



Full Proposal Submission

Section 1: General Project Information

Project Title: Collaborative Disaster Preparedness through Shared Ontologies: A Design Science Research Approach

Duration of Project: 2 years (Jan. 2015- Jan. 2017)

Countries included in this project: Jamaica, St. Vincent

Regions included in this project: Caribbean

Research Themes and Justification:

(T2): Infrastructures & Technologies - the DRP ontology is a technology which can be a component of a DRP information or knowledge management system;

(T3): Communities of Practice – the collaborative methodology used in this research seeks to mobilize a community of practitioners and stakeholders around a common shared problem, specifically the threat of natural disasters in the Caribbean. Given that the ontology will be an Open Artifact it can be adopted and adopted by other researchers/practitioners; and

(T4): Potential Impacts of OCS as we evaluate whether the collaborative approach will lead to a better understanding, at the regional level of the factors for effective DRP and for *Open* approaches to problem solving.

Total Budget Cost (CAD): \$ 67,513.57

Section 3: Proposed Study Information

Research Project Abstract

WORD LIMIT: 250.

It is well recognized that an effective Disaster Recovery Plan (DRP) is essential for a speedy return to normalcy following a natural disaster. Many Small Island Developing States (SIDS), although susceptible to such disasters, lack the resources required to develop such plans. A more efficient and cost effective development methodology might be for these states to adopt a collaborative approach involving the sharing of cost of the resources required and their existing data. However a barrier to collaborating with and integrating disparate and different entities and sources is the probability that there will be ambiguities and inconsistencies in the information. To ensure that this probability is minimized, a common and consistent language (i.e. set of terminologies) for communication is required. A DRP ontology can provide this common language. This research demonstrates the use of this ontology (an Open Source Artifact) to develop consistent, integrated disaster recovery plans that can be shared within and among countries. The approach will be evaluated using a case study of the Caribbean region where a number of SIDs are in both hurricane and earthquake zones.

Research Problem, Significant and Justification

WORD LIMIT: 1,000. Please provide a brief overview of relevant literature and highlight the knowledge gaps that this project will address. Indicate the size and scope of the problem, as well as how the problem relates to the purpose and goals of OCSDNet; broader national development priorities, and the research and capacity needs of the countries involved.

The scale of recent disasters highlights the need for a holistic approach to address and plan for them (Joshi et al., 2007), thus, the need for disaster recovery plans (DRPs). The aim of a DRP is to ensure that entities (e.g. organisations, countries) function effectively during and following a disaster (Bryson et al., 2002). A well thought out DRP can play a major role in an organization's/country's survival/success (Fallara, 2003). A disaster recovery plan (DRP) focuses on ensuring the speedy restoration of services for critical organizational processes in the event that there are operational failures due to natural or man-made disasters. A DRP aims to minimize potential loss by identifying, prioritizing and safeguarding those organizational assets that are most valuable and that need the most protection

(Bryson et al., 2002). The plan must be a comprehensive statement of consistent actions to be taken before, during and after a disaster. The contents of the plan should follow a logical sequence and be written in a standard and understandable format (Wold, 2002).

Many SIDS are susceptible to natural disasters which have the potential to inflict extensive damage on a country's society and infrastructure. Furthermore the longer it takes to return to normalcy following the disaster, the greater will be the effect on what might already be a fragile economy. Yet many SIDS do not have DRPs because the development of these plans requires significant resources, the coordination and collaboration of a number of stakeholders and the access to a number of disparate data sources. Operationalizing a plan requires the communication and coordination of a number of authorities (e.g. public services, government agencies) and access to many sources of data. Their development, therefore, can be expensive which makes it infeasible for SIDS to undertake individually. Therefore, it would be beneficial for these countries to collaborate and share data to not only make the DRP more cost effective but also to improve their quality.

Currently, the United Nations Division for Sustainable Development lists fifty-one (51) SIDS, of these the largest number, twenty-two (22), is in the Caribbean region (United Nations Division for Sustainable Development, n.d.). The region is prone to both hurricanes and earthquakes. Additionally torrential rains, which may or may not be associated with hurricanes, sometimes result in disastrous flooding of low-lying areas and landslides. The region would seem to be ideal for testing the proposal of a collaborative approach to developing DRPs.

