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The functions of the OPS-DIS in the Space operations concept : the risk disaster management of the african rift

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Abstract

The OPS-DIS is an operational concept in which the drone platform is integrated in the Space domain as the satellites functions on orbit. Considering the OPS-DIS realize the same mission of the satellites in three dimensions except the capacity to be on a permanent high point covering the large areas and with the capacity to be more flexible, the drone-in-Space provide the coverage of specific area at the choosen moments. The functions of observation is used in the BVLOS and the FPV mode. Through the study of African rift effects in Kenya on terms of risk management, the OPS DIS can be integrated in the data sets of the Rift observation by using the same sensors as the satellites as SAR or LIDAR and the GNSS capacity to explore deeper some area. In this case, it demonstrates the OPS DIS to give the inputs to monitor the fissures noticed on the ground around the Suswa location thanks to the data from Copernicus, Sentinel, open source data from the area. The observation by medium altitude provide a surface factor of resolution different from a plane and a satellite with specific management of the precision for the risk management.

Keywords: African Rift, Drone, Sensors, fissures, Datasets methodology

Acronyms/Abbreviations : OPS DIS, FPV, GNSS, LIDAR

1. Introduction

The objectives of the work is to present the role of Space sensors in the management of the ground to plan the infrastructures incoming linked with the rift evolution in Africa. Some effects appears already and the purpose is to provide the inputs to make the orientation for the data sources available in a Space program and the way to underline some outputs to make decisions.

1.1 The Rift definition

A Rift is a feature able to be visible on Earth as other planets on solar system. Each one is specific and the generic one on the way on Earth consists of a tectonic ditch corresponding to an area of fracture of the Earth's crust. Several exists on Earth as Rio Grande, Corinthe Gulf, Oslo Graben Norway, Rhean ditch in France. The most important Rift on Earth is the African Rift. This point suggests the scientific attention.

The East African Rift joins the sea, between the Gulf of Aden and the Red Sea at a triple point of tectonic junction between a continental rift and two oceanic rifts. The Red Sea began to open around the same time as the African Rift. However, its opening speed being greater, the evolution from a continental rift to an oceanic Rift had the opportunity to be fulfilled. Near Djibouti, at the meeting point between the African Rift and the sea, this transition manifests itself at the border faults, which collapsed the floor of the ditch. The rift can be passive or active. In the use case studied, the East African Rift gets the features of the passive and active one. It means the evolution could turn on active depending on the evolution with some effects on the ground.

1.2 The East African rift

The East African Rift [1] can be considered by the two Rifts : the oriental Rift and the western Rift. Several thesis showing the future evolution of the East African Rift remains uncertain. It is believed that over time, as it cools, the underlying mantle currents will weaken. The mantle will cool, contract and the domes will subside. The East African Rift will then cease to be active.

The second thesis is the establishment of a subduction zone connected to the Rift system, whose suction or traction effect could allow it to continue. The spacing of the edges of the continental lithosphere could then continue, preceding the appearance of oceanic crust. The sea would then rush into the Rift to form a large area of water.

For example, several lakes have formed in the Rift Gap, including Lakes Turkana, Tanganyika and Nyasa (or Malawi). The walls of the Rift form spectacular escarpments several hundred meters high. Normal fault escarpments, little or not eroded, testify to recent Rift activity.

Heat flow is very important in some parts of the Rift, mainly near active volcanoes. In fact, 10% of Kenya's electricity comes from geothermal energy. However, on the flanks of the Rift, the heat flow is equivalent to that of a «non-rifted» continent.

2. Material and methods

The purpose of the Kenya use case is to show the effects of the active and passive Rift on the ground through the requirements of data to be applied. The methodology consists on to collect the geological data, data from Space by the last capabilities of the satellites. These are mixed with the local context to improve the acknowledge of the Rift on regard of the settlement of the area. Then, the structure able to apply the requirements for Space program could be the African Space agency and its regional dependencies in the countries where the Rift is a point for risk management. The framework of the program should be considered by an Earth observation completed by the support of the department in an agency. Even more, the requirements take into account the East African Rift as the largest of the world with 4 500 kilometers with the African plate and the Somali plate moves away between 6 and 7 mm by year. The material is to visualise the area and make some decision on the ground thanks to multiple sources of datas. The methodology and the materials should give the basis of the requirement to etablish a specific program to study the dimensions and the evolutions of the Rift from the North to the South with a focus on the oriental Rift and the western Rift.

