

Kariba Dam Rehabilitation Project – Specifications and system requirements for Drone Based Monitoring System



SPECIFICATIONS AND SYSTEM REQUIREMENTS

FOR

**Supply, Testing, Commissioning and Training of Staff in the
Utilisation of an Unmanned Aerial Vehicle (UAV) for Site
Monitoring**

FEBRUARY 2023

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1. Project Information

1.1. General information

The Kariba dam is a double-curvature arch dam built between 1956 and 1959 across the Zambezi River, on the border of Zambia and Zimbabwe. It creates one of the largest artificial lakes in the world (181 km³). It is owned and operated by Zambezi River Authority (ZRA).



Figure 1 - The Kariba Dam General Location

It supplies water to two underground hydropower stations located on the North (left) bank in Zambia 1050 MW (being updated to 1080MW) and on the South (right) bank in Zimbabwe 750 MW (after extension 1050MW).

The Kariba Dam has over 20 years of sustained heavy spillage developed a scour plunge pool down to 80 m below the normal tail water level. There is a major concern regarding its further development from intense spillage which may occur in the case of exceptional floods.

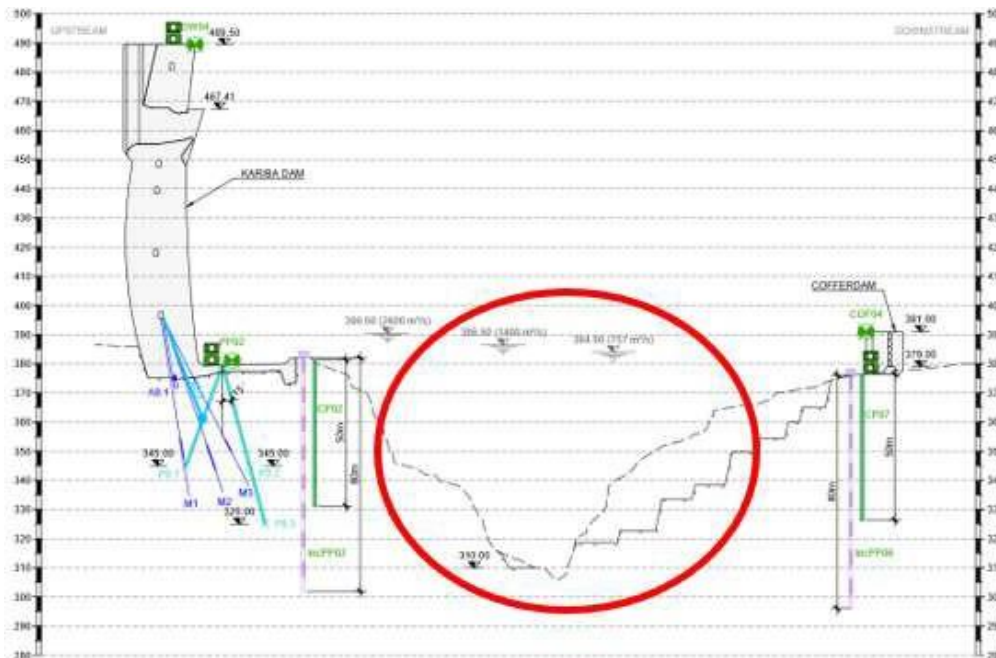


Figure 2 - Cross-section showing the 80m deep Plunge Pool

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In order to control its future development and avoid dam toe weakening, the studies came to the conclusion that the best solution is enlarging the plunge pool, mainly towards downstream but also towards both banks and protecting the fault in the downstream toe of the dam with a concrete filling. The reshaping shall indeed facilitate the evacuation of spillage flows in the downstream direction and avoid the concentration of turbulence in a restricted and confined area.

1.2. Site location

The Kariba dam is located on the Zambezi River, at the boarder of Zambia and Zimbabwe. It is 130 km south-east of Lusaka (Zambia), and 280 km north-west of Harare (Zimbabwe). Geographical coordinates of the dam are 16°31'18"S and 28°45'41"E.

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2. Unmanned Aerial Vehicle (UAV) Based Monitoring System

2.1. Background

Considering the size and the exceptional aspect of Plunge Pool reshaping works, surveillance and monitoring of the dam during excavation and dewatering works is of a prime concern. Existing structures have to be closely monitored to make sure that they are not damaged during the plunge pool works and especially during dewatering and the blasting activities.

