
Tool design error
Algorithm implementation error
Logic errors of software tools (unpredictable output)
Poor algorithm (tool)
Erroneous tool output
Tools
Limitation of Tools & Methods
Tool, Techniques & Method Reproductibility
Reliability of Tools & Methods
Lack of transparency (tools)
Inconsistency and ambiguity in the display of results
Accuracy & precision of tools & methods
Evaluation of tools & methods
Absence of methods/tools requirements & performance metrics
Lack of common knowledge
Lack of understanding of phenomena
Lack of scientific knowledge
Understanding of the digital trace
Lack of empirical studies / research
Disregarding fundamentals
Weak scientific base
Academic limitations & Research skills (Expert)
Knowledge
Lack of knowledge exchange
Dissemination of erroneous knowledge
Limited / poor academic literature
Unreliable knowledge
Lack of tool knowledge
Limited applicability of the experiments
Restricted opportunity to develop the knowledge
Small personal continuity in research
Lack of etablished error rate /Difficulty establishing error rates
Lack of reproductibility studies
Unrepresentative of real population
Lack of reference / experimental datasets
Difficult to establish/unknown ground truth
Complex life cycle
Integrity (data)
Fidelity (data)
Credibility (data)
Unreliable (data)
Admissibility
Comprehensiveness (data)
Not mutually independent
Past event inaccurate descriptor
Unrepresentative of entire population
Interpretive (data)
Processed (data)
Contradictive (data)
Biased (data)
Quality (data)
Inaccurate / imprecise (data)
Incomplete / imperfect (data)
Insufficient (data)
Irrelevant (data)
Contamination (data)
Tampered (data)
Fabricated data
Vulnerable
Data
Forensic model results conflict
No evidence of sufficient probative valu
Unknown / not studied (data)
Frangibility (data)
Inherent uncertainty
Accessibility
Foreign language content
Volume
Loss
Volatile
Complex (data)
Structure (data)
Variable (data)
Diversité des objets
Lack of control of all parameters.
Evolving priorities
Organization strategies
Customer
External influences
Willingness
Dependence on third-party service activation
Dependence on the magistrate's will
Expert involvement
Preferences for traditional traces
Understanding
Dependence on investigators' numerical understanding (data collection)
Needs
Customers' level of apprehension
Forensic techniques
Digital trace
Communication of needs
Lack of feedback (customer -> expert)
Temporality of the intervention
Backcasting
Problems unifying the information timeline
Inherent
Process
Work environment
Work intermediary
Ressources
Data sorting
Time pressure
Moral pressure
Measuring variables in real time
Context & Case dependent reasoning
Information evolution
Bounded expert knowledge (context)
Institutional restrictions
Ethical restrictions
Fortuitous restrictions
Legaly bounded expert
Inherent uncertainty of the field
Scientists multiple times removed from the Event under scrutiny
Inherently uncertain nature of science
Models as inherent approximations
Subjective nature of DF
Relayability of DF process
Search by personal affinity (experience, judgement of relevance)
Complexity of questions
Difficulty in determing investigation completeness
Complexity of DF investigations
Complexity of DF domain
Diversity of DF domain
Unknown problems & uncertainties
Difficulty of the questions asked
Transfer of theory to practice
Disponibility/trust in literature
Lack of information about what a normal behavior is
Lack / variable / poor peer-review methods
Difficulty/Impossibility in establishing ground truth
Bias from the reference material
Confidence in Method & Tools & Techniques
Heavely dependent on tools
Methodoloy
Management of work environment
Work environment & Accessibility to tools
Data storage and management
Inadequate case management
Lack of documentation
Poor quality management
Collaboration with other experts or investigation team
Problems associating data
Leaving the more complex forensic questions unanswered
Appropriate use of appropriate equipment/tools
Misinterpretation of Data & Tools outputs
Unsure of the interpretation of findings
Clarity of the method used
Methodological & Technical errors
Data acquisition errors *
Output methods limitations
Misrepresentation of data
Difficult to find the most investigatively-useful information
Quality (Work)
Lack of agreement on best practice
Methodology & techniques variability
Reporting outputs (multiple formats)
Communication format
Communicating uncertainty / confidence
Clarity of communication
Presentation / communication standard
Lack of scientific rigor
Lack of search for contradictory facts
Presumption of reliablility
Methodology validation & verification
Lack of approaches to deal, measure and define uncertainties
Procedure & Results Reproductibility
Lack of clear & up-to-date standardized procedures and principles
Lack of resources and data sets for testing
Lack of methods & models
Method of evaluation of hypotheses
Assigning weights or signification to the observations/events
Requirements and Testing of Techniques, Tools & Methods
Multi interaction of variables on the experiment
No treatment of uncertainty in reports