3. Theory and calculation

3.1 The combination of datasets

The datasets means the capacity to provide a map to enlarge the Rift effects on the ground.The parameters can be divided by those available on the ground and those on Space. The art of statement for the Rift combines data from the ground through the tools like the seismograph. The calculation used combines data from the ground by interferometric synthetic aperture radar plus subpixel correlations of synthetic aperture radar with Spot images archives. To go further in the frame of the requirements the conception of the program could use the Space data from others sensors like Copernicus, Sentinel, Pléiades constellation with GNSS CORS stations located in Kenya and the Taifa-1. It can be completed by data of local public organization like Kenya National Highways Authority. This conception is based on the computation of the multi-factor data base. Moreover, the combination with others sources of data gives a perspective of requirements expected and unexpected. It take account the pre-event and post-event from a broke line which cross the East of Africa. The building of Space program requires the fundings, the technical means, the partnerships with private and public organisation. These points exist by the African Space agency and the regional agencies forsome partnerships have been created to build satellites, to train teams. The data sources methodology are multiple :

- data proven through the interferometric synthetic aperture radar,
- data from the GNSS constellation via the CORS station available on Kenya,
- data from Sentinel constellation after the removal of Spot and EnviSat,
- data from Taifa-1 from Kenyan Space Agency via optical sensor,
- data from the ground via multi-channel to complete the social and the geological context, particulary, with the data of seismograph,
- data from the drone thanks to GNSS coordinates of the fissures recorded in Chasm, Mosiro, Narok location and close the Mai Mahiu road,

- data from the cyber components of the available picture. This point is to consider the pixels and the sub-pixels of the pictures. The conditions of the pixels determine the data quality of the observation. The format provide details without loss of data. The "png" and "gif" format is better than the "jpeg" format. And the primary colors red, green, blue with the level of the color depths fix the colors transitions. The finesse of these transitions is linked with the details on the ground. Through the method, the point is to check the properties of the picture with the level of resolution with PPP parameters. The value of 300 PPP is recommended to ensure the data quality for operational management. The purpose of the data sources is to estimate specific transient signals and the very slow slip of events able to be understanding by anomalous deformations on the ground. In the use case, the model comes from the nature itself by the precision of post effect of the deformations combined by their reinforcements by the heavy rains cycle due to el Nino effects in the area of Narok.

3.2 The drone capacity

The drone resolution depends on the camera and its focal, the sensors, the lensing quality, the distance, the light, the focal length (figure 1). The drone capacity can be considered by its own capacity or the function could be embedded to increase the observation by the duration and the quality. In this case, the function consists in to use a balloon with drone on attachment to make the observation with the camera and use the propulsion for specific area. One of the most interest from the rift risk management is to anticipate the detection of problems from small fissures recorded on the ground. And the drone resolution provide the requirement to give precision data to manage and build the 3D model for the futur. From the scenario, to determine the details en cm with a 35 mm camera of 50 megapixels maximum for an altitude of 20 km, the ground sample distance or GSD compute.
The H = Altitude of the drone, the p=Pixel size of the sensor, the f=Focal length of the sensor, 1000 is the conversion factor to ensure units match for consistent results to millimeters.

$$GSD = \frac{H \cdot p}{f \cdot 1000}$$

The scenario consists tha values following : H=20,000 m, p=5 µmp, f=35. It produces a GSD of 2,86 cm/pixel with the details noticed with 2,86 cm on the ground. The drone capacity would be able to underline the fissures with 2,86 cm on the ground.