The use of an Unmanned Aerial Vehicle (UAV) in additional monitoring devices already being utilized shall enhance visibility around the plunge pool in areas not easily accessible to enable the scanning of the rock surfaces for geological mapping, calculation and monitoring of excavated volumes including remote supervision using high resolution cameras on the UAV.

Furthermore, to complement the existing monitoring system for monitoring of the plunge pool the Authority deems it appropriate that the Kariba Complex Slopes are monitored by use of advanced technology and software that will guarantee high accuracy of slope displacement measurements.

The required monitoring system shall comprise of hardware and software supply including commissioning and training of Project Staff to perform drone-based site supervision for the period of the plunge pool reshaping works scheduled to end in December 2024.

The Authority wished to acquire suitable hardware and a software/online platform solution in order to perform drone-based site supervision for the period of the plunge pool reshaping works of the Kariba dam rehabilitation project.

The drone-based site supervision required shall consist of a proper and repeatable method for UAV data acquisition and processing with suitable software or online platform and hardware which will assure that the engineering team will receive deliverables of 1cm to 3cm absolute accuracy in the most efficient and easy way possible.

2.2. Drone-Based Monitoring System

2.2.1. The Objective of the Solution

The objective is to acquire suitable hardware and a software/online platform solution to perform drone-based site supervision for the period of the Plunge Pool Reshaping works under the Kariba Dam Rehabilitation Project.

The drone-based site supervision required shall consist of a proper and repeatable method for UAV data acquisition and processing with suitable software or online platform and hardware which will assure that the engineering team will receive deliverables of 1cm to 3cm absolute accuracy in the most efficient and easy way possible.

The objective is to carry out surveys on a regular basis and build up a record of progress including engineering analysis in assessing volume of excavations and scanning of rock slopes for geological feature mapping. It shall be possible to do ad hoc surveys and to incorporate them into the same software platform.

2.2.2. Scope of the works solution

The geographical scope of the drone flight path (and therefore the photographic records) will cover the plunge pool, the cofferdam and the surroundings within approximately 300 meters specifically including the slopes at either side of the downstream face of the dam.

In principle, a pre-programmed flight path shall be flown at regular intervals (approximately twice per week). After the flight the data from the camera shall be recuperated and transferred to a software package or online platform where the data analysis and post-processing shall be performed either manually or preferably automatically. The processed data as well as standard regular reports from each survey in PDF format shall be accessible from the software/platform.

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2.2.3. Technical Specification of UAV equipment and software

The UAV shall have the following capability and characteristics:

1. **Usage:** Mapping small to large scale areas – Construction monitoring
2. **Application:** Land surveying, GIS, natural hazards,
3. **Specs:** Quadcopter or equivalent
4. **Landing and take-off:** Automated vertical take-off and landing
5. **Range:** not less than 50Km
6. **Flight time:** 30 minutes minimum
7. **Lidar Module:** Lidar Sensor/Module integrated with Camera

The UAV shall comprise of 2 cameras to be supplied which should be included in the supply offer:

1. One that can be used to create topographic maps and DEMs,
2. Excavation and Quarries Monitoring (RGB, 42 MP, 1.5 cm resolution)
3. Useful for land cover mapping and vegetation indices extraction (RGB NIR RE/ LWIR: TIR, 4.5 cm per band and around 60 cm for thermal band).
4. Capable of a 4x Zoom

The supply offer for the UAV should also include technical deliverables:

1. **Camera resolution:** 42MP (RGB) minimum
2. **Sampling distance:** \approx 1.5 cm (RGB) minimum
3. **Payload capability and compatibility:** the payload should prove capability and compatibility to hold LiDAR scanners for future consideration.
4. **Radio linkage range:** > 7 km
5. **Automatic 3D flight planning:** Yes
6. **Wind tolerance:** 9 m/sec
7. **GPS with compass:** yes
8. **PPK to reduce GNSS geotagging errors:** Yes
9. **Ground control Station:** yes
10. **GNSS reference station:** yes
11. **Automatic landing:** linear and/or vertical landing with \leq 5m accuracy
12. **Multi-drone operation:** Yes
13. **Software:** flight planning & control software
14. **Point Cloud:** Real-time point clouds to provide immediate insights onsite for operators to informed critical decisions quickly.
15. **Lidar Sensor:** Frame Lidar with up to 100% effective point cloud results and integrated operation with Camera
16. **Security:** The supplier should provide a detailed security program for the drone operation so as to guard against, Hacking, Drone Flight Networking Mirroring.

2.2.4. Data Management

Ground control must be used in order to generate engineering grade documentation and deliverables. The supplier should provide a workflow that should be put in place during a visit to the site and can be followed to create easily repeatable and comparable results.

