

# **A Goal-oriented Method for Regulatory Intelligence**

**Okhaide Samson Akhigbe**

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# Abstract

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When creating and administering regulations, regulators have to demonstrate that regulations accomplish intended societal outcomes at costs that do not outweigh their benefits. While regulators have this responsibility as custodians of the regulatory ecosystem, they are also required to create and administer regulations transparently and impartially, addressing the needs and concerns of all stakeholders involved. This is in addition to regulators having to deal with various administrative bottlenecks, competing internal priorities, as well as financial and human resource limitations. Nonetheless, governments, regulated parties, citizens and interest groups can each express different views on the relevance and performance of a piece of regulation. These views range from too many regulations burdening business operations to perceptions that crises in society are the results of insufficient regulations. As such, regulators have to be innovative, employing methods that show that regulations are effective, and justify the introduction, evolution or repeal of regulations.

The regulatory process has been the topic of various studies with several such studies exploring the use of information systems at the software level to confirm compliance with regulations and evaluate issues related to non-compliance. The rationale is that if information systems can improve operational functions in organizations, they can also help measure compliance. However, the research focus has been on enabling regulated parties to comply with regulations rather than on enabling regulators to assess or enforce compliance or show that regulations are effective. Regulators need to address concerns of too much regulations or too little regulations with data-driven evidence especially in this age of big data and artificial intelligence enhanced tools. A method that facilitates evidence-based decision-making using data for enacting, implementing and reviewing regulations is now inevitable. In response to the above challenges, this thesis explores the use of a goal-oriented modelling method and a data analytics software, to create a method that enables monitoring, assessing and reporting on the effectiveness of regulations and regulatory ini-

tiatives. This Goal-oriented Regulatory Intelligence Method (GoRIM) provides an intelligent approach to regulatory management, as well as a feedback loop in the use of data from and within the regulatory ecosystem to create and administer regulations.

To demonstrate its applicability, GoRIM was applied to three case studies involving regulators in three different real regulatory scenarios, and its feasibility and utility were evaluated. The results indicate that regulators found GoRIM promising in enabling them to show, with evidence, whether their regulations are effective.

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# List of Acronyms

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<b>Acronym</b>	<b>Definition</b>
ACM	Association for Computing Machinery
AI	Artificial Intelligence
AR	Annual Review
BI	Business Intelligence
BSC	Business Source Complete
CBA	Cost Benefit Analysis
CES	Critical Effect Size
CFR	Community of Federal Regulator
CIAO	Columbia International Affairs Online
CMMI	Capability Maturity Model Integration
COTS	Commercial off-the-shelf
CPIQ	Canadian Periodical Index Quarterly
CSV	Comma Separated Values
CWS	Canadian Wildlife Service
DP	Design Problem
DSR	Design Science Research
DSRM	Design Science Research Methodology
ECCC	Environment and Climate Change Canada
EB	Ebrary
EP	Econpapers
EPB	Environment Protection Branch
EPCO	Environmental Protection Compliance Order
ESP	Evaluation Strategies Processor
FA	Factiva
GoRIM	Goal-oriented Regulatory Intelligence Model
GRL	Goal-oriented Requirement Language
GS	Google Scholar
KP	Knowledge Problem
KPI	Key Performance Indicator
HIPAA	Health Insurance Portability and Accountability Act
ICW	Industrial sectors, Chemicals and Waste
IEEE	Institute of Electrical and Electronics Engineers
IMF	International Monetary Fund
IP	Implementation Problem
IS	Information System
IT	Information Technology
ITU	International Telecommunication Union
MBR	Migratory Bird Regulations
MBCA	Migratory Birds Convention Act
NBER	National Bureau of Economic Research
NFR	Non-Functional Requirements
NSIT	National Institute of Standards and Technology

OECD	Organization for Economic Cooperation and Development
OHTA	Ontario Highway Traffic Act
OMG	Object Management Group
ORSAR	Ontario Road Safety Annual Reports
PHIPA	Personal Health Information Protection Act
PM	PubMed
PQ	ProQuest
RBA	Risk Based Approach
RE	Requirements Engineering
RELAW	Requirements Engineering and Law
REJ	Requirements Engineering Journal
RIA	Regulatory Impact Assessment
ROI	Return on Investments
RORIF	Regulator-Oriented Regulatory Intelligence Framework
SD	Science Direct
SC	Scopus
SLR	Systematic Literature Review
SSRN	Social Science Research Network
UCM	Use Case Map
URN	User Requirements Notation
WOS	Web of Science

# Definitions

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The following terms are used extensively in this thesis. They are key to understanding the contributions and they will be illustrated in more detail in relevant sections.

- **Objective:** a government's intention behind a legislation, the purpose for which governments introduce legislations and how they evaluate regulatory solutions. An example is Statistics Canada's "Mandate and objectives" (Statistics Canada, 2008). The two listed objectives are the reasons for the introduction of the Statistics Acts (Government of Canada, 1985b).
- **Outcome:** refers to what activities of regulators achieve in the short-term, medium-term or long term. An example is the "Descriptors for Government of Canada Outcome Areas" (Government of Canada, 2015).
- **Regulation:** a type of regulatory instrument backed by penalties, intended specifically to modify the behaviour of regulated parties. An example is the Administrative Penalties Regulations (Government of Ontario, 2017a). This particular regulation prescribes different types of penalties for various driving offences such as driving with a suspended license, cancellation of driving in the case of failure to pay a previous fine, etc.
- **Regulatory intelligence:** involves continuously collecting and processing data from multiple sources, and analyzing them based on the respective context towards generating and communicating meaningful insights (Felgate, 2013; Hynes, 2014).
- **Regulatory initiative:** refers to any form of activity done by a regulator to make, operate or review a regulation, including activities in the cycle of regulatory activities (OECD, 2014).

- **Regulatory instrument:** a type of tool used to express government policies and ensure conformity with a rule or law.
- **Regulatory performance:** the performance of a regulation is measured in terms of both its *effectiveness* and *efficiency*. A regulation is *effective* when it achieves its desired objective and accomplishes its intended outcomes. A regulation is *efficient* when the benefits derived from the regulation exceeds the resources involved in creating, administering and reviewing it. In this doctoral research, my reference to regulatory performance mainly addresses the *effectiveness* of regulations.

# Chapter 1. Introduction

---

This thesis contributes a Goal-oriented Regulatory Intelligence Method (GoRIM), whose motivation is presented in this chapter. In addition, this chapter introduces research questions and the research approach used in this thesis, together with an overview of the thesis contributions.

## 1.1. Motivation

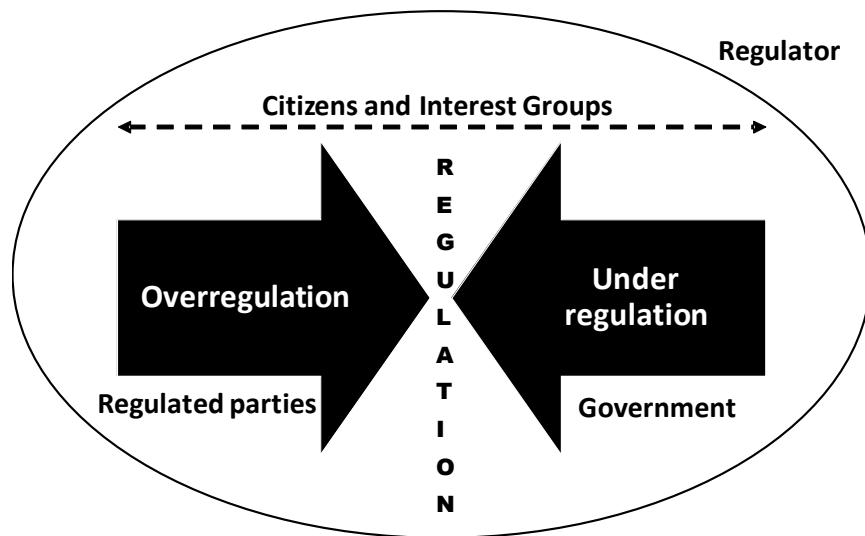
Regulators are mandated to administer laws introduced by governments to keep their citizens and communities safe, secure and prosperous. This mandate requires regulators to be fair and transparent while they show that the laws are sufficient to achieve the desired objectives that informed the creation of the regulation. To do this, regulators make use of tools known as regulatory instruments (i.e., *regulations, performance agreements, standards; codes of practice* etc.), to dictate or change behaviours in order to accomplish or improve outcomes, or maintain outcome quality (Coglianese, 2012). For example, to address the rise in deaths caused by motoring in the early 1900s, in 1914, the Canadian province of Ontario introduced an act, the Ontario Highway Traffic Act (OHTA) (1914). In spite of amendments over the years, this act still addresses deaths due to motoring as observed in its most recent amendment (Government of Ontario, 1990). Different types of regulatory instruments have been and are presently being used to administer the OHTA. These include the Speed Limits Regulation (Government of Ontario, 2018b) that outlines speed limits on Ontario roads, and Display Screen and Hand-Held Regulations (Government of Ontario, 2018c) that outline exemptions to distracted driving.

Regulations<sup>1</sup> are the most common type of regulatory instruments and are typically used when referring to regulatory instruments. Regulations can consist of a multifaceted series of interventions, interactions and impacts (Coglianese, 2012) all aiming to achieve

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<sup>1</sup> For simplicity in this thesis, I use regulations to refer to both regulations and regulatory instruments.

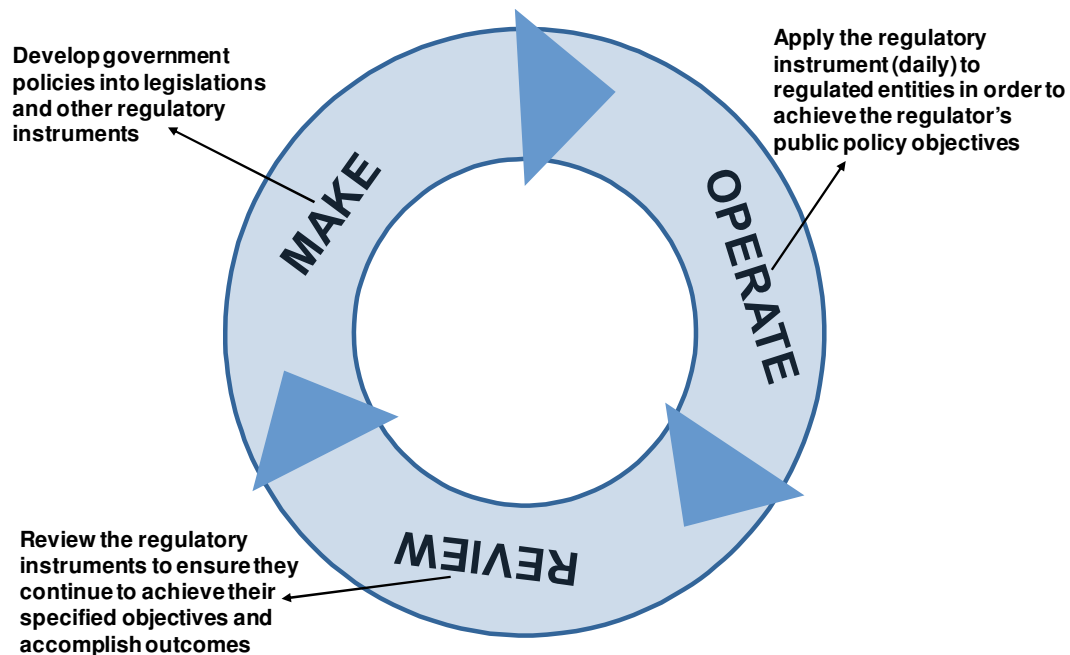
desired objectives of the law or to accomplish intended outcomes. As a result, the administration of regulations needs to address not only the complex causal relationships that contribute to the social and economic problems the introduced laws seek to address, but also other relationships. These relationships exist between the regulator and stakeholders who influence the regulations, such as governments who introduce laws, interest groups who have varied interests about the laws or regulations, and stakeholders affected by the regulations such as citizens or businesses parties. Having these different stakeholders creates different positions and divergent views about any law or piece of regulation. A common perception is that regulations are often reactive in addressing problems i.e., they are introduced in reaction to crises that have already happened. Examples such as the US “Dodd-Frank Wall Street Reform” and the “Consumer Protection Act” introduced after the financial crisis of the late 2000s (H. Rept. 111-517, 2010) attest to this perception. Other examples include changes to the “Railway Safety Act” and the “Canada Transportation Act”, revised after the Lac-Mégantic explosion in 2013 (Government of Canada, 2014). The reactivity of regulations also includes their introduction or evolution to reduce the effects of potential crises, for example the Paris Accord of 2015 (UNFCCC, 2015) in response to climate change concerns.



**Figure 1** Divergent Views on Regulations

As illustrated in Figure 1, the motivation for the introduction of regulations and their reactive nature suggests that society is *under-regulated*, that is, society is insufficiently regulated and is hence, requiring more regulations. This can lead to instances of the introduction of more laws by governments leading to multiple regulations and possible regulators regulating the same issues, often with overlaps (Black & Jacobzone, 2009; Nazareth & Rosenberg, 2013) as well as a high frequency of changes in regulations (Maxwell, Antón, & Swire, 2012). In contrast, considering the time and cost implication involved in complying with an increasing number of frequently changing regulations, the regulated parties often complain of *overregulation*, that is, an excessive burdening with regulations (Baldwin & Cave, 1999; Ellig & Broughel, 2011). For example, the cost of complying with regulations in the United States of America has been estimated at \$20,000 (US) for every American worker (Durden, 2017). In addition, based on perceived benefits, citizens and interest groups express different concerns about regulations, e.g., lobbyists about *over-regulation*, and watchdog organizations about *under-regulation* (Ainsworth, 1996; Baldwin & Cave, 1999). Regulators, as custodians of the regulatory ecosystem, have to address all these divergent views impartially and accountably, in addition to dealing with competing external (often political) and internal priorities, limited human and financial resources, as well as various administrative bottlenecks.

A look at how regulators function shows that they do this within the context of a lifecycle approach (OECD, 2014; Ullmann, 1985). This lifecycle implies that every activity of the regulator associated with making, operating, reviewing, modifying or repealing a regulation is essential to the outcomes of the regulation (Ullmann, 1985; UNEP, 2005). When observed within the context of what a regulator does daily, the regulatory lifecycle is categorised into three phases that occur concurrently: *make*, *operate* and *review*. These phases are collectively referred to as the *cycle of regulatory activities* (OECD, 2014), which is illustrated in Figure 2.



**Figure 2** Cycle of Regulatory Activities (adapted from OECD, 2014)

The cycle of regulatory activities consists of activities for creating and administering regulations. This cycle also comprises regulators interacting with all stakeholders involved in the regulatory ecosystem. The cycle's activities include making regulations through consultations with respective stakeholders at different stages of the development of regulations (Ullmann, 1985) in the *make* phase. They also include setting different objectives, expected results and how to achieve them using tools such as regulatory impact assessments (RIA) (Kirkpatrick & Parker, 2007; Radaelli & De Francesco, 2010). Additionally, the *operate* phase involves implementing and enforcing the regulations (Hawkins & Thomas, 1984; OECD, 2002), and the *review* phase involves reviewing and revising the regulations to see how they perform and ensure that they remain relevant (Arndt et al., 2015; Parker & Kirkpatrick, 2012). We can refer to the activities in the cycle as regulatory initiatives since they are activities initiated and used by regulators to support regulation creation and administration (Akhigbe, Amyot, et al., 2017).

Unfortunately, while regulators have been successful in the *make* phase and are showing progress in the *operate* phase, they have not been too successful with the *review* phase. Reasons for this include regulators being unsure of what to measure (Coglianese,

2012; Nielsen & Parker, 2006) and a limited understanding of data requirements (Jacobzone, Miguet, & Choi, 2007; Radaelli & Fritsch, 2012). An additional challenge is the existence of disparate information management systems used in the regulatory process. These reasons have resulted in the neglect of the *review* phase. Nevertheless, current trends, including climate change and global warming, cyber and biosecurity threats, disruptive technologies as well as the rise of populist governments, are driving an increased interest in demonstrating whether regulations actually achieve their desired objectives or accomplish their intended outcomes. As a result, reviewing regulations to show how they perform continues to be of utmost interest to regulators (Parker & Kirkpatrick, 2012; Radaelli & Fritsch, 2012).

In this context, how do we know whether a regulation is achieving its desired objectives or accomplishing its intended outcomes? Can regulators show that they are targeting the right objectives to attain expected societal outcomes with the regulations they introduce? While regulations routinely evolve through their introduction, modification, and repeal to meet societal needs, do regulations inform behaviours? Do regulatory initiatives such as programs and enforcement activities done by regulators improve compliance with regulations? To what degree does non-compliance with a regulation leads to societal problems. To what extent does observed compliance with a regulation implies that behavioural changes were achieved, and outcomes will be accomplished. A difference between perceptions of how regulations perform in relation to the desired objectives, and observed compliance levels with regulations, may indicate that regulations do not target the right issues.

Governments wanting to be more open and transparent about their activities advocate using data-driven evidence to gain and maintain a consensus on both achieved objectives and accomplished outcomes. Citizens and businesses, who today are more aware and knowledgeable than in the past, engage their governments to seek such evidence. As a result, an important task of regulators is to show a credible return on investment (ROI) on their efforts in creating and administering regulations. This implies providing evidence that regulations actually do what they were intended for and at adequate costs (Head, 2008; Marston & Watts, 2003). Such evidence could serve as a justification for the introduction, change or repeal of regulations. Consequently, showing the link between regulations, at-

tained compliance levels, achieved objectives and accomplished outcomes becomes necessary. Such link enables ascertaining the influence or impact of any regulation and aids addressing concerns related to *overregulation* or *under regulation*.

The primary focus of this thesis is to apply goal modeling and data analytics to show whether regulations are effective, that is, whether they achieve their desired objectives and accomplish their intended societal outcomes. The research described in this thesis achieves these results by providing a data-driven method that enables linking regulations with the regulatory initiatives employed by regulators to support these regulations, their desired objectives and their intended societal outcomes. The method, named *Goal-oriented Regulatory Intelligence Method (GoRIM)*, enables monitoring, analysis and reporting on the effectiveness of regulations using this data link. Furthermore, using analytics and data visualization software, the analysis of the causal relationships between regulations, regulatory initiatives, objectives and outcomes can be done to provide data-driven evidence of the effectiveness of regulations and performance of regulatory initiatives, and on objectives and outcomes of regulations. GoRIM helps regulators show how their regulations perform. It also assesses regulatory initiatives in order to identify opportunities for their continuous improvement.

## 1.2. Research Questions

Coglianesse (2012) posits that to measure the performance of a regulation or regulatory policy, evaluations are needed of:

- a) the substantive outcomes of the regulations, *and*
- b) any relevant process-oriented outcomes based on administrative, democratic, or technocratic values.

*Substantive outcomes* imply outcomes of regulations that are technocratic and economic, and *process-oriented outcomes* imply administrative and democratic outcomes of regulations. Technocratic outcomes include:

- i) the effectiveness of the regulation in solving the problem it was designed to address,
- ii) the quality of the scientific analysis underlying the regulation, and
- iii) the extent to which the regulated parties comply.

Economic outcomes are:

- i) the cost-effectiveness of the regulation
- ii) the net benefits of the regulation, and
- iii) the impacts of the regulation on the overall economy.

Administrative outcomes include:

- i) the time (staff; full time equivalent or chronological; start-to-finish time) it takes to implement a regulation,
- ii) the cost of implementing the regulation, and
- iii) whether regulators produce regulations that minimize subsequent disputes or litigations.

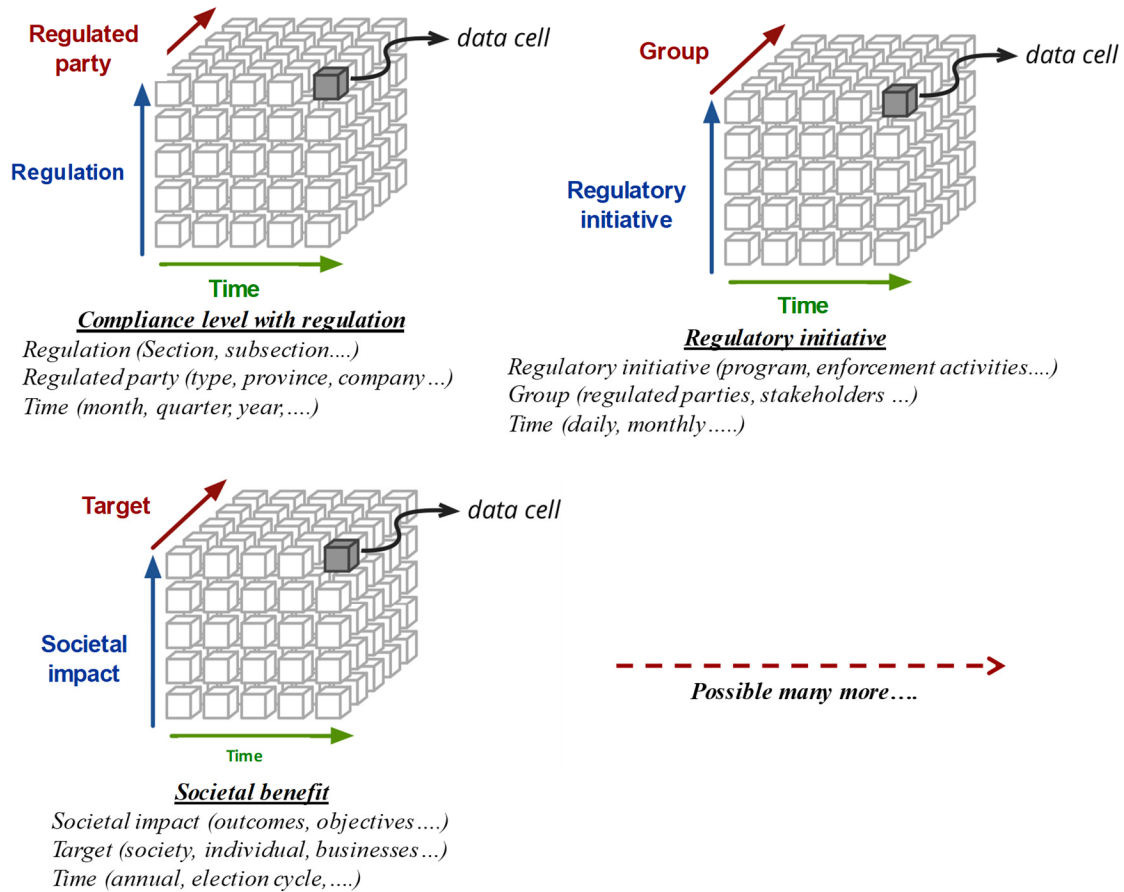
Finally, democratic outcomes include:

- i) the number of public participants in regulatory decision making,
- ii) how meaningful the participation is, and
- iii) the level of public support for or perceived legitimacy of the regulation.

In addition, Coglianesi (2012) suggests that regulators need to obtain data from activities such as randomised experiments and analyze them using sophisticated statistical techniques to determine the aforementioned outcomes. This hypothesis implies that to show the performance of regulations, we need to obtain data from and within the regulatory process, and then analyze these data. Building the results of the analyzed data on the relationships existing between regulations and the regulatory process will facilitate the understanding of the analyzed data and the results they infer. In this regard, the proliferation of software and tools that focus on the analysis of data today can imply that such sophisticated data analyses are possible. On the other hand, identifying what to measure to derive required data for analysis is still challenging (Coglianesi, 2012; Nielsen & Parker, 2006).

However, we can observe that the outcomes of regulations include *substantive* and *process-oriented outcomes* resulting from the objective of the regulations. In addition, the activities that result in *substantive* and *process-oriented outcomes* are the ones that regula-

tors carry out in the cycle of regulatory activities (OECD, 2014), i.e., the *regulatory initiatives* illustrated in Figure 2. Hence, a focus on the data created and used by regulatory initiatives appears essential in identifying whether the objectives of regulations are achieved and/or whether intended outcomes are accomplished. Indeed, how data are obtained and used plays an important role in the regulatory process.



**Figure 3** Types and Dimensions of Data involved in the Regulatory Process

As illustrated in Figure 3, the data involved in the regulatory process have different dimensions and their exploration can provide many insights. Therefore, data from compliance with regulations and from the performance of regulatory initiatives can prove useful to measuring regulatory performance. Here, the achievement of desired objectives and the accomplishments of outcomes are expressed using data. Accordingly, if we can link data on regulatory compliance, data from regulatory initiatives, as well as data on the desired objectives and intended societal outcomes, this enables opportunities to explore and use data to show and describe regulatory performance. To achieve such links, we need a better

understanding of the regulatory ecosystem, particularly how regulators review regulations to show if regulations are effective. Such knowledge will enable identifying any evidence of regulatory performance, what works or not, and opportunities for improvements.

In addition, we can identify opportunities to better monitor and analyze the data in the regulatory ecosystem towards reporting on regulatory performance with data-driven evidence. To do this requires distinguishing between *knowledge problems* and *practical problems* (Wieringa, 2009; Wieringa & Heerkens, 2006), two mutually nested problems common within design science research (DSR). DSR attempts to create innovative artifacts that solve human and organizational problems in a formalized manner (Simon, 1996). A knowledge problem is a difference between what we know about the world and what we would like to know about it, while a practical problem consists of a difference between the way the world is and the way we think it should be (Wieringa & Heerkens, 2006). Knowledge problems require a change in our knowledge about the world where the problem exists whereas practical problems require a change in the world so it better agrees with the stakeholders' goals (Wieringa, 2009). Knowledge problems are solved by asking others, searching existing literature or doing research. When researching, we search for propositions empirically proven to be true to the respective laws in the problem environment. To solve a practical problem, we investigate the goals of the stakeholder and utilize criteria specific to that stakeholder. There are two type of practical problems, design problem (DP), where we construct a specification of a solution to a practical problem, and implementation problem (IP), where we implement the specification.

Accordingly, in this thesis, I distinguish between knowledge problems (KP) and practical problems (DP and IP). The knowledge problem I address is enhancing our knowledge on how to review regulations to determine whether they are achieving their desired objective and accomplishing their intended outcomes. The practical problem I address is how to provide data-driven evidence that demonstrates that regulations are achieving their desired objectives and accomplishing their intended outcomes. Hence, to guide the research described in this thesis, I define the following research questions:

- **Research Question 1 (KP):** What are the existing approaches used to demonstrate the performance of regulations? Are these approaches suitable for demonstrating the performance of regulations?

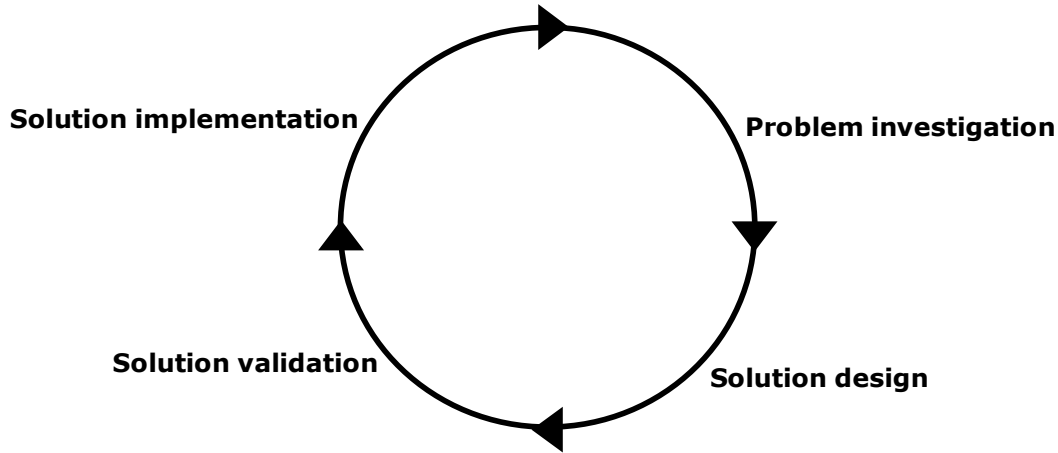
- **Research Question 2 (KP):** Can Information Systems enable deriving data-driven evidence on the performance of regulations?
- **Research Question 3 (DP):** To what extent can linking compliance with regulations, regulatory initiatives, and desired objectives and intended outcomes enable demonstrating, with data-driven evidence, that regulations achieve desired objective and accomplish intended societal outcomes?
- **Research Question 4 (IP):** Is there any efficacy in linking compliance with regulations, regulatory initiatives, desired objectives and intended societal outcomes to provide data-driven evidence on regulatory performance?

### 1.3. Research Approach

As discussed in Section 1.2, knowledge problems and practical problems are common within design science research (DSR). The proposition when applying DSR to a problem domain is that knowledge and understanding of the domain and solutions are attained when building and applying innovative artifacts (Vaishnavi, Kuechler, & Petter, 2004). These innovative artifacts, also known as Information Technology (IT) artifacts, take the form of *construct, models, methods* and *instantiations* (Hevner et al., 2004) and are prescriptive knowledge designed to improve the natural world (Gregor & Hevner, 2013; Simon, 1996). Applying DSR to a problem domain enables a research activity to focus on the domain where the problem exists, and the knowledge base of scientific foundations, experience and expertise that informs the research (Hevner, 2007; Hevner & Chatterjee, 2010). Such focus facilitates building and evaluating the innovative artifact, and the process of the research. This thesis uses a method based on DSR precepts to answer the research questions and carry out the research, i.e., the “engineering cycle”.

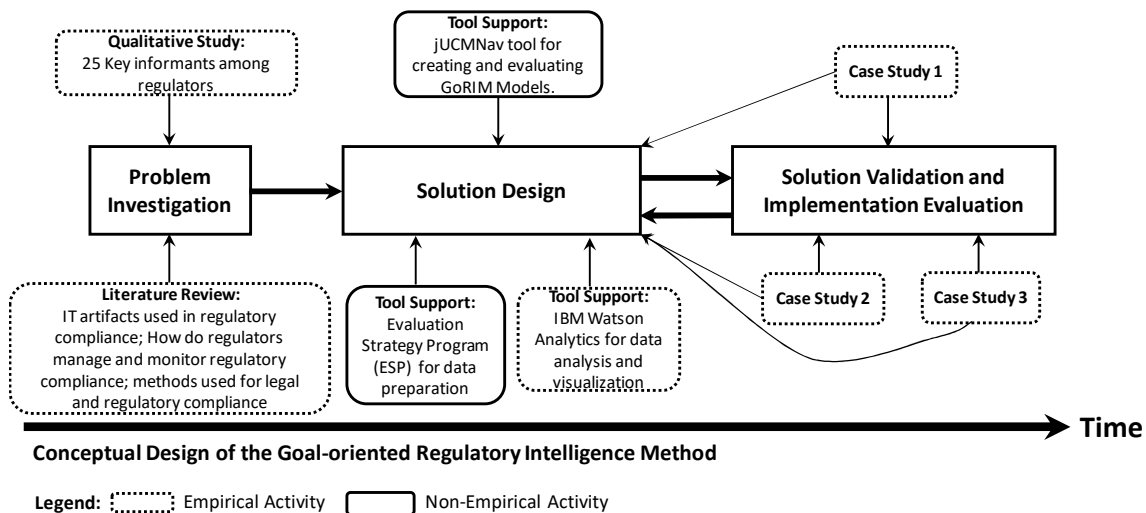
The engineering cycle, illustrated in Figure 4 below, is a logical structure for solving knowledge and practical problems (Wieringa, 2009). The cycle consists of four phases: problem investigation, solution design, solution validation and solution implementation. In the *problem investigation* phase, a researcher seeks information about and obtains an understanding of the given problem domain towards describing the problem. In the *solution*

*design* phase, the researcher comes up with a plan towards a solution and communicates the plan to the respective stakeholders.



**Figure 4** The Engineering Cycle (Wieringa, 2009; Wieringa & Heerkens, 2006)

In the *solution validation*, the researcher assesses the specified solution to ensure it meets the stakeholder’s goals as close as possible when implemented. Finally, in the *solution implementation* phase, the researcher applies the solution based on the design specifications and evaluates the perceived impact on the respective stakeholders' activities that the solution provides. In this doctoral thesis, my use of the engineering cycle comprises these four phases.



**Figure 5** Research Approach

As illustrated in Figure 5 above, I started out with a *problem investigation* phase consisting of discussions with regulators and reviews of the literature on the regulatory process. The aim was to understand how regulators currently demonstrate that regulations achieve their desired objectives and accomplish intended outcomes. I also wanted to be acquainted with the approaches that regulators use in this regard. Based on these activities and their results, I proceeded to design a solution, a method artifact called GoRIM (*solution design phase*) that enables providing data-driven evidence for use in demonstrating whether regulations achieve their desired objectives and accomplish intended societal outcomes. Finally, I demonstrated, modified and evaluated GoRIM in three different case studies involving real-life regulatory scenarios (*solution validation and implementation phases*).

#### **1.4. Significance and Thesis Contributions**

Measuring the progress of regulations and their outcomes through the regulatory process has been the topic of various studies. Common examples include studies that use artificial intelligence (AI) and requirements engineering (RE). In these domains, research explores the use of Information Systems (IS) at the software level to facilitate regulatory compliance through confirming compliance and evaluating the issues related to non-compliance (Akhigbe, Amyot, & Richards, 2015, 2016). In this respect, software serves as the foundation for research on regulatory compliance. The rationale is that if software can improve operational functions in organizations, it can also help measure compliance (Akhigbe et al., 2015). These researches however focused on enabling *regulated parties* to comply with regulations rather than on enabling *regulators* to assess and enforce compliance or monitor and manage the regulatory process. For example, a review on modelling methods used for legal and regulatory compliance indicates that only 12% of reviewed articles addressed how regulators used these modelling methods in contrast to 82% for regulated parties and 6% for regulators and regulated parties together (Akhigbe, Amyot, & Richards, 2018).

Consequently, this research has brought to bear the challenges regulators face when creating and administering regulations. It does so by providing a description of the current state of research in the legal and regulatory compliance domain. This research and its results can serve as a motivation and guidance for further research in the legal and regulatory compliance domain, particularly from the viewpoint of regulators, which does not get much

coverage in academic literature. Accordingly, the contributions of this research include major and minor contributions.

### **1.4.1 Major Contributions**

The major contribution of this research is the Goal-oriented Regulatory Intelligence Method (GoRIM), which regulators can use to monitor, analyze and report on whether regulations achieve their desired objectives and accomplish intended societal outcomes. This method covers the following sub-contributions:

1. A meta-model for regulatory initiatives that enables modelling and analyzing how regulatory initiatives support achieving the objectives of regulations.
2. The use of the same goal modelling views for the regulations, regulatory initiatives, and desired objectives and intended societal outcomes. This enables robust analysis within each view and across the views.
3. How to use data analytics/visualization software exploiting artificial intelligence to explore and analyze data derived from the goal models. The case studies with real regulatory contexts show the exploration and analysis of relationships between models of regulations and regulatory initiatives, as well as within these models.
4. Demonstrations of analysis involving compliance with regulations and performance of regulatory initiatives in real regulatory scenarios. The three cases studies evaluated in this thesis also explore regulatory contexts other than privacy and domains other than healthcare, as recommend by Akhigbe, Amyot, & Richards (2018).

### **1.4.2 Minor Contributions**

The minor contributions of this research pertain to the literature on legal and regulatory compliance with a description of the current state of research in the domain. The challenges regulators encounter in showing whether regulations achieve objectives and accomplish outcomes has been highlighted in conference proceedings (Akhigbe, 2016; Akhigbe et al.,

2015) and journal articles (Akhigbe et al., 2016, 2018). This research has also introduced the use of data analytics tools to visualize and analyze data from goal models (Akhigbe, Heap, Amyot, & Richards, 2017; Akhigbe, Heap, Islam, Amyot, & Mylopoulos, 2017). In addition, this research makes use of Python (Rossum, 1995) for preparing data from the regulatory process towards their evaluation by goal models, leading to a new tool (Evaluation Strategies Processor – ESP). Such data, akin to Big Data in some cases, includes daily, weekly, monthly or annual data on compliance with regulations or data on regulatory initiatives.

## 1.5. Publications and Presentations Based on the Thesis

Publications that has resulted from this doctoral research include:

1. **Akhigbe, O.**, Amyot, D. and Richards. G.: “Information Technology Artifacts in the Regulatory Compliance of Business Processes: A Meta-Analysis”. In: Benyoucef, M., Weiss, W., and Hafedh, M. (eds.) 6th International MCETECH Conference on E-technologies, LNBIP, Vol. 209, Springer International Publishing, Switzerland, pp. 89–104 (2014).

This article, which I presented at the MCETECH conference, is a systematic literature review on IT artifacts that facilitate regulatory compliance. I defined the research questions, carried out the literature review and led the writing of this paper. I used this paper in the systematic literature review described in Section 2.2.

2. **Akhigbe, O.**, Amyot, D. and Richards. G.: “Monitoring and Management of Regulatory Compliance: A Literature Review”. *International Journal of Information Processing and Management (IJIPM)*, Vol. 7, No. 2, pp. 20–35, (2016).

This journal article is a systematic literature review on how regulators monitor and manage regulatory compliance. I also defined the research questions, carried out the literature review and co-wrote this paper. I used this paper in the systematic literature review described in Section 2.3.

3. **Akhigbe, O.:** “Towards a Regulator-Oriented Regulatory Intelligence Framework”. In: Proceedings of the 24th IEEE International Requirements Engineering Conference (RE’16), Beijing, China, September, IEEE CS, pp. 415-4250, (2016).

This article, published in the RE 2016 doctoral symposium, introduces the Regulator-Oriented Regulatory Intelligence Framework, an earlier iteration of the Goal-oriented Intelligence Method (GoRIM). I used this paper in Chapter 4.

4. **Akhigbe, O., Amyot, D., Richards, G., and Mylopoulos, J.:** “What can Information Systems do for Regulators? A Review of the State-of-Practice in Canada”. In: Proceedings of the 11th IEEE International Conference on Research Challenges in Information Science (RCIS), IEEE CS, pp. 57-65, (2017).

This article, which I presented at the RCIS Conference, is a study of the state-of-practice of regulators in Canada. The article highlights challenges in the regulatory domain and opportunities for information systems to improve the practice of regulators. I defined the research questions, interviewed the regulators, analyzed the results and co-wrote this paper.

5. **Akhigbe, O., Heap, S., Islam, S., Amyot, D., and Mylopoulos J.:** “Goal-Oriented Regulatory Intelligence: How Can Watson Analytics Help?” In: Proceedings of the 36th International Conference on Conceptual Modeling (ER 2017), Valencia, Spain, LNCS, Springer, pp. 77-91 (2017).

This article, which I presented at the ER conference, introduces GoRIM and shows how it can be used to measure and visualize the effectiveness of regulations. I created and evaluated the models used to describe the applicability of GoRIM. I was involved in the analysis of the evaluated regulatory compliance data and program data using IBM Watson Analytics and I co-wrote the paper. I also co-supervised the second and third authors in their work. I used this paper in the case studies described in Chapter 5, Chapter 6 and Chapter 7.

6. **Akhigbe, O., Heap, S., Amyot, D., and Richards, G.:** “Exploiting IBM Watson Analytics to Visualize and Analyze Data from Goal-Based Conceptual Models

(Demo Paper)”. In: Proceedings of the 36th International Conference on Conceptual Modeling (ER 2017) Forum and Demo Track, Valencia, Spain. CEUR-WS.

This article, which I presented at the ER conference, is a demonstration of how GoRIM’s tools support (jUCMNav) and data analytics component (IBM Watson Analytics) work together. I created and evaluated the models used to demonstrate GoRIM as well as the analysis using IBM Watson Analytics, and I co-wrote this paper. I used this paper in the case studies described in Chapter 5, Chapter 6 and Chapter 7.

7. **Akhigbe, O.**, Amyot, D. and Richards. G.: “A Systematic Literature Mapping of Goal and Non-Goal Modelling Methods for Legal and Regulatory Compliance”. Requirements Engineering Journal, 1–23, <https://doi.org/10.1007/s00766-018-0294-1> (2018). Online First.

This journal article is a systematic literature review on the benefits and drawbacks of the use of goal-oriented modelling methods in comparison to non-goal-oriented modelling methods for legal and regulatory compliance. I defined some of the research questions, carried out the literature review and co-wrote this journal paper. I used this paper in the systematic literature review described in Section 2.4

Presentations that I have made based on this doctoral research include:

- a) **Akhigbe, O** (2017, September). Towards Regulatory Intelligence. Talk presented at the Government Analytics Network, Telfer School of Management, University of Ottawa. (<http://sites.telfer.uottawa.ca/cbap/government-analytics-network/>).
- b) **Akhigbe, O** (2017, December). Applying Conceptual Modelling and Data Analytics to Regulatory Management. Talk presented at the Community of Federal Regulators (CFR) 2017 Annual Conference, Ottawa, Canada. (<http://cfrconference.ipac.ca/#>)

## **1.6. Thesis Outline**

The rest of the thesis is composed of nine chapters and organized as follows. In Chapter 2, I discuss the investigation of the problem domain, the regulatory domain; how regulators demonstrate regulatory performance, how information systems can enable deriving data-driven evidence on the performance of regulations, and hence address the knowledge problems. Chapter 3 presents the methodology I used for this doctoral research. I introduce GoRIM in Chapter 4 and thereby address the first practical (design) problem. I present three case studies used to design, develop, and demonstrate GoRIM in Chapter 5, Chapter 6 and Chapter 7. I evaluate GoRIM in Chapter 8 and hence address the second practical (implementation) problem. I discuss lessons learned and the implications of the research results in Chapter 9. Finally, I summarize contributions of the research and I provide an outlook on future research in Chapter 10.

## Chapter 2. Problem Investigation

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As discussed in Chapter 1, regulators need to provide evidence that demonstrate that the regulations they administer are performing. Regulators who provide such evidence accentuate their transparency and accountability as custodians of the regulatory ecosystem. Nonetheless, how do regulators do this? How do regulators demonstrate that the regulations they create and administer are performing? Is there evidence that regulation perform? How do they ensure that they address all stakeholders' concerns about the regulations they create and administer? Are the approaches regulators use suitable for demonstrating that regulations perform?

To answer these questions, I spoke with regulators and reviewed literature on the regulatory process to understand what is involved in demonstrating regulatory performance. My speaking with regulators provided an opportunity to understand key challenges regulators face when carrying out their mandate of creating and administering regulations (Akhigbe, Amyot, et al., 2017). These challenges included reviewing regulations to demonstrate achieve their desired objectives and accomplish intended outcomes, which I address in this doctoral research.

Reviewing the literature on a research topic uncover sources that are relevant to the topic, enables expanding on the problem under investigation, and makes a vital contribution to the relevance and rigour of the research (Brocke et al., 2009). My review of literature on the regulatory process is composed of three different systematic literature reviews (SLRs) that exploited the method described by Kitchenham and Charters (2007). SLRs are rigorous in their identification, selection, analysis and synthesis of findings in studies on a particular topic or question. They provide clarity and quality in understanding a topic or domain and add to the thoroughness in the research process. These characteristics contribute to the use and appreciation of SLRs as an integral part of research across different academic domains. An SLR comprises three stages: *planning*, *conducting* and *reporting*. Planning the SLR involves selecting articles to review and conducting the SLR is carrying out the analysis and synthesis. Finally, the reporting stage is the process of outlining and

communicating the results of the SLR. In this chapter, I first I discuss how regulators demonstrate the performance of regulations and the suitability of approaches they use for this purpose (Section 2.1). I then discuss the three SLRs on how regulators can use information systems to demonstrate, with data-driven evidence, the effectiveness of regulations (Sections 2.2, 2.3 and 2.4).

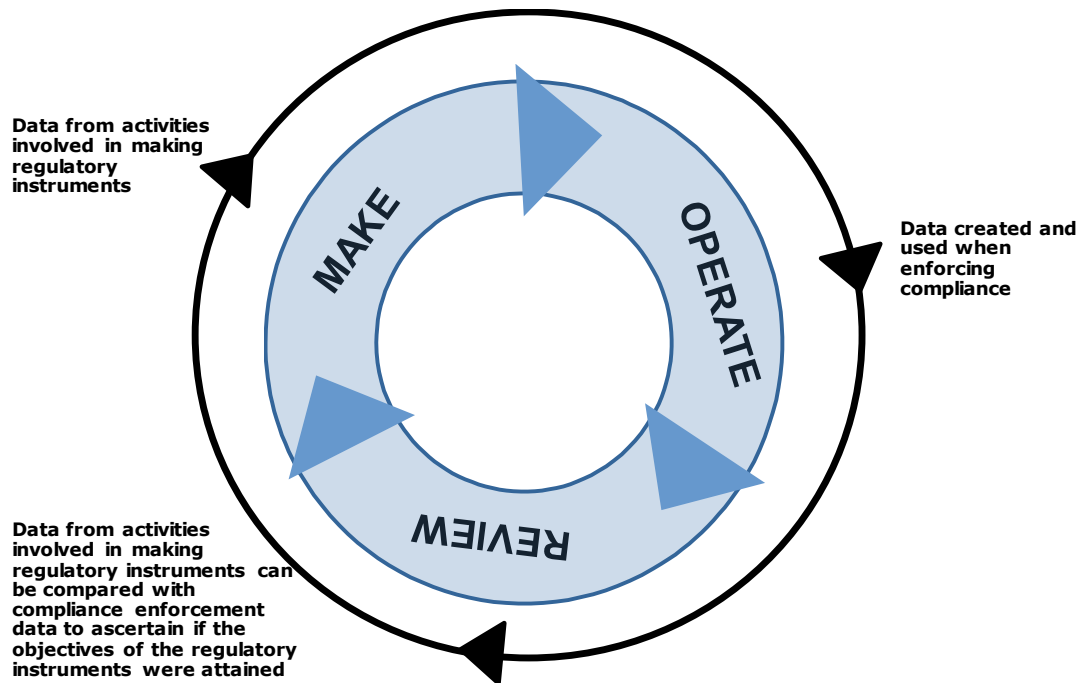
## 2.1. The Challenge of Demonstrating Regulatory Performance

To show how regulations *perform*, regulators need to demonstrate that regulations are *effective* and *efficient*. Ideally, the review of regulations takes place in the *review* phase of the *cycle of regulatory activities* described in Section 1.1. When regulations are reviewed, a regulation that maximizes the desired objective or intended outcomes while minimizing cost, is considered to be better performing (Davies, 2014). Unfortunately, demonstrating how regulations perform is not commonly done. When regulations are reviewed, demonstrating regulatory performance ends up addressing not necessarily the outcomes of the regulation but how well the regulator discharges its mandate in governing the concerned sector (Yandle & Young, 1986). The performance of the regulation is described in terms of how the regulator functions administratively and economically (Baldwin & Cave, 1999; Levy & Spiller, 1994), the regulator's political accountability (Gasmi, Noumba, & Virto, 2007, 2011; Laura, Gasmi, & Noumba, 2008) or how the concerned sector is governed (Berg, 2000a, 2000b, 2016).

In this regard, once the regulator performs its functions well with fiscal responsibility and the regulated parties are in compliance, we assume that the regulation is performing. This approach to reviewing regulations results in too much focus on attaching an economic value to the benefits of a regulation (Coglianese, 2012; Parker & Kirkpatrick, 2012) rather than on what the regulation achieves or accomplishes; the focus is not on the regulation's *effectiveness*. Similarly, regulatory initiatives that support regulations tend to pay attention to how much it costs to create and administer the regulation. These regulatory initiatives such as *programs*, *enforcement activities*, and *cost benefit analysis* (CBA), or *risk-based approaches* (RBA) etc. whether used *ex ante* (based on forecasts) or *ex post* (based on actual results), end up highlighting how efficient the regulation was and not whether the regulation was effective.

Following this emphasis on the regulator, the review phase of the cycle of regulatory initiatives ends up not determining if regulations were effective. For example, let us consider a review of the Speed Limits Regulation (Government of Ontario, 2018b), created to administer the OHTA (Government of Ontario, 1990) described in Chapter 1. Such review will address how the regulator ensures that drivers respect the speed limits and the costs associated with ensuring this, and not whether the speed limits work or what the speed limits should be. Notwithstanding the focus on the cost of operating regulations, assessments of the costs of regulations are frequently challenged, as many believe economic criteria are inadequate for evaluating if regulations result in societal impacts (Baldwin & Cave, 1999; Hahn & Hird, 1991; Hahn, 1990). Indeed, this approach to reviewing regulations with a focus on the regulator, regulated parties and the cost associated with the regulation, suggests that regulators already do things that could show how regulations are performing.

Regulators already do assessments to show the results of their regulatory initiatives, what it costs to design and implement a regulation, promote and enforce compliance with the regulations. Regulators also carry out studies to show the relevance and importance of regulations and, to some extent, they can also show the societal outcomes that regulations accomplish. In the case of the Speed Limits Regulation (Government of Ontario, 2018c), annual information on outcomes of this regulation are available in the Ontario Ministry of Transportation's annual "Ontario Road Safety Annual Reports (ORSAR)" (Government of Ontario, 2017c). This suggests that regulators carry out some sort of review. The challenge with such reviews is that regulators are unable to link the outcomes they obtain to the regulation or to exclude other causes for these outcomes. Observed societal outcomes could occur, but not necessarily because of the regulation or of the enforcement processes. In the case of the Speed Limits Regulation, if the intended outcome is to reduce deaths on highways, for example, this outcome might be observed but perhaps not because of speed limits. Safer cars or better highway maintenance might be the actual cause.



**Figure 6** The Use and Creation of Data in the Cycle of Regulatory Activities

How then does the regulator connect all the views in the regulatory process to provide a proper and reliable perspective? Certainly, all these different views contain data on the regulatory process that could be useful for assessing the next concurrent phase, as illustrated in Figure 6. A holistic view that includes all independent views would offer a more comprehensive way to demonstrate regulatory performance and adequately utilize the data therein. Consequently, a systematic way of connecting all the different views to facilitate demonstrating regulatory performance appears to be missing. The concept of *regulatory intelligence* proves useful in this regard.

*Regulatory intelligence* involves continuously collecting and processing data from multiple sources, and analyzing them based on the respective context towards generating and communicating meaningful insights (Felgate, 2013; Hynes, 2014). Inspired from the heavily regulated pharmaceutical industry that is often characterized by ever-increasing and changing regulatory requirements (Hynes, 2014), regulatory intelligence facilitates a feedback loop that links activities towards supporting decision-making. Using regulatory intelligence, companies in the pharmaceutical industry regularly monitor their respective regulatory ecosystem to identify opportunities where they can utilize obtained insights to

remain locally and globally compliant. Although often presented from the regulated parties' perspective, in recent years, regulatory intelligence has also been addressed from the regulator's viewpoint (Badreddin et al., 2013). Regulated parties such as pharmaceutical companies can use regulatory intelligence to explore how regulations affect them. Likewise, regulators can apply the concept of regulatory intelligence to obtain insights from the regulatory ecosystem such as how the regulations are performing.

Hence, I posit that applying the concept of regulatory intelligence to the cycle of regulatory activities will enable collecting and analyzing the data created and used in the regulatory process to support regulatory decision-making. Regulators can then take advantage of IS, such as data analytics and data visualization software, to carry out the kinds of sophisticated statistical analysis Coglianese (2012) suggests using, to provide evidence on regulatory performance. Such data-driven evidence will be useful not only to demonstrate regulatory performance, but also to influence the regulatory process and ecosystem. As such, a review of the regulatory process to identify IS that are currently used to create and use data becomes necessary.

## **2.2. Information Technology Artifacts in Regulatory Compliance**

When enforcing compliance with regulations, regulators compel regulated parties to prove that they comply with regulations. To do this, the regulated parties identify legal requirements in the respective regulation and check them to ensure that they are in compliance. The regulated parties then report on their compliance in line with the medium required by the regulator. These activities of the regulated parties represent basic units of work and are generally described as tasks (OMG, 2008). Within regulatory compliance, there are compliance *modelling*, *checking*, *analysis* and *enactment* tasks (El Kharbili, 2012). Compliance *modelling* tasks address sourcing and eliciting towards discovery and formalization of requirements in the laws and regulations. Compliance *checking* tasks ensure that any created formalized representation of the business processes is valid and meets relevant compliance requirements. Compliance *analysis* tasks involve getting insights on the state of compliance. Finally, compliance *enactment* tasks include mechanisms to dynamical react to violations in order to re-establish compliance.

Regulated parties, such as organizations, utilize IS in these compliance tasks, thereby creating and using IT artifacts (Hevner et al., 2004). In this regard, I carried out an SLR on the IT artifacts involved in the regulatory compliance of business processes to regulations (Akhigbe et al., 2015). In doing this, the SLR also identified and situated the compliance tasks (*modelling, checking, analysis and enactment*) that created and used these IT artifacts. The SLR is composed of a synthesis of research findings from nine other peer-reviewed SLRs and state-of-the-art studies, as well as of the articles that they reviewed to identify these IT artifacts, the compliance tasks that created them, and how they are used. In the planning stage of this SLR, I defined four research questions and selected databases and engines to search for articles. I also identified keywords and a query to search with, and defined inclusion and exclusion criteria to exclude or include relevant studies. The research questions are:

1. What are the phases in the lifecycle of regulatory compliance?
2. What compliance tasks create or use Information Technology artifacts?
3. What are the types of Information Technology artifacts created or used in regulatory compliance?
4. What are the research approaches that define the usage or creation of Information Technology artifacts within the domain of regulatory compliance?

I identified seven academic databases and search engines where I could obtain relevant articles:

ACM Digital Library (ACM), Business Source Complete (BSC), IEEE Xplore (IEEE), ProQuest, Scopus, Web of Science (WOS) and Google Scholar (GS).

I defined keywords and query based on the systematic literature review's objective:

("Business process compliance" OR "Regulatory compliance" OR "Legal compliance")

AND

("Systematic review" OR "Systematic survey" OR "Literature review" OR "Literature survey" OR "State-of-the-art")

I applied two exclusion/inclusion criteria to exclude or include relevant articles in two levels as follows:

**Exclusion:** *Exclude studies from searches that do not fit the purpose of the search query (e.g., included keywords without discussing them), or that are not written in English.*

**Inclusion:** *Include studies that address the compliance of business processes with laws and regulations, and an Information Technology artifact, and have an accessible list of all articles the study reviewed.*

In the conducting the review stage, I applied the query to all seven databases and search engines. It was necessary to adapt the query to suit the options and constraints required for each database or search engine. I also did a Google search on authors of studies identified in the searches on the seven databases and search engines. This approach resulted in four additional studies not returned in the earlier searches. I ended up selecting the nine articles listed in Table 1 below from a pool of 364 studies using the exclusion and inclusion criteria.

**Table 1** Summary of Selected Studies and their Source

No.	Study
1	Addressing legal requirements in requirements engineering (Otto & Antón, 2007)
2	State-of-the-art in the field of compliance languages (Tilburg University, 2008)
3	Business process compliance checking: current state and future challenges (El Kharbili, et al., 2008)
4	Compliance in e-government service engineering: state-of-the-art (Turki & Bjekovic-Obradovic, 2010)
5	A systematic review of compliance measurement based on goals and indicators (Shamsaei, Amyot, & Pourshahid, 2011)
6	A systematic review of goal-oriented requirements management frameworks for business process compliance (Ghanavati, Amyot, & Peyton, 2011)
7	Business process regulatory compliance management solution frameworks: a comparative evaluation (El Kharbili, 2012)
8	Generalizability and applicability of model-based business process compliance-checking approaches — a state-of-the-art analysis and research roadmap (Becker et al., 2012)
9	State-of-the-art of business process compliance approaches: a survey (Fellmann & Zasada, 2014)

I read and analyzed the 342 unique articles<sup>2</sup> reviewed by the nine studies listed in Table 1 to identify IT artifacts and the compliance tasks that created and used them. I categorized the identified IT artifact based on the artifact topology described by Offermann et al., (2010). This topology consists of eight artifact types that “faithfully mirror what practitioners in Information Technology and IS would recognize as key types of artifacts” (Johannesson & Perjons, 2014). Table 2 shows the IT artifact topology and a mapping of the eight artifact types to the working definitions of IT artifacts postulated by Hevner & Chatterjee (2010).

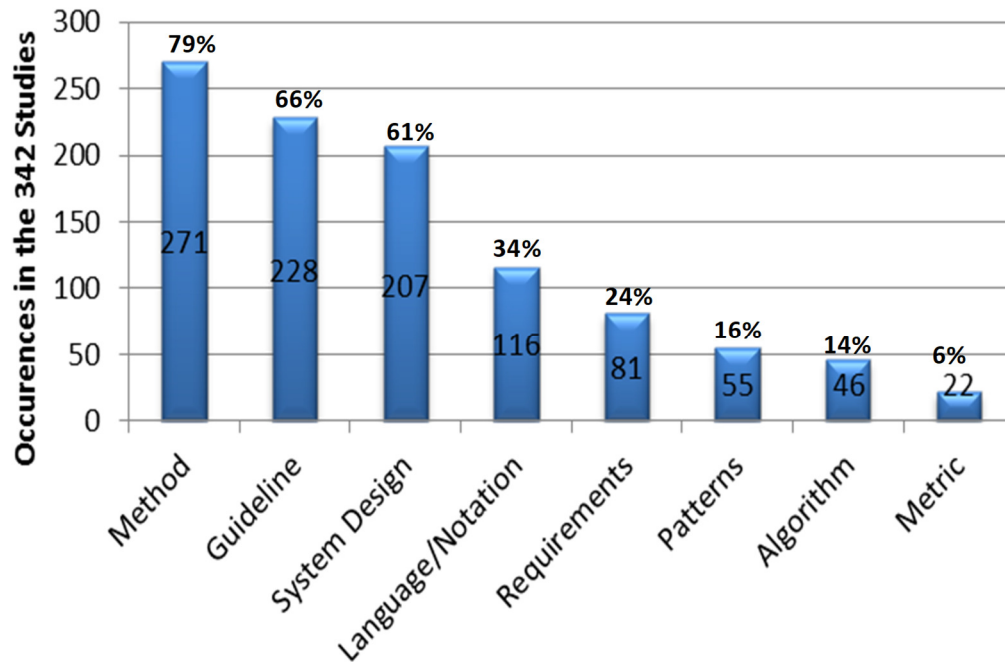
**Table 2** IT Artifact Topology (adapted from Offermann et al., 2010)

<b>Artifact Type</b>	<b>Use</b>	<b>Structure</b>	<b>(Hevner &amp; Chatterjee, 2010)</b>
System design	Description	Structure or behaviour-related description of a system, commonly using some formalism (e.g., UML) and possibly text.	Instantiations, Model
Method	Support	Definition of activities to create or interact with a system.	Method
Language / Notation	Support	A (generally formalized) system to formulate statements that represents parts of reality.	Construct, Model
Algorithm	Description	Executable description of system behaviour.	Method
Guideline	Support	Suggestion regarding behaviour in a particular situation (if in situation X do Y).	Construct
Requirements	Description	Statement about Systems (a system of type X shall have some property Y [because of Z]).	Construct
Pattern	Support	Definition of reusable elements of design with its benefits and application context.	Instantiations, Model
Metric	Support	A mathematical model that is able to measure aspects of systems or methods.	Model, Method

In the reporting stage, I use descriptive statistics on the 1026 IT artifacts that I identified along with the following observations:

<sup>2</sup> Available online at <http://bit.ly/1BUK182>

a) As illustrated in Figure 7, “Methods” and “Guidelines” appeared the most frequently in the articles with 79% and 67% of the occurrences respectively, while “Algorithm” and “Metrics” appeared the least often with 14% and 6% of the occurrences.



**Figure 7** IT Artifact Created and Used in Regulatory Compliance (Akhigbe et al., 2015)

b) As illustrated in Table 3, there are strong positive correlations between “Guideline” and “Method” ( $r = 0.647, p < 0.001$ ), and between “Requirements” and “Language/Notation” ( $r = 0.647, p < 0.001$ ). The strong significant correlations appear to suggest a link with the frequent use of methodologies in the regulatory compliance of business processes. As observed from Table 2, “Methods” indicates activities carried out in creating or interacting with business processes and regulations, and “Guidelines” provides generalized suggestions on how to use “Methods”. Similarly, while “Language/Notation” constitutes formalized structures to formulate statements about business processes and regulations, “Requirements” provides assertions about required behaviours and functions of the business processes and regulations system. In the reviewed articles “Methods” and “Guidelines” were often

represented together as methodologies, e.g., see (Ghanavati, Amyot, & Peyton, 2007; Young & Antón, 2010), as was “Language/Notation” with “Requirements”, e.g., see (Giblin et al., 2005; Governatori et al., 2005). Both combinations present different expressions of methodologies.

**Table 3** Correlation Statistics for IT Artifact Types (Akhigbe et al., 2015)

	<b>M</b>	<b>G</b>	<b>SD</b>	<b>L/N</b>	<b>R</b>	<b>P</b>	<b>A</b>
<b>G</b>	0.647 0.000						
<b>SD</b>	0.073 0.176	0.140 0.010					
<b>L/N</b>	-0.440 0.000	-0.607 0.000	-0.217 0.000				
<b>R</b>	-0.393 0.000	-0.627 0.000	-0.249 0.000	0.647 0.000			
<b>P</b>	-0.129 0.017	-0.045 0.407	-0.249 0.000	-0.045 0.411	-0.057 0.296		
<b>A</b>	-0.031 0.572	-0.085 0.117	-0.137 0.011	-0.138 0.011	-0.018 0.740	-0.033 0.548	
<b>Mr</b>	0.017 0.759	0.034 0.534	0.017 0.759	-0.087 0.108	-0.090 0.097	-0.017 0.748	0.036 0.503
<b>Legend</b> M = Method, G = Guideline, SD = System Design, L/N = Language/Notation, R= Requirements, P = Pattern, A = Algorithm, Mr = Metrics							
<b>Note:</b> the top number is the <i>Pearson’s correlation</i> whereas the bottom number is the <i>p-value</i>							

- c) Although weak, there is an interesting observation of a positive significant correlation between “System Design” and “Method”, and “System Design” and “Guideline”. This is indicative of the emergence of the use of tools designed to support “Methods” and “Guidelines” in the regulatory compliance of business processes. These combinations are called frameworks (Kumar & Liu, 2008; Siena et al., 2009).

As observed from this SLR, the IT artifacts used the most by regulated parties to comply with regulations are “Methods” and “Guidelines”. In addition, there is an increase in the use of methodologies (Methods and Guidelines or Language/Notation and Requirements) and framework (System Design and Method or Guidelines). Hence, in the next SLR that I

carried out, I looked at how regulators use these identified IT artifacts to collect and analyze data on the regulatory process towards demonstrating how regulations perform.

### **2.3. Monitoring and Managing Regulatory Compliance**

When enforcing compliance with regulations, regulators carry out inspections to observe compliance, introduce penalties or fines to punish defaulters, and engage in consultations with regulated parties to address any concerns. These activities can be broadly described as *monitoring* and *managing* regulatory compliance. Here, regulators monitor compliance with regulations by taking snapshots at different times (daily, monthly, annually, etc.) to analyze how the regulated parties comply with requirements in the regulations. Regulators manage regulations by looking at the entire periods of compliance with a regulation to analyze if the regulated parties meet defined objectives. The defined objectives, derived from the respective regulations, enable regulators to ascertain if the regulations are effective. To facilitate understanding of the way regulators monitor and manage compliance with regulations using IT artifacts, I carried out a second SLR (Akhigbe et al., 2016).

The objective of this SLR was to identify and assess the effectiveness of the IT artifacts regulators use to monitor and manage regulatory compliance. Based on the observations in section 2.2, the IT artifacts that I explored were method and frameworks. I also explored the use of models in the place of language/notation since the latter appeared more frequently as “models” in the literature. The selection of nine articles out of a pool of 1207 indicate a paucity on information on this topic and suggests that studies on how regulators monitor and manage regulations is of urgent concern. In the planning stage of this SLR, I defined two research questions, and selected keywords to search in order to arrive at relevant articles. I also identified relevant databases and search engines, and defined inclusion and exclusion criteria to guide my selection of articles.

The defined research questions were:

1. What are the frameworks, methods or models used by regulators to measure, assess or evaluate regulatory compliance?
2. How effective are these frameworks, methods or models in determining the effectiveness of regulations?

The search query includes the different forms of representations of regulators, what they use to ascertain compliance and how they go about ascertaining compliance. The query is as follows:

```
("Regulatory Agency" OR "Regulatory Authority" OR "Regulatory Body" OR  
"Regulatory Department" OR "Regulatory Organization" OR "Regulating  
Agency" OR "Regulating Authority" OR "Regulating Body" OR "Regulating  
Department" OR "Regulating Organization")
```

AND

```
("Framework" OR "Method" OR "Methodology" OR "Model")
```

AND

```
("Assess*" OR "Evaluat*" OR "Manag*" OR "Measure*" OR "Monitor*")
```

AND

```
("Compliance" OR "Policy" OR "Regulation")
```

To identify the relevant databases and search engines, I took a domain-generic approach to address many types of regulators and domains. I consulted with a librarian at the University of Ottawa in this regard. This approach enabled me to arrive at databases that provide academic and, in most cases, peer-reviewed articles and non-academic sources that capture the views of regulators. The academic databases were:

Business Source Complete (BSC), Columbia International Affairs Online (CIAO), Ebrary (EB), Econpapers (EP), Factiva (FA), ProQuest (PQ), PubMed (PM), Science Direct (SD), Scopus (SC), Social Science Research Network (SSRN) and Web of Science (WOS)

The non-academic databases were:

Annual Review (AR), Canadian Periodical Index Quarterly (CPIQ), National Bureau of Economic Research (NBER) and Organization for Economic Cooperation and Development (OECD)

These were the inclusion criteria chosen to enable the inclusion of articles:

1. *The abstract of the article is written in English, and it addresses a regulator and regulations or policies.*

2. *The article includes at least one mention of the word “compliance”.*
3. *The article includes at least one mention of any of the following words: assessment, evaluation, measurement, monitoring or management. It may also include these words in any of their wildcard forms expressed in the search query.*
4. *The article includes at least a mention of any of the words: framework, model or method.*
5. *The article addresses a regulator, compliance with a regulation or policy, and a measurement, assessment, monitoring, evaluation, or management using a framework, model or method.*

I chose the following exclusion criteria to enable the rejection of articles:

1. *Articles that did not address regulators as a body or agency mandated to enforce compliance with a regulation or policy.*
2. *Articles where the keywords (compliance, assessment, evaluation, monitor, management, framework, model or method) were not addressed directly in the article. This includes mentions only in the references or titles.*
3. *Articles where the keyword “method” signified a research approach and not the way regulators measure, assess, monitor, evaluate or manage regulatory compliance.*

During the review, I use the query on the selected databases and search engines, and then applied the inclusion and exclusion criteria concurrently. I selected nine articles from a pool of 1207 articles<sup>3</sup>. Table 4 shows a summary of my application of the inclusion and exclusion criteria.

