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GBON National Contribution Plan of *Guyana*

Systematic Observations Financing Facility

Weather and climate data for resilience

GBON National Contribution Plan

[Guyana]

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Module 1. National Target toward GBON Compliance

The GBON Global Gap Analysis conducted by WMO in June 2023, considering Guyana as SIDS, stated that the country is responsible of providing data from 2 surface stations only. However, as Guyana is a continental country with a significantly larger size compared to other SIDS members, the real GBON requirement of internationally shared stations sums up to 6 surface stations and a single upper-air to achieve low-resolution GBON requirments. In addition, Guyana possesses quite a large Exclusive Economic Zone (EEZ), almost equivalent to half of its land territory. In this regard, additional surface measurements from 4 buoys are required. Furthermore, with potentially larger funds possibilities, Guyana might also reach a high-resolution GBON compliance (22 surface stations).

Surface Stations
The internationally available measurement data coming from Guyana still comes from a network of six (6) manual stations, which only one of which is GBON-compliant (the station at the international airport is the only operating 24/7, the rest only during daytime) and all of which are only partially sustainable, due to manpower shortage. As for sustainability, there is constantly a high risk of losing local experienced observers. Nevertheless, the Guyanese Hydrometeorological Service (GHS) has sufficient experience with the deploying, maintaining and running of different types of AWSs which is the basic step for sustainability. Through the USAID CCAP Project (Nov. 2017), the GHS was granted 21 AWSs produced by OTT Hydromet. These stations were deployed in different parts of the country (with the attempt to cover the country with a higher-resolution coverage, representing different climatic zones and subzones of the country), but from that point on, they were discovered to be totally dysfunctional. An investigation conducted by the technical staff of the GHS revealed that in all of these stations, the enclosures could not have been hermetically closed. This issue led to the aforementioned issues due to environmental exposure of sensitive components within the enclosure which resulted in continuous damage. Despite a large investment of resources (out of the quite constrained resources of the GHS), the existing defects could not be repaired and hence, recently, the GHS took the decision to stop attempts aimed at reactivating these stations. Subsequently, the GHS started to acquire, from its own budget, AWSs from Vaisala (AS810). To date, four of these were installed in the most challenging areas in order to evaluate their capability to withstand local harsh conditions. These stations have been functioning quite satisfactorily and are proving to be quite suitable for Guyana's environment. It should be added here, that these stations were intentionally installed in very remote and difficult-to-access locations – hence, in terms of accessibility and sustainability, these cannot be considered by for the basic low-resolution GBON network. Moreover, none of these locations had prior manual observations, and hence no reference climatology (except Kamarang, all the other locations chosen for the GBON network have prior measurements. Kamarang was chosen as to complete the geographical coverage of Guyana as well as its relative accessibility – the planned station is at the quite busy local airfield).

Currently, the needed expansion of the network is a challenge due to the elevated costs of the stations compared to the national funds of GHS. Taking advantage of the experience and the already existing knowhow of the technical staff of the GHS, this NCP considers the purchasing and deployment of six (6) new AWSs of the existing type (Vaisala), through the SOFF resources and activities, **utilizing the same tender specifications used for purchasing the current stations (Annex 2),** replacing eventually the already existing manual stations in these spots. These stations can be used as a full GBON low-density surface network for Guyana and in the event of additional funding, to achieve the high-resolution network target of twenty-two (22) surface stations.

Upper Air stations
In order to reach a full GBON upper-air compliant network, the NCP takes into account the purchasing, deployment and maintenance of a single upper air station (subject to regional decision).

Marine surface stations
As mentioned above, Guyana has to provide data from 4 marine stations. Currently, the GHS has purchased 2 of these stations (from Frankstar Technology Group PTE LTD) scheduled for deployment in the first half of 2025. Therefore, the NCP seeks to support the GHS with maintaining these two stations and also the installation and deployment of two additional stations, utilizing the same tender specifications used for purchasing the 2 already planned stations (Annex 3).

Table 1. GBON National Contribution Target

Type of station	WMO GBON Global Gap Analysis, June 2023				GBON National Contribution Target	
	Target	Reporting	Gap		To improve	New
			To improve	New		
	[# of stations]				[# of stations]	
Surface	2	1	1	0	6*	0
Upper-air	1	0	0	1	0	1
Marine	4	0	0	4	2	2

* The target of 6 stations to improve was accepted in the NGA by the WMO Technical Departement – as the initial gap analyse was done for a SIDS the deviation can be explained – it was mututally decided that Guyana should be classified as a mainland country regarding GBON standards, therefore the target changed from 2 to 6.