The data analysis and post processing shall be done using a suitable software package or online platform, the drone images shall be transformed into a point cloud consisting of thousands of points, each containing geospatial (X, Y, Z) and colour information. Then, using the same or another

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software/platform, the following tasks should be capable of being performed:

1. Progress tracking volumes (survey to survey, survey to design, design to design)
2. Point of interest (with coordinates and elevation history if needed)
3. Cross section analysis
4. Berm checks
5. Gradient maps
6. Slope measurement
7. Pre and post blast volume measurement tools (with these tools we can measure a volume of an area before and after the blasting)
8. CAD design overlays
9. Stockpile measurements
10. Timeline presentation
11. Information Storage and management including a detailed description of the hosting of collected data.

The software/platform should allow for the standardized production of reports in PDF for each view and review of the above.

The processed data and resulting reports shall be made available to all stakeholders including those onsite with a week of receipt of the data. It shall be categorized chronologically for ease of search. This timeline of information can then be used to control and validate tasks more quickly, saving time and ensuring that deadlines are met.

2.2.5. Deliverables of the UAV Drone-Based Slope Monitoring Solution

The UAV supply shall not only satisfy the technical characteristics and data management procedures but also will be expected to satisfy the deliverables as below:

1. Set of 1 RTK enabled drone equipped with camera, built-in autopilot for fully autonomous navigation, automatic vertical take-off and landing control, camera battery chargers with cables, data storage capacity of 512GB, (SD card), radio modem for data link or equivalent, drone batteries with its recharger, ground control station and reference GNSS station, PPKcapable system, transport case and remote controller, user manual
2. Software for mission planning (perpetual license) and data processing (any repetitive costs should be clearly specified)
3. One or more Software packages or online platform for data analysis/treatment and postprocessing as described above.
4. Spare parts: a) Propellers, (2 full sets of replacements) b) 2 X battery sets (UAV), c) any spare parts to execute any mission properly and safely
5. 2 cameras (RGB, 42 MP, <1.5 cm resolution). one camera having the possibility to a minimum 4x zoom with an expected focal length of between approximately 7mm to 120 mm.
6. Lidar Sensor which shall be integrated with the other operations of the UAV and ensure effective point clouds with the most competitive and best rates of points taken per second.
7. 1-year warranty on parts failure
8. Full board training: 5 days (for 6 persons) for both flight planning, and operations followed by Data processing training and 5 days to execute a live project with the

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Zambezi River Authority Team and the Consultant's Experts.

9. Training in 8 above should be in accordance with the requirements for the drone pilot licence requirements.

10. After sales service as and when required by Zambezi River Authority.

3. Roles and Responsibilities for Additional Monitoring System

3.1. The Client (ZRA)

- Negotiate final terms of supply, commissioning and Testing of the UAV with the Supplier.
- Facilitate payment to the Supplier for the supply, installation, commissioning, and training services.
- Take custody of the monitoring equipment at the end of the project implementation period.

3.2. The Supplier

- Supply, install, test and commission the specified monitoring equipment in ZRA's name as the Purchaser and Consignee of Goods.
- Provide Operation and Maintenance Manual for the equipment
- Train ZRA employees and Consultant Staff on the operation and maintenance of the supplied monitoring equipment.
- Handover to ZRA the monitoring equipment, monitoring systems and data after final acceptance by the Consultant.
- If the Supplier is not the Original Manufacturer, they must obtain and provide together with their Bid, the Original Manufacturers Authorization.
- Assist the Authority in obtaining the necessary regulatory approvals for flight and operation of the drone.

4. Local Services

The Supplier shall be responsible for the access to any local services as may be necessary. The Client's role will be solely to facilitate. after the Supplier shall be responsible for after service requirements such as maintenance and supply of service parts preferably in the country of the purchaser or within the sub region. The Supplier should mention which will apply and provide details, other local services may include user training unless this cannot be carried out locally, in which case the supplier will specify how this will be carried out. The Purchaser expects to have about ten (10) staff training in country in the use and minor operational maintenance of the UAV.

5. Personnel

The Client will designate a representative or representatives to work with the Supplier's staff during the equipment setup, commissioning and training.

6. Facilities

The Supplier's personnel during the setup, training and commissioning of the system shall share office space with the other personnel from the Consultant and Client working at the KDRP Project site. The

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Supplier shall provide for vehicles, computer equipment and telecommunication systems for its personnel.