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<sup>3</sup> Available online at <http://www.eecs.uottawa.ca/~damyot/pub/AkhigbePhD/>

**Table 4** Summary of Inclusion and Exclusion Criteria and their Application

No.	Inclusion/Exclusion Criteria	Available Articles	Selected Articles	
1	<p><b><u>Inclusion</u></b> Abstract of the article is written in English, addresses a regulator, a regulation(s) or regulations, policy or policies.</p> <p><b><u>Exclusion</u></b> The article does not address regulators as a body or agency mandated to enforce regulatory compliance.</p>	2531	1207	
2	<p><b><u>Inclusion</u></b> Article includes at least a mention of the word “compliance”.</p>	1207	699	
	<p><b><u>Inclusion</u></b> Article includes at least a mention of “assessment, evaluation, measurement, monitoring or management”. It may also include these words in any of their wildcard forms expressed in the search query.</p>	699	696	
	<p><b><u>Inclusion</u></b> Article includes at least a mention of “framework, model or method”.</p>	696	694	
3	<p><b><u>Inclusion</u></b> Article addresses a regulator, compliance with a regulation or policy and a measurement, assessment, monitoring, evaluation or management using a framework, model or method.</p> <p><b><u>Exclusion</u></b> Keywords are not addressed directly in the article. Mentioned in reference, title etc.</p> <p>Use of “method” is in reference to research approach and not a way regulator used to measure, assess, monitor, evaluate or manage.</p>	Keywords are addressed in the article	694	241
		Remove IMF and OECD articles	241	80
		Addresses a regulator, compliance with a regulation or policy and a measurement, assessment, monitoring, evaluation or management using a framework, model or method.	80	9

Notably excluded from the nine selected articles were articles by the International Monetary Fund (IMF) and the Organization for Economic Cooperation and Development

(OECD). These articles were not empirical and only provided summaries of assessments or evaluations countries had on regulations or policies. Their recommendation of areas needing improvements were neither detailed nor specific neither were method, framework or models (International Monetary Fund, 2009; OECD, 2013). As such, the articles selected involved a regulator, compliance with a regulation or policy, and a measurement, assessment, management, evaluation or monitoring using a framework, model or method.

In the last stage, I reported on the nine articles selected and shown in Table 5.

**Table 5** List of Articles in SLR 2

No.	Title	Year	Domain	Used		
				F	M1	M2
1	A framework for understanding individual response to regulation (Kaine et al., 2010)	2010	Agriculture	Y	N	N
2	A Game-Theoretic Approach to Regulatory Negotiation and a Framework for Empirical Analysis (Hsu, 2001)	2002	Environment	Y	Y	Y
3	A risk appraisal system regarding the implementation of maritime regulations by a ship operator (Karahalios, Yang, & Wang, 2015)	2014	Transport	N	Y	Y
4	Continuous Effluent Consents: Modelling and Compliance Testing (Crabtree, Crockett, & Ellis, 1989)	1989	Environment	Y	Y	Y
5	Development of a framework to measure health profession regulation strengthening (McCarthy et al., 2014)	2014	Health	N	N	Y
6	From punishment to prevention: A French case study of the introduction of co-regulation in enforcing food safety (Rouvière & Caswell, 2012)	2012	Agriculture	Y	N	N
7	The use of simple models in the regulation of the impact of fish farms on water quality in Scottish sea lochs (Gillibrand & Turrell, 1997)	1997	Environment	N	Y	Y
8	Towards medicines regulatory authorities' quality performance improvement: value for public health (Pejović et al., 2016)	2016	Health	Y	N	Y
9	Use of measurement uncertainty in a probabilistic scheme to assess compliance of bottled water with drinking water standards (Demetriades, 2010)	2010	Environment	N	Y	N
<b>Legend:</b> F = Framework, M1 = Method, M2 = Model, Y = Yes, N = No						

The nine articles identified five frameworks, six models and five methods that regulators use to measure, assess or evaluate the monitoring and management of regulatory compliance. I observed that regulators use frameworks in testing hypotheses on how compliance leads to favorable or unfavorable outcomes. I identified two types of frameworks: conceptual and empirical. Regulators use models in relating quantifiable entities in the respective ecosystem towards showing compliance. I identified two types of models, mathematical models and models based on existing principles such as the Capability Maturity Model (Paulk et al., 1993) and Total Quality Management (Feigenbaum, 1983).

Finally, I observed that regulators used methods to indicate steps or procedures for connecting identified quantifiable entities in the regulatory ecosystems. I identified two types of methods: statistical and analytical. I also observed that mathematical models appeared with the observed methods, indicating that methods were used extensively and that they offered more value. Furthermore, I observed that there is a paucity of research on how regulators address regulatory compliance. None of the nine reviewed articles was written by a regulator. Rather, researchers wrote the articles either to analyze regulators or propose approaches they deemed useful for monitoring or managing regulatory compliance.

Consequently, the use of methods proves useful in measuring, assessing or evaluating the monitoring and management of regulatory compliance. This confirms findings by the first SLR described in Section 2.2 on methods being the most used IT artifact. Additionally, applying methods with models that involve some form of analysis and involving regulators themselves are useful in deriving data to demonstrate regulatory performance. In this regard, it will be useful to identify what types of methods exist for regulatory compliance, in order to make recommendations on use to demonstrate regulatory performance. Hence, in the final SLR, I explored methods used for regulatory compliance in terms of the benefit and drawbacks different methods provide.

## **2.4. Methods used in Regulatory Compliance**

Of note in the research on regulatory compliance is work by the requirements engineering (RE) community (Akhigbe et al., 2018). In the RE domain, goal-oriented and non-goal-oriented modelling methods are used for regulatory compliance. Goal-oriented modelling methods are conceptual modelling methods and they use models composed of goals from

various stakeholders and their relationships, including AND/OR decompositions and positive/negative contributions. Goal-oriented modelling methods offers ways of structuring requirements according to the way they contribute towards achieving the goals of the stakeholders (Kavakli, 2002; Yu, 1997). Non-goal-oriented modelling methods, in contrast, do not use goals. Instead, they use methods such as natural language-based techniques, e.g., semantic annotations (Governatori et al., 2008; Zeni et al., 2008) or logic-based programming techniques (Sherman, 1987).

Typically, there are different contexts, such as over speeding on highways or privacy issues when dealing with health records, which require legal or regulatory compliance. These contexts exist in different domains, such as transportation or healthcare, and these contexts present compliance concerns that need addressing. The application of compliance tasks to these contexts enables addressing the concerns and results in compliance or non-compliance. Hence, it is in using modelling methods through compliance tasks to address compliance concerns in different contexts that the benefits or drawbacks of an applied modelling method become apparent. Therefore, the SLR described in this section explored how goal-oriented and non-goal-oriented modelling methods have been used for legal and regulatory compliance, and identifies their main claimed benefits and drawbacks (Akhigbe et al., 2018). In the planning stage of this SLR, I defined three research questions to identify the uses of each type of modelling methods for legal and regulatory compliance. These research questions also enabled me to identify the different contexts, domains of use and main claimed benefits or drawbacks of these methods.

I defined and utilized three search strategies composed of different steps and tasks in order to arrive at relevant articles to review. In addition, I also defined inclusion and exclusion criteria to guide the selection of articles to review.

The define research questions are:

1. What domains and contexts have goal-oriented and non-goal-oriented modelling methods been applied to for legal and regulatory compliance?
2. What are the main claimed benefits of using goal-oriented modelling methods for legal or regulatory compliance over non-goal-oriented modelling methods?
3. What are the claimed drawbacks to the use of goal-oriented modelling methods in comparison to non-goal-oriented modelling methods?

Based on these research questions, I arrive at this simple search query:

```
("Legal Compliance" OR "Regulatory Compliance")  
AND  
"Goal Model*")
```

Although this query is more exhaustive for one category (goal-oriented) than the other, it is however sufficient to enable answering the research questions about the use and comparative claimed benefits and drawbacks of each type of method. I defined three search strategies to identify articles for the review:

1. A search with the query on major IS research databases: ACM Digital Library, IEEE Xplore, Scopus and Springer Link. I included Google Scholar to this list in order to help identify articles not covered in the four databases.
2. A search with the query on conference venues and journals that publish methods related to legal or regulatory compliance. Here I used the list of the top twelve conference venues provided in the extended systematic mapping study on goal-oriented requirements engineering by Horkoff et al. (2017). In addition to these twelve venues, I included proceedings of the Requirement Engineering and Law (RELAW) workshop. RELAW is co-located with the IEEE International Conference on Requirements Engineering (RE) and includes explicitly legal and regulatory compliance articles.
3. The final search strategy was a manual search of the 342 articles I reviewed in Section 2.2. At the time this SLR was done, Akhigbe et al., (2015) represented the most recent review in the legal and regulatory compliance domain.

I defined and applied the following exclusion and inclusion criteria:

Inclusion: *Articles with modelling methods for legal and regulatory compliance in the requirements engineering domain.*

Exclusion: *Articles that did not have evidence of the modelling methods applied to real laws or regulations.*  
*Articles with a mention of legal or regulatory compliance only in their title.*

*Articles that were systematic literature reviews.*

*Articles with proposals and prototypes that did not include an evaluation or validation against a law or regulation.*

While conducting the review, with this stage illustrated in Table 6, I selected 70 articles from the 601 returned in the searches by using the first search strategy and applying the exclusion and inclusion criteria.

**Table 6** Summary of the Search Strategy Results for SLR 3

<b>Search Strategy 1</b>					
<b>Order</b>	<b>Database</b>	<b>Search Result</b>	<b>Article Selected</b>	<b>Articles Dropped</b>	<b>Duplicates</b>
1st	ACM	310	4	306	0
2nd	IEEE Explore	30	16	14	1
3rd	Scopus	71	40	31	10
4th	Google Scholar	190	48	142	27
<b>Totals for Strategy 1</b>		<b>601</b>	<b>108</b>	<b>493</b>	<b>38</b>
			<b>108</b>		<b>38</b>
<b>Articles selected with inclusion criterion</b>			<b>70</b>		
<b>Search Strategy 2</b>					
<b>No.</b>	<b>Journal/Conference</b>	<b>Search Results</b>	<b>Articles Selected</b>	<b>Articles Dropped</b>	
1	Requirements Engineering Conference (RE)	38	26	12	
2	Requirements Engineering Journal (REJ)	38	13	25	
3	Conceptual Modelling (ER)	30	21	9	
4	ACM Symposium on Applied Computing (ACM SAC)	67	14	53	
5	Journal of Systems and Software (JSS)	1	1	0	
6	Transactions on Software Engineering (TSE)	2	2	0	
7	International Journal of Intelligent Systems (IJIES)	7	1	6	
8	Information and Software Technology Journal (ISTJ)	11	3	8	
9	Requirements Engineering: Foundation for Software Quality (REFSQ)	17	9	8	
<b>No.</b>	<b>Journal/Conference</b>	<b>Search Results</b>	<b>Articles Selected</b>	<b>Articles Dropped</b>	
10	Conference on Advanced Information Systems Engineering (CAiSE)	69	30	39	
11	International Conference on Software Engineering (ICSE)	17	8	9	

12	Model Driven Engineering Languages and Systems (MODELS)	11	4	7
13	Requirements Engineering and Law (RELAW)	50	47	3
<b>Totals for Strategy 2</b>		<b>358</b>	<b>179</b>	<b>179</b>
<b>Selected articles from searches</b>			<b>179</b>	
<b>Articles selected with inclusion criterion</b>		<b>117</b>		
<b>Search Strategy 3</b>				
	<b>Articles Reviewed</b>	<b>Search Result</b>	<b>Articles Selected</b>	<b>Articles Dropped</b>
From Akhigbe et al. (2015)	342	278	165	113
			<b>165</b>	
<b>Articles selected with inclusion criteria</b>		<b>165</b>		

Using the second and third search strategies, together with exclusion and inclusion criteria, I selected respectively 117 articles from a pool of 358 articles, and 165 articles from a pool of 342 articles.

After applying the three search strategies and removing articles that were duplicates, I ended up with 103 articles<sup>4</sup> to review, as shown in Table 7.

**Table 7** Summary of the Selection for 103 Articles

<b>Search Strategy</b>	<b>Articles Selected with Inclusion Criterion</b>	<b>Duplicates</b>
Strategy 1	70	0
Strategy 2	117	24
Strategy 3	165	42
<b>Total of all strategies</b>	<b>352</b>	<b>66</b>
<b>Articles selected</b>	<b>286</b>	
	<b>Search Results</b>	<b>Articles Selected</b>
Total articles selected with inclusion criteria	1237	286
Total articles selected with exclusion criteria	286	103
<b>Final articles selected for review</b>	<b>103</b>	

In the reporting stage, I reported on the following observations based on the analysis of the selected 103 articles, to answer the research questions:

<sup>4</sup> <http://www.eecs.uottawa.ca/~damyot/pub/Akhigbe/ListArticles2016.xlsx>

- a) Goal-oriented modelling and non-goal-oriented modelling methods vary in the way they relate with laws or regulations. This fundamental difference determines how we can assess their benefits.
- b) Although both goal-oriented modelling and non-goal-oriented modelling methods focus on modelling the *intent* of the law, non-goal-oriented modelling methods primarily address the *intent* of the law. That is, the latter seek to directly understand and represent what the law says or means, often by identifying deontic norms (obligations and permissions) or Hohfeldian norms (e.g., duties and rights). Examples of non-goal-oriented modelling methods include the methodology for extracting formal descriptions of rules that govern stakeholder actions from policies and regulations (Breux et al., 2006) and the use of a production rule model to check software requirements for legal compliance (Maxwell & Antón, 2009).
- c) Goal-oriented modelling methods are often used to capture the *structure* of the law. That is, they abstract from semantics of the law and explore intended relationships between structural elements of the law (e.g., articles and sections), as well as between the law and processes it regulates. Examples of goal-oriented modelling methods include the use of the Goal-oriented Requirement Language (GRL) to assess the degree to what business strategies ensure business goal comply with applicable laws and regulations (Ghanavati et al., 2010). GRL is also used to generate questions for inspection activities, and to enable flexible conversions of real-world data into goal satisfaction levels for analysis of compliance levels (Tawhid et al., 2012).
- d) The healthcare domain has had the highest coverage by both types of modelling methods with 55% of the reviewed articles, while privacy is the most addressed context with 54% of the reviewed articles. The security context comes second at a distant 13%.

- e) The compliance concerns of *regulated* parties were the most-often addressed ones with 82% of the reviewed articles focusing on how regulated parties addressed regulatory compliance. The concerns of regulators were addressed by 12% of the reviewed articles, while 6% of the reviewed articles addressed the concerns of both regulators and regulated parties.

These results validate the observation about the paucity of research (described in Section 2.3) on how regulators address regulatory compliance. The results, based on claimed benefits in the literature, also suggest that the use of goal-oriented modelling methods for regulatory compliance offers more benefits in comparison to using non-goal-oriented modelling methods, particularly since the former can be used to capture regulations, stakeholders (including regulators and regulated parties), objectives, outcomes, processes, and their relationships. These relationships can also be monitored and assessed using indicators that represent different measures, hence offering a viable means for addressing compliance *analysis* and *enactment* tasks and deriving data-driven evidence on regulatory compliance. Consequently, goal-oriented modelling methods are good candidates for offering a holistic view of the regulatory ecosystem, i.e., to capture regulations, regulatory initiatives, desired objectives and intended outcomes in order to collect and analyze data aiming to demonstrate regulatory performance.

## 2.5. Chapter Summary

This review of the literature on the regulatory process, performed to understand what is involved in demonstrating regulatory performance, highlights many gaps and a motivation for change. Regulators rarely review the regulations they create and administer, but rather review how well they carry out their mandate to regulate and its associated cost, and how regulated parties comply with regulations. This approach is not suitable for regulatory performance since it does not really address whether regulations achieve their objectives or accomplish intended societal outcomes.

In this regard, applying the concept of *regulatory intelligence* to the regulatory process offers much potential to link regulatory activities and societal impact, and hence could

facilitate deriving inferences or attributions of regulatory effectiveness. Regulatory intelligence addresses a feedback loop that links regulations, regulatory initiatives, objectives and outcomes. Hence, the application of IS to the cycle of regulatory activities will facilitate continuously collecting and processing data from the regulatory process to derive data-driven evidence on regulatory performance.

To achieve this vision, IT artifacts would prove useful. In this regard, a review of literature on the regulatory process indicate that methods are the most used IT artifacts, and methods incorporated with models having analytical capabilities, enable representing and analysing different regulatory contexts. Using such methods to capture regulatory initiatives, objectives and outcomes, in addition to regulations themselves, can form the basis for offering data-driven evidence on the performance of the respective regulations. Here, the method should be able to use a modeling language that supports capturing regulatory initiatives, objectives and outcomes as well as a way of representing compliance with the regulations, performance of the regulatory initiatives, objective and societal outcomes. In addition, the modeling language should also support analysis of data on compliance with the regulations as well as data on performance of the regulatory initiatives, objective and societal outcomes. The literature indicates that methods based on goal-oriented modelling appears useful in this regard due to their distinct capability of enabling the visualization of regulatory contexts in proper perspectives and the analysis of data from respective regulatory processes.

## Chapter 3. Methodology

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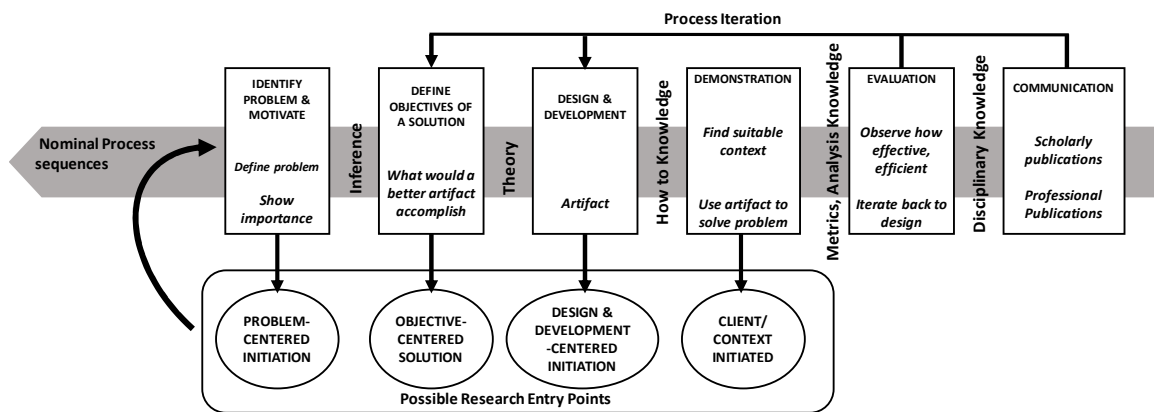
As described in Section 1.2, the problems this thesis addresses are knowledge and practical problems aiming to enable regulators to use data-driven evidence to show how their regulations perform. Since knowledge and practical problems are two mutually nested problems common with design science research (DSR), a methodology based on the principles of DSR can be appropriate in addressing them. In this chapter, I present such a methodology. In addition, I describe the case study method and qualitative data analysis technique that I used in this thesis to design, develop, implement and evaluate GoRIM, the proposed solution that addresses how regulators can show if regulations are effective using data-driven evidence. Consequently, I show how the research activities, which are iterative, are used to design, develop and evaluate GoRIM.

### 3.1. Design Science Research Methodology (DSRM)

To create and evaluate GoRIM, this doctoral research adopts the *Design Science Research Methodology* (DSRM) (Peffer et al. 2007). DSRM offers conceptual principles, practice rules and a process for carrying out and presenting research in line with Design Science Research (DSR) principles. DSR takes a problem-solution approach through the introduction of innovative artifacts to solve existing organizational problems. These artifacts “extend the boundaries of human problem solving and organizational capabilities by providing intellectual as well as computational tools” (Hevner et al., 2004).

The emphasis by DSR on evaluating the utility, quality and efficacy of the created artifact not only shows the rigour involved in the creation of the artifact but also highlights the artifact’s relevance to the problem it addresses (Gregor & Hevner, 2013; Hevner et al., 2004). DSRM reinstates the DSR approach of understanding the problem domain in order for the proposed solution to be relevant. As such, DSRM informed my choice to speak with regulators and to carry out reviews of the literature on the regulatory process to understand the challenges associated with demonstrating regulatory performance. In addition, DSRM’s emphasis on rigour informed my choice of the multi-case study research method

and qualitative data analysis that I use to design and develop, implement and evaluate GoRIM. DSRM provides a template in this doctoral research that enables me to present GoRIM based on its knowledge contributions as an *exaptation*, i.e. extending known solutions to new problems, and to communicate these knowledge contributions (Gregor & Hevner, 2013). With GoRIM, I am extending the application of goal-oriented modelling, a known solution in the requirements engineering domain, and a data analytics software (IBM Watson Analytics), to address a new problem. The new problem is regulators using data-driven evidence to show the effectiveness of their regulations.



**Figure 8** Design Science Research Methodology Process Model (adapted from Peffers et al., 2007)

As illustrated in Figure 8, the DSRM conceptual process model consists of six activities in a nominal sequence that make up the core research activities, and four possible entry points to the research. The description of these six activities and four research entry points are:

1) Activities

- a. *Problem identification and motivation:* The researcher defines the specific research problem and justifies the value of a proposed solution.
- b. *Define the objectives for a solution:* From the defined problem and knowledge of what is possible and feasible, the researcher defines objectives for the solution.
- c. *Design and development:* The researcher creates an artifact, which embodies the solution.

- d. *Demonstration*: The researcher shows the use of the artifact to solve one or more instances of the problem.
- e. *Evaluation*: The researcher observes and measures how well the artifacts supports a solution to the problem.
- f. *Communication*: The researcher communicates the problem and its importance as well as the artifact, its utility and novelty, the rigor of its design, and its effectiveness to other researchers and relevant audiences.

## 2) Entry points

- a. *Problem-centered initiation*: The researcher initiates the research because of the observation of a problem or suggested future research from a previous project. The research therefore starts with the “*problem identification and motivation*” activity.
- b. *Objective-centered solution*: The researcher initiates the research because there is an industry or research need that can be addressed by developing an artifact. The research therefore starts with the “*define the objectives for a solution*” activity.
- c. *Design & development-centered initiation*: The researcher initiates the research because of the existence of an artifact that can address an explicit problem domain although the artifact has not been formally tried in the domain. The research therefore starts with the “*design and development*” activity.
- d. *Client/context-initiated*: The researcher initiates the research because of a practical solution that worked, which is then worked backwards to apply rigor to the process of its creation and evaluation retroactively. The research therefore starts with the “*demonstration*” activity.

**Table 8** DSRM Process Model Entry Points and Activities for GoRIM

<b>DSRM Components</b>	<b>Application of DSRM to GoRIM</b>	<b>Method Used</b>	<b>Corresponding Chapter</b>
<b>Entry point into the re-search process</b>	<ul style="list-style-type: none"> <li>• Problem-centered initiation</li> </ul>		Chapter 1
<b>Problem identification and motivation</b>	<ul style="list-style-type: none"> <li>• Regulators do not have a systematic and formalised data-driven way of demonstrating whether regulations achieve their desired objectives and accomplish intended outcomes.</li> </ul>	Literature Review	Chapter 1 Chapter 2
<b>The objectives of the solution</b>	<ul style="list-style-type: none"> <li>• Provide a comprehensive method to link regulations, attained compliance levels, regulatory initiatives, desired objectives and intended societal outcomes of regulations in a way that enables data-driven analysis, exploration of relationships and reporting on any derived inferences or attributions based on these relationships.</li> </ul>	Literature Review	Chapter 2
<b>Design and development</b>	<ul style="list-style-type: none"> <li>• Design a Goal-oriented Regulatory Intelligence Method (GoRIM) that enables modelling regulations, regulatory initiatives, the desired objectives and intended societal outcomes of regulations with the same views using concepts from the User Requirements Notation’s “Goal-oriented Requirement Language” (Amyot &amp; Mussbacher, 2011; International Telecommunication Union, 2012).</li> <li>• Develop GoRIM to populate the models with respective data, analyze the models and facilitate reporting on regulatory performance using data analytics/data visualization software.</li> </ul>	Literature on goal-oriented modelling	Chapter 4

<b>DSRM Components</b>	<b>Application of DSRM to GoRIM</b>	<b>Method Used</b>	<b>Corresponding Chapter</b>
<b>Demonstration</b>	<ul style="list-style-type: none"> <li>• Create a proof-of-concept design of GoRIM, modify and apply it to demonstrate its ability to represent and analyze regulations and regulatory initiatives of different regulators.</li> <li>• Implement GoRIM to solve regulatory performance problems in real-life regulatory scenarios involving regulators in the case studies.</li> </ul>	Surveys	Chapter 5 Chapter 6 Chapter 7
<b>Evaluation</b>	<ul style="list-style-type: none"> <li>• Assess if the application of GoRIM is feasible in the regulators' contexts after applying it to represent and analyze regulations and regulatory initiatives of different regulators.</li> <li>• Evaluate if the application of GoRIM offers any utility to the regulator applying GoRIM to solve performance problems in real-life regulatory scenarios involving regulator.</li> </ul>	Surveys	Chapter 8
<b>Communication</b>	<ul style="list-style-type: none"> <li>• Communicate the knowledge contribution of GoRIM, its design, development, implementation in the real-life regulatory scenarios and its evaluation results and findings.</li> </ul>	Thesis	Chapter 9 Chapter 10

Accordingly, Table 8 illustrates my application of the DSRM process model to GoRIM in this doctoral research. The table also shows the method I used for the activities in each DSRM component and the corresponding chapters where each activity was addressed in detail.

### **3.2. The Case Study Method**

To enable the design, demonstration and evaluation activities of the DSRM process model, I utilize in this thesis a type of case study method called *multiple-case study* (Mills, Durpos, & Wiebe, 2010; Yin, 2009). The case study method is relevant to DSR as it aids in observing how effective and efficient a designed artifact solves a defined problem. The case study method proves more useful when the phenomenon investigated is difficult to

study outside its natural setting and when the investigated concepts and variables are difficult to quantify (Bonoma, 1985; Ghauri & Gronhaug, 2010), which is the case for the regulatory ecosystem and the effectiveness of regulations. Using a case study method allows an in-depth study of a particular research problem, often by narrowing down a very broad field of research into parts that are easily researchable. Thus, the examination of real-life scenarios is possible using case studies since they provide opportunities to apply concepts and theories, and the extension of methodologies (Gerring, 2004; Yin, 2009). Accordingly, a case study can allow the examination of real-life instances of the cycle of regulatory activities described in Chapter 1, and hence the examination of the links and relationships between compliance levels with regulations, performance of regulatory initiatives, achieved objectives and accomplished outcomes.

The case study method aids generalizing the result of an intensive study of a single unit across a larger set of units. As such, multiple-case studies, which are repeated experiments, ensure that replication corroborates, qualifies and/or extends the findings of the first case, and facilitates generalisation (Yin, 2009). This aligns well with the demonstration and evaluation activities of the DSRM process model. Multi-case studies rely on multiple sources of evidence. The evidence, which is either quantitative, qualitative or both, obtained from the data in the first case can support or revise the evidence from successive cases, iteratively evolving and expanding generalization. Using a multiple-case study method therefore enables checking whether the application of GoRIM is practical in more than one type of regulatory domain as well as checking whether GoRIM offers utility to regulators independently from the regulator's context.

The unit of analysis of the multiple-case study is regulatory effectiveness, which refers to how a regulator demonstrates with evidence that its regulations and regulatory initiatives achieve the desired objectives and accomplishes the intended societal outcomes. This unit of analysis is in line with the mandate of creating and administering regulations given to regulators (Parker & Kirkpatrick, 2012). Consequently, the scope of analysis in the doctoral research is the ability of a regulator to use GoRIM to show regulatory effectiveness.

### 3.3. Qualitative Data Analysis Technique

Qualitative data are usually in the form of words rather than numbers, and they deal with meanings. These types of data are normally a source of well-grounded, rich descriptions and explanations of processes derived from identifiable local contexts (Miles & Huberman, 1994). Conceptually, qualitative data support understanding behaviours from an informant's perspective, e.g., how the informants perceive their social realities and, hence, how they act within the social world. Therefore, qualitative data prove more suitable for evaluating GoRIM than quantitative data, as qualitative data will offer more insights on the regulators' perception of GoRIM.

Methods employed to collect qualitative data are through participant observations and interviews. The data are analyzed using descriptions provided by informants and are reported in the language of the informant (Minichiello, Aroni, & Minichiello, 1990). Hence, meanings derived from qualitative data collected from Key Informants amongst regulators in the multiple-case study on GoRIM is vital. This qualitative data focuses on the Key Informants' opinions of GoRIM's ability to show whether their regulations are effective. Consequently, to derive insight from the collected qualitative data, I apply *thematic analysis* as a qualitative data analysis method to identify and understand meanings from the qualitative data on GoRIM collected from the Key Informants in the multiple-case study. Thematic analysis, a method for identifying, analysing and reporting themes within data, offers an accessible and theoretically flexible approach to analysis qualitative data (Braun & Clarke, 2006; Mills et al., 2010). I used inductive coding to derive themes from the collected qualitative data (Miles & Huberman, 1994). The themes derived through thematic analysis are idea categories that emerge within the data and that answer the research questions. The application of thematic analysis enables identifying and reporting on the experiences, meanings and reality of the Key Informants in the multiple-case study in their interactions with GoRIM. The application of thematic analysis also enables answering the practical problems (design and implementation problems) outlined in Section 1.2.

### 3.4. Research Activities

The research activities that I carried out in this doctoral research and present here are iterative, in line with principles of DSR and the DSRM process model. The research activities affirm that designing and developing an artifact is an iterative process of planning, generating alternatives, and selecting a satisfactory design that addresses the problem in context (Hevner & Chatterjee, 2010). In addition, the iterative process of the research activities facilitates obtaining and utilizing feedback with demonstrating and evaluating the designed artifact based on the reality and the knowledge that emerges from the research efforts towards improving the designed artifact (Vaishnavi et al., 2004).

Accordingly, the knowledge and learning from GoRIM in the first case study is applied to the subsequent case studies, the latter being used iteratively to confirm, revise or improve that knowledge.

#### 3.4.1 Development of Research Instruments and Recruitment Activities

In this phase of the study, I developed, submitted and received approval from the University of Ottawa Research Ethics Board for the research instruments I used in this doctoral research:

- 1) University of Ottawa Research Ethics Board, Ethics Approval Notice (H12-16-14)
- 2) University of Ottawa Research Ethics Board, Ethics Renewal Notice (H12-16-14)

The approved research instruments<sup>5</sup> that I used to recruit participants for the multiple-case study are: *recruitment letters*, *consent letters*, *a meeting session protocol* that outlines how every meeting with participants should go, and *questionnaires*. To identify participants for the study, I informally contacted the director of the Certificate Program in Regulatory Leadership at the Centre for Public Management and Policy (Odell House) at the University of Ottawa, as well as two senior executives of Canada's Community of Federal Regulators (CFR). The Certificate Program in Regulatory Leadership is an advanced professional development program run by the Centre for Public Management and Policy for per-

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<sup>5</sup> Research instruments available at <http://www.eecs.uottawa.ca/~damyot/pub/AkhigbePhD/>

sonnel in the Government of Canada involved in leading any facet of regulation from policy and design to implementation and evaluation (University of Ottawa, 2013). The CFR is a body that facilitates collaboration and the professional development of about 6000 employees involved in regulations across different agencies in the federal government of Canada (Community of Federal Regulators, 2012). I used CFR and the Centre for Public Management and Policy as liaisons to identify and recruit Key Informants and agencies/departments of the Government of Canada involved with creating and administering regulations.

I sent contact emails to identified agencies and departments to participate in the research. Based on favorable and unfavourable responses that I obtained from the agencies and departments, I iteratively improved on my manner of contact. Every agency or department that indicated interest in the research were required to nominate Key Informants to participate in the study. I asked for individuals who held management positions or who are subject matter experts or decision makers, to serve as Key Informants. Such Key Informants should be involved in developing regulations, interpreting objectives and outcomes of the regulations into objectives for the respective regulatory initiatives, promoting the regulations or enforcing compliance with regulations. I gave each Key Informant the consent letter and only asked Key Informants who returned the signed consent form, together with their respective agency or department, to participate in the study.

In the end, the Canada Wildlife Service (CWS) and the Environment Protection Branch (EPB), both from Environment and Climate Change Canada (ECCC), agreed to participate offering two different case studies for the multiple-case study. In addition, a regulator that chose to remain anonymous agreed to participate as well, for a third case study. These three regulators offered fourteen Key Informants (CWS – 4, EPB – 4, and the anonymous regulator – 6) to the multiple-case study. There was no conflict of interest between me and the fourteen Key Informants that agreed to participate in the multiple-case study. I had no prior relationship with anyone of the fourteen Key Informants neither did I receive any funding from them or the agencies and departments they represent.

### 3.4.2 GoRIM Model Creation and Analysis

The case studies were done over the span of two years, from July 2016 to July 2018. I met with each Key Informant from the three participating agencies and departments in person, a minimum of three times during the study and corresponded with them over the phone and through emails, numerous times. The in-person meetings were at the Key Informant's office and each one lasted no more than sixty minutes, as outlined in the "meeting session protocol"<sup>6</sup>. The first set of meetings aimed to understand the agency or department's respective regulations and regulatory initiatives. Next, I created models of the regulations and regulatory initiatives, and analyzed the models using sample data provided by the Key Informants. I further analyzed and derived insights using a data analytics/data visualization software. Then I met with the Key Informants to validate the models, analyses and derived insights obtained using GoRIM. This process was iterative and carried out concurrently, as will be explained in Chapter 5, Chapter 6 and Chapter 7. I applied the knowledge and learning I derived from one case study to the subsequent case studies to improve how to create the model, populate the models with data, carry out analysis and derive insight. Afterwards I presented the models, result of the analysis and derived insights to the Key Informants as a proof-of-concept of GoRIM's ability to offer a true representation of the respective regulatory context. This process corresponds with the "Demonstration" activity of the DSRM process model described in Section 3.1. I then collected feedback from the Key Informants representing evaluations on the proof-of-concept design of GoRIM at this point. This process corresponds with the "Evaluation" activity of the DSRM process model described in Section 3.1.

The last set of meetings I had with the Key Informants was to collect and analyze more data on compliance with the regulation and on the regulatory initiatives in order to answer performance-related questions unique to the regulator's context. This process was also iterative and carried out concurrently across case studies. Afterwards, I presented the performance-related models and analysis results to the Key Informants, a "demonstration" of GoRIM's ability to address real performance-related concerns. In addition, I collected

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<sup>6</sup> Research instruments available at <http://www.eecs.uottawa.ca/~damyot/pub/AkhigbePhD/>

feedback on the Key Informant's perception of the utility of GoRIM in showing the effectiveness of their regulation, an "evaluation" of GoRIM's utility.

### **3.4.3 Data Collection and Analysis**

I collected qualitative data from the Key Informants using questionnaires administered to each Key Informant in each case study after I did a presentation on GoRIM during the "Demonstration" and "Evaluation" activities, as described in Section 3.4.2. In addition, I took note of comments and questions asked during the presentations. Afterwards, I applied thematic analysis to identify themes in the collected data. I use the following phases, as recommended by Braun & Clarke (2006), to analyze data during thematic analysis:

- 1) *Familiarise yourself with the data*: I administered the questionnaires to the Key Informants after I did a presentation on the studies. Hence, I went through the answered questionnaires, comments and questions asked during the presentations. As a result, I was able to make notes on recurrent themes discussed during the presentation that I saw again in the questionnaires.
- 2) *Generating initial codes*: After reading and familiarising myself with the data obtained from the Key Informants, I generated initial codes from the Key Informants responses using the inductive coding technique.
- 3) *Searching for themes*: After generating the codes, I organised the codes into different themes that address GoRIM's feasibility in the Key Informant's context and whether GoRIM offers any utility to the Key Informant.
- 4) *Reviewing themes*: Using the two levels ( reviewing and refining themes) recommended by Braun & Clarke (2006), I check the selected themes first in relation to the codes I created and then in relation to the entire data set.
- 5) *Defining and naming themes*: I arrived at clear definitions and explanations of each theme identified for GoRIM's feasibility and utility to demonstrate regulatory performance.

- 6) *Producing the report*: I then created a report on how the identified themes in the study enabled answering questions on GoRIM's feasibility and utility.

#### **3.4.4 Evaluation of Findings**

To evaluate the findings resulting from the qualitative data analysis of GoRIM's feasibility and utility in the multiple-case study involving Key Informants amongst regulators, I used the tests proposed by Yin (2009). These tests establish the quality of case study results and address factors that can influence the validity of the research. The tests are:

- 1) *Threat to Construct Validity*: refers to how well the studied parameters and their outcomes are relevant to the research questions addressed (Feldt & Magazinius, 2010; Perry, Porter, & Votta, 2000; Yin, 2009). In this doctoral research, the construct validity reflects whether I established correct measures of the concept I studied, namely the effectiveness of regulations. To mitigate this threat, I first demonstrated and validated GoRIM's ability to capture the regulatory context to the Key Informants before using GoRIM to address real regulatory performance issues of the regulators. Hence, I was able to establish a chain of evidence on what GoRIM addressed. In addition, I provided a draft report of my presentations to the Key Informants to peruse and comment before any presentations to ensure they were knowledgeable and in agreement with it.
  
- 2) *Threat to External Validity*: refers to the ability of generalizing research findings obtained to other domain under different settings (Feldt & Magazinius, 2010; Perry et al., 2000; Yin, 2009). In this doctoral research, the external validity reflects the extent to which I can generalize the research findings on GoRIM. To mitigate this threat, my research design involved applying GoRIM to a multiple-case study involving three studies. In addition, I applied analytical induction across all the studies by focusing on the review phase of the cycle of regulatory activities where regulations are reviewed, and hence ensured that I had similar activities in all three studies (Wieringa & Daneva, 2015; Yin, 2009).

- 3) *Reliability*: refers to demonstrating that the operations of the study can be repeated, with the same results (Yin, 2009). In this doctoral research, reliability reflects the consistency of the research process over time and across methods. To achieve reliability, I developed a case study database for each study, separate from the case study report. In addition, I followed the same research protocol for each case.

### **3.5. Conclusion**

The DSRM provides a proven methodology for carrying out design science research. In this chapter, I described how I used DSRM as a methodology and the specific methods that I used to collect and analyze data to evaluate GoRIM's feasibility and utility in demonstrating regulatory effectiveness. Hence, the results and findings presented in the case studies described in Chapter 5, Chapter 6 and Chapter 7 can be evaluated against the standards presented in Section 3.4.4. However, applying GoRIM in the three regulators' contexts has led to some limitations, which I discuss in Section 8.4. In the next chapter, I introduce and describe GoRIM.

## Chapter 4. Goal-oriented Regulatory Intelligence Method (GoRIM)

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In Chapter 2, after a review of the existing literature on the regulatory process, “methods” appeared as the most frequently used IT artifact for addressing regulatory compliance. Methods applied with models that have analytical capabilities (see Section 2.3) have been employed to monitor and manage regulatory compliance with success. Incorporating methods and these types of models proved useful to measure, assess or evaluate regulatory compliance and hence will facilitate the application of the concept of *regulatory intelligence* to the cycle or regulatory activities to demonstrate regulatory performance. Subsequently, I observed that goal-oriented modelling, with roots in a requirement engineering domain that researches regulatory compliance extensively, offered much potential for demonstrating regulatory performance.

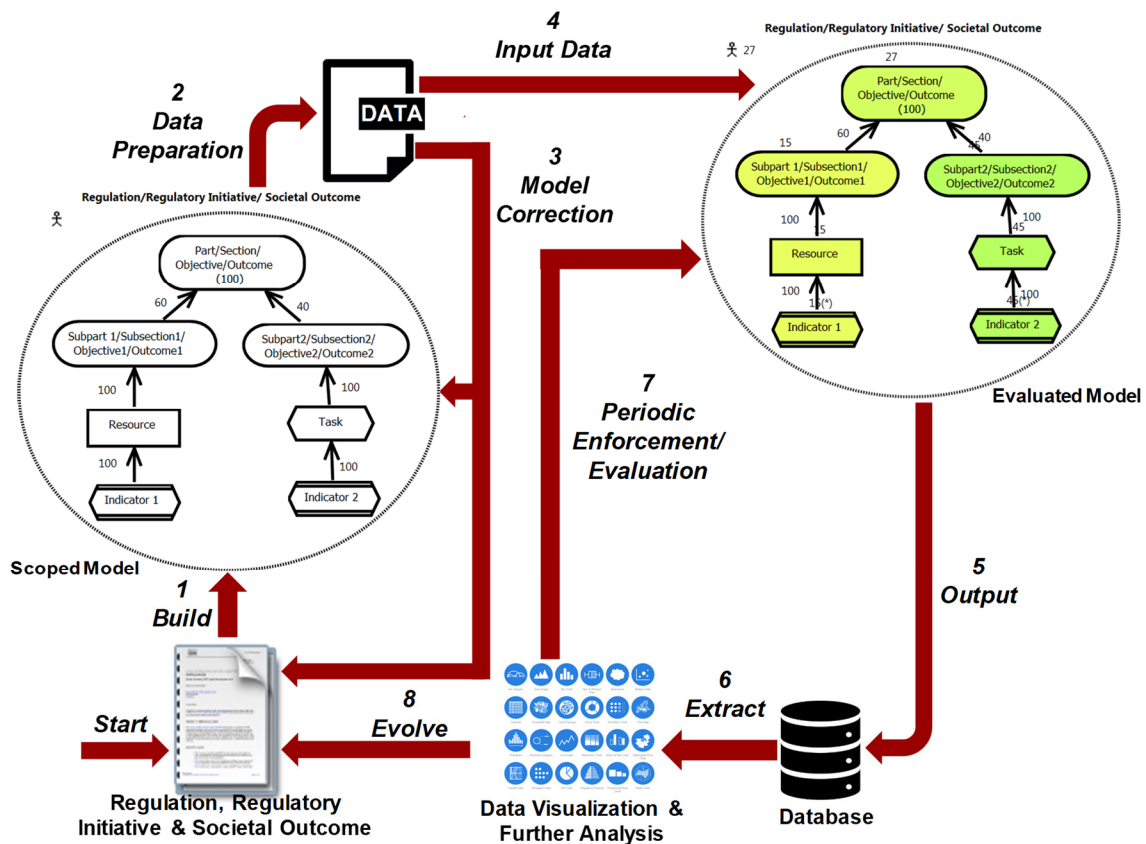
In this chapter, I describe a new Goal-oriented Regulatory Intelligence Method (GoRIM), which combines goal modelling and data analytics to show whether regulations are effective. GoRIM exploits that capability to structure how a performance management framework can be established using commonly available data analytics software. GoRIM utilizes the User Requirements Notation (URN) (Amyot & Mussbacher, 2011; International Telecommunication Union, 2012) a standard modelling language used for goal modelling. URN provides support for the quantification of business strategy and measurement of performance using indicators

This chapter gives an overview of GoRIM and its main elements. It then presents a process on how to use GoRIM, with a detailed description of each main step. The typical usage of GoRIM and of its tools is also illustrated.

## 4.1. Overview and Elements of GoRIM

### 4.1.1 GoRIM Overview

The Goal-oriented Regulatory Intelligence Method (GoRIM) illustrated in Figure 9, is a method for monitoring and reporting on regulations, supporting regulatory initiatives and societal outcomes, and for assessing their performance. GoRIM is composed of eight steps that enable modelling, analyzing, monitoring, and evolving regulations, regulatory initiatives and societal outcomes.



**Figure 9** Overview of the Goal-oriented Regulatory Intelligence Method (GoRIM)

GoRIM, along with its tool, provides a monitoring and assessment system that collects, analyzes and reports on regulatory effectiveness. GoRIM takes advantage of the jUCMNav tool (Amyot et al., 2011; jUCMNav, 2013) for modelling and analyzing regulations, regulatory initiatives, objectives and societal outcomes. GoRIM also uses IBM Watson Analytics (IBM, 2016) to report on observed compliance levels, and to explore what they mean

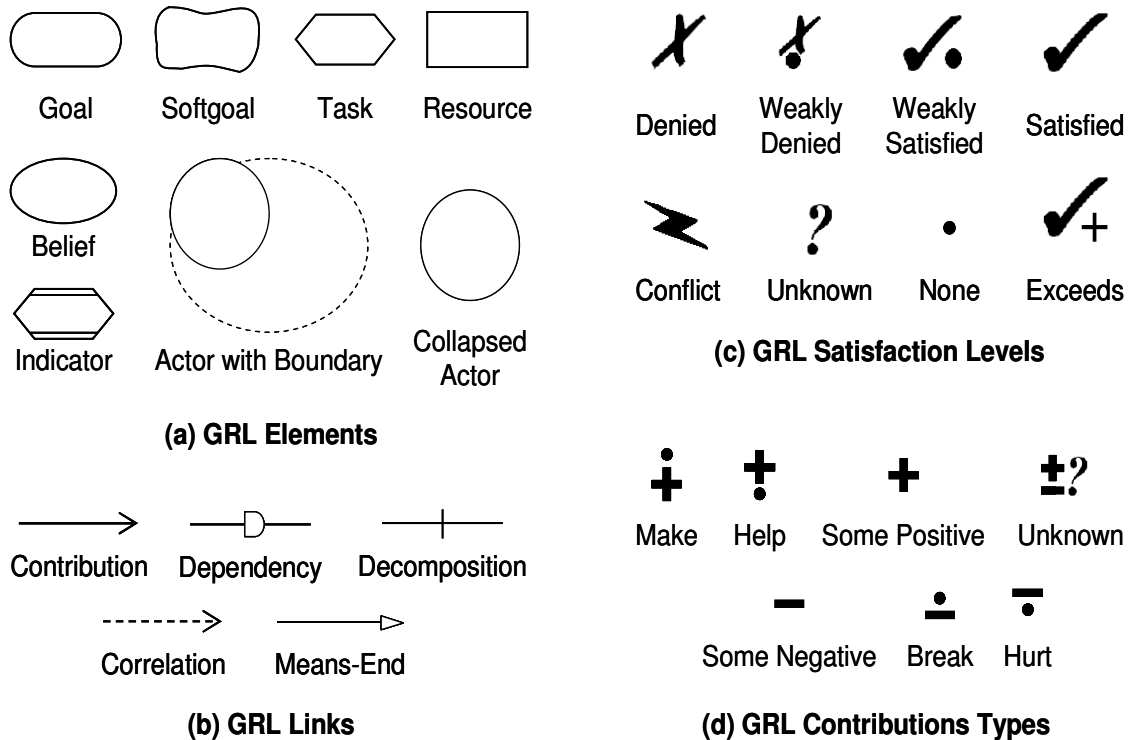
relative to the regulations and how regulatory initiatives contribute to the observed compliance and societal outcomes. GoRIM also uses jUCMNav and IBM Watson Analytics to detect and visualize opportunities to evolve regulations and regulatory initiatives to make them more effective. I discuss the goal modelling and data analytics components of GoRIM in the next sections.

#### 4.1.2 Goal Modelling in GoRIM

Standardized in 2008 and revised in 2012 by the International Telecommunication Union (ITU), URN is a modelling language used to model and analyze requirements. URN's typical usage includes capturing stakeholders (including regulators, governments, regulated parties and interest groups in this thesis' context), goals (including regulations, objectives and outcomes in this thesis), tasks, indicators and processes, together with their relationships. URN allows reasoning about these relationships and measuring compliance and performance using indicators, while supporting monitoring and what-if/trade-off analysis. URN has been successfully used to model various laws and regulations (e.g., for privacy in healthcare (Ghanavati et al., 2007a)) and to measure compliance and assess regulation effectiveness (e.g., with the aviation security group at Transport Canada (Tawhid et al., 2012)). URN combines two sub-languages: the Goal-oriented Requirement Language (GRL) for modelling actors and their intentions, and the Use Case Maps notation (UCM) for describing scenarios/processes and underlying architectures.

GRL has its roots in the Non-Functional Requirements (NFR) framework (Chung et al., 1999) and the *i\** framework (Yu, 1997). GRL is a graphical and visual goal-oriented modelling language that links intentional elements with evaluation mechanisms. It models and answers “*why, what, who and how well*” questions by capturing stakeholders' goals, alternatives to be considered, decisions made and rationales that aided making those decisions. In GRL, *actors* are active entities in the system or its environment who want goals achieved, tasks performed, resources to be available, and softgoals to be satisfied. *Goals* can be fully satisfied whereas *softgoals* relate more to non-functional aspects, and are usually not fully achieved but are instead satisfied to a suitable extent. *Tasks* represent solutions to goals or softgoals and mostly require resources to be utilized in achieving them (Amyot, 2003; Amyot et al., 2011). *Links* connect elements in a goal graph. They include

decompositions links (which allows the decomposition of elements into sub-elements through AND/OR/XOR relationships) and contribution links (which point to positive/negative impacts of elements on other elements qualitatively or quantitatively). Links also include correlation links (which describe side effects rather than impacts) and dependency links (which model relationships between actors).



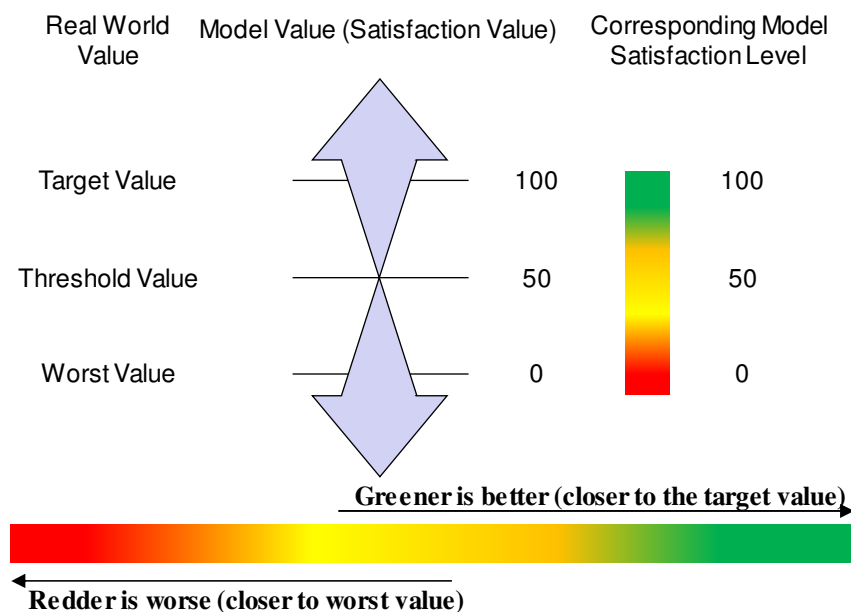
**Figure 10** Goal-oriented Requirement Language (GRL) Notation Elements (International Telecommunication Union, 2012)

As illustrated in Figure 10, GRL has four primary categories of concepts: *intentional elements* (such as goals, softgoals, tasks, resources, and beliefs), *indicators* (also called key performance indicators – KPIs), *intentional links* (such as contributions, correlations, dependencies and decompositions) and *actors* (different forms of stakeholders, or systems). The GRL approach describes a particular configuration of alternatives and satisfaction values in the GRL model. Initial qualitative or quantitative satisfaction levels are assigned to some intentional elements in the model. Such initialization is called an evaluation strategy and it is expressed in a unit of the respective context. There are currently seven types of GRL evaluation algorithms tailored to suit different types of analysis: “*Quantitative*”,

“Qualitative”, “Mixed”, “Formula Based”, “Constrained-oriented”, “Conditional” and “Feature Model Strategy”. In the GRL diagrams, initial satisfaction values are annotated by an asterisk (\*). A GRL evaluation algorithm propagates this information to other intentional elements of the model through their links and computes their satisfaction levels either interactively or automatically. Evaluation strategies are defined manually or come from data sources such as Business Intelligence (BI) systems. Indicators convert observable evaluation values (in some units such as hours, dollars, and meters) into satisfaction values (on GRL’s [0..100] scale) by taking these four values into consideration (Amyot et al., 2010):

- *Target Value*: used to specify the target for the indicator, corresponding to a satisfaction value of 100 on a [0..100] satisfaction scale;
- *Threshold Value*: specifies the least acceptable value for the indicator, corresponding to 50 on a [0..100] satisfaction scale;
- *Worst Value*: specifies the maximum value of dissatisfaction, corresponding to a satisfaction of 0 on a [0..100] scale; and
- *Evaluation Value*: specifies the actual measured value of the indicator.

To aid better visibility and comprehension of satisfaction levels, colour coding of the intentional elements is used (the greener, the better, while the redder, the worse), as illustrated in Figure 11 below.



**Figure 11** Colour Coding for GRL Indicators and Evaluation Strategies

Furthermore, strategies can be compared to each other to aid getting the most appropriate trade-offs amongst the often-conflicting goals of stakeholders (Amyot et al., 2010, 2011). *jUCMNav*, a free and comprehensive Eclipse-based graphical editor and an analysis and transformation tool, is used to analyze and manage URN/GRL models (Amyot et al., 2011; *jUCMNav*, 2013). *jUCMNav* employs well-formedness rules defined using Object Constraint Language (OCL) constraints (Amyot & Yan, 2008; *jUCMNav*, 2016) to ensure that the GRL models are built and used correctly.

While there are other goal modelling notations such as *i\**, the Non-functional Requirements (NFR), KAOS and Tropos (Horkoff et al., 2016, 2016), I selected GRL for GoRIM because it offers many advantages over the alternatives, including the following:

- 1) GRL is part of URN, the only standardized language among the options above. With regulators getting involved in and adopting standards (Akhigbe, Amyot, et al., 2017), GRL offers a definite benefit here.
- 2) GRL can be tailored through its *metadata* concept (i.e., as a lightweight profile), for example, to support mapping new element types to standard GRL intentional elements (Amyot et al., 2009). Hence, elements in the regulatory ecosystem, such as regulatory initiatives, objectives or societal outcomes, can be represented and distinguished using GRL. Well-formedness rules that target these new elements can be specified and checked automatically to ensure models are created correctly (*jUCMNav*, 2016).
- 3) GRL can be used to model regulations, regulatory initiatives, objectives and societal outcomes. This further enables robust analysis within each view and across views. For example, consider a context for distracted driving with the OHTA (Government of Ontario, 1990) where measures for the regulation, regulatory initiative and societal outcome are set as illustrated in Figure 12. Using GRL, we can model each view of the regulation, regulatory initiative and societal goal as shown in Figure 13.



**Regulation:** Drivers shall not text on mobile phones while driving  
**Compliance Measure:** # of infractions per 100,000 inhabitants per month

**Regulatory Initiative:** Advertisement program on social media that aims to raise awareness about the regulation

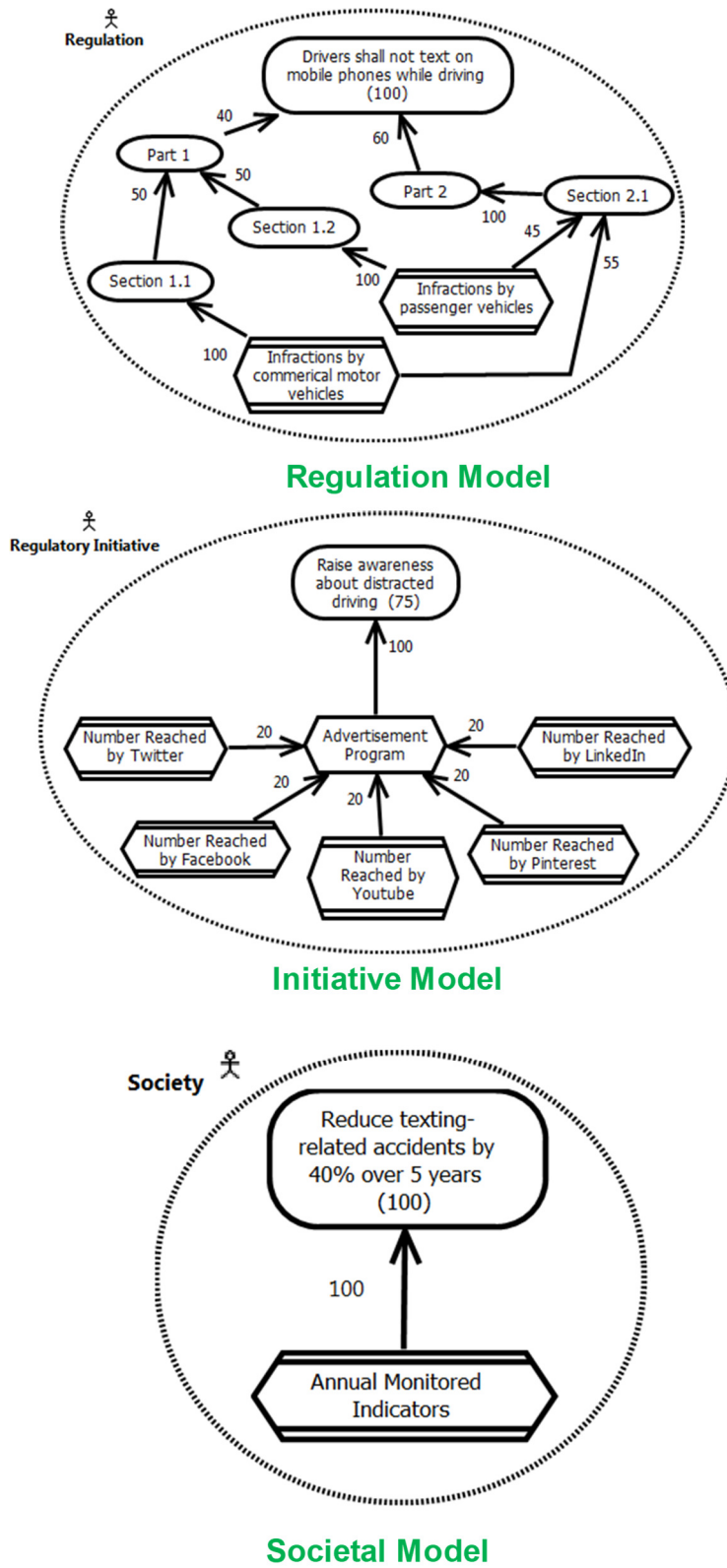
**Performance Measure:** # of people reached per \$1,000

**Societal Goal:** Reduce texting-related accidents by 40% over 5 years

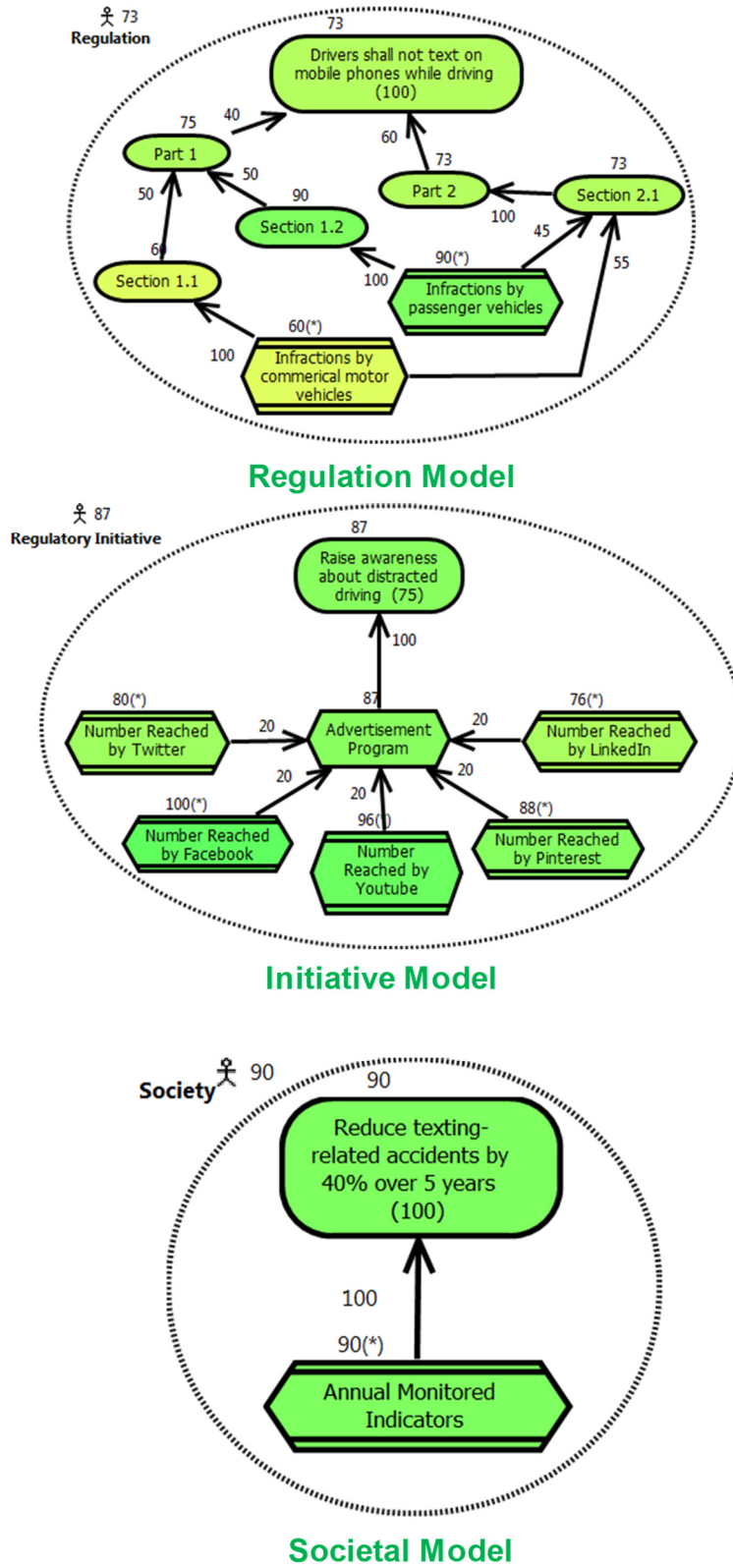
**Measure:** # of texting-related accidents per year

**Figure 12** Sample Distracted Driving Regulatory Context (Akhigbe, 2017)

- 4) GRL supports indicators (Pourshahid et al., 2009), which are useful for measuring performance and effectiveness of various views of a regulatory context, including for example the measures shown in Figure 12.
- 5) GRL has a mature tool that enables the creation of models and their analysis using different evaluation algorithms (Amyot et al., 2011; jUCMNav, 2013). Figure 14 shows a sample evaluation of the models created with jUCMNav in Figure 13.
- 6) GRL supports the definition of evaluation strategies from data sources such as Business Intelligence Systems or data analytics/data visualization software, as described in Section 4.3.2.



**Figure 13** Using GRL for Modelling the Different Views of the Regulatory Context in Figure 12



**Figure 14** Sample Evaluated Model of the Regulatory Context in Figure 12

### 4.1.3 Data Analytics in GoRIM

As mentioned in Section 1.2, Coglianese (2012) argued that data from the regulatory ecosystems need to be obtained and analysed using sophisticated statistical techniques to show whether regulations achieve their objectives and accomplish societal outcomes. As such, a tool that offers sophisticated statistical techniques (correlations, trends, etc.) and an explanation of the analysis done to derive results could be a candidate for a tool that can be used to demonstrate regulatory performance. Additionally, such a tool would offer visualizations and interactivity (ideally using natural language) with the derived results as well as the opportunity to create reports. In this regard, data analytics tools are a good candidate for use in GoRIM.

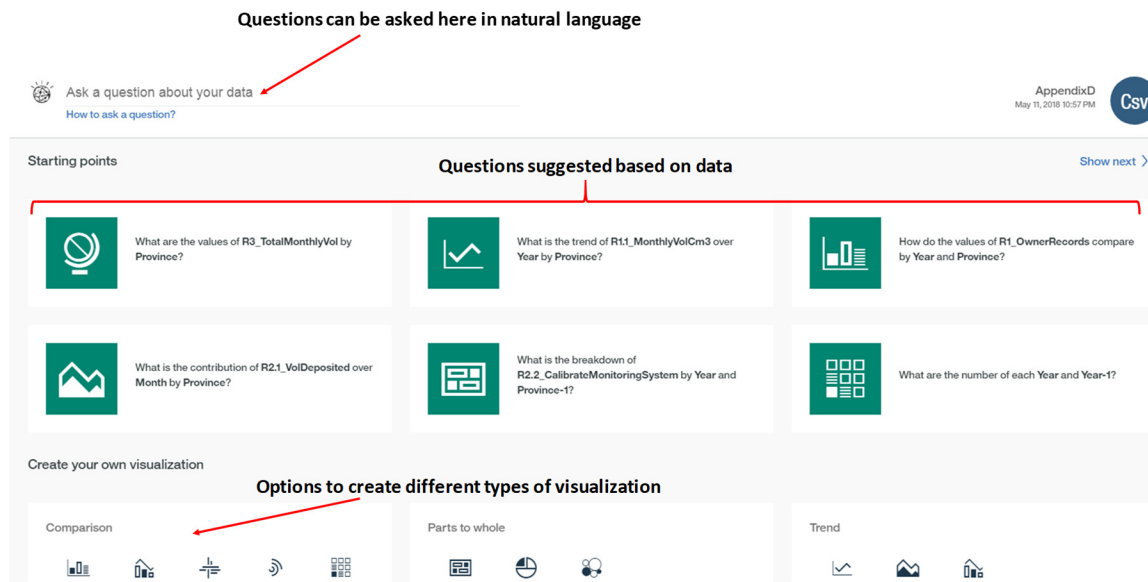
*Data analytics* comprises qualitative and quantitative techniques and processes used to derive insight from data, whereas *data visualization* involves visually representing data. Data analytics is the science of examining raw data in order to draw conclusions about that information (Talukdar, 2014). The use of data analytics enables making better-informed decisions and verifying or disproving existing models, theories and hypotheses. Data visualization presents data in a pictorial or graphical format (Aparicio & Costa, 2015; Friendly, 2008). The use of data visualization enables understanding the significance of data as patterns, as well as visually exposing and recognizing trends and correlations. In GoRIM, data analytics enable deriving inferences and attributions on the regulatory processes towards describing the effectiveness of regulations. These inferences and attributions are possible through examining and visualizing the data obtained from the models of regulations, regulatory initiatives and outcomes.