4. Results and Discussion

4.1 OPS-DIS Space operation conception

The OPS-DIS Space operation conception is defined by the capacity to use Drone in the Space. It concerns those used with the capacity to improve the observation on the ground with another resolution.
The characteristics of an OPS-DIS concerns the altitude of the operations, the size and the propulsion, the resolution inputs. The means are multiple like balloons, the autonomous drone in high altitude with the applicability of the Newton law in Space. The first point is the OPS-SAT are closed to OPS-DIS Space operation concept except the OPS-DIS Space can flight in high altitude in which it exists enough air to use the propellers. The second point is to use the BVLOS and the FPV with an operator able to manage them from the ground to make the manoeuver and takes the pictures. This point would provide more details about the ground to check the fissures. The result is linked with the pixel and subpixel move at the specific moment of the time to invert the processing to notice the feature of the move and to make a trend for the evolutions.
The detection of the fissures is difficult and the combination with other factors are the inputs to introduce the requirements in the Space program. It means in the use case of Mai Mahiu Narok road the destruction visual effect comes from the heavy rains which have amplified the fissures. In other words, the result could be extended by other source of data in the framework of the requirements. The result demonstrates that the features to study the African East Rift shall follow the requirements based on the functions from the use case of Manda Hararo-Dabbahu event in 2005.
The second use case is the effect with the Mai Mahiu Narok road destruction. The point show two events on 2018 and 2023 with the inputs of flood events provoking disaster management on the ground. Considering the theory and the computation of discrete inverse theory, the model can be reproduced for the use case with new capabilities from Space Agencies. The first step is to consider the event on 2018 with a crack of 15 meters deep and more than 20 meters wide split making observable [2]. This case have been studied through the interferometry technique at

Chasm location. A vertical deformation of 5-7,5 cm has been underlined along the line of sight of the satellite along the fault located at Mosiro, Suswa region between 15th March and 4th April 2018. To go further the add-on the heavy rains during the period should make the correlation for the deformation recorded on the road (figure 2-figure 3). The location is confirmed by the local guide by social context for the deformation on march 2018. And another one was noticed along the highway road on north West at chasm location.

Figure 1- drone image of the crack in 2018

The point is today this location is close with infrastructure populated considering picture taken on 2024 around the area of anormalous deformation [3]. Then, the context of the rains in Kenya changes following the regions and the factor of el Nino. The North of the country receives less rain than the West. The moment of the potential floods are between March until June and on November of each year. The point on 2018, the floods happened between March and April after one year of the drought. Moreover, the El Nino effects should take account into the variation of rain intensity and the drought because of the low pressure existing on the atmosphere. At last, the geological context recorded in the Chasm location report could be taken account.
Over western Kenya and eastern Uganda rainfall was estimated by IMERG to frequently exceed 200 mm (7.9 inches). IMERG Data are produced using data from the satellites in the GPM Constellation, and are calibrated with measurements from the GPM Core Observatory satellite as well as rain gauge networks around the world (figure-5). By reverse geo-engineering, the water should identified the locations of the fissures. It depends on the resolution and the capacity of the sensors to send light on the ground to identify the blue color with the nuances linked with the lack of deeper of the fissures. And the shade could include the particles of the soil content from the geolocigal context. In this case, the blue color will turn on green or it could be clearer.
By taking the data from this period plus the add-on, it figures the inputs to manage the road with a baseline of data to build the requirements and a program. This example can be compared with the another events several years later by the same baseline of data. The second step is to to consider the 30th April 2023, from six kilometers of Mai Mahiu town, the cutting of the road because of some crack noticed [3]. This pushed the KeNHA to restore the road on the affected zone (figure-6). The alternative roads adviced by the agency were Narok - Kisiriri - Mau Summit - Njoro turn off (B18) Road, to join Nakuru and other destinations, Narok - Bomet - Kaplong (B6) Road and connect to Kaplong - Kericho (B7) Road.
The effects have been that the sand harvesting and operations at the Dry Port were adversely affected and we are calling on the Ministry of Roads to get a permanent solution to this problem.