Mapping of factors of uncertainty: 9 sources

- Innate (environmental)
- Innate (process)
- Data
- Methodology
- Knowledge
- Tools
- Expert
- Semantics
- Probabilities



Lack of communication about uncertainties

Next question: managing uncertainty?

The management of uncertainty, regardless of its form, appears to be a necessity both in the literature and in the results of the field study and the questionnaire.

Accumulation of theoretical propositions for uncertainty management.

Gap between theory and practice

Lack of a formal process for uncertainty management.

Next question: managing uncertainty?

Explicit characterization of uncertainty

- Qualitative/graphical/quantitative instruments to assess uncertainty
- Evaluative models of uncertainty
- Studies on standardization processes/peer review

Gap between theory and practice

Implicit presence of uncertainty

- Recognized presence, rarely mentioned
  - Informal management, No process in place
- Recognized presence, lack of explicit characterization
  - No explicit mention

Next step ?

1. Index of factors of uncertainty
2. Ranking / Risk analysis
3. Mitigation / Management
4. Evaluation / Communication

Index of factors of uncertainty

- Develop a comprehensive list of potential uncertainty factors
- Categorize these factors → Needs to be refined
- Regularly update the index

Solve-IT ?

Ranking / Risk analysis

Participatory assessment of identified factors

Refine the identified factors

- Screening the identified factors
- Utilize participatory risk analysis techniques to prioritise key factors
- Engage experts to refine and validate the ranking.

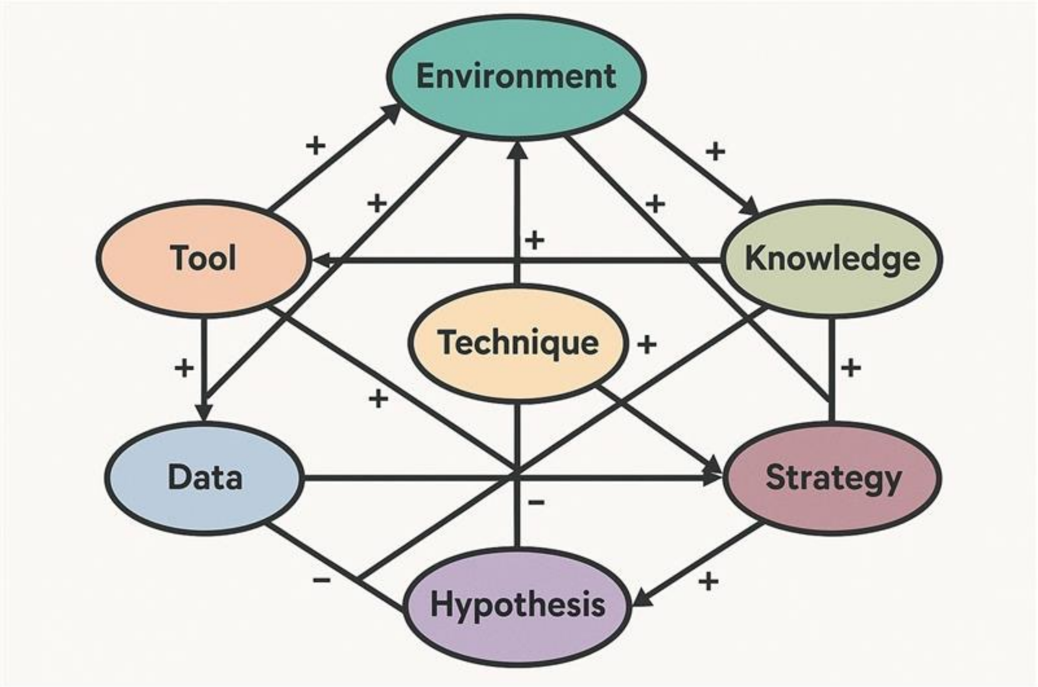
From 228 factors to 127 factors ?

