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Earth Observation for Development

Risk Information Services for Disaster Risk Management (DRM) in the Caribbean

Service Readiness Document

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1 INTRODUCTION

1.1 Scope of the document

This document specifies the EO information products / services to be delivered in support of the World Bank project (Handbook for the Assessment of Landslide and Flood Hazards and Risks to Support Development Processes, led by ITC Netherlands), and describes the scope and extent of assessment that will be carried out following production and delivery.

It is to be reviewed and agreed by the WB TTL for the project (and local users, if applicable), and will form the basis of subsequent activities to be carried out in the service assessment phase.

1.2 Acronyms and abbreviations

BGS	British Geological Survey
CHARIM	Caribbean Handbook on Risk Information Management
DEM	Digital Elevation Model
EO	Earth Observation
EO-RISC	Earth Observation for Risk Information Services in the Caribbean
ESA	European Space Agency
EU	European Union
FP	Final Products
FR	Final Report
GMES	Global Monitoring of Environment & Security
KO	Project kick-off
MDB	Multi-Lateral Development Bank
MMU	Minimum Mapping Unit
OD	Operational Documentation
PM	Progress meeting
SOW	Statement of Work
SRD	Service Readiness Document
SRR	Service Readiness Review
SUR	Service Utility Review
SUD	Service Utility Document
TPM	ESA Third Party Mission
TTL	Task Team Leader
VP	Validation Protocol
WB	World Bank

2 WORLD BANK PROJECT CONTEXT

2.1 Project Background

The project is designed within the context of ***eoworld*** to demonstrate the benefits of satellite Earth Observation (EO) technology as a standard tool in planning, implementing, monitoring and assessing for World Bank projects / programmes, and further to establish its use in World Bank operations on a sustainable basis. This project is focussed on “risk information services for disaster risk management in the Caribbean” a title that has been abbreviated to **EO-RISC** (Earth Observation for Risk Information Services in the Caribbean) internally by the British Geological Survey (BGS) which is undertaking the project on behalf of the European Space Agency (ESA).

EO-RISC is addressing various issues in the Caribbean. In broad terms, the Latin America and Caribbean Regional Disaster Risk Management and Urban Unit (LCSDU) in partnership with the Global Facility for Disaster Reduction Recovery (GFDRR) has begun the “Caribbean Risk Information Programme to support the Integration of Disaster Risk Management Strategies in Critical Sectors” project. This has been initiated in order to strengthen the regional and national capacity to create and use hazard and risk information for planning and development processes, and consists of four components: (a) creation of a geospatial information basis, focusing on the collation, quality control and adequate storing, management and sharing of existing geospatial data in a spatial data infrastructure, (b) development of a methodological framework for the development of hazard and risk information for development and planning processes, (c) implementation of five national pilot hazard studies aimed at implementing the methodological framework in partnership with Caribbean countries, and (d) integrating institutional strengthening as a cross-cutting activity to all components. This LCSDU/GFDRR activity forms part of the Probabilistic Risk Assessment (CAPRA) Program whose objective is to enhance the capacity of targeted sectors in Latin America and the Caribbean region to develop and mainstream disaster risk information into development programs and policies by providing knowledge products and services. Counterpart agencies are the Ministries of Works and Physical Planning in the following countries: Belize, Dominica, Grenada St. Lucia, St. Vincent and the Grenadines, Haiti, Guyana and Jamaica. With a focus on national-level landslide and flood hazard assessments, country-wide baseline data and information are required. They span a broad range such as: Land Use/ Land Cover, updating of river and stream courses, extent of lakes, water bodies, and watersheds, basic road network, landslide inventory, Digital Elevation Models, geology including fault lines, geomorphology, soil maps, etc.

The EO-RISC project specifically addresses the four target countries of Belize, Grenada, St Lucia, and St Vincent & the Grenadines (Figure 1), each if which is affected by natural hazards.

Figure 1 Location of the four target countries for EO-RISC. 1. Belize, 2. Grenada, 3. St Vincent and the Grenadines, 4. St Lucia © OpenStreetMap contributors.

The Caribbean itself is in the path of Atlantic hurricanes bringing extreme weather which, in combination with the terrain and geological conditions, makes them prone to landslides. Furthermore there is a susceptibility to floods, storm surges and tsunamis. The seismic and volcanic activity in the area also poses a hazard. In addition, it was noted in van Westen (2014) that “the small island states in the Caribbean – especially those of volcanic origin with rugged and steep terrain – have limited suitable surface area for development and agricultural production. Most of the population live along the coast….these areas are affected by floods” while “vital infrastructure that traverses the mountainous areas can be severely damaged by landslides…these events have a severe impact on the relatively small economy of these countries”.

Table 1 General disaster management and hazard characteristics for the four countries in EO-RISC (Source: CDEMA website, and modified from van Westen, 2014).

	Belize	**Saint Lucia**	**St. Vincent and the Grenadines**	**Grenada**
Area	22,806 km^2	606 km^2	389 km^2 (Saint Vincent 344 km^2) with 32 islands and cays	344 km^2
Coastline	386 km	158 km	84 km	121 km
Terrain	Flat, swampy coastal plain; low mountains in south. Max. elevation 1,160 m	Volcanic and mountainous with some broad, fertile valleys. Max. elevation: 950 m	Volcanic, mountainous. Max. elevation: 1,234 m	Volcanic in origin with central mountains. Max elevation: 840 m
Natural hazards	Frequent, devastating hurricanes (June to November) and coastal flooding (especially in south),	Hurricanes and volcanic activity, debris flows, flashfloods	Hurricanes; Soufriere volcano on the island of Saint Vincent is a constant threat. Flashfloods and landslides	Lies on edge of hurricane belt; hurricane season lasts from June to November. Flashfloods and landslides.
Hazard characteristics	Hurricanes and tropical storms are the principal hazards, causing severe losses from wind damage and flooding due to storm surge and heavy rainfall. Hurricanes Keith (2000), and Iris (2001) caused some of the worst damage ever, reaching 45% (US$280 million) and 25% of GDP, respectively.	Saint Lucia's mountainous topography coupled with its volcanic geology means that it experiences landslides, particularly in the aftermath of heavy rains. Much of the island's housing is distributed along steep slopes and poorly engineered and constructed housing is particularly at risk. Additionally, the island periodically experiences earthquakes of generally lower magnitudes. Also storm surge and flash floods are among the other risks regularly faced by the island.	Landslides, particularly on the larger islands, are a significant hazard and the risk is increased during the seasonal rains. Coastal flooding is a major concern particularly relating to storm surge and high wave action. The Grenadines are more susceptible to drought. The active volcano La Soufriere, located on the north end of St. Vincent is another risk factor, posing threats from shallow earthquake and eruption events. Since 1900, St. Vincent has been hit by 8 named storms, the strongest being Hurricane Allen (Category 4), which passed between St. Lucia and St. Vincent in 1980. The 1939 eruption of the volcano Kick-'em-Jenny located some 100 km reports S of Grenada, generated a 2-meter high tsunami.	The country was heavily affected by Hurricane Ivan in 2004, and Hurricane Emily in 2005. There are two active volcanoes in Grenada, Mount St. Catherine in the center of the island and the submarine volcano Kick-'em-Jenny is located 8 km north of the island and has led to tsunami in the past. Flood risk in Grenada is largely associated with storm surge in low lying coastal areas. Flash flooding from mountain streams coupled with storm surge events are the primary causes of flood events and effects are generally limited to communities located in the coastal margins along stream passages. Landslides are a common event in Grenada, with much of the impact experienced along the roadway network.
Population	334,297 (2013)	174,000 (2010).	104,574 (2009)	110,000 (-)