IBM Watson Analytics offers data analysis and visualization services on the cloud (IBM, 2016). A cloud-based solution i) enables users to access this software anywhere and anytime using an Internet browser, and ii) simplifies maintenance. This software combines an IBM Watson front-end with an SPSS (IBM, 2018) backend (for statistical analysis), in a way that makes IBM Watson Analytics better than IBM SPSS from performance, usability, and user satisfaction perspectives (FinancesOnline, 2018). IBM Watson is a cognitive computing platform where apps and systems interact with humans via natural language in order to discover insights that can help answer simple and complex questions. IBM Watson

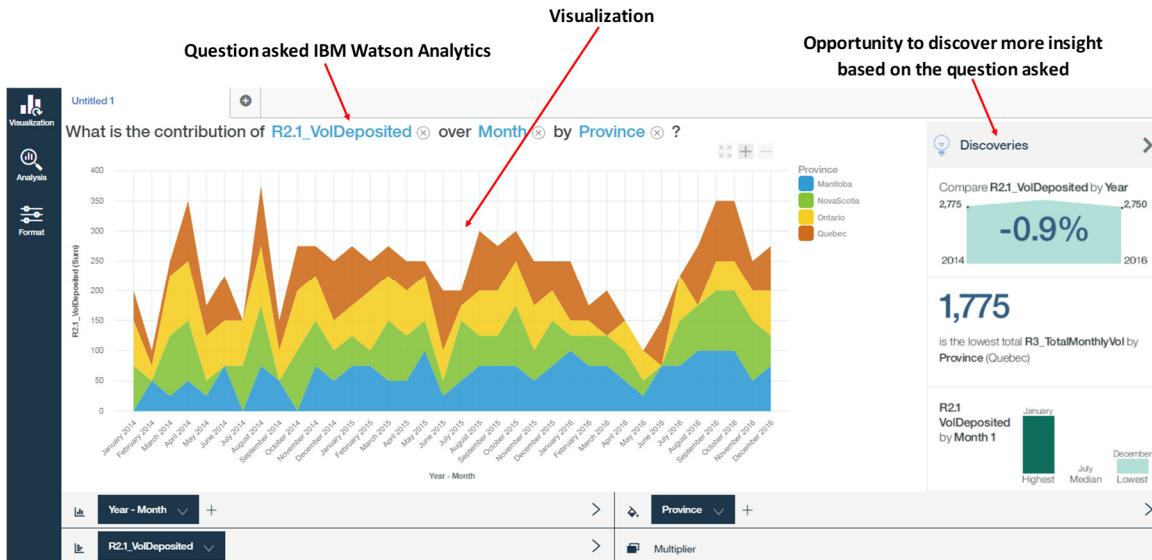
“understands” the nuances of human language and gets smarter from each interaction with its users, and each piece of data it ingests.

IBM Watson Analytics provides quick discovery of patterns and meanings in data and guides the user through the analysis and discovery of their data regardless of the skill level of the user. IBM Watson Analytics reduces the complexity of data analytics and is practical for use in the regulatory domain, where the traditional actors are not inclined to learn the computing and software skills most data analytics and data visualization software require. As shown in Figure 15, using natural language, users can ask questions as in a conversation to inquire on the data, and IBM Watson Analytics suggests more concise questions based on the questions previously asked. Furthermore, IBM Watson Analytics not only answers the questions asked, but also suggests other related questions that could help the user arrive at a clear and concise conclusion.

In addition, IBM Watson Analytics intuitively guides data exploration by providing default visualizations and by providing a “discovery” dashboard, as illustrated in Figure 16, to discover more insights based on the question asked. IBM Watson Analytics also currently supports 32 connectors for importing data from various sources.



**Figure 15** Asking Questions in IBM Watson Analytics



**Figure 16** Data Analytics using IBM Watson Analytics

These advanced features prompted my choice of IBM Watson Analytics for data analytics in GoRIM in comparison to other existing solutions in that domain.

## 4.2. A Process Model for the Use of GoRIM

Regulators typically employ personnel with different expertise and skill sets involved in creating and administering regulations, including subject matter experts and compliance enforcement officers. The skills and expertise required to utilize GoRIM draw upon the skills of such personnel. In this regard, a process model for the use of GoRIM that identifies the kinds of personnel and expertise required to carry out the steps of GoRIM becomes useful. To specify such a process model, I utilize Use Case Maps (UCM), the other sub-language of URN used for describing scenarios/processes (Amyot & Mussbacher, 2011; International Telecommunication Union, 2012).

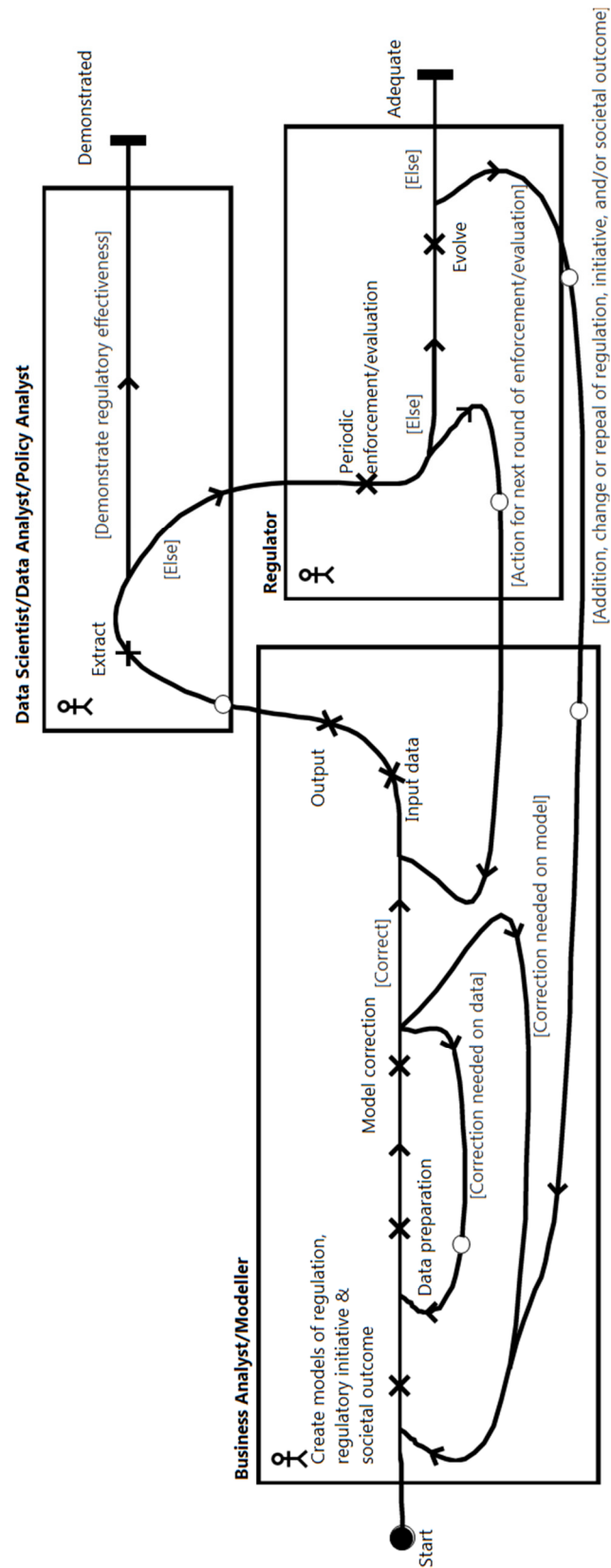
UCM answers the *what*, *when*, *where*, and *who* questions about a process. UCM is a visual scenario notation aiming to model functional or operation requirements. UCM is used to model processes as causal flows of responsibilities that can be superimposed on underlying structures of components. UCM's basic elements include *maps* that contain any number of paths and components, and *paths* that express causal sequences composed of several types of path nodes. Paths have a *start point* (●, e.g., Start in Figure 17) and an

*end point* (■, e.g., Demonstrated in Figure 17). *Responsibilities* (✕, e.g., Data preparation in Figure 17) represent required actions or tasks performed during processes. UCM basic elements also include, *OR-forks* ( $\neg$ ) for alternatives that possibly have guarding conditions such as [NotOk], and *OR-joins* ( $\simeq$ ) to combine alternative paths (Amyot & Mussbacher, 2011).

Figure 17 illustrates a UCM model that describes the process of using GoRIM for regulatory effectiveness. This process has one start point and two possible end points. While using GRL to create models of the regulations, regulatory initiatives or societal outcomes is the first responsibility when using GoRIM, a regulator can decide to stop after demonstrating regulatory effectiveness or after additions, changes or repeals to the regulations, regulatory initiative, and/or societal outcomes. In addition, the UCM process model for GoRIM contains three actor roles (shown as rectangles) and the eight steps of GoRIM as responsibilities.

The roles involved in the use of GoRIM are:

1. *Business Analyst/Modeller* – this role is responsible for creating the models of the regulations, regulatory initiatives or societal outcomes. As such, this role should have expertise in requirements gathering to enable adequate elicitation of the relative importance of input contributions for the regulations, initiatives and outcomes, and input indicator definitions and their contributions. The Business analyst/Modeller should also have expertise in the creation of models using jUCMNav. Other responsibilities involved in this role include using a new tool proposed in this thesis (Evaluation Strategies Processor – ESP) for data preparation, making model corrections, inputting the strategies produced by ESP into the models and outputting the model satisfaction values into a database.
2. *Data Scientist/Data Analyst/Policy Analyst* – this role is responsible for deriving different types of insights from the satisfaction values of model elements using data analytics/visualization software. As such, this role should have expertise in the regulatory context and in drawing inferences from data and showing attributions.



**Figure 17** Process Model for the Different Roles and Activities involved in GoRIM

3. *Regulator* – this role is responsible for making decisions concerning periodic enforcement or evaluation of compliance, regulatory initiatives or societal outcomes. As such, this role should be part of the decision-making body of the regulator. In addition, this role is responsible for decisions to evolve or not to evolve the regulations, regulatory initiatives or societal outcomes.

### 4.3. GoRIM Steps

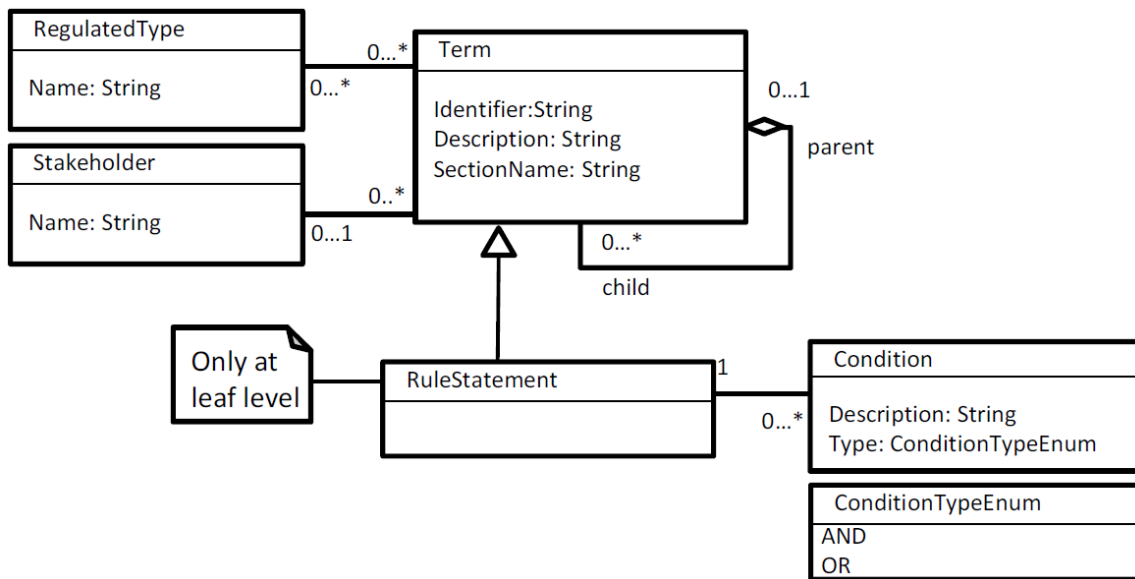
This section details each of the eight steps of the GoRIM process (Figure 9 and Figure 17).

#### 4.3.1 The Build Step

In this step, the Business Analyst (or simply Modeller in the rest of the thesis) creates models of the regulations, regulatory initiatives and/or outcomes as follows:

##### 1. Building models of the regulations

In Shamsaei (2012), a metamodel for the structure of regulations that uses a string description to capture the textual content of terms (including rule statements) and conditions was introduced. Illustrated in Figure 18, the regulations structure metamodel makes it possible to map regulations, laws and policies to GRL elements, and hence use GRL to create models of regulations, their goals (objectives) and indicators measuring these goals.

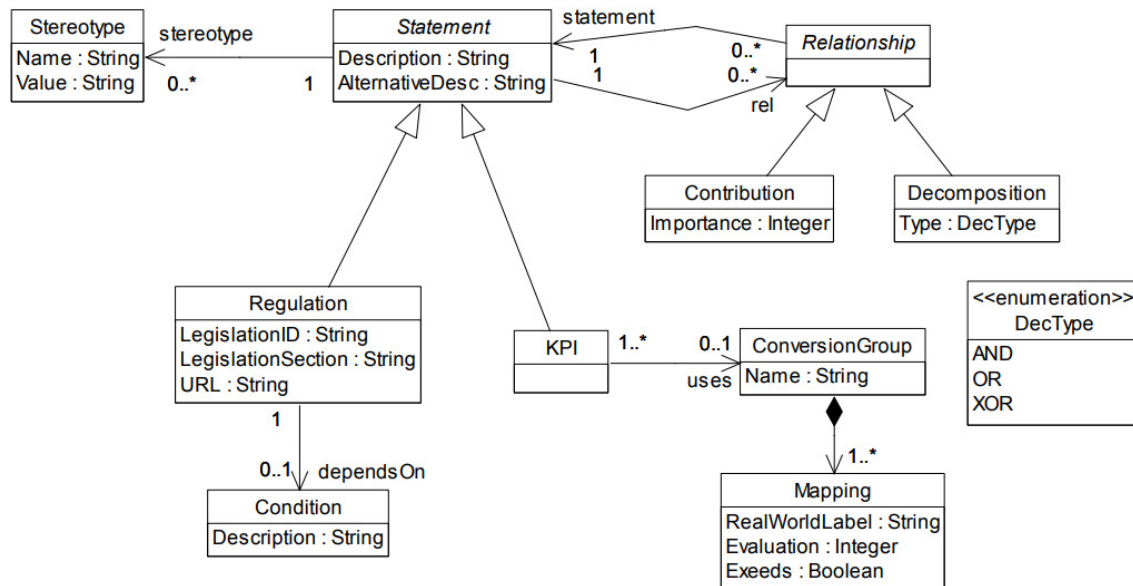


**Figure 18** Regulations Structure Metamodel (Shamsaei, 2012)

In this metamodel:

- a) *Term*: refers to the various structural elements in regulations along with their hierarchical characteristics such as *Parts/Title/Pillar/Chapter/Policy*, *Sub-part/Sub-pillar/Sub-chapter/Sub-policy*, and *Section*
- b) *Rule Statement*: refers to a special kind of term at the leaf level of a regulation, a more measurable and actionable level.
- c) *Condition*: refers to a precondition required for a rule to be applicable in a situation.
- d) *Stakeholder*: An entity responsible for acting upon regulations/rules.
- e) *Regulated Types*: Some regulation elements that are only applicable to specific types of regulated parties.

Building on this work, Rashidi-Tabrizi (2013) proposed the tabular presentation meta-model illustrated in Figure 19 for mapping the elements in Shamsaei (2012)’s regulation structure metamodel to data fields in a Comma-Separated Value (CSV) file, as shown in Table 9. This resulted in a novel method of *automatically* creating goal models of regulations, their goals and indicators in tabular forms such as with CSV files, using GRL. Furthermore, his work enhanced the jUCMNav tool with an import mechanism to automatically create goal models of regulations from their tabular form, import GRL evaluation strategies into the created models, and offer better ways to display and interact with the created regulation goal models.



**Figure 19** Tabular Presentation Metamodel (Rashidi-Tabrizi, 2013)

**Table 9** Mapping between the Regulation Structure Metamodel (Shamsaei, 2012) and Comma-Separated Value (CSV) Data Fields

Class	Attribute	Data Field in CSV File
Regulation	Description	ENGLISH_DESCRIPTION
Regulation	LegislationID	LEGISLATION_ID
Regulation	Legislation-Section	LEGISLATION_SECTION
Regulation	URL	URL
KPI	Description	KPI
Contribution	Importance	IMPORTANCE
Decomposition	Type	DECOMPOSITION
Regulation	Alternative-Desc	ALTERNATIVE_DESCRIPTION
KPI	Alternative-Desc	ALTERNATIVE_KPI
Conversion Group	Name	KPI_STEREOTYPES
Stereotype	Value	STEREOTYPE and KPI_STEREOTYPES
Condition	Description	KPI_IMPORTANCE

Table 10 lists the mapped Comma-Separated Value (CSV) data fields from Table 9 and their meanings.

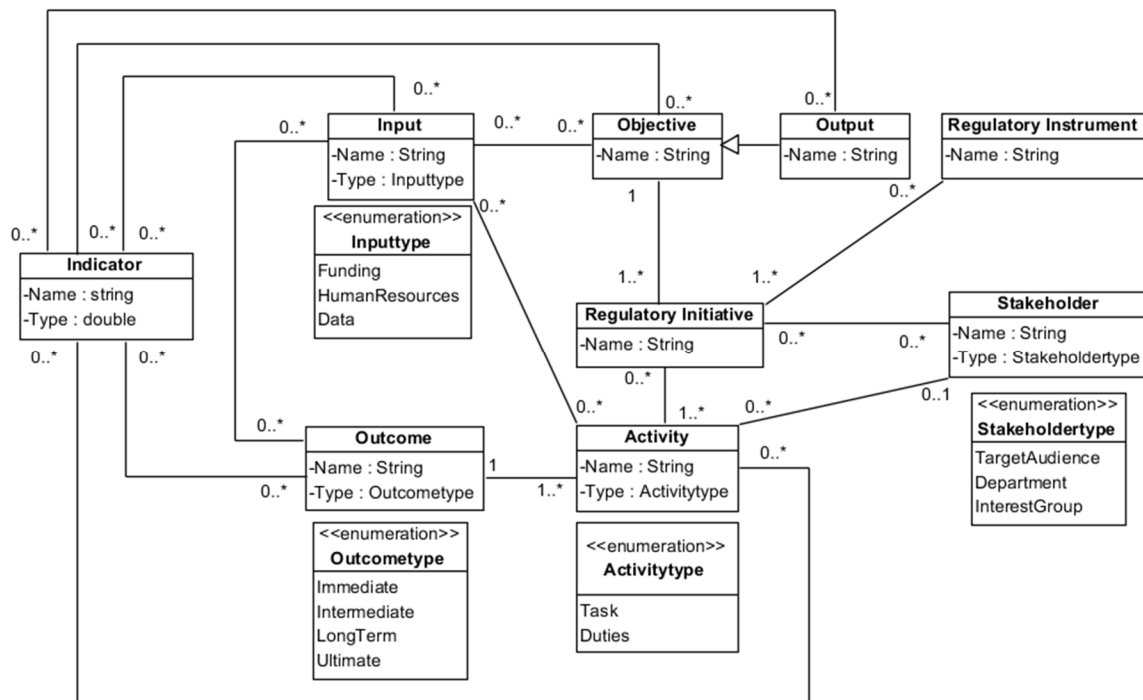
**Table 10** Comma-Separated Value (CSV) Data fields and their Meanings

Data Field in CSV File	Meanings
LEGISLATION_ID	Contains the identifier (ID) of the legislation/regulation. It is a unique ID distinguishes regulations from each other.
LEGISLATION_SECTION	Contains a regulation/legislation section identifier. It captures the structure of the regulation and reflects this in generated goal model.
ENGLISH_DESCRIPTION	Contains the description (or name) of the regulation. This field literally contains regulation statements.
ALTERNATIVE_DESCRIPTION	The same as the ENGLISH_DESCRIPTION but in a different language.
URL	Contains the hyperlink to the original regulation statement if available. This field can be empty.
IMPORTANCE	Contains the relative value of contribution of the regulation statements to its parent regulation. This value is obtained from the regulator.
DECOMPOSITION	Contains the decomposition type (AND, OR, XOR) of a child regulation.

Data Field in CSV File	Meanings
STEREOTYPE	Contains one or more stereotype tag for the regulation statement based on the needs of the domain.
KPI	Contains key performance indicators used to measure. This field is optional and hence may not be included.
KPI_IMPORTANCE	Contains the relative value for contributions between a KPI and its parent regulations.
ALTERNATIVE_KPI	Contains an alternative name or description for a KPI
KPI_STEREOTYPES	Contains stereotypes definitions that qualifies a KPI.

Many of the columns of such CSV files can be extracted automatically from regulation databases. Information to be added manually include KPI definitions (usually not available in regulations) and the relative importance values of contributing terms.

## 2. Building models of the regulatory initiatives and societal outcomes



**Figure 20** Regulatory Initiatives Metamodel

Similarly, to create models of regulatory initiatives and societal outcomes using GRL, we need to map their structures to GRL elements. In this regard, after reviewing the literature

on the regulatory process and discussing with regulators, I created the metamodel illustrated in Figure 20 based on the structure of regulatory initiatives. Table 11 shows mappings between elements of this regulatory initiative metamodel and GRL. Using jUCMNav, the Modeller can create models of the regulatory initiatives using these elements. This process of creating regulatory initiatives is currently manual and is not as automated as creating GRL models of regulations.

I also observed from the regulatory process literature and from discussions with regulators that the structure of societal outcomes is identical to the structure of regulatory initiatives. Societal outcomes can also encompass activities, inputs, objectives, outcomes, outputs, regulatory initiatives, regulatory instruments and stakeholders. Hence, the Modeller can create models of societal outcomes using the mapped GRL elements of the regulatory initiative metamodel.

**Table 11** Mapping between Regulatory Initiatives and GRL Model Elements

<b>Term</b>	<b>Definition</b>	<b>GRL Element</b>
Activity	Refers to a process, i.e., the combination of actions that result in a certain set of products.	Task
Activity-type	Refers to the type of activity e.g. task, duties.	<i>Metadata on Task</i>
Indicator	Refers to a qualitative, quantitative or time factor used to measure.	Indicator
Input	Refers to what is put in or operated on.	Resource
Inputtype	Refers to the type of input, i.e., human resource, time, or money.	<i>Metadata on Resource</i>
Objective	The purpose for which the regulatory initiative is required.	Goal
Outcome	Refers to what an activity achieves.	Goal
Outcome-type	Refers to the type of outcome, i.e., immediate (short term), intermediate (medium-term), long-term or ultimate.	<i>Metadata on Goal</i>
Output	Refers to what an activity produces directly or immediately. It also refers to a direct or immediate objective.	Goal
Regulatory Initiative	Refers to actions, steps or things done that lead to actions on administering regulatory instruments	Task
Regulatory Instrument	Refers to tools Regulators use to change or modify behaviours in order to meet the objectives of each act or law, e.g., Regulation, Standard, or Code of Practice.	Goal

Term	Definition	GRL Element
Stakeholder	Party or person with an interest or concern in the objective or outcome of the regulatory initiative.	Actor
Stakeholdertype	Refers to the type of stakeholder, i.e., department, target audience or interest group.	<i>Metadata on Actor</i>

This homomorphic nature of the created models enables having the same views (and the same language used) for regulations, regulatory initiatives and societal outcomes. This quality simplifies greatly the learning of GoRIM and the integration of tools.

### 4.3.2 The Data Preparation Step

The visual representation of the created GRL models provides insight on how the different elements in the regulation, regulatory initiative and societal outcome models should look like and behave. Hence, the created models bring to bear the type of data needed to populate the KPIs in the respective models for analysis. In this step, the Modeller collects and prepares data on compliance with the regulation and data on performance of the regulatory initiative or societal outcome for input into the KPIs of the models.

Typically, GRL evaluation strategies (which provide initial values to some KPIs and intentional elements of the model) are defined with values provided manually or obtained automatically using, for instance, BI systems. The Modeller sets the *target*, *threshold* and *worst* value parameters for the KPIs in jUCMNav while defining the strategies. However, judging from the enormous amount of changing data involved in compliance with regulations, performance of regulatory initiatives or societal outcomes, i.e., big data, setting the *target*, *threshold* and *worst* values for each evaluation strategy in jUCMNav is impractical and hence needs automation.

In order to simplify the creation of GRL strategies (including KPI parameters) for large data sets, the *Evaluation Strategies Processor* (ESP) was created by Labasse et al. (2017), under my supervision. ESP is a Python program that computes evaluation strategies outside jUCMNav using principles of the GRL evaluation algorithm. ESP uses two Microsoft Excel (.xls) files to produce a CSV file with the desired evaluation strategies for all KPIs in a model. The first “Source file” contains the *evaluation* values for the KPIs and the second “Indicator file” contains preconfigured *target*, *threshold* and *worst* value parameters for the each KPI in the models. Appendix A provides a detailed example on how

ESP works and can be used in this context. As a result, the Modeller can import the produced CSV file directly into jUCMNav to derive satisfaction values for the GRL model elements. ESP hence helps dealing with the complexity of the data sources in an automated way.

### 4.3.3 The Model Correction Step

In this step (#3 in Figure 9), based on the created models and prepared data, the Modeller selects a sample of the ESP-created evaluation strategies for input into the models of the respective regulation, regulatory initiative and societal outcome. The purpose of this step is to create an analysis scenario to test whether the models look and behave correctly in their respective contexts and if the data to be used to populate the models are correct. In addition, the Modeller checks the models against URN well-formedness rules selected for the profile used in this thesis. These rules are OCL constraints for GRL models and are supported by jUCMNav (jUCMNav, 2016).

**Table 12** Regulatory Performance Profile OCL Rules

S/N	Rule Name	Description
1	GRLactorEmpty	GRL actor is empty
2	GRLactorNoCLASSTYPE	ST_CLASSTYPE stereotypes cannot be used on actors
3	GRLactorNoCycle	GRL actor must not be part of a containment cycle
4	GRLactorWithoutRef	GRL actor definition without reference
5	GRLconditionDependeeOfIE	A GRL resource with a ST_CONDITIONTYPE metadata must be a dependee of an intentional element
6	GRLconditionNotADepender	A GRL resource with a ST_CONDITIONTYPE metadata cannot depend on anything else
7	GRLcontributionRange	GRL quantitative importance must be between 0 and 100
8	GRLdependencyEvaluationConsistency	The depender of a GRL dependency should not have an evaluation value higher than its dependee's.
9	GRLgraphEmpty	GRL graph is empty
10	GRLimportanceRange	GRL quantitative importance must be between 0 and 100

S/N	Rule Name	Description
11	GRLincomingContributionsNotMoreThan100	Contributions to an intentional element must not sum up to a value higher than 100.
12	GRLindicatorThresholdConsistency	Indicator threshold value must be between the target and worst values.
13	GRLintentionalElementInManyActors	GRL intentional element must not be bound to more than one actor
14	GRLintentionalElemWithoutRef	GRL intentional element definition without any reference
15	GRLintentionalLinkWithoutRef	GRL intentional link definition without any reference
16	GRLintentionElemInsideButUnbound	GRL intentional element is visually contained by actor but is not bound to it
17	GRLnoOverlappingActors	GRL actor boundary must not overlap with the boundary of another actor
18	GRLnoOverlappingIEonActor	GRL intentional element must not overlap with the boundary of an actor
19	GRLstrategyWithIncorrectXORinit	GRL strategy initializes more than one child of an XOR decomposition

Table 12 lists the 19 OCL rules selected from existing URN well-formedness rules to ensure that the input models satisfy specific static properties that go beyond standard URN.

After checking the models with the OCL rules, if the models and evaluations are correct, the Modeller proceeds to step 4 “Input Data”. If the models are incorrect, the Modeller goes back to step 1, “Model Creation”. If the analysis shows problems, e.g. there is no data for some or all of the indicators, the data is unaligned with the indicators, or evaluation results are irregular, the Modeller goes back to step 2, “Data Preparation”.

#### 4.3.4 The Input Data Step

When the models and data are correct, in this step, the Modeller imports all the ESP-created evaluation strategies into the goal models of the respective regulation, regulatory initiative and societal outcome. The resulting satisfaction levels for the KPIs are then propagated to the other elements in the model according to the “Conditional GRL Algorithm” introduced by Shamsaei (2012), which extends the standard quantitative goal evaluation algorithm presented by Amyot et al., (2010) with conditions and ways to disconnect parts of a model.

The resulting satisfaction values of model elements are the compliance levels for the regulation model and the performance levels for the regulatory initiative and societal outcome models.

#### **4.3.5 The Output Step**

In this step, the Modeller takes snapshots of different compliance and performance satisfaction values of the models and stores these values in a database. A snapshot comes from the evaluation of one model for one regulated entity at a given time. The database then contains compliance/performance data structured along three dimensions (regulated parties, time, and goal model elements).

#### **4.3.6 The Extract Step**

In this step (#6 in Figure 9), the Data Scientist or Data Analyst or Policy Analyst (collectively referred to as Data Analyst in the rest of the thesis, for simplicity) extracts the data from the database into IBM Watson Analytics for further analysis and visual exploration of the large datasets. Here, the Data Analyst can explore and analyze the data on compliance and performance for individual models (regulations, initiatives, societal outcomes) or for several models together in order to derive different types of insights. The Data Analyst also validates the visualizations from IBM Watson Analytics and the insights they provide. These insights, which encompass inferences and attributions of the regulations, regulatory initiatives and societal outcomes, can show whether the initiatives and regulations are effective (e.g., by looking for correlations between elements of two models).

#### **4.3.7 The Periodic Enforcement/Evaluation Step**

In this step (#7 in Figure 9), based on the compliance and performance analysis results, the Regulator is equipped with insights towards making different types of decisions concerning short-term courses of action (e.g., warnings or penalties, and early visit) or focus on the regulations, regulatory initiatives or societal outcomes at the next rounds of enforcement or evaluation.

### **4.3.8 The Evolve Step**

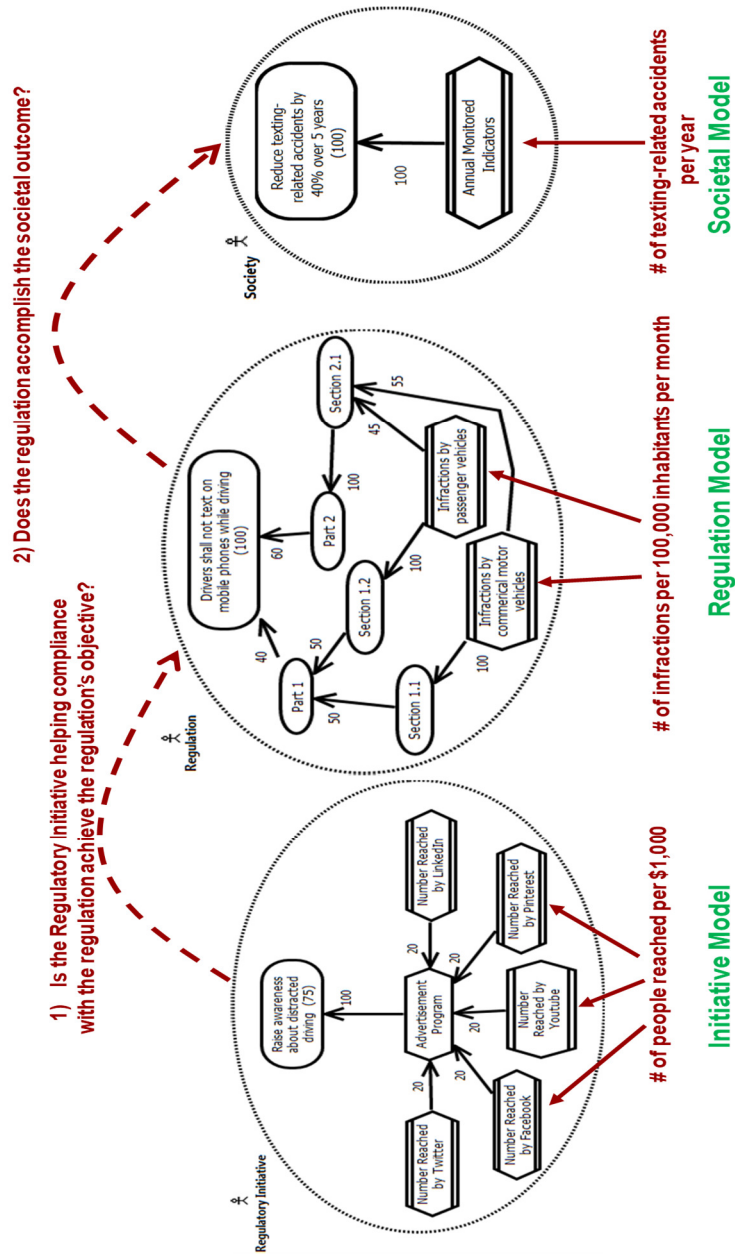
In this step, based on the insights obtained in step 6 (Extract step), the needs for evolution (addition, change or repeal) of the regulations and/or regulatory initiatives, and/or societal outcomes can be triggered by the Regulator.

## **4.4. Applying GoRIM**

As an illustration of GoRIM application, consider the scenario for distracted driving with the OHTA shown in Figure 12 and described in Section 4.1.2. If the regulator is interested in finding out whether the regulation is effective, the context could be as illustrated in Figure 21. A review of the regulation will assess whether reducing the number of times drivers are texting on their mobile phones while driving led to a reduction in the number of texting-related accidents by 40% over 5 years. Hence, questions to explore could be:

- a) Does the regulatory initiative help compliance with the regulation achieve the regulation's objective?
- b) Does regulation compliance lead to the societal outcome?

Applying GoRIM to this scenario in order to show whether these two questions are answered, and by implication whether the regulation is effective, will require the regulator to go through the steps of GoRIM described in Section 4.3.



**Figure 21** Sample Distracted Driving Regulatory Effectiveness Scenario

#### 4.4.1 Model Building

Let the sample regulation “RG 336/20: Drivers Shall Not Text on Mobile Phones While Driving” adapted from the province of Ontario notice on distracted driving (Government of Ontario, 2018a), be the regulation used to ensure that drivers do not text on mobile phones when driving. To create the model for this regulation from its textual format shown in Figure 22, the Modeller will create the tabular representation of the regulation shown in

Figure 23 following the descriptions in Table 10. Much of the information absent from formal documents, such as indicator definitions and contribution values, can be obtained from experts through various consensus mechanisms (Akhigbe et al., 2014).

**Rg 336/20: Drivers shall not text on mobile phones while driving**

Part 1 Distracted driving

Section 1.1 If you have an A, B, C, D, E, F and/or G licence, you face bigger penalties when convicted of distracted driving:

- a fine of \$490, if settled out of court (includes a victim surcharge and the court fee),
- a fine of up to \$1,000 if a summons is received or if you fight the ticket in court and lose,
- three demerit points

Section 1.2 If you hold a G1, G2, M1 or M2 licence, and are convicted of distracted driving, you face the same fines as drivers with A to G licences. But you won't receive any demerit points. Instead of demerit points you'll face:

- a 30-day licence suspension for a first conviction
- a 90-day licence suspension for a second conviction
- cancellation of your licence and removal from the Graduated Licensing System (GLS) for a third conviction
  - to get your licence back you'd have to redo the GLS program

Part 2 Careless driving

Section 2.1 You face more charges – for careless driving – if you endanger other people because of any kind of distraction. This includes distraction caused by both hand-held (e.g., phone) or hands-free (e.g., Bluetooth) devices. If convicted of careless driving, you may receive:

- six demerit points
- fines up to \$2,000 and/or
- a jail term of six months
- a licence suspension of up to two years

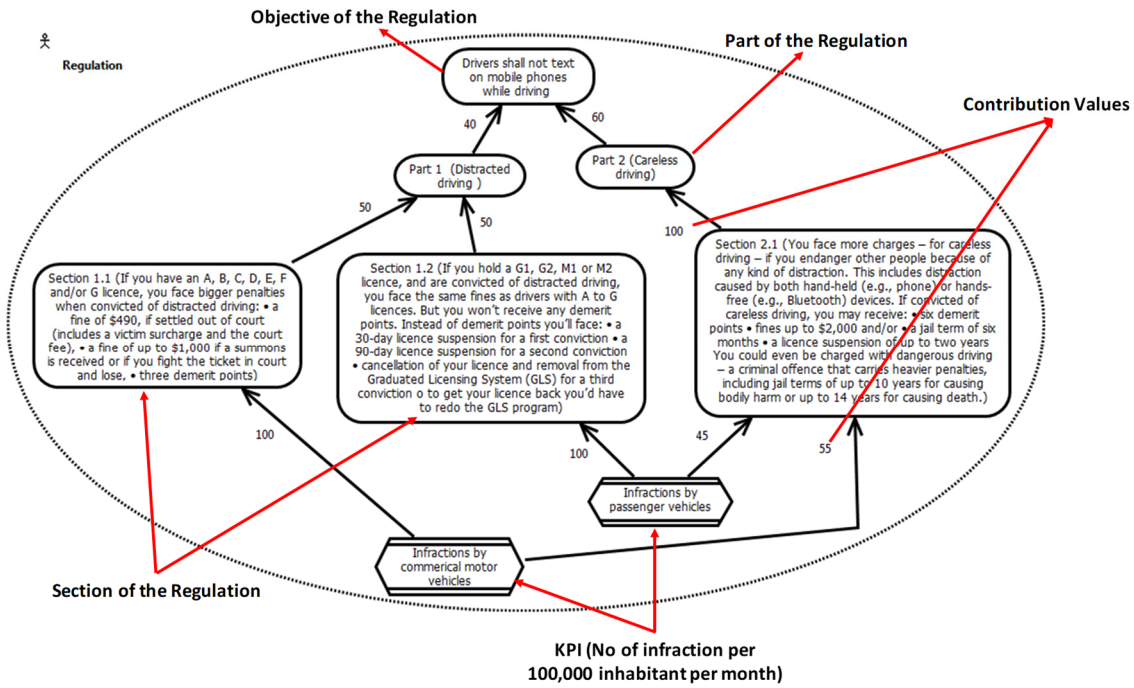
You could even be charged with dangerous driving – a criminal offence that carries heavier penalties, including jail terms of up to 10 years for causing bodily harm or up to 14 years for causing death.

**Figure 22** Textual Formal of Sample Regulation RG 336/20

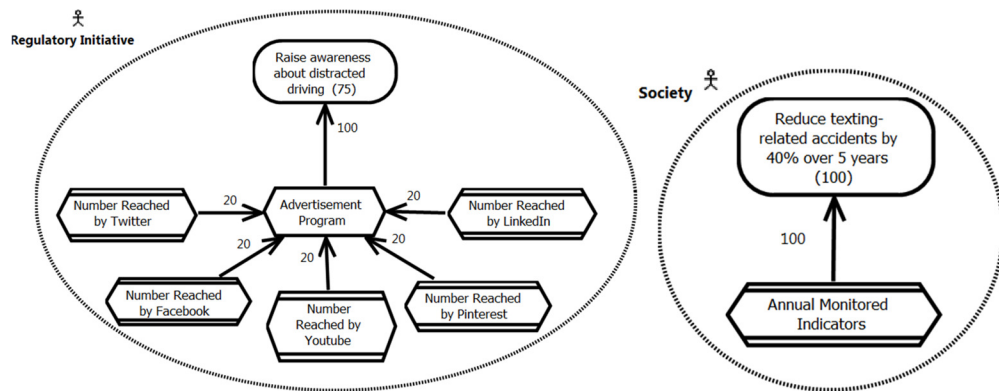
	A	B	C	D	E	F	G	H	I
1	LEGISLATION_ID	LEGISLATION_SECT	ENGLISH_DESCRIPTION	ALTERNATIVE_DESCR	URL	IMPORT.	DECOMP	KPI	KPI_IMPORTANCE
2	Rg 336/20	Rg 336/20	Drivers shall not text on m	Les chauffeur ne doit	http://www.				
3		(A)	Part 1 (Distracted driving	Partie 1 (Conduite di	http://www.	4;			
4		(A)(1)	Section 1.1 (If you have	Section 1.1 (Si vous a	http://www.	1;		Infractions by commerical m	
5		(A)(2)	Section 1.2 (If you hold	Section 1.2 (Si vous è	http://www.	1;		Infractions by passenger veh	
6		(B)	Part 2 (Careless driving)	Partie 2 (Conduite in	http://www.	6;			
7		(B)(1)	Section 2.1 (You face mc	Section 2.1 (Vous fait	http://www.	1;		Infractions by passenger veh	45;55;

**Figure 23** Tabular Representation of the Sample Regulation

Illustrated in Figure 24 is the derived model of the sample regulation. It shows the objective, parts and sections of the regulation including KPIs used as compliance measures when enforcing the regulation. The Modeller then manually creates models of the regulatory initiative (with its objective and performance measures) and societal outcome (with measures) as shown in Figure 25 using the regulatory initiatives metamodel described in Section 4.3.1.



**Figure 24** Model of the Sample regulation



**Figure 25** Model of the Sample Regulatory Initiative and Societal Outcome

#### 4.4.2 Data Preparation

If five years of data (2012–2016) on compliance and performance measures are available, the Modeller can set the parameters of KPIs of each model as follows:

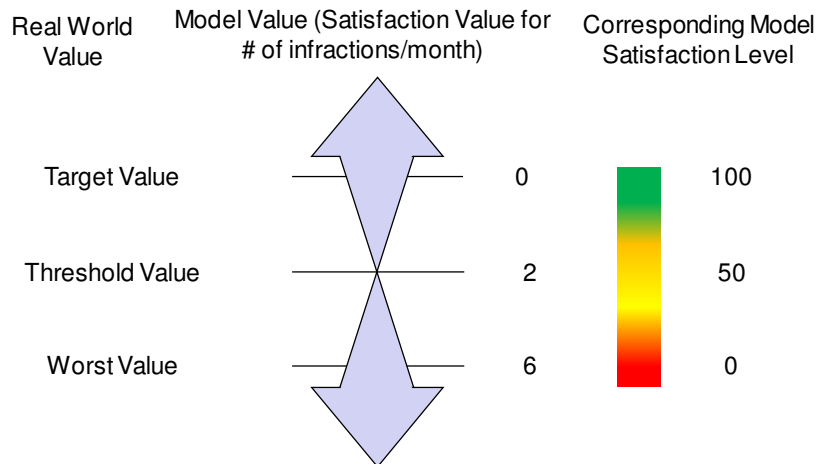
a) Regulation KPI

*Target Value:* Having 0 infractions per 100,000 inhabitants per month

*Threshold Value:* Having 2 infractions per 100,000 inhabitants per month

*Worst Value:* Having 6 infractions per 100,000 inhabitants per month

Figure 26 illustrates the structure of the compliance measure KPI. When analysing the model of the regulation, the KPI compares the actual measured value obtained by the regulator (in the strategy) against the parameter values to ascertain what the level of compliance means.



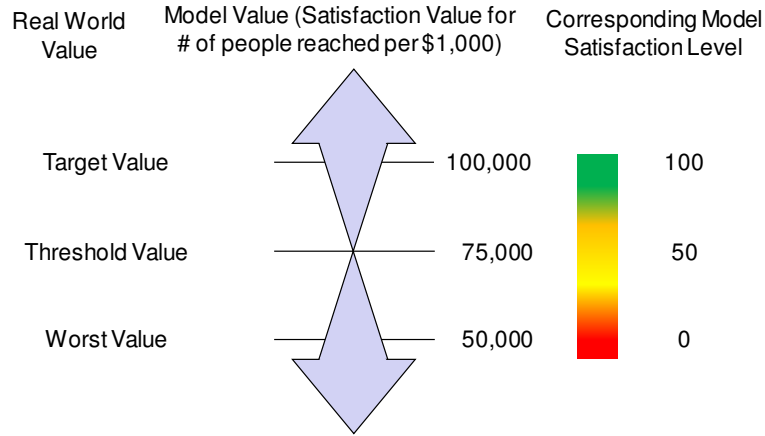
**Figure 26** KPI Structure and Colour Coding for the Compliance Measure

b) Regulatory Initiative KPI

*Target Value:* Reaching 100,000 people on social media per \$1,000 spent

*Threshold Value:* Reaching 75,000 people on social media per \$1,000 spent

*Worst Value:* Reaching 50,000 people on social media per \$1,000 spent



**Figure 27** KPI Structure and Colour Coding for the Performance Measure

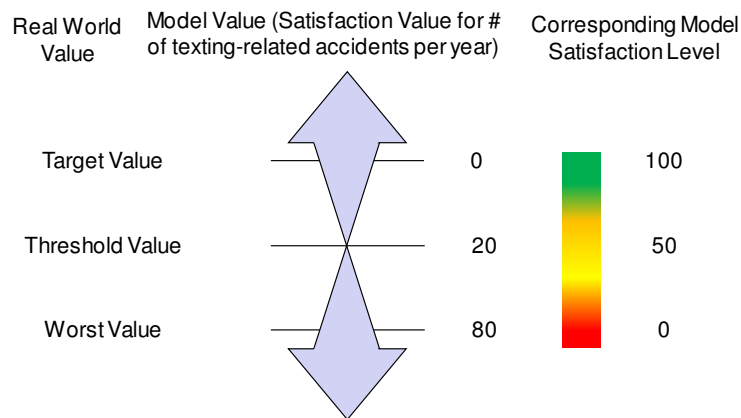
In addition, Figure 27 illustrates the structure of the performance measure KPI, used to ascertain what the level of performance means when analysing the regulatory initiative model. Likewise, Figure 28 illustrates the structure of the societal outcome measure used to ascertain the level of performance when analysing the societal model.

c) Societal Outcome KPI

*Target Value:* Having 0 texting-related accidents per year

*Threshold Value:* Having 20 texting-related accidents per year

*Worst Value:* Having 80 texting-related accidents per year



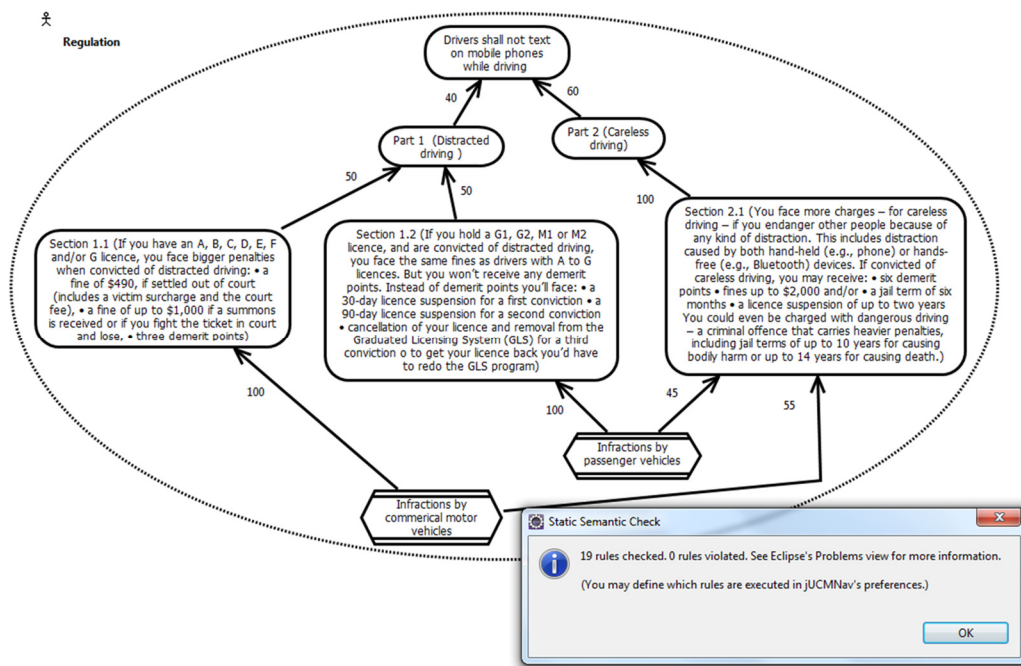
**Figure 28** KPI Structure and Colour Coding for the Societal Outcome Measure

Using such *target*, *threshold* and *worst* parameter values, the Modeller uses the new ESP tool (Appendix A) to derive the evaluation strategies for each KPI in the regulation, regulatory initiative and societal outcome models for the five years. To do this, the indicator

definitions of all KPIs will be saved in an “Indicator” CSV file. The evaluation value of each KPI, which represents the actual measured value obtained by the regulator for the KPI for each of the five years, is saved in the “Source” CSV file. ESP then uses both files to produce automatically the GRL evaluation strategies.

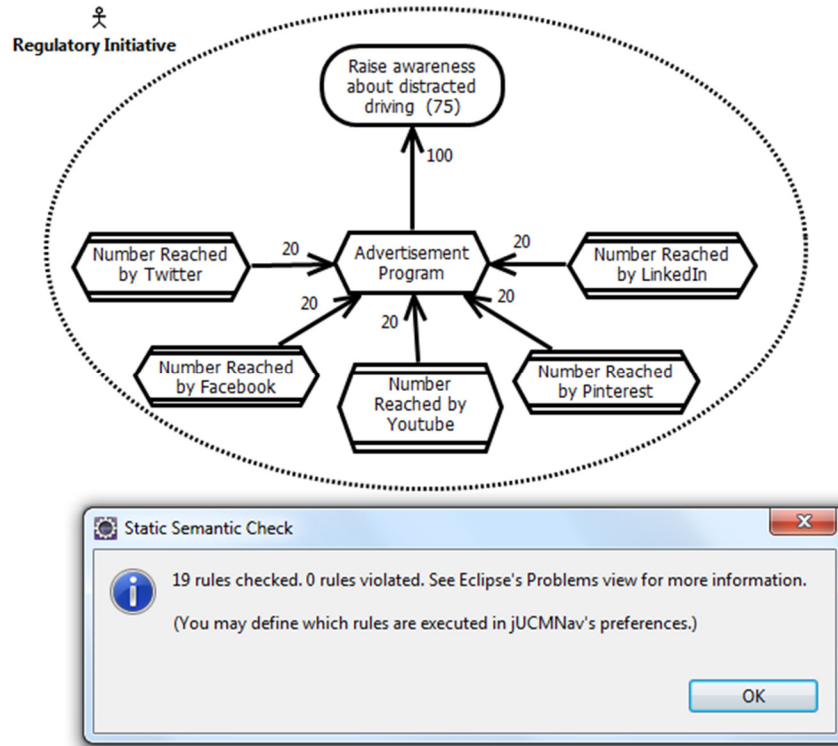
### 4.4.3 Model Correction

The Modeller selects a few ESP-derived GRL evaluation strategies for input into the models to see whether their evaluations are as expected from the distracted driving regulatory context. In addition, the Modeller checks models for structural issues using the 19 URN well-formedness rules listed in Table 12.

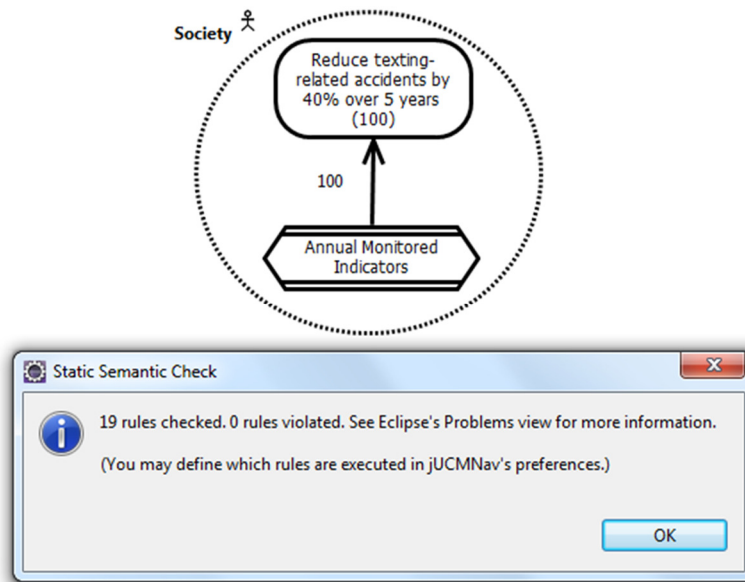


**Figure 29** Checking the Regulation Model against URN Well-Formedness Rules

Figure 29, Figure 30 and Figure 31 illustrate the feedback provided by the jUCMNav tool when the 19 URN well-formedness rules are checked against the models of the regulation, regulatory initiative and societal outcomes. The feedback in this example shows that all three models are correct and behave as expected in the distracted driving regulatory context. If a rule violation is detected, then jUCMNav shows the location of the model element violating the rule, which helps the Modeller diagnose and fix the model.



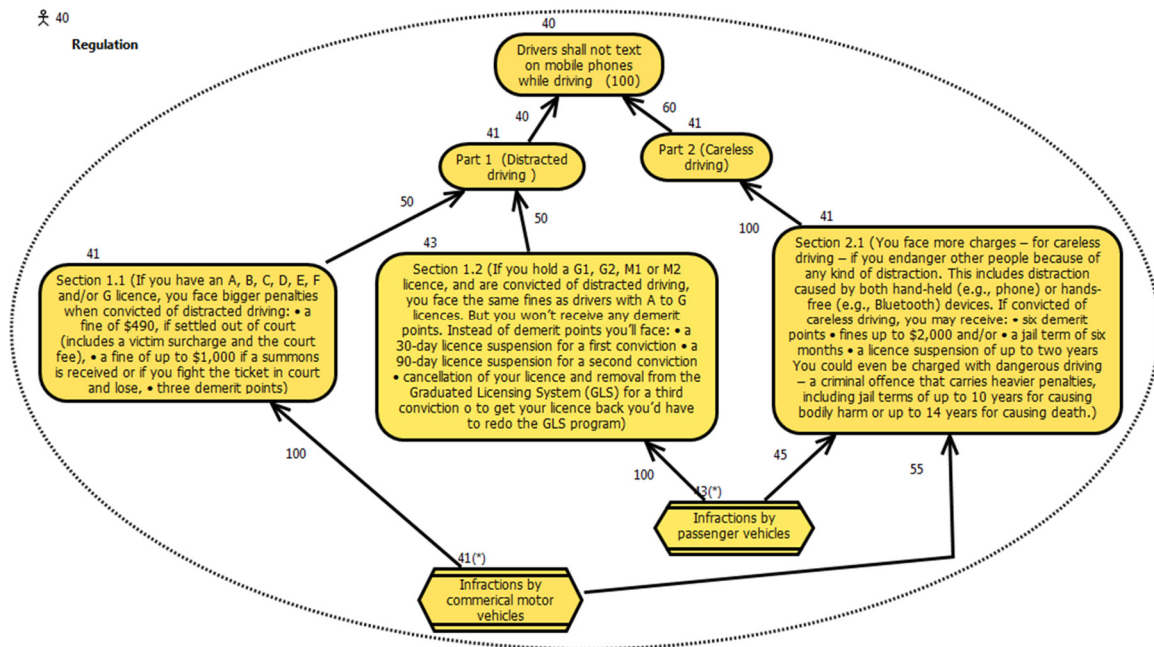
**Figure 30** Checking the Regulatory Initiative Model against URN Well-Formedness Rules



**Figure 31** Checking the Societal Outcome Model against URN Well-Formedness Rules

#### 4.4.4 Data Input and Data Output

After the Modeller checks and corrects the models, all the ESP-derived GRL evaluation strategies for the five years are imported into jUCMNav to compute the satisfaction values of each GRL intentional element and actor in each model. Illustrated in Figure 32 is the evaluation of the compliance level with the regulation in 2012 as “40” on a scale of 0 to 100. Here, the value “41” for the “Infractions by commercial motor vehicles” KPI indicates that the annual number of infractions per 100,000 inhabitants per month recorded in 2012 by commercial vehicles was a little less than the threshold value of “2” infractions per month.

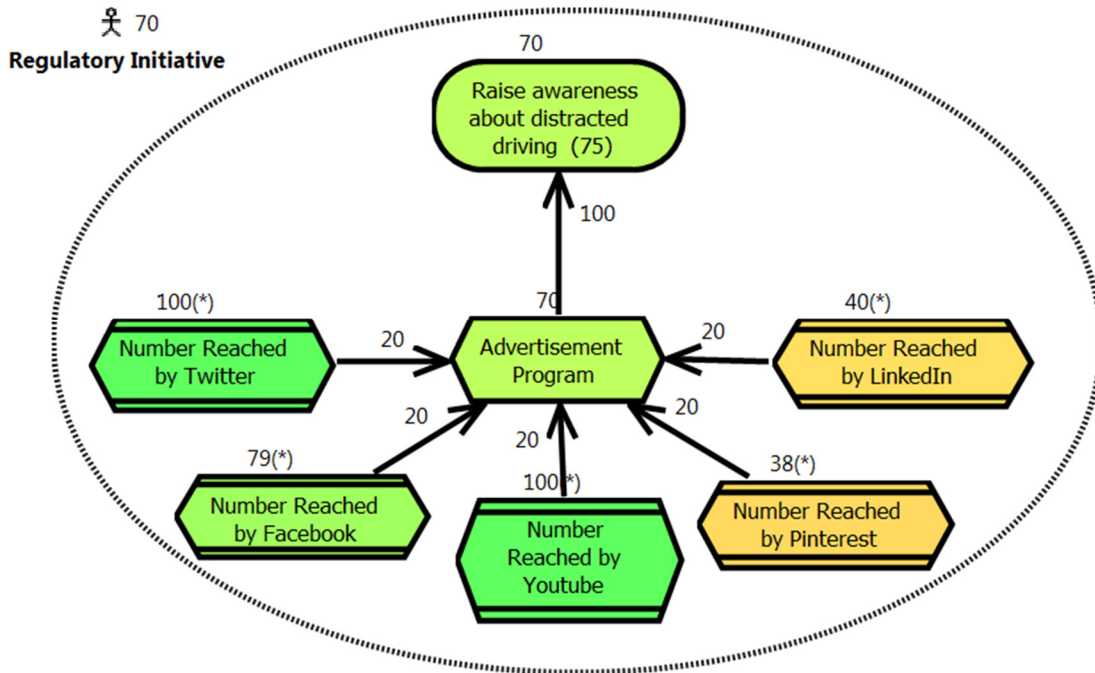


**Figure 32** 2012 Evaluated Model of the Sample Regulation

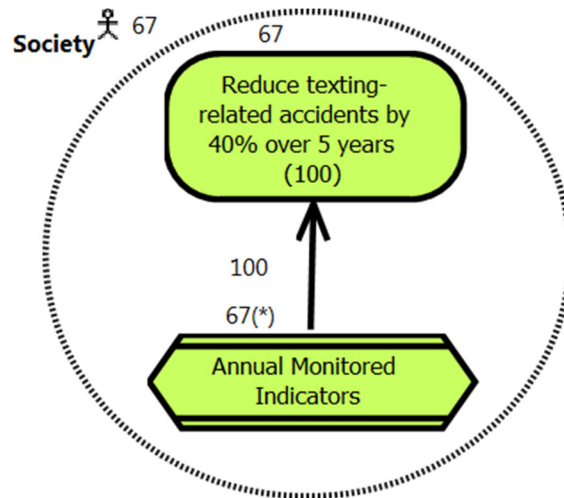
Similarly, Figure 33 illustrates the evaluation amounting to the performance level of the regulatory initiative in 2012 as “70” on a scale of 0 to 100. Here, the value “79” for the “Number Reached by Facebook” KPI indicates that the number of people reached per \$1000 spent on advertisements on Facebook to raise awareness about the regulation was well above the threshold number of 50,000 people but not up to the target of 100,000 people.

Finally, Figure 34 illustrates the evaluation amounting to the measure of the societal outcome in 2012 as “67” on the same scale of 0 to 100. The value “67” for the “Annual

Monitored Indicators” indicates that the number of texting-related accidents in 2012 was less than the threshold number of 20 texting-related accidents while still being higher than the target (0). The Modeller can then export the model satisfaction values for the regulation, regulatory initiative and societal outcomes models for the five years from jUCMNav into a database.



**Figure 33** 2012 Evaluated Model of the Regulatory Initiative



**Figure 34** 2012 Evaluated Model of the Societal Outcome

#### 4.4.5 Extraction

Figure 35 shows the data obtained from the evaluated models for the regulation, regulatory initiative and societal outcome. The Data Analyst imports these data into IBM Watson Analytics. Next, the Data Analyst joins<sup>7</sup> the data in IBM Watson Analytics as illustrated in Figure 36 based on a variable common with all the data sets, “Date”.

**Compliance Measure Data for Regulation**

	A	B	C	D	E	F	G	H
1	Regulation Evaluation	Date	Regulation (A)	Drivers shall not text on mobile phones while driving	Part 1 (Distracted driving)	Section 1.1 (If you have an A, B, C, D, E, F and/or G licence, you face bigger penalties when convicted of distracted driving: • a fine of \$490, if settled out of court (includes a victim surcharge and the court fee), • a fine of up to \$1,000 if a summons is received or if you fight the ticket in court and lose, • three demerit points)	Section 1.2 (If you hold a G1, G2, M1 or M2 licence, and are convicted of distracted driving, you face the same fines as drivers with A to G licences. But you won't receive any demerit points. Instead of demerit points you'll face: • a 30-day licence suspension for a first conviction • a 90-day licence suspension for a second conviction • cancellation of your licence and removal from the Graduated Licensing System (GLS) for a third conviction or to get your licence back you'd have to redo the GLS program)	Part 2 (Careless driving)
2	2012 Assessment	2012	40	40	41	41	43	41
3	2013 Assessment	2013	60	60	62	52	72	60
4	2014 Assessment	2014	42	42	44	45	44	43
5	2015 Assessment	2015	50	50	52	48	56	51
6	2016 Assessment	2016	50	50	51	42	60	50

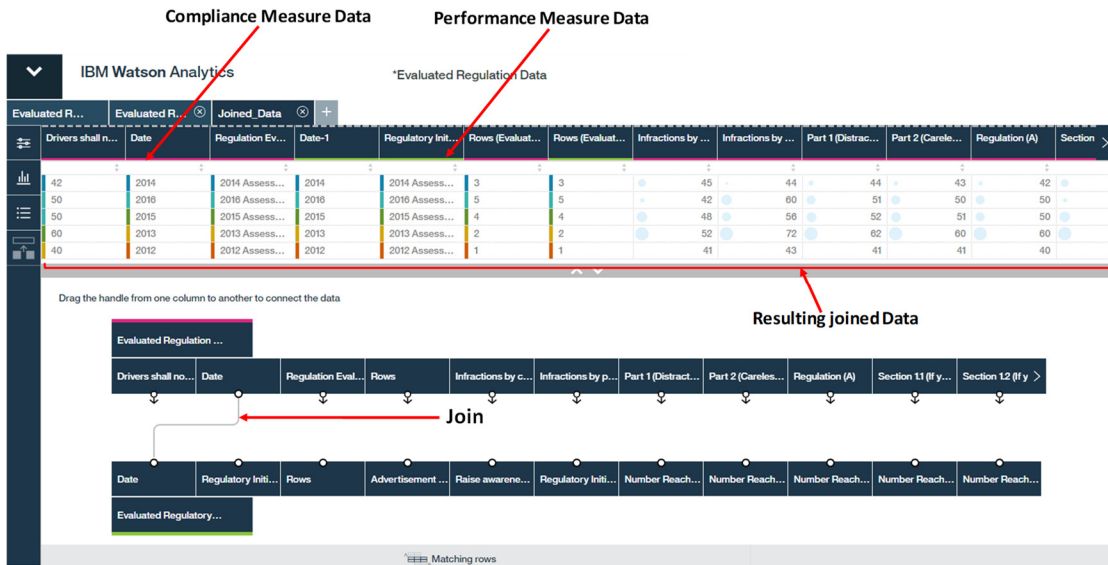
**Performance Measure Data for Regulatory Initiative**

	A	B	C	D	E	F	G	H	I	J
1	Regulatory Initiative Evaluation	Date	Regulatory Initiative (A)	Raise awareness about distracted driving	Advertisement Program	Number Reached by Twitter	Number Reached by Facebook	Number Reached by Youtube	Number Reached by Pinterest	Number Reached by LinkedIn
2	2012 Assessment	2012	70	70	70	100	79	100	38	40
3	2013 Assessment	2013	82	82	82	100	89	100	67	60
4	2014 Assessment	2014	81	81	81	100	80	100	47	81
5	2015 Assessment	2015	90	90	90	100	100	100	51	100
6	2016 Assessment	2016	90	90	90	100	100	100	59	100

**Measure Data for Societal Outcome**

	A	B	C	D	E
1	Societal Outcome Evaluation	Date	Society (A)	Annual Monitored Indicators	Reduce texting-related accidents by 40% over 5 years
2	2012 Assessment	2012	67	67	67
3	2013 Assessment	2013	55	55	55
4	2014 Assessment	2014	50	50	50
5	2015 Assessment	2015	49	49	49
6	2016 Assessment	2016	45	45	45

**Figure 35** Data from the Evaluated Models



**Figure 36** Joining the Data Sets in IBM Watson Analytics

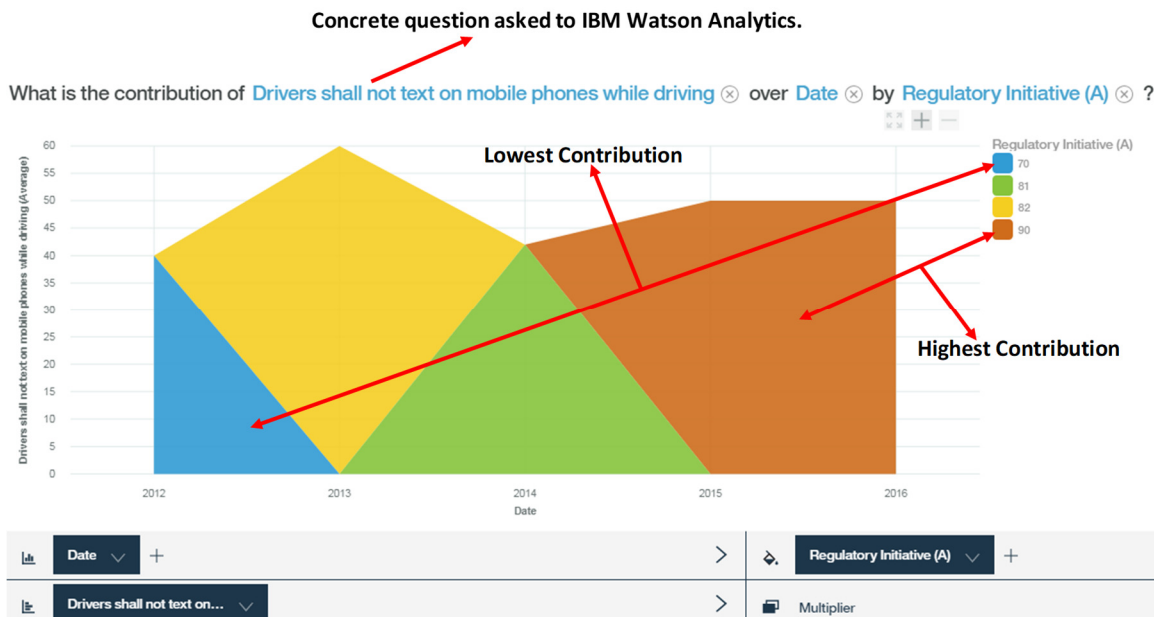
<sup>7</sup> Currently, IBM Watson Analytics does not support joining more than two different data sets. Alternatively, the datasets can be joined in separate pairs or externally and imported into IBM Watson Analytics.