A major obstacle to this collaborative approach and to the integration of the data stores that may already exist in the region, is the lack of a common language that can be used to address the ambiguity, inconsistency and communication problems that may arise when loosely connected organizations are required to work together and when disparate data sources are to be integrated and shared. In many cases, the poor response to disasters has been blamed on the lack of communication and coordination among these relevant authorities and the unavailability of critical information. If these authorities and the communication and coordination that needs to take place between them can be captured in a central and formal representation (e.g. in a computer-based system) with a fixed controlled vocabulary that can be queried and searched, there will be a common point of reference, readily accessible

to all, in a language common to all, the responsiveness to disasters should improve.

An ontology provides a formal description of a domain that can be shared among different applications and expressed in a language that can be used for reasoning (Noy, 2004; Gruber, 1995). An ontology can provide a framework for facilitating effective and efficient knowledge-sharing by formally modelling the domain of discourse. Ontologies are typically viewed as presenting a shared understanding of some domain of interest, which is often conceived as a set of classes (concepts), relations, functions, axioms and instances (Noy and McGuinness, 2001). Noy and McGuinness (2001) highlight several benefits of developing an ontology to make domain assumptions explicit: (1) facilitating the sharing of a common understanding of the structure of information among stakeholders in a domain (2) facilitating more effective communication and idea-sharing (3) assisting new entrants in a field to quickly assimilate important domain concepts and knowledge and (4) supporting the analysis of domain knowledge.

These benefits make ontologies well suited for DRP because:

1. The facilitation of the sharing of a common understanding in DRP reduces the possibility of confusion and ambiguity that may arise when different groups of stakeholders come together to make decisions (Altay and Green, 2006).
2. Given that the SIDS will be asked to share data sources it is possible that there is semantic ambiguity in the data which can be addressed in the ontology.
3. The formal ontology (implemented as a computer-based artifact) allows for the automated evaluation of the DRP.
4. SIDS wanting to develop DRPs can use the ontology to understand the important domain knowledge.

We will develop an ontology (described as the artifact in the methodology) in the domain of disaster recovery and will demonstrate how it can be used to develop/improve existing DRPs. It will be developed using an Open Source software and a collaborative approach and will be openly available for others to adopt and adapt. Therefore, the ontology can be classified as an *Open Source Artifact*.

In terms of the OCS focus:

(T2): Infrastructures & Technologies - the DRP ontology is a technology which can

be a component of a DRP information or knowledge management system;

(T3): Communities of Practice – the collaborative methodology used in this research seeks to mobilize a community of practitioners and stakeholders around a common shared problem, specifically the threat of natural disasters in the Caribbean. Given that the ontology will be an Open Artifact it can be adopted and adopted by other researchers/practitioners; and

(T4): Potential Impacts of OCS as we evaluate whether the collaborative approach will lead to a better understanding, at the regional level of the factors for effective DRP and for *Open* approaches to problem solving.

Research Questions and Objectives

WORD LIMIT: 500. Outline your project's central research question(s), sub-questions, and objectives. There must be congruency between the questions, objectives, research design and methods. You should highlight how the study's questions and objectives will contribute to the research themes of the OCSDNet.

The research will seek to answer the following question

1. Can a collaborative and shared approach provide a solution to the need for cost effective and efficient disaster recovery planning in SIDS in the Caribbean?
2. Since a collaborative and shared approach will require the integration of information from disparate sources, how can this be done?
3. Can a DRP ontology be developed that will address the need for a common language and thus facilitate the integration of information from disparate sources?
4. Can Caribbean countries use the DRP ontology to develop or improve existing DRPs?
5. Can a similar collaborative and open approach be applied to other common problems faced by SIDS?

Objectives of the research are to develop a DRP ontology that will address the problem of integrating information from disparate sources and to do this in a collaborative way. When the ontology is developed it will be made available to other SIDs and they in turn will become part of the integrated and collaborative effort.

The development of the DRP ontology (i.e. artifact) will contribute to the OCSDNet's technological research theme. The collaborative and integrated methodology used in developing DRPs will help to build communities of Practice in Open and Collaborative Science and will increase the awareness of the importance of a shared and collaborative approach in the Caribbean region. The fact that the DRP ontology will be designed as an Open Source Artifact will also help build these communities of practice.