The susceptibility to natural hazards described above makes monitoring hazards, understanding their causes, and potentially forecasting their locations a vital task in the geographic region.

EO-RISC is linked to the World Bank project "Handbook for the assessment of landslide and flood hazards and risks to support development processes" that is led by ITC (Faculty of Geo-Information Science and Earth Observation) at the University of Twente. The principal objective is to strengthen the regional and national capacity of governments in the Caribbean Region to develop or procure the development of landslide and flood hazard and risk information. Four main components of the ITC/WB project are:

i) the development of a methodological framework for the generation of landslide and flood hazards and risk information required for DRM to be documented in a handbook;
ii) the implementation of national-level hazard mapping studies to test and refine the methodological framework;
iii) the compilation and creation of data to support the implementation of national-level hazard mapping studies; and
iv) capacity building in the application of the methodological framework.

The WB/ITC project is working on same islands as EO-RISC, with the addition of Dominica. Having started prior to EO-RISC, and having a broader remit (e.g. ITC will produce landslide risk assessments, while EO-RISC will provide a landslide inventory) and funding base, ITC and their partners have already established contacts in-country and engaged with the appropriate institutions. It has been agreed that EO-RISC will work closely with the existing WB project including:

- utilising the ITC and partners as users
- sharing data and expertise as appropriate and possible within IPR conditions
- providing products and services to ITC
- coordinating work with ITC (e.g. to potentially increase the temporal or spatial coverage if each institution was working in isolation)
- cross-validating methods and products
- collaborating in the field, where appropriate and efficient
- sharing stakeholder events
- contributing to reports, products and services, as appropriate.

All sixteen ***eoworld*** projects are following the same work logic that comprises three primary tasks:

Task 1 - Service Set-up

Task 2 - Service production, quality checking, initial validation and delivery

Task 3 - Service assessment.

This Service Readiness Document is the deliverable for Task 1. Details of this task are outlined below, derived from the Statement of Work:

<u>Task 1 – Service Set-up</u>.

Input:
• Requirements driving the definition of EO information products / services as described in the Annexes of the SOW.

• Contractor's proposal (including first assessment of EO data required)

Activities:
• Establish direct contact with World Bank users, verify that the type, scope and scale of planned service production is consistent with any evolution in project requirements, further consolidate the participation and activities expected of the users, define and establish the use and role of any ancillary / in-situ information required and the methods for how EO products / services can be validated against this information, begin discussion how the assessment of the utility / value / benefit of EO products / services will be carried out (what success criteria?, quantitative? qualitative?)

• Define the procurement plan for all EO data required, confirm availability and negotiate procurement agreements with data suppliers / mission operators (including any discounts on full commercial prices)

• Participate in a 2-day Service Readiness Review (SRR) to be held at World Bank (Washington DC) at KO + 1 month (jointly organised and chaired by World Bank and ESA) to finalise with the users the specifications and delivery schedule all of EO products / services to be produced

• Consolidate all outcomes of the Service Review meeting into a Service Readiness Document.

Deliverables:
• D1: Service Readiness Document (SRD) i.e. this document.

The Activities have been extracted directly from the SoW, and therefore there are some caveats to note.

- Establishing direct contact with World Bank users was discussed with the WB TTL (Dr Melanie Kappes) and the ITC (Dr Dinand Alkema & Dr Cees van Westen) who are already running the project in the region that EO-RISC is to coordinate with. WB and ITC requested that we do not contact the users directly, and in fact their preliminary assessment report (Draft version May 2014) states that "The contractor of ESA (this service will be carried out by the British Geological Survey) will not by-pass ESA and WB and will only contact ITC or the user via ESA and the World Bank". BGS understands this request as we do not want to confuse the users with multiple contacts and we have agreed to work closely with ITC who have already been in contact with users, albeit with some different priorities to the EO-RISC project.
- Participate in a 2-day Service Readiness Review (SRR) at KO+1 month. This SRR was cancelled by ESA, therefore we have lost the primary opportunity to liaise with the users and to understand their expectations, specifications and requirements.

The aim of EO-RISC is to deliver three services including i) land use / land cover mapping, ii) hazard mapping to support landslide risk assessment, and iii) Digital Elevation Model (DEM) as outlined in Table 2.