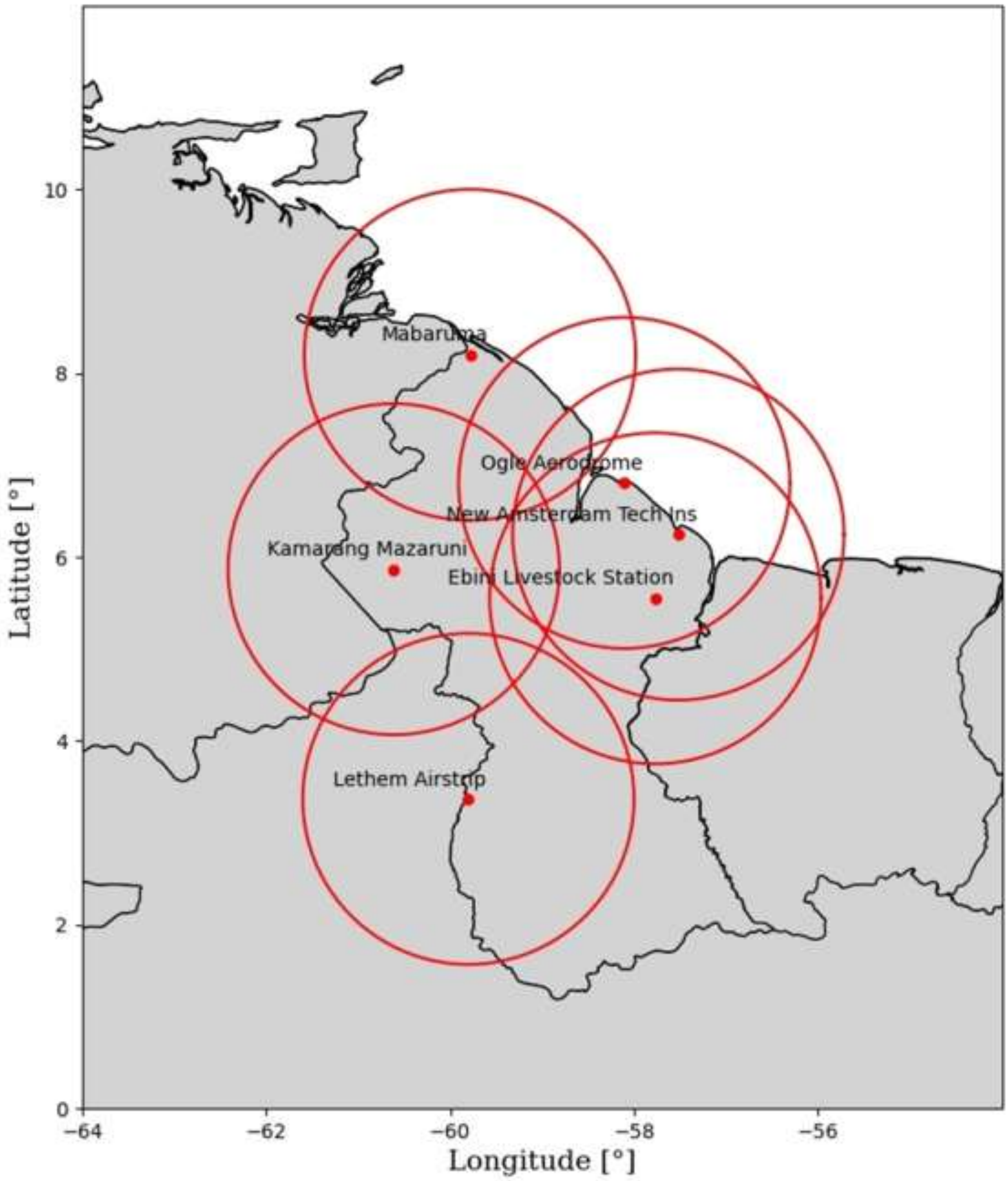

Figure 1: Map of existing and proposed locations for GBON Surface AWSs

Selection of GBON Surface Stations

Table 2 and Figure 1 (circle radius of 200 km) show the list of the six locations chosen for the installation of surface AWSs, which are required for Guyana to achieve a GBON compliance. These locations were chosen for several reasons: a. Currently, manual stations are already functioning there (for reference). b. They satisfactorily represent the climate of Guyana on a wider scale. c. They are relatively accessible. d. There are local communities, which might be encouraged to support their basic maintenance as well as security.

Table 2: Proposed locations for GBON stations in Guyana

surface network – GBON target			
Station Num.	**Station Name**	Lat	Lon
1.	**Kamarang**	5.867° N	-60.612° W
2.	**Lethem**	3.367° N	-59.800° W
3.	**Mabaruma**	8.200° N	-59.783° W
4.	**New Amsterdam**	6.244° N	-57.517° W
5.	**Elbini**	5.550° N	-57.767° W
6.	**Timehri Airport**	6.5035° N	58.2526° W

Identification of upper air observation sites

Taking into account the size of Guyana, the country requires one (1) upper-air station. Currently, the GHS does not operate any upper air (or operated ever since independence). The decision on the proposed location of the upper-air station for the country had taken into consideration the following reasons: a. The Cheddi Jagan International Airport (Timehri) is located, more or less, in the centre of the joined land and ocean mass of Guyana, as can be seen in Fig 2. b. The GHS has part of its staff at the location, including forecasters and observers, who can help in the operation and maintenance of the station. c. The GHS also has its own facilities and protected area at the airport zone, where the equipment and consumables could be stored safely. d. Due to the high importance of upper air soundings for Aviation, the airport authorities might be supporting the station in close proximity to the airport. e. The airport is a highly secured zone and is easily accessible from Guyana's capital, Georgetown. **Hence, from the main facilities of the GHS are the most optimal place for a deployment of an upper-air station.**

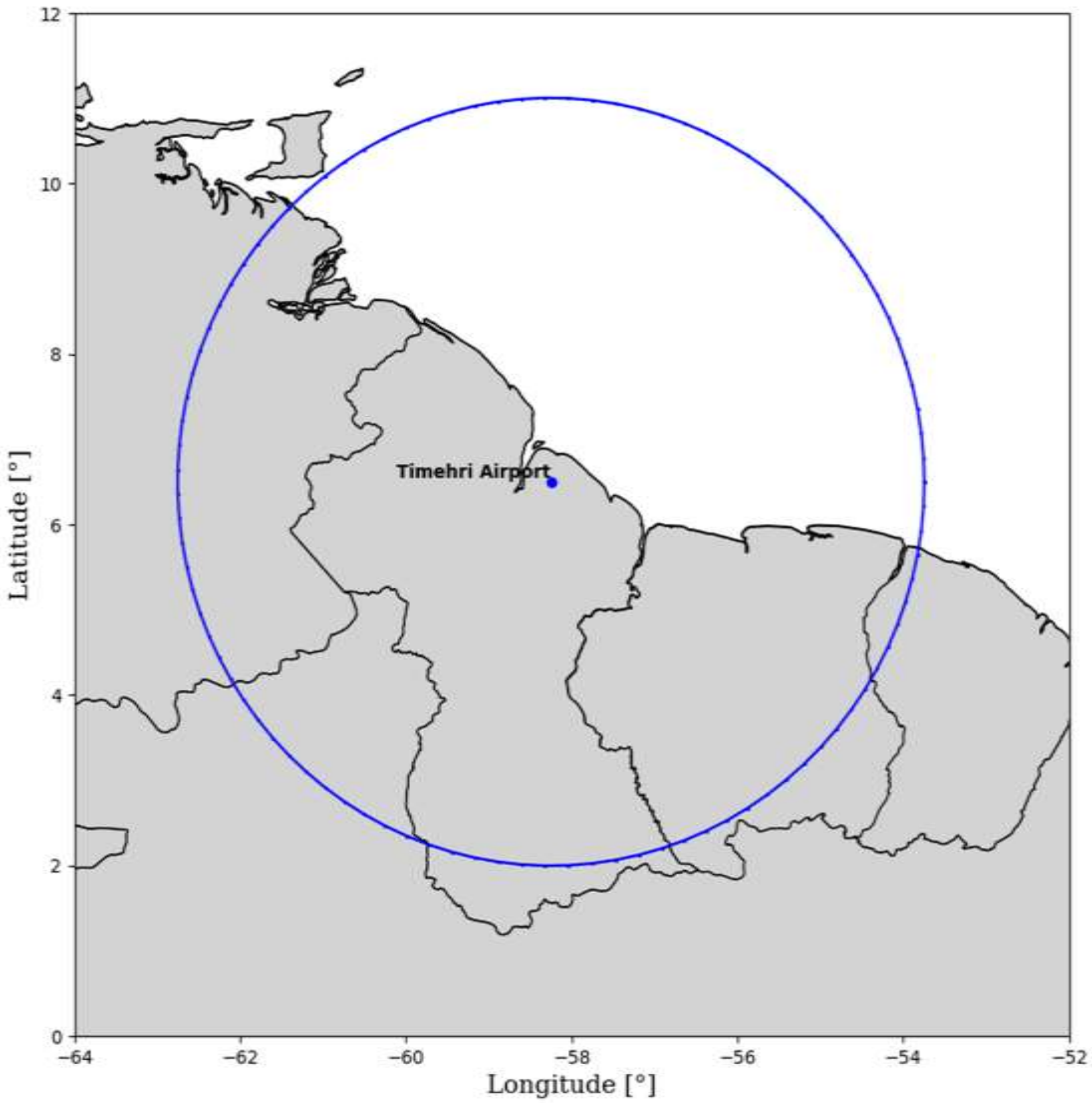

Figure 2: Proposed location for the GBON Upper Air Observation Site.