Stakeholders

WORD LIMIT: 250. Identify and briefly describe your project's stakeholders. How will your project respond to their needs and interests?

Some countries have some structure in place to manage disasters. For example, in Jamaica the Office of Disaster Preparedness and Emergency Management (ODPEM) is the main body within the National Disaster Committee (NDC) responsible for coordinating the management of the various types of disasters. The Prime Minister is the Chairman of the NDC. Several agencies are members of NDC and work alongside ODPEM:

- i) All government ministries
- ii) All utility companies
- iii) International donor agencies (e.g. Salvation Army, Red Cross)
- iv) Search and rescue organizations (e.g. the Jamaica Defence Force, the Jamaica Police Force and the Fire Brigade).

In St. Vincent and the Grenadines the National Emergency Management Office (NEMO), under the Ministry of National Security, Air and Sea Port Development, is assigned the role of activating the community on a countrywide basis to deal with disasters.

The Caribbean Disaster Emergency Management Agency (CDEMA) is an inter-regional supportive network of independent emergency units throughout the

Caribbean region. It supports the principles and practice of Comprehensive Disaster Management (CDM) which is an integrated and proactive approach to disaster management. This agency will be engaged to act as the catalyst for the collaborative approach to the development of these formal DRPs.

Improving the efficiency of disaster recovery is extremely important for the citizens and private sector of the country. The longer it takes to restore essential services, the more likely the productivity of individuals and companies as a whole are affected and therefore there are significant loss in revenues for these entities.

Although the citizens and community members are stakeholders in DRP, we do not envisage that they would have a direct role in the development of the ontology. Rather we envisage that we will begin to develop the ontology in cooperation with the Office of Disaster Preparedness and Emergency Management (ODPEM) and the National Emergency Management Office (NEMO) in St. Vincent and the Grenadines. We believe that these agencies, based on their experience and training, are aware of the important role that citizens can play during and immediately following a disaster particularly in the age of mobile technologies and social media. We will therefore be guided by the agencies as to how this immediate role might best be represented in the ontology. If represented, it would also serve to alert small island states with less developed DRPs or no present formal plan who use the ontology when it becomes openly available, to the important role of citizens.

The ontology could provide information that can be used by agencies in consultation with the communities to prioritize the allocation of recovery funds.

Additionally, it is important that unlike traditional disaster recovery tools the ontology is not static. Feedback from communities would help in the improvement and refinement of the ontology.

Research Design & Methods

WORD LIMIT: 1,000. In this section, applicants should clearly indicate and justify the proposed study design. You should discuss how you intend to collect the data that you will need to achieve the study's objectives and answer the project's research questions. You should clearly outline how each data collection activity will contribute to the study objectives.

Altay and Green (2006) state that disasters are large, intractable problems that test the ability of communities, nations, and regions to effectively protect their populations and infrastructure, to reduce both human and property loss, and to

rapidly recover. The huge loss (in both dollars and loss of life) resulting from these disasters make disaster recovery an important area of research as better solutions are needed to deal with planning and recovery. They point out that much of the research in disaster management has been in the social sciences and humanities and while important the research in social sciences has primarily focused on disaster results, sociological impacts on communities, physiological effects on survivors and rescue teams and organizational design and communication problems. They argue that there is a need for more Management Science and Operational Research in the area of DRP.

This research will use a Design Science approach (Hevner et al. 2004; March and Smith 1995; Peffers et al. 2007) for the establishment of an open methodology for DRP and will demonstrate the importance of the DRP ontology as a part of this methodology. The Design Science paradigm seeks to extend the boundaries of knowledge by creating new and innovative artifacts (Hevner et al. 2004). Hevner et al. (2004) specify the following set of guidelines for conducting and evaluating good Design Science research which will be adopted for this research:

- 1) *Design as an Artifact* – the research must produce a viable artifact (e.g. a method or instantiation)
- 2) *Problem Relevance* – the artifact produced must be a solution to an important and relevant problem.
- 3) *Design Evaluation* – the utility, quality and efficacy of the design artifact must be rigorously demonstrated using a reputable evaluation method, such as:
 - i. Observational Methods (e.g. case studies and field studies)
 - ii. Analytical Methods (e.g. optimization)
 - iii. Experimental Methods (e.g. simulation)
 - iv. Testing (e.g. structural and functional testing)
 - v. Descriptive Methods (e.g. informed arguments, scenarios)
- 4) *Research Contributions* – the output must make verifiable contributions to extending the body of knowledge within a specified area.
- 5) *Research Rigor* – rigorous methods must be used both in the construction and evaluation of the artifact.
- 6) *Design as a Search Process* – the development of the artifact requires the utilization of available means to reach desired ends while satisfying the requirements within the problem environment.
- 7) *Communication of Research* – the research must be presented effectively both

to the various audiences and to researchers and practitioners.