Table 2 Services to be delivered by EO-RISC

Service Number	Service type	Service coverage	Comment
# 1	Land use / land cover mapping	St Vincent and the Grenadines St Lucia Grenada	Dominica was replaced by St. Vincent & the Grenadines at the request of the WB.
# 2	Hazard mapping to support landslide risk assessment	Grenada St Lucia	Landslide inventory map of Grenada at 1:20,000 Landslide inventory map of ST Lucia at 1:20,000 with key areas (no more than 50%) at 1:10,000.
# 3	Digital Elevation Model (DEM)	Belize	Nationwide DEM covering 80% of the territory, and a high resolution DEM covering no more than $100km^2$

Each of the services has **mandatory requirements** that were outlined in the SoW and listed below:

i) Land use / land cover mapping – shall seek to capture vegetation, sealed surfaces, basic road network, water bodies. The water features (vector) product shall include rivers, streams, lakes, water bodies and watersheds. The project is focussing on hazard analysis at a national level, therefore detailed information on building footprint / building type / location etc. is not a priority.
Geometric accuracy: depends on the spatial resolution of the input EO data, typically < 1 pixel.
Spatial resolution: MMU; metric depending on the pixel size of the raster product(s).
Thematic accuracy: target between 90% and 80% (depending on the quality of the EO data). In the absence of ground truth data or aerial photos, methods for checking the thematic accuracy shall be proposed, documented and applied by the contractor.
Period and update frequency: the date of the satellite observations used for mapping shall not be older than 3 years.
Preferred EO sources are primarily Very High Resolution optical (VHRO) but others such as High Resolution Optical (HRO) or Landsat shall be considered if justified.
The minimum spatial coverage of the product shall correspond to a representation portion (80%) of the AOI.

ii) Hazard mapping to support landslide risk assessment. The service shall comprise:

a) Landslide inventory mapping shall seek to capture as far as possible information on landslides including the location, and where known, the date of occurrence and types of observable landslides.
b) A DEM generated using EO data (such as SPOT or ASTER) or other non-EO data to be proposed by the bidder.
c) Ground truth in St Lucia and Grenada. Collecting in-situ measurement to support the landslide hazard mapping.

Geometric accuracy: depends on the spatial resolution of the input EO data, typically <1 pixel
Spatial resolution: typically at a scale of 1:20,000. Key areas of St Lucia (no more than 50%) will have a spatial resolution of 1:10,000 (as agreed during contract negotiations).
The DEM should have a spatial grid of 30m or better.
Thematic accuracy: target between 90% and 80% (depending on the quality of the EO data). In the absence of ground truth data or aerial photos, methods for checking the thematic accuracy shall be proposed, documented and applied by the Value Adding specialist. The DEM should have a vertical accuracy in the range of 5 to around 10 meters.
Period and update frequency: As a baseline survey, satellite observations used for hazard mapping shall not be older than 2010. In addition, to make the analysis more robust, it is intended that they are complemented with several past observations using imagery from previous acquisition dates. The satellite observations used for the DEM mapping should not be more than 5 years old.

Preferred EO data sources: It is expected that the landslide inventory is based on the analysis of optical imagery, possibly combining different viewing angles and different observation times. Interferometic methods such as Persistent Scatterers Interferometry can be considered but it is anticipated that the necessary conditions are not met to apply this because of the limited archive data availability and the characteristics of the site (e.g. vegetation cover).
Related information: the minimum requirements are for the landslide risk inventory and the DEM to correspond to a representative portion (minimum 60%). Ground truthing shall be on a sample basis.

iii) The Digital Elevation Model service shall comprise
   a) DEM at high resolution over the whole of the AOI
   b) A precise DEM shall be provided as a demonstration over a limited area <100 km^2, to support hazard / risk assessment.

Geometric accuracy: depends on the spatial resolution of the input data, typically < 1 pixel.
Spatial resolution: MMU metric depending on pixel size of the raster product(s). The DEM should have a spatial grid of 30 m or better, and the precise DEM should have a spatial grid of around 1 m.

Thematic accuracy: The DEM should have a vertical accuracy in the range of 5 to around 10 meters. The precise DEM should have a vertical accuracy between 1 and 1.5 meters.
Period and update frequency: Satellite observations used for DEM mapping should not be more than 5 years old.
Preferred EO data sources: The DEM should be at least of the quality of the ASTER GDEM (version 2). The precise DEM shall be based on VHRO data / stereo imagery. It is intended that it will be produced using stereo imagery or, if possible, using triple acquisitions with different viewing angles.
Related information / comments: The spatial coverage of the DEM shall correspond to a representative portion (minimum 80%) of the AOI. The precise DEM shall cover only a limited portion, agreed as <100 km^2 and shall cover an area specified by and agreed with WB/ITC.

There are several EO-related issues that this project is addressing. The primary issue is that there is a limited archive of radar data so we are restricted to using optical data in this tropical humid climate zone with abundant cloud cover. Whilst some archive data exist, we need to task the acquisition of VHRO data including Pleiades. This is a challenge because discussions were ongoing between ESA and Airbus regarding TPM contracts to acquire Pleiades data, therefore the tasking was not accepted until 6 August 2014. June to November is the rainy season, therefore it will be a challenge to acquire suitably cloud-free imagery in the timescale of this project.

2.2 Requirements for Geo-Spatial Information

EO-RISC will deliver a range of products / services that require certain geospatial information to underpin their delivery. This selection of information has been included specifically for this project because it relates to the terrain and climate conditions of the region. It should be noted that other information may be more suitable for other geographic areas.

Some information is mandatory in order to deliver the products / services while there is additional geospatial information that could either increase the accuracy of the products, or potentially add to their usability. The geospatial information required by EO-RISC is listed below.

EO data are listed in Section 2.4 and Section 4 and therefore will not be included in detail here. The EO data will be used to produce elevation information, land cover / land use information, and both manual and automatic methods will be used to extract / interpret landslide inventory data.

In addition to the information directly produced from the EO data, it is useful to have pre-existing information that can a) provide a baseline either derived from other sources e.g.

in-situ or from time periods prior to the existence of satellites, b) provide calibration / validation information to improve the accuracy of the information derived from the satellite imagery and c) provide information that is difficult to obtain from satellite data e.g. administrative boundaries that might be of importance when assessing risk.

Elevation information at a suitable scale and accuracy is vital for a variety of reasons including:

- direct mapping of features such as landslides
- direct and indirect mapping of geology and soils
- modelling of drainage flow paths and drainage basins
- modelling flooding including surface water run-off routes and coastal surges
- as a means of displaying complex information to a range of users, e.g. plotting a landslide inventory map onto a shaded relief to explain potential correlations.

Elevation data (including contours) were historically derived from ground surveys and aerial photogrammetry. This project aims to deliver elevation data at a variety of scales from satellite imagery, highlighting the coverage and ease of use of this type of information from satellite sources.