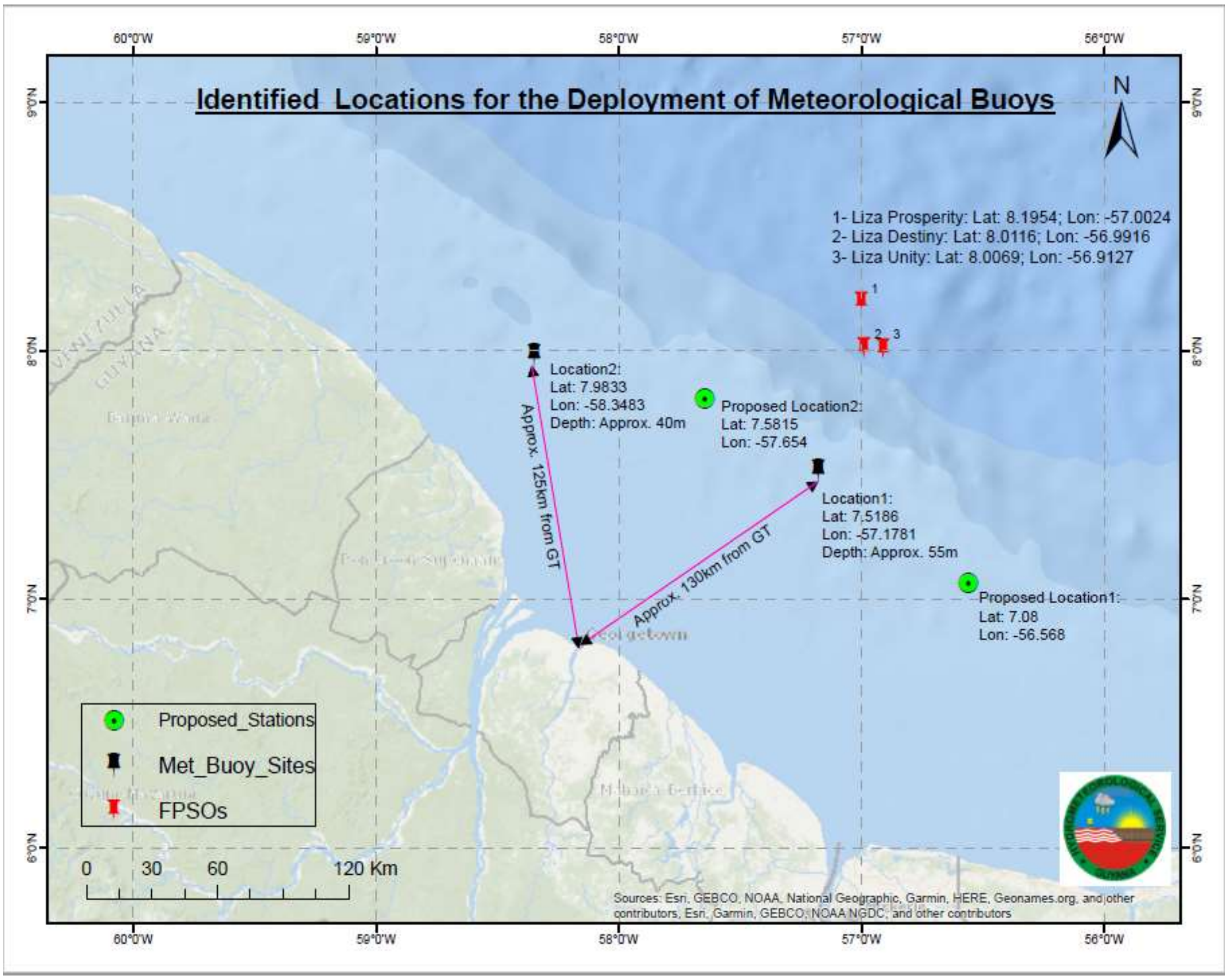

Figure 3: Location for the planned (black dots) and proposed (through SOFF) GBON Marine stations.

Module 2. GBON Business Model and Institutional Development

2.1. Assessment of national governmental and private organizations of relevance for the operation and maintenance of GBON

The Guyanese Hydrometeorological Service (or the Hydrometeorological Service of the Cooperative Republic of Guyana, GHS) is the national Hydrological and Meteorological Service of the Republic of Guyana, being a department under the Ministry of Agriculture and operating under the Water and Sewerage Act, 2002. However, as it would be elaborated later on in module 2.5, the existing law is already outdated and does not cover all the standard activities of a modern Hydromet service. The GHS provides services and products to most of the agencies of the Guyanese government, especially for the Aviation Authority, Ministry of Agriculture, the Emergency Department, regional councils, etc.

Currently, the GHS is the sole governmental stakeholder to operate and acquire meteorological observations. No other governmental or private stakeholder is performing such activity or is planning to start doing so in the known future.

Related to the private sector, there is no across-country private meteorological service or firm that operates an observational network and that could provide support to the GBON compliance strategy and or that could be approached for a potential partnership. There is, however, the potential for interaction with some of the bigger farms as well as the oil industry (for the marine stations), but it would likely comprise a more “services provided to client” approach and not a joint venture or a public private partnership to enhance the national capacities as a whole.

Due to the relatively small size of the Guyanese market, there are no private companies, which are providing or able to provide maintenance or operation services of meteorological stations and equipment.

Recommendations

a. It is of high importance to support the GHS in its ongoing efforts toward a new legislation, providing a solid, up-to-date and **coherent legislative framework around the activities and mandate of the GHS.** This action would gear the development of the GHS and would bring appropriate organizational and governance structure for additional funding acquisition. National and international advocacy (with the support of the Caribbean Meteorological Organisation (CMO), which has supported the legislative effort since its inception) towards this action should highlight **the importance of the GHS as a national critical infrastructure** that is essential for the well-being of the nation as well as to facilitate inflow of mostly governmental resources.

b. Following from the item above, there should be an increased **national budget allocation for the GHS**, to ensure the sustainability of the modern observational network supported by SOFF**, beyond the investment and early compliance horizons.**

c. As also depicted in the sections below, **stakeholder** (considering stakeholders that can benefit from the services, contribute to the services as well as the government structures that should provide the framework for the GHS operations. Regional entities, such as CMO and WMO Sub-regional offices for North and South America should be engaged in this process as well, to leverage and capitalize upon potential regional-level cooperation) and **end-user engagement** coordinated activities should occur. This engagement should include the following specific actions:

   1. Yearly stakeholder workshop, if possible facilitated by a community member that is familiar with institutional whereabouts at national and international levels. This workshop should gather key government institutions, as well as the private sector. Not only this workshop would serve to strengthen the business model taken but would also open the possibility to explore other potential approaches while in turn exploring additional sources of revenue that may add to the long-term sustainability of the network. These workshops can also trigger regional capitalization and act as a platform for engagements of both the governmental and private sectors of Guyana.

d. Outreach to large scale farmers and the oil industry, in order to:

   1. To determine whether any observational stations (surface or marine) are operated by these entities. In the event that they do, assess their quality against WMO standards, to explore their owners' willingness to share their data internationally and to assess whether these stations will be operated well into the future. In different parts of the country, there are large farms, whose production is focusing on rice and sugarcane. One such farm was visited during the mission to region 9 (Lethem). The oil industry is concentrated mainly in the large sea shelf of Guyana and is operated by major international oil producers. **In any case, such stations could serve only as additional stations to the GBON ones or as potential back-ups, but NOT as standard GBON stations.**
   2. To reach out to the previously mentioned private entities and explore the possibility of their support and **assistance with parts of the maintenance processes for specific stations,** located in the vicinity of their facilities.

      i.

e. **However, over the long term, the only viable and actual partners would only be found outside the borders of Guyana** (such as international private companies providing maintenance and calibration services, major research and training institutions in the Caribbean and North American Regions, etc.).