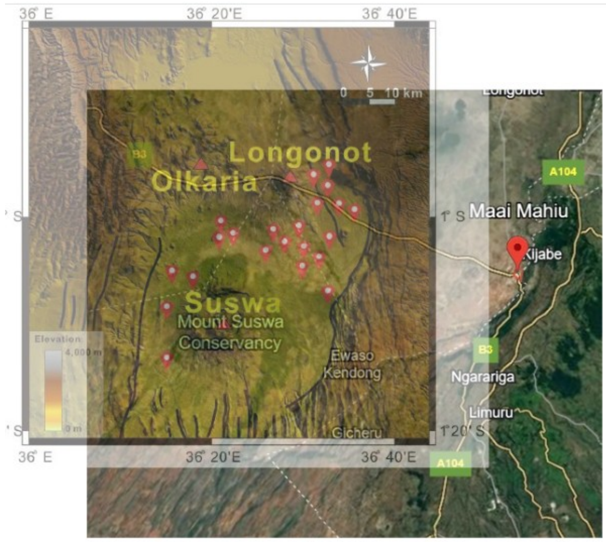

Figure 2- fissures in Suswa area

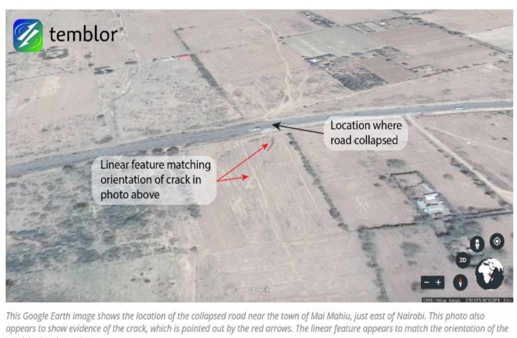

Figure 3- explained location of fissures in 2023

4.2 OPS DIS and GNSS data

The requirements should include the GNSS data of the fissures noticed by CORS at the moment where the fissures appeared. The add-on of the floods estimation would provide the inputs to observe the fissures due to the infiltration inside provoking the risk disaster concerning the Suswa area with the Mai Mahiu road inside. It means the reflectante of the water is a factor to observe the features and the evolution of the fissures. Once the coordinates identified by a picture or by a GNSS station, the drone shall use the map path to follow up the preliminary design of the fissures on the ground. The thrid step should be to compare the images with add-on data like heavy rains in the area to detect the potentials zone to follow up. The hypothesis is to consider the flood cycle which continued on 2024.

Within of the images, the cracks are pixelised with the layer of the heavy rains location via GNSS data and the others. The purpose being to identify the correlation between the fissures, the heavy rains, the risk of Earthquake. The limit of the study depends on the access of specific data which needs partnerships or agreement to resume the data precision. The surveys of geological data by the seismograph would permit to identify the origin point of the fissures. The risk of seism is moderated around the Narok location. The fissures are not appeared on the items of risk disaster whereas for the crack of 2018 did in short time. In the last figures, the collapsed noticed on the Mai Mahiu is marked by the coordinates 0 59 59S 36 32 29E (figure-2-3). The crack is linked with the line from geological activity

which is considered as high and medium around the area of Narok. With the heavy rains factors, the water could infiltered the fissures of the basement. Even more, the soil of the Suswa permit the creation of the context able to accelerate the collapse in the area. The ground fissures are not fixed and it depends on the rock fractures activity. The width can be evaluated between several centimeters or more. The deeper are estimated between some centimeters until several meters.
In the case where no water exists in the fissures, the datasets requirement should be used from the lidars or the spectrometry. The latter should detect the degassing from the fissures to improve the methodology to detect the fissures locations [3]. The observation of the fissures through the degassing requires the spectral band to identify the gas from the crack. By this, the precision of the fissures can be noticed on the map. Indeed the gas noted is the CO_2 , the CH_4, the SO_2 which escapes from the rock fractures. The mix gives the colours or the heat to be taken account for an imagery according to the bands of each chemical component. The infrared is priviligied for the bands of these chemical components with high level of resolution.
It means that the colours spectral bands able to identify the degassing from the fissures is a methodology to be used in the Space programm for the Rift study. It should complete the datasets to get the inputs for the risk management.
The requirements of the Rift in Space program shall include the sensors of in Space to complete the data from the ground and from the air by SAR measures [4-7]. Program plan would be following the methods of Mai Mahiu road to use and to combine these technologies, make partnerships with the public organization and others Africain countries concerning by the effects of the Rift and the ressources required on terms of data. The function identified is the protection and by simulation a risk disaster able to be integrated in Space program policy through the program existing or to build thanks to the source of data. The purpose would permit the KeNHA (Kenya National Highways Authority) to alert people using the road before the events happened and to manage the road to mitigate the fissures avoiding the potential collapse.

5. Conclusions

By the Kenya example, the requirements would integrate a Space program for Space agency concerned by the African rift to manage the risk disaster by the combination of data available from a public organisation. The OPS-DIS complete the requirements to follow the location of the fissures to provide the baseline to understand the pattern of the direction and its forms.

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