Land cover and land use information. EO-RISC is tasked with producing maps of vegetation, sealed surfaces, basic road network, water bodies. The water features (vector) product shall include rivers, streams, lakes, water bodies and watersheds. The project is focussing on hazard analysis at a national level, therefore detailed information on building footprint / building type / location etc. is not a priority. Existing satellite-derived land use/land cover maps for ca. 2000 are available for Grenada, St. Lucia and St. Vincent and the Grenadines (Helmer et al., 2007; 2008). It is intended to use these as a baseline during service production. Specifically, these existing maps will be used to help define the appropriate land use/land cover classes, to define training areas for supervised image classification, and for validation purposes. The thematic accuracy of the land use/land cover maps produced as part of this service will be determining using the standard confusion matrix approach. Validation parcels with unambiguous class identifies will be identified using a combination of the RapidEye and Pleiades imagery, and existing maps, wherever land use/land cover can be reasonably assumed to have remained unchanged in the period between ca. 2000 and the acquisition date of the current imagery.

2.3 Current Practices

The schedule for EO-RISC included a brief period at the outset of the project to compile this SRD, therefore it has not been possible to conduct an exhaustive review of the geospatial information sources or practices currently being used by WB teams and local users. However we can draw upon previous research undertaken by BGS and current research being done by the ITC/WB CHARIM project.

There are a range of skills and experience amongst the local users, ranging from little or no use of geospatial data, to complex use and understanding e.g. at the University of West Indies, which has campuses at Barbados, Jamaica, Trinidad & Tobago and an Open Campus with 52 education centres in 16 different countries including St Lucia, Grenada and St Vincent & the Grenadines. BGS coordinated with the Unit for Disaster Studies at the University of West Indies in 2000 on a project funded by the UK Department for International Development (DfID) in Jamaica to carry out a landslide hazard mapping case study. That project utilised a range of geospatial data including geology, soils, elevation, vegetation, climate, seismicity and a landslide inventory derived from aerial photography, Radarsat imagery, and fieldwork, supplemented by extant published information. Table 3 lists the geospatial information sources currently used in the Caribbean.

Table 3 Geospatial information sources currently used by WB teams and / or local users (derived from van Westen, 2014)

Current geospatial information sources	Grenada	St Vincent and the Grenadines	Saint Lucia	Belize
DEM	10m raster DEM (source unknown) and partial LiDAR coverage	5m raster DEM (higher parts are not covered). There are LiDAR data of St.V but the format is incorrect so they cannot be analysed	50m raster maps and contours with 2.5m intervals	ASTER and SRTM. Higher resolution data are urgently required for flood risk modelling.
Landcover	USDA 30m raster map	Polygon map exists with 11 land use classes	1:50,000 raster maps. Vegetation information is in vector format	
Elements-at-risk	Non-attributed building footprints	Not available	Available for the country, including building footprints – though occupancy and structural type is unavailable	Not available
Geological map	A very general one is available, made by USGS	A very general one is available, made by USGS	Vector map is available	
Soil map	A 1959 soils report exists but ITC have not been able to obtain the 1959 map	General soil map from USAID from 1990	Vector map is available	General map has been scanned by ITC
Discharge data	Continuous stream flow data do not exist	None available	None available	None available
Geotechnical data	None available to date	None available	None available	
Rainfall data	Approx 50 rainfall stations.	None obtained thusfar, but	Hourly rainfall data for 24	Missing

	Data is not continuous. Data available from the Land Use Division, Ministry of Agriculture, Lands, Forestry and Fisheries	rainfall stations do exist	stations	
Landslide inventory and hazard map	1988: OAS study for selected towns. 2006: CBD/CDERA study – limited inventory of 40 landslides, but not available digitally	Landslide footprints are available, but there is no detail	2010 inventory map has been produced from satellite imagery	Not applicable
Socio-economic data	Missing	Missing	Missing	Missing

The data listed above are utilised by World Bank and local users through a variety of projects and initiatives. In **Grenada** mapping and GIS capability is managed predominantly by the Ministry for Agriculture, but progress is limited. A school landslide vulnerability assessment has been completed (http://www.oas.org/CDMP/document/schools/vulnasst/gre.htm). No comprehensive multi-hazard map compilation has been prepared. The WB is implementing a Disaster Vulnerability Reduction Programme (DVRP). Component 2 (Disaster and Climate Risk Reduction) of the Disaster Vulnerability Reduction Project which would consist of new construction and rehabilitation of existing infrastructure in order to reduce their vulnerability to natural hazards and climate change. Included within the activities are consultancy services to undertake soil investigation mitigation measures for landslip sites in several sites.

In **St. Vincent and the Grenadines**, progress in preparation of hazard maps is limited. To date, risk mapping has been limited to volcanic risks and some coastal vulnerability analyses. Basic GIS-ready maps of roads, contours, rivers, coastlines, agricultural & urban land use have been prepared – primarily available through the Ministry of Planning and the National Emergency Managements Organisation (NEMO). The WB is implementing a Disaster Vulnerability Reduction Programme (DVRP). Components include identification and creation of required baseline data for hazard assessment; development of institutional systems for the collection, sharing and management of geospatial data among national agencies and with regional institutions; training and education in applications integrating geospatial data systems, hazard and risk assessment to support decision making within various sectors and mainstream the use of these tools as a standard practice in development planning.

In **Saint Lucia**, hazard maps have been produced for debris flows, but these may not reflect current conditions. Furthermore, (NEMO) is not equipped to support GIS data and there is no program to support additional hazard mapping. The WB is implementing a DVRP. Component 2 (Technical Assistance, Regional Collaboration Platforms for Hazard and Risk Evaluation, Geospatial Data Management, and Applications for Improved Decision-Making) would finance: a series of capacity-building, knowledge-building and technical assistance interventions at the national and regional levels to support disaster risk management and climate change adaptation. There are specific areas that have been identified and proposed as high priorities for intervention. At the national level, activities would include, inter alia: i) enhancement of national hydro-meteorological monitoring networks; ii) development of an integrated watershed management plan for flood mitigation; iii) technical assistance for the establishment of maintenance monitoring systems for bridges and public buildings that would integrate natural hazards and extreme events considerations; iv) establishment of geo-spatial data sharing and management platform and related training activities; and v) climate change adaptation public education and awareness campaigns. The GeoNode platform for Saint Lucia http://sling.gosl.gov.lc is accessible.

In **Belize**, no nationwide flood hazard maps have been made for the country based on hydrological modelling, and the source of the only flood map identified by van Westen (2014) was unclear. However, hazard mapping has been completed in several areas with GIS datasets covering landslide risk, volcanic hazard assessment and storm hazards amongst others. Belize is participating in the Central American Probabilistic Risk Assessment (CAPRA) platform but the initiative remains modest in Belize.