2.2. Assessment of potential GBON sub-regional collaboration

Given the geopolitical circumstances in the region around Guyana and the harsh climatic and geographic conditions in Guyana itself, optimization with neighboring countries is a challenge. There are however several potential collaborations for optimization of the operations of the network deployed. The following have been identified:

a. There was a previous attempt of the GHS to foster stronger collaboration, through the **Amazon Cooperation Treaty Organisation (ACTO)**, but due to manpower constraints at the GHS, these were never materialized. There is some information exchange with the neighboring Suriname, but much less with Brazil (due also to language barriers).
b. Regionally, Guyana is a member state of the Caribbean Community (CARICOM). **The Caribbean Meteorological Organisatio**n **(the CMO)** was founded under the auspices of CARICOM and its role is to coordinate the cooperation and collaboration between all of the NMHSs of the Member countries. As such, CMO is supporting the GHS with its current meteorological legislation efforts as well as introducing the WIS2 protocol into the data dissemination system of the GHS.
c. **The Caribbean Institute for Meteorology and Hydrology (CIMH)**, which is a part of CMO, is responsible for training as well as calibration services for CMO's members. The current calibration capacities of the CIMH are limited to only part of the meteorological parameters and are not suited to any instrument of any vendor, especially of the Vaisala company, whose equipment has proven to work effectively in the conditions of Guyana. Therefore, another solution for calibration should be sought after (to be elaborated later).
d. In terms of cooperation with neighboring countries, cooperation with Suriname (also a SOFF country) might be the most relevant, due to the almost identical environmental conditions in both countries.
e. It is important to highlight that Guyana is one of the **countries targeted within the Early Warnings for All initiative (EW4All)**. As it is well known, SOFF is contributing to the pillar "Detection, observations, monitoring, analysis and forecasting of hazards" with specific actions towards closing the significant Global Basic Observing Network (GBON) gap. Currently, since the initiative only recently commenced its activity with the GHS, it is still too early to clearly identify actionable touch points among those initiatives.

Recommendations

a. **With the support of the Ministry of Foreign Affairs and International Cooperation in Guyana, strengthen the participation of the GHS within the ACTO framework** and explore possibilities for a further collaboration with Brazil, which among Guyana's neighbors, is the most advanced in the field of Meteorology. This might be done by delegating a focal point from the GHS to ACTO, but also executing a visit to the headquarters of the National Institute of Meteorology of Brazil, the provincial office for the Northern Amazonas region, with the perspective of signing a MoU with the neighboring country.

b. Should an upper-air station be installed and operated in Guyana, in terms of GBON compliance, **it will also relieve Suriname from the need of providing data for a fully GBON-compliant station**, as can be seen in Figure 3. Suriname does operate an upper-air station in Paramaribo, but due to financial and technical constraints, it faces challenges in making it fully GBON-compliant. On the other hand, **a fully operational upper-air station in Paramaribo will be able to cover only the Eastern Part of Guyana**, hence deploying an upper-air station in Guyana is mandatory in order to achieve full GBON-Compliance.

c. Further cooperation between Guyana and Suriname can be explored, through a dialogue between all of the six players: the SOFF implementing entities (UNDP and IaDB), the two NMHSs of both countries and both peer advisors (GeoSphere Austria and KNMI). Together, they may consider the possibilities of either a joined tender OR separate tenders with identical technical specifications. If possible, it might ensure that both countries will have surface networks composed of stations from the same vendor. T**hus, a real collaboration could be considered, perhaps with the support of the CARICOM and CMO, encompassing a wide spectrum of activities: from constant knowledge and experience exchange, through loaning spare parts and other equipment to each to engaging the same private company to provide high-level maintenance to the combined network. The same can also go for the marine network.**

d. As mentioned above (and later elaborated in module 2.5), the GHS, together with the support from SOFF, CARICOM and CMO, s**hould aspire towards a successful completion of the legislative process**, so that the GHS will have a full mandate to operate its network, together with **ensuring full governmental support with resources for this cause.**

e. The CMO, together with the GHS, should take into consideration **the long-term sustainability of the WIS2 procedure** as it helps Guyana to develop, especially in terms of the future IT personnel, who are expected to sustain this system in the long term (also for the entire region under CARICOM).

f. The CIMH should be used as much as possible for providing the required training for the current and future staff, related to the station network. However, it should be taken into account that CIMH might not be able to answer all the training needs of the GHS. **In such a case, additional training possibilities should be explored (Maryland University, Reading University, vendor training courses, etc.).**

g. As for calibration, **it seems that the GHS will have to seek for opportunities beyond CARICOM**, most probably by engaging the private sector in the process.

h. **Explore the potential linkages between the future activities of the EW4All and SOFF** and try to leverage them, so that it could benefit the end goals of both initiatives (A fully GBON-compliant observational network to contribute to a modern, full and effective early warning system for Guyana).

2.3. Assessment of a business model to operate and maintain the network

Given the situation within Guyana as well as the manpower constraints with respect to the work of the GHS, it is **at this stage advisable to operate under a hybrid public private business model (State/National Meteorological and Hydrological Service owned and Private Partner operated (GBON infrastructure)**, in which the stations are owned by the GHS, but part of the maintenance is performed by a private company (at least for the next few years) is recommended, w**ith a future perspective of arriving towards a fully public business model**. In such an approach, the GHS would be responsible for the operations, most of the maintenance as well as replacement of the equipment considering the life cycle of the specific equipment and its replacement after the end of the life-cycle, whereas the private sector could support with high-level maintenance and calibration. The private sector would enjoy a. a long-term relationship with a national actor. b. A proof of concept for its stations and services in the wider Amazonas basin region and/or similar rainforests regions worldwide. c. in case, additional funds will be available, and the network of Guyana will extend well beyond the requested six (6) surface stations, there will be an additional revenue base for the private sector.

It is to be mentioned, however, that the lack of a legal framework or even national strategic plan, adds an extra level of risk to this business model approach that needs careful consideration (Table 3).

Looking into the three types of observations required, it would be advisable to:

a. for Surface stations: their maintenance should be performed in three levels: basic maintenance by local people, whether other governmental officials, farmers or local communities, paid for these services by the GHS, medium-level maintenance by the GHS technical staff and **high-level maintenance (if required) by a private company, preferably Vaisala, which would be the recommended Vendor in the case of Guyana**. As for calibration, the recommendation is to purchase an additional set of measurement instruments, which will be used as reference instruments. **Only the reference instruments will be sent abroad for calibration, on a yearly basis**. This will ensure a more sustainable and cost-effective approach towards calibration.
b. **Part of the basic maintenance can also be performed by the private farms and/or the oil industry, in case where a common agreement could be achieved**.
c. For the upper-air station: It is recommended that it would be a manual one, and to be operated and maintained solely by the GHS' observers at the international airport, together with the technical staff of the GHS. However, it is also recommended to leave a possibility of advisory and support from the producer of the upper-air station equipment.
d. For the marine stations: the same as with the surface stations, but also exploring the possibility of support from the oil industry, which in the case of Guyana, is concentrated in its exclusive economic zone.

Through SOFF, it is of the highest importance also to support political lobbying, through which either **the salaries of the GHS employees could be considerably enlarged and/or strive**

towards a full cost-recovery mechanism for the meteorological services the GHS is providing for aviation. As the Country Hydromet Diagnostics (CHD), performed for Guyana, has clearly shown - the main challenge of the GHS is the extremely high staff turnover. Due to which, a support from a private company would be mandatory, at least in the initial phase, until a potential success with one or both of these items would be able to substantially decrease the dependency upon the services of the private company and hopefully **lead to Guyana moving into the first business model, of fully government owned and operated meteorological stations network.** However, in case the issue with the high turnover rate will not be completely solved, **Guyana should continue working through the second business model, thus the one of hybrid Public-Private Partnership**.

Table 3: identified risks fort he proposed business model.