After joining and saving the resulting data set, the Data Analyst then queries IBM Watson Analytics to answer the two regulatory effectiveness questions stated in Section 4.4.

To answer the first question “Does the regulatory initiative help compliance with the regulation achieve the regulation’s objective?” the Data Analyst can query the evaluated data of the models in IBM Watson Analytics. A starting point could be finding out whether the regulatory initiative contributes to “Drivers shall not text on mobile phones while driving”, the objective of the regulation, by asking:

*“What is the contribution of regulatory initiative to drivers shall not text on mobile phones while driving by date?”*

The Data Analyst could choose the question illustrated in Figure 37 from questions automatically suggested by IBM Watson Analytics. From the visualization, we observe that the regulatory initiative contributed to “Drivers shall not text on mobile phones while driving” every year within the five-year period with the lowest contribution of “70” in 2012 and the highest of “90” in 2016.



**Figure 37** Sample Analysis in IBM Watson Analytics 1

The Data Analyst could explore the results further by comparing values of “Drivers shall not text on mobile phones while driving” and these contributions.



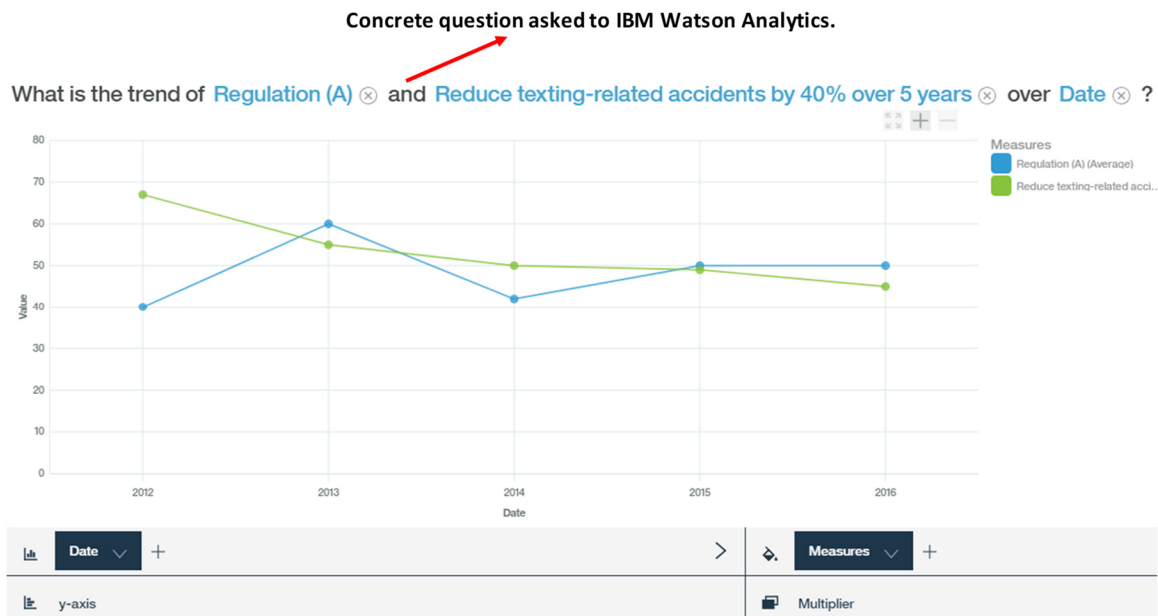
**Figure 38** Sample Analysis in IBM Watson Analytics 2

Figure 38 illustrates such an analysis. We observe that the values for “Drivers shall not text on mobile phones while driving” was the lowest in 2012 with “40” when the value of the regulatory initiative contributed was the lowest (70), but the highest in 2013 with “60” when the value of the contribution from the regulatory initiative was “82”. The Data Analyst could explore further to see why such value was obtained when the contribution of the regulatory initiative was not at its highest value of “90”.

We observe from the two visualizations in IBM Watson Analytics that having a high value of performance of the regulatory initiative results in a high value for “Drivers shall not text on mobile phones while driving”. This suggests that the regulatory initiative helps the compliance with the regulation achieve the regulation’s objective. It implies that the advertisement program on social media (Twitter, Facebook, YouTube, Pinterest and LinkedIn), helped reduce the number of infractions per 100,000 inhabitants per month, between 2012 and 2016.

The Data Analyst can also query the evaluated data of the models in IBM Watson Analytics to answer the second question: “Does the regulation compliance lead to the societal outcome?” A starting point for this could be to explore the trend of the regulation and the societal outcomes “Reduce texting-related accidents by 40% over 5 years” by asking IBM Watson Analytics:

“What is the trend of Regulation and Reduce texting-related accidents by 40% over 5 years by date?”



**Figure 39** Sample Analysis in IBM Watson Analytics 3

Illustrated in Figure 39 is the question and visualization IBM Watson Analytics suggests that the Data Analyst could choose. We observe a steady decrease in value for the societal outcome measure from “67” in 2012 to “45” in 2016. Within this same period, there was a fluctuation in value for the regulation from its lowest on 2012 with “40”, highest in 2013 with “60” and final value of “50” in 2016. We can also observe that despite the fluctuation in value for the regulation, the value for the societal outcome steadily decreased, suggesting other factors could be contributing to this. This implies that drivers not texting on mobile phones while driving did not result in an annual reduction of texting-related accidents between 2012 and 2016. While the Data Analyst could decide to explore what other factors could be contributing to this steady decline in the value of the societal outcome, the result suggests that the regulation does not accomplish the societal outcome.

Based on the questions asked and the level of sophistication of the statistical analysis used to derive the answers, IBM Watson Analytics can provide an explanation of the underlying statistical analysis used to derive the answers. Hence, the Data Analyst can view the different types of statistical analyses that IBM Watson Analytics uses.

#### **4.4.6 Periodic Enforcement/Evaluation**

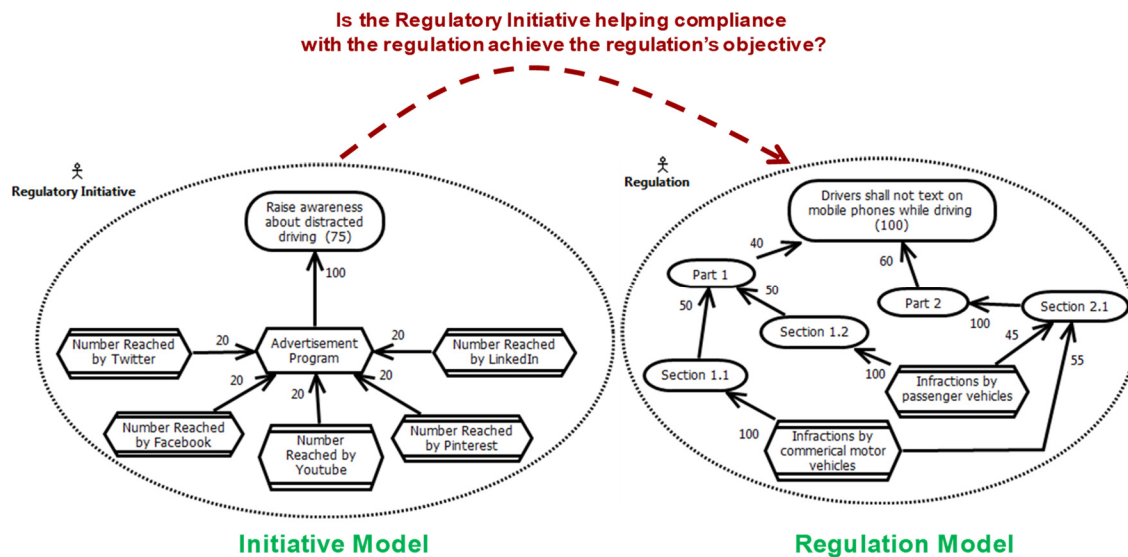
With the results obtained from the compliance and performance analysis, the Regulator is now equipped with insights on whether the advertisement program on social media about the regulation on distracted driving helped compliance with the regulation. In addition, the Regulator has also assessed whether compliance with the regulation actually reduced texting-related accidents by 40% between 2012 and 2016. With the regulatory initiative helping compliance with the regulation, the Regulator could decide to focus on the regulation and societal outcome in the next rounds of enforcement or evaluation, since it does not appear compliance with regulation resulted in accomplishing the societal outcome. In this regard, the regulator could decide to change the frequency of data collection for evaluation of the societal impacts to “per month” and not “per year” or the frequency of reporting on the accomplishment of the societal impacts to “every year”. Such focus could enable assessing whether a reduction on the number of infractions per 100,000 inhabitants per month could result in a reduction in the number of texting-related accidents per month, or whether assessing the satisfaction of the societal outcome annually could highlight any contribution from compliance to the regulation. If the former line of action is chosen, in the data input and output steps of the distracted driving regulatory effectiveness scenario (see Section 4.4.4), the data that the Modeller imports into jUCMNav, evaluates with the models and exports into a database would be based on months, not years. Similarly, when deriving insights from the evaluated data in the extract step, the Data Analyst could explore the visualizations described in Section 4.4.5. In this case, the insights derived could show if monthly compliance with the regulation results in reduction on the monthly number of texting-related accidents.

#### **4.4.7 Evolution**

Finally, since the insights derived in Section 4.4.5 indicate that while the regulatory initiative is helping compliance with the regulation, the regulation is not leading to the societal outcome. The regulator could hence decide to repeal or change the regulation. If the initiative had not been helping compliance, then a similar decision (change or repeal) could have been made about the initiative.

## 4.5. Application of GoRIM in the Case Studies

The application of GoRIM in the sample distracted driving scenario described in the previous section helped assessing the effectiveness of regulations, regulatory initiatives and societal outcomes. However, this thesis focuses on a reduced scope based on the availability of the case studies and Key Informants participation. The case studies described in this thesis only address the effectiveness of regulations and regulatory initiatives, as illustrated in Figure 40. As societal outcome models and data were difficult to obtain, the case studies do not assess whether compliance with regulations results in intended societal outcomes. However, given the homomorphic nature of the three types of models involved, it is likely that the thesis conclusions related to the initiative/regulation context will be generalizable to the regulation/outcome context.



**Figure 40** Scope of Focus in this Doctoral Research

## 4.6. Conclusion

In this chapter, I described GoRIM and how it exploits the Goal-oriented Requirement Language and IBM Watson Analytics to model and analyze regulations, regulatory initiatives, societal outcomes, as well as the way they influence each other. In addition, I introduced a process for the use of GoRIM and described its steps. Finally, using a sample

distracted driving scenario based on the OHTA (Government of Ontario, 1990), I discussed how to apply GoRIM to show the effectiveness of a regulation and its regulatory initiative.

In the next three chapters, I describe the application of GoRIM to case studies involving real regulators and their regulations.

## Chapter 5. Case Study 1: Migratory Bird Regulations

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In this chapter, I apply GoRIM to the first study in the multiple-case study involving a real-life regulatory scenario. Here, I illustrate the use of GoRIM to address the effectiveness of the Migratory Bird Regulations – MBR (Government of Canada, 2016a).

Note that this chapter reports on a proof of concept used as one iteration in my DSRM-based approach (Figure 5). In that context, the analysis results reported in this chapter are for illustration purposes only and should not be used in any way to influence decision-making by the Government of Canada or to draw conclusions about the performance of the regulator or the regulation.

First, I give an overview of the case study and then I apply the steps of GoRIM.

### 5.1. Case Study Overview

The Migratory Bird Regulations (MBR) (Government of Canada, 2016a) is administered by the Canadian Wildlife Service (CWS), a unit within Environment and Climate Change Canada (ECCC). The MBR in turn is the regulatory instrument used to administer the Migratory Birds Convention Act (MBCA) (Government of Canada, 1994b). The MBCA, originally enacted in 1917 and significantly updated in June 1994, contains regulations to protect migratory birds, their eggs, and their nests from unauthorized hunting, trafficking and commercialization (Environment and Climate Change Canada, 2011). A permit is required to hunt birds considered as migratory birds in Canada.

The Migratory Birds Program (MBP) is the regulatory initiative employed by CWS to support the MBR and therefore, used to implement the MBCA. The objectives of the CWS in administering the MBR through the MBP are:

- 1) Providing the core information to ensure sound decision-making for setting conservation and protection goals.
- 2) Enforcing the regulations and the adoption of effective policies (including harvest regulations).

- 3) Championing actions to sustain healthy populations of migratory birds.

This case study focuses on sections of the MBR related to hunting and activities by the MBP involved in managing the MBP to support the provisions. Four Key Informants from the CWS agreed to participate in this case study. Their roles and years of experience in these roles are listed in Table 13.

**Table 13** Summary of Key Informants in Canadian Wildlife Service (CWS)

S/N	Role	Years in Role	Duties
01	Subject Matter Expert on Regulations.	15 years or more	Involved in creating and administering the MBR
02	Responsible for Regulatory Initiatives	Less than 5 years	Involved in creating and administering the MBP
03	Responsible for Regulatory Initiatives	10 to 14 years	Involved in administering the MBP
04	Responsible for Regulatory Initiatives	15 years or more	Involved in creating and administering the MBP

In participating in the case study, the CWS was interested in:

- a) Improving tracking and reporting on *non-compliance levels*<sup>8</sup> with respect to the hunting provisions of the MBR.
- b) Assessing the effectiveness of the hunting provisions of the MBR and activities involved in the MBP related to these sections.
- c) Showing how performance of the MBP directly influences non-compliance levels observed in the MBR.

The application of GoRIM to the MBR and MBP involved creating models of the hunting provisions of the MBR and the activities that are involved in managing the MBP. After creating the models, I inputted data on non-compliance with the hunting provisions of the MBR and on performance of the activities involved in running the MBP into the models to enable assessing the levels of non-compliance and performance of the hunting provisions of the MBR and MBP respectively. I then exported the data analyzed from the models into

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<sup>8</sup> CWS was more interested in non-compliance issues, as the absence of non-compliance evidence does not imply compliance.

IBM Watson Analytics (IBM, 2016), to enable visualization and further analysis of the effectiveness of the hunting provisions of the MBR. I describe how I used the steps of GoRIM to achieve this in the following sections.

## 5.2. Creating Models of the MBR and MBP

Listed below are the sections of the MBR considered as hunting provisions (Government of Canada, 2016b). These sections were selected by the Key Informants. Figure 41 shows Sections 7 and 8 of the MBR in textual format.

- a) General Prohibition: Subsections 5(4) and (11)
- b) Bag Limits: Sections 7 and 8
- c) Possession: Subsections 10(1) and (2)
- d) Shipment: Paragraphs 13(2)(a) and (c)
- e) Hunting Methods and Equipment: Paragraphs 15(1)(c) and 15.1(2)(a) and (b)
- f) Overabundant Species: Subsections 23.1(2) and (3) and 23.3(1), subparagraph 23.3(2)(d)(iii), subsection 23.3(3) and subparagraph 23.3(4)(d)(ii)

### Bag Limits

**7** Subject to section 8, no person shall in any area in Canada kill, in any one day, a number of migratory birds of any species that, in the aggregate, exceeds the number specified as the daily bag limit for that area and that species in Schedule I.

SOR/79-544, s. 3; SOR/2000-331, s. 3.

**8** Any person who hunts in more than one province or area in any one day, may kill in that day a number of migratory birds of any species that, in the aggregate, does not exceed the number specified as the daily bag limit in Schedule I for that species in the province or area having the highest daily bag limit of those provinces or areas in which the person hunts.

SOR/79-544, s. 3.

**9** No person shall hunt migratory birds in any day after he has killed the number of birds he is permitted to kill under section 7 or 8.

SOR/2000-331, s. 3.

### Maximums de prises

**7** Sous réserve de l'article 8, il est interdit, dans toute région du Canada, de tuer au cours d'une même journée un nombre d'oiseaux migrateurs, d'une espèce quelconque, supérieur au maximum de prises par jour établi à l'annexe I pour cette région et cette espèce.

DORS/79-544, art. 3; DORS/2000-331, art. 3.

**8** Quiconque chasse dans plusieurs provinces ou régions le même jour peut, ce jour-là, tuer un nombre d'oiseaux migrateurs d'une espèce quelconque ne dépassant pas le maximum le plus élevé de prises par jour établi à l'annexe I à l'égard de cette espèce pour ces provinces ou régions.

DORS/79-544, art. 3.

**9** Il est interdit de chasser les oiseaux migrateurs après avoir tué, en une journée, le nombre d'oiseaux qu'il est permis de tuer en vertu de l'article 7 ou 8.

DORS/2000-331, art. 3.

**Figure 41** Snippet of the MBR, showing Bag Limits (Government of Canada, 2016a)

In enforcing the hunting provisions of the MBR, the CWS focuses on instances of non-compliance. Not all provisions in the hunting sections of the MBR are subject to enforcement actions. Some provisions are administrative in nature, and the others, subject to enforcement actions. In enforcing compliance, the CWS uses the following enforcement activities to respond to incidents of non-compliance: *No Action, Warning, Direction, Ticket, EPCO, Ministerial Order, Arrests and Prosecution*. One or more enforcement activities can respond to a case of non-compliance.

To create a GRL model of this regulation, as described in Section 4.3.1, I created a tabular representation of the regulations from the text for the hunting provisions available from the MBR (Government of Canada, 2016a). I also added, from discussions with the Key Informants, KPIs that measure non-compliance. However, to obtain the contribution weights for KPIs to subparagraphs, subparagraphs to paragraphs, paragraphs to subsections, and subsections to sections of the MBR, I discussed with the Key Informants who are subject matter experts on the MBR, as recommended in Akhigbe et al., (2014). The opinion given was that the hunting provisions have Equal Relative Weights (ERW). That is, “all contributions targeting the same intentional element have equal weights, neglecting the fact that some contributors might be more important than others” Akhigbe et al., (2014). The CWS kept records of occurrences of the enforcement activities. I proposed the use of the enforcement activities as KPIs since they are tools used to respond to incidents of non-compliance, and this suggestion was accepted. To obtain contribution values for the KPIs to the respective hunting provisions, based on discussions with the Key Informants, I ranked each enforcement activity as shown in Table 14.

**Table 14** Ranking of Enforcements Activities to obtain Contribution Values

<b>Rank</b>	<b>Enforcement Activity</b>	<b>Average</b>	<b>Percentage</b>
1	No Action	0.0278	3
2	Warning	0.0556	6
3	Direction	0.0833	8
4	Ticket	0.1111	11
5	EPCO	0.1389	14
6	Ministerial Order	0.1667	17
7	Arrest	0.1944	19
8	Prosecution	0.2222	22
<b>TOTAL</b>		<b>1</b>	<b>100</b>

Table 14 is based on the perceived effort required to enforce non-compliance by the CWS. The proposed percentages were also accepted by the Key Informants.

Figure 43 gives an overview of the derived GRL model of the hunting provisions of the MBR. Figure 44 to Figure 49 show the sub-parts of that GRL model for each of the MBR provisions from Figure 43: “General Prohibitions”, “Bag Limits”, “Possessions”, “Shipment”, “Hunting Methods and Equipment” and “Overabundant Species”.

A	B	C	D	E	F	G	H	I
LEGISLATION_ID	LEGISLATION_SECTION	ENGLISH_DESCRIPTION	ALTERNATIVE_DESCRIPTION	URL	IMPORTANCE	DECOMPOSITION	KPI	KPI_IMPORTANCE
1	C.R.C., c. 1035	Migratory Birds Regulations	Règlement sur les oiseaux migrateurs	<a href="http://laws-lois.j">http://laws-lois.j</a>				
2	(a)	General Prohibitions	Restrictions générales	<a href="http://laws-lois.j">http://laws-lois.j</a>				
3	(a)(5)(4)	Subject to section 23.1, no person shall	Sous réserve de l'article 23.1, aucune personne ne	<a href="http://laws-lois.j">http://laws-lois.j</a>			5(4)_Prosecution; 5(4)_Arrest; 5(4)_Ministerial Order; 5(4)_EPCO	22:19:17;14:11:8;6;3;
4	(a)(5)(11)	Despite subsections (1) and (3), a person	Malgré les paragraphes (1) et (3), une personne	<a href="http://laws-lois.j">http://laws-lois.j</a>				
5	(a)(5)(11)(a)	is lawfully able to hunt in the province	est légalement en mesure de chasser dans la province	<a href="http://laws-lois.justice.gc.ca/en/And">http://laws-lois.justice.gc.ca/en/And</a>				
6	(a)(5)(11)(b)	is accompanied by a migratory game warden	est accompagnée par un garde-forestier migrateur	<a href="http://laws-lois.justice.gc.ca/en/And">http://laws-lois.justice.gc.ca/en/And</a>				
7	(b)	Bag Limits	Maximums de prises	<a href="http://laws-lois.j">http://laws-lois.j</a>				
8	(b)(7)	Subject to section 8, no person shall	Sous réserve de l'article 8, aucune personne ne	<a href="http://laws-lois.j">http://laws-lois.j</a>			7_Prosecution; 7_Arrest; 7_Ministerial Order; 7_EPCO; 7_Ticket	22:19:17;14:11:8;6;3;
9	(b)(8)	Any person who hunts in more than	Quiconque chasse dans plus d'une	<a href="http://laws-lois.j">http://laws-lois.j</a>			8_Prosecution; 8_Arrest; 8_Ministerial Order; 8_EPCO; 8_Ticket	22:19:18;14:11:8;6;3;
10	(c)	Possession	Possession	<a href="http://laws-lois.j">http://laws-lois.j</a>				
11	(c)(10)(1)	No person shall have in his possession	Il est interdit d'avoir en sa possession	<a href="http://laws-lois.j">http://laws-lois.j</a>			10(1)_Prosecution; 10(1)_Arrest; 10(1)_Ministerial Order; 10(1)_EPCO	22:19:18;14:11:8;6;3;
12	(c)(10)(2)	No person shall have in his possession	Il est interdit d'avoir en sa possession	<a href="http://laws-lois.j">http://laws-lois.j</a>				
13	(c)(10)(2)(a)	an export permit certifying that those	un permis d'exportation attestant que ceux	<a href="http://laws-lois.justice.gc.ca/en/Or">http://laws-lois.justice.gc.ca/en/Or</a>			10(2)_Prosecution; 10(2)_Arrest; 10(2)_Ministerial Order; 10(2)_EPCO	22:19:18;14:11:8;6;3;
14	(c)(10)(2)(b)	a valid licence for hunting migratory	une licence valide de chasse migratoire	<a href="http://laws-lois.justice.gc.ca/en/Or">http://laws-lois.justice.gc.ca/en/Or</a>			10(2)_Prosecution; 10(2)_Arrest; 10(2)_Ministerial Order; 10(2)_EPCO	22:19:18;14:11:8;6;3;
15	(d)	Shipment	Expédition	<a href="http://laws-lois.j">http://laws-lois.j</a>				
16	(d)(13)(2)	Subject to subsection (1), no person	Sous réserve du paragraphe (1), aucune personne ne	<a href="http://laws-lois.j">http://laws-lois.j</a>				
17	(d)(13)(2)(a)	those birds were taken under a migratory	ces oiseaux ont été pris en vertu d'une	<a href="http://laws-lois.justice.gc.ca/en/And">http://laws-lois.justice.gc.ca/en/And</a>			13(2)(a)_Prosecution; 13(2)(a)_Arrest; 13(2)(a)_Ministerial Order; 13(2)(a)_EPCO	22:19:18;14:11:8;6;3;
18	(d)(13)(2)(c)	the number of those birds does not	le nombre d'oiseaux n'est pas	<a href="http://laws-lois.justice.gc.ca/en/And">http://laws-lois.justice.gc.ca/en/And</a>			13(2)(c)_Prosecution; 13(2)(c)_Arrest; 13(2)(c)_Ministerial Order; 13(2)(c)_EPCO	22:19:18;14:11:8;6;3;
19	(e)	Hunting Methods and Equipment	Méthodes et matériel de chasse	<a href="http://laws-lois.j">http://laws-lois.j</a>				
20	(e)(15)(1)	Subject to subsections (4) and (5) and	Sous réserve des paragraphes (4) et (5) et	<a href="http://laws-lois.j">http://laws-lois.j</a>				
21	(e)(15)(1)(c)	by the use or aid of recorded bird	en utilisant ou avec l'aide d'appareils	<a href="http://laws-lois.j">http://laws-lois.j</a>			15(1)(c)_Prosecution; 15(1)(c)_Arrest; 15(1)(c)_Ministerial Order; 15(1)(c)_EPCO	22:19:18;14:11:8;6;3;
22	(e)(15.1)(2)	The exceptions of woodcock, band-tail	L'exception visant les bécasses et les	<a href="http://laws-lois.j">http://laws-lois.j</a>				
23	(e)(15.1)(2)(a)	any area in which the use of non-toxic	tout lieu où l'usage de produits	<a href="http://laws-lois.justice.gc.ca/en/And">http://laws-lois.justice.gc.ca/en/And</a>			15.1(2)_Prosecution; 15.1(2)_Arrest; 15.1(2)_Ministerial Order; 15.1(2)_EPCO	22:19:18;14:11:8;6;3;
24	(e)(15.1)(2)(b)	the wildlife areas set out in Schedule	les réserves d'espaces sauvages	<a href="http://laws-lois.justice.gc.ca/en/And">http://laws-lois.justice.gc.ca/en/And</a>			15.1(2)_Prosecution; 15.1(2)_Arrest; 15.1(2)_Ministerial Order; 15.1(2)_EPCO	22:19:18;14:11:8;6;3;
25	(f)	Overabundant Species	Especies surabundantes	<a href="http://laws-lois.j">http://laws-lois.j</a>				
26	(f)(23.1)(2)	The birds referred to in subsection	Les oiseaux visés au paragraphe	<a href="http://laws-lois.j">http://laws-lois.j</a>			23.1(2)_Prosecution; 23.1(2)_Arrest; 23.1(2)_Ministerial Order; 23.1(2)_EPCO	22:19:18;14:11:8;6;3;
27	(f)(23.1)(3)	Birds of species of migratory	Oiseaux de certaines espèces	<a href="http://laws-lois.j">http://laws-lois.j</a>			23.1(3)_Prosecution; 23.1(3)_Arrest; 23.1(3)_Ministerial Order; 23.1(3)_EPCO	22:19:18;14:11:8;6;3;

Figure 42 Tabular Representation of the Hunting Provisions of the MBR

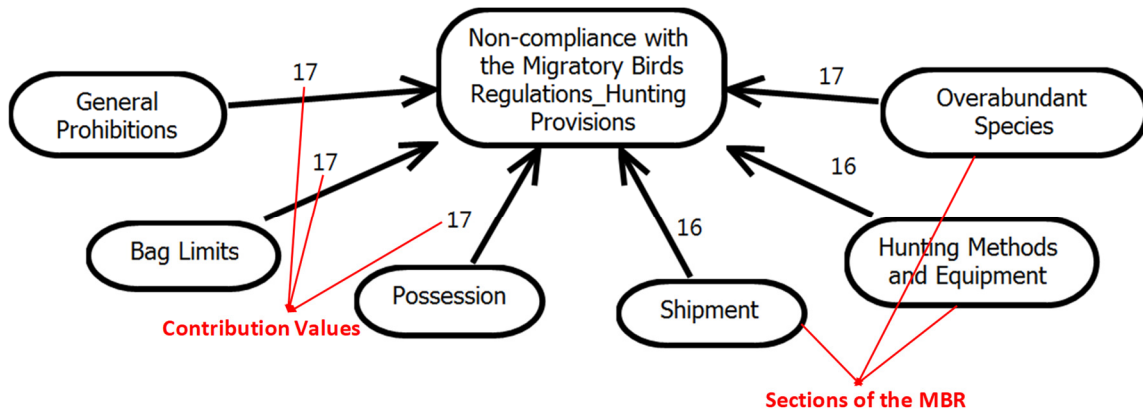
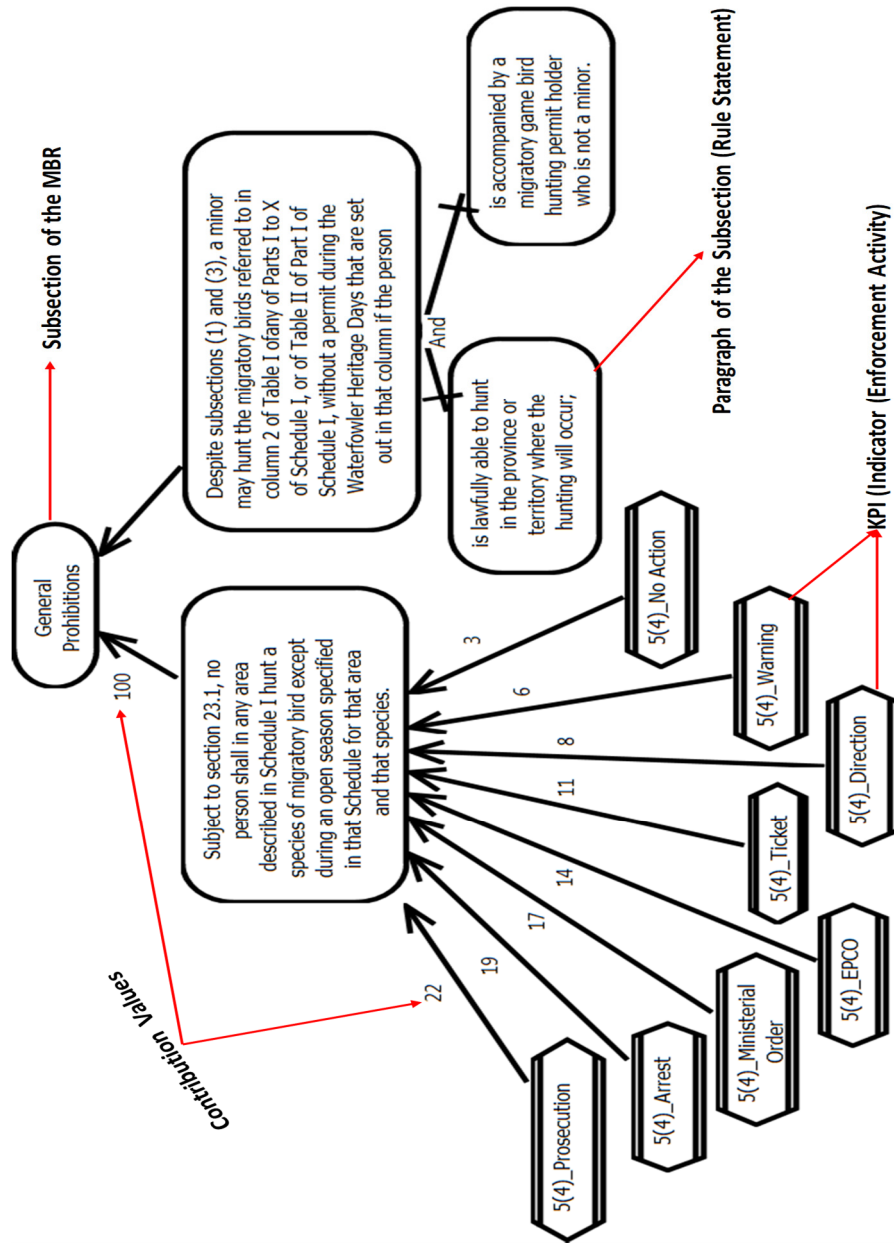


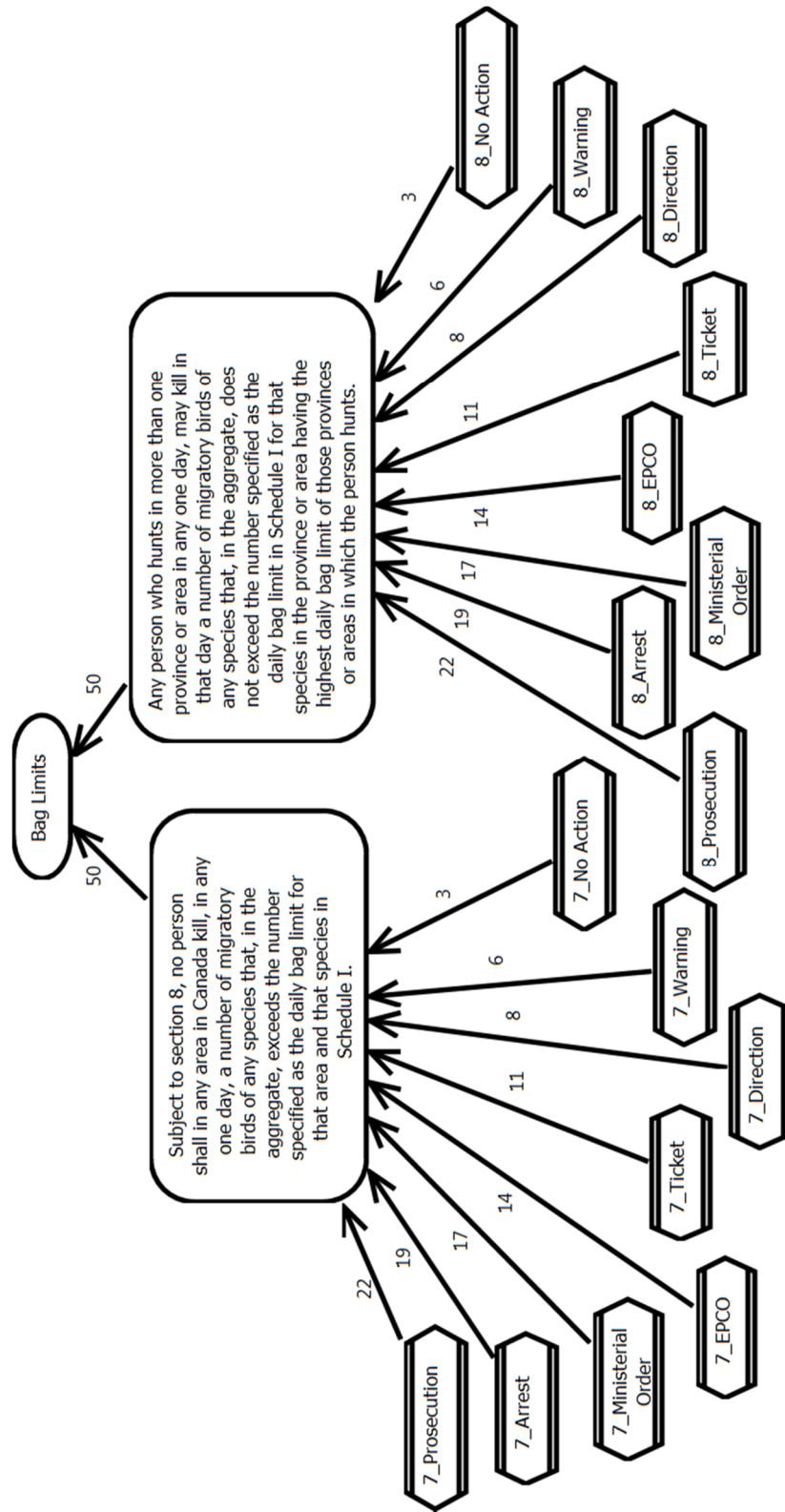
Figure 43 Overview GRL Model of the Hunting Provisions of the MBR

For the regulatory initiative model, the MBP encompasses many activities that contribute to the overall goal of conserving migratory birds. These activities include the development of scientifically sound regulations through bird population surveys, banding of waterfowls and harvest surveys, also referred as “Status Analysis”. In addition, the MBP carries out

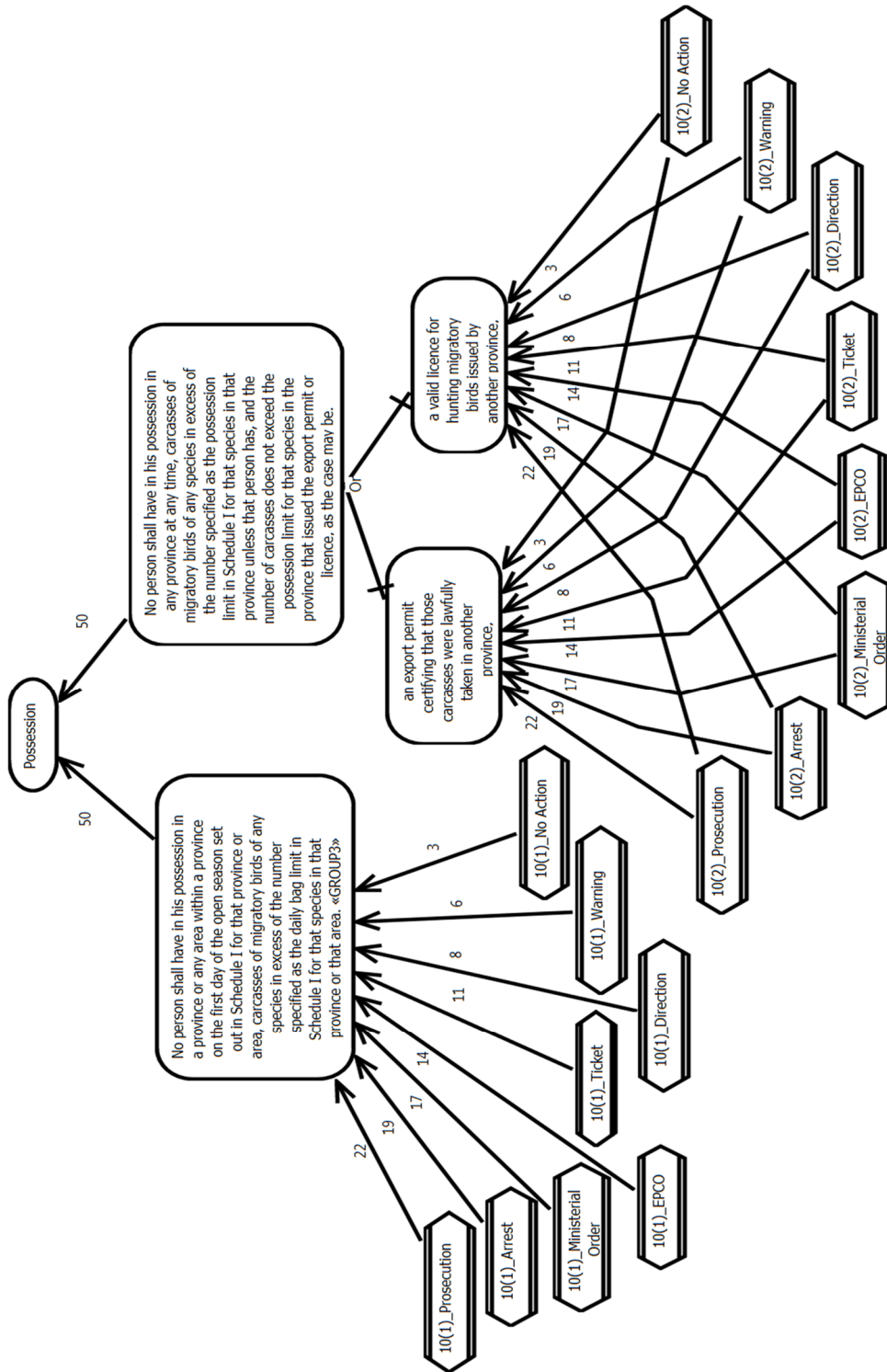
compliance promotion activities that aim to influence hunting behaviour. One such compliance promotion activity is hunting summaries, a one-paged summary of annual hunting regulations for each province and territory in Canada, including season dates and bag limits (Environment and Climate Change Canada, 2010).



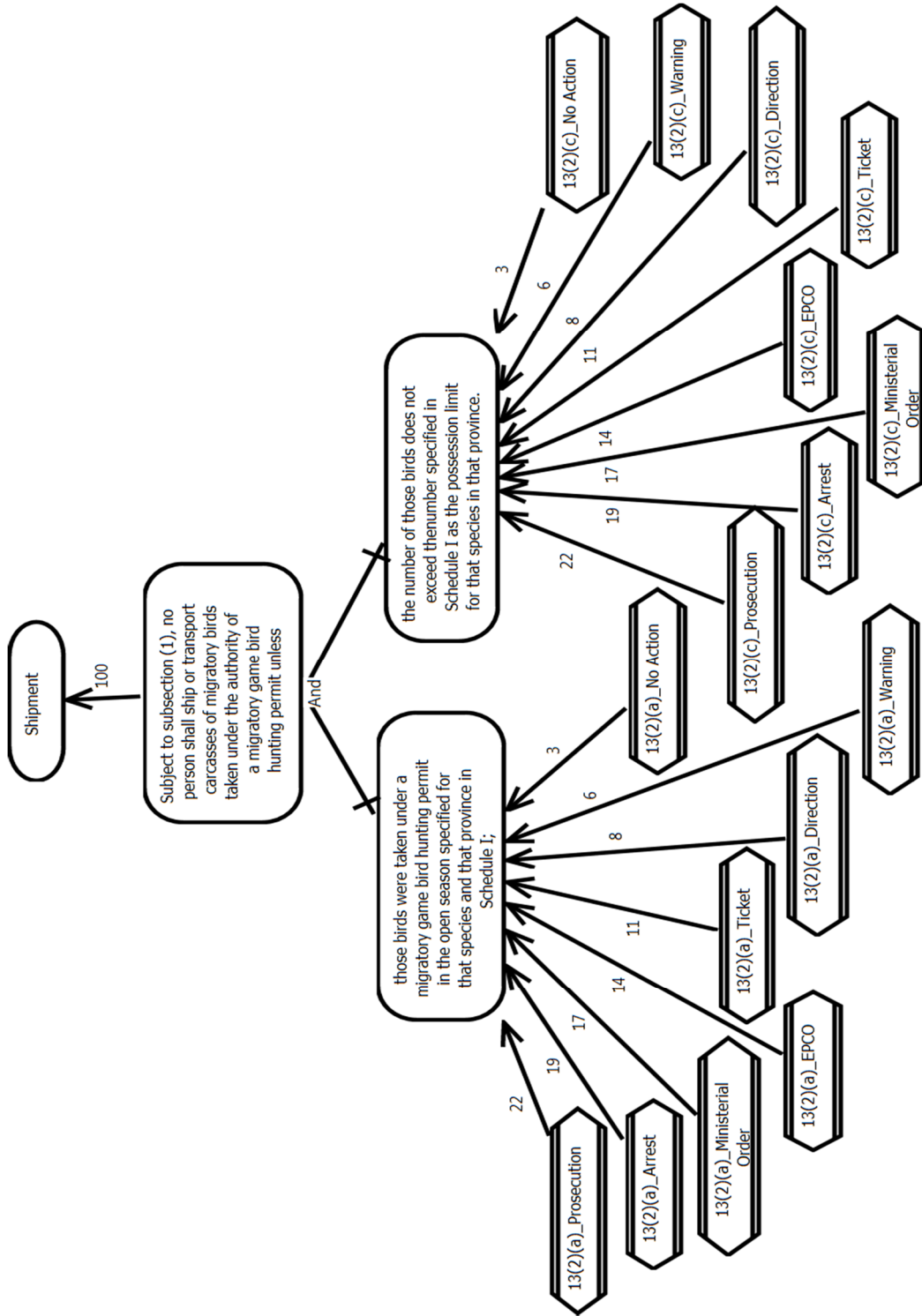
**Figure 44** Part of the GRL Model for Subsections 5(4) and 5(11) of the MBR, along with KPIs



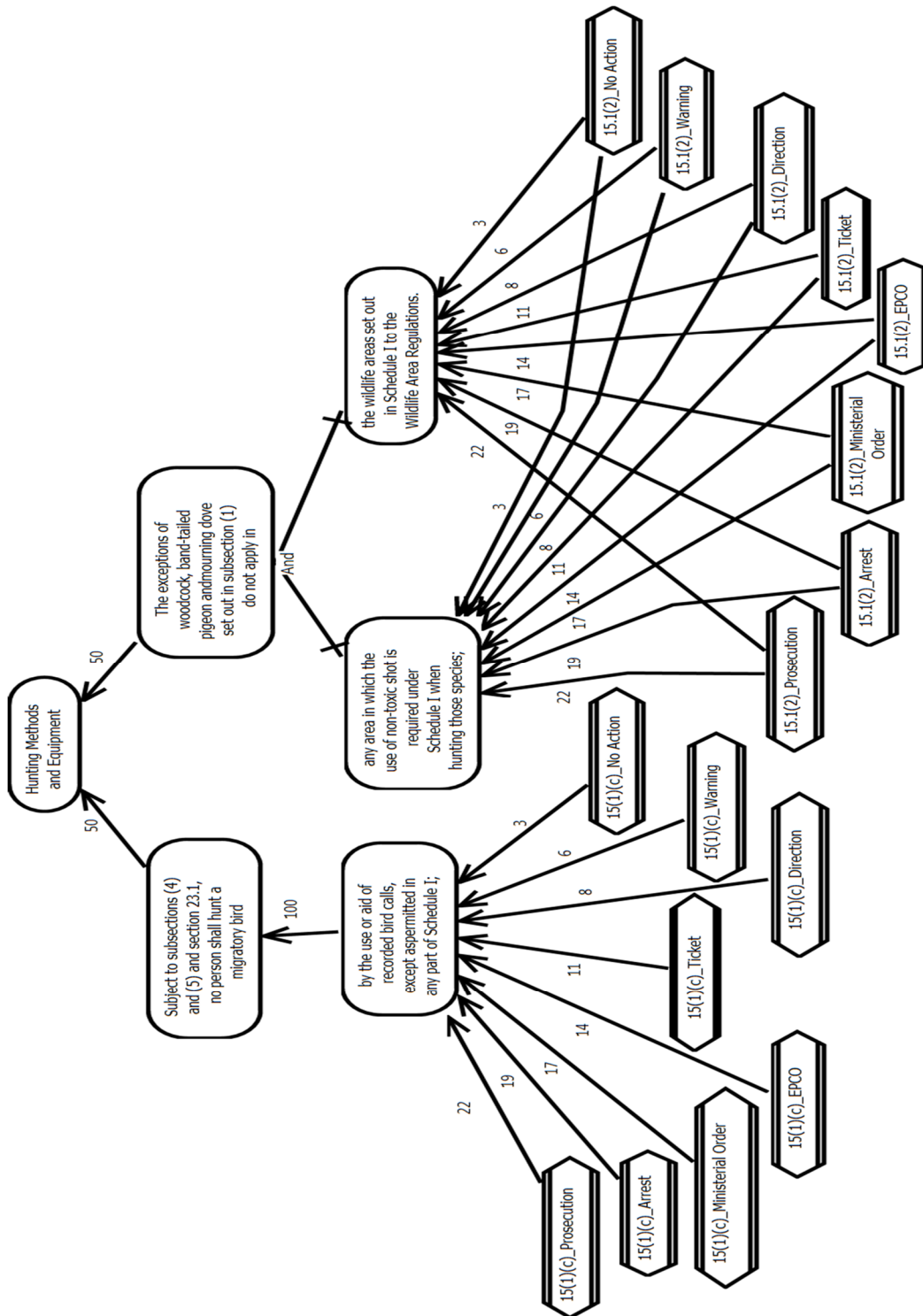
**Figure 45** Part of the GRL Model for Sections 7 and 8 of the MBR, along with KPIs



**Figure 46** Part of the GRL Model for Subsections 10(1) and (2) of the MBR, along with KPIs



**Figure 47** Part of the GRL Model for Paragraphs 13(2)(a) and (c) of the MBR, along with KPIs



**Figure 48** Part of the GRL Model for Paragraphs 15(1)(c) and 15.1(2)(a) and (b) of the MBR, along with KPIs

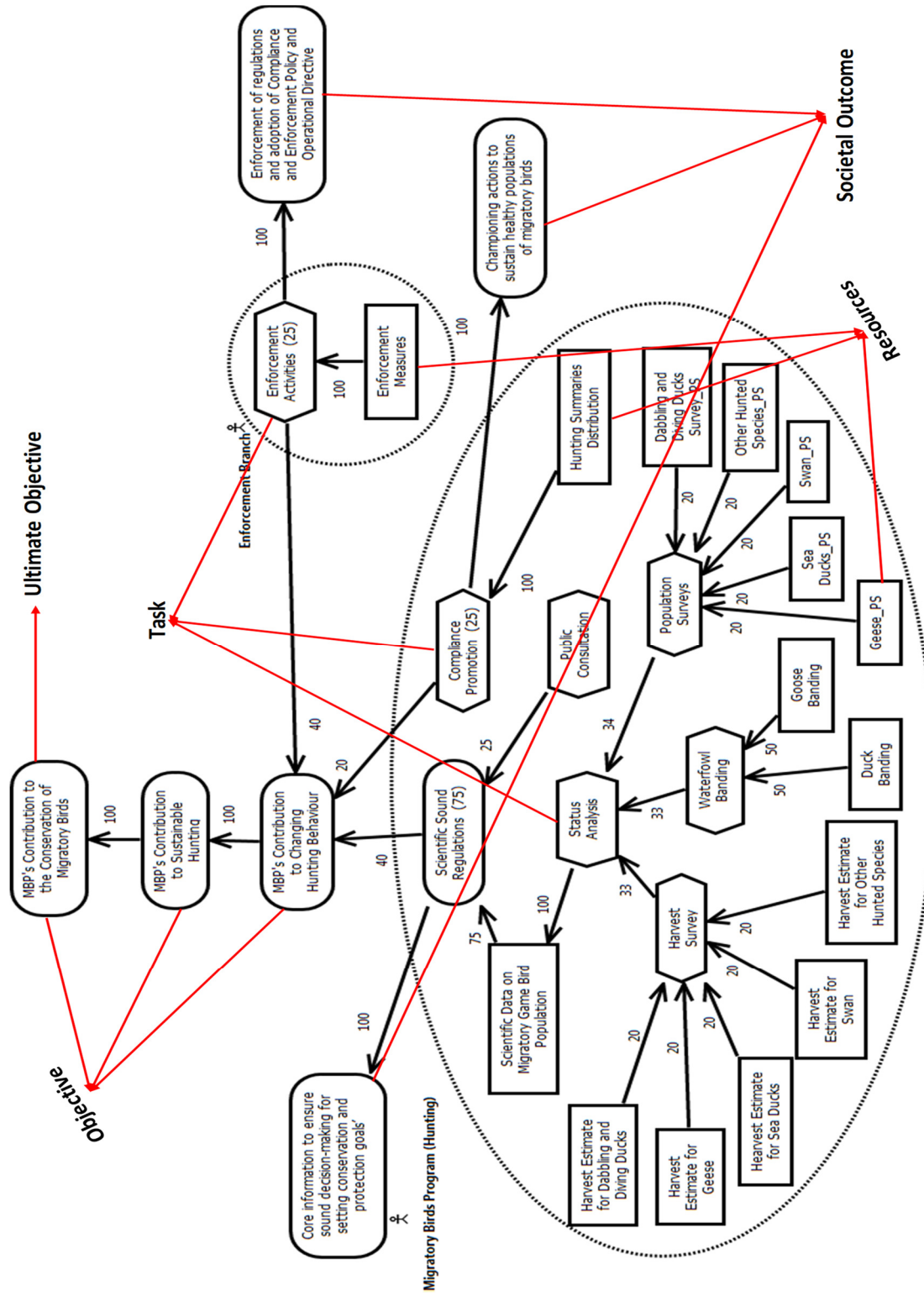


While the MBP team is responsible for creating and administering the MBR and for planning and implementing compliance promotion activities, the Enforcement Branch of ECCC is responsible for enforcing compliance with the MBR. The Enforcement Branch also records and reports on non-compliance. Hence, the regulatory initiative model must capture all these activities and the two actors involved, namely the MBP and the Enforcement Branch of ECCC.

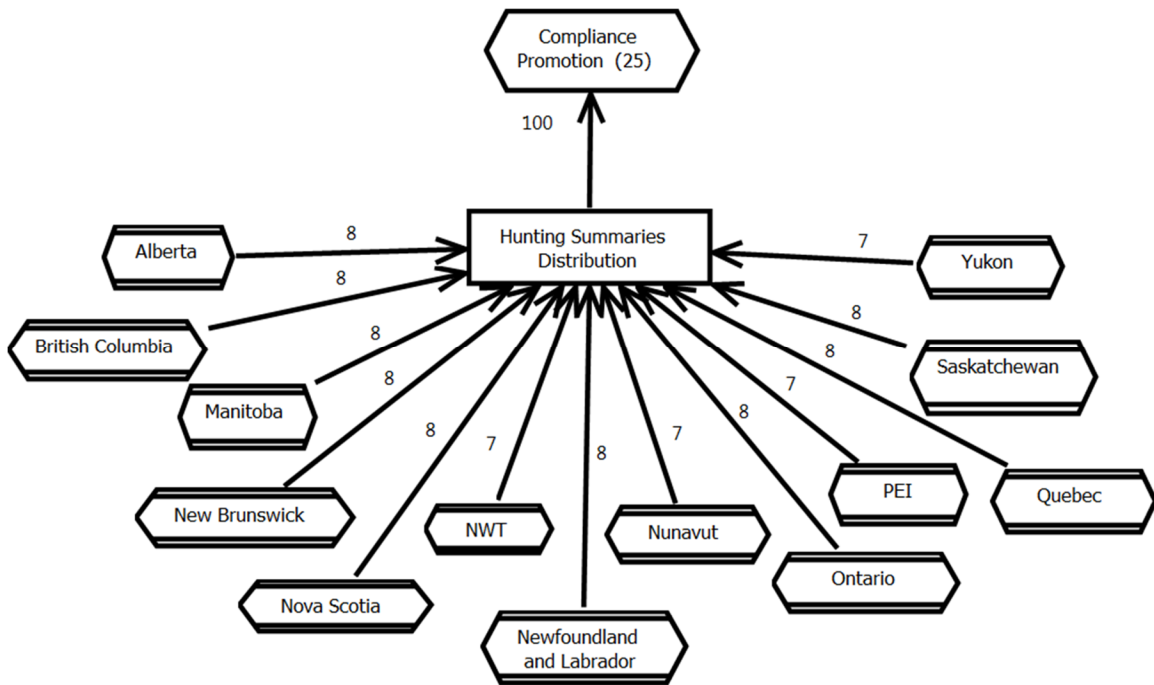
For the KPIs measuring the performance of the MBP and Enforcement Branch activities, I observed from information provided by the Key Informants that in the population surveys, banding of waterfowls and harvest surveys, counts of different species of migratory birds are provided annually. The CWS compares the counts obtained with values obtained in previous years in order to ascertain whether there are increases or decreases in the number of migratory birds. Hence, these counts influence hunting season dates and bag limits. As such, I used the numbers of different species of birds in the population surveys, banding of waterfowls and harvest surveys obtained from these counts to define KPIs. I describe the performance of the “Status Analysis” activity in terms of differences in the number of migratory birds observed annually, i.e., increasing means better and decreasing means worse. Similarly, I used the number of hunting summaries distributed in each province and territory to define KPIs for the “Compliance Promotion” activity, and the number of enforcement measure recorded for each enforcement activity type to define KPIs for the “Enforcement” activity.

Consequently, in line with the regulatory initiatives metamodel described in Section 4.3.1, I modelled the “Status Analysis”, “Harvest Surveys”, “Waterfowl Banding” and “Population Surveys” as GRL tasks. I modelled the different species of migratory birds as resources, since the KPIs result in a satisfaction value for them each year and this value contributes to creating and administering the MBR. I modelled the “Compliance Promotion” activity as a GRL task, the “Hunting Summaries Distribution” as a GRL resource, the “Enforcement” activity as a GRL task and “Enforcement Measures” as a GRL resource. Figure 50 gives an overview of the GRL model for the MBP and Enforcement Branch with activities, objectives and outcomes. Figure 51 shows the part of the GRL model about the compliance promotion activity and Figure 52 the part related to the Enforcement Branch activities. Figure 53 and Figure 54 show the part of the GRL model related to population

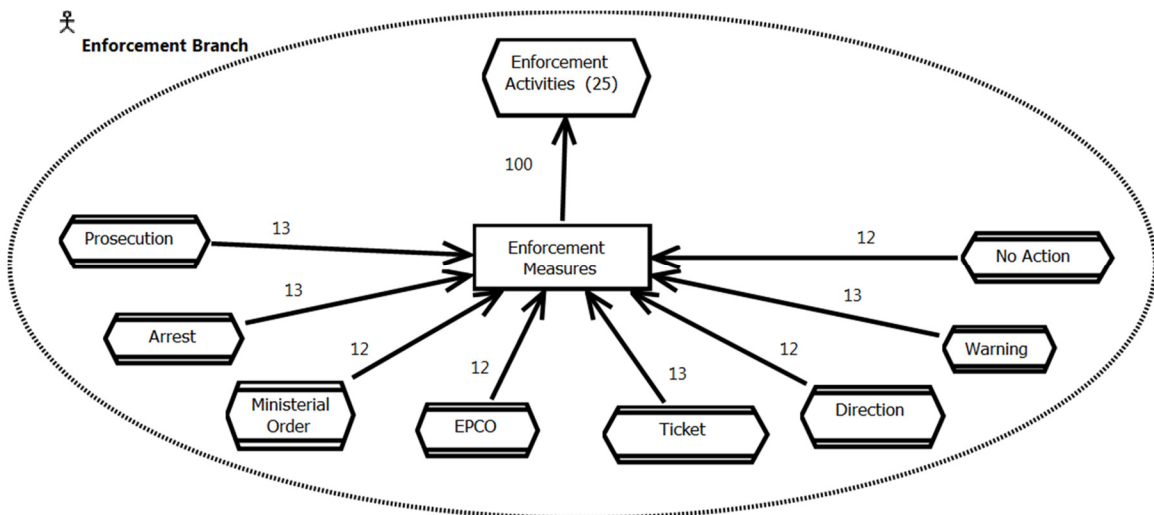
surveys, and Figure 55 and Figure 56 the parts related to the waterfowl banding and harvest survey, respectively.



**Figure 50** Overview GRL Model of the MBP and Enforcement Branch Activities



**Figure 51** Part of the GRL Model for the Compliance Promotion Activity of MBP

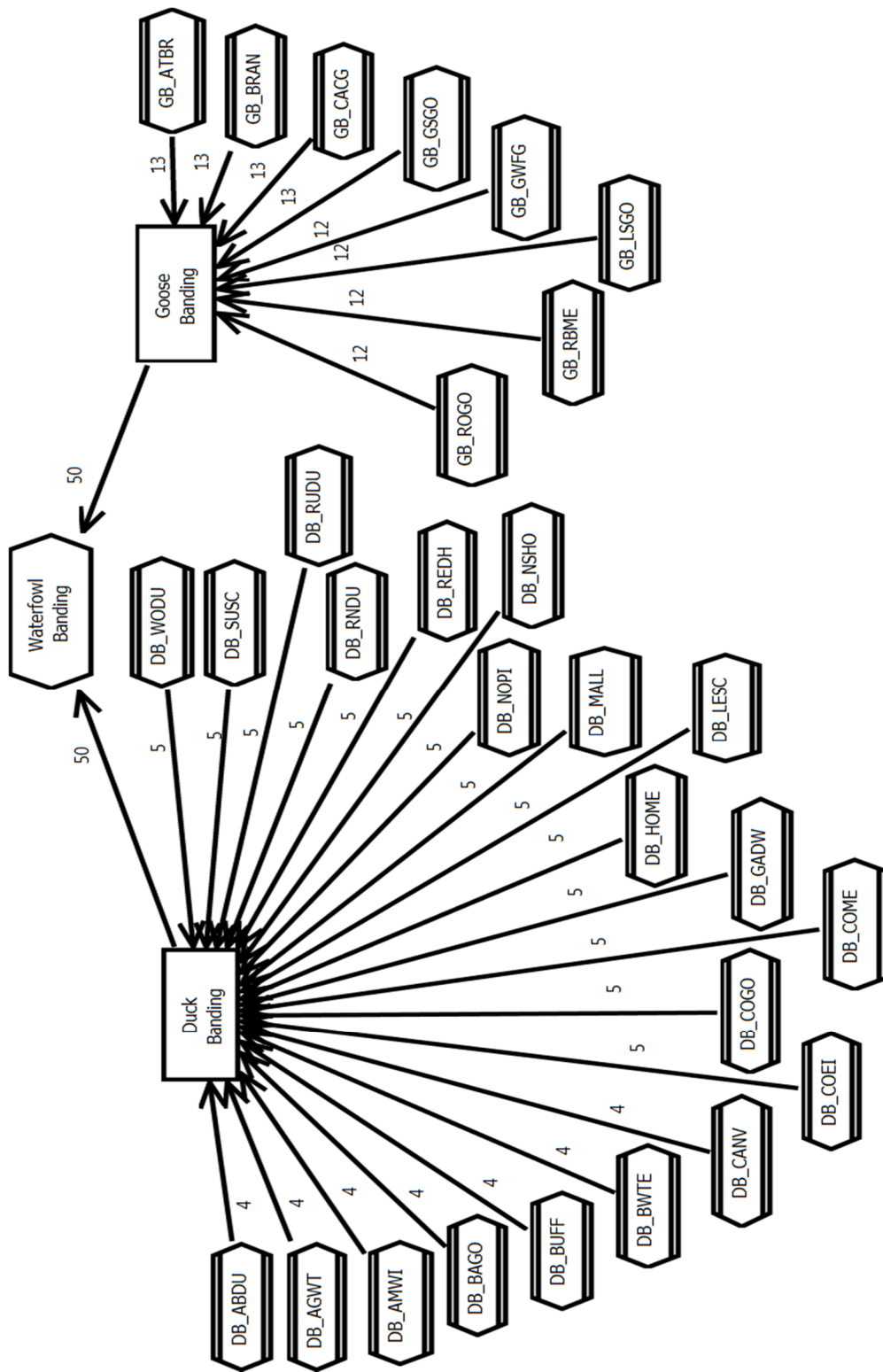


**Figure 52** Part of the GRL Model for the Enforcement Branch's Enforcement Activity





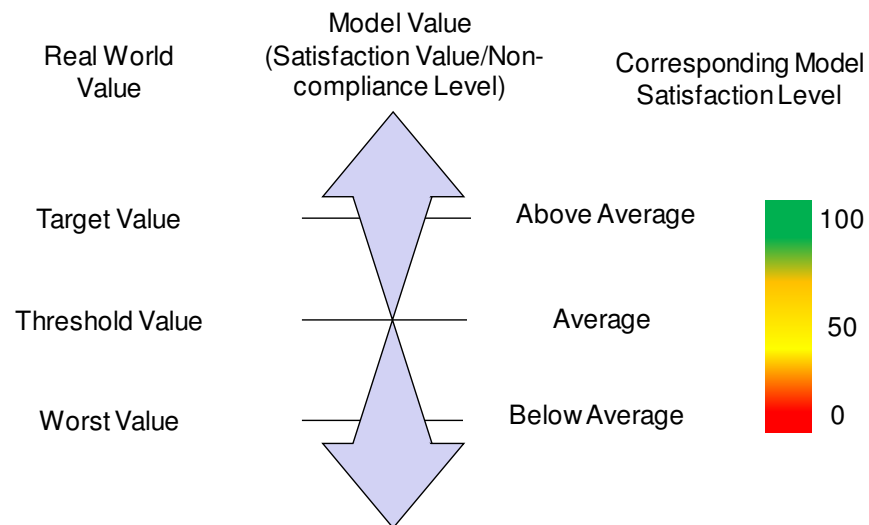




**Figure 56** Part of the GRL Model for the Waterfowl Banding

### 5.3. Data Preparation for MBR and MBP Models

For the MBR, the data provided by the CWS were on alleged violations to the hunting provisions of the MBR. These data capture, from 2006 to 2016, the numbers of non-compliance incidents recorded annually for each enforcement activity against the hunting provisions. I observed that the current practice is limited to collecting these violations with no parameter set to show a better/worse number of violations allowed. Hence, I proposed using the average amount of violations recorded for each enforcement activity for the period of analysis (2006 to 2016) as a baseline. This enables determining *target*, *threshold* and *worst values* for the KPIs. The threshold is the computed average and, as that average was a small value, the target was set as the average plus a small value (e.g., 1) and the worst value as the average minus a small value (e.g., 1). These parameters were validated by the Key Informants. Figure 57 illustrates the structure of the KPIs that I used for non-compliance with the hunting provisions of the MBR. When analysing the models, the annual recorded values obtained from the CWS are compared against these values to ascertain whether the non-compliance level was better or worse.