2.4 The Role of EO

This section is intended to consider what the WB and local users will be expecting EO to contribute. Once again it should be clarified that BGS has not had direct contact with the local users yet, since it has all been channelled through WB and the ITC. Direct contact will happen at the CHARIM meeting in St. Vincent while we are conducting the fieldwork. Therefore we cannot ascertain exactly what the local users are expecting EO to contribute in detail. Nevertheless, we know that the WB has identified a lack of the most basic spatial data such as updated land use maps or good quality DEMs, while other studies (such as CHARIM) have established that EO data are seen as a solution to fill the current baseline information gaps in the region. Furthermore, EO data are also envisaged as an efficient way to update baseline data in the future. It is envisaged that demand for satellite imagery and derived products will grow once local users gain more familiarity with these types of data.

Radar data could provide valuable input to the products and services required of the project, however there are no suitable archives of ESA or TPM datasets. Nevertheless ESA have agreed to add the eastern Caribbean to the background acquisition profile of Sentinel-1A, therefore some of those data (hopefully a time series) could be available to incorporate into the project in due course.

The role of EO in this project will be primarily filled by high and very high resolution optical data including Pleiades and RapidEye, supplemented by Landsat-8, ASTER and SRTM. Some datasets are clearly lacking in the region e.g. high resolution elevation data in Belize, and this project will provide significant updates in the form of a 20 m DEM derived from SPOT data along with a high resolution DEM for 100 km^2 in Belize if the Pleiades satellite is able to acquire suitable imagery within the project timeframe.

Table 4 identifies the broad EO datasets that will be acquired by the project and lists the role that each one will play. Further detail on the EO data is provided in the Data Procurement Plan later in this report.

Table 4 Role of EO data in each service

Service	Service type	Service coverage	Role of EO data
# 1	Land use / land cover mapping	St Vincent and the Grenadines St Lucia Grenada	Pleiades, RapidEye & Landsat 8 – a combination of automatic feature extraction and manual digitisation of features where appropriate. ASTER GDEM & SRTM DEM used with the optical data to visualise and refine the land use maps.
# 2	Hazard mapping to support landslide risk assessment	Grenada St Lucia	Pleiades (tasked stereo), RapidEye & ASTER will be the data sources for the landslide inventory using automatic feature extraction (bare soil as an indicator of active landsliding) and manual interpretation. A selection of features will be corroborated with fieldwork.
# 3	Digital Elevation Model (DEM)	Belize	i) Pleiades (tasked tri-stereo) – precise DEM for ~100km^2 area around Philip Goldson International Airport ii) SPOT HRS 30m DEM – high resolution DEM for 11792km^2, covering 8952km^2 of Belize landmass. ii) ASTER stereo – 30m DEM covering at least 80% of the area.

3 EO INFORMATION SERVICES TO BE DELIVERED

3.1 Service Specifications

This section addresses the EO service specifications in so far as they can be identified prior to direct user access, and before all of the datasets have been acquired and subsequently assessed for quality and accuracy. Where possible, the thematic content, resolution, coverage, timeliness, accuracy and format of the products / services are outlined in Table 5.

Table 5 Service specifications

Service	Service coverage	Thematic content	Resolution	Timeliness	Format	Comment
Land use / land cover mapping	St Vincent and the Grenadines St Lucia Grenada	i) Landcover - we shall seek to capture vegetation, sealed surfaces, basic road network & water bodies. ii) Water features – rivers, streams, lakes, water bodies, watersheds.	Spatial resolution will be typically 1 pixel. This cannot be ascertained until the imagery is delivered and its quality is assessed	The EO data shall not be older than 3 years, although older imagery will be used for context	Raster – land use / land cover Vector – water features	Limited ground checking will be undertaken whilst validating the landslide inventory. 80% of the area of interest will be covered.
Hazard mapping to support landslide risk assessment	Grenada St Lucia	i) Landslide inventory map of Grenada at 1:20,000, and St Lucia at 1:20,000 with key areas (no more than 50%) at 1:10,000. ii) DEM generated using ASTER	i) Landslide inventory at 1:10,000 to 1:20,000 scale. ii) DEM at 30 m horizontal resolution & vert. accuracy 5-10 m.	Inventory EO data will not be older than 2010.	Inventory – vector DEM – raster grid	Multiple years of EO will be used for the landslide inventory to provide context of active and non-active features. Ground truthing will be on a sample basis.
Digital Elevation	Belize (or parts	i) High resolution DEM over all of Belize	i) High resolution DEM will be 30 m	i) 30 m DEM derived from	Raster grids	Nationwide DEM will cover at least 80% of the territory. The

Model (DEM)	thereof)	ii) Precise DEM over a limited area	for at least 80% of Belize, and 20m for 8952 km^2. ii) Precise DEM will be in the order of ~1 m. We cannot be certain until the data are acquired and assessed.	2010 imagery. ii) 20 m DEM from SPOT data from within 5 years of present. iii) ~1 m DEM is from imagery that is tasked to be acquired.		EO data for the precise DEM have been tasked for acquisition by Pleiades in triplet mode – this acquisition is dependent on cloud-free conditions.

The format of the products will be delivered in the most appropriate mode for that product, which is sometimes defined in the SoW e.g. it states that the water features of Service 1 will be in vector format. In general, all products will be delivered in digital format, although analogues copies will be delivered at least to comply with ESA specifications. The data will be readily ingestible into standard GIS. Additional formats, such as 3D PDFs could be produced if requested by the users as they have been found in other projects to increase understanding and usage of 3D EO data.

Regarding the thematic content of the landslide inventory, BGS has defined the following attributes (Table 6) and iterated them with ITC to ensure that both organisations will use compatible attributes when producing their inventory. Not all of the attributes will be completed, depending on the quality of the imagery and the terrain conditions.