Risk	**Impact**	**Likelihood**
Financial risk – changing funding based on political governance changes, leading to limited or discontinued budget and resources	Medium	Medium – might be aggravated by the current outdated legislative framework around the role and responsibility of the GHS.
Sustainability challenges – low flexibility on adapting to changing circumstances or if political forces drive in other directions	Medium	Medium – the main challenge is the above mentioned high staff turnover as well the difficulty with hiring skilled technical staff
Market competition – potential competition with the private sector and leading to distorted markets	Low	Low – since there is no private sector operating weather information in the region.
Quality of the services – due to limited resources	Low	Low– the current state of the services provided by the GHS are already not bad. The only main issue is again the high staff turnover rate.
Management competence – due to lack of personnel or corresponding training to manage a larger and more complex service	Medium	Low – it is envisaged that training at management level occurs and should bring best practices and know-how into a growing organization. The main challenge is staff recruitment for management support
Limited legal frameworks and data policies in place that limit the exploitation of the new capacities	Medium	Medium– according to the existing legal framework, the data produced by the GHS is a public good. The same goes with the future legislative efforts. However, the new act should

		clearly state that the GHS is the only governmental body authorized to provide permissions for privately-owned stations.
Data gaps usually due to “operate to fail” approach triggered by constrained resources	Low	Medium – the main two challenges are the demanding environmental conditions, together with, again, the high staff turnover rate.
Station accessibility and maintenance logistics, associated with getting to the stations for maintenance due to local conditions (roads, rivers), vehicles, boats, weather and access to finance,	Medium	Medium - due to lack of/poor roads in the hinterland, especially during the rainy season, many locations are accessible only via river/air, which makes the accessibility slower/expensive/risky, and eventually the inability to get to stations in a timely manner to maintain and replace parts.
Logistics	Medium	Medium -
Ineffective monitoring and tracking of the network and its related purchases etc	Low	Low – the GHS already have quite a good monitoring procedure in place, together with an experienced staff in procurement.
A sudden end to the contractual agreement	Medium	Low - The contractual relations should also include the corresponding exit clauses with timeframes and conditions.
Reputational risks, if they see the weather service matching with a private (strong) corporate.	Low	Low - as long as the relations will be well defined, it might make Guyana as a good example for such relations.
Manpower/Technological risks - in case GHS (together with the CIMH) would not be able to replace the private company	Medium	Low - the contractual relations with the private company should include the option for a continuous relationship. Or even for the private company to provide additional services, in case GHS will find itself incapable for providing them itself (or in case, the CIMH would not be able to provide a full support to the GHS)

A detailed financial plan is to be prepared in the Funding Request for the Investment Phase to ensure a pragmatic and actionable approach is taken and in preparation for minor modifications in the plan according to the Implementing Entity (IE) guidance. However, the costing of the new infrastructure will be based on the World Bank activities including the estimation of Total Ownership Costs detailed in “Charting a Course for Sustainable Hydrological and Meteorological Observation Networks in Developing Countries” by Grimes et al. 2022, considering not only purchase costs but all the surrounding costs related to maintenance and operation.

2.4. Assessment of existing national strategies and projects related to observing networks

The GHS strategy (for the years 2022 - 2026), developed with the support of CMO, puts particular emphasis on strengthening the observation and monitoring fields, as one of its main five pillars, especially for climate services. Additionally, emphasis is placed on the upgrade of the data collection platforms and the dissemination of this data.

Practically, GHS strives towards adding more AWSs, slowly replacing the current manual stations and adding new stations, in places, which had no stations beforehand. However, heavy budgetary and human resources constraints are slowing this process. However, the GHS was already exploring the feasibility of installation and operation of an upper-air station, even before SOFF commenced and in the short term, it will be installing two (2) marine stations on anchored buoys.

GHS, as mentioned beforehand, is the sole governmental operator of meteorological measurement stations, as mentioned in the Water and Sewerage Act, as well as in the envisioned future hydromet act. Due to its high staff turnover rate, the GHS is considering moving towards partial outsourcing of the network's maintenance to private companies.

Currently, there are two internationally funded projects related to GHS, which might be of relevance. The first ist he regional CREWS Caribbean 2.0, which was already approved. Due to the decision of the Guyanese government to participate in CREWS on a national level, the GHS could only enjoy part of the regional, rather than the national activities under CREWS (these may include support with WIS2 and WIGOS, political leveraging, support for the continuation of the legislation process, etc.). The second of which is the EW4All, which at this current is planned to commence, together with UNDRR, around May 2025. Nevertheless, as part of the SOFF investment phase, possible linkages between these two initiatives should be seriously explored, as any reliable early warning system will be based on accurate real-time observational data.

As mentioned in the National Gap Analysis of Guyana (NGA), 21 AWSs were purchased and installed through the USAID CCAP Project (Nov, 2017). Since their installation, these stations were either providing erroneous data, totally dysfunctional or were unable to establish continuous data transmission. Despite a large investment of resources (out of the quite constrained resources of the GHS), the existing defects could not be repaired and hence, recently, the GHS took the decision to stop attempts aimed at reactivating these stations.

2.5. Review of the national legislation of relevance for GBON

The current Act, forming the main existing legal framework for the work and activities of the GHS, thus the Water and Sewage Act from 2002, states that one of the main functions of the GHS is "to establish, manage and operate national systems to monitor atmospheric conditions, climate change and water resources". As for national systems, the GHS is "to continue to operate its existing network of climate, synoptic and water monitoring stations". However, this act is focusing its attention more into the direction, as its name implies, of water resources management of the country.

There is already a well-prepared act, the “hydromet act”, which was a few years ago under a process of legislation. According to the national strategic plan, the hydromet act was to be approved at least by 2023, but while approaching the end of 2024, **this important activity is already de-facto dormant for the last four years**, due to different reasons, mainly weak political support for the GHS’ efforts in this respect. The new Act, prepared with the support of the World Wildlife Fund, already focuses on the GHS itself and provides a more solid and coherent base for the different activities of the GHS, with a stronger emphasis on the operation and further development of the observational network of the GHS.

The main overall **recommendation** is to make all possible efforts, in coordination with the Ministry of Agriculture and perhaps also with the support of CREWS Caribbean 2.0, to effectively push towards the finalization of the legislation and approval of the new Act. While steering the political agenda as a whole is beyond the capacities or intentions of the activities within SOFF, advocacy towards the establishment of this updated legal framework will be performed in all the instances possible. In order to potentiate and trigger the needed dialogues, it is recommended to make use of the planned stakeholder engagement workshops (Module 4) to include an action item at the policy level and advocate for a general support of the stakeholders with the legislative process. This should be supported by bilateral engagements with decision-making bodies. This engagement should be facilitated by those actors that can interface across institutions. The Peer Advisor shall as well support the interaction with the different national stakeholders in Guyana.

It is also to be considered as a recommendation that, at the time of procurement or purchasing of the stations (spare parts and all related infrastructures) regulated taxes and potential custom fees should be properly accounted for. All regulations related to tax, customs or international shipping will be considered at the time of procurement by the IE.

Module 3. GBON Infrastructure Development

3.1. Design the surface and upper-air observing network and observational practices

Provide recommendation on a harmonized observing network design, including siting and instrumentation of new and improved stations, including:

As the National Gap Analysis states, Guyana is generally in a good position to achieve the low-resolution, and eventually even the high-resolution GBON-compliance.