**Figure 57** KPI Structure and Colour Coding for Non-compliance with MBR

Here are the KPIs for measuring non-compliance with the Hunting section of the MBR:

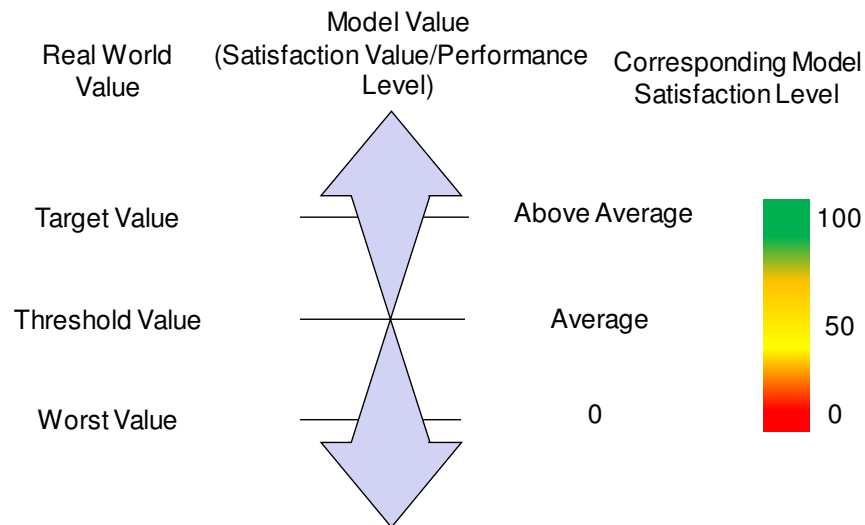
- *Target Value*: Value above the average amount of the enforcement activity type based on available data.

- *Threshold Value*: Average amount of the enforcement activity type based on available data.
- *Worst Value*: Value below the average amount of the enforcement activity type based on available data.

I collected the following data from 2006 to 2016 for the MPB and Enforcement Branch activities:

- Harvest surveys: number of migratory birds of different species harvested.
- Population survey: number of migratory birds of different species counted.
- Waterfowl banding: number of migratory birds of different species banded.
- Compliance promotion: number of hunting summaries sold by province or territory.
- Enforcement measures: number of occurrences of each enforcement activity.

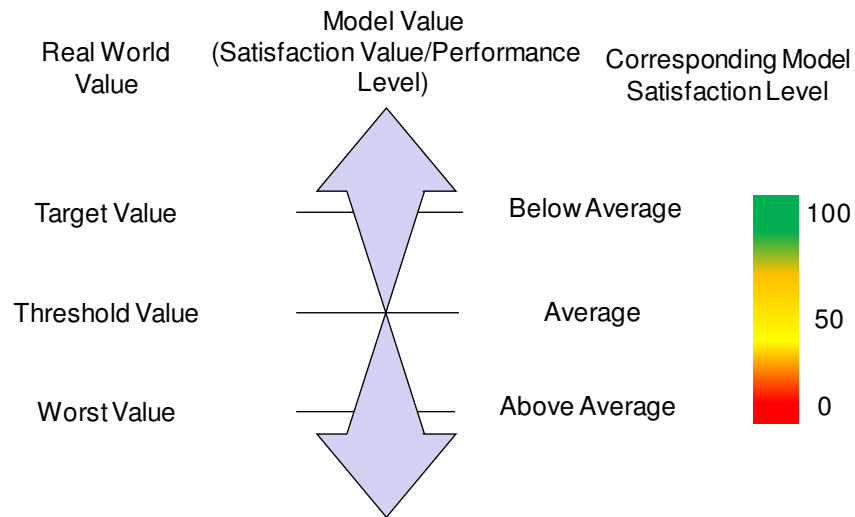
There were no baselines provided for these data, which prompted me to use their averages for the period 2006 to 2016 to determine the target, threshold and worst values for the KPIs. The threshold is the computed average, the worst case is 0, and the target is the average plus an extremely small delta compared to the average, so that any current value above the average would lead to complete satisfaction. Hence, for the MBP activities, Figure 58 illustrates the structure of the KPIs used for the satisfaction of the MBP activities. When analysing the models, the annual recorded values obtained from the CWS are compared against these values to ascertain whether the survey satisfaction value was better or worse.



**Figure 58** KPI Structure and Colour Coding for MBP Activities

- *Target Value*: Value above the average amount of the data of surveys, banding or compliance promotion activities.
- *Threshold Value*: Average amount of the data of surveys, banding or compliance promotion activities
- *Worst Value*: “0”, signifying the absence of data from surveys, banding, compliance promotion or enforcement activities.

Figure 59 illustrates the structure of the KPIs used for Enforcement Branch activities.



**Figure 59** KPI Structure and Colour Coding for Enforcement Activities

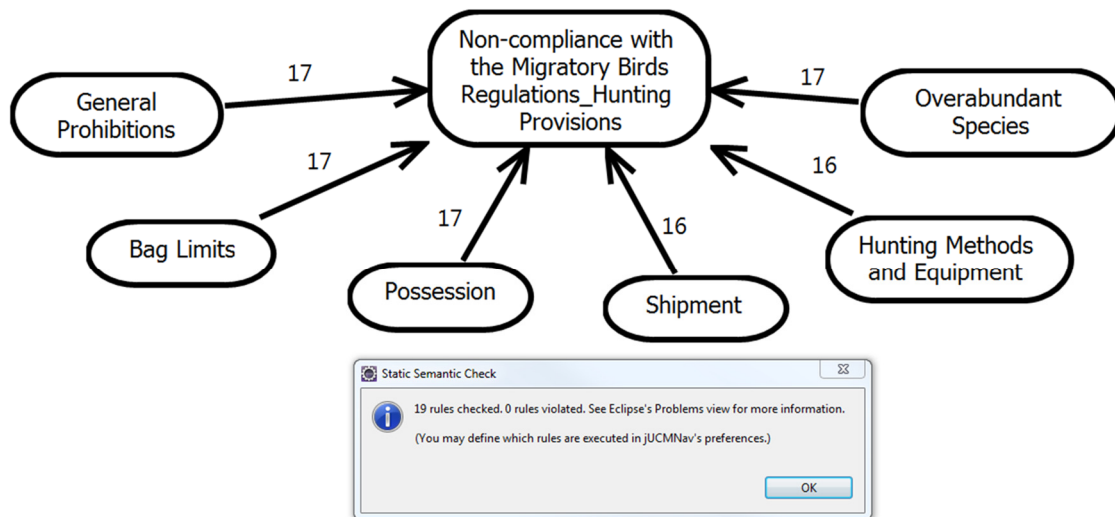
- *Target Value*: Values below the average amount of occurrence of an enforcement activity based on available data.
- *Threshold Value*: Average amount of occurrence of an enforcement activity based on available data
- *Worst Value*: Values above the average amount of occurrence of an enforcement activity based on available data

When analysing the models, the annual recorded values obtained from the Enforcement Branch are compared against these values to ascertain whether the Enforcement Branch activities satisfaction value was better or worse.

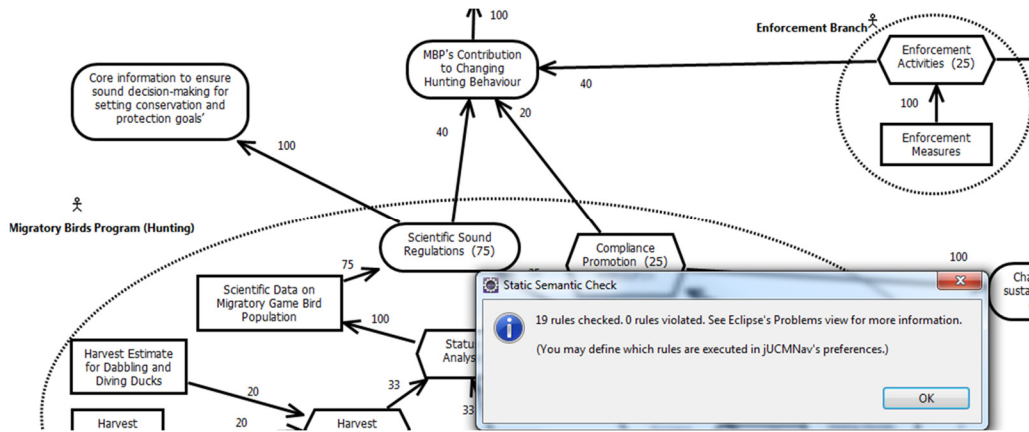
Given these decisions about KPI definitions, I set the *target*, *threshold* and *worst* values for the KPIs of the MBR, MBP and Enforcement Branch activities as preconfigured values in “Indicator” files. I then used the ESP tool (see Appendix A) to produce GRL evaluations strategies from 2006 to 2016 using the “Indicator” files and annual values for each KPI obtained from the CWS, i.e., the “Source” files. These strategies can then be imported into the GRL models of MBR (regulation) and of MBP (initiative).

## 5.4. MBR and MBP Model Corrections

After deriving the evaluations strategies from ESP, I randomly selected a strategy for 2016. I inputted this evaluation strategy into the models of the hunting provisions of the MBR, and the MBP and Enforcement Branch models. In addition, I checked the models against the 19 URN well-formedness rules listed in Table 12. This was meant to ensure that the models are syntactically correct and behave correctly in the migratory bird context. Figure 60 and Figure 61 show the models’ responses to the 19 rules.



**Figure 60** Checking the MBR Model against URN Well-formedness Rules



**Figure 61** Checking the MBP and Enforcement Branch Model against URN Well-formedness Rules

From the data collected on the hunting provisions of the MBR, the MBP and Enforcement Branch activities, I observed that there were missing data. Not every KPI had a value for a given year. When these data are evaluated using the ESP, the output also produces no data (or blanks). The jUCMNav tool does not allow importing evaluation strategies with missing values. However, representing these missing data with “zero” values would influence the evaluated GRL model satisfaction level, as zero is not the same thing as the absence of a value. For example, consider the scenario in Figure 62, where in 2006, there were no data for 7\_Arrest, 7\_Ministerial Order, 7\_EPCO, 8\_Prosecution, 8\_Arrest, 8\_Ministerial Order, 8\_EPCO, 8\_Ticket, 8\_Direction, 8\_Warning and 8\_No Action. The resulting evaluation strategy derived from the ESP also shows no value for these KPIs.

**Raw Data**

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1 Name	Date	7_Prosecution	7_Arrest	7_Ministerial Order	7_EPCO	7_Ticket	7_Direction	7_Warning	7_No Action	8_Prosecution	8_Arrest	8_Ministerial Order	8_EPCO	8_Ticket	8_Direction	8_Warning	8_No Action	
2 NonComplLevel	2006	9				3	0	7	0									

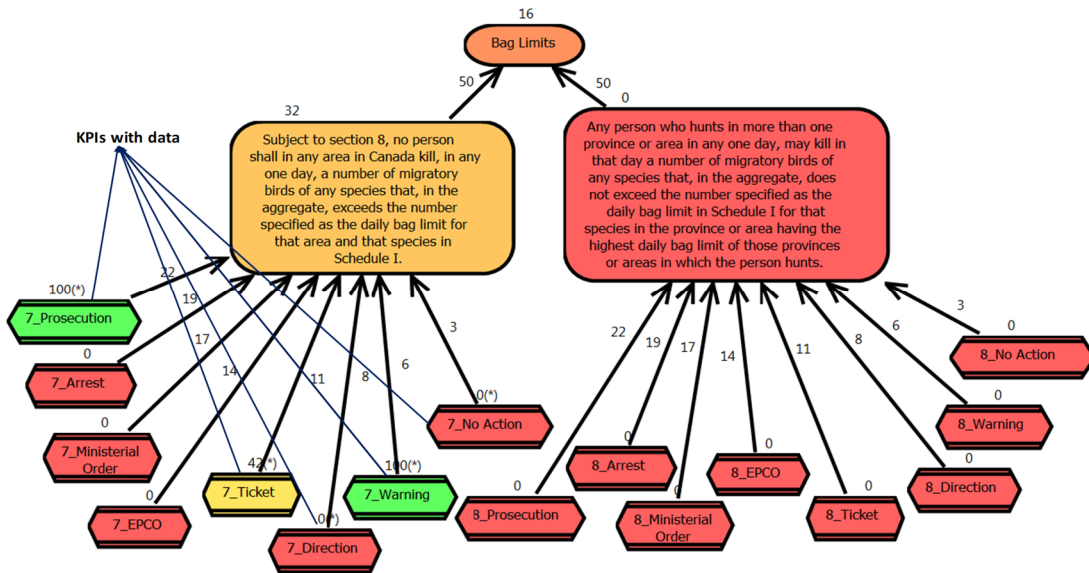
**No Data**

**ESP derived Evaluation Strategy**

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1 Name	Date	7_Prosecution	7_Arrest	7_Ministerial Order	7_EPCO	7_Ticket	7_Direction	7_Warning	7_No Action	8_Prosecution	8_Arrest	8_Ministerial Order	8_EPCO	8_Ticket	8_Direction	8_Warning	8_No Action	
2 NonComplLevel	2006	100				42	0	100	0									

**Figure 62** Example showing Absence of Data in the Collected Dataset

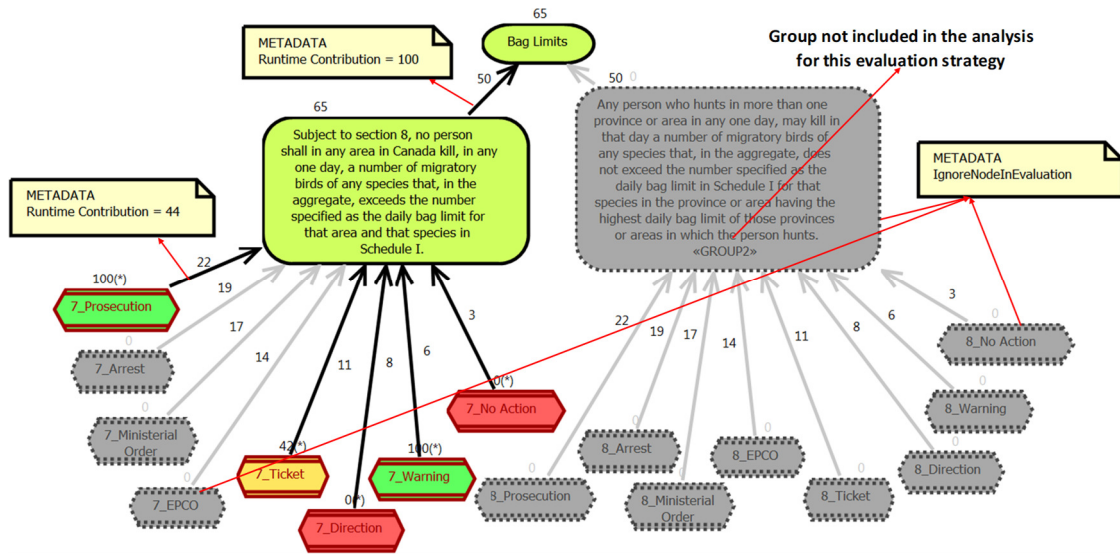
Replacing the KPIs that have no data with zero implies that they have the same value as 7\_Prosecution, 7\_Tickets and 7\_Warning. Such assumptions will result in an incorrect evaluation of the models as shown in Figure 63.



**Figure 63** Incorrect Model Evaluation Resulting from Replacing 0 for Missing Data

The best way to resolve this is to *ignore* the KPIs with missing data from the evaluation, as if these KPIs were disconnected from the rest of the model, as suggested by Shamsaei (2012). Here, a special character “#” is used by ESP to represent any absence of data, and jUCMNav was extended to take such special character into consideration to ignore the corresponding model element for that strategy. The “Conditional GRL Algorithm” introduced by Shamsaei (2012) takes ignored model elements into consideration and redistributes their contributions to remaining contributors, if any.

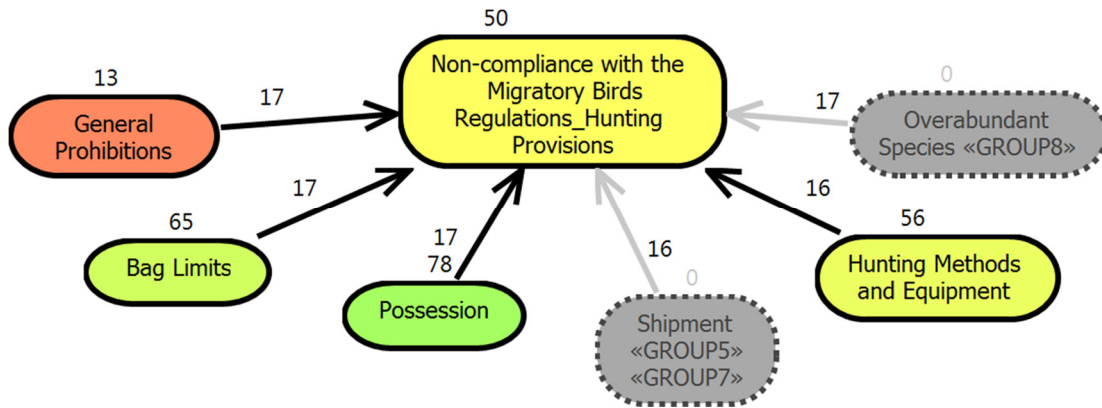
Since the KPIs without data for a given year could have data in other years, I then tag the metadata of the intentional elements that the KPIs contribute to as a group (or type) and set the evaluation strategy not to include these intentional elements during the analysis. In Figure 62, we observe that the KPIs of Section 8 in the “Bag Limits” provisions of the MBR have no data. Using the ignore condition and tagging Section 8 as “GROUP 2”, as illustrated in Figure 64, we observe that this section along with its KPIs are greyed out. GRL automatically distributed the contributions values of this Section and its KPIs to the other KPIs with data. The model analysis hence includes neither Section 8 (and its KPIs) nor the KPIs in Section 7 that have no data during the evaluation of the 2006 evaluation strategy.



**Figure 64** GRL Evaluated Model showing Ignored Model Elements

This mechanism hence enables the model to produce reasonable results in the absence of some data, a situation that is frequent in a regulatory context.

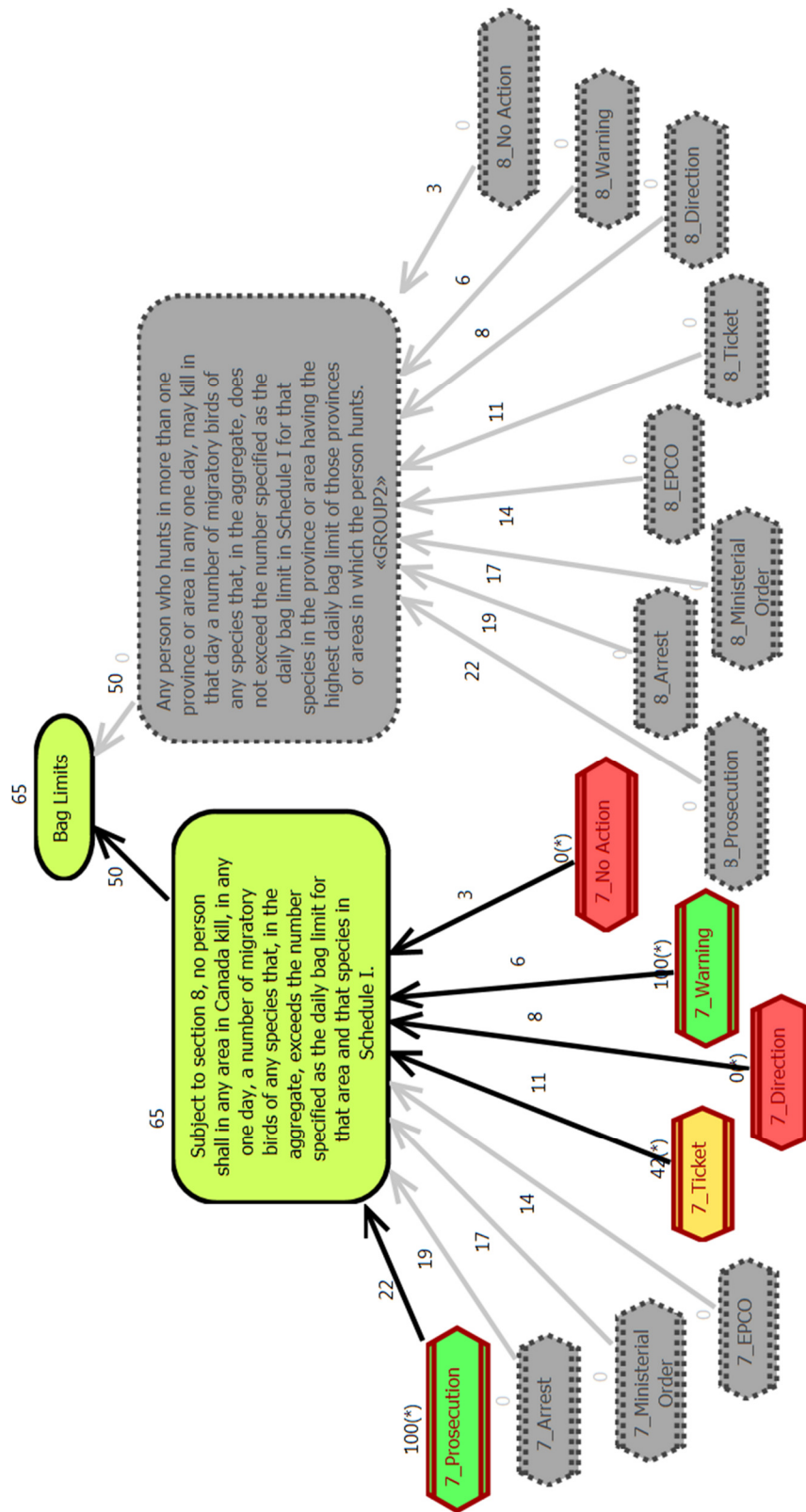
Going back to the case study, Figure 65 to Figure 78 show the evaluated models of the hunting provisions of the MBR model and of the MBP and the Enforcement Branch model for the 2006 evaluation strategy, after the model correction step.



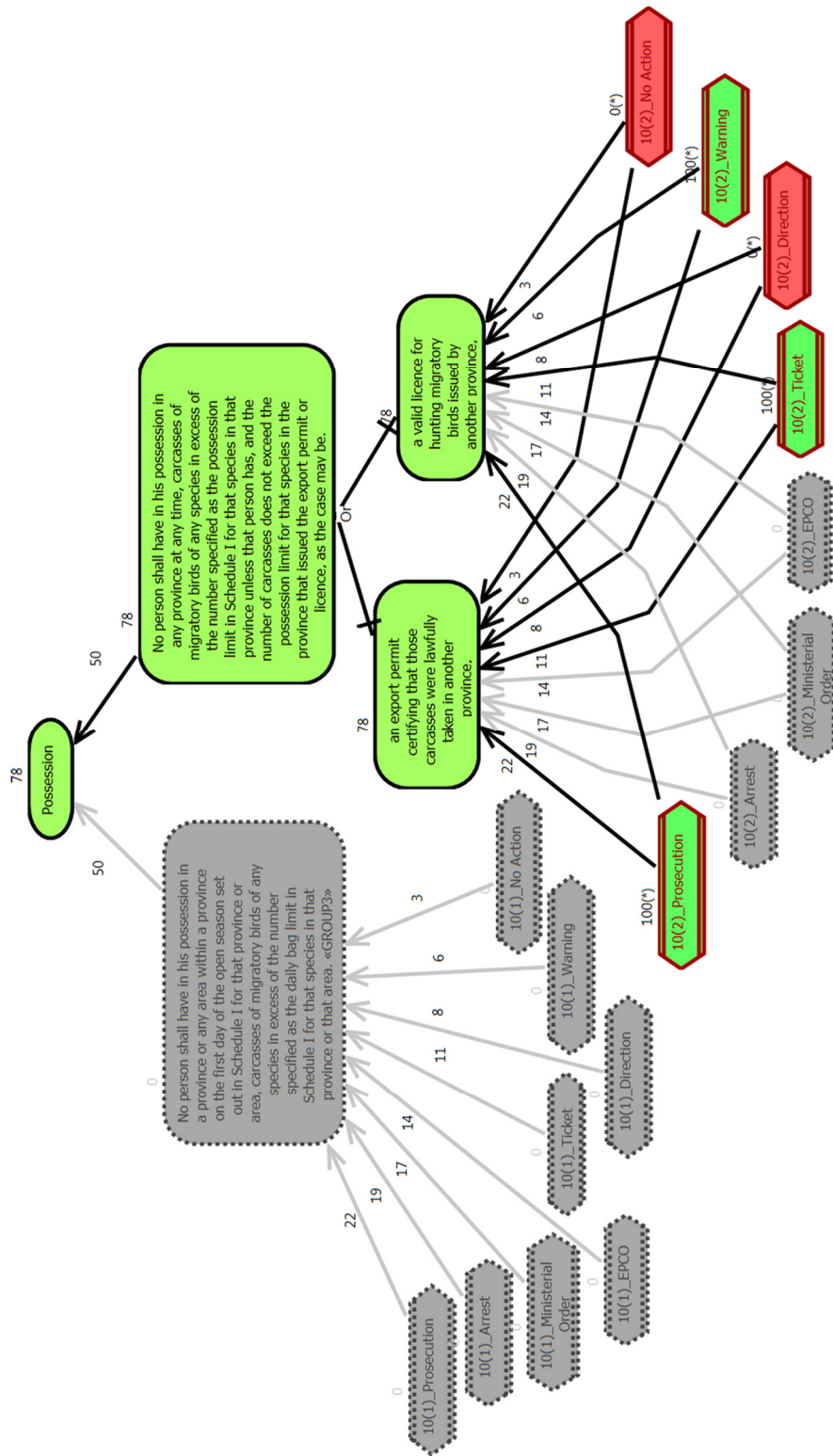
**Figure 65** 2006 Evaluated Overview Model of the Hunting Provisions of the MBR



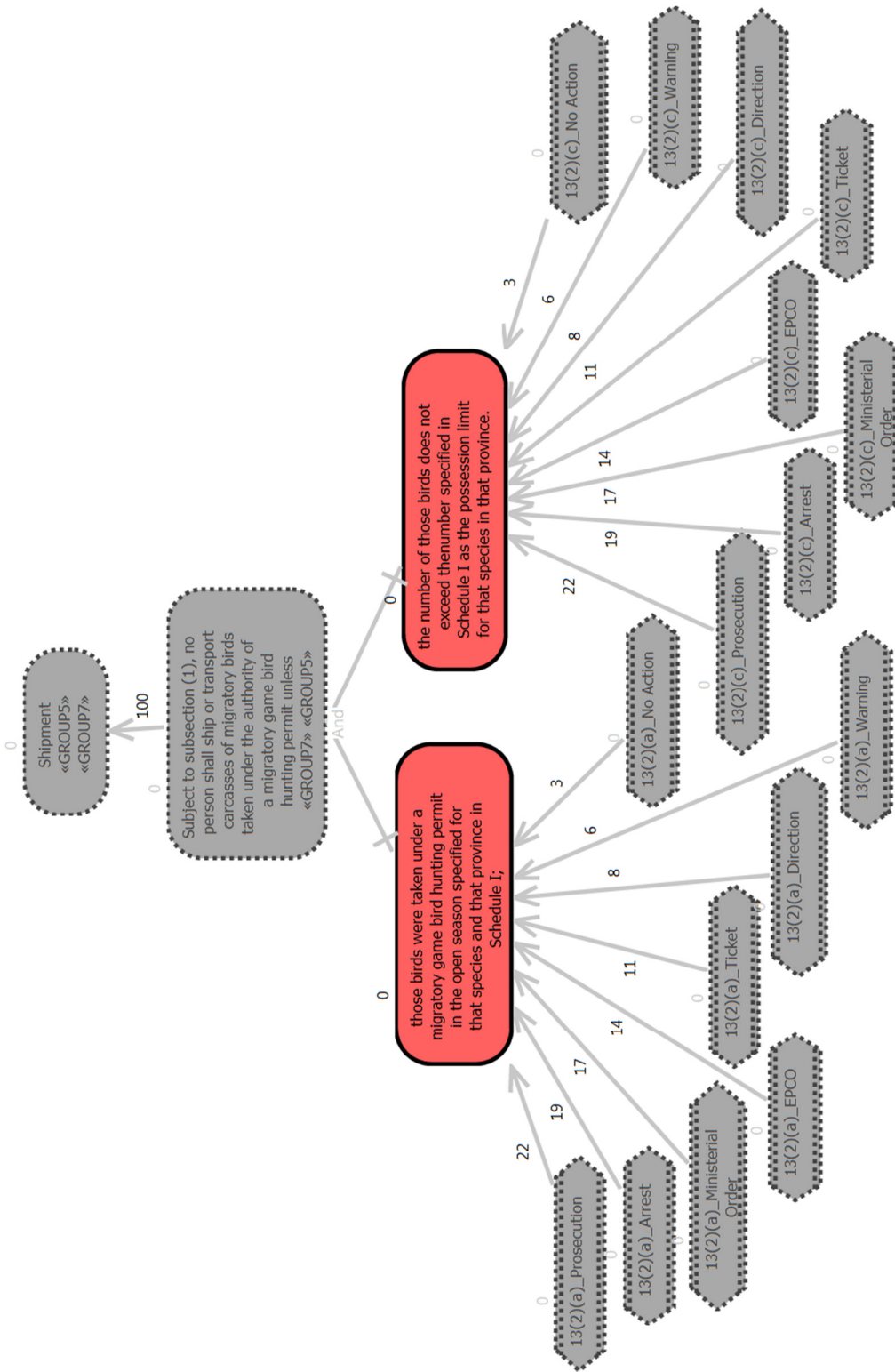
**Figure 66** 2006 Evaluated GRL Model for Subsections 5(4) and 5(11)



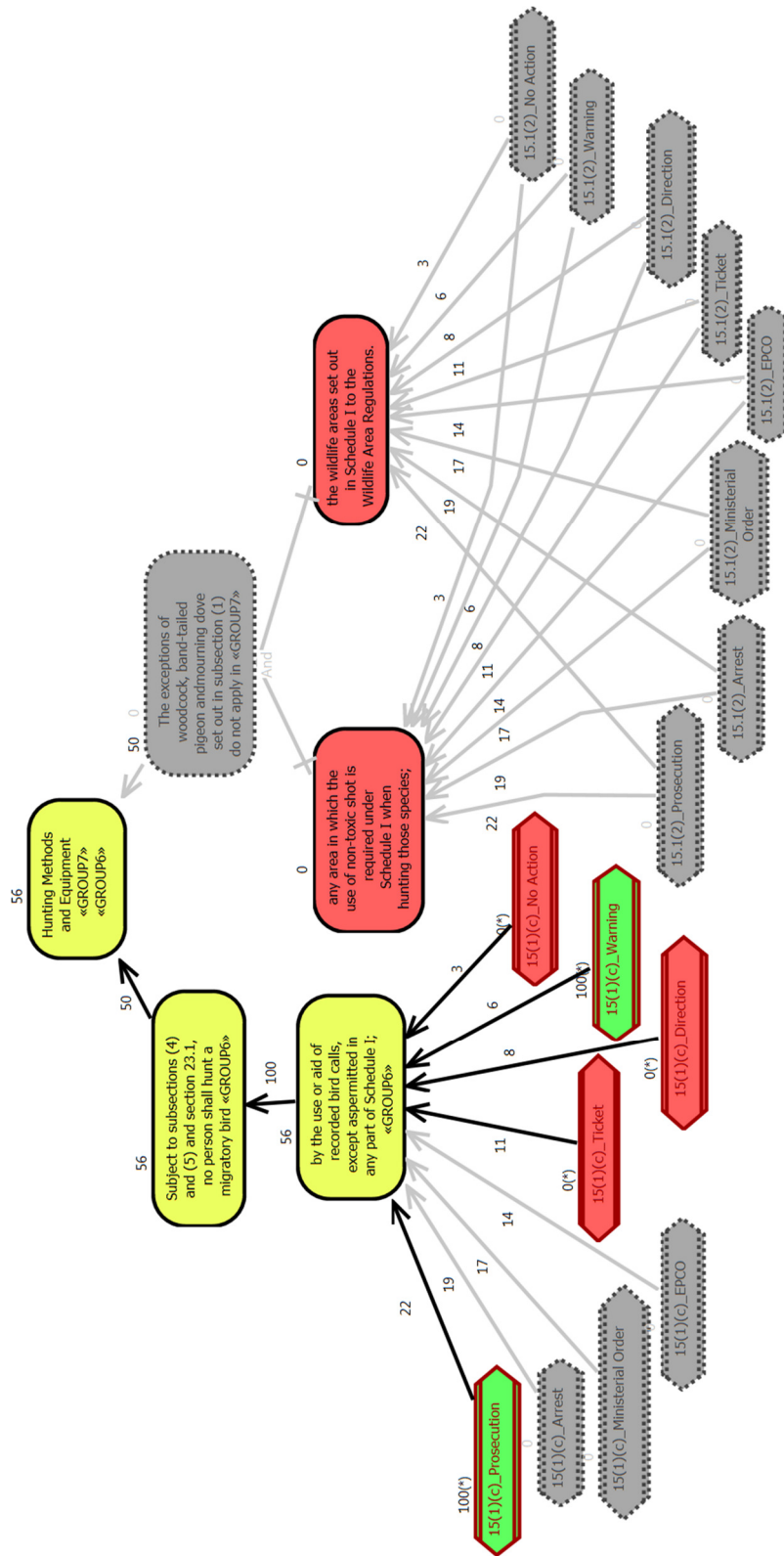
**Figure 67** 2006 Evaluated GRL Model for Sections 7 and 8



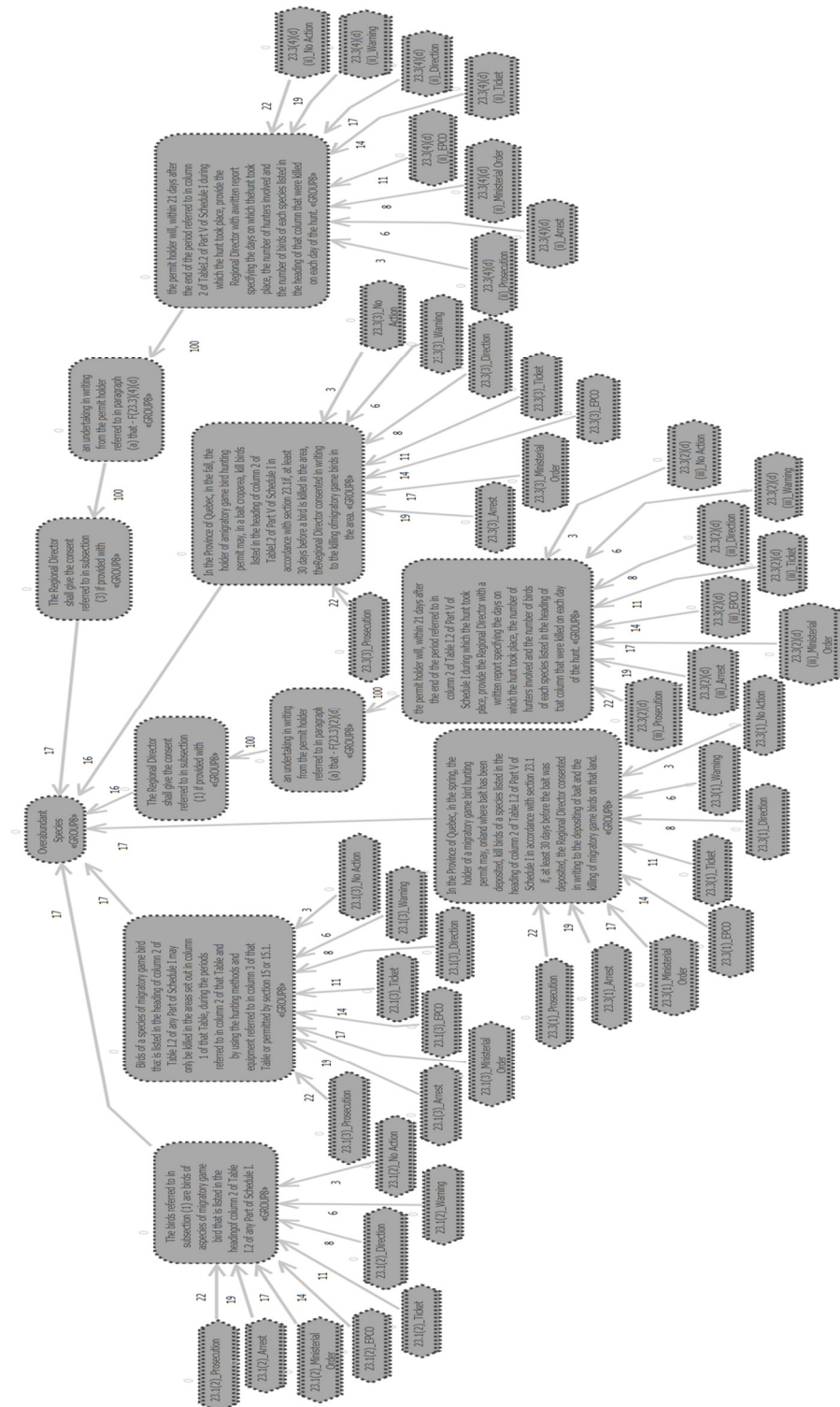
**Figure 68** 2006 Evaluated GRL Model for Subsections 10(1) and (2)



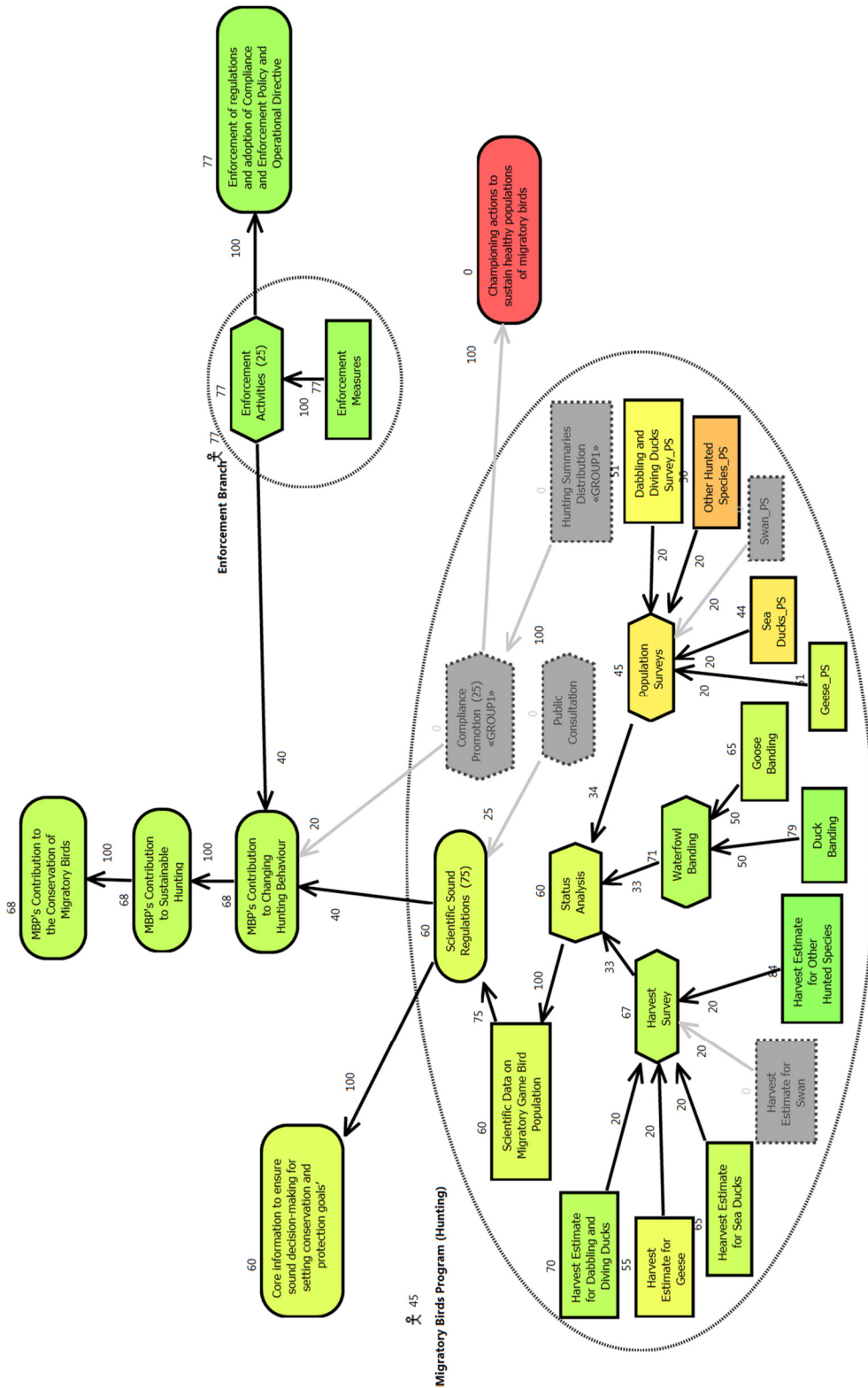
**Figure 69** 2006 Evaluated GRL Model for Paragraphs 13(2)(a) and (c)



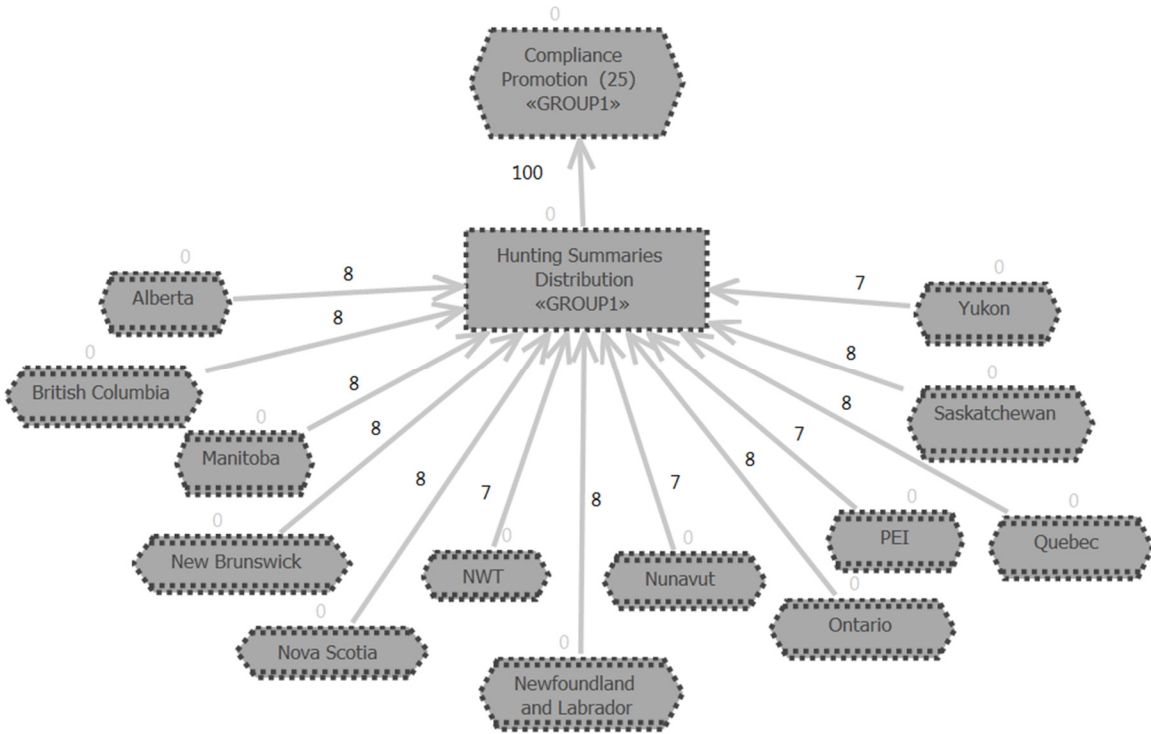
**Figure 70** 2006 Evaluated GRL Model for Paragraphs 15(1)(c) and 15.1(2)(a) and (b)



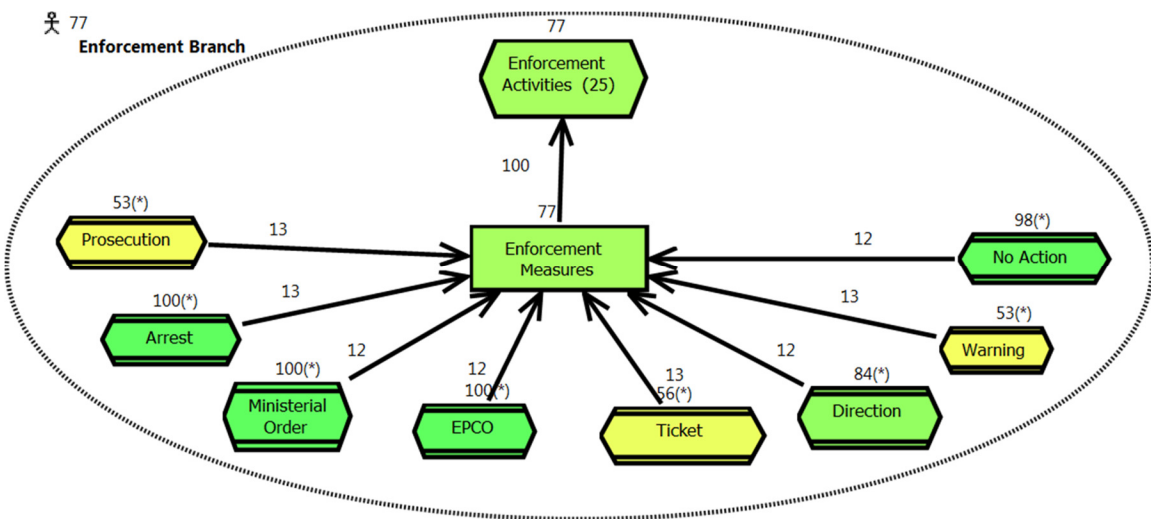
**Figure 71** 2006 Evaluated GRL Model for Subsections 23.1(2) and (3) and 23.3(1), Subparagraph 23.3(2)(d)(iii), Subsection 23.3(3) and Subparagraph 23.3(4)(d)(ii)



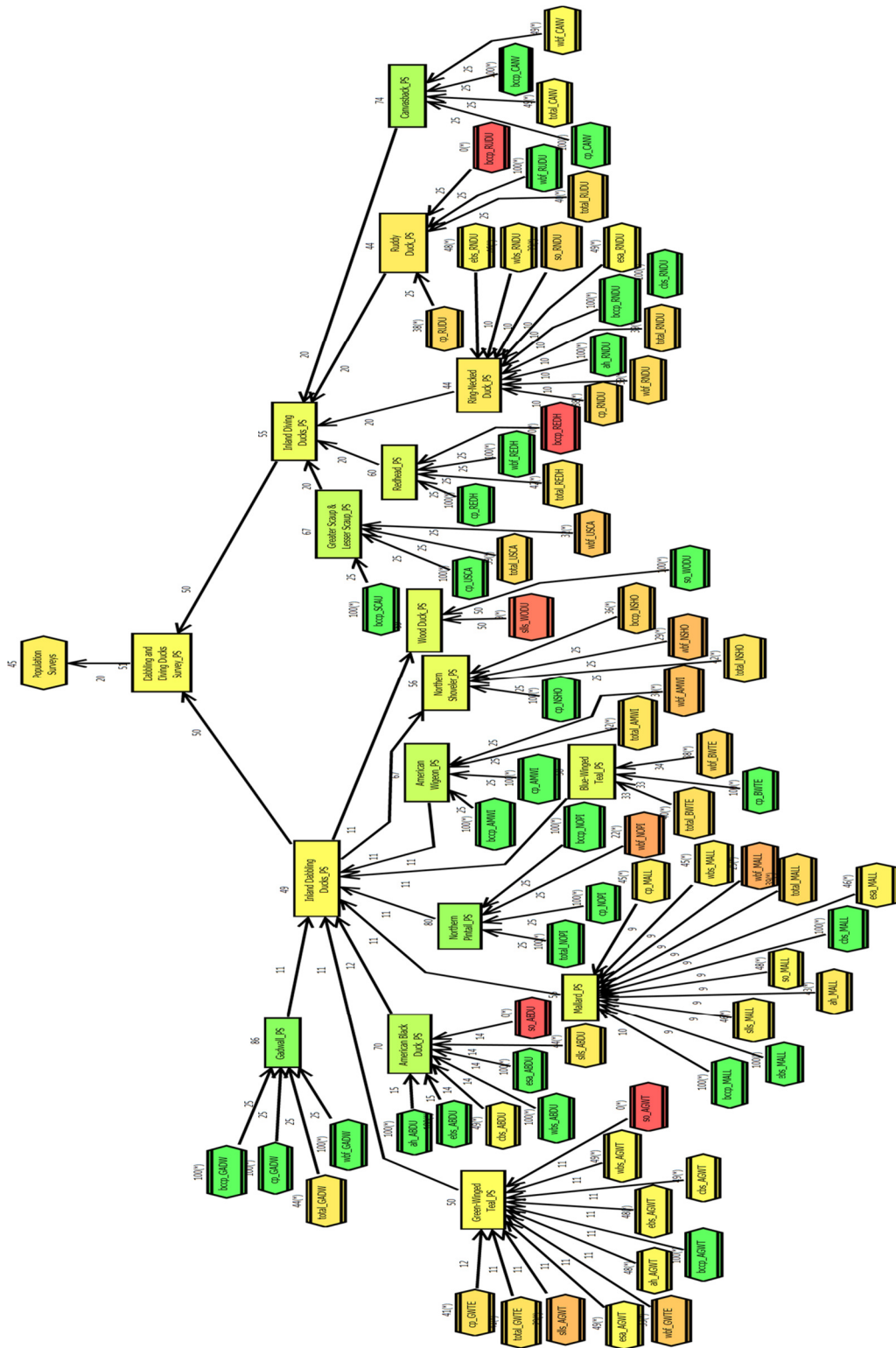
**Figure 72** 2006 Evaluated GRL Model of the MBP and Enforcement Branch Activities



**Figure 73** 2006 Evaluated GRL Model for the Compliance Promotion Activity (Not Performed that Year)



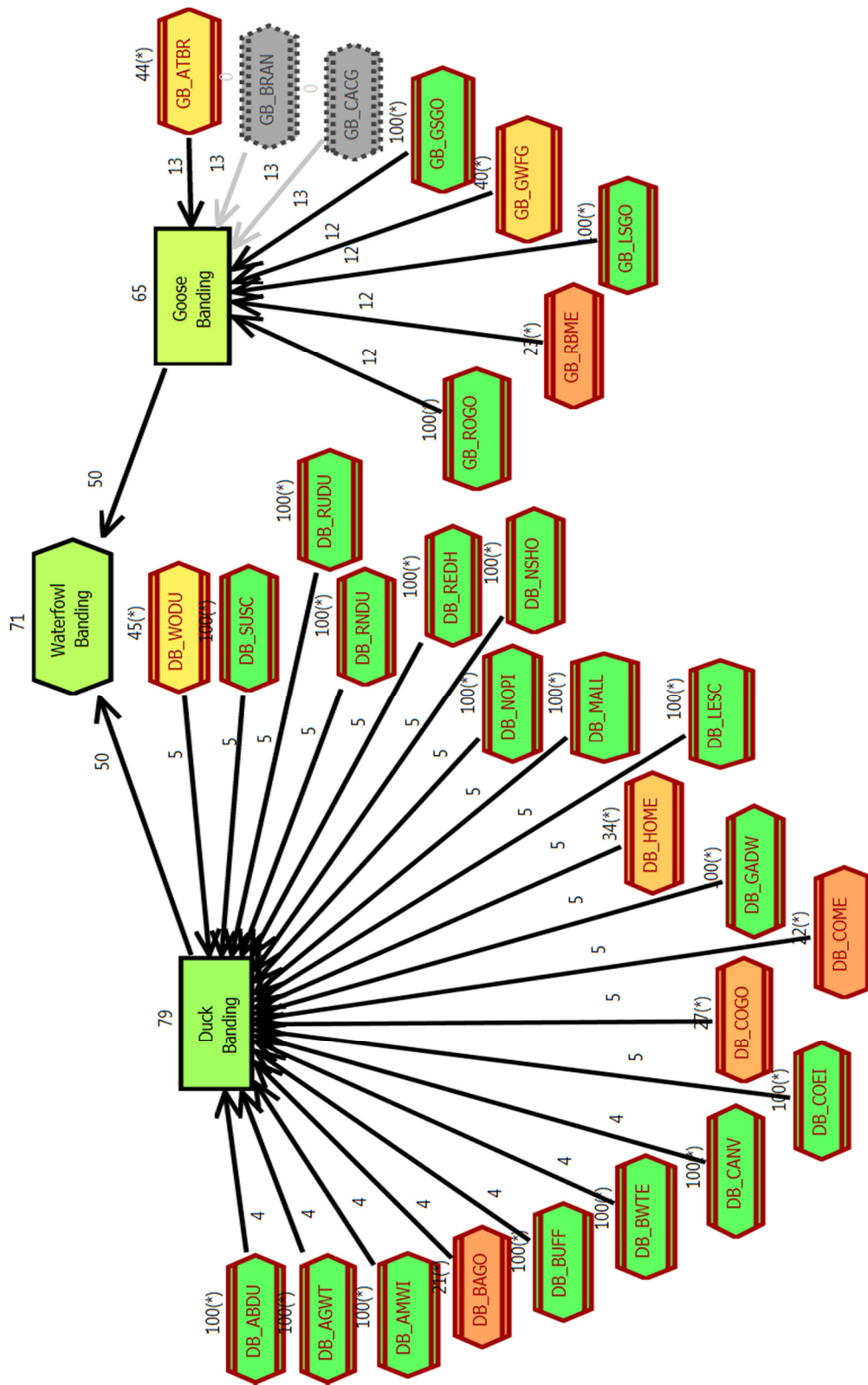
**Figure 74** 2006 Evaluated GRL Model of the Enforcement Branch Enforcement Activities



**Figure 75** 2006 Evaluated GRL Model for the MBP Population Survey-Dabbling and Diving Ducks Survey



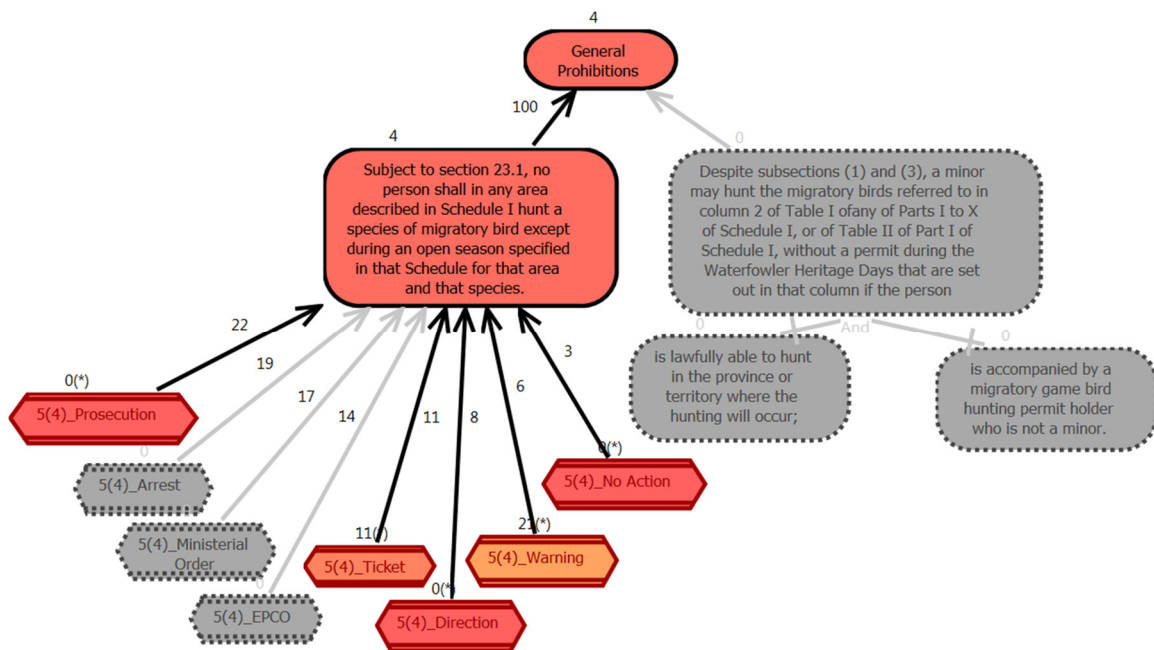




**Figure 78** 2006 Evaluated GRL Model for the MBP Waterfowl Banding

## 5.5. Data Input and Output

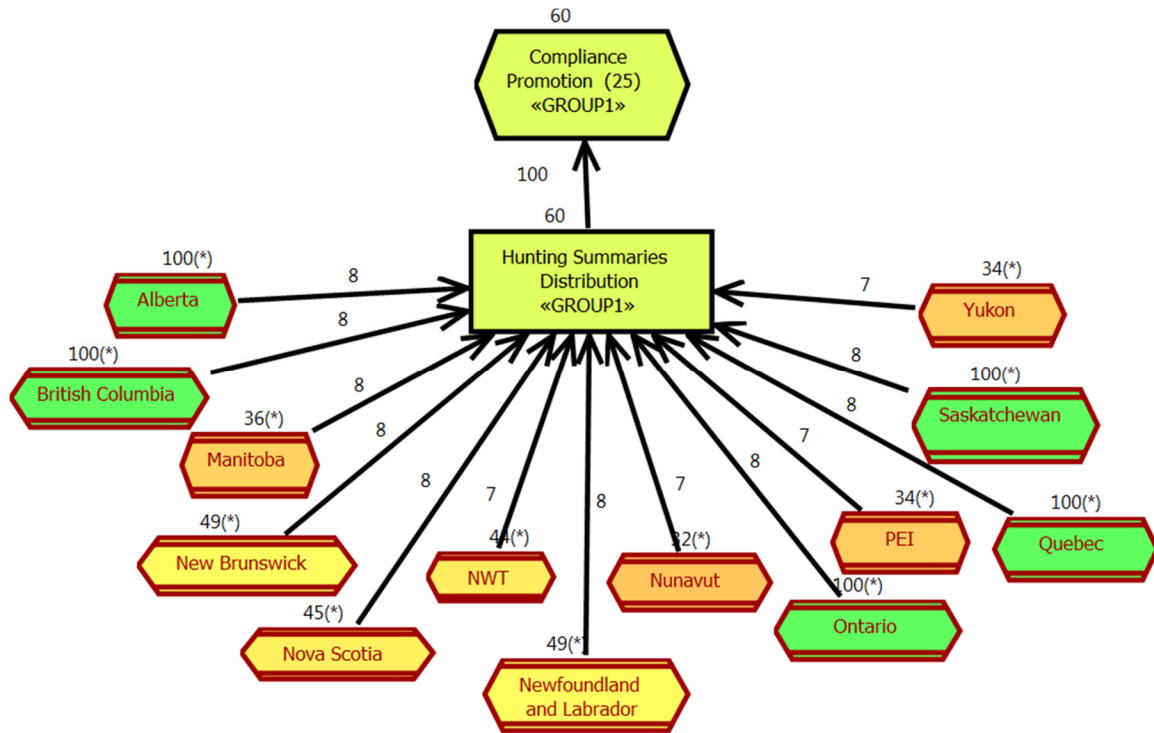
After correcting the models, I imported into jUCMNav the CSV file containing the ESP derived evaluation strategies for 2006 to 2016, in order to get satisfaction values for the models of the hunting provisions of the MBR and of the MBP and Enforcement Branch activities. There were eleven evaluation strategies for each model. I created eight groups in the models of the hunting provisions of the MBR, and four groups in the models of the MBP and Enforcement Branch activities, for conditions with no data. I then tagged the respective intentional elements in each of the evaluation strategies. Here, the GRL propagation algorithm propagates the evaluated satisfaction value of each KPI to the other intentional elements and actors of the model via their decomposition, contribution, dependency and containment relationships. Since the propagation algorithm excludes the intentional elements and KPIs with no data from the analysis, the latter return no value.



**Figure 79** 2016 Evaluated GRL Model for Subsections 5(4) and 5(11) of MBR

Illustrated in Figure 79 is the evaluation amounting to the non-compliance level for the “General Prohibitions” hunting provisions of the MBR (Subsections 5(4) and 5(11)) in 2016 as “4” on a scale of 0 to 100. Here the value “0” for the indicator “5(4)\_Prosecution” indicates that the value recorded for this indicator in 2016 is lower than the average ex-

pected during the period of analysis (2006 to 2016). Similarly, the evaluated model illustrated in Figure 80 shows the evaluation amounting to the satisfaction level of the “Compliance Promotion” task of the Migratory Bird Program as “60” on a scale of 0 to 100. Here 100 for the indicator “Ontario” indicates that the value recorded for this indicator in 2016 is above the average for compliance promotion during the period of analysis (2006 to 2016), and is the best expected value.



**Figure 80** 2016 Evaluated GRL Model of Subsections 5(4) and 5(11)

I then exported and saved the values of non-compliance levels from the GRL model of the MBR and the performance values from the GRL model of the MBP and Enforcement Branch activities from jUCMNav as CSV files.

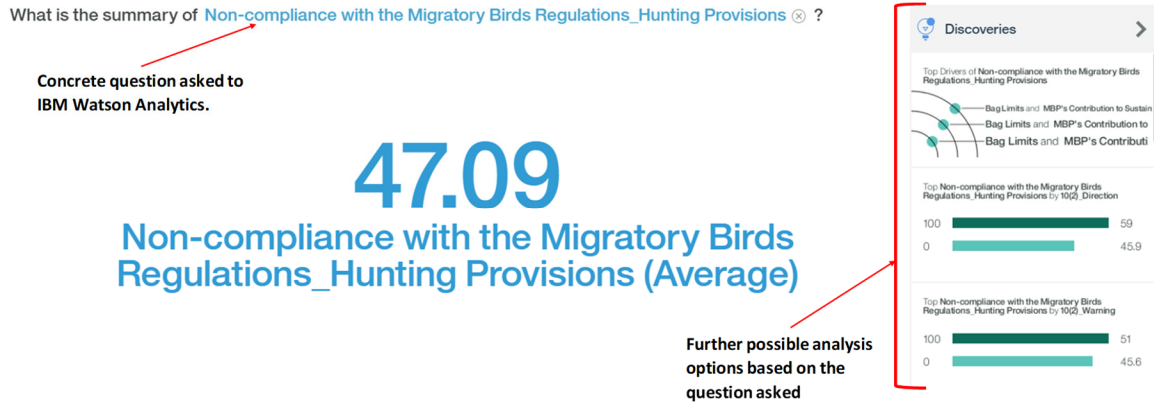
## 5.6. Extracting Insights from IBM Watson Analytics

The CSV files containing values on the non-compliance level of the MBR and performance values of the MBP and Enforcement Branch activities can then be imported into IBM Watson Analytics. These files are then joined using the approach described in Section 4.4.5. Based on the regulatory effectiveness insights of interest to the CWS discussed in Section

5.1, I obtained the insights presented in the following subsections using IBM Watson Analytics on the GRL-evaluated data on non-compliance levels and performance values.

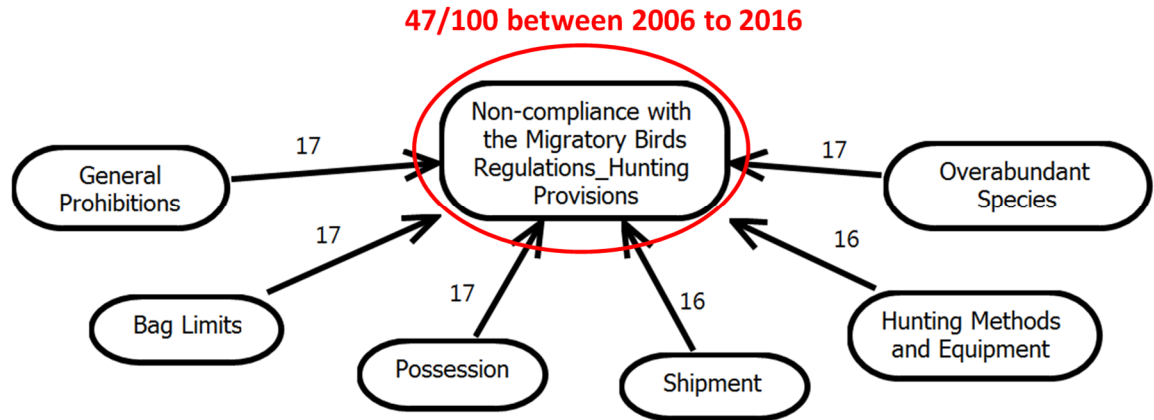
### 5.6.1 Within the Regulation and Regulatory Initiative Models

To determine the overall level of non-compliance from 2006 to 2016, the abstract question I asked in IBM Watson Analytic was “*What is the value of Non-compliance with the Migratory Birds Regulations Hunting Provisions?*”



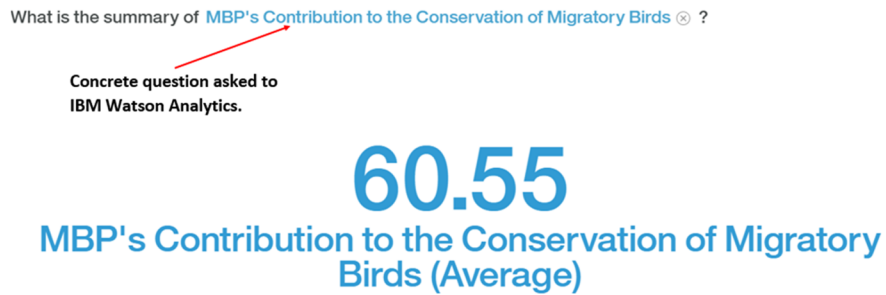
**Figure 81** Summary Value of Non-compliance with the Hunting Provisions of the MBR

Figure 81 shows the corresponding concrete question suggested by IBM Watson Analytics and the default visualization of its answer. The average level of non-compliance with the hunting provisions of the MBR between 2006 and 2016 is 47 on a scale of 100. Figure 82 puts this value in perspective in the GRL model of the hunting provisions of the MBR.