Table 6 Landslide inventory attributes

#	Description	Identifier	Type	Dimen-sion	Comments
1		FID			
2		Shape	text	10	polygon
3		Id			
4	Landslide ID	LID	number	7	polygon identifier that can be related to landslide database entry point
5	Location District	DISTR	text	30	district name
6	Location Locale	LOCAL	text	30	locality name
7	Movement type	TYPE	code	2	.. (not entered), FL (flow), SR (rotational slide), SP (planar slide), SU (undifferentiated slide), FA (fall), TO (topple), SP (spread), UN (undefined)
8	Morphology	MORPH	code	1	L, S, T, A (Landslide undifferentiated, Scarp, Transport zone, Accumulation zone)
9	confidence	CONF	code	1	H, M, L (High, Medium, Low)
10	2010	2010	code	1	N, I, A - (Not present - No slide visible), (Inactive - The slide can be recognized but no activity visible, in the form of disrupted vegetation or bare surface), A (Active - Slide shows clear signs of recent activity in the form of bare surfaces, disrupted vegetation etc)
11	2011	2011	code	1	N, I, A - (Not present - No slide visible), (Inactive - The slide can be recognized but no activity visible, in the form of disrupted vegetation or bare surface), A (Active - Slide shows clear signs of recent activity in the form of bare surfaces, disrupted vegetation etc)
12	2012	2012	code	1	N, I, A - (Not present - No slide visible), (Inactive - The slide can be recognized but no activity visible, in the form of disrupted

					vegetation or bare surface), A (Active - Slide shows clear signs of recent activity in the form of bare surfaces, disrupted vegetation etc)
13	2013	2013	code	1	N, I, A - (Not present - No slide visible), (Inactive - The slide can be recognized but no activity visible, in the form of disrupted vegetation or bare surface), A (Active - Slide shows clear signs of recent activity in the form of bare surfaces, disrupted vegetation etc)
14	2014	2014	code	1	N, I, A - (Not present - No slide visible), (Inactive - The slide can be recognized but no activity visible, in the form of disrupted vegetation or bare surface), A (Active - Slide shows clear signs of recent activity in the form of bare surfaces, disrupted vegetation etc)
15	FIELD CHECK	FIELD	TEXT	50	free text

The coverage of the precise DEM i.e. the area that has been tasked for Pleiades triplet acquisition is illustrated in Figure 2. This area was agreed in discussion with the WB. Acquisition of imagery is highly dependent on cloud-free conditions.

Figure 2 Outline (in red) of the proposed area for the precise DEM of Belize, dependent upon tasked Pleiades data acquisition.

3.2 Relevance to User Requirements

The hazard characteristics row of Table 1 summarises the hazards that are of importance to the users of the services in each territory, while Table 3 lists the current geospatial information sources that are available to address those characteristics. This is the situation that EO-RISC endeavours to address. Additional information regarding user requirements and the existing geospatial information sources may be known by the CHARIM project, and BGS will have the opportunity to liaise with the user community at the CHARIM meeting in late September 2014.

The products / services delivered by EO-RISC will certainly be of benefit in their own rights, Cecy Castillo (Science Dept. Chair at the University of Belize) commented that they “will definitely be able to make use of these datasets” and that the project is an “exciting development” while Carren Williams (Principal Land Information Officer, Department of Lands and Surveys, Belize) stated that “the information will be very beneficial for the country”. However, the EO-RISC project will dovetail with CHARIM to produce the Caribbean Handbook for Risk Information Management with BGS staff already identified to contribute to several sections. This handbook will help to build capacity of governments in the region to generate landslide hazard and risk information, and to apply this in disaster risk reduction use cases. The target audience of the handbook is technical staff from government organisations and private consultants, representatives from government sectors such as Ministries of Planning and Public Works, representatives of National Disaster Management Organisations, representatives from NGO’s dealing with risk reduction, representatives from communities and World Bank consultants.

3.3 Advantages/Benefits

It is too early in the project to provide detailed comments on the advantages / benefits of the EO Information services to be delivered – these will be finalised in D3 Operational Documentation. Initial comments can confirm that the general advantages of EO data hold true in this geographic region:

- EO data are remotely derived i.e. non-intrusive;
- The imagery and the processing / interpretative methodology is generally objective and consistent for other areas of similar terrain and data availability;
- Archive data can be accessed to provide historic data (i.e. a baseline). This is particularly important for dynamic features such as landslides where they may appear intermittently in the record, but the combination of their appearances in history (and currently) enables models to be constructed regarding possible future occurrences;

- Programmes such as GEO and Copernicus support long term image acquisition, therefore the methodology used in EO-RISC can be implemented for monitoring programmes within the *eoworld* initiative and beyond.
- Projects elsewhere (e.g. EO-MINERS; www.eo-miners.eu) have shown that products developed primarily from EO data sources can provide authoritative and objective bases for discussion between stakeholders interested in environmental conditions.

3.4 Limitations/Constraints

It is too early in the project to provide detailed comments on the limitations /constraints of the EO Information services to be delivered – these will also be finalised in D3 Operational Documentation. Nevertheless, as with every EO-based project, we are constrained by data availability and cost. In this situation there is not a suitable archive of radar data for InSAR analysis to be undertaken, so we are limited to optical data and the associated techniques.

Pleiades very high resolution data (including triplets for Belize) have been tasked, however the time constraints of this project mean that it is possible that these data will not be acquired as the climate at this time of year generally results in significant cloud cover.

The EO services lack some input from the user community due to the postponement of the meeting at Washington DC. This has meant that EO-RISC is dependent upon feedback from other projects until BGS can liaise directly with the users in late September 2014.

3.5 Guidelines for Use

It is too early to provide guidelines on the utilisation of the EO Services. These will be finalised in D3 Operational Documentation. However, it is recommended that we take advantage of the WB CHARIM project which has a larger remit in the area. The input of EO data will be advertised and promoted via the Caribbean Handbook for Risk Information Management. BGS will also working directly with local users (where resources permit) to embed and stimulate the use of the EO-RISC services as appropriate.

4 EO INFORMATION SERVICES PRODUCTION, QUALITY-CHECKING AND DELIEVRY

4.1 EO Data Procurement Plan

All EO data required to generate the products for the three services is detailed in Table 7.