Nevertheless, the following conditions must be taken into account during network design and planning:

1. **Accessibility -** Large parts of Guyana, especially its hinterland, is only accessible by air and/or water (also heavily depending on the season and the weather), which makes the logistics much more complicated and expensive. Many areas are actually not accessible throughout large parts of the year.
2. **Environmental conditions and station resilience** - most of Guyana is covered by dense rainforests, areas of high temperatures and humidity and a very fast growing flora and multiple kinds of fauna, which might cause issues with the stations in the long run (insects, reptiles, birds, etc.). Hence, **only AWSs that were proven to function well under these constraints should be installed aiming at true robustness and sustainability.**
3. **Security and safety** – it is very difficult to guarantee the safety and integrity of stations, especially in the hinterland. Poor roads and transport infrastructure add to these issues.
4. **Maintenance and calibration** – the main challenge related to maintenance is the relatively high staff turnover rate and the difficulty in recruiting skilled technical staff (due to the low salary scales available). As for calibration, there are no adequate facilities currently and in terms of manpower constraints, it would be difficult to assign special staff for calibration. In addition, the regional calibration center, thus the CIMH, does not have the full capacity for calibrating different instruments (pressure and wind, for example). Moreover, its lab is unable to perform calibration for the recommended station type for Guyana. Nevertheless, using field computers and field calibration toolkits can provide a good initial answer to the calibration challenge. Each instrument will be compared to the reference instrument, which will be sent once to the vendor for further calibration, on a yearly basis.
5. **Data communication and transmission** – the current manual stations report using the cellular network, but this network is far from covering the entire country with reasonable stability and bandwidth. The new stations will transmit using the NOAA satellites. However, it has additional implications, as additional power supply and the need to purchase additional modems for all of the stations becomes necessary.

These five items alone already limit the potential deployment locations to those near or within a populated area that have minimum infrastructure that can enable the operation of a station as well as at least basic accessibility possibilities, through land, sea or air.

In addition, the design, planning and budgeting of the network should consider all the costs related to procurement of the necessary equipment for building up the surface observational network (sensors, modems, fences, transport) and the the upper- air station (a list of the required equipment and consumables is given in Annex 4), for the continuous operation and maintenance (vehicles, transport for maintenance, ICT, licensing, 2 field computers and a single field calibration toolkit , spare parts and common equipment), training, management and administrative workload among others. As for spare parts, due to the already mentioned harsh environmental conditions, **it is highly recommended to explore three options: a. either to purchase at least 1 additional set of sensors per station. This might be the safest, but also the most expensive option.** b. to explore a sharing of spare parts procedure with neighboring countries (in case they are using or going to use a similar station type). However, transportation might be a challenge as well. c. through the contractual agreement with the private vendor, assure an easy and fast access to the spare parts inventory of the company. However, transportation and its speed-of-delivery might be an issue here as well.

In addition, the GHS should purchase services from a foreign private company (high-level maintenance and reference instruments calibration for the surface network).

During the implementing period of 2 years the goal would be to strive towards low-resolution GBON compliance (including upper-air and marine stations, Fig 1, 2 & 3 and Table 1&2, surface stations marked by light green).

A potential second investment phase (See all relevant data in Annex 1), in case additional funding would become available, would enable to bring the country into a high-level GBON compliance. This approach would aim to make use of the already available capacities of the GHS, while dealing with the acute manpower and resources needs throughout the entire investment phase.

Implementing Plan to reach GBON low-resolution (2 years)

Aim: Bringing the country into a full low-resolution GBON compliance. During this tranche, the following actions will be necessary:

<u>Technical components:</u>

1. Perform full stations (surface AWSs, an upper air manual station) procurement procedure - The procurement, led by the GHS, with the support of the Implementing entity (IE, in this case, the Inter-American Development Bank, the IADB) and supervised by the peer advisor, should also explore potential maintenance plans and spare parts acquisition. Following the regional gains, a dialogue will be established with the neighboring SOFF countries (especially Suriname) to try to achieve best value for money in the procurement actions and / or follow-up maintenance plans. **It is highly recommended that, in the case of the surface stations, the GHS should proceed with purchasing similar stations to the ones, which were already installed in the country and proven to operate well. This will also ensure compatibility with existing hardware, software and HR competencies.**
2. Once procurement is achieved for 6 surface AWSs to:
    a. transport, create the necessary local arrangements (civil works, fences, etc.) and deploy the 6 new stations, according to Table 1 and Fig 1, stations marked in light green.
3. Once procurement is achieved for the single manual upper-air station, to:
    a. transport, create the necessary local arrangements (adequate consumables storage, fences, etc.) and deploy the new system at the Cheddi Jagan Airport (year 1)
    b. Perform a series of test launches (three months, at least)
    c. Start launching operationally (second year)

4. As for the marine stations, to limit the SOFF support at this tranche, for the already/planned two (2) marine stations (fig 3), with spare parts, maintenance and calibration.
5. Perform the procurement and installation of the necessary additional ICT equipment corresponding vendor offers and quality control and assurance mechanisms. The hardware should also include the hardware that would allow for the receipt, storage, processing, transfer, etc of the data that these data stations will be recording/reporting.
6. To procure an additional set of instruments for a surface station, to serve as reference instruments.
7. To reach out and come into formalized contractual relations with potential private companies, to provide high-level maintenance for the stations' network and calibration services for the single reference surface station. These relations should include clear definitions of the responsibilities of the private company/ies, its liability, as well as exit clauses. As mentioned before hand, it should also include possibilities for: a. continuation of the relations in the longer-term. b. training services for the staff of the GHS. c. the possibility of making effective use of the available company's spare parts stock. d. the possibility of expanding the maintenance services provided by the company/ies, in the event that the GHS is incapable of solely executing this function. These relationships should be supported closely by the IE and the Peer Advisor.

Human capacity development:

1. Make the necessary arrangements with the CIMH and additional potential relevant training providers, to perform relevant training for the current technical staff of the GHS, as well as build a new training procedure for the future staff. The training should cover technical and scientific aspects related to both manual and automatic stations. The training should address A) maintenance of the stations, B) training for the ICT infrastructure envisioned for the stations, including data management/storage/transfer/dissemination/QC, etc. and C) management (best management practices). The management aspect should be aimed at generating the organizational and managerial knowhow to prepare for the growth of the weather service. This specific management topic may be coordinated with WMO ETR and will be also supported by the Peer Advisor, which may host a specific meeting at the Peer Advisor's facilities to share best practices and know-how.

2. Support the GHS in locating potential local support staff and training them to perform basic-level maintenance.

3. Make the necessary arrangements with the private vendor, CIMH and any additional potential relevant training providers, to perform training for operators of the upper-air station and build a new training procedure for future operators.

4. Making similar arrangements for the current and future technical staff, as for the operation and maintenance of the marine stations.

Governance and stakeholder engagement:

1. Establish advocacy to paraministry. This advocacy action will take advantage of the planned stakeholder engagement workshops, which will offer a unique set-up to discuss the criticality for the nation of a well-functioning weather service, particularly with the coming climate change effects. The advocacy will be triggered by bilateral discussions and be supported by the peer advisor, CMO, CIMH, representatives of CARICOM, representatives of the WMO regional office and relevant national actors where possible. This advocacy should be

used to push towards completion of the legislative process of the Hydromet Act, encouraging the government to increase the budgetary allocations to the GHS (also through a potential cost-recovery process for at least the aviation services) and strive towards finding ways to substantially increase the salaries of the GHS employees and by this, **to substantially decrease the staff turnover rate.**

2. Establish dialogues with stakeholders that may have specific actions or interests in the country that can be synergised aiming at a better usage of respective resources and boosting cooperation.