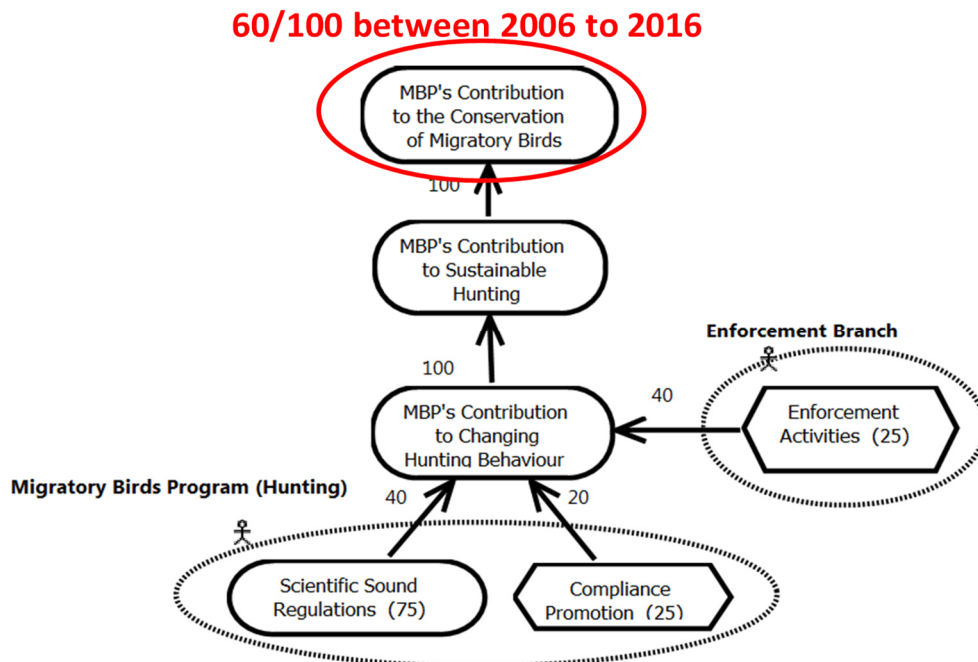
**Figure 82** Average Non-compliance Level put in Context using the GRL Model

Similarly, to determine the overall satisfaction value of the MBP and Enforcement Branch activities from 2006 to 2016, I asked IBM Watson Analytic this abstract question; “*What is the value of the MBP's Contribution to the Conservation of Migratory Birds?*” Here, I used the ultimate objective of the MBP and Enforcement Branch activities, “MBP's Contribution to the Conservation of Migratory Birds”, as the focus of my query. Figure 83 shows the question suggested by IBM Watson Analytics and the visualization of its answer.



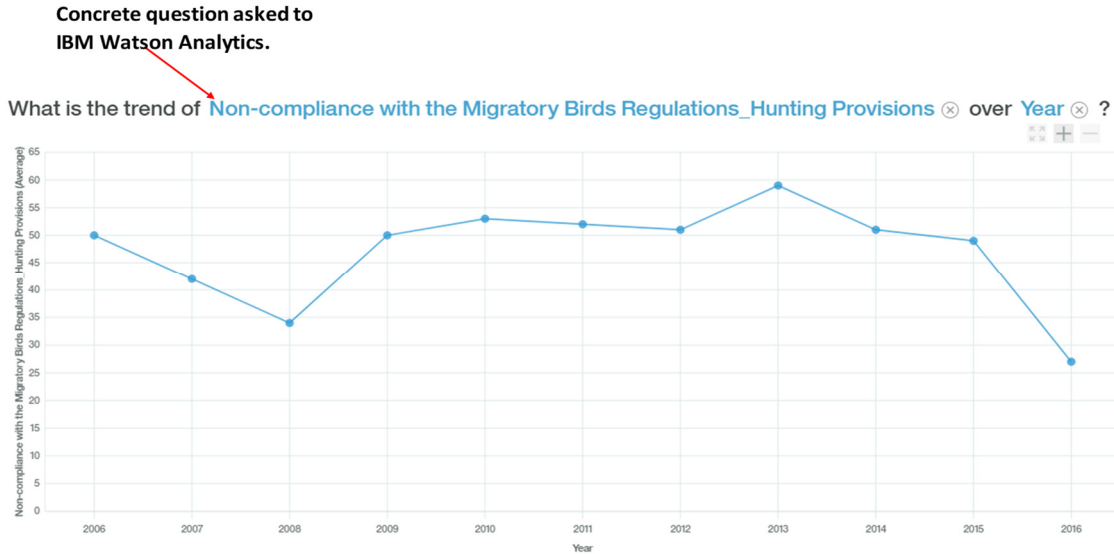
**Figure 83** Summary of Value of the MBP and Enforcement Branch Activities objective

The average performance level of the MBP and Enforcement Branch activities between 2006 and 2016 is 60 on a scale of 100. Figure 84 below puts this value in perspective in the GRL model of the MBP and Enforcement Branch activities.



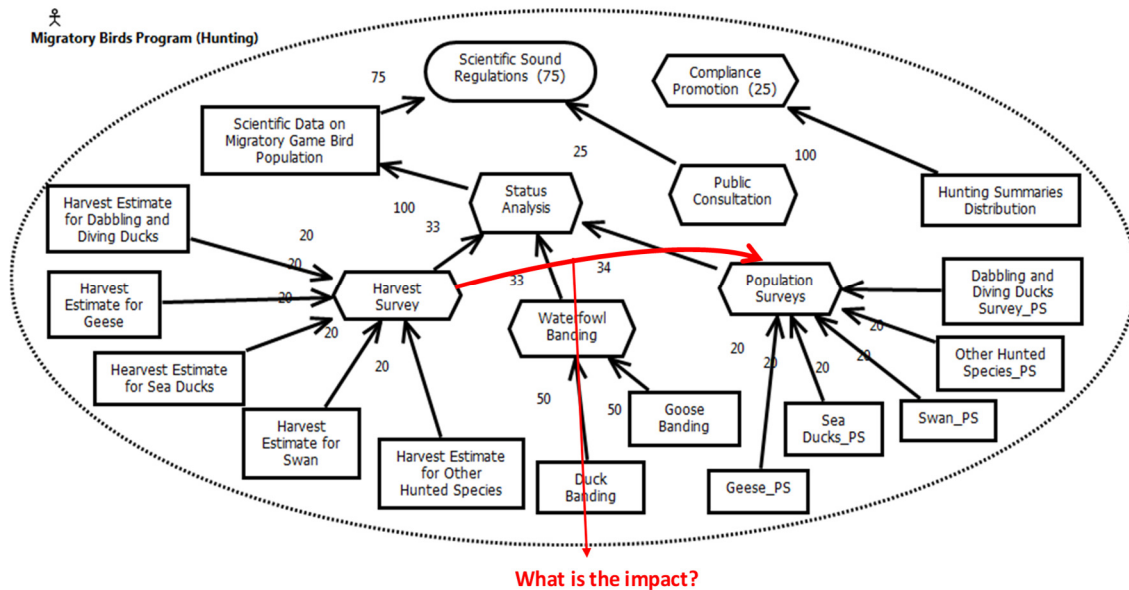
**Figure 84** Average Performance Level put in Context using GRL Model

To determine the level of non-compliance with the hunting provisions across the period of analysis, I asked IBM Watson Analytics this abstract question: “How does Non-compliance with the Migratory Birds Regulations Hunting Provisions compare by year?”



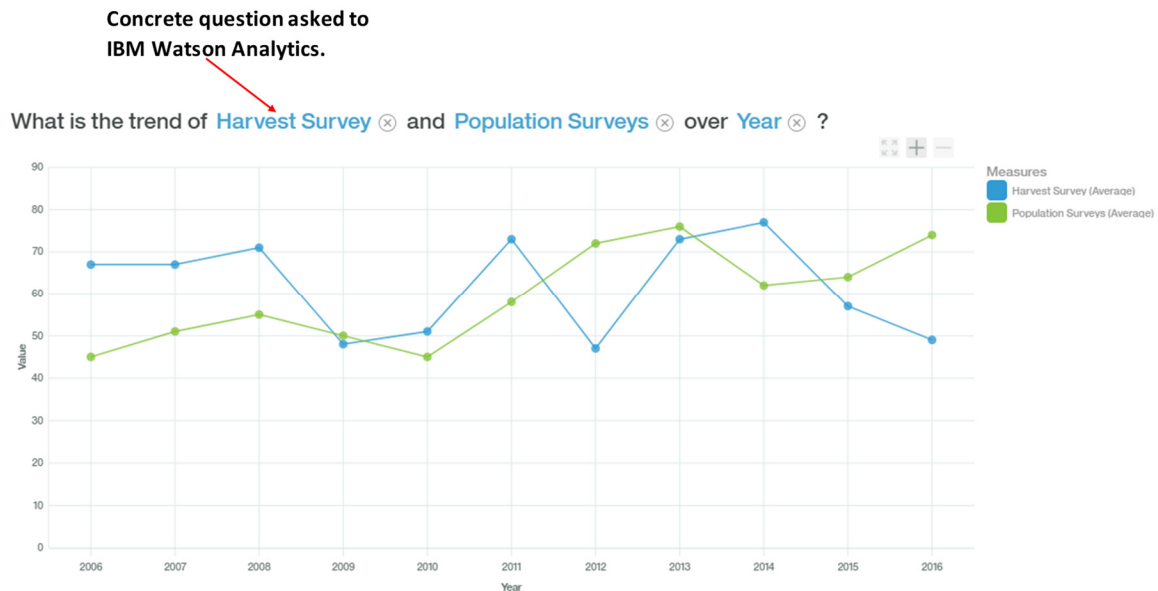
**Figure 85** Trend of Non-compliance with Hunting Provisions of the MBR

IBM Watson analytics suggested exploring the trend to answer this question, as shown in Figure 85. Here we observe a steady decrease in non-compliance since 2013, suggesting an increase in compliance with the hunting provisions of the MBR.



**Figure 86** GRL Model of only MBP Activities

As illustrated in Figure 86, since the number of migratory birds of a given species harvested could lead to an increase or decrease in the population of that species, I further explored in IBM Watson analytics what the impact of the harvest survey on the population survey was. The abstract question I asked was, “*What is the impact of Harvest Survey on the Population Survey over the period of analysis?*”



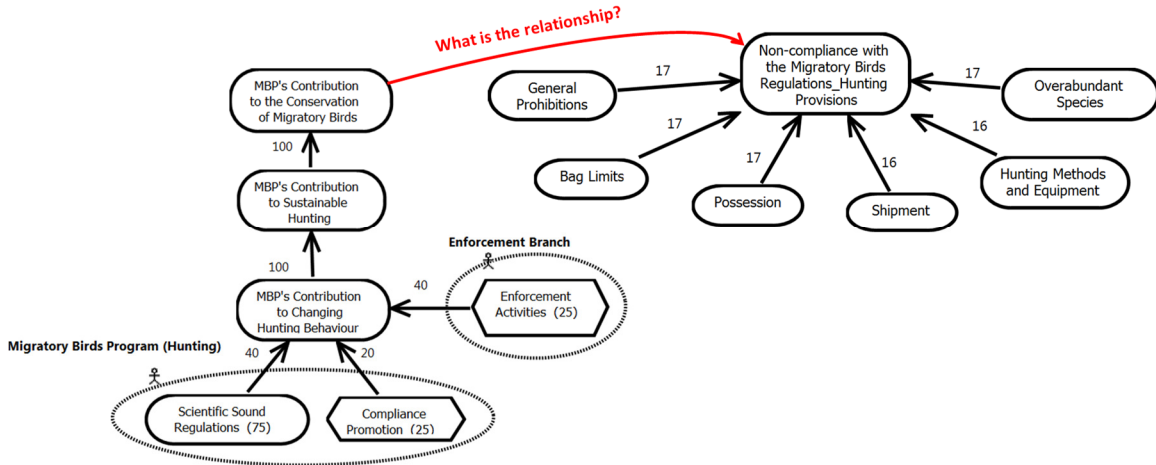
**Figure 87** Comparisons between the MBP’s Harvest and Population Surveys

Figure 87 provides the trend between the harvest and population surveys. Exploring this trend shows the impacts of the population survey on the harvest survey between 2006 and 2016. For example, since 2014, there has been a steady decrease in the harvest of migratory birds leading to an increase in average population within the same period.

### 5.6.2 Between Regulation and Regulatory Initiative Models

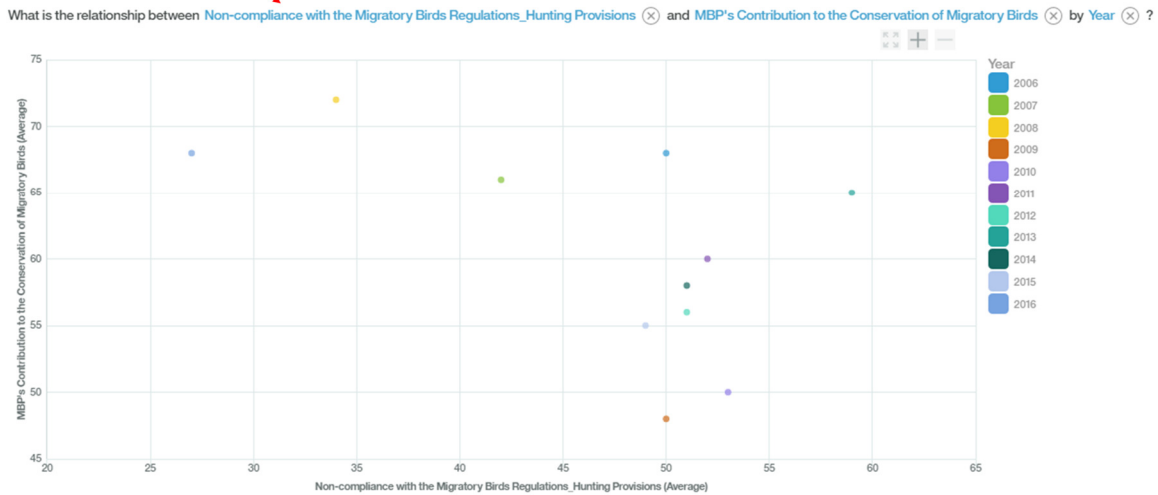
The Data Analyst can also use a combination of the data generated by two different models, e.g., data on non-compliance levels with the hunting provisions of the MBR and data on satisfaction values of the MBP and Enforcement Branch activities. To determine the relationship between non-compliance with the hunting provisions of the MBR and the objective of the MBP and Enforcement Branch activities from 2006 to 2016, I queried IBM Watson Analytics with this abstract question “*What is the relationship between Non-compliance with the Migratory Birds Regulations Hunting Provisions and the conservation of*

migratory birds by year?” The “MBP’s Contribution to the Conservation of Migratory Birds” is the ultimate objective of the MBP and Enforcement Branch activities, as illustrated in Figure 88.



**Figure 88** Investigating Relationships between the GRL Models of the MBP and Enforcement Branch Activities and of the Hunting Provisions of the MBR

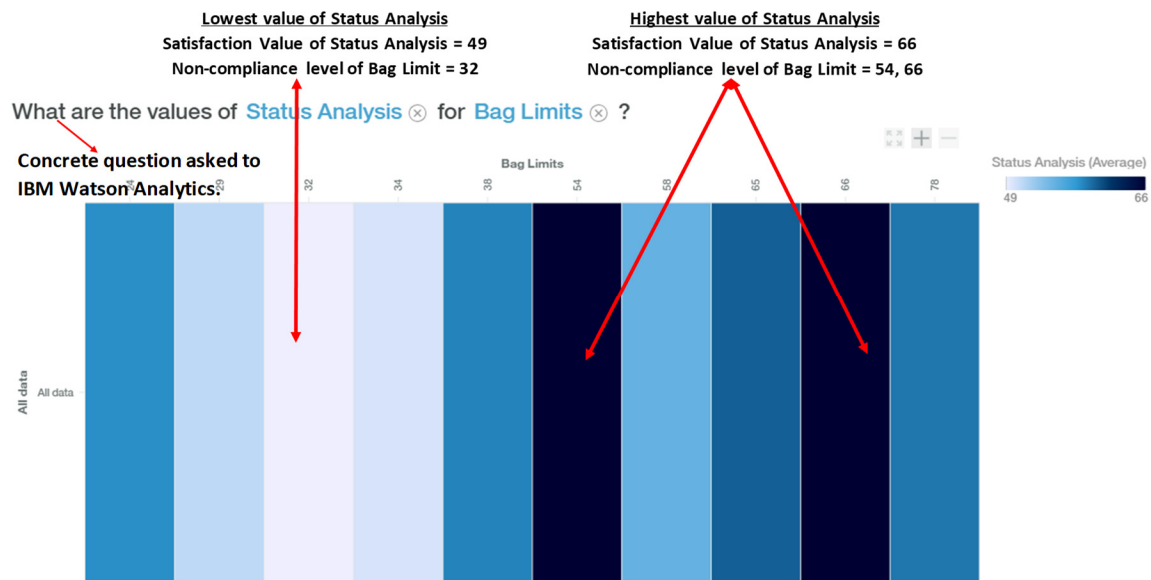
Concrete question asked to IBM Watson Analytics.



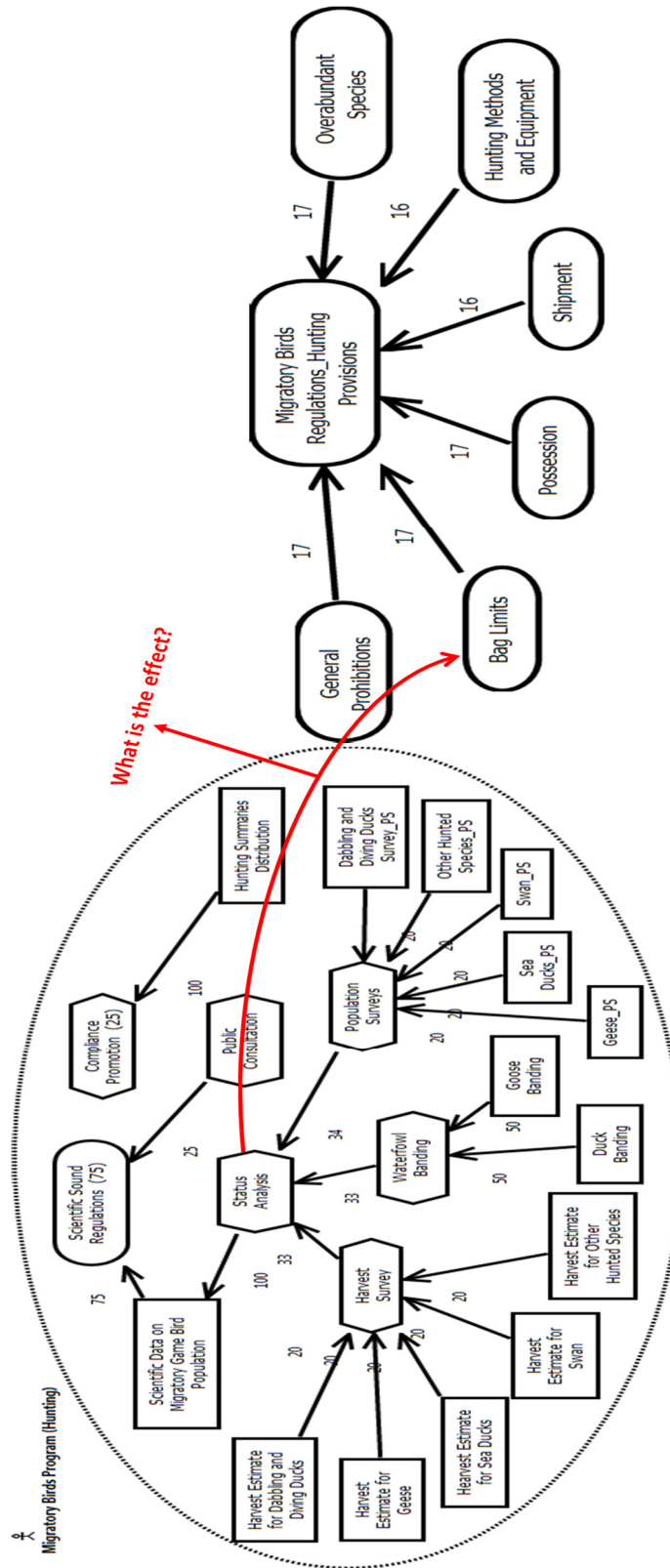
**Figure 89** Relationship between Non-compliance with the Hunting Provisions of the MBR and the Objective of the MBP and Enforcement Branch Activities

Figure 89 shows the concrete question suggested by IBM Watson Analytics and the corresponding visualization of its answer. This figure provides different insights on the relationship between the regulation and its regulatory initiative. For example, we can observe that when non-compliance with the hunting provision of the MBR is low, the conservation of migratory birds is high as expected. In addition, we observe that the satisfaction level of the conservation of migratory bird objective was at its lowest in 2009 with a score of 48 when the non-compliance level to the hunting provisions was and it highest was 50. Its highest was 72 in 2008 when the non-compliance level to the hunting provisions was 34. This implies that there is a negative correlation between non-compliance with the hunting provisions of the MBR and the objective of the MBP and Enforcement Branch activities with the former decreasing as the later increases.

The annual hunting summaries sets bag limits for each hunting season based on the status of migratory birds. Therefore, to determine whether the status analysis has any effects on non-compliance with the bag limits provision of the MBR between 2006 and 2016, I inquired of IBM Watson Analytics. The abstract question I asked was “Does status analysis have any effect on Bag Limits?” Figure 91 enables putting the answer to this question in a proper perspective using the GRL model.

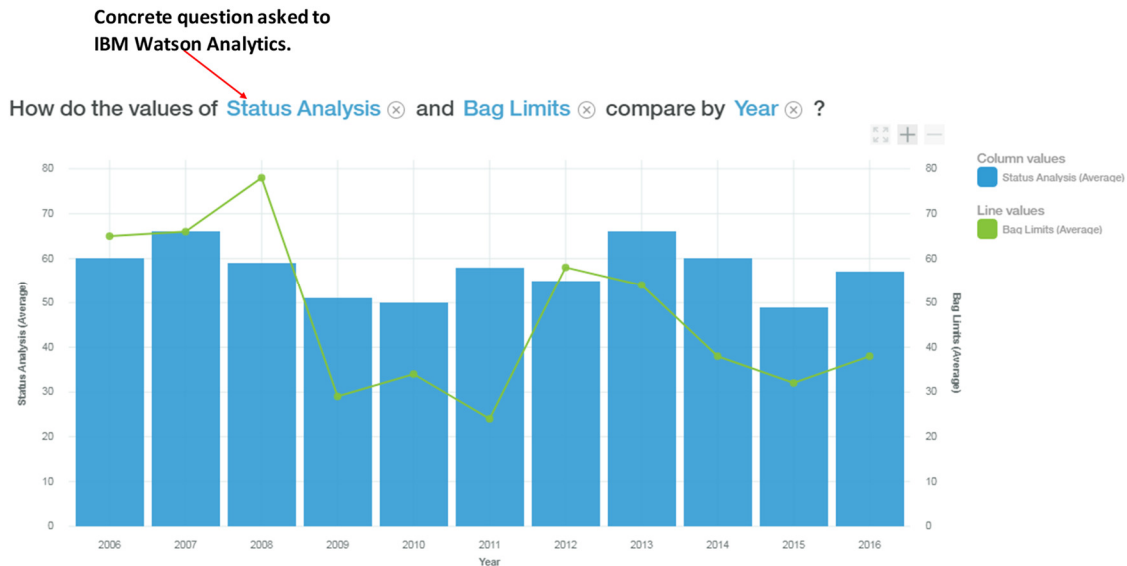


**Figure 90** Values of the Bag Limits Provision of the MBR for the Status Analysis Activity of the MBP



**Figure 91** Investigating Relationships between the GRL Models of the MBP (Hunting) Activities and of the Hunting Provisions of the MBR

Figure 90 shows the question suggested by IBM Watson Analytics and the visualization of its answer. Here we can see that the non-compliance level of the Bag Limits provision of the MBR ranges from 24 to 78. Within this range, when the average performance value of the Status Analysis activity is at its lowest (49), the level of non-compliance with the Bag Limit is low (32), although not the lowest. Similarly, when the average performance value of the Status Analysis activity is at its highest (66), the level of non-compliance with the Bag Limits is equally high (54 and 66) but not the highest. This positive correlation could imply that the Status Analysis activity of the MBP does not improve compliance with the Bag Limits provision of the MBR. In this regard, further analysis, such as comparing the performance of the Status Analysis activity and the level of non-compliance with the Bag Limits provisions over the period of analysis, could provide deeper insights.



**Figure 92** Comparison between values of the Status Analysis Activity of the MBP and of the Bag Limits Section of the Hunting Provisions of by year

Figure 92 shows an example of such additional analysis of the performance of the Status Analysis activity of the MBP and of the non-compliance with the Bag Limits provisions of the MBR, between 2006 and 2016. Here, we observe a correlation where, on average, an increase (resp. a decrease) in the performance of the Status Analysis activity in a year results in an increase (resp. a decrease) in non-compliance with the Bag Limits provision in the following year. Thus, a positive correlation exists between the performance of the initiative in a year and the level of non-compliance with the regulation in the following year.

## 5.7. Conclusion

In this chapter, I presented how I used GoRIM to demonstrate the effectiveness of the Migratory Bird Regulations (MBR), using GoRIM steps discussed in Section 4.3. Additionally, as described in Section 4.2, the endpoint for the application of GoRIM to the MBR was Step 6, the “Extract” step. Although the CWS could use the insights derived from the use of GoRIM for the “Periodic Enforcement/Evaluation” and “Evolve” steps, (Step 7 and 8), I did not address them in this case study.

The GRL models I created and analyzed in this case study were large. I was able to break the models into more than one diagram and analyze the models with no issues. In total, the model of the hunting provisions of the MBR comprised eight diagrams, one for each of the selected sections plus one for the overview, and a diagram for the condition. The GRL model contained 156 intentional elements (35 goals, 1 resource and 120 KPIs) and eleven GRL evaluation strategies (each of which initializing the 120 KPIs). The MBP and Enforcement Branch GRL model also included eight diagrams. It contained two actors, 300 GRL intentional elements (7 Goals, 7 Tasks, 62 Resources and 224 KPIs), and eleven GRL evaluation strategies. These large models confirm GRL’s ability to provide a scalable and consistent representation of multiple views/diagrams of the same model and accentuates ESP and jUCMNav as robust tools for analyzing goal models (Amyot et al., 2013, 2009).

Using GoRIM in this case study, I encountered instances of missing data for some of the defined KPIs in the goal models of the regulation and regulatory initiative. Missing data are a real issue Regulators often encounter and it affects their ability to use evidence-based decision-making. To address this issue, an extension to jUCMNav enabled ignoring the affected KPIs and the intentional elements connected to them from the analysis and redistributing their contributions to the remaining contributors if they had any. Hence, the regulator is provided with the goal model analysis results that exclude the affected KPIs and intentional elements.

In addition, using GoRIM, I was able to answer the questions of interest to the CWS introduced in Section 5.1, which led to questions for Watson Analytics in Section 5.6:

- a) The analysis of the models of the hunting provisions of the MBR and activities of the MBP provides an opportunity to improve tracking and reporting. An example

in this regard is the CWS maintaining enforcement activities at their current levels, based on the summary report of a non-compliance level of 47.09 with the hunting provision of the MBR and a steady decrease in non-compliance levels since 2013.

- b) An assessment of the impact of the Harvest Survey Activity of the MBP on the Population Survey of the MBP showed a steady decrease in the harvest of migratory birds and increase in their average population since 2014. This assessment shows that the Harvest Survey and Population Survey activities of the MBP are effective since they achieved the objective of conserving migratory birds.
- c) The assessment of the performance of the Status Analysis activity of the MBP and of the non-compliance level of the Bag Limits provision of the MBR shows how the performance of the MBP activities directly influence non-compliance levels of the hunting provisions of the MBR. Furthermore, the observed correlation could provide a basis for the limits set in the Bag Limits provision of the MBR.

In the next chapter, I describe the application of GoRIM to the second case study.

## Chapter 6. Case Study 2: Metal Mining and Effluent Regulations

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This chapter describes my application of GoRIM to a second study involving a real-life regulatory scenario. Here, GoRIM is used to show the effectiveness of the Metal Mining and Effluent Regulations – MMER (Government of Canada, 2002b).

Note also that this chapter reports on a proof of concept used as one iteration in my DSRM-based approach (Figure 5). In that context, the analysis results reported in this chapter are for illustration purpose only and should not be used in any way to influence decision-making by the Government of Canada or to draw conclusions about the performance of the regulator or the regulations.

I first give an overview of the case study, and then I show my application of GoRIM to the MMER.

### 6.1. Case Study Overview

Environment and Climate Change Canada (ECCC) is responsible for the *Metal Mining and Effluent Regulations* (MMER) (Government of Canada, 2002b) through the Industrial sectors, Chemicals and Waste (ICW) directorate. The MMER is a regulatory instruments that ECCC uses to administer Section 36 of the Fisheries Act (Government of Canada, 1985a). Enacted in 1985, the Fisheries Act contains two key provisions on the conservation and protection of fish habitat that are essential to sustaining freshwater and marine fish species in Canada (Environment and Climate Change Canada, 2007). Section 36 of the Fisheries Act, also known as the “Key Pollution Prevention Provision”, addresses prohibiting the deposit of deleterious substances into waters frequented by fish, unless authorized by regulations under the Fisheries Act. Herein, a deleterious substance can be any substance that, if added to any water, would degrade or alter its quality such that it could be harmful to fish, fish habitat or the use of fish by people (Environment and Climate Change Canada, 2007).

The *Environmental Effects Monitoring* (EEM) requirements of the MMER provide information that ECCC uses to periodically amend the MMER. EEM is the regulatory initiative used by the ECCC for the MMER and managed by the Environment Protection Branch (EPB), a unit of the ICW. The objectives of EEM are to:

- 1) Assess the effects of effluent on fish, fish habitat, and the use of fisheries resources.
- 2) Evaluate the adequacy of the regulations to protect fish, fish habitat, and the use of fisheries resources.

This case study focuses on sections of the MMER related to environmental effects monitoring, and to reporting monitoring. Four Key Informants from the EPB agreed to participate in this case study. Table 15 shows their roles and years of experience.

**Table 15** Summary of Key Informants in the Environment Protection Branch (EPB)

S/N	Role	Years in Role	Duties
01	Subject Matter Expert on Regulations.	15 years or more	Involved in creating and administering the MMER and EEM
02	Responsible for Regulatory Initiatives	Less than 10 years	Involved in creating and administering the MMER and EEM
03	Subject Matter Expert on Regulations.	Less than 15 years	Involved in creating and administering the MMER and EEM
04	Responsible for Regulatory Initiatives	Less than 5 years	Involved in creating and administering the MMER and EEM

Data over a ten-year period (2004 to 2014) show that despite compliance with MMER, mining effluents continue to have a negative impact on the receiving environment. Through an ongoing regulatory amendment process, ECCC is proposing stringent standards for effluents. As such, in participating in the case study, the EPB was interested in a *third-party assessment* of the effectiveness and efficacy of the MMER.

My application of GoRIM to the MMER and EEM involved creating models of sections of the MMER on the environmental effects monitoring and on reporting monitoring (i.e., monitoring that results are provided to the government by the mines), as well as of tests involved in the EEM. After creating the models, I inputted data on compliance with

the respective sections of the MMER and EEM test results from the mines regulated by the MMER. I then exported the data analyzed from the models into IBM Watson Analytics to enable visualization and further analysis of the compliance with the MMER and performance of the EEM tests. The following sections describe how I used the steps of GoRIM in this domain.

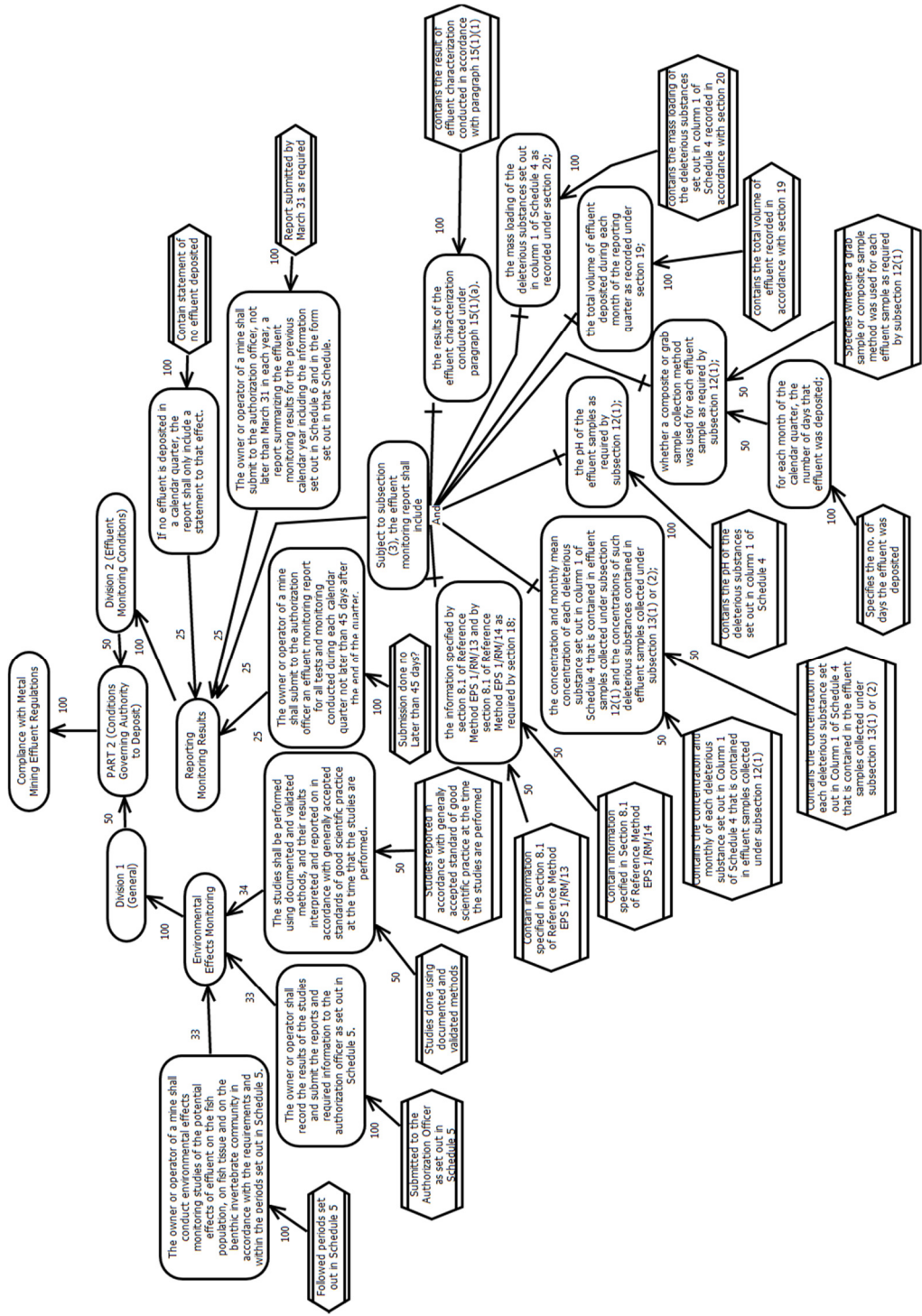
## **6.2. Creating Models of the MMER and EEM**

Listed below are the sections of the environmental effects monitoring, and reporting monitoring results sections of the MMER.

- a) Environmental Effects Monitoring: Sections 7(1), (2) and (3)
- b) Reporting Monitoring: Sections 21(1), (3) and Section 22

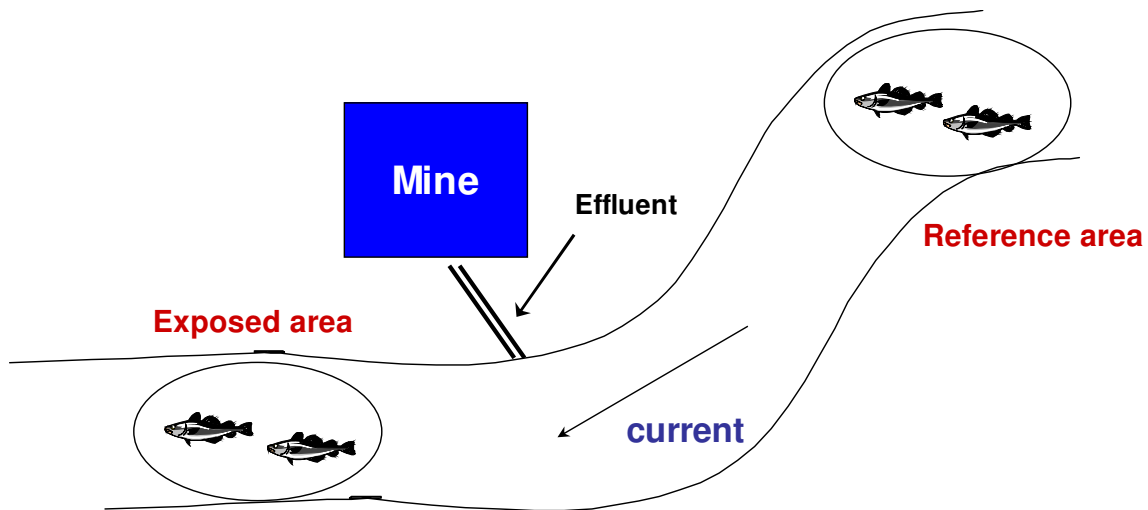
In enforcing compliance with the environmental effects monitoring, and reporting monitoring sections of the MMER, ECCC receives the information required under Section 7 and the data required under Sections 21 and 22 from mines that fall under the MMER. The mines that provide the required information and data are complying. To create the GRL model for the respective sections of the MMER, I discussed with the Key Informants as recommended in Akhigbe et al. (2014) to obtain contributions weights for KPIs to subparagraphs, subparagraphs to paragraphs, paragraphs to subsections and subsections to sections of the MMER. The environmental effects monitoring, and reporting monitoring sections of the MMER also had Equal Relative Weights (ERW). The EPB had KPIs for measuring compliance with the respective sections of the MMER, which I collected from the Key Informants. I proceeded to create the tabular representation of the respective sections of the MMER and imported the file into jUCMNav to derive the respective GRL model shown in Figure 93.

For the regulatory initiative, EEM requirements stipulate that mines subject to the MMER must conduct monitoring tests to assess the impacts of effluent on a receiving environment. The monitoring tests strongly focus on biological monitoring studies (e.g., fish population survey, fish tissue analysis and invertebrate communities' survey) and other analyses that bring vital information such as effluent and ambient water analyses, sub-lethal toxicity testing and acute-lethality toxicity testing.



**Figure 93** GRL Model of the Environmental Effects Monitoring and Reporting Results Sections of the MMER together

EEM analyzes the results from these monitoring tests to identify trends in effluent-related effects on fish, fish habitat and/or use of fisheries resources, and to determine whether limits in the regulations are protective of fish, fish habitat and/or use of fisheries. “The information obtained through the EEM can be used to determine the effectiveness of the MMER and provide a basis for determining the need for enhanced site-specific or national pollution prevention and control measures” (Government of Canada, 2002a). EEM requirements include the biological monitoring studies, complementary measures and water quality studies. As illustrated in Figure 94, the biological monitoring studies compare fish, fish habitat and the usability of fisheries resources in areas exposed to effluent (exposed areas) to those in similar areas not exposed to effluent (reference area). The complementary measures and water quality studies seek to understand any observed difference in the areas exposed to effluent and areas not exposed to effluent because of mining activities.



**Figure 94** Basis for Environmental Effects Monitoring (Environment Canada, 2017)

The biological monitoring studies occur every three to six years depending on the reoccurrence of similar effects. The biological monitoring studies include the following:

1. *Fish Survey*: comparison of fish in reference and exposed areas using Survival (age), Growth (weight-at-age), Body Condition (weight relative to length), Energy Storage (liver size) and Reproduction (gonad size) as indicators.
2. *Fish Habitat Survey*: comparisons of benthic invertebrate communities in reference and exposed areas using Density (individuals/m<sup>2</sup>), Richness (number of different types of organisms), Evenness (number of individuals for each type) and Similarity

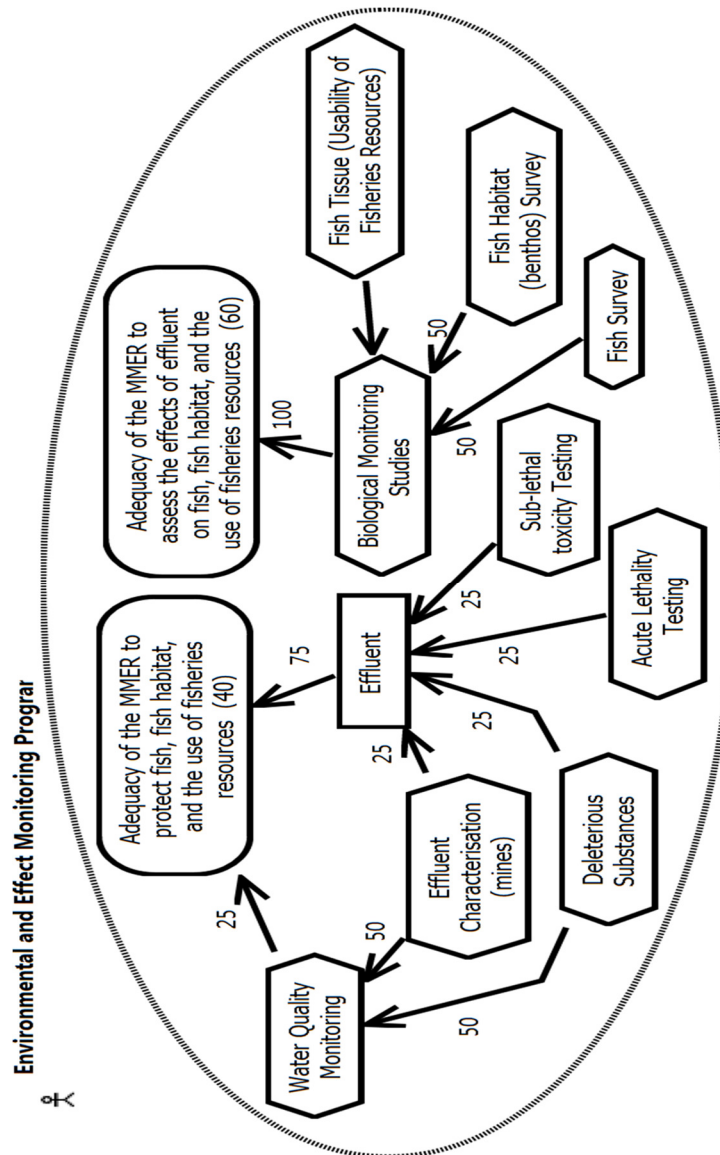
- (comparison of community structure between exposed and reference areas) as indicators.
3. *Fish Tissues Survey*: usability of fisheries resources using mercury levels in fish tissues as an indicator.

The complementary measures studies include:

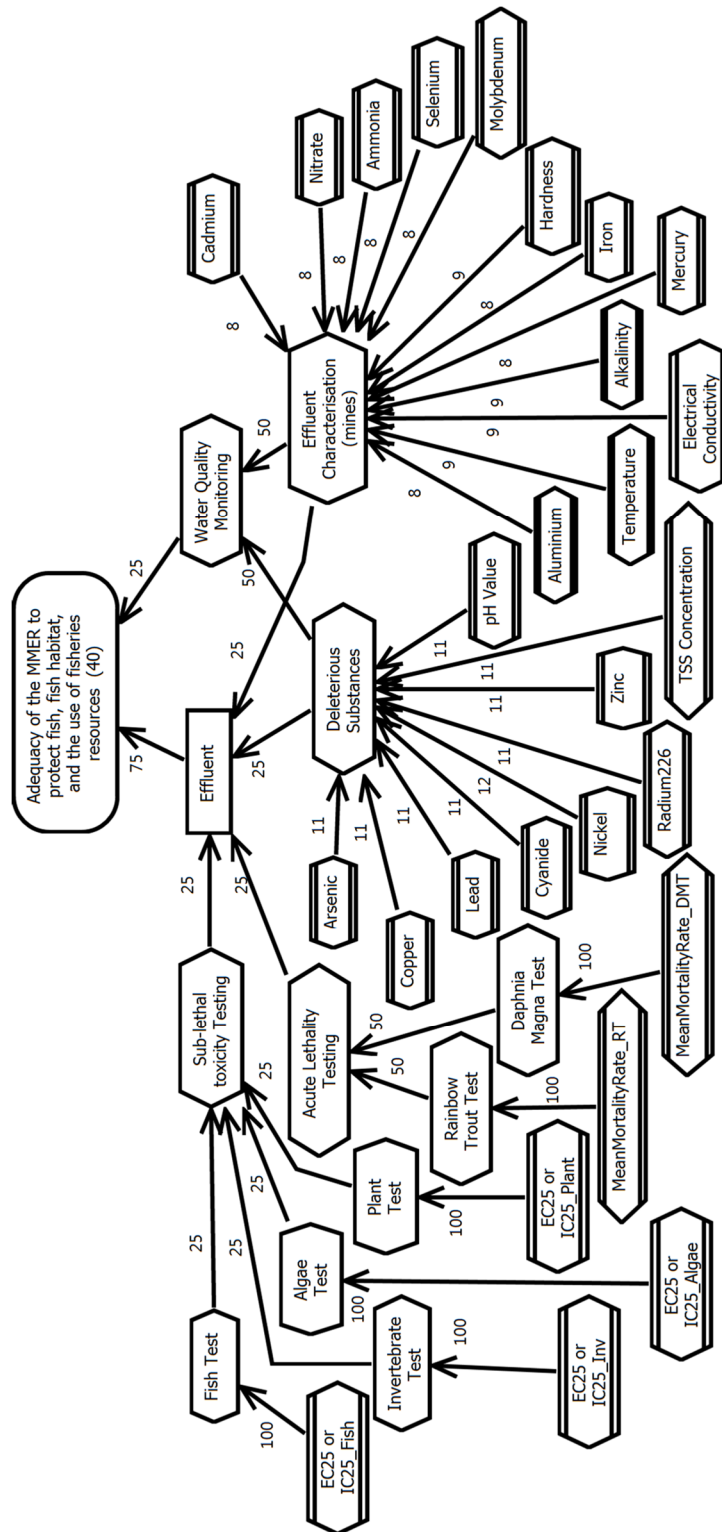
1. *Effluent Characterization*: occurs four times per calendar year and measures the presence of Aluminium, Mercury, Iron, Molybdenum, Selenium, Ammonia, Nitrate, Water Hardness, Alkalinity, Temperature and Electrical Conductivity in the receiving environment.
2. *Water Quality Studies*: occur four times per calendar year and measures the presence of deleterious substances in the receiving environment. The current list of deleterious substances includes Arsenic, Copper, Lead, Cyanide, Nickel, Radium226, Zinc, total suspended solid (TSS) concentration and pH value. Schedule 4 of the MMER lists the allowable limits for these deleterious substances.
3. *Sub-lethal Toxicity Testing*: occurs twice per year for the first three years after a mine opens and, afterwards, once a year every three years. This tests the effluent concentration that causes reduction in growth or reproductive impairment of fish, invertebrates, vascular plants (freshwater only) and algae.
4. *Acute Lethality Testing*: tests the acute lethality of effluents to rainbow trout and daphnia magna.

Consequently, I used the indicators of the respective biological monitoring studies surveys and the elements measured in the complementary measures studies as KPIs in the created GRL models of the EEM requirements. In line with the regulatory initiative metamodel described in Section 4.3.1, I modelled the “Biological Monitoring Studies”, “Fish Survey”, “Fish Habitat Survey” and “Fish Tissue Surveys” as GRL tasks because they are EEM activities. I also modelled the complementary measures studies, i.e., “Effluent Characterization”, “Water Quality Studies”, “Deleterious Substances”, “Sub-Lethal Toxicity Testing” and Acute Lethality Testing”, as GRL tasks. In addition, I modelled the respective tests on fish, invertebrates, vascular plants and algae, done as part of the sub-lethal toxicity

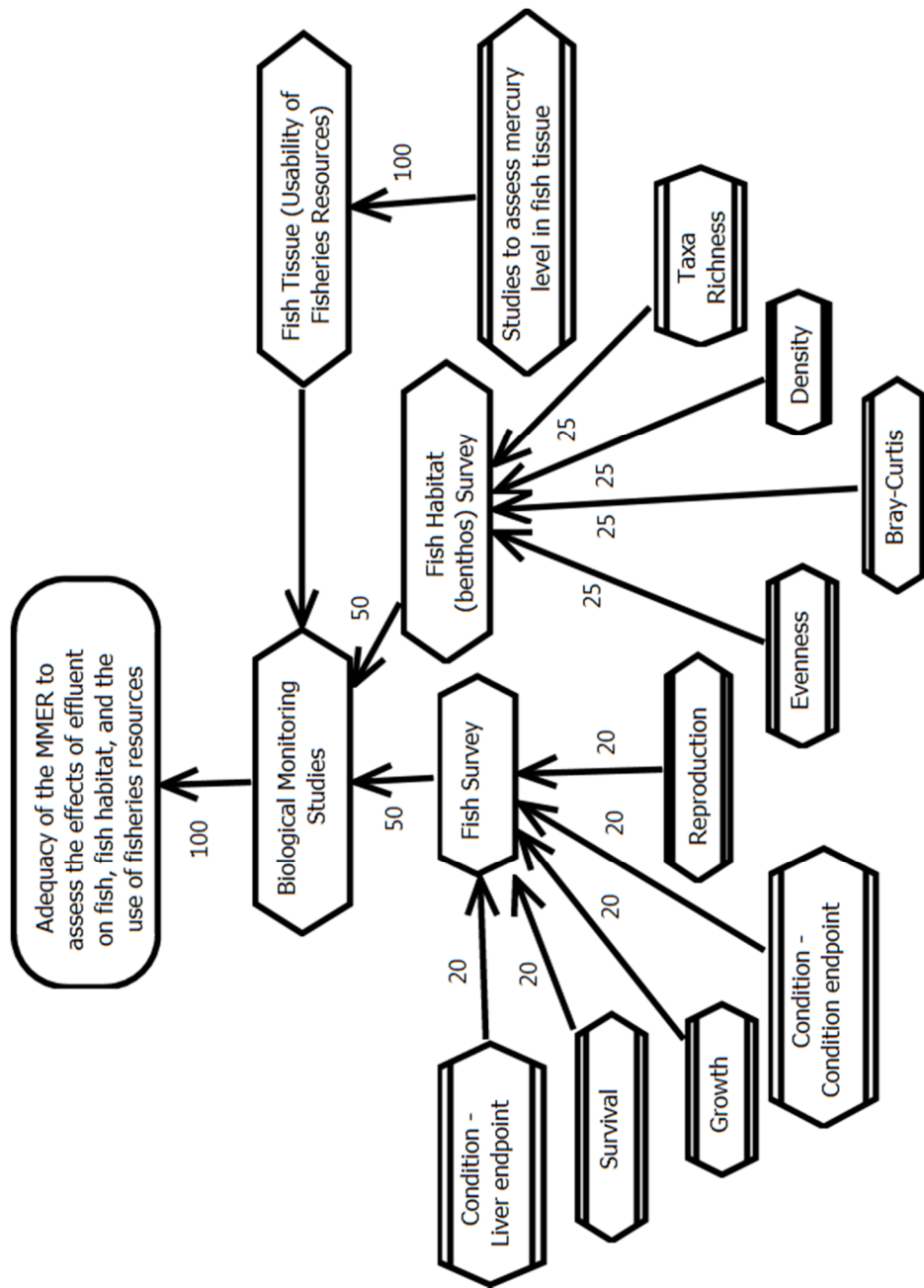
test, and tests on rainbow trout and *Daphnia magna* done as part of the acute lethality tests, as GRL tasks. Finally, I modelled the respective indicators in the biological monitoring studies and the different elements measured in the effluent characterization, water quality studies, sub-lethal toxicity testing and acute lethality testing, as KPIs. Figure 95 below shows an overview GRL model of the MMER EEM requirements. Figure 96 shows the part of the model related to the Complementary Measures Studies & Water Quality Studies and Figure 97 shows the part related to the Biological Monitoring Studies.



**Figure 95** Overview GRL Model of MMER EEM Requirements



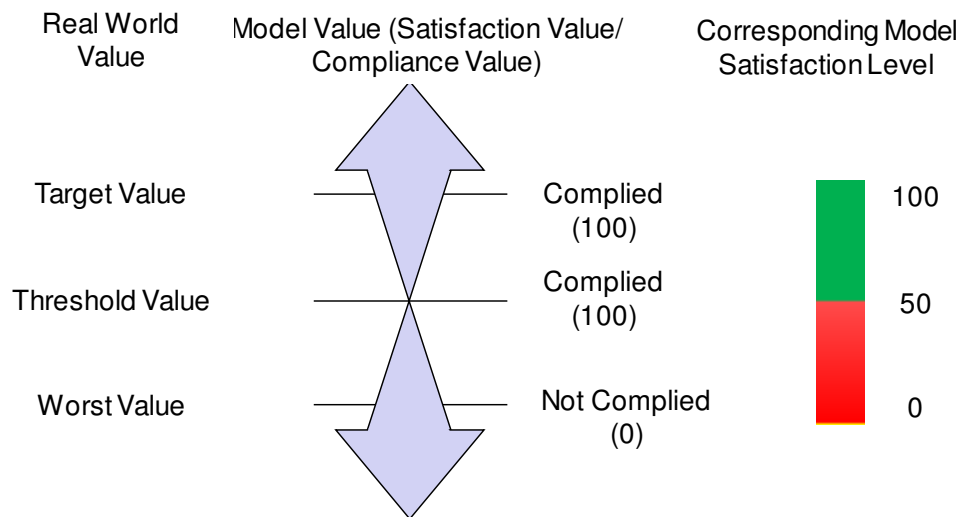
**Figure 96** Part of the GRL Model for the Complementary Measures Study & Water Quality Study



**Figure 97** Part of the GRL Model for the Biological Monitoring Study

### 6.3. Data Preparation for the MMER and EEM Models

The EPB provided data on 25 mines within the scope of the MMER that include mines with no effects and mines with varying degrees of effects, from 2002 to 2014. For the environmental effects monitoring, and reporting monitoring results sections of the MMER, compliance was binary. Either mines comply or they do not comply. As such, Figure 98 illustrates the structure of the KPI that I used for compliance with the environmental effects monitoring, and reporting monitoring results sections of the MMER.

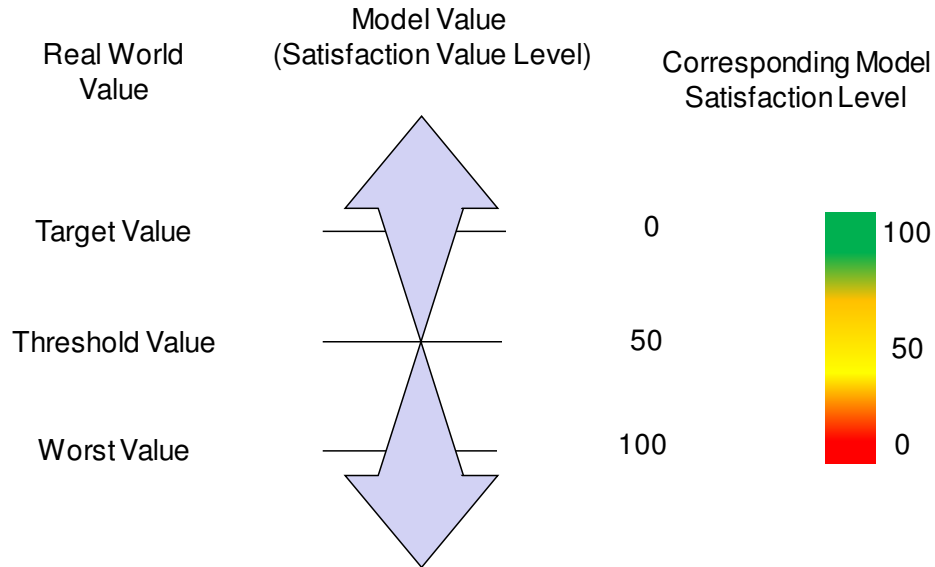


**Figure 98** KPI Structuring and Colour Coding for Compliance with the MMER

Here:

- *Target Value*: Complied, signifying that there is evidence the mine met the requirements of the respective section of the MMER.
- *Threshold Value*: Same as the target value
- *Worst Value*: Not-complied, signifying that there is evidence the mine did not meet the requirements of the respective sections of the MMER.

For the EEM requirements, the data are comprised of values reported by the 25 mines under the MMER for sub-lethal toxicity testing, effluent characterization, and water quality studies, from 2002 to 2014. Figure 99 illustrates the structure of the KPIs that I used for the sub-lethal toxicity testing, acute lethality testing, effluent characterization, and water quality studies based on the information provided by the Key Informants.



**Figure 99** KPI Structuring and Colour Coding for Complementary Measures Studies

Here:

- *Target Value*: zero, signifying the absence of effluent concentration that causes a 25% reduction in growth.
- *Threshold Value*: 50, signifying the minimum level of effluent concentration that causes a 25% reduction in growth.
- *Worst Value*: 100, signifying the maximum level of effluent concentration that causes a 25% reduction in growth.

For the KPIs measuring the acute lethality test on rainbow trout and *Daphnia magna*:

- *Target Value*: zero mortality rate, signifying no adverse effect from exposure to effluents.
- *Threshold Value*: 50% mortality rate resulting from exposure to effluents.
- *Worst Value*: 100% mortality rate resulting from exposure to effluents.

For KPIs measuring the effluent characterization and water quality monitoring studies:

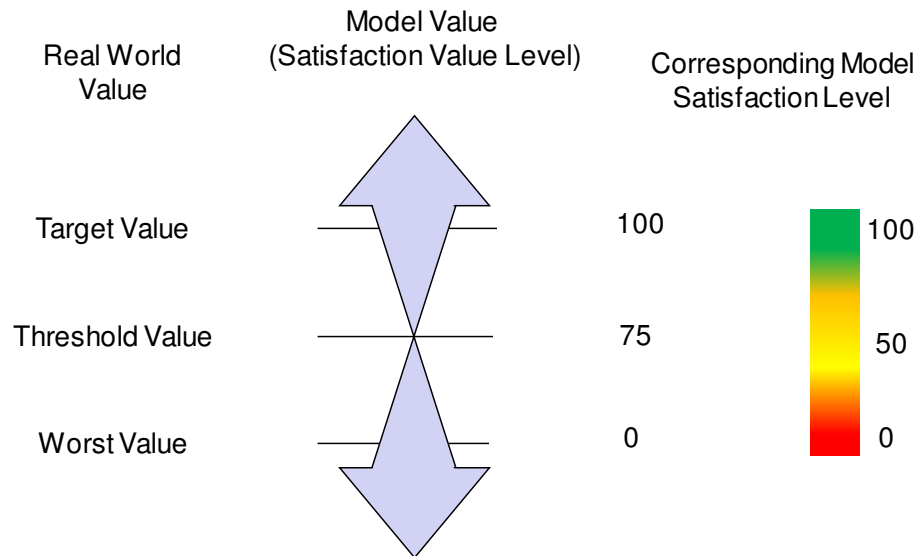
- *Target Value*: zero signifying the absence of the presence of the element.
- *Threshold Value*: specifies the limit set for the element.
- *Worst Value*: signifies any value above the set limit.

Regarding the biological monitoring studies, since these studies occur every three to six years and not annually, the data provided were values reported by the 25 mines under the MMER for one of such studies in 2014. The Key Informants provided categories that described the different levels of effects or absence of effects associated with the biological monitoring tests, as illustrated in Table 16.

**Table 16** Matching GRL KPIs Values to Levels of Biological Monitoring Effects

Description	Associated Categories	Nu- meric Ranking	KPI Value
Confirmed absence of effects	<ul style="list-style-type: none"> <li>• Absence of effect</li> <li>• NA</li> </ul>	100	Target
Confirmed effects below CES	<ul style="list-style-type: none"> <li>• Confirmed &lt; CES (+)</li> <li>• Confirmed &lt; CES</li> <li>• Confirmed &lt; CES (-)</li> <li>• &lt; CES (+)</li> <li>• &lt; CES (-)</li> <li>• &lt; CES</li> </ul>	75	Threshold
Confirmed effects. IOC concluded that effects are NOT mine-related	<ul style="list-style-type: none"> <li>• Effect of unknown magnitude (-)</li> <li>• Effect of unknown magnitude (+)</li> <li>• Effect of unknown magnitude</li> <li>• Confirmed unknown magnitude (-)</li> <li>• Confirmed unknown magnitude (+)</li> </ul>	60	
Variable results - effects (above or below CES) reported in one phase but no effects reported in the other phase.	<ul style="list-style-type: none"> <li>• Confirmed variable magnitude (+)</li> <li>• Confirmed variable magnitude (-)</li> <li>• Confirmed variable magnitude</li> </ul>	50	
Confirmed effects, above CES in one phase, below CES in the other phase	<ul style="list-style-type: none"> <li>• ≥ CES (+)</li> <li>• ≥ CES (-)</li> <li>• ≥ CES</li> </ul>	25	
Confirmed effects above CES in both phases	<ul style="list-style-type: none"> <li>• Confirmed ≥ CES (+)</li> <li>• Confirmed ≥ CES</li> <li>• Confirmed ≥ CES (-)</li> </ul>	0	Worst
<p><b>Legend</b> CES = Critical Effect Size, KPI = Key Performance Indicator</p>			

Table 16 also shows how I matched these categories to get target, threshold and worst values for the KPIs based on recommendations from the Key Informants. The Key Informants asked that I exclude the “Fisheries Tissues Survey” from the analysis of the model since the results were not showing any effluent-related effects.



**Figure 100** KPI Structuring and Colour Coding for Biological Monitoring Studies

Figure 100 shows the structure of the KPIs that I used for the “fish survey” and “fish habitat survey” of the biological monitoring studies based on the information provided by Key Informants in Table 16. Here:

- *Target Value*: Value considered the most satisfactory (Confirmed absence of effects)
- *Threshold Value*: Value considered minimally satisfactory (Confirmed effects below CES)
- *Worst Value*: Value considered unsatisfactory (Confirmed effects above CES in both phases)

I set these targets, threshold and worst values for the KPIs of the environmental effects monitoring, and reporting monitoring results sections of the MMER, as well as for the complementary measures and biological monitoring studies of EEM requirements. These were stored as preconfigured values for each KPIs in the “Indicator” files. I then used ESP

(see Appendix A) to derive corresponding GRL evaluations strategies for 2002 to 2014 using the “Indicator” files and annual values for each KPI obtained from the EBP, i.e., the “Source” file.

#### **6.4. MMER and EEM Model Corrections**

After using the ESP to derive evaluation strategies for the 25 mines from 2002 to 2014, I randomly selected one evaluation strategy for a mine. I inputted this evaluation strategy into the models generated in the previous step. In addition, I checked the models against the 19 URN well-formedness rules listed in Table 12. The models of the MMER sections, complementary measures and biological monitoring studies of EEM responded and behaved correctly in the metal mining effluent monitoring context.

There was no occurrence of missing data for the MMER model. Hence, the model had no needs for conditions linked the KPIs or tagged groups. In the EEM model however, as some data were missing from the dataset, I created thirteen groups for the complementary measures and water quality studies, and two groups for the biological monitoring studies for conditions with no data. Accordingly, I tagged the respective intentional elements in each of the evaluation strategies, as described in Section 5.4.

#### **6.5. Data Input and Output**

After correcting the models, I imported the CSV file containing the derived ESP evaluation strategies for 2002 to 2014 into jUCMNav to get satisfaction values for the models. There were 211 evaluation strategies for models of the respective sections of the MMER and complementary measures and water quality studies, and 25 evaluation strategies for the biological monitoring studies. Afterwards, I exported the model satisfaction values of compliance with the MMER and performance values of the complementary measures, water quality, and biological monitoring studies models from jUCMNav as CSV files.

## 6.6. Extracting Insight from IBM Watson Analytics

As observed in Section 6.5, the metal mining effluent regulations context indicates the 25 mines analyzed complied with the environmental effects monitoring, and reporting monitoring results sections of the MMER. Hence, my use of IBM Watson Analytics was only on the GRL-evaluated data related to performance values. I imported the data (CSV files) about compliance and performance values with the MMER and complementary measures, water quality, and biological monitoring studies, and joined the generated tables as described in Section 4.4.5. Based on the insights on regulatory effectiveness of interest to the EPB discussed in Section 6.1, I obtained insights for the EPB, the most important ones being presented in the following subsections.

### 6.6.1 Within the Regulatory Initiative Models

Schedule 4 of the MMER lists the limits of deleterious substances allowed for discharge in the aquatic environment by mines. To determine whether the set of 25 mines complied with these limits, I asked IBM Watson Analytics this abstract question: “*What was the average compliance rate for data on deleterious substances reported by the mines?*” Figure 101 shows the concrete question suggested by IBM Watson Analytics and the resulting visualization of a summary average compliance level of 97, on a scale of 0 to 100.

What is the summary of Deleterious Substances ⊗ ?

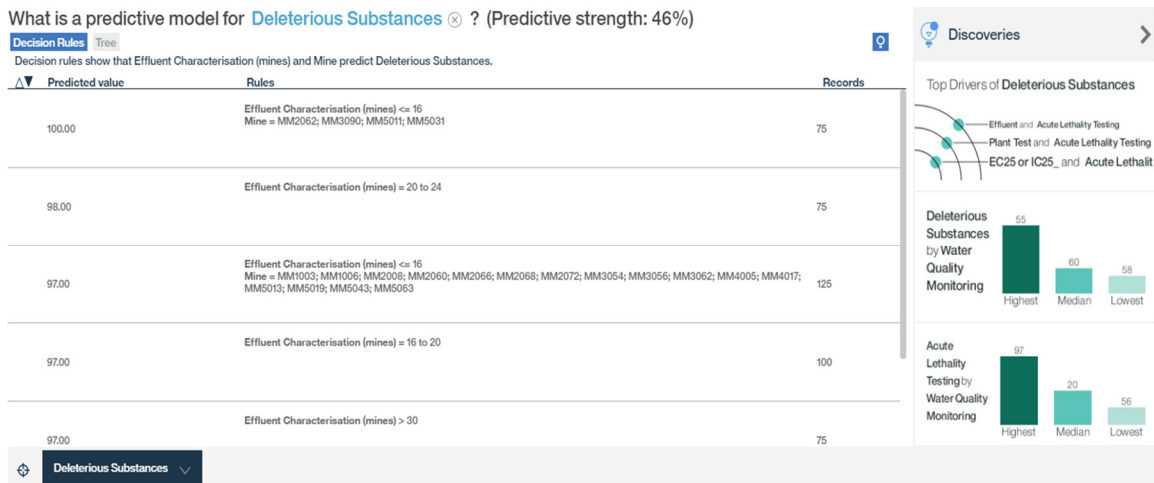
Concrete question asked to  
IBM Watson Analytics.