2

Ranking/Risk analysis

Participatory assessment of identified factors

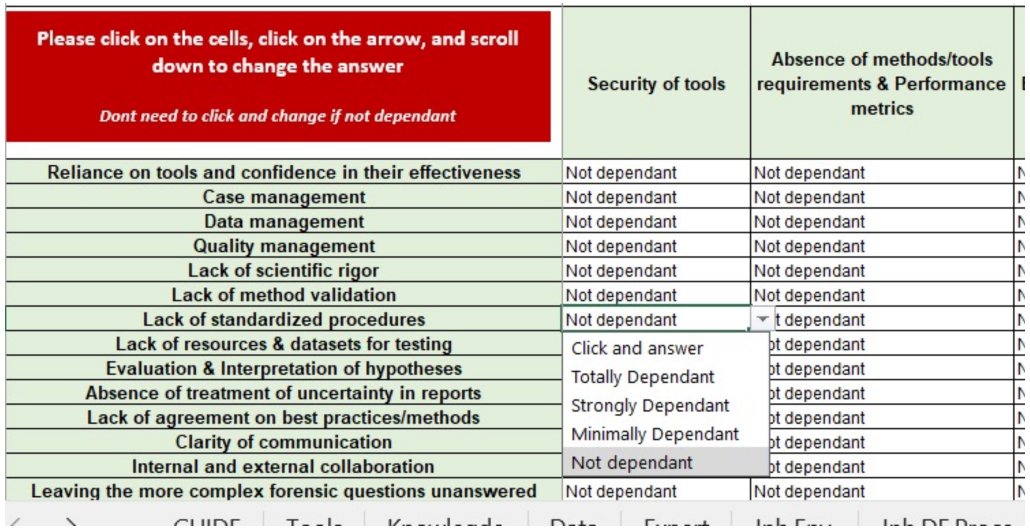
- Extract the experts' knowledge
- Identify the interrelationships of the identified factors
- Analyse the direct and indirect interaction of systemic and external systemic factors
- Rank and categorise the identified factors based on their level of influence and being influenced
- Employ effective systems modelling approaches for further analysis



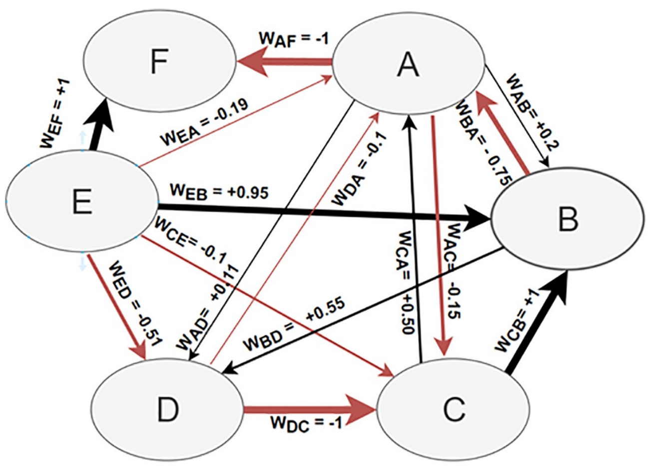
A high-level dependency / Causal network diagram of factors