3.2. Design of the ICT infrastructure and services

The Information and Communication technology (ICT) infrastructure for a meteorological network is crucial for its operation and, more importantly within the SOFF scope, for the data transmission and dissemination in real-time. The infrastructure must consider very critical aspects that can largely modify the costs and should be carefully considered at the time of preparing the funding proposal:

1. Data loggers, as mentioned in Annex 12, chapter 1 & Annex 3
2. Transmission: satellite network, providing access to the NOAA/NESDIS GOES Data Collection System (DCS) for Data Collection Platforms (DCPs). With the purchase of the Vaisala Direct Readout Ground Station which is already installed at GHS, GOES is the preferred communication mode for telemetry. It is important to note that **cellular Data is not available throughout Guyana and even in areas with coverage, this can be unreliable at times**.
3. Power supply: Wired supply is preferable but also solar power is OK (1 m^2 Solar Panel = 100W Peak), Akku to bridge breakdowns in power supply or to store solar power for the night: 50-100 Ah Solar power should take first priority here instead of a wired supply being preferable as most of our AWSs are at remote locations. Even if there is utility power at the site, this can be unstable and unpredictable at times. An efficiently designed solar system for the AWSs is included in the Vaisala AWS810 Stations. If we are speaking in terms of having redundancy, solar power still takes priority and a wired supply can be a secondary power source at locations where this is possible.
4. Sensors for surface stations: Temperature, Humidity, Precipitation, Wind speed and direction, pressure are the basic sensors. For upper air: height/pressure, temperature, Humidity, Wind Speed and direction. For marine stations: Temperature, Humidity, Precipitation, Wind speed and direction, pressure, Wave Height and Frequency, Salinity.
5. Surface stations should be located in a protected area, someone has to have a look at the sensors at least once a week for cleaning and should be able to do small repairs (change a fuse, restart the logger, etc.) or should help to identify problems when someone guides him by phone. Nevertheless, **Vaisala AWSs are capable of performing optimally without human intervention.** The GHS can maintain its current three visits per year maintenance strategy and also be guided by the Direct Readout Ground Station for more effective assessment of a Station's health and performance status. Still, **support of local people can**

help reduce maintenance costs and provide improved security and safety for the stations. The upper-air will be located at the GHS compound at the airport.

It is to be noted that sustainability requires that a budget is allocated to the ICT for the lifespan of the network and the ITC itself and with proper back-up and data storage and data services systems. The budget should cater for additional servers for redundancy and possible offsite backups of the Direct Readout Ground Stations central database.

Data exchange will be WIS2 compliant thanks to the engagement and cooperation with CMO, who will cater for the deployment of WIS2 in a box for the deployed stations.

3.3. Design the data management system

An operational data management system already exists in Guyana. However, adaptations should be made, as with the large data volumes about to enter the system, thus additional computing power as well as sufficient storage space should be taken into consideration (perhaps through a cloud storage. However, the latter might be costlier, as well as the question of the internet bandwidth of the GHS should be re-evaluated). So or so, a redundancy in servers and internet connection is a must for data protection and reliability.

The transmission of data from an observing station to the national data management system should already be performed through reliable communications infrastructure. Currently the NOAA/NESDIS GOES Data Collection System (DCS) transmissions appear to be the most feasible and cost-efficient approach for the current setting. However, at the procurement point, additional options may be explored.

The receiving units may be hosted by cloud computing services with a direct connection to a temporary file storage where the original data protocols may be kept for data buffering, technical monitoring, and maintenance purposes. Received data may be decoded and rendered instantaneously and sent to the central PostgreSQL database holding the full raw data archive. Additional data servers will be required.

This database is a secure, highly redundant storage service and shall be the data backbone of the whole data management system. Since the WMO Information System 2.0 (WIS 2.0) has already entered a pre-operational stage, it is highly recommended to base all national and international data transmission processes of the GHS network on the wis2box toolset operating close to the central database. Some new weather station concepts offer direct upload of data to WIS 2.0 (https://www.campbellsci.eu/gbon-and-soff). Highly redundant storage services are required. Currently, the only storage point for the AWS data is on the central database server that runs the Vaisala Network Manager in the Direct Readout Ground Station.

- The GHS data management system shall benefit from various features of the wis2box (https://docs.wis2box.wis.wmo.int/en/1.0b4).

- WIS2 compliant: easily register your wis2box to WIS2 infrastructure, conformant to WMO data and metadata standards.
- WIS2 compliance: enables sharing of data to WIS2 using standards in compliance with WIS2 technical regulations.
- event driven or interactive data ingest/process/publishing pipelines.
- visualization of stations/data on interactive maps.
- discovery metadata management and publishing.
- download/access of data from WIS 2 network to your local environment.
- standards-based data services and access mechanisms.
- robust and extensible plugin framework. Write your own data processing engines and integrate seamlessly into wis2box.
- Free and Open Source (FOSS).
- containerized: use of Docker, enabling easy deployment to cloud or on-premises infrastructure.

All downstream applications such as data monitoring, internal and external data transmission, quality control and data processing will depend on the reliability of the central database for raw data.

Following the Guidelines on Surface Station Data Quality Control and Quality Assurance for Climate Applications (WMO-No. 1269) mandatory data quality control (QC) and assurance (QA) tests will be established. Ready-made Software for QC and QA often needs elaborate and costly adaptations to fit to the local technical and meteorological environment and to meet local needs. Offering a long-term perspective for local and self-determined development with PYTHON and PostgreSQL, it is recommended that GHS re-evaluate and consider an upgrade of its own QC software involving local IT staff. A first point of QC will be done by Vaisala's Network Manager which is bundled with the Direct Readout Ground Station. **Currently, the GHS uses an advanced database management system known as Clidata. The Service has been actively involved in the maintenance, upgrades and training of staff on its use. More advanced QC and manipulation/processing of the data can be done using Clidata.**

Last, it will be the role of the IE, supported by the Peer Advisor, to ensure that not only the purchasing of the equipment is performed but installed, operated and managed within the Investment Phase and for its sustainable future. Details on the execution and working plan shall be provided in the corresponding Funding Request.

3.4. Environmental and sustainability considerations

The procurement specifications will include also, as much as possible, elements, such as: prioritatization of equipment with low energy use, minimal hazardous materials, and ecofriendly packaging. Anybody dealing with the stations: the local communities, the GHS' staff as well as the employees will be trained and encouraged to use sustainable and eco-friendly practices for procurement, maintainance, disposal and calibration.

AWSs, the upper-air and marine station deployed, will undergo maintenance as per funding request to make use of the lifecycle and extend it as possible. They will also be GBON compliant in terms of requirements and characteristics. Sustainability shall be also boosted by synergizing maintenance, calibration and training with other initiatives and ongoing programmes. It is also important to highlight that the stations' locations are to be optimized so that maintenance is facilitated by being deployed in or near populated areas.

Strong government commitment is expected. Awareness creation at the policy and political levels of government about the importance of improving the availability of the real-time accurate meteorological data, which have a direct positive impact on the quality of weather forecasts, thus helping in ex-ante climate risk management and improving the safety and well-being of the population will create buy-in and ensure sustainability of the initiatives. Moreover, the need to enhance climate preparedness by enhancing the capacity for climate data collection, analysis and dissemination is an explicit request from the government. The support provided to GHS is expected to be well received and the investments safeguarded since improvement of climate services is a critical need for the country. The linkage to CMO, CIMH and other potential future partners for capacity building will ensure sustained support from the regional centre of which Guyana is a member.

Module 4. GBON Human Capacity Development Modul

4.1. Assessment of human capacity gaps

Due to insufficient remuneration (as can be seen in table 4.), the GHS is facing two related challenges: a high staff turnover rate as well as a difficulty with recruitment of new skilled employees. This situation is especially evident with the technical and IT staff, which is constantly contested with private enterprises. For the successful implementation of the SOFF activities in the country, there is an emerging need for substantial change with the governmental remuneration policy of the government (or a substantial outsourcing, which can cause a considerable weakening of the GHS as a whole). Only with a substantial change with this policy, the turnover is expected to decrease and it would be easier to find new and promising experts outside of the GHS.