97.1  
Deleterious Substances (Average)

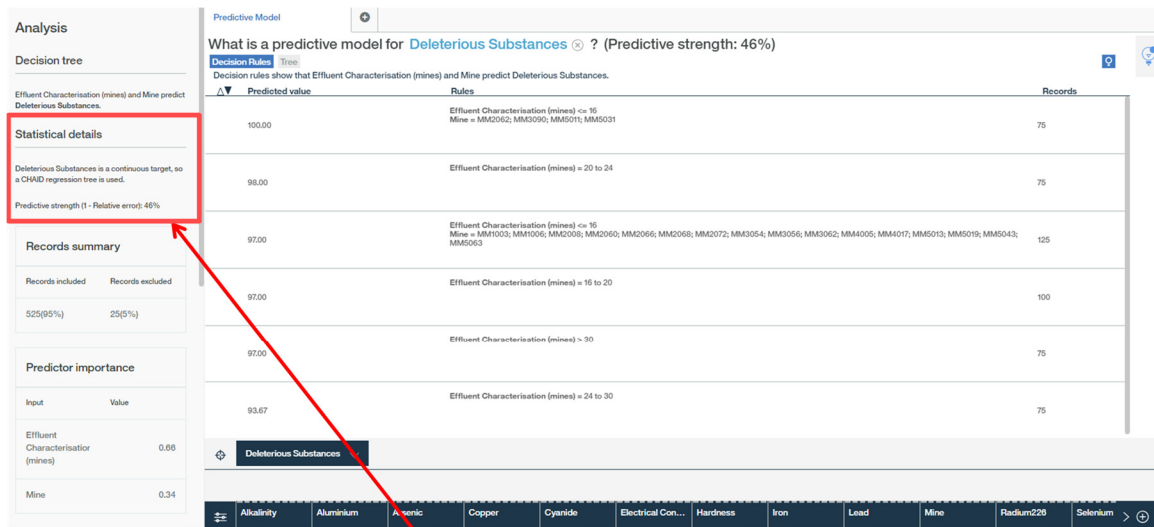
**Figure 101** Summary Value of the Deleterious Substances from 2002 to 2014

With such a high compliance rate by the 25 mines for limits of deleterious substances set in Schedule 4 of the MMER, it becomes useful to know what factors contributes to this. Hence, to determine what factors are responsible for a mine’s compliance with the limits for deleterious substances, I asked IBM Watson Analytics this abstract question: “*What*

factors can predict the compliance with the limits for deleterious substances?”. Figure 102 shows that with a predictive strength of 46%, “Effluent Characterization” and “Mine” can predict how well a mine complies or does not comply with the limit set in Schedule 4 of the MMR. Figure 103 shows that a chi-squared automatic interaction detection (CHAID) regression tree was used to derive this prediction.



**Figure 102** Predictive Model for Deleterious Substances



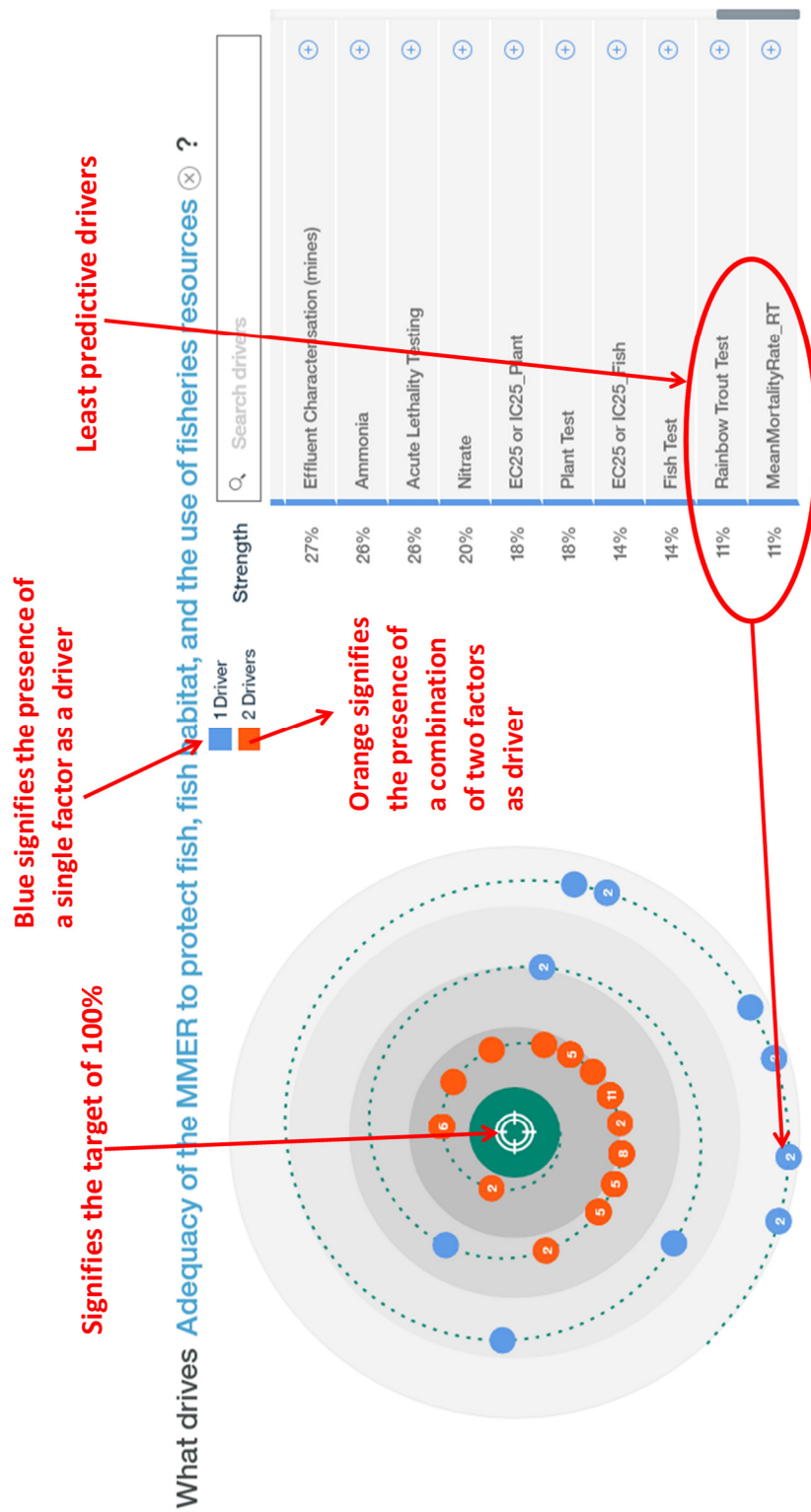
**Statistical test IBM Watson Analytics carries out**

**Figure 103** Statistical Test Used to Arrive at the Predictive Model

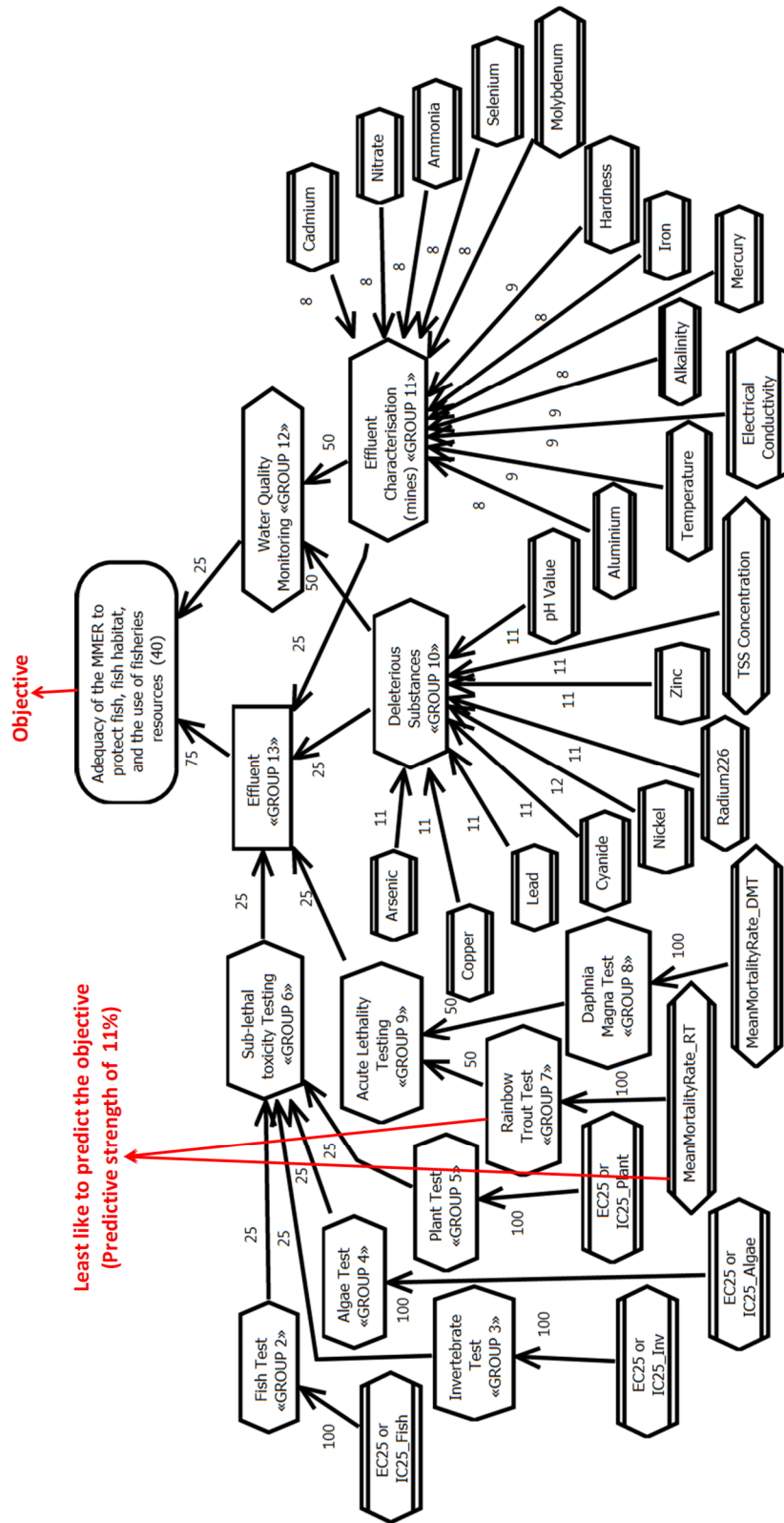
Based on the resources that mines involve in carrying out the complementary measure studies and water quality studies, it becomes useful to identify what contributes the least to these activities. As such, I asked IBM Watson Analytics this abstract question: “*What contributes the least to achieving the objective of the complementary measures studies and water quality studies?*” The objective of the complementary measures studies and water quality studies is the “*Adequacy of the MMER to protect fish, fish habitat, and the use of fisheries resources*”.

Figure 104 shows the concrete question suggested by IBM Watson Analytics. We observed that with a predictive strength of 11%, the “*Rainbow Trout Test*” and its KPI “*MeanMortalityRate\_RT*”, which assesses the mortality rate resulting from the exposure of rainbow trout to effluents, have the least predictive strength. This implies that they have the weakest correlation with achieving the objectives of the complementary measure studies and water quality studies.

Hence, between 2002 and 2014, the evaluated values for the “*Rainbow Trout Test*” and “*MeanMortalityRate\_RT*” of the acute lethality testing were least likely to contribute in demonstrating whether the MMER was adequate to protect the aquatic environment. Figure 105 places this correlation in proper perspective. However, after presenting this result to the Key Informants at the EPB, I learned that, over the years, many control measures such as setting limits for deleterious substances have gone into ensuring that results from acute lethality testing are low. Therefore, the low correlation observed could be an effect of these control measures.



**Figure 104** Least-impactful Drivers of the Complementary Measures Study & Water Quality Study from 2002 to 2014



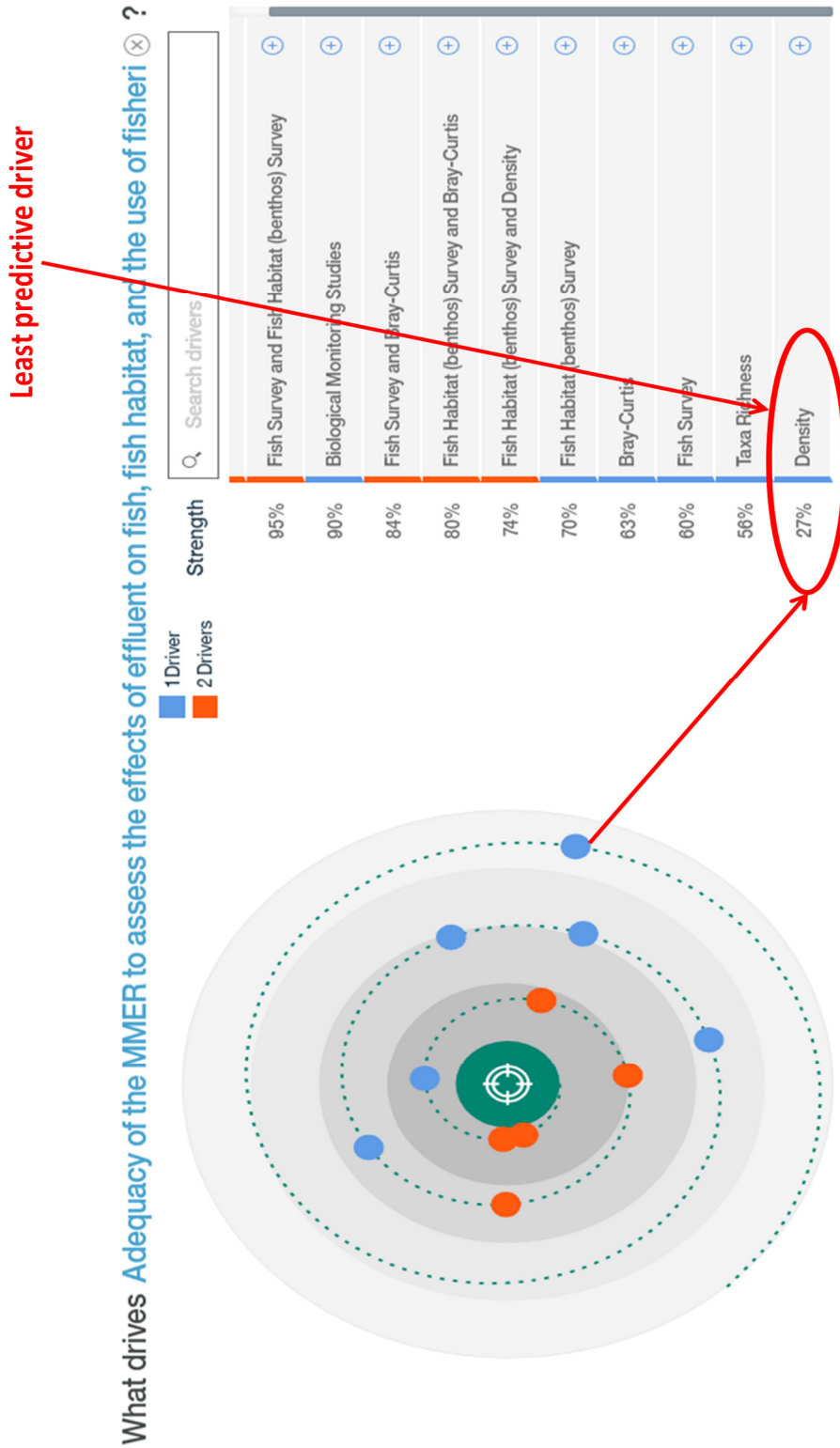
**Figure 105** GRL Model showing the Least-impactful Drivers of the Complementary Measures Study & Water Quality Study from 2002 to 2014 in Proper Perspective

Similarly, to identify what contributes the least to the biological monitoring studies, I asked IBM Watson Analytics this abstract question: “*What contributes the least to achieving the objective of the Biological Monitoring Studies?*” The objective of the biological monitoring studies is the “*Adequacy of the MMER to assess the effects of effluent on fish, fish habitat, and the use of fisheries resources*”. Figure 106 shows the concrete question suggested by IBM Watson Analytics. Here, we observe that with a predictive strength of 27%, the “*Density*” indicator of the fish habitat survey, which indicates the number of benthic invertebrate individuals per square meter, has the least predictive strength. This implies that it has the weakest correlation with achieving the objective of the biological monitoring studies. The evaluated value for “*Density*” in 2014 was therefore least likely to contribute in demonstrating whether the MMER is adequate to assess the effect of effluents on the aquatic environment. In addition, Figure 107 puts this in perspective.

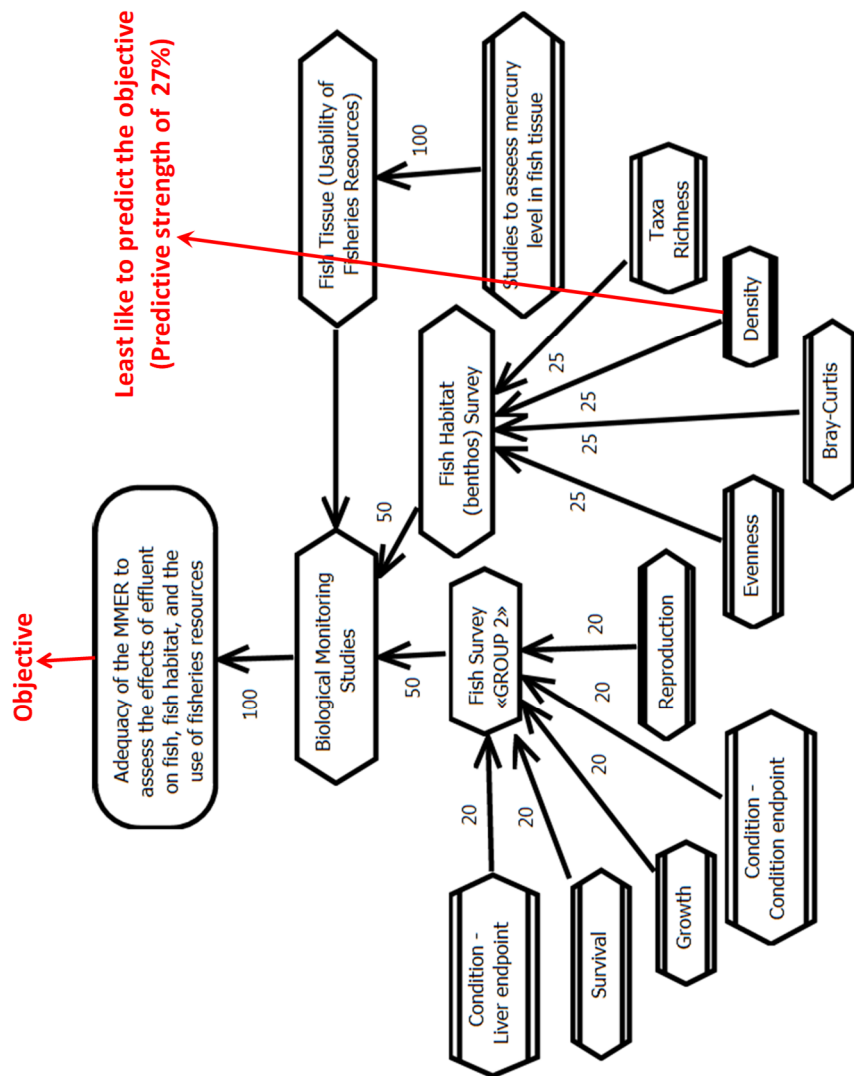
## 6.7. Conclusion

In this chapter, I presented how I used GoRIM in a third-party assessment of the effectiveness and efficacy of the MMER using the GoRIM steps described in Section 4.3. The feasibility of third-party assessment of their regulation was of high interest to the EPB regulator. Based on GoRIM’s steps described in Section 4.2, I only used Steps 1 to 6 for this application of GoRIM to the MMER. Although I did not address the “Periodic Enforcement/Evaluation” and “Evolve” steps (Steps 7 and 8) in this case study, the EPB could use the insights derived from the use of GoRIM for these steps.

In this case study, I was able to use the lessons I learned on addressing instances of no data when evaluating the models that I encountered in the first case study, which I discussed in Section 5.4. This iterative learning facilitated adequately the valuation of the models on EEM’s complementary measures and water quality, and biological monitoring studies, as I discussed in Section 6.5. In addition, I was able to derive new insights that infer and attribute to the effectiveness of a regulation using IBM Watson Analytics. These insights such as elements in the model that are able to predict results, and elements in the models that are drivers of the models. These insights are different from those derived in the first case study and contribute to the knowledge of using GoRIM to show regulatory effectiveness.



**Figure 106** Least-Impactful Drivers of the Biological Monitoring Study for 2014



**Figure 107** GRL Model showing the Least-impactful Drivers of the Biological Monitoring Studies for 2014 in Proper Perspective

The identification of least-impactful drivers (often indicators) in a single model, for example “Effluent Characterization” in Section 6.6.1, is also a feature that benefits from evidence. Modellers could believe that they can always identify the indicators with the lowest global contribution to a top-level goal from the structure of the GRL model itself. However, the presence of AND/OR decompositions and dependencies in a model make this identification difficult, and the absence of data for some strategy also compound this identification problem. The use of a tool such as IBM Watson Analytics enables the evidence-based identification of (single or pairs of) least-impactful drivers in a reliable way.

Furthermore, my assessment of the effectiveness and efficacy of the MMER, based on the regulator's interests introduced in Section 6.1, showed:

- a) With a predictive strength of 46%, the values reported by mines for elements that constitutes "Effluent Characterization" and the mine itself are most likely to predict how well a mine complies or does not comply with the limits sets in Schedule 4 of the MMER. This suggests that the requirements in the MMER such as the limits in Schedule 4 are more likely to determine if a mine's activity are protective of the aquatic environment fisheries and could imply that the MMER is effective.
  
- b) Drivers in the complementary measures and water quality studies demonstrate that the MMER was adequate to protect fish, fish habitat, and the use of fisheries resources. In addition, drivers in the biological monitoring studies demonstrate that MMER was adequate to assess the effects of effluent on fish, fish habitat, and the use of fisheries resources. This information on the drivers can trigger a discussion among the EBP team members as to whether low-impact indicators (such as "MeanMortalityRate" and "Density") should be monitored and used in the future. This could lead to potential cost-saving and time-saving opportunities with focus on other indicators of higher impact.

The GRL models in this case studies were also large. There were 38 GRL intentional elements (21 Goals, and 17 KPIs), and 210 GRL evaluation strategies in the MMER model (regulation). This model is also comprised of three diagrams, one for each of the two sections and one for the overview. The GRL model of the EEM requirements had four diagrams, one for the complementary measures study and water quality study, one for the biological monitoring, one for the overview and one for the conditions. In total, the models had one actor, 57 intentional elements (2 goals, 15 tasks, 1 resource and 39 KPIs). The model also had 210 evaluation strategies for the complementary measures study and water quality study, and 25 evaluation strategies for the biological monitoring study.

In the next chapter, I describe the application of GoRIM to the third and final case study.

## Chapter 7. Case 3: Regulator X Legislative Requirements

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In this chapter, I apply GoRIM to the third and final study in the multiple-case study, which again involves a real-life regulatory scenario from a new domain. Here, I describe my use of GoRIM to show the effectiveness of the legislative requirements of a Canadian regulator (anonymized here as *Regulator X*).

Note that this chapter reports on a proof of concept used as one iteration in my DSRM-based approach (Figure 5). In that context, the analysis results reported in this chapter are for illustration purpose only and should not be used in any way to influence decision-making or to draw conclusion about the performance of the regulator or the regulation.

I first give an overview of the case study, and then I show my application of GoRIM to the legislative requirements of the regulator.

### 7.1. Case Study Overview

Regulator X is a regulator in Canada that oversees the safety of facility and infrastructure projects. As such, Regulator X has different legislative requirements with which companies have to comply. To achieve its top priority of safety, Regulator X requires companies under its legislative requirements to report on their activities. The mandated reporting includes:

- a) *Measures 1*: A historic view of a company's performance. These are reports of incidents (release of substances, injuries, etc.).
- b) *Measures 2*: A prediction of a company's performance.

A mix of *measures 1* and *2* provides an overview of a company's effectiveness in meeting Regulator X's legislative requirements. This mix of *measures 1* and *2*, called the "Safety Protection function", is the regulatory initiative employed by Regulator X to administer its legislative requirements.

Consequently, this case study focuses on the effectiveness of Regulator X’s legislative requirements and the Safety Protection function. Six Key Informants from Regulator X agreed to participate in this case study. Table 17 lists their roles and years of experience.

**Table 17** Summary of Key Informants in Regulator X

<b>S/N</b>	<b>Role</b>	<b>Years in Role</b>	<b>Duties</b>
01	Subject Matter Expert on Regulations and responsible for regulatory initiatives	5 to 10 years	Involved in creating and administering Regulator X’s legislative requirements and the Safety Protection function
02	Responsible for Regulatory Initiatives	Less than 10 years	Involved in creating and administering the Safety Protection function
03	Subject Matter Expert on Regulations.	Less than 5 years	Involved in creating and administering Regulator X’s legislative requirements
04	Responsible for Regulatory Initiatives	Less than 10 years	Involved in creating and administering the Safety Protection function
05	Responsible for Regulatory Initiatives	Less than 10 years	Involved in creating and administering the Safety Protection function
06	Responsible for Regulatory Initiatives	Less than 5 years	Involved in creating and administering the Safety Protection function

In participating in the case study, Regulator X was interested in:

- a) Reviewing the effects of its legislative requirements on a company’s performance, and on the safety protection outcomes.
- b) Identifying the linkage between the legislative requirements and observed compliance results.
- c) Identifying data gaps that exist in order for Regulator X to measure regulatory effectiveness.

The application of GoRIM to Regulator X’s context involved creating models of the legislative requirements and activities involved in the Safety Protection function. After creating the models, I inputted into the models collected data on non-compliance with the legislative requirements and performance of the activities involved with the Safety Protection func-

tion. This enables Regulator X to assess the level of non-compliance of the legislative requirements and performance of the Safety Protection function. I then exported the analyzed data from the models into IBM Watson Analytics to enable visualization and further analysis of the effectiveness of Regulator X's legislative requirements. In the following sections, I describe how I used the steps of GoRIM in this context.

## 7.2. Creating Models for Regulator X

Regulator X has different legislative requirements in twelve regulatory instruments with which companies have to comply. Compliance with these legislative requirements is binary. Either companies comply or they do not. Regulator X audits and evaluates companies against the legislative requirements to determine instances of non-compliance. Non-compliance means a company fails to meet all requirements in the respective regulatory instrument and a company that meets all requirements in the respective regulatory instrument is complying.

Regulator X uses five tools to identify non-compliance with the legislative requirements. Let these tools be “*Tool 1 (T1)*”, “*Tool 2 (T2)*”, “*Tool 3 (T3)*”, “*Tool 4 (T4)*” and “*Tool 5 (T5)*”. Regulator X uses each non-compliance identification tool independently for each regulatory instrument. For example, “*Tool 2 (T2)*” can be used independently for the regulatory instrument 1 or for the regulatory instrument 8. To create the GRL model of Regulator X's legislative requirements, I created a tabular representation of the regulatory instruments that the Key Informants provided using the approach described in Section 4.3.1. The Key Informants provided only the requirements in the regulatory instruments that had non-compliance. I obtained the text of these requirements from the respective legislative documents. I also obtained their contributions (subparagraphs to paragraphs, paragraphs to subsections and subsections to sections) from the Key Informants that are subject matter experts on the legislative requirements. The opinion given was that, the hunting provisions have Equal Relative Weights (ERW), i.e., “all contributions targeting the same intentional element have equal weights, neglecting the fact that some contributors might be more important than others” (Akhigbe et al., 2014).

Regulator X did not have any KPIs for measuring non-compliance. As such, I proposed using the five tools used to identify non-compliance. With input from the Key Informants at Regulator X, I ranked the tools based on the perceived weight of the tool in its use to identify non-compliance. Hence, this ranking determines the contribution of the tools in terms of effort to identify non-compliance with the respective subparagraph, paragraph, subsection or section of the regulatory instrument for the purpose of analysis. Table 18 shows the ranking for Regulator X’s non-compliance identification tools. I then created a tabular representation for all Regulator X’s legislative requirements, saved the tabular representation as a CSV file and imported the file into jUCMNav to derive the produce the GRL model.

**Table 18** Ranking of the RX Non-Compliance Identification Tool

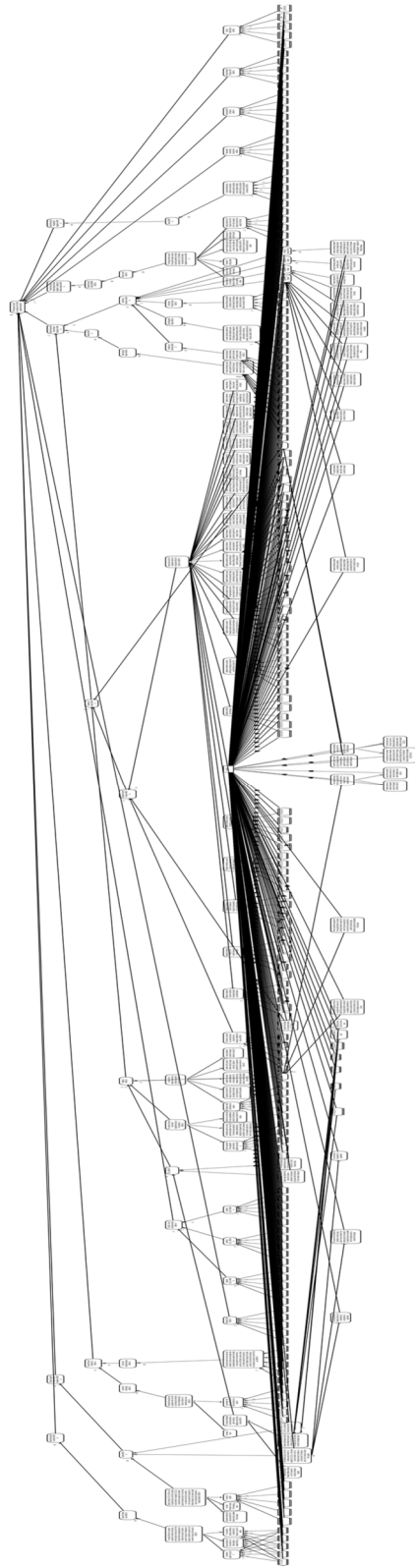
<b>Rank</b>	<b>Non-Compliance Identification Tool</b>	<b>Average</b>	<b>Percentage</b>
1	Tool 3 (T3)	0.0833	8
2	Tool 1 (T1)	0.1667	17
2	Tool 5 (T5)	0.1667	17
4	Tool 2 (T2)	0.2500	25
5	Tool 4 (T4)	0.3333	33
<b>TOTAL</b>		<b>1</b>	<b>100</b>

Similarly, I manually created the model for Regulator X’s Safety Protection function, including its activities, resources used and objectives, in line with the regulatory initiatives metamodel described in Section 4.3.1. Regulator X uses *measures 1* and *measure 2* to facilitate oversight of companies under the scope of the legislative requirements. As such, Regulator X had indicators for *measures 1* and *measure 2*, which I collected from the Key Informants to create the GRL models.

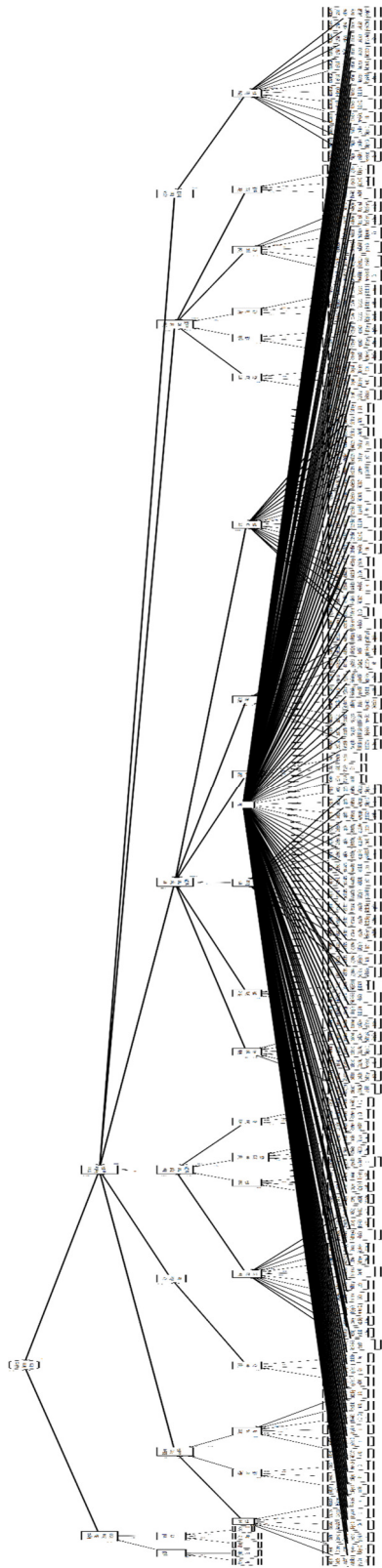
Figure 108 and Figure 109 illustrate the detailed models of Regulator X’s legislative requirements and safety protection function, respectively<sup>9</sup>.

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<sup>9</sup> These detailed models of Regulator X’s legislative requirements and safety protection function are for illustration purposes to illustrate how comprehensive the models are while keeping the models anonymized.



**Figure 108** GRL Model of Regulator X's Legislative Requirements Function (Not Meant to Be Read)

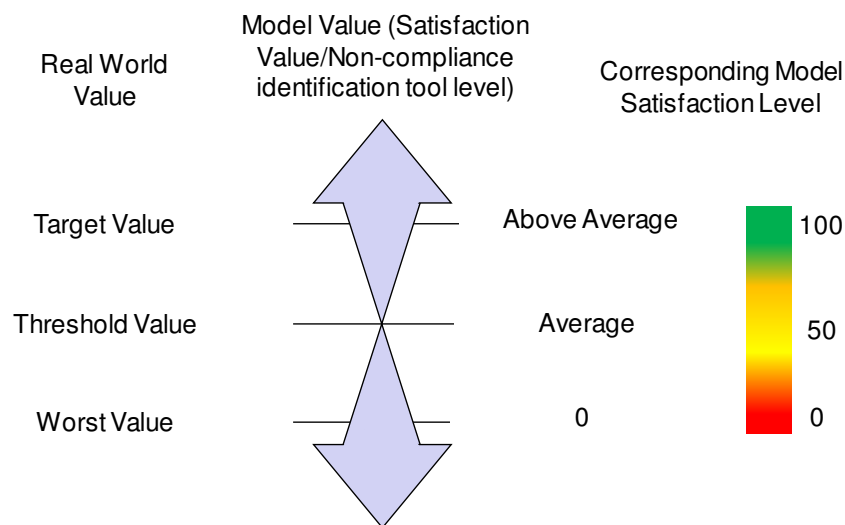


**Figure 109** GRL Model of Regulator X’s Safety Protection Function (Not Meant to Be Read)

### 7.3. Data Preparation for Regulator X

Regulator X provided data from 2016 to 2017 on the identification of non-compliance with its legislative requirements. These data represented the numbers of occurrences for each of the non-compliance identification tools. I observed that no limits were set as benchmarks to ascertain what numbers of occurrences are better or worse. Hence, based on the data provided, I proposed using the average of the number of occurrences for each non-compliance identification tool as a baseline, which was accepted by the Key Informants. This enabled determining target, threshold and worst values for the KPIs. Figure 110 illustrates the structure of the KPI that I used for the effort towards identifying non-compliance with Regulator X’s legislative requirements. Here:

- *Target Value*: Value above the average occurrence of the non-compliance identification tool based on available data.
- *Threshold Value*: Average value of occurrence of the non-compliance identification tool based on available data.
- *Worst Value*: zero, signifying no occurrence of the non-compliance identification tool, i.e., the legislative requirements have been satisfied.

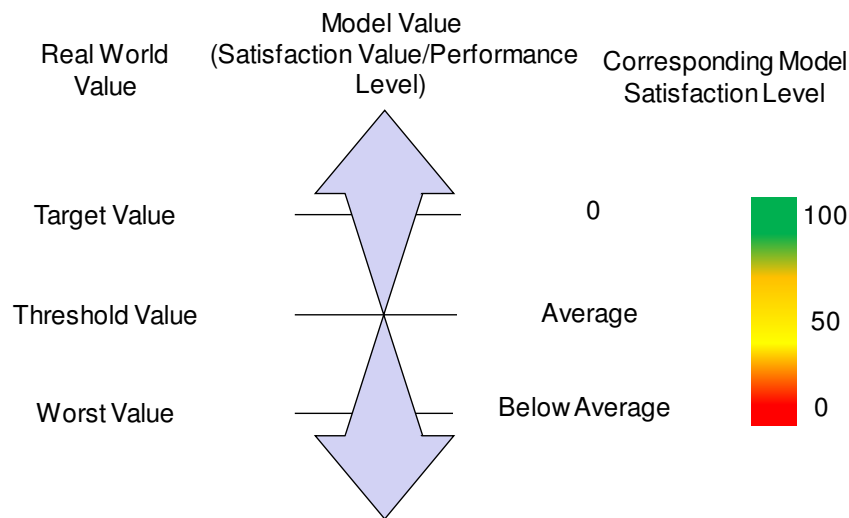


**Figure 110** KPI Structuring for Occurrence of the Non-Compliance Identification Tool

In addition, Regulator X provided data from 2008 to 2017 on *measures 1* and from 2013 to 2014 for *measures 2*. In the absence of a baseline, I also used averages of *measures 1* and *measure 2* based on the available data to determine the target, threshold and worst

values for the KPIs of the Safety Protection function. Accordingly, Figure 111 and Figure 112 show the structure of the indicators that I used respectively for *measures 1* and *measures 2*. Here, for the *measures 1*:

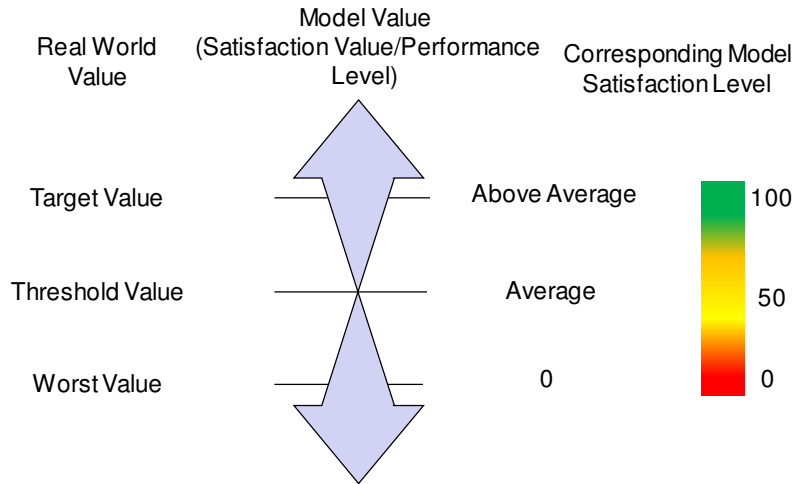
- *Target Value*: Zero, signifying no report of any incident or unauthorized activity by any company based on available data.
- *Threshold Value*: An average value of the recorded incidents or authorized activities based on available data.
- *Worst Value*: Value above the average of the recorded incidents or authorized activities based on available data.



**Figure 111** KPI Structuring for the Measures 1

For the leading *measures 2*:

- *Target Value*: Value above the average value of performance measure aimed based on available data.
- *Threshold Value*: Average value of the performance measure aimed based on available data
- *Worst Value*: Zero, signifying the least absence of any value for the performance measure based on available data.



**Figure 112** KPI Structuring for the Measures 2

As for the two previous case studies, I set these target, threshold and worst values for the respective KPIs of Regulator X’s legislative requirements and the Safety Protection function, as the preconfigured values for each KPI in the “Indicator” files. I then used the ESP tool (see Appendix A) to derive respective GRL evaluations strategies for 2008 to 2017 using the “Indicator” files and values for each KPI obtained from Regulator X, i.e., the “Source” file. Although the data on the Regulator X’s legislative requirements were from 2016 to 2017, from 2013 to 2014 for *measures 1* and from 2008 to 2017 for *measures 2*, I derived evaluation strategies for all models from 2008 to 2017, as requested by the Key Informants in order to have uniformity.

#### **7.4. Model Corrections for Regulator X Models**

After producing the GRL evaluations strategies with ESP, based on available data, I selected the strategies from 2014 and 2017 as input to the GRL models for the Safety Protection function and Regulator X’s legislative requirements. This is because there were data available for both *measures 1* and *measure 2* in 2014, and there were data available for Regulator X’s legislative requirements in 2017. In addition, I checked the models against the 19 URN well-formedness rules listed in Table 12. The models of the Safety Protection function and Regulator X’s legislative requirements responded and behaved correctly. After inputting the selected evaluation strategies, I set the condition to ignore all KPIs that do not have any data, as described in Section 5.4. I also created five groups in the model of

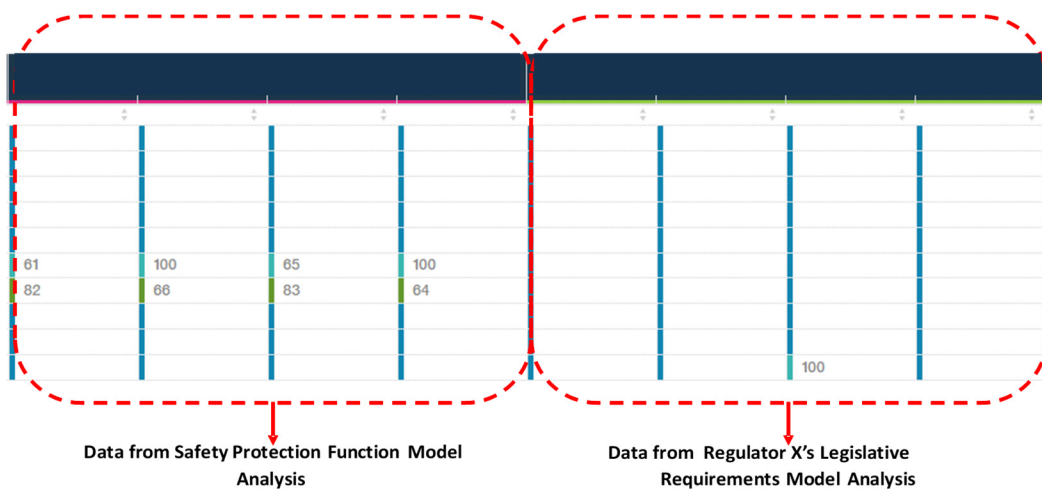
Regulator X’s legislative requirements, and three groups in the model of the Safety Protection function, for conditions with no data. I then tagged the respective intentional elements in each of the evaluation strategies.

## 7.5. Data Input and Output

After correcting the models, I imported the 10 GRL evaluation strategies produced by ESP for each model. I then exported and saved the model satisfaction values for effort required to identify non-compliance with Regulator X’s legislative requirements and performance of the Safety Protection function from jUCMNav as CSV files.

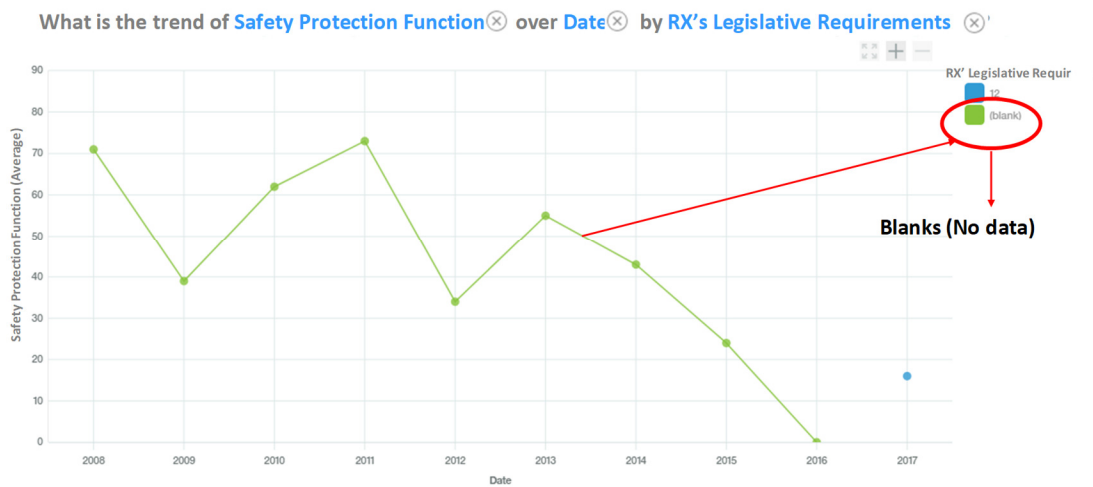
## 7.6. Extracting Insight from IBM Watson Analytics

As presented in Section 7.1, Regulator X’s context shows the legislative requirements that regulated companies have to comply with, together with measures used to report on the safety protection function. Hence, I imported the output of jUCMNav (one file for the legislative requirements results and another one for the safety function results) into IBM Watson Analytics. I also joined the files using the approach described in Section 4.4.5. However, owing to very limited data provided for evaluation, the CSV files had many blanks (no data). Consequently, the joined data in IBM Watson Analytics also had many blanks, as shown in Figure 113.



**Figure 113** Joined Data of Regulator X’s Legislative Requirements and Safety Protection Function in IBM Watson Analytics

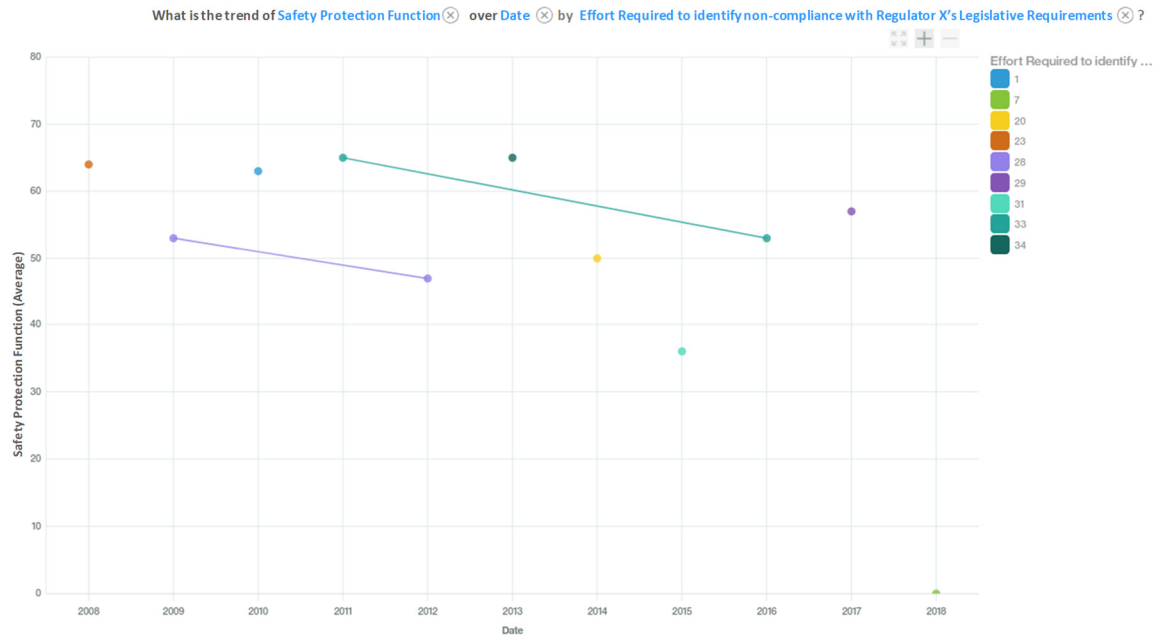
As such, I could not infer much with the insight I obtained from IBM Watson Analytics on the regulatory effectiveness interests of Regulator X, discussed in Section 7.1. For example, when I asked IBM Watson Analytics an abstract question to determine the effects of Regulator X’s legislative requirements on a company’s performance and on the safety protection outcomes, I obtained the suggested question and visualization shown in Figure 114. We can see from the visualization that there is indeed a trend in the Safety Protection function resulting from the level of the effort required to identify non-compliance with Regulator X’s legislative requirements between 2008 and 2016. However, IBM Watson Analytics made the trend projections based on the presence of multiple blanks (no data) in analyzed data. Hence, the presence of these blanks makes it almost impossible to ascertain what the trend means since it just reflects the absence of data in the data sets IBM Watson Analytics is analysing.



**Figure 114** Sample Visualization with Sparse or No Data in IBM Watson Analytics

Therefore, to address the presence of blanks in the visualizations provided by IBM Watson Analytics and to provide meaningful insights on the effectiveness of Regulator X’s legislative requirements, I used some data randomly generated under some assumptions discussed with the Key Informants. After importing and joining the synthetic data in IBM Watson Analytics, Figure 115 illustrates the suggested question and visualization to the same abstract question to determine the effects of Regulator X’s legislative requirements on a company’s performance and on the safety protection outcomes. Here, we can explore

whether there is a more meaningful trend of the performance of the Safety Protection function resulting from the level of effort required to identify non-compliance with Regulator X’s legislative requirements, between 2008 and 2016.



**Figure 115** Sample Visualization with Complete Data in IBM Watson Analytics

The line between 2009 and 2012, and between 2011 and 2016, indicate that for the same effort on these years, the performance of the Safety Protection function went down. More interestingly, similar performances are observable in 2008, 2010, 2011, and 2013, but for vastly different levels of effort during these years (23, 1, 33, and 34), suggesting there is no clear trend observable. Additional analysis (involving linear regression) might provide a clearer picture, but the presence of much synthetic data used as input did not make it worth having additional investigation at this time.

## 7.7. Conclusion

In this chapter, I presented how I used GoRIM to demonstrate the effectiveness of Regulator X’s legislative requirements comprising twelve regulatory instruments. As in the two previous case studies, I did not address the “Periodic Enforcement/Evaluation” and “Evolve” steps here, although a regulator could. While I iteratively applied the lessons

learned in the first and second case studies described in Chapter 5 and Chapter 6 to evaluate and exploit the models developed for Regulator X, I also learned new lessons.

This case study presented me the opportunity to address a real-life scenario with very sparse data, but the same requirement of showing regulatory effectiveness. I was unable to demonstrate regulatory effectiveness without sufficient data, but the use of synthetic data allowed me to show how regulatory effectiveness could potentially be evaluated, and this proved to be of high interest to Regulator X (as initially highlighted in Section 7.1). This also became a motivation for Regulator X to start collecting data more rigorously to address the data gap highlighted during the case study.

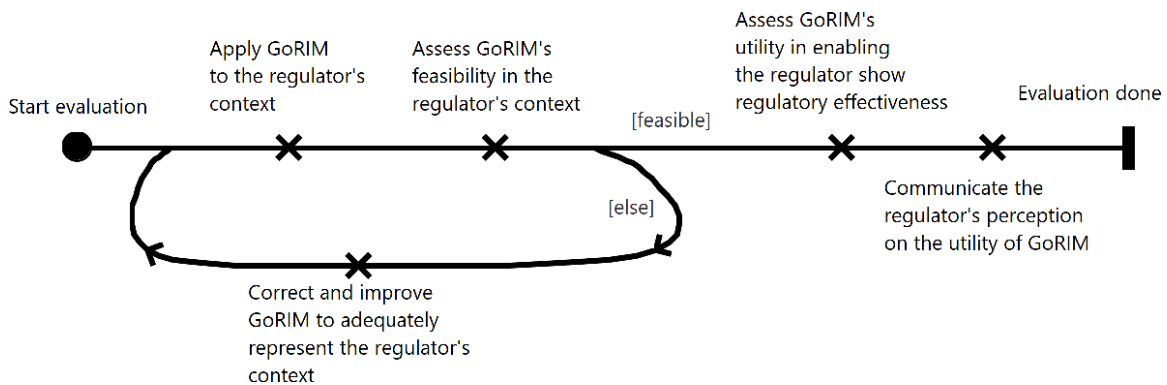
The GRL model of Regulator X's legislative requirements was very large, comprising 21 diagrams, 303 intentional elements (132 goals, 170 KPIs and 1 resource), and 10 evaluation strategies. The Safety Protection function model had 10 diagrams, 160 intentional elements (1 goal, 30 resources and 129 KPIs) and 10 evaluation strategies. The handling of these very large models and their evaluation strategies also confirm the scalability and robustness of GRL, jUCMNav, ESP, and IBM Watson Analytics for regulatory intelligence.

In line with the principles of DSR, and the DSRM the thesis employs, in the next chapter, I present and discuss the results of the evaluation of GoRIM in the three case studies presented in Chapter 5, Chapter 6 and this chapter (Chapter 7), which collectively make up the multiple-case study, and the limitations of the evaluation.

## Chapter 8. Evaluation of GoRIM

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In this chapter, I present the evaluation of GoRIM used to assess its feasibility in different regulator contexts and its utility to regulators in showing the effectiveness of regulations. As described in Section 3.4.2, the UCM process model illustrated in Figure 116 outlines the steps I used in evaluating GoRIM with each regulator. In line with DSR principles, I assessed GoRIM after I demonstrated, in each of the three case studies described in Chapter 5, Chapter 6 and Chapter 7, that GoRIM captures each regulator's regulations and regulatory initiatives. I then applied GoRIM to address regulatory effectiveness questions of interest to the regulator in each case, demonstrated how I used GoRIM and the results I obtained. Afterwards, I assessed the utility of GORIM.



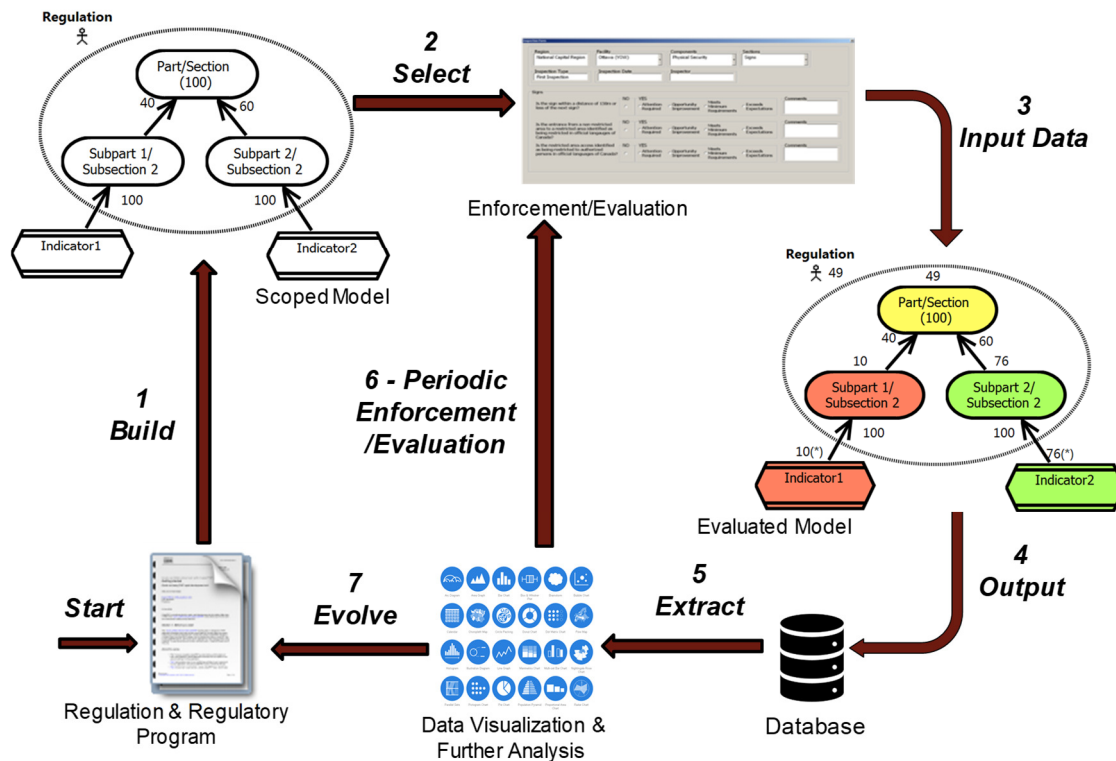
**Figure 116** Steps Followed for Evaluating GoRIM in this Thesis

After applying GoRIM in each case study, I assessed the Key Informants' perception on GoRIM's feasibility, i.e., its ability to model the regulations and regulatory initiatives, to utilize the provided data to analyze the models and to provide meaningful insights using analytics tools. If the Key Informants agreed that using GoRIM in their context was feasible, I moved on to use GoRIM to address their real-life, performance-related questions. Then, I assessed GoRIM's perceived usefulness in enabling the regulator to show whether the regulation and its supporting regulatory initiatives were effective, and communicated these positive and negative perceptions. If the Key Informants did not agree that GoRIM was feasible in their context, I moved on to correct the issues or concerns raised, applied

GoRIM again to the regulator’s context, assessed its feasibility and then proceeded to assess its utility or to address, iteratively, more issues or concerns raised.

## 8.1. Evaluating the Feasibility of GoRIM

Building upon the process for managing outcome-based regulations proposed by Tawhid et al. (2012), Figure 117 illustrates the first iteration of GoRIM.

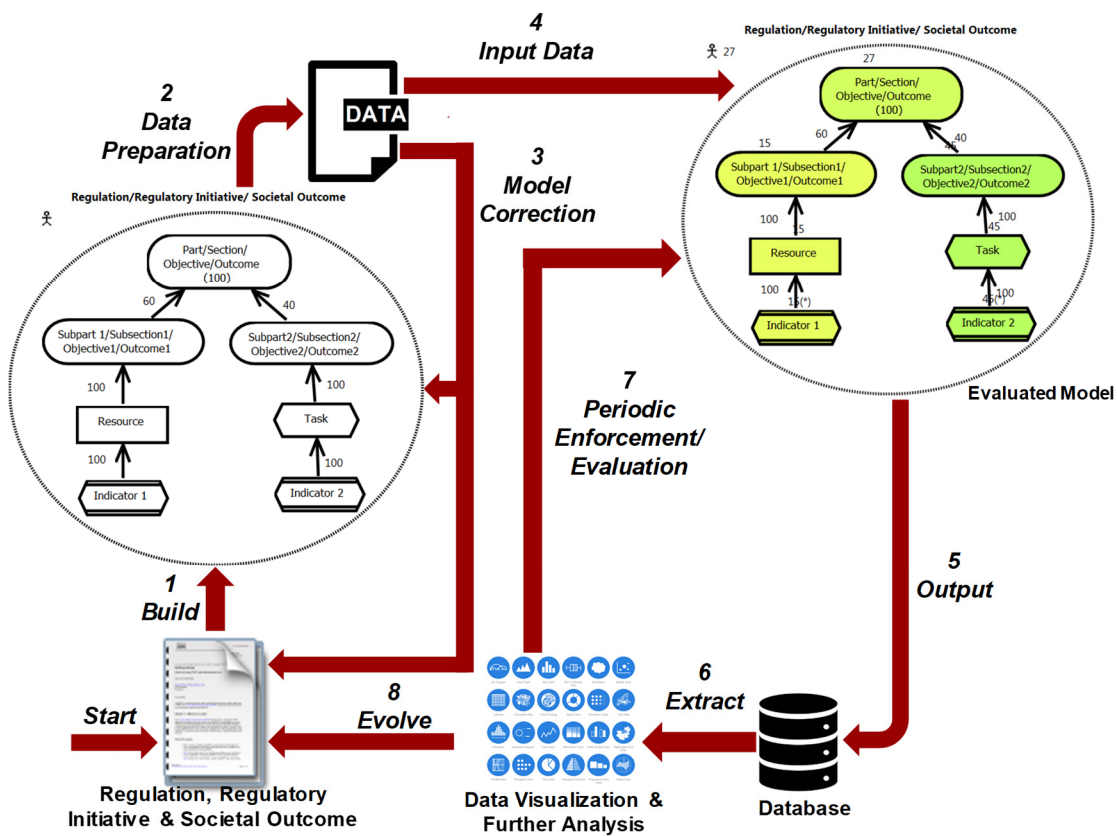


**Figure 117** First iteration of GoRIM (Akhigbe, Heap, Islam, et al., 2017)

In this iteration, presented in Akhigbe, Heap, Islam et al., (Akhigbe, Heap, Islam, et al., 2017), GoRIM starts with the “*Build*” step where the models of the regulation and regulatory initiative (i.e., a program) are built using jUCMNav. In Tawhid et al. (2012), the “*Select*” step was used to select questions to be answered by inspectors/auditors/enforcement officers (or regulated parties themselves when self-reporting), during periodic compliance enforcement activities. These questions help collect values to feed indicators. In our case, such questions were unavailable and hence we simply assumed that regulators had mechanisms in place to collect data. Such data are input into the goal models as GRL evaluation

strategies in the “Input Data” step. After evaluating the models by taking snapshots of different compliance levels of the regulation and performance levels of the regulatory initiative, the model satisfaction values are stored in a database in the “Output” step. In the “Extract” step, the stored data are extracted, analyzed or visualized using a data analytics or data visualization software, and needs for reinforcements or re-evaluations are highlighted in the “Periodic Enforcement/Evaluation” step. Finally, based on the needs for evolution (addition, change, or repeal) identified in the “Extract” step, the regulation or regulatory initiatives are evolved.

During the case studies described in Chapter 5, Chapter 6 and Chapter 7, meeting the Key Informants to understand their contexts and applying GoRIM, this first iteration was improved substantially to its current state, illustrated in Figure 118. I described the second iteration of GoRIM in Chapter 4.



**Figure 118** Second Iteration of GoRIM

Among noticeable improvements to GoRIM, I removed the “Select” step where questions to be answered are selected, and added the “Data Preparation” step, where sample data are

tested on the model. I also added the “Model Correction” step, where the models are checked against well-formedness rules and sample strategies and then corrected to ensure that their analysis behaviour is aligned with the given regulatory context. As such, the evaluation of the feasibility of GoRIM reported in this thesis was done after applying the first and second iteration of GoRIM to the case studies. The evaluation assessed whether GoRIM was feasible in the regulator’s context and whether the improvements to GoRIM made it more feasible. The evaluation of the feasibility of GoRIM was done between August and December 2017, a little over a year after the case studies started. This was partly a result of challenges with the availability of the Key Informants to participate in the evaluations.

The evaluation of GoRIM involved administering the “Questionnaire for Key Informant on GoRIM Validation”<sup>10</sup>. Of the four Key Informants from the CWS that agreed to participate in the first case study, three also participated in the evaluation of GoRIM’s feasibility. For the second case study, all four that agreed to participate from the EPB also participated to the feasibility evaluation. Finally, for the third case study, four of the six Key Informants from Regulator X participated. This results in a total of eleven individual responses for the evaluation of GoRIM’s feasibility for the first iteration, and nine for the second iteration. While the Key Informants at the CWS and Regulator X participated to the first and second evaluations, the Key Informants at the EPB were satisfied with the first iteration of GoRIM’s feasibility and did not answer the second evaluation, as their opinion had not changed.

The questionnaire focusing on GoRIM’s feasibility consisted of questions that describe the ability of GoRIM to adequately model the regulator’s regulation and regulatory initiative, to utilize provided data to analyze the models and to provide meaningful insights using analytics tools. The questionnaire is composed of 15 questions.

Question 1 (“*What best describes your role?*”), Question 2 (“*How long have you been in this role?*”) and Question 5 (“*How does your department/agency describe the performance of a regulation?*”) collected demographic information from the respective Key Informants. As shown in Table 19, I have used responses to these questions in my description of the cases studies in Sections 5.1 (Table 13), 6.1 (Table 15) and 7.1 (Table 17).

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<sup>10</sup> Questionnaire available at <http://www.eecs.uottawa.ca/~damyot/pub/AkhigbePhD/>

**Table 19** Use of Q1, Q2 and Q5 in the Summary of Key Informants

<b>Role</b>	<b>Years in Role</b>	<b>Duties</b>
Obtained from Q1	Obtained from Q2	Obtained from Q5

Questions 3 and 4 addressed the regulator and their current approach to regulatory performance. Questions 6 to 12 addressed comments on the application of GoRIM, while Questions 13 to 15 addressed the characteristics of GoRIM that the Key Informants liked or disliked, or for which there are required improvements.

### **8.1.1 Questions on the Regulator and on the Use of GoRIM**

In line with the qualitative data analysis technique selected in this thesis and to target the responses from the Key Informants, I used some questions in the Likert format. The Likert scale method is a unidimensional method of measuring responses about agreement or disagreement (Likert, 1932). I used Likert five-item questions for Questions 3, 4 and 6 to 12 because I was interested in the responses of the Key Informants for each individual question. Given the low number of respondents (11 in total), responses to these questions are provided in a descriptive, tabular format. This format describes responses (X) of each Key Informant for the first and second evaluations, which enable to understand whether Key Informants became more positive or negative about GoRIM during the study. The column for responses of the second evaluation are in grey. Note that EPB's Key Informants chose not to participate in the second evaluation since they were fine with the first iteration of GoRIM and did not change their mind. The responses to the "Questionnaire for Key Informant on GoRIM Validation" are described in the next tables.

Question 3: *Your department/agency monitors and reports on regulations.*

As mentioned in Section 8.1, this question provides simple insight on the regulators and this analysis only reports on how the Key Informants view the regulator. Questions 3 assessed whether the regulator monitors and reports on regulations. We observe from the responses in Table 20 that while most Key Informants (9/11) agreed or strongly agreed that their department or agency monitors and reports on the regulation, two were neutral and none disagreed. We also observe that three Key Informants (underlined) changed their views to a lower score after the second iteration of GoRIM, suggesting that some people

better understood the concepts of monitoring and reporting, and their own contributions in that area.