7. Supply duration

8. The equipment should preferably be supplied ex stock (if provided from within the Country that is Zambia and or Zimbabwe and if supplied from outside the country delivery will be CIP Kenneth Kaunda Airport, Lusaka, Zambia with Final Destination being Siavonga which is 200km south of Lusaka. Earliest Delivery will be 2 Weeks and latest 4 weeks. Delivery will be as per INCOTERMS 2020. The proposed payment terms are:

The payment terms shall be as follows:

1st Payment: 70% of the contract sum as advance payment supported by an equivalent advance payment guarantee from a commercial bank acceptable to the client using format attached as an Annex. Alternatively, a Letter of Credit can be used and Supplier must include the administrative costs of arranging the Letter of Credit or Advance Payment Guarantee in the price.

After submission of Invoice for advance payment together with the advance payment bank guarantee, the client will send within 10 business days evidence of payment to the supplier who will in turn within 7 business days thereafter send Shipment of goods documents issued in the name of ZRA, with insurance cover as specified in the applicable incoterms CIP Kenneth Kaunda Airport Lusaka, Zambia.

2nd balance Payment: 30% of the contract sum after setup, testing and commissioning is completed and after training has been carried out. Payment will be made within 10 business days of the date of submission of the invoice by the supplier to ZRA.

Advance Payment Guarantee

[Guarantor letterhead or SWIFT identifier code]

Beneficiary: *[Insert name and Address of Purchaser]*

Date: *[Insert date of issue]*

ADVANCE PAYMENT GUARANTEE No.: *[Insert guarantee reference number]*

Guarantor: *[Insert name and address of place of issue, unless indicated in the letterhead]*

We have been informed that *[insert name of Supplier, which in the case of a joint venture shall be the name of the joint venture]* (hereinafter called "the Applicant") has entered into Contract No. *[insert reference number of the contract]* dated *[insert date]* with the Beneficiary, for the execution of *[insert name of contract and brief description of Goods and related Services]* (hereinafter called "the Contract").

Furthermore, we understand that, according to the conditions of the Contract, an advance payment in the sum *[insert amount in figures]* () *[insert amount in words]* is to be made against an advance payment guarantee.

At the request of the Applicant, we as Guarantor, hereby irrevocably undertake to pay the Beneficiary any sum or sums not exceeding in total an amount of *[insert amount in figures]* (_____) *[insert amount in words]*¹ upon receipt by us of the Beneficiary's complying demand supported by the Beneficiary's statement, whether in the demand itself or in a separate signed document accompanying or identifying the demand, stating that the Applicant has used the advance payment for purposes other than toward delivery of Goods.

A demand under this guarantee may be presented as from the presentation to the Guarantor of a certificate from the Beneficiary's bank stating that the advance payment referred to above has been credited to the Applicant on its account number *[insert number]* at *[insert name and address of Applicant's bank]*.

The maximum amount of this guarantee shall be progressively reduced in proportion to the value of the Goods shipped (for Goods supplied from abroad) and/or the value of the Goods delivered at the named place of destination (for Goods supplied from within the Purchaser's country), as evidenced by copy(ies) of [].¹

¹ *The Guarantor shall insert an amount representing the amount of the advance payment and denominated either in the currency(ies) of the advance payment as specified in the Contract.*

¹ *Insert shipping/other applicable documents establishing "delivery" of the Goods in accordance with the applicable Incoterm to the Contract.*

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This Guarantee shall expire upon our receipt of copy(ies) of the above referenced documents, evidencing that at least ninety (90) percent of the Contract Price of the Goods has been delivered or on the [insert day] day of [insert month], [insert year]², whichever is earlier.

Consequently, any demand for payment under this guarantee must be received by us at this office on or before that date.

This guarantee is subject to the Uniform Rules for Demand Guarantees (URDG) 2010 Revision, ICC Publication No.758, except that the supporting statement under Article 15(a) is hereby excluded.

[signature(s)]

Note: All italicized text (including footnotes) is for use in preparing this form and shall be deleted from the final product.

² *Insert the Delivery date specified in the Contract Delivery Schedule. The Purchaser should note that in the event of an extension of the time to perform the Contract, the Purchaser would need to request an extension of this guarantee from the Guarantor. Such request must be in writing and must be made prior to the expiration date established in the guarantee. In preparing this guarantee, the Purchaser might consider adding the following text to the form, at the end of the penultimate paragraph: "We agree to a one-time extension of this guarantee for a period not to exceed [six months][one year], in response to the Purchaser's written request for such extension, such request to be presented to us before the expiry of the guarantee."*