Design science research involves the design of novel or innovative artifacts (in this case the DRP ontology) and the analysis of the use and/or performance of such artifacts to improve and understand the behavior of aspects of Information Systems (Disaster Recovery Systems). The guidelines in this methodology were included in the proposal to show how it differs from other research methodologies in other disciplines and that its objectives are of a more pragmatic nature.

Ontologies have been developed in many domains including anatomy, genomics, geopolitics and biomedical sciences.

The design science approach to the development of the DRP ontology artifact seeks to address a gap in research of operational research and management science solution to DRP problems (Altay and Green 2006).

In this research the *artifact produced* will be the DRP ontology together with the methodology for developing the ontology (i.e. the shared collaborative approach). The choice of a formal ontology in the development of DRPs was based on a comparison of the characteristics of ontologies and the requirements of a collaborative and shared approach to the development of the plans (see Research Problem section).

Producing the artifact. The Caribbean Disaster Emergency Management Agency (CDEMA) will be invited to host an initial workshop for potential stakeholders. Stakeholders will be sensitized to the project, the benefits of adopting a shared computer-based approach to developing or improving existing DRPs and the role the open source artifact can play in this process. Existing DRPs will be examined and discussed to arrive at a better understanding of the current approaches being used to formulate them and of the concepts, functions etc. to be included in the ontology. From the workshop discussions and the existing documents the facilitators will seek to extrapolate the various concepts and terms used by the stakeholders. There are a number of knowledge elicitation techniques that can be used in this process (e.g. laddering, card sort, 20 questions, and document analysis) (Shadbolt and Burton (1989); Nakhimovsky et al. (2006); Rao et al. (2009)).

Following the workshop and based on the information gathered, we will begin to develop the ontology. Since domains of interest are conceived as a set of classes (concepts), relations, functions, axioms and instances, the following are examples of

what the DRP ontology will represent:

- *The target and solution resources.* The target resources are those that need to be protected while the solution resources are those that are used to carry out the tasks that must be performed as part of the DRP. It is possible for solution resources to require other solution resources (e.g. the deployment of an emergency vehicle requires the utilization of emergency crews) and this must be captured as it is important to know, during disaster planning, how many of a given solution resource have been utilized and how many remain available.
- *The location of the resources.* This is essential if the resource is to be protected (target resources) and utilized (solution resources). Information about the location of the resources will assist in optimizing the deployment of solution resources. Different disasters are likely to affect particular types of locations and capturing this information before the disaster occurs will improve the effectiveness of the plan. Knowing where the solution resources are located and which locations are affected by a particular type of disaster helps to ensure that the solution resources are not stored in these likely affected areas.

There have been cases where DRPs cannot be put into operation because the solution resources have become inaccessible when the disaster occurs. For example, in New Orleans there was a plan in place to evacuate persons using school buses in the event of a hurricane. However when Hurricane Katrina struck the location of the buses made them inaccessible because of the amount of flooding in the area. This example also demonstrates the need to ensure that it is well understood beforehand which disasters commonly co-occur as this can also reduce the impact of a disaster. In the case of New Orleans the disaster domain ontology could represent the fact that in the event of a hurricane it is possible that flooding may occur and if it is known where the hurricane is likely to hit, then it could be determined where the flooding is likely to occur.

The *problem relevance* has been discussed in the Justification section above.

Design evaluation. When the “test” artifact is constructed, it will be evaluated using the observational method of a case study. Working collaboratively with the St. Vincent and the Grenadines National Emergency Management Office (NEMO), we will develop a set of questions, based on the information they typically require in carrying out their DRP. Those questions will be posed on the ontology and the results of the

questions assessed (i.e. could they be answered, was the information provided what the participants expected, was the information provided useful for decision making). We will also assess the improvements in efficiency, from the stakeholders' perspective, that using the ontology for the DRP provides. Based on the evaluation, the ontology will be refined before it is made available throughout the Caribbean and to other SIDs outside the region.