**Table 20** Key Informants Responses to Question 3

Key Informants	Role	Yrs. in Role	First Evaluation					Second Evaluation				
			SA	A	N	D	SD	SA	A	N	D	SD
CWS01	Regulation	≥15		X						X		
CWS02	Regulatory Initiative	<5		X					X			
CWS03	Regulation	<10	X									
EPB01	Regulatory Initiative	≥15		X								
EPB02	Regulatory Initiative	<10		X								
EPB03	Regulation	<15		X								
EPB04	Regulatory Initiative	<5	X									
RX01	Both	<15			X							X
RX02	Both	<15			X					X		
RX03	Both	<10		X						X		
RX04	Regulatory Initiative	<10		X								

**LEGEND**  
SA: Strongly Agree A: Agree N: Neutral D: Disagree SD: Strongly Disagree

Question 4: *Your department/agency does a formal review of regulations.*

**Table 21** Key Informants Responses to Question 4

Key Informants	Role	Yrs. in Role	First Evaluation					Second Evaluation				
			SA	A	N	D	SD	SA	A	N	D	SD
CWS01	Regulation	≥15		X						X		
CWS02	Regulatory Initiative	≤5		X						X		
CWS03	Regulation	<10	X									
EPB01	Regulatory Initiative	≥15		X								
EPB02	Regulatory Initiative	<10		X								
EPB03	Regulation	<15		X								
EPB04	Regulatory Initiative	<5	X									
RX01	Both	<15			X							X
RX02	Both	<15				X				X		
RX03	Both	<10		X						X		
RX04	Regulatory Initiative	<10		X								

**LEGEND**  
SA: Strongly Agree A: Agree N: Neutral D: Disagree SD: Strongly Disagree

Questions 4 assessed whether the regulator does a formal review of regulations. We observe from the responses in Table 21 that most Key Informants (9/11) agreed or strongly

agreed that their department or agency monitors does a formal review of regulations, one was neutral and one disagreed. We also observe that five Key Informants (underlined) from the first and third case studies changed their views for a more negative answer after the second iteration of GoRIM, again suggesting a better understanding of formal reviews and their current practices in that area.

Question 6: *The GoRIM model of the regulation, its parts and subsections, is an accurate representation of the regulation and shows its complete structure.*

Questions 6 assessed whether GoRIM adequately models the *regulation*. We can observe from the responses in Table 22 that four Key Informants (underlined) changed their views to a positive perception after the second iteration of GoRIM, which suggests the usefulness of the improvements made to GoRIM. Also, five of the six Key Informant responsible for regulations (in **bold**) agreed that adequately modelling the regulations using GoRIM is feasible, but the sixth disagreed.

**Table 22** Key Informants Responses to Question 6

Key Informants	Role	Yrs. in Role	First Evaluation					Second Evaluation					
			SA	A	N	D	SD	SA	A	N	D	SD	
<b><u>CWS01</u></b>	<b><u>Regulation</u></b>	<b><u>≥15</u></b>			<b><u>X</u></b>								
CWS02	Regulatory Initiative	<5		X					X				
<b><u>CWS03</u></b>	<b><u>Regulation</u></b>	<b><u>&lt;10</u></b>			X								
EPB01	Regulatory Initiative	≥15		X									
EPB02	Regulatory Initiative	<10		X									
<b><u>EPB03</u></b>	<b><u>Regulation</u></b>	<b><u>&lt;15</u></b>		X									
EPB04	Regulatory Initiative	<5				X							
<b><u>RX01</u></b>	<b><u>Both</u></b>	<b><u>&lt;15</u></b>			<b><u>X</u></b>					<b><u>X</u></b>			
<b><u>RX02</u></b>	<b><u>Both</u></b>	<b><u>&lt;15</u></b>				<b><u>X</u></b>				<b><u>X</u></b>			
<b><u>RX03</u></b>	<b><u>Both</u></b>	<b><u>&lt;10</u></b>			<b><u>X</u></b>					<b><u>X</u></b>			
RX04	Regulatory Initiative	<10			X								
<b>LEGEND</b>													
SA: Strongly Agree A: Agree N: Neutral D: Disagree SD: Strongly Disagree													

Question 7: *The GoRIM model of the regulatory initiative, its inputs, outputs, objectives, tasks and key performance indicators (KPIs) is accurate.*

Question 7 assessed whether GoRIM adequately models the *regulatory initiative*. The responses in Table 23 show that one Key Informant (underlined) changed their view from “Neutral” to “Agree” after GoRIM’s second iteration, again suggesting an appreciation for the improvements made along the way. In addition, after the second iteration, five of the seven Key Informants responsible for regulatory initiatives (in **bold**) agreed that modelling the initiatives using GoRIM is feasible, and one disagreed.

**Table 23** Key Informants Responses to Question 7

Key Informants	Role	Yrs. in Role	First Evaluation					Second Evaluation				
			SA	A	N	D	SD	SA	A	N	D	SD
CWS01	Regulation	≥15		X					X			
<b>CWS02</b>	<b>Regulatory Initiative</b>	<b>&lt;5</b>		X					X			
CWS03	Regulation	<10			X							
<b>EPB01</b>	<b>Regulatory Initiative</b>	<b>≥15</b>		X								
<b>EPB02</b>	<b>Regulatory Initiative</b>	<b>&lt;10</b>		X								
EPB03	Regulation	<15		X								
<b>EPB04</b>	<b>Regulatory Initiative</b>	<b>&lt;5</b>				X						
<b>RX01</b>	<b>Both</b>	<b>&lt;15</b>			X					X		
<b>RX02</b>	<b>Both</b>	<b>&lt;15</b>		X					X			
<b><u>RX03</u></b>	<b><u>Both</u></b>	<b><u>&lt;10</u></b>			X				X			
<b>RX04</b>	<b>Regulatory Initiative</b>	<b>&lt;10</b>		X								
<b>LEGEND</b>												
SA: Strongly Agree A: Agree N: Neutral D: Disagree SD: Strongly Disagree												

Question 8: *GoRIM models show the objective of the regulation and the resulting relationship between the regulation and supporting regulatory initiative.*

Question 8 of the “Questionnaire for Key Informant on GoRIM Validation” assessed whether models created with GoRIM show the objective of the regulation and relationships between the regulation and regulatory initiative. The responses in Table 24 indicate that one Key Informant (underlined) changed their view after the second iteration of GoRIM, on the positive side. After the second iteration, seven out of nine Key Informants (highlighted) agree that showing the objective and relationships is feasible with GoRIM-created models, one was neutral and one disagreed.

**Table 24** Key Informants Responses to Question 8

Key Informants	Role	Yrs. in Role	First Evaluation					Second Evaluation				
			SA	A	N	D	SD	SA	A	N	D	SD
CWS01	Regulation	≥15		X					X			
CWS02	Regulatory Initiative	<5		X					X			
CWS03	Regulation	<10			X							
EPB01	Regulatory Initiative	≥15		X								
EPB02	Regulatory Initiative	<10		X								
EPB03	Regulation	<15		X								
EPB04	Regulatory Initiative	<5				X						
<u>RX01</u>	<u>Both</u>	<u>&lt;15</u>			<u>X</u>				<u>X</u>			
RX02	Both	<15			X				X			
RX03	Both	<10				X				X		
RX04	Regulatory Initiative	<10			X							
<b>LEGEND</b>												
SA: Strongly Agree A: Agree N: Neutral D: Disagree SD: Strongly Disagree												

Question 9: *GoRIM is useful for measuring compliance levels of the modelled regulation.*

**Table 25** Key Informants Responses to Question 9

Key Informants	Role	Yrs. in Role	First Evaluation					Second Evaluation				
			SA	A	N	D	SD	SA	A	N	D	SD
<b>CWS01</b>	<b>Regulation</b>	<b>≥15</b>			<b>X</b>					<b>X</b>		
CWS02	Regulatory Initiative	<5				X					X	
<b>CWS03</b>	<b>Regulation</b>	<b>&lt;10</b>			<b>X</b>							
EPB01	Regulatory Initiative	≥15			X							
EPB02	Regulatory Initiative	<10			X							
<b>EPB03</b>	<b>Regulation</b>	<b>&lt;15</b>			<b>X</b>							
EPB04	Regulatory Initiative	<5					X					
<u><b>RX01</b></u>	<u><b>Both</b></u>	<u><b>&lt;15</b></u>				<u><b>X</b></u>				<u><b>X</b></u>		
<u><b>RX02</b></u>	<u><b>Both</b></u>	<u><b>&lt;15</b></u>			<u><b>X</b></u>				<u><b>X</b></u>			
<u><b>RX03</b></u>	<u><b>Both</b></u>	<u><b>&lt;10</b></u>			<u><b>X</b></u>				<u><b>X</b></u>			
RX04	Regulatory Initiative	<10			X							
<b>LEGEND</b>												
SA: Strongly Agree A: Agree N: Neutral D: Disagree SD: Strongly Disagree												

Question 9 of the “Questionnaire for Key Informant on GoRIM Validation” assessed whether GoRIM is useful for measuring the compliance levels of the modelled regulation. Table 25’s responses show that three Key Informants (underlined) changed their views to a more positive answer after the second iteration of GoRIM. In the end, two of the six Key

Informants responsible for regulations (in **bold**) agreed that GoRIM is useful for measuring the compliance levels of the modelled regulations while the other four were neutral.

Question 10: *GoRIM is useful for assessing how the measured compliance level translates to the objective of the regulation.*

**Table 26** Key Informants Responses to Question 10

Key Informants	Role	Yrs. in Role	First Evaluation					Second Evaluation						
			SA	A	N	D	SD	SA	A	N	D	SD		
<u>CWS01</u>	<b>Regulation</b>	<u>≥15</u>			<u>X</u>									
CWS02	Regulatory Initiative	≤5			<u>X</u>									<u>X</u>
<u>CWS03</u>	<b>Regulation</b>	<u>&lt;10</u>			<u>X</u>									
EPB01	Regulatory Initiative	≥15		X										
EPB02	Regulatory Initiative	<10		X										
<u>EPB03</u>	<b>Regulation</b>	<u>&lt;15</u>		X										
EPB04	Regulatory Initiative	<5					X							
<u>RX01</u>	<b>Both</b>	<u>&lt;15</u>				<u>X</u>				<u>X</u>				
<u>RX02</u>	<b>Both</b>	<u>&lt;15</u>			<u>X</u>					<u>X</u>				
<u>RX03</u>	<b>Both</b>	<u>&lt;10</u>			<u>X</u>					<u>X</u>				
RX04	Regulatory Initiative	<10			X									
<b>LEGEND</b>														
SA: Strongly Agree A: Agree N: Neutral D: Disagree SD: Strongly Disagree														

Question 10 assessed whether GoRIM is useful for assessing how measured compliance levels translate to the objective of the regulation. Table 26 shows that five Key Informants (underlined) changed their views after the second iteration of GoRIM; three were more positive and two were more negative, suggesting mixed feelings about the latest version of GoRIM for that aspect. Four of the seven Key Informants responsible for regulations (in **bold**) agreed that GoRIM is useful for assessing how the measured compliance level translates into the objective of the regulations, while two disagreed. One potential issue here is the fact that the societal objectives (which indirectly provide regulation objectives) were not modelled explicitly in the case studies.

Question 11: *GoRIM is useful for assessing how well the objectives of regulations are met.*

Question 11 assesses whether GoRIM is useful for assessing how well the regulations meet their objectives. Table 27 show that four Key Informants (underlined) changed their views after the second iteration of GoRIM; three had a more positive view and one had a more negative view. Two Key Informants (**in bold**) agreed that GoRIM is useful for assessing how well regulations meet their objectives while seven were neutral, one disagreed (in a regulation role) and one strongly disagreed (in a non-regulation role).

**Table 27** Key Informants Responses to Question 11

Key Informants	Role	Yrs. in Role	First Evaluation					Second Evaluation				
			SA	A	N	D	SD	SA	A	N	D	SD
<u>CWS01</u>	<u>Regulation</u>	<u>≥15</u>			<u>X</u>						<u>X</u>	
<u>CWS02</u>	<u>Regulatory Initiative</u>	<u>&lt;5</u>				<u>X</u>				<u>X</u>		
CWS03	Regulation	<10			X							
<b>EPB01</b>	<b>Regulatory Initiative</b>	<b>≥15</b>		<b>X</b>								
EPB02	Regulatory Initiative	<10			X							
EPB03	Regulation	<15			X							
EPB04	Regulatory Initiative	<5					X					
<u>RX01</u>	<u>Both</u>	<u>&lt;15</u>				<u>X</u>				<u>X</u>		
<b>RX02</b>	<b>Both</b>	<b>&lt;15</b>			<b>X</b>				<b>X</b>			
RX03	Both	<10			X					X		
RX04	Regulatory Initiative	<10			X							
<b>LEGEND</b>												
SA: Strongly Agree A: Agree N: Neutral D: Disagree SD: Strongly Disagree												

Question 12: *GoRIM is useful for monitoring and reporting on the performance of the regulation.*

Question 12 assessed whether GoRIM is useful for monitoring and reporting on the performance of the regulation. Table 28 shows that three Key Informants (underlined) changed their views after the second iteration of GoRIM for a more positive answer. Additionally, three Key Informants (**in bold**) agreed that GoRIM is useful for monitoring and reporting on the performance of the regulation while seven were neutral and one strongly disagreed.

**Table 28** Key Informants Responses to Question 12

Key Informants	Role	Yrs. in Role	First Evaluation					Second Evaluation				
			SA	A	N	D	SD	SA	A	N	D	SD
CWS01	Regulation	≥15			X					X		
CWS02	Regulatory Initiative	<5				X				X		
CWS03	Regulation	<10			X							
<b>EPB01</b>	<b>Regulatory Initiative</b>	<b>≥15</b>		X								
EPB02	Regulatory Initiative	<10			X							
EPB03	Regulation	<15			X							
EPB04	Regulatory Initiative	<5					X					
<b>RX01</b>	<b>Both</b>	<b>&lt;15</b>				X			X			
<b>RX02</b>	<b>Both</b>	<b>&lt;15</b>			X				X			
RX03	Both	<10			X					X		
RX04	Regulatory Initiative	<10			X							
<b>LEGEND</b>												
SA: Strongly Agree A: Agree N: Neutral D: Disagree SD: Strongly Disagree												

### 8.1.2 Questions on the Characteristics of GoRIM

Using the thematic analysis method described in Section 3.4.3, I identified these themes in response to the following questions on the characteristics of GoRIM. The inductive coding used to arrive at the themes is available in Appendix B.

Question 13: *What features about GoRIM did you like?*

The features of GoRIM that the Key Informants liked were the visual view of the created models and GoRIM’s analytical capabilities.

- 1) *GoRIM is visual*: The models created with GoRIM describe regulations, regulatory initiatives and their individual components in a visual, pictorial way. The graphical views of the models help comprehension and show the links between the regulations, regulatory initiatives and their individual components. This enables thinking about each element of a regulation or regulatory initiatives in terms of how they relate to each other. The graphical view helps see the impact of compliance with a regulation or performance of a regulatory initiative and this informs whether regulations or initiatives are actually useful or the best way to accomplish outcomes. In addition, it is possible to aggregate large amounts of data in a few KPIs and see their effects on the models during analysis.

- 2) *GoRIM is analytical*: The ability to join different types of data that GoRIM facilitates provides many opportunities for analysis such as evaluating the relative influence of specific regulatory provisions. Additionally, analyzing the links between outcomes and specific regulatory clauses, verifying compliance or identifying correlations/drivers could be useful for targeting and aligning initiatives. Such analysis can facilitate a better understanding of the business of regulating.

Question 14: *What features about GoRIM do you dislike?*

The feature of GoRIM that the Key Informants disliked centered on the nature of the models derived using GoRIM. The models derived using GoRIM appear to be too large and complex. Such models will be difficult for some regulators to comprehend, especially without proper training. In addition, the structure and weights for elements in the models such as contributions appears too linear and may need further adjustments in relation to the respective contexts before drawing conclusions.

Question 15: *What more performance related feature should GoRIM address?*

As regards the performance related feature that GoRIM should address, the Key Informants requested that GoRIM models should capture influences that are external to the regulator but relevant to the regulations such other stakeholders involved in the regulatory ecosystem. In addition, the Key Informant requested that GoRIM identifies gaps in regulations and parts in regulations where greater clarity is needed.

## **8.2. Evaluating the Utility of GoRIM**

Although Key Informants from all three case studies were involved in the evaluation of the utility of GoRIM, only seven out of the fourteen Key Informants that agreed to participate in the case studies provided answers: two from CWS, two from EPB, and three from Regulator X. I carried out the evaluations of the utility of GoRIM in the case studies around

April 2018. I administered the “Questionnaire for Key Informant on GoRIM Implementation”<sup>11</sup>, which includes eleven questions. Question 1 identified the main responsibility of the Key Informant. Questions 2, 3, 4 and 5 investigated regulatory decisions carried out by the Key Informants while Question 6 assessed GoRIM’s usefulness in supporting those decisions. Questions 7 and 8 addressed how the regulators approach regulatory performance, whereas Questions 9 and 10 assessed GoRIM’s usefulness in showing regulatory performance. Finally, Question 11 solicited potential improvements for GoRIM.

Using the thematic analysis method described in Section 3.4.3 and the inductive coding shown in Appendix B, the following section presents responses to the questionnaire on GoRIM’s perceived usefulness in enabling regulators to show the effectiveness of their regulations and regulatory initiatives.

### 8.2.1 Questions on Key Informants Responsibilities

The first question on the “Questionnaire for Key Informant on GoRIM Implementation” sought to understand the responsibilities the Key Informants have in their respective roles.

Question 1: *What are your main responsibilities?*

Table 29 shows the responsibilities of the seven Key Informants who participated in the evaluation of GoRIM’s utility. Their responsibilities clearly align with the activities involved in the cycle of regulatory activities (see Section 1.1).

**Table 29** Responsibilities of Key Informants Involved in Evaluating GoRIM’s Utility

Key Informant	Role	Responsibilities
CWS01	Regulation	<ul style="list-style-type: none"> <li>• Manage team involved in enforcing compliance and identifying non-compliance</li> </ul>
CWS02	Regulatory Initiative	<ul style="list-style-type: none"> <li>• Manage proposal for regulations</li> <li>• Manage compliance promotion</li> </ul>
EPB01	Regulatory Initiative	<ul style="list-style-type: none"> <li>• Manage different regulatory initiatives</li> <li>• Provide technical and strategic advice to senior management</li> </ul>

<sup>11</sup> Questionnaire available at <http://www.eecs.uottawa.ca/~damyot/pub/AkhigbePhD/>

Key Informant	Role	Responsibilities
EPB03	Regulation	<ul style="list-style-type: none"> <li>• Provide oversight for regulatory provisions.</li> </ul>
RX01	Both	<ul style="list-style-type: none"> <li>• Provide technical leadership on regulatory framework</li> </ul>
RX02	Both	<ul style="list-style-type: none"> <li>• Manage compliance verification activities</li> </ul>
RX03	Both	<ul style="list-style-type: none"> <li>• Manage compliance verification activities</li> </ul>

## 8.2.2 Questions on Regulatory Decision Making

Questions 2 to 5 sought to understand the kinds of decisions the Key Informants made on regulations and regulatory initiatives, and the processes supporting these decisions. Question 6 then sought to understand how GoRIM supported these decisions and processes.

Question 2: *What types of decisions, if any, are involved in carrying out these responsibilities?*

Responses from the Key Informants showed that they carry out decisions in three primary areas:

- a) *Regulations*: decisions relating to different levels of advice on existing regulations as well as decisions on planning and developing amendments to the existing regulations.
- b) *Compliance*: decisions on designing and implementing risks that inform compliance activities, recommending appropriate compliance activities, and staffing needs. This is supplemented by decisions about identifying types of activities to use for general or specific risk concerns, decisions on what compliance tools are more effective for use to enforce compliance, and decisions involved in assessing compliance effectiveness.

- c) *Regulatory Initiatives*: decisions towards identifying areas of improvement as well as identifying indicators for measuring regulatory effectiveness. There are also decisions on how to communicate the regulations and impact of the regulations on the corresponding stakeholders in the regulatory ecosystem.

Question 3: *What decisions do you make on regulatory initiatives because of the performance of regulations they support?*

The decisions made by Key Informants here focus on modifying regulatory initiatives based on the state of the regulation, in particular:

- a) Ensuring that regulations are enforceable by identifying and communicating issues with enforcement.
- b) Recommending solutions or alternatives to compliance.
- c) Observing compliance results and effects of regulations as a way of informing recommendations to amendments of regulations.

Question 4: *What factors about the regulation determine priority areas that regulatory initiatives should focus on?*

Responses from the Key Informants show that three factors about the regulation determine priority areas that regulatory initiatives should focus upon:

- a) *The nature of the regulation*: Is the regulation clear? What provisions or requirements are important or more important? How should regulated parties approach compliance, i.e., are the regulations prescriptive, outcome or management based, or do they require self-regulation?
- b) *The objective the regulation aims to achieve*: Why was the regulation created? For example, the MBR (Government of Canada, 2016a) was created to address sustain-

able population of migratory birds. In addition, the MMER (Government of Canada, 2002b) was created to identify causes of confirmed effects of mining activities and to achieve best quality effluent reasonably achievable (Government of Canada, 2002b), and the legislative requirements to ensure safety.

- c) The level of compliance or non-compliance with the regulatory requirements.

Question 5: *Is there a process in place to obtain feedback on how regulatory initiatives perform?*

Responses to this question were in the affirmative. While some Key Informants were unsure of the mechanisms in place to obtain feedback on how their regulatory initiatives performed, descriptions of such feedback mechanism by other Key Informants were on reporting the performance of the regulatory initiative. The responses did not indicate or address the process of the feedback mechanism. The feedback mechanisms mentioned by participants include consultation processes on amendments of regulations and annual reports by the regulators. However, the Government of Canada has mechanisms in place for departments and agencies to report on their activities as part of the reports on plans and priorities (Treasury Board of Canada, 2015).

Question 6: *Does GoRIM support this process and these decisions? How?*

This question aimed to assess the perception of the Key Informants on GoRIM's usefulness in supporting the decisions they make on regulation and regulatory initiatives, and the process of obtaining feedback. The Key Informants responded that GoRIM appeared to support these decisions and feedback in the following ways:

- a) Modelling regulations, regulatory initiatives along with their inputs, contributions, objectives and outcomes along with their links helps understand and decide on the overall regulation or regulatory initiative. Considering multiple factors in one visual graph is helpful.

- b) GoRIM provides an appropriate method to analyze links between regulation and outcomes and this facilitate determining where to focus regulatory improvement and compliance efforts.
- c) GoRIM has potential for use to identify factors to monitor in order to indicate achieving the objectives of regulations.

### **8.2.3 Questions on Regulatory Effectiveness**

Questions 7 and 8 sought to understand how the Key Informants currently address the performance of regulations and information systems they used for this. Questions 9 and 10 then sought to find out whether the Key Informant would used GoRIM to show the performance of regulations and the reasons why they would use or not use GoRIM for this.

Question 7: *What are the current practices on the performance of regulations?*

Current practices on the performance of regulations by the Key Informants include:

- a) Defining indicators for performance-related factors and continually assessing them to see how they do. Examples include collecting and analysing data on the population status of migratory birds by the CWS, collecting and analysing reports from mines by the EPB and collecting and analysing different types of incidents by Regulator X.
- b) Interviews with staff involved with the regulation, e.g., compliance program staff.
- c) Monitoring and reviewing data on compliance or non-compliance with the regulations, as well as performing focused gap analysis on specific regulations or provisions in the regulations.
- d) Assessing the performance of the regulated domain using assumptions for the contributions of the regulator and regulation.

Question 8: *What Information System tools do you use to support these practices?*

The Information Systems used by the Key Informants to support their practices on the performance of regulation were mainly custom-built software to:

- a) Track enforcement activities,
- b) Collect data on compliance with regulatory requirements,
- c) Perform risk analysis
- d) Consolidate information and carry out analysis

Question 9: *Would you use the Goal-oriented Regulatory Intelligence Method (GoRIM) in its current state to show the performance of regulations?*

While three of the Key Informants responded that they would use GoRIM in its current state, three others said they would not. The seventh Key Informant was unsure and mentioned that GoRIM could show the performance of some aspect of their regulations.

Question 10: *Could you provide reasons for your answer to Question 9 above?*

The reasons provided by Key Informants for their decisions on using GoRIM in its current state to show the performance of regulations were:

- a) *Would not use GoRIM:* Further adjustments to GoRIM are necessary especially in terms of accounting for some of the more complex information involved in the regulatory process, such as the level of effort from enforcement. In addition, GoRIM needs data to work. It might be challenging getting the types of data needed to make GoRIM functional. Hence, GoRIM is prone to being redundant.
- b) *Would use GoRIM:* GoRIM clearly works and delivers results. It provides a means to produce and then refine models and analysis to show the performance of regulations such as interesting correlations and weighting potential for regulatory requirements at different levels. In addition, GoRIM could be useful to identify areas for

improvement in regulation and drafting updated regulations. GoRIM seems flexible and adaptable to a multitude of regulatory contexts.

#### **8.2.4 Recommendations on Improving GoRIM**

The final question of the “Questionnaire for Key Informant on GoRIM Implementation” solicited recommendations on the improvement of GoRIM.

Question 11: *Can you suggest potential improvements to GoRIM?*

The recommendations from the Key Informants on improvements to GoRIM were primarily on the models derived with GoRIM:

- a) Make the model strategic by selecting fewer KPIs that relate to provisions of the regulation of interest. This would reduce the current complexity with the models.
- b) Include creating different models of regulations and regulatory initiatives based on different hypotheses to enable exploring a variety of analysis options.

### **8.3. Summary of Evaluation Results**

The evaluation results show that the vast majority of Key Informants found GoRIM feasible in their respective context with utility to address performance-related concerns such as the effectiveness of regulations and regulatory initiatives.

In regards to the feasibility of GoRIM in the respective regulatory context, the Key Informants liked the visual and analytical characteristics of GoRIM. In addition, the Key Informants found GoRIM useful:

- a) To model their respective regulations and regulatory initiatives.
- b) To analyze the created models of their regulations and regulatory initiatives using their data.
- c) To derive meaningful insights on their respective regulatory context using IBM Watson Analytics.

Most changed answers of the Key Informants in terms of perceived feasibility, between the first and second iteration (underlined in the tables of Section 8.1.1), were positive. This suggests that the improvements made to GoRIM based on feedback received during the case studies addressed real concerns of the regulators involved.

Furthermore, in regards to the utility of GoRIM, the Key Informants agreed that GoRIM had utility to support the decisions they made about regulations, compliance and regulatory initiatives. Although the Key Informants mainly used custom-built information systems to support their practice, they had split views concerning using GoRIM for those practices. However, based on the recommendations for improvements on GoRIM that the Key Informants provided, i.e., making the models strategic by focusing on specifics and, exploring a variety of analysis options, it is obvious that the Key Informant saws utility in GoRIM. In addition, as described in Section 4.3.1 and shown in the distracted driving context discussed in Section 4.4, while GoRIM can capture influences that are external to the regulator such as societal outcomes, the case studies did not address this. This absence of explicit societal outcomes in the case studies might explain in part why some of the Key Informants disagreed that GoRIM can analyze the satisfaction of a regulation's objectives (see Questions 10 and 11 of the feasibility survey in Section 8.1.1).

The Key Informants also provided some informal but positive observations on GoRIM:

- They affirmed that the application of GoRIM was accurate in reproducing results of assessments of regulatory initiatives they had done. There were similarities between their results and the results from GoRIM.
- They liked the fact that GoRIM can help them determine where to focus their efforts and hence where to collect more data on compliance and regulatory initiatives.

## **8.4. Limitations of GoRIM's Evaluation**

In Section 3.4.4, I addressed threats to validity of the findings obtained from the evaluation of the qualitative data obtained from the Key Informants and how I intended to mitigate them. However, after carrying out the evaluations, I observed some limitations to the evaluation results. Firstly, although I was careful to follow accepted practices in design, administration and interpretation of the survey results, self-reported results can be unreliable.

In addition, I carried out the surveys alone and had a few passes during the coding done as part of the thematic analysis. Although the evaluations had a good coverage of the links between regulations and their regulatory initiatives, societal outcomes were not modelled explicitly and their indicators were not populated with data. Chapter 4 demonstrated that models for societal outcomes are homomorphic to models for regulatory initiatives, as they are both instances of the same conceptual metamodel. Hence, I do not foresee theoretical challenges in managing the links between regulations and societal outcomes with GoRIM. Yet, practical challenges might exist, in relation with the creation of the models (as there are fewer formal documents on outcomes than on regulations), the provision of data (which likely come from sources external to the regulator) and to the analysis (as it might be difficult to isolate the contributions of a given regulation on large-scale societal outcome).

Secondly, I evaluated the feasibility of GoRIM first and then its utility in each of the three case studies based on the premise that before implementing GoRIM to address real performance concerns of regulators, it should adequately represent their context. Apparently, this approach caused the Key Informants to view and evaluate GoRIM more in terms of the models produced and not as a method. While the Key Informants agreed with the analysis and insights extracted with IBM Watson Analytics, they questioned the correctness of the GRL models that provided the data used for the analytics tool. In addition, the structuring of the questions in the questionnaire appeared to prompt this view of GoRIM as the produced models rather than the method itself. This could be the reason behind the mixed reviews from the regulators. I partly overcame this limitation by making presentations on GoRIM to the Key Informants before administering the questionnaires and evaluating GoRIM's feasibility twice.

Moreover, of the 14 Key Informants that signed the consent form agreeing to participate in the case studies, only eleven participated in the evaluation of the feasibility of GoRIM and only seven participated in the evaluation of GoRIM's utility. I partly overcame this limitation by ensuring that all three case studies had Key Informants participating in each of the evaluations. Yet, more participants would be needed to get statistically significant conclusions about feasibility and utility.

Finally, as I was the main and at times only contributor to the creation of the models, and the analysis of data, there could be a perception of bias. This was mitigated by

involving my co-supervisors in the review of the created models, as well as by involving the Key Informants in the review of the models and analysis results. The evaluation plan and questionnaires were also approved by the University of Ottawa's Research Ethics Board.

## **8.5. Conclusion**

In this chapter, I evaluated GoRIM's feasibility and utility in the three case studies and observed favourable responses. The Key Informants found GoRIM feasible in their respective contexts as they agreed that it could adequately model their regulations and regulatory initiatives, utilize available data to analyze the models and provide meaningful insights using IBM Watson Analytics. While most Key Informants agreed that GoRIM had utility and could support their regulatory decision-making, they had split views on using GoRIM in its current state and recommended further improvements.

In the next chapter, I present lessons learned from this doctoral research and implications of its results.

## **Chapter 9. Lessons Learned and Implications of the Research**

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In this chapter, I discuss the lessons I learned while designing, developing, demonstrating, implementing and evaluating GoRIM in the three different case studies. I then discuss the implications of this doctoral research and its results for the practice of regulators, for research on the regulatory process, as well as for business intelligence-oriented decision support systems at large.

### **9.1. Lessons Learned**

#### **9.1.1 Regulatory Initiative Metamodel**

The Regulatory Initiative Metamodel (see Figure 20), introduced in Section 4.3.1, enables creating models of regulatory initiatives and societal outcomes. Table 11 describes a GRL profile through a mapping between the elements of the Regulatory Initiative Metamodel and elements of GRL's metamodel. While this mapping exists, I did not need this distinction from an analysis point of view when creating and analysing the regulation and regulatory initiative models. For example, there was no distinction between “Objectives” as GRL goals and “Outcomes” as GRL goals. Specifically, such distinctions did not offer any value when analysing the created GRL models in the case studies. Nevertheless, the Regulatory Initiative Metamodel is useful to model regulatory initiatives and societal outcomes as I have demonstrated in this thesis. Distinguishing between the components of the Regulatory Initiative Metamodel might be useful in situations that require using GoRIM or GRL to model regulatory initiatives and societal outcomes, which future work could address.

#### **9.1.2 Modelling and Analysing Regulatory Instruments**

Although not done in a systematic way, regulators choose certain regulatory instruments to address governments' legislations and policy objectives from an array of regulatory instruments. For example the Migratory Bird Regulations (MBR) (Government of Canada,

2016a) is a regulatory instrument used to administer some parts of the Migratory Birds Convention Act (MBCA) (Government of Canada, 1994b). CWS also uses other regulatory instruments such as the Migratory Bird Sanctuary Regulation (MBRS) (Government of Canada, 1994a) to administer the MBCA. In addition, a regulator could focus on only certain provisions of the regulatory instrument to carry out their mandate, e.g., CWS's focus on the Migratory Game Bird Hunting Regulations (MGBHR) (Government of Canada, 2016b), which are sections of the MBR that address hunting. If regulators are to assess whether regulations achieve their objectives and accomplish outcomes in order to show the effectiveness of the regulations, such assessments become difficult. If other regulators also use other regulatory instruments to administer the other parts of the same governments' legislations and policy objectives, determining whether regulations are performing becomes a challenging task.

When and how does the CWS ascertain whether it has achieved the government policy objective of protecting migratory birds, their eggs, and their nests from unauthorized hunting, trafficking and commercialization? Should the CWS describe performance in relation to the MGBHR, the MBRS, the MBR or the MBCA? Obviously, when describing the performance of a regulation, the regulator should not address regulatory instruments in isolation. Hence, the CWS description of performance should be in terms of all regulatory instruments used to achieve the governments' legislations and policy objectives.

Using GoRIM in such a case enables the regulator to capture all the respective legislative requirements, the regulatory initiatives that support them, as well as the intended societal outcomes. My use of GoRIM to show the effectiveness of Regulator X's legislative requirements in Chapter 7 is a useful example in this regard. In this case study, I was able to use GoRIM to create models enabling the effectiveness assessment of twelve different legislative requirements that a regulator uses to carry out its mandate. Although I focused on only the specific provisions of interest in each legislative requirement, the resulting GRL model was strategic enough to discuss certain aspects of the effectiveness of the regulatory instruments. Since that model does not capture each regulatory instrument in full, and since other regulators who could be involved in administering certain aspects of Reg-

ulator X's legislative requirements, the current model and its analysis might not be comprehensive enough to assess performance. However, this still represents a good example of where and how to start.

### 9.1.3 Data Availability is a Problem

Regulators collect and use a lot of data when creating and administering regulations. However, in many situations, either regulators do not have enough data to arrive at the kinds of results they need, or they do not collect the right type of data, possibly because they do not know what to collect (Akhigbe, Amyot, et al., 2017). With data being an integral part of GoRIM, I observed that some of the regulators that participated in the multi-case study did not have enough data or the right data needed to fully leverage the functionality of GoRIM in their respective context. As such, I took the following steps when I applied GoRIM in the case studies:

- *Instances of Missing Data*

When I encountered cases where there were missing data resulting from voluntary omission or a lack of proper collection mechanism, I chose to ignore the KPIs that use the missing data from the model analysis (for a specific dataset, e.g., one regulated party at a given moment in time). Ignoring KPIs was possible through an extension of jUCMNav, which also reused a feature ignoring the model elements connected to these KPIs and redistributing their contributions to the remaining model elements, if any. jUCMNav also highlights (in gray) the parts of the GRL model that are ignored, so modellers and analysts are aware of that issue. Section 5.4 describes such instances of missing data and my use of jUCMNav to ignore the affected model elements.

- *Instances of Incomplete Data*

When I encountered a case where the regulator had highly sparse data because the regulator did not collect data frequently or rigorously enough, I randomly generated data to populate the models. The use of synthetic data informs regulators of the types of analysis that are useful in their context should they collect that data more

systematically. Section 7.6 describes an instance of such occurrence of incomplete data and my use of synthetic data.

#### **9.1.4 IBM Watson Analytics Offers Potential and Challenges**

The application of data analytics and data visualization tools or software, such as IBM Watson Analytic, to the regulatory domain enables regulators to interact intuitively with their data. Using IBM Watson Analytics in that context also provides insights to answer questions of different complexity about the regulatory process. At the time of writing this thesis, this work and some of its companion publications (Akhigbe, Heap, Amyot, et al., 2017; Akhigbe, Heap, Islam, et al., 2017) are the only work in the regulatory domain that has used IBM Watson Analytics from an academic research perspective. Hence, since IBM Watson Analytics was not designed specifically to address the regulatory domain, its use required some additional tailoring to address this research. For example, I had to do some additional data preparation of the evaluated GRL model satisfaction values outside IBM Watson Analytics. I have also explored many visualizations in IBM Watson Analytics before I could arrive at useful insights.

#### **9.1.5 Ownership Concerns**

Based on their administrative structure, regulators involve people with different roles and responsibilities for carrying out the mandate of creating, administering or amending regulations. These roles come with different views about what the performance of a regulation imply. As such, when a regulator applies GoRIM to its context, there are also different interpretations of the derived models and analysis results from IBM Watson Analytics. It was common in the case studies described in this thesis to find that Key Informants who were not involved in the creation of certain models disagreed on elements represented in the models. In addition, some Key Informants were not aware that certain provisions of the regulation they deemed important were not enforced or that provisions they deemed unimportant were enforced.

In this regard, who takes ownership of reviewing the regulations using GoRIM becomes important. Such roles, which should be central to the regulator, should define what

guides the application of GoRIM to determine the effectiveness of the regulation based on the regulator's mandate.

### **9.1.6 Model Correction**

The approach of most goal modelling methods is to correct the models as they are created, often with the involvement of their stakeholders. This approach also applies to models that have analytical capabilities. Oftentimes, after creating the models, the stakeholders indicate that models are correct and reflect their respective contexts. However, when data are input into the models, the stakeholders often disagree with the analysis results they see and request changes to the models. This was the case when I used GRL to create models in the different case studies. In this regard, GoRIM includes the "Model Correction" step for inputting some sample data into the model and analysing the model to test whether it looks and behaves correctly, as part of the model creation process. Using this approach, where stakeholders other than the modeller can also be involved, will enable creating and validating models faster.

### **9.1.7 Other Potential Uses of GoRIM**

While applying GoRIM to the case studies, the Key Informants raised certain scenarios in their respective contexts for which GoRIM could be useful. I had not considered these potential uses when designing and developing GoRIM. These potential uses of GoRIM are:

#### **Modernization of regulations**

As part of efforts by regulators to make regulations relevant and aligned with leading industry practices and contemporary society, reviews to modernize regulations are ongoing in different jurisdiction and domains, independently of regulation performance. Using GoRIM, this effort could focus on identifying what regulations are up-to-date or on the trend and nature of compliance with specific parts of the regulations over the years. In addition, regulators could use data on initiatives to identify what provisions of the regulations really need attention.

## Anticipate Effects of Regulatory Amendments

Prior to or as part of the amendment of a regulation, the regulator could use GoRIM to explore the potential effects of the envisioned changes. For example, Schedule 4 of the MMER (Government of Canada, 2002b), shown in Figure 119, lists the authorized limits of deleterious substances allowable for discharge by mines into receiving environments. The EPB could use GoRIM to explore the effects of increasing or decreasing these limits on the objective of the complementary measures and water quality studies before any amendments, as illustrated in Figure 120.

### SCHEDULE 4

(Section 3, paragraph 4(1)(a), subsections 12(1) and (3), section 13, subsections 15(1), 19.1(1) and 20(1), paragraphs 21(2)(b) and (f), 24(1)(a) and 34(1)(b), subsection 34(3), paragraphs 34(4)(a) and (5)(a) and (b), 35(2)(b), 36(d) and 37(1)(a) and Schedules 5 and 7)

### Authorized Limits of Deleterious Substances

	Column 1	Column 2	Column 3	Column 4
Item	Deleterious Substance	Maximum Authorized Monthly Mean Concentration	Maximum Authorized Concentration in a Composite Sample	Maximum Authorized Concentration in a Grab Sample
1	Arsenic	0.50 mg/L	0.75 mg/L	1.00 mg/L
2	Copper	0.30 mg/L	0.45 mg/L	0.60 mg/L
3	Cyanide	1.00 mg/L	1.50 mg/L	2.00 mg/L
4	Lead	0.20 mg/L	0.30 mg/L	0.40 mg/L
5	Nickel	0.50 mg/L	0.75 mg/L	1.00 mg/L
6	Zinc	0.50 mg/L	0.75 mg/L	1.00 mg/L
7	Total Suspended Solids	15.00 mg/L	22.50 mg/L	30.00 mg/L
8	Radium 226	0.37 Bq/L	0.74 Bq/L	1.11 Bq/L

**Figure 119** Schedule of the MMER (Government of Canada, 2002b)



In addition, the MMER is a Canadian federal regulation and provinces also have similar regulations, e.g., the Effluent Monitoring and Effluent Limits - Metal Mining Sector regulation of Ontario (Government of Ontario, 2017b). Hence, the EPB could compare existing or proposed amendments of limits for deleterious substances against the limits set by the provinces. Such comparisons would also prove useful in domains or jurisdictions where overlaps in regulations exists.

### **Predictions**

The previous example on amendments is one where the model changes and existing data is used to understand the consequences of such changes based on current evidence. Another type of predictions mentioned by the regulators is to anticipate values of indicators based on trends and predict compliance or performance based on the current models. This could be used to predict likely unsatisfactory situations.

## **9.2. Implications of Research and Results**

### **9.2.1 Implications for the Practice of Regulators**

Regulators need help with the constantly changing landscapes they regulate. Showing how the regulations they administer perform presents a helpful way to build trust and confidence in the regulatory systems. This also demonstrates that the regulator operates with transparency and responsiveness to all stakeholders in the regulatory ecosystem. To this end, the introduction of GoRIM is timely. Moving away from the usual practice of describing how regulations perform based on the state of the regulator or the industry, GoRIM employs a data-driven, evidence-based approach to regulatory management. This approach applies the concept of *regulatory intelligence*, a feedback loop in the use of data from the regulatory ecosystems to create and administer regulations.

GoRIM enables taking a holistic view of the regulatory ecosystem by representing and linking regulations, regulatory initiatives, and objectives and outcomes of the regulations. It also captures and links the different stakeholders in the regulatory ecosystems and their objectives. GoRIM does this while supporting monitoring, reporting, the exploration of what-if/trade-off analysis, and intuitive visualization a data visualization tool. GoRIM also enables identifying what to measure as the created models highlight the type of data

needed to populate the indicators in the models for analysis. Using data from and within the regulatory ecosystem helps us understand the relationships between the different elements in the ecosystem. The result is an in-context analysis of data that enables interpreting derived metrics and reaching proper conclusions. Furthermore, the application and validation of GoRIM in three real-life regulatory scenarios provided working examples demonstrating the effectiveness of regulations that regulators can utilize and refer to.

Using GoRIM, regulators can review their regulations by creating models of their regulations, regulatory initiatives and intended societal outcomes. The created models contain information not present in the regulations such as contribution weights attached to different sections as well as indicators used to measure compliance with the regulations. In addition, created models of the regulatory initiatives and societal outcomes also include the different objectives to be achieved, tasks and resources utilized as well as indicators representing different measures involved. Hence, regulators can better interpret what compliance with sections or the regulation as a whole means in relation to how well (or not) regulatory initiatives are performing and the impact expected in society. Further analysis of the data from the different models using data analytics tools enables identifying correlations and attributions otherwise not identified. This use of GoRIM aids in providing data-driving evidence on the effectiveness of regulations in a timely manner, with visibility and traceability.

### **9.2.2 Implications for Research on Regulatory Compliance**

While most research on the regulatory domain focuses on the compliance needs of the regulated party, monitoring, evaluating and improving regulations are equally important aspects. These activities are the mandate of regulators who serve as custodians of the regulatory ecosystem. Regulators not only determine who complies but also support innovation and ensure a competitive environment for businesses and citizens. Although the needs and challenges of regulators are often ignored by most research on regulatory compliance, addressing these needs is becoming urgent (Akhigbe et al., 2018). As such, the proliferation of methods and tools that address how regulated parties comply with regulations could lend itself to addressing the needs of regulators. In this regard, GoRIM utilizes existing methods

for addressing regulatory compliance, i.e., the goal-oriented modelling methods with indicators to carry out evidence-based evaluation of three complementary views in the regulatory ecosystem:

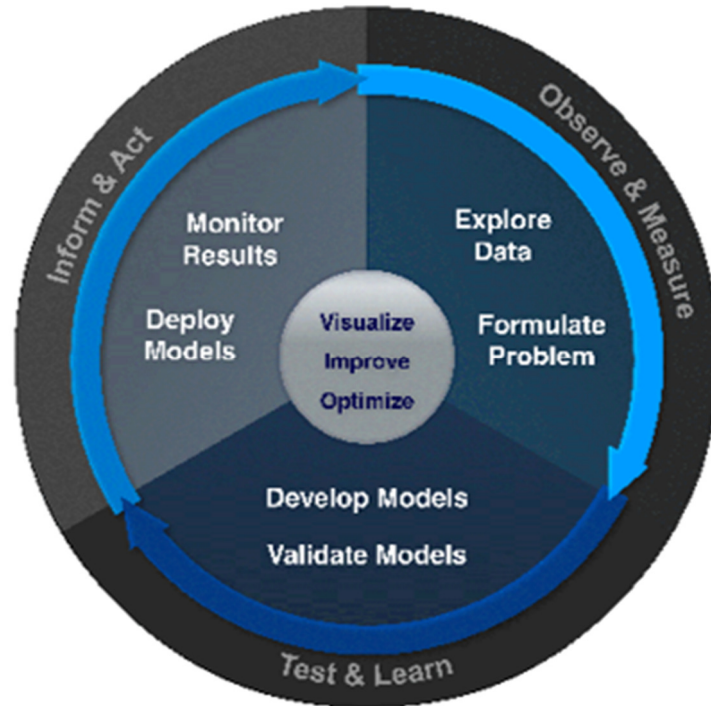
- a) Compliance with regulations
- b) Performance of regulatory initiatives
- c) Satisfaction of regulatory objectives and societal outcomes.

The result of the application of GoRIM is the equipping of regulators with adequate analysis of compliance and regulatory initiatives, leading to easier ways for regulator to assess and report on the effectiveness of their regulations. Furthermore, the application of GoRIM in this doctoral research to three different domains and contexts provides additional examples of the usefulness of research on regulatory compliance to domains other than healthcare and to contexts other than privacy or security, the latter having extensive coverage in existing literature (Akhigbe et al., 2018). In addition, this application and validation of GoRIM accentuates the usefulness of the research on regulatory compliance, especially as this thesis addresses stakeholders of the regulatory ecosystem other than regulated parties.

### **9.2.3 Implications for Business Intelligence-oriented Decision Support Systems**

The organizational structure of most regulators includes different functional areas with activities, processes and objectives defined in order to accomplish the organization's outcomes. To achieve objectives and ensure the smooth running of operations, organizations employ different types of decision support systems (DSS) targeting managers (Burstein & Holsapple, 2008; Power, 2004). Business Intelligence systems are a form of DSS that organizations use to support managerial decision-making (Sauter, 2011). In theory, Business Intelligence fosters the analysis of data at different levels of an organization to improve the quality of decision-making. As illustrated in Figure 121, Business Intelligence can help decision makers understand what is happening in their organizations and act accordingly as they “*observe and measure*”, “*test and learn*” and “*inform and act*” based on analyzed data.

Although organizations utilize different BI-oriented systems to aid in decision-making, the implementation and use of such systems are often heterogeneous. Some reasons for this arrangement include the nature of functions in organization, the types of activities the organization is involved in or financial concerns.



**Figure 121** Uses of Business Intelligence Oriented DSS throughout the Organization, Adapted from Sauter (2011)

As such, a common challenge facing organizations is how to leverage their heterogeneous information and information systems to enable the organizations to achieve their objectives. More so, when departments/units within or between organizations collaborate, several questions become important. How do they leverage the heterogeneous information and information systems to achieve the common objective? How are external factors relevant to the objective captured and analyzed in relation to the stakeholders involved?

While organizations generally grapple with this question and its resolution, solutions proffered in academia and industry tend to isolate this problem to one specific area within the organization or address the objectives and stakeholders individually rather than offer a holistic and integrated view. In this regard, GoRIM's ability to capture and link different stakeholders, activities, resources, objectives or outcomes proves useful. The use

of data from the different data sources and their analysis to understand the created relationships, and their roles in achieving the objectives, facilitated by GoRIM, provide the basis for a common framework of analysis that is homogenous, i.e., a BI-oriented DSS that enables an evidence-based integrative view of regulatory performance.

Consequently, the capabilities of GoRIM to capture the regulatory ecosystem, link regulatory initiatives and societal outcomes to show attributions and impacts could position GoRIM as a BI-oriented DSS for achieving Business Intelligence interoperability.

### **9.3. Conclusion**

This chapter discussed the lessons learned from the design, development, implementation and evaluation of GoRIM, and the implication of the research and research results. The Regulatory Initiative Metamodel introduced in Section 4.3.1, which enables modelling regulatory initiative and societal outcomes, forms a basis for capturing and analysing the created models towards demonstrating the effectiveness of regulations. In addition, IBM Watson Analytics enables intuitive interaction and visualization of the analysed data.

Although the availability of data is a challenge, GoRIM's functionality can be leveraged to address instances of missing or incomplete data. While the application of GoRIM has potential for the modernization of regulations, and anticipating and managing regulatory amendments, there are challenges to the application of GoRIM, including data availability and ownership. In addition, this research on GoRIM provides and validates, in three real-life regulatory contexts, a data-driven evidence-based approach to regulatory management that equips regulators with easier ways to assess and report on the effectiveness of their regulations.

In the next chapter, I conclude this thesis with a summary of contributions of the doctoral research identify potential future work items.

# Chapter 10. Conclusion and Future Work

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This chapter summarizes the contributions of this doctoral research. In addition, I discuss limitations of the research and recommend avenues of exploration for future research on this topic.

## 10.1. Contributions

### 10.1.1 Thesis Contributions

This thesis introduced the Goal-oriented Regulatory Intelligence Method (GoRIM), which regulators can use to show the effectiveness of their regulations and regulatory initiatives. The thesis has one major contribution and several minor contributions. The major contribution is a method for monitoring, analysing and reporting whether regulations achieve their desired objectives and accomplish intended societal outcomes. The sub-contributions of this method include:

- A meta-model that formalizes regulatory initiatives that regulators use to support regulations. The meta-model can also be used to model societal outcomes.
- The use of the same goal modelling views for modelling regulations, regulatory initiatives and their objectives.
- Guidance on the use of an AI-driven data analytics software used to explore and analyze data derived from the goal models.
- Demonstration of different types of analyses involving compliance with regulations and performance of regulatory initiatives in real scenarios with regulators.
- The development and use of the ESP tool (Appendix A) for preparing heterogeneous data towards their evaluation in goal models.
- A process model and definitions of roles for the use of the method.

The minor contributions of this thesis are:

1. A study to understand the key activities of regulators and the challenges they face in carrying out their mandate of creating and administering regulations.
2. A systematic literature review on IT artifacts involved in the regulatory compliance of business processes with regulations. This review also identified and situated the compliance tasks (modelling, checking, analysis and enactment) that created and used these IT artifacts.
3. A systematic literature review on the ways regulators monitor and manage compliance with regulations using IT artifacts.
4. A systematic literature review on the use of goal-oriented and non-goal-oriented modelling methods for legal and regulatory compliance. This review also identified the main claimed benefits and drawbacks of both methods.
5. The use of a data analytics tool to visualize and analyze data from goal models.

### **10.1.2 Answers to Research Questions**

The thesis contributions helped answer the four research questions raised in Section 1.2 as follows:

1. Research Question 1 (KP): *“What are the existing approaches used to demonstrate the performance of regulations? Are these approaches suitable for demonstrating the performance of regulations?”*

The discussion on the problem investigation in Chapter 2 showed that existing approaches for regulatory performance tend to focus on how regulators or regulated domains are performing and are not concerned with how regulations perform per se. They are hence not suitable for demonstrating regulatory performance.

2. Research Question 2 (KP): *“How can Information Systems enable deriving data-driven evidence on the performance of regulations?”*

The concept of regulatory intelligence discussed in Chapter 2 proposes a feedback loop in the use of data from the regulatory ecosystem to show regulatory per-

formance. GoRIM is a method and an IS artifact that provides a structure and accompanying tools to instantiate regulatory intelligence. GoRIM provides evidence of the performance of regulations.

3. Research Question 3 (DP): *“To what extent can linking compliance with regulations, regulatory initiatives, and desired objectives and intended outcomes enable demonstrating, with data-driven evidence, that regulations achieve desired objective and accomplish intended societal outcomes?”*

In Chapter 4, the introduction of GoRIM, a method that incorporates modeling and data analytics, showed that we can link data on compliance with regulations, data on regulatory initiatives, and data on intended outcomes. The links can be analyzed and visualized to show regulatory effectiveness, i.e., part of regulatory performance. The case studies described in Chapters 5 to 7 further evidenced how this linking of compliance with regulations, regulatory initiatives, desired objectives and intended outcomes can be done and, hence, addresses the design problem.

4. Research Question 4 (IP): *Is there any efficacy in linking compliance with regulations, regulatory initiatives, desired objectives and intended societal outcomes to provide data-driven evidence on regulatory performance?*

The demonstration and evaluation of GoRIM in three case studies involving real-life regulatory scenarios (Chapter 8) showed that regulators found GoRIM generally feasible and useful in their context. The responses to a survey of Key Informants amongst regulators in each case study were however mixed on some questions and contained opportunities for GoRIM’s improvement. For example, when asked if they would use GoRIM in its current state, of the seven Key Informants that responded, three answered negatively, three responded positively, and one was unsure.

### **10.1.3 Knowledge Contributions**

The knowledge contributions of this doctoral research are as follows:

1. Reviewing regulations as required in the *review* phase of the cycle of regulatory activities introduced in Section 1.1 is now practicable for regulators. The creation of models of regulations, regulatory initiatives and societal outcomes, together with the analysis of their data, provide data-driven evidence of regulatory effectiveness. GoRIM also provides opportunities for traceability of regulatory effectiveness as the models can be monitored, analysed and reported continually to show how well (or not) a regulation is performing.
2. The mixed evaluations of GoRIM by the Key Informants, presented in Section 8.4, is in agreement with extant literature on goal-oriented modelling that frameworks and methods based on goal models are at times difficult to use or understand by stakeholders. However, the process model for the use of GoRIM introduced in Section 4.2 attempts to address this difficulty by identifying different roles involved in its use and providing guidance on how the roles function when using GoRIM.
3. Finally, the ability to join and analyze data on compliance with regulations, on the performance of regulations and on societal outcomes using data analytics tools such as IBM Watson Analytics offers the possibility of a homogenous framework for analysis. In this regard, data analytics tools can be applied to enable analysis of data from different sources in a homogenous way.

## 10.2. Limitations of the Research and Results

In Section 3.4.4, I presented potential threats to the *construct* and *external* validity, and threats to the reliability of the research and how I intended to mitigate them. In addition, in Section 8.4, I discussed limitations to the evaluation and result of the evaluation carried out in this research. In this section, I discuss the remaining threats and limitations I recognized upon completing the research.

The first limitation of this doctoral research is about having created and analyzed the GRL models myself in the three case studies. This was because the Key Informants involved in the case studies did not have the required modelling skills. This could raise

questions on the applicability of GoRIM since regulators might not have the required expertise on URN and jUCMNav, causing reliance on someone with such skills to create and analyze the models. I partly overcome this limitation with a description of the different roles involved in the use of GoRIM in Section 4.3 as a guide on what to look for when choosing to use GoRIM. In addition, the choice of IBM Watson Analytics as the data analytics/data visualization software is deliberate. This off-the-shelf tool was selected because regulators of different skill levels can derive insight from the analyzed data using natural language.

Secondly, the case studies to which I applied GoRIM are not reflective of all domains that regulators cover. However, the case studies present three different domains with different regulatory challenges and regulations. They also came with different levels of data variability and quality, and they each provided a good mix of roles related to the creation and monitoring of regulations and initiatives. Yet, applying GoRIM to more case studies from different domains and jurisdictions (including multiple regulators on one domain but from different jurisdictions) would confirm the scope of applicability of the findings and results from this doctoral research.

### **10.3. Future Work**

Future work on addressing the effectiveness of regulations encompasses the evolution of GoRIM and improvements to the practice of regulators.

#### **10.3.1 Evolution of GoRIM**

Future work on GoRIM should:

- Apply GoRIM in case studies focusing on whether regulations accomplish societal outcomes.
- Apply GoRIM to more regulatory contexts as a way of further validating and improving GoRIM as a method to show the effectiveness of regulations.
- Explore the use of GoRIM to address new potential areas, such as modernization, amendments and predictions, as raised by the Key Informants in Section 9.1.6. In

addition, given the interest of regulators in risk-based regulatory assessments, whether GoRIM is general enough to address risks is a research issue.

- Better guidance on a sequence/tree of questions to ask data analytics tools used with GoRIM.
- Explore the use of the principles of GoRIM for achieving interoperability between information and information systems within and between organizations.
- Explore the use or development of better and more integrated tools (beyond jUCMNav and IBM Watson Analytics) for supporting GoRIM.

### **10.3.2 Improvements to the Practice of Regulators**

Future work on the practice of regulators should address the following:

- Explore solutions to the challenges that regulators face while creating and administering regulations identified in Akhigbe, Amyot et al. (2017).
- Explore the relationships between Information Systems and information used in the regulatory ecosystem, and the practice of regulators. Study the impacts of these ISs and related regulator's practices on the regulatory process as a way of identifying proven practices on what works and what could be improved.
- Develop a maturity model for use to assess a regulator's relative proficiency in creating and administering regulations.

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# Appendix A: How the Evaluation Strategies Processor (ESP) Work

ESP is a new tool written by Labasse et al. (2017) that is used to pre-process vast quantities of raw data and generate GRL strategies (where the input indicators also have their satisfaction values pre-computer) importable by jUCMNav. This tool takes two CSV files as input (source data definition and indicator definitions) and generates a new CSV file describing the resulting GRL strategies. ESP aims to accelerate the creation of many strategies for GRL models (especially as models and datasets evolve), palliate for existing errors and limitations in jUCMNav in the computation of indicator satisfaction, and avoid errors based on manual transformations.

Consider a scenario where we want to assess whether a regulation administered to five entities over a two-year period, is achieving its objective. To do this, we decide to explore the relationship between data collected on each entity's compliance level with the regulation, and data on how efficiently a regulatory initiative was administered to support the regulation. The goal model for this scenario is illustrated in Figure 122.

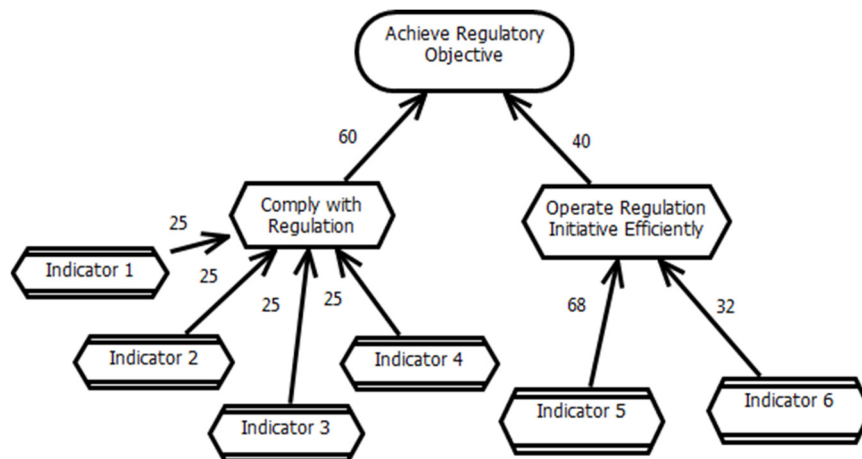


Figure 122 ESP Example Goal Model

The “Source file” illustrated in Figure 123 contains data for the different entities collected at different intervals in time. These data are entered in different columns. We want to evaluate the values in the columns in relation to *target*, *threshold* and *worst* values in order to derive respective satisfaction values for compliance, efficiency and objective achievement.

	A	B	C	D	E	F	G	H
1		Time	Indicator 1	Indicator 2	Indicator 3	Indicator 4	Indicator 5	Indicator 6
2	Entity A	2016	40	40	50	50	50	80
3	Entity B	2016	50	40	60	60	80	80
4	Entity C	2016	40	50	50	70	80	50
5	Entity D	2016	60	60	80	70	50	60
6	Entity E	2016	70	80	70	80	60	60
7	Entity A	2017	70	50	70	50	50	70
8	Entity B	2017	70	50	70	50	80	70
9	Entity C	2017	60	60	80	70	80	70
10	Entity D	2017	70	50	70	80	70	50
11	Entity E	2017	70	80	80	80	80	60
12								

**Figure 123** ESP Example Source File

We create an “Indicator file”, illustrated in Figure 124, which contains constant numbers for the *target*, *threshold* and *worst* values for the corresponding columns in the “Source file” being evaluated. These values are used to compute a value for the “GRL Satisfaction” column in the “Indicator file”.

	A	B	C	D	E	F	G	H	I
1	Indicators						GRL Satisfaction	GRL Satisfaction	Valid Indicator?
2	Name	Target	Threshold	Worst	Unit	Current	[-100..100]	[0..100]	Th in between?
3	Indicator 1	90	50	20	mg/L		-100.00	0.00	TRUE
4	Indicator 2	90	50	20	mg/L		-100.00	0.00	TRUE
5	Indicator 3	90	50	20	mg/L		-100.00	0.00	TRUE
6	Indicator 4	90	50	20	ug/L		-100.00	0.00	TRUE
7	Indicator 5	90	50	20	mg/L		-100.00	0.00	TRUE
8	Indicator 6	90	50	20	mg/L		-100.00	0.00	TRUE
9									

**Figure 124** ESP Example Indicator File

When we use ESP (Labasse et al., 2017) to create evaluation strategies, for a particular entity at a specific time period, some or all values are selected for a column in the “Source file”. These values are put in the “Current” column of the “Indicator file” to compute a value for the “GRL Satisfaction” column as illustrated in Figure 125.

	A	B	C	D	E	F	G	H
1		Time	Indicator 1	Indicator 2	Indicator 3	Indicator 4	Indicator 5	Indicator 6
2	Entity A	2016	40	40	50	50	50	80
3	Entity B	2016	50	40	60	60	80	80
4	Entity C	2016	40	50	50	70	80	50
5	Entity D	2016	60	60	80	70	50	60
6	Entity E	2016	70	80	70	80	60	60
7	Entity A	2017	70	50	70	50	50	70
8	Entity B	2017	70	50	70	50	80	70
9	Entity C	2017	60	60	80	70	80	70
10	Entity D	2017	70	50	70	80	70	50
11	Entity E	2017	70	80	80	80	80	60
12								

	A	B	C	D	E	F	G	H	I
1	Indicators						GRL Satisfaction	GRL Satisfaction	Valid Indicator?
2	Name	Target	Threshold	Worst	Unit	Current	[-100..100]	[0..100]	Th in between?
3	Indicator 1	90	50	20	mg/L		-100.00	0.00	TRUE
4	Indicator 2	90	50	20	mg/L	40	-33.33	33.33	TRUE
5	Indicator 3	90	50	20	mg/L		-100.00	0.00	TRUE
6	Indicator 4	90	50	20	ug/L		-100.00	0.00	TRUE
7	Indicator 5	90	50	20	mg/L		-100.00	0.00	TRUE
8	Indicator 6	90	50	20	mg/L		-100.00	0.00	TRUE
9									

**Figure 125** ESP Evaluation

The evaluated value (GRL Satisfaction column) is then output to a new “Strategy file” shown in Figure 126. The strategy name is a combination of the entity name and time interval from the “Source file” and the other columns are the other columns from the “Source file”. The data value for these columns are the evaluated value (GRL Satisfaction column) from the “Indicator file”. The strategy file is in a format that can be imported directly into a GRL model edited with jUCMNav. The strategies can hence be executed to propagate the values to the other elements of the model.

	A	B	C	D	E	F	G	H
1		Time	Indicator 1	Indicator 2	Indicator 3	Indicator 4	Indicator 5	Indicator 6
2	Entity A	2016	40	40	50	50	50	80
3	Entity B	2016	50	40	60	60	80	80
4	Entity C	2016	40	50	50	70	80	50
5	Entity D	2016	60	60	80	70	50	60
6	Entity E	2016	70	80	70	80	60	60
7	Entity A	2017	70	50	70	50	50	70
8	Entity B	2017	70	50	70	50	80	70
9	Entity C	2017	60	60	80	70	80	70
10	Entity D	2017	70	50	70	80	70	50
11	Entity E	2017	70	80	80	80	80	60
12								

	A	B	C	D	E	F	G	H	I
1	Indicators						GRL Satisfaction	GRL Satisfaction	Valid Indicator?
2	Name	Target	Threshold	Worst	Unit	Current	[-100..100]	[0..100]	Th in between?
3	Indicator 1	90	50	20	mg/L		-100.00	0.00	TRUE
4	Indicator 2	90	50	20	mg/L	40	-33.33	33.33	TRUE
5	Indicator 3	90	50	20	mg/L		-100.00	0.00	TRUE
6	Indicator 4	90	50	20	ug/L		-100.00	0.00	TRUE
7	Indicator 5	90	50	20	mg/L		-100.00	0.00	TRUE
8	Indicator 6	90	50	20	mg/L		-100.00	0.00	TRUE
9									

	A	B	C	D	E	F	G
1	Strategy Name	Indicator 1	Indicator 2	Indicator 3	Indicator 4	Indicator 5	Indicator 6
2	Entity A 2016		33.33				
3	Entity B 2016						
4	Entity C 2016						
5	Entity D 2016						
6	Entity E 2016						
7	Entity A 2017						
8	Entity B 2017						
9	Entity C 2017						
10	Entity D 2017						
11	Entity E 2017						
12							
13							
..							

Figure 126 ESP Example Strategy File

## Appendix B: Thematic Analysis Coding

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This appendix includes 16 tables that show the inductive coding I did as part of the thematic analysis used in this doctoral research to identify themes that correspond to the Key Informants' views on the *feasibility* and *utility* of GoRIM in their respective regulatory context. All tables follow the format illustrated in Table 30:

**Table 30** Table Format Used for Thematic Analysis Coding, with Example

<b>Question: What features about GoRIM do you like?</b>	<b>First Pass (Focused Codes)</b>	<b>Second Pass (Perceived Theme)</b>	<b>Chosen Theme</b>
"I think the model accurately describes the program and its various components in a useful and helpful visual"	... model accurately describes ... in a useful and helpful visual	Visual Model	Visual

Traceability to individual Key Informants is not included to protect anonymity. Due to its large size, this appendix is only available online at:

<http://www.eecs.uottawa.ca/~damyot/pub/AkhigbePhD/AppendixB.pdf>