Ranking/Risk analysis

Experts'knowledge elicitation procedure



Please click on the cells, click on the arrow, and scroll down to change the answer *Dont need to click and change if not dependant*	Security of tools	Absence of methods/tools requirements & Performance metrics
Reliance on tools and confidence in their effectiveness	Not dependant	Not dependant
Case management	Not dependant	Not dependant
Data management	Not dependant	Not dependant
Quality management	Not dependant	Not dependant
Lack of scientific rigor	Not dependant	Not dependant
Lack of method validation	Not dependant	Not dependant
Lack of standardized procedures	Not dependant	t dependant
Lack of resources & datasets for testing	Click and answer	ot dependant
Evaluation & Interpretation of hypotheses	Totally Dependant	ot dependant
Absence of treatment of uncertainty in reports	Strongly Dependant	ot dependant
Lack of agreement on best practices/methods	Minimally Dependant	ot dependant
Clarity of communication	Not dependant	ot dependant
Internal and external collaboration		ot dependant
Leaving the more complex forensic questions unanswered	Not dependant	Not dependant



	A	B	C	D	E	F
A	0	+0.2	-0.15	+0.11	0	-1
B	-0.75	0	0	+0.55	0	0
C	+0.5	+1	0	0	0	0
D	-0.1	0	-1	0	0	0
E	-0.19	+0.95	-0.1	-0.51	0	+1
F	0	0	0	0	0	0

A sliced example of a direct influence/ adjacency matrix

Mitigation/ Management

Employ Systems modelling techniques

Evaluate and employ the most applicable and effective analysis/ systems modeling approach

Network analysis/ Causal Diagram

Visualise the distribution and evolution of uncertainty

Detect emerging uncertainty patterns

Fuzzy cognitive mapping

Understand co-dependance variables

Bayesian Network

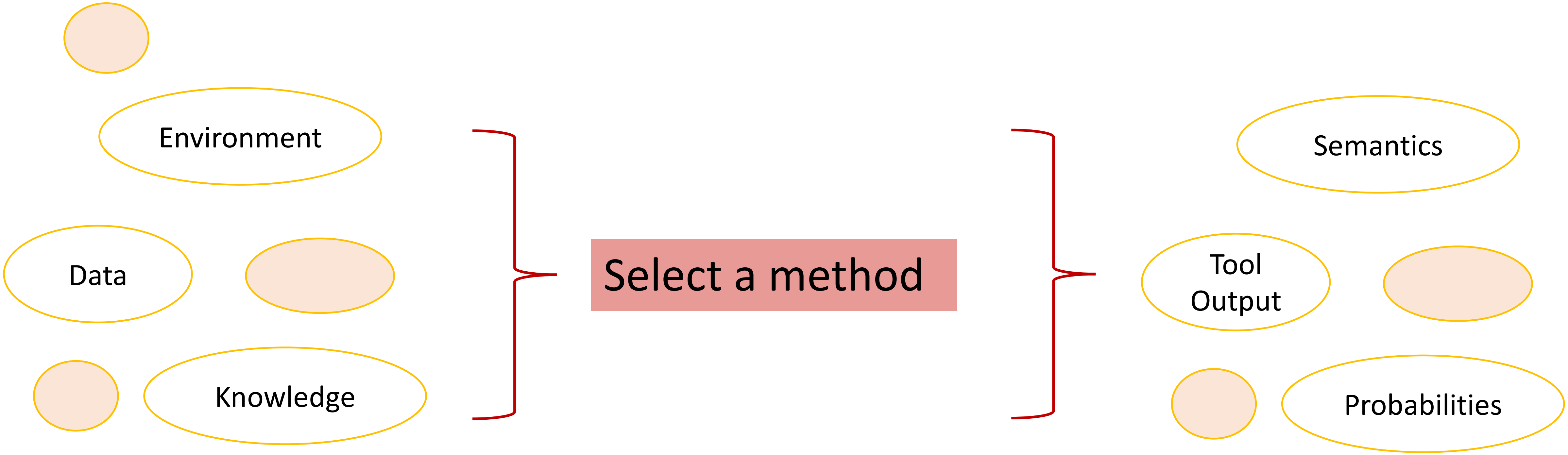
Simulate impact of mitigation strategies

Communicate residual uncertainty

For what outcome?

Solve-IT ?

4



Evaluate the effectiveness of mitigation strategies through **performance metrics** and **feedback loops**.

For what outcome?

- ➢Document successes and challenges to inform future practices ?
- ➢Communicate findings transparently to stakeholders/ clients ?
- ➢…

Thanks !

Link to manifest interest