Communication of Research. CDEMA will be invited to host a second workshop which will bring together the important stakeholders from across the Caribbean region. Here the open source artifact will be demonstrated and released. Other forms of communication are described in the Knowledge Translation and Dissemination section.

Other guidelines in the methodology are covered in various sections of this proposal.

Analysis & Synthesis

WORD LIMIT: 1,000. Describe how you intend to organize, examine and model data to arrive at conclusions and insights.

The Design Science approach has a set of guidelines, a number of which are very important in arriving at conclusions and insights. So using this approach forces one to explicate how the research will lead to conclusions and insights and has been described in the *Research Design and Methods* section. One such guideline is to describe how the solution artifact addresses an important and relevant problem. To do this it is important to understand the importance of DRP to the region and to demonstrate how the proposed solution will address inefficiencies in how things are currently done. The initial stakeholder workshop described above is intended to do just this. The current practices, documents and data sources for DRP will be identified and will be used in the design of the artifact. The DRP entities within each country as well as the CDEMA are likely to have their own set of practices, documents and data sources. These must be examined and the stakeholders interviewed if a true understanding of the existing DRP practices (if any) and the concepts, terms and activities currently being used locally are to be understood and synthesized across countries.

Another important guideline for Design Science is the design evaluation that requires rigorously demonstrating the utility, quality and efficacy of the design artifact using a reputable evaluation method. One such acceptable method that will be used for this research is the Case Study in which the artifact is evaluated in the environment it is intended for. In our research we will evaluate the initial ontology in one of the Caribbean countries (St. Vincent). The insights from this initial case study may lead to a refinement of the DRP ontology. The lessons learned from the collaborative development and evaluation of this artifact will provide useful insights into the acceptance of the collaborative approach to DRP in SIDs and to Open approaches to addressing common regional problems generally.

The Design Science approach requires that there must be defined research contributions and specifies that the output must make verifiable contributions to extending the body of knowledge within a specified area (i.e. research rigor). The fact that there are expected to be two peer-reviewed journal publications coming out of this research will validate the rigor the research.

Outcomes & Outputs

WORD LIMIT: 700. Describe the major project outputs and intended outcomes. Your project outputs should creatively reflect the principles of open and collaborative science.

The major output of this project will be the developed artifact, the DRP ontology, to be used by SIDS in the Caribbean. However the collaborative methodology used to develop the ontology can be used by other regions and countries and can be applied to other domains.

In addition we expect the project to have the following outcomes:

- The very important issue of DRP will be brought to the forefront. Although many SIDs do have some structure in place to address disaster recovery planning, the responses to the recent spate of natural disasters suggest that there is still a lot of work to be done in this area.
- Given the level of stakeholders involved in these discussions, we expect that policy documents related to Disaster Recovery Preparedness within the Caribbean region will be revised with an emphasis on addressing these issues in a collaborative way.
- We expect to increase regional awareness of the possibilities that are available in solving regional problems if an integrated and open approach is taken. This approach allows for more efficient and effective use of the limited resources available to many SIDs.

The hosting of the initial workshop that will bring together the important stakeholders from across the Caribbean region will be a first step in developing awareness of both the importance of disaster recovery for the region and also the possibilities that are open to countries and entities within these countries if they are willing to collaborate and share information. In most of these countries the body in charge of DRP reports to the Prime Minister of the country and therefore if the bodies are confident of this approach then this will be supported at the highest level. The outputs and outcomes of this project can be an important support for CDEMA, the inter-regional supportive network tasked with supporting the principles and practice of Comprehensive Disaster Management - an integrated and proactive approach to disaster management.

In terms of the linkage between this research and development we believe that the ontology will not only lead to more effective use of resources during and immediately following a disaster but that it will also provide information to support longer term development plans. It can be described as an “a priori effort [that] can formalize and predict at least some of the strategic and resource commitments that may be needed for recovery planning, implementation and performance management. Planning for

recovery can also mitigate against recurring challenges in sustaining national ownership and development cooperation inherent in maintaining traction and momentum on recovery.” (Global Facility for Disaster Reduction and Recovery, 2014, p. 86). The Global Facility for Disaster Reduction and Recovery advises that governments should take advantage of recovery plans to put forward national poverty alleviation and long-term development objectives (p. 89). Therefore the ontology may be seen as an innovative artifact that can be used in the effort to build back better.