Table 7 EO data to be acquired in the project

Platform	Product	Date	Scenes	Primary service	TPM?
Pleiades	Bundle (0.5m Pan + 2m MS)	25/02/2014	2	1 - LCM (AOI-A)	Yes
Pleiades	Bundle (0.5m Pan + 2m MS)	06/08/2013	2	1 - LCM (AOI-B)	Yes
Pleiades	Bundle (0.5m Pan + 2m MS)	11/04/2014	1	1 - LCM (AOI-B)	Yes
Pleiades	Bundle (0.5m Pan + 2m MS)	18/04/2014	1	1 - LCM (AOI-B)	Yes
Pleiades	Bundle (0.5m Pan + 2m MS)	15/08/2013	1	1 - LCM (AOI-C)	Yes
Pleiades	Bundle (0.5m Pan + 2m MS)	28/01/2014	2	1 - LCM (AOI-C)	Yes
Pleiades	Bundle (0.5m Pan + 2m MS)	23/02/2014	1	1 - LCM (AOI-C)	Yes
RapidEye	MS 5m L3A	12/02/2014	4	1 - LCM (AOI-C)	Yes
RapidEye	MS 5m L3A	27/12/2014	1	1 - LCM (AOI-C)	Yes
RapidEye	MS 5m L3A	27/02/2011	1	1 - LCM (AOI-C)	Yes
RapidEye	MS 5m L3A	27/09/2012	1	1 - LCM (AOI-C)	Yes
RapidEye	MS 5m L3A	03/01/2014	1	1 - LCM (AOI-C)	Yes
Landsat-8	OLI/TIRS	01/02/2014	1	1 - LCM (AOI-A)	Yes
Landsat-8	OLI/TIRS	16/01/2014	1	1 - LCM (AOI-B)	Yes
Landsat-8	OLI/TIRS	05/03/2014	1	1 - LCM (AOI-C)	Yes
SRTM	SRTM DEM	2000	-	1 - LCM (AOI-ABC)	No
ASTER	ASTER GDEM	-	-	1 - LCM (AOI-ABC)	No
RapidEye	MS 5m L3A	18/08/2010	4	2 - LSM (AOI-A)	Yes
RapidEye	MS 5m L3A	03/01/2011	4	2 - LSM (AOI-A)	Yes
RapidEye	MS 5m L3A	29/09/2012	4	2 - LSM (AOI-A)	Yes
RapidEye	MS 5m L3A	15/01/2013	2	2 - LSM (AOI-A)	Yes
RapidEye	MS 5m L3A	14/02/2013	2	2 - LSM (AOI-A)	Yes
RapidEye	MS 5m L3A	03/01/2014	2	2 - LSM (AOI-A)	Yes
RapidEye	MS 5m L3A	19/02/2014	2	2 - LSM (AOI-A)	Yes
RapidEye	MS 5m L3A	10/03/2011	6	2 - LSM (AOI-B)	Yes
RapidEye	MS 5m L3A	12/02/2012	6	2 - LSM (AOI-B)	Yes
RapidEye	MS 5m L3A	03/01/2014	1	2 - LSM (AOI-B)	Yes
Pleiades	Fresh stereo	2014	2	2 - DEM (AOI-A)	Yes
ASTER	VNIR stereo	2009/11	2	2 - DEM (AOI-A)	No
Pleiades	Fresh stereo	2014	2	2 - DEM (AOI-B)	Yes
ASTER	VNIR stereo	2010	2	2 - DEM (AOI-B)	No
SPOT	Elevation30 DEM	-	-	3 - DEM (AOI-D)	No
ASTER	VNIR stereo	2009-13	19	3 - DEM (AOI-D)	No
Pleiades	Fresh tri-stereo	2014	3	3 - DEM (AOI-D)	Yes

To date, all RapidEye, Landsat-8, ASTER, SRTM and ASTER GDEM data have been procured. The Spot Elevation30 DEM covering ~40% of the total landmass of AOI-D (i.e. Belize) has been ordered and will be delivered shortly after all end-users have been approved by Airbus.

Acquiring Pleiades imagery has been problematic because the ESA TPM contract with Airbus is still officially under negotiation. Nevertheless, the requested archived Pleiades data for use in land use/land cover and landslide inventory mapping has now been obtained ahead of the ESA TPM contract being finalised. Additionally, our request for the acquisition of fresh stereo and tri-stereo Pleiades imagery was approved by Airbus on 6 August 2014, and will be acquired if/when a suitable window of opportunity arises. Stereo and tri-stereo Pleiades imagery is essential for producing the DEMs in service 2 and precise DEM in service 3. Failure to procure the data within the planned schedule due to factors such as cloud coverage will affect the delivery of the associated products.

4.2 Ancillary Data Procurement Plan

Due to the request not to contact the users directly, access to ancillary data is largely restricted to that already acquired as part of the WB/ITC project. Luckily, a wealth of ancillary data has been collated for each area of interest (AOI) and uploaded to the ITC FTP site, to which we have been granted access. The main data include limited high-resolution satellite imagery and LiDAR data, cadastral GIS layers, DEMs, geological maps and existing landslide inventories. More detailed description of the available ancillary data for each AOI is provided van Westen (2014). Additionally, existing land use/land cover maps produced for AOI-A (St. Lucia), B (Grenada) and C (St. Vincent and the Grenadines) by the US Department for Agriculture Forest Service and The Nature Conservancy have been acquired. A summary of the main procured ancillary datasets and their intended use is provided below.

Service	AOI	Dataset	Intended use
1 - LCM	A	Land use/land cover map	Production/Quality check/Validation
1 - LCM	A	Cadastral GIS (e.g. roads, settlements)	Production/Quality check/Validation
1 - LCM	B	Land use/land cover map	Production/Quality check/Validation
1 - LCM	B	Cadastral GIS (e.g. roads, settlements)	Production/Quality check/Validation
1 - LCM	C	Land use/land cover map	Production/Quality check/Validation
1 - LCM	C	Cadastral GIS (e.g. roads, settlements)	Production/Quality check/Validation
2 - LSM	A	Existing landslide inventories	Production/Quality check
2 - LSM	A	Geological map	Production/Quality check
2 - LSM	A	Landslide susceptibility map	Quality check
2 - LSM	B	Geological map	Production/Quality check
2 - LSM	B	Soil map	Production
2 - DEM	A	50 m DEM and contour map	Quality check/Validation
2 - DEM	B	10 m DEM and limited LiDAR data	Quality check/Validation
2 - DEM	B	Cadastral GIS (e.g. roads, buildings)	Quality check
3 - DEM	D	Cadastral GIS (e.g. roads, buildings)	Quality check

Additional elevation data is required for a robust validation of the DEMs to be produced for service 2 and 3. It is intended to seek access to a set of ground-based GPS data via the WB and ITC.

4.3 Production and Delivery Schedule

The planned production and delivery schedule for the three services is outlined below.

	Jul	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**
Data compilation for all services							
SERVICE 2: Initial landslide inventory mapping							
SERVICE 2: Landslide inventory validation							
SERVICE 2: Revise landslide inventory validation							
SERVICE 1: Land use/land cover mapping and validation							
SERVICE 2: DEM generation and validation – *subject to successful, timely acquisition*							
SERVICE 3: DEM generation and validation – *subject to successful, timely acquisition*							
SERVICE 1: Product delivery							
SERVICE 2: Product delivery							
SERVICE 3: Product delivery							

4.4 Quality Checking

The basic quality checking will involve confirming that all products satisfy the defined criteria in terms of spatial resolution, geometric accuracy and spatial coverage. More specific quality checks will also be undertaken for each product. For instance, the initial quality of the land use/land cover maps in service 1 will be visually compared to the existing maps and also layers such as roads, buildings, water bodies contained in the Cadastral GIS. Any major inconsistencies not attributed to temporal offsets will be noted and then appropriate revisions will be made. The landslide inventory maps in service 2 will be quality checked by visually comparing them to the exiting landslide inventory maps, geological maps and landslide susceptibility maps to ensure they are coherent. The DEMs to be generated in both service 2 and 3 will be automatically quality checked as part of the elevation extraction process of the ERDAS Imagine LPS module. Additionally, the initial quality of the DEMs will be visually assessed through comparison with features contained in the cadastral GIS, and manually compared to existing DEMs and contour maps.

4.5 Initial Validation

Once quality checked, the products will undergo a more rigorous validation process. For the land cover/land use maps in service 1, this will involve a conventional classification accuracy assessment through the calculation of a confusion matrix. Wherever possible, the land cover/ land use at several sample locations will also be noted during field trips to St. Lucia and Grenada. These observations will help to provide an additional level of control on the performance of the land use/land cover mapping. The landslide inventory map in service 2 will also be validated during field trips to St. Lucia and Grenada. Validation will primarily consist of a verifying landslides (and their attributes, where possible) recorded in the inventory with evidence on the ground. Field-based validation will be confined to accessible areas, which are anticipated to be those largely proximal to the road network. The DEMs produced for service 2 and 3 will be validated using accurate elevation data, preferably obtained on the ground using a GPS. Attempts will be made to obtain such data from local users through the WB/ITC. As a fall-back option, the accuracy of the DEMs will be assessed using the existing LiDAR data (where available), DEMs and contour maps. The vertical accuracy will be reported using a set of summary statistics, such as the mean, standard deviation and root-mean-square error.

Necessary revision of the products will be subsequently undertaken to ensure that they all meet the desired thematic accuracy. The products will then be supplied to ITC for initial feedback on their suitability (i.e. specifications have been met, format). This feedback will then be considered and appropriate amendments will be made prior to delivery of the final products.

5 EO INFORMATION SERVICES ASSESSMENT AND FEEDBACK

5.1 Scope

With respect to the four attributes of a sustainable service (available, useful, reliable, affordable) it is useful to determine the success criteria for Service acceptance by WB and by Local Users. The primary aim is to respond to the requirements. These requirements are not fully identified at present (due primarily to a lack of direct contact with Users), however it is understood that ITC have completed a questionnaire survey and once the results of these are known, and the CHARIM workshop has been held, BGS can incorporate the information into the service design and the service assessment.

Available. As noted previously in this report, one of the strengths of EO is its global availability. Archive data have been obtained and additional very high resolution stereo and triplet imagery has been tasked. The short timescale of this project means that the tasking has not been aligned with the optimum time of year (in terms of climate, cloud cover) and so there is a risk that weather conditions will limit the availability of the service in terms of its comprehensiveness. The availability of the service into the future is less prone to time restrictions, therefore the service(s) can be readily updated as soon as suitable imagery is acquired. Long term sustainability of the service is dependent on local experts applying the methodology and providing the service to agreed standards. This project does not have the remit or the resources to provide training, although BGS is contributing to the WB Caribbean Handbook for Risk Information Management which provides use cases and training for future service provision.

Useful. It is not expected that the EO-RISC services will be stand-alone. For example, the landslide inventory is a valuable product in its own right that will identify current areas undergoing ground motion – however its value will be increased when additional work is undertaken (in conjunction with ITC) to address risk levels associated with the hazard. This stepped usefulness will need to be accounted for in the service assessment.

Reliable. Each service has appropriate validation methodologies to gauge the reliability of the result. In brief these are:
Service 1 – Existing land use classifications will be used as a baseline to define training areas for supervised classification of the optical imagery. The thematic accuracy will be determined using a standard confusion matrix approach supplemented by limited field verification at point sample locations.
Service 2 – A supervised classification of exposed ground (i.e. vegetation scars due to landslides) using the optical imagery will be assessed using a standard confusion matrix approach. However, the classification results will not be integrated directly into the

service; each potential landslide will undergo manual visual assessment using the EO data by experienced landslide and geoengineering specialists at BGS. The inventory will subsequently evaluated against existing inventories (bearing in mind different scales and sources of the inventories) augmented by ground truthing.
Service 3 – The DEMS generated will be validated against ground control data, where available. The ground control data should be in the form of authoritative survey points such as trig stations.

The reliability of the services into the future is determined by the quality of the EO data, and the expertise of the image analysts.

Affordable. The affordability of any service is defined by what is believed to be within ones financial means. It does not mean that something is necessary low cost, but that it is value for money. In this case ESA has provided a modest budget ~€120,000 to provide all three services over several territories. To define if each service is affordable by one or more users (or a consortium of users) it would be necessary to obtain feedback from the users regarding their abilities to pay for one or more service.

5.2 Schedule

Planned schedule for all Service assessment activities is outlined in this section. At the highest level, the service assessment plan was outlined in the SoW as follows:

- KO+1: Service Readiness Review meeting with Users, ESA and WB in Washington DC. *This was to provide the first opportunity to meet the WB and Local Users and to define the services and discuss their mode(s) of assessment. This meeting was cancelled.*
- KO+2: Delivery of D1, Service Readiness Document (SRD) i.e. this document. *At the time of writing BGS has had extremely limited to contact with the Local Users via WB and their CHARIM project. We have had access to the CHARIM Preliminary Assessment Report*
- KO+7: Delivery of D3, Operational Documentation (D3) and visit to the project User with the WB TTL.
- KO+9: Service Utility Review (SUR) at the WB in Washington
- KO+10: Delivery of D4, Service Utility Document.

At this point it is clear that increased contact with the Local Users is mandatory. BGS will participate in the CHARIM workshop in the Caribbean at the end of September and we intend to use this brief meeting to discuss the services with the Local Users along with ways in which they can be assessed.

6 REFERENCES

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