Knowledge Translation & Dissemination

WORD LIMIT: 700. Describe how you will disseminate your outputs. To ensure that the results of your study are applied to address development challenges, explain how you intend to package, disseminate and promote the application of your findings amongst relevant stakeholder groups.

In terms of the dissemination of the outputs, the approach used will include:

1. The case study approach is being used as the evaluation method for this design science process which will involve at least two countries in the Caribbean. The demonstration of the applicability of the DRP ontology to the stakeholders in these countries is expected to promote the results of this work.
2. Given that a workshop will be organized at the start of the project to sensitize all stakeholders to the objectives of the research, understand how they currently carry out DRP and explain how the artifacts proposed can improve their current processes. The agencies and stakeholders that are involved in the DRP process are under the Office of the Prime Minister in Jamaica and the Minister of National Security, Air and Sea Port Development in St. Vincent and the Grenadines and therefore it is expected that as the project develops there will be buy-in from all levels within the region and that the artifacts should be readily accepted. Partnering with the Caribbean Disaster Emergency Management Agency (CDEMA) will be an important approach to ensuring that the outputs are disseminated within the region.
3. The research is expected to influence policy related to both disaster recovery and collaborative, open approaches to solving problems that are common to the Caribbean region and SIDs elsewhere. Given the makeup of the stakeholders who will be included in the project it is expected that policy, as it relates to DRP, will be revised and policy related to Open approaches for problem will be established.

These discussions related to Open approaches have started in the Caribbean and there is quite an interest at the regional level, especially as it relates to Open data and FOSS (Free and Open Source Software). Therefore, this research is very timely for the region.

4. The Open Source Artifact (i.e. the DRP ontology) produced from this work will be freely available on line so others may adopt and adapt it (e.g. by extending it to include others languages spoken in the Caribbean region). National and regional disaster recovery entities will be asked to provide links to the artifact on their websites.
5. While this research has a significant practical component, it will also result in at least two scholarly articles which will be submitted to relevant journals. Therefore the artifact developed, the information gathered and the lessons learned from this research will be disseminated to other researchers to utilize and build on the contributions of this particular research project.

Network Connections & Interactions

WORD LIMIT: 500. Illustrate how you will contribute to the overall OCSDNet framework and themes. Draw on other initiatives and approaches discussed at the OCSDNet workshop, if applicable.

(T2) *Infrastructures & Technologies*. The DRP ontology will be developed in a collaborative way and will be designed as an Open Source Artifact that can be shared across SIDS. The ontology can become an important component of a DRP Information or Knowledge Management System. Additionally, the methodology used for this research can be reused by SIDs in other regions and can be applied in other domains that are essential for the development in those regions.

(T3) *Communities of Practice in Open and Collaborative Science*. By exploring how an Open Science approach can be beneficial in the mobilization of a community of practitioners and stakeholders around a common shared problem space, specifically the threat of natural disasters in the Caribbean. There is already some indication that the stakeholders agree that a collaborative approach is needed to address DRP (given the establishment of the regional body CEDMA) and this research will give further support to this view.

(T4) *Potential Impacts of OCS*. As we implement the project we will be able to evaluate whether the collaborative approach, enabled through the shared ontology,

will lead to a better understanding, at the regional level, of the issues and solution for effective disaster recovery planning. The learnings from applying the collaborative methodology will provide further insights to determining the potential impacts of OCS.

In terms of terms of linkage to other proposals Ontologies have been applied in a number of areas and for a number of domains (e.g. in anatomy, genomics, geopolitics and biomedical sciences). Therefore, projects in the network that require the sharing of a common understanding of the structure of information among stakeholders in a domain and the analysis of the domain knowledge will be benefit from the development of a shared ontology. This is especially important in domains and for problems where heterogeneous data sources and collaborators need to come together to solve a common problem as they may be affected by the ambiguity of the information (i.e. concepts and terms) used within the domain. For example, “Brazil’s Virtual Herbarium” study may benefit from the construction of an ontology as this will facilitate the information sharing and retrieval within this domain.

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