Table 4. List of relevant specialists (for the observational network) – filled and vacant positions

Designation/ Position	Qualification	Additional Qualification/ Professional Training	No. Filled	No. Vacant	Remarks
Hydromet. Technical Assistant	Sound Primary/Elementary Education	On-the-job training is required	15	5	These staff are recruited mainly in rural areas to observe and record meteorological and hydrological phenonmena at synoptic/climatological and hydrological stations.
Meteorological Technician I	Five (5) O'Level Subjects including Mathematics, English Language and at least one Science Subject (Chemistry, Biology, Physics, Integrated Science, Agriculture Science).	CIMH	7	14	This number is divided between the Climatology (8), Agrometeorology (1) and the Aernautical Meteorology (12) Sections.
Meteorological Technician II	Five (5) O'Level Subjects including Mathematics, English Language and at least one Science Subject (Chemistry, Biology, Physics, Integrated Science, Agriculture Science).	ELMT plus at least three (3) years post-qualification experience.	1	5	There is curently only one (1) Meteorological Trchncian II on staff. This staff is assigned to the Aeronautical Meteorology Section.

Telecommunication Technician	Five (5) O'Level Subjects including Mathematics, English Language and at least one Science Subject (Chemistry, Biology, Physics, Integrated Science, Agriculture Science).	Electronics Certificate/Diploma from the Government Technical Institute	4	0	This position was created less than ten (10) years ago to allow for staffing of the recently formed Telecommunication and Maintenance Section. However, at least an additional four (4) positions are desireable given the expanding observational network.
Senior Meteorological Technician	Five (5) O'Level Subjects including Mathematics, English Language and at least one Science Subject (Chemistry, Biology, Physics, Integrated Science, Agriculture Science).	Senior Level Meteorological Technicians' Course offered by the CIMH.	1	7	This staff typical works as a Weather Forecaster or supervises the Meteorological Technicians. This position needs to be rationalized with the Meteorologist position given the "new" definition of a Meteorologist under the BIP-M course. At least an additional five (5) Meteorologists/Senior Meteorological Technicians are desireable.
Electrical Engineer	Degree in Electrical Engineering	Appropriate Professional Development Courses.	3	0	This position was created less than fifteen (15) years ago to allow for staffing of the Telecommunication and Maintenance Section. However, at least an additional position is desireable given the expanding observational network.

The GHS still has a well-skilled staff, which is capable and competent in dealing with a growing observational network, however, for the long-run, the above mentioned issues might cause a potential risk for the sustainability of the network.

Undoubtedly, any project that aims at establishing an observational network requires a strong and well-crafted plan for human capacity. **This plan should encompass augmenting the workforce of the institution along with enhancing the background and technical expertise to perform the required duties.**

4.2. Design capacity development activities for technical staff

With the perspective of a drastic change of governmental remuneration in mind (at least an increase of 50% with the average salary), the GHS is hoped to grow within the SOFF activities and so will its staff members. A training and capacity development plan is required with clear objectives that have measurable milestones and that are aligned with the GHS strategic goals in the short and long terms. The plan should be tailored to the initial levels of expertise of the staff members and the levels that are expected to be achieved. In order to do so, a structured curriculum has to be designed that covers the technical skills and basic knowledge with a mixture of practical and theoretical components. The training should be focused and tailored to specific individuals (or groups of individuals) trying to develop focal points of expertise rather than making general training to all staff members.

As stated above in this document, the training will build on cooperation that will be established under the SOFF umbrella, the following are envisaged:

1. Further Cooperation with CIMH, the university of the West Indies and more, regionally.
2. Exploring other training opportunities, through universities and institutions, especially in the US and the UK.
3. Exploring training opportunities with NOAA, NCEP, NCAR and similar institutions in the US.
4. Exploring the possibilities of an on-job-training in other NMHSs, especially such, which operate in similar environmental conditions (Brazil, Belize, Suriname, etc.)
5. Enhance of usage of WMO specific training through specific contacts with the Education and Training Programme (ETRP) of WMO.

The training plan should include the following specific components:

- **Automatic Surface Weather Stations and weather parameters**: this training should offer the fundamentals to move forward station operations. It should give basic understanding of the parameters that are critical, their interrelations and basic meteorological background information with a focus on observations and guidelines, functionality and fundamental principles, maintenance of electronic components (rules and procedures), data collection, storage (data logger) and transfer general concepts.
- **Station components and maintenance**: conducting weather observations, maintenance, and operations of automatic stations. These trainings should also be offered to those individuals located at or near the station location for easier maintenance and operations. Specific technicians should result from this training, with a minimum of 2 to cover the 6 stations targeted in GBON. The operations and maintenance should as well include a managerial aspect on generation of SOPs and checklists. Very important to highlight and focus on in-situ maintenance, maintenance of mechanic and electronic components
- **Calibration:** this training should be performed in cooperation with CIMH and the Vendor's calibration experts and should include a visit to CIMH and the facilities of the Vendor. It is particularly relevant that the role of calibration is explained and embedded into procedures downstream and all maintenance aspects that will require this knowledge.
- **IT, ICT and potentially HPC or cloud services:** the insufficient IT personnel will need to be addressed with at least two IT experts to handle all that relates to communication etc. They may as well facilitate the in-house programming of simplified but effective data quality and management procedures. This training should include Ubuntu, Linux, docker and python at a minimum. The training should work on configuration and

administration of hardware (server, networks, clients) and software (operative systems, databases, communication)

- **Data transfer and WIS2 specific training:** this will be coordinated with CMO and CIMH which will address the deployment of WIS2 in a box system for the international transmission as well as for the additional capacities the tool has to offer that can assist in other activities of the SSMS.
- **Best practices in data quality and quality management:** this should support the IT training to enable that there is a quality management system in house that can evolve according to the SSMS needs. This training should offer knowledge on the value chain and its components where QM is needed as well as usability of benchmarking.

In addition, for the upper-air station the marine stations: additional training on safety regulations, operation, functionality and fundamental principles, maintenance of electronic and mechanical components (rules and procedures), data collection, storage (data logger) and transfer general concepts as well calibration. Fundamentals of higher atmosphere and marine meteorology should be also taught.

It is to be noted that other international training courses can complement the program. Those courses could comprise the freely available courses from COMET (Cooperative Program for Operational Meteorology, Education and Training), EUMETSAT (European Organization for the Exploitation of Meteorological Satellites), EUMETCAL (European Meteorological Computer Assisted Learning) and others, which offer the opportunity to enhance personal and institutional knowledge easily and remotely in many instances.

4.3. Design capacity development activities for senior management

A weather service is a complex institution that requires effective capacity development activities that empower senior and junior management to lead with excellence and drive the organization toward success and, in this case, the very needed growth. The design of the development activities for management is crucial to ensure the right skills and knowledge to lead effectively. This design should consider the organization's main strategic goals and competences that want to be achieved and be aligned with the mission of the SSMS. It is also very important to customize the activities to the reality of the organization in a gradual approach and with a pragmatic and realistic perspective adapting to the specific needs and evolving capacity. The capacity development activities at this initial stage should focus on:

- Developing leadership skills, including strategic thinking, decision-making and communication.
- Change management, especially in the evolving nature of SOFF, it is important to gather the skills to lead and manage change within the organization and its staff members.
- Financial training and financial management and budgeting. Managers need to familiarize themselves with financial statements, resource allocation and the financial implications of the decisions taken.
- Project management training and Measurement and evaluation through the definition of key performance indicators to assess effectiveness of the activities.

- Strategic planning and regional networking, especially within the UN arena to develop action plans that have cross-sectorial approaches and optimize networks to achieve strategic national objectives.
- Enhancement of communication skills to become the spokesperson of the organization and establish the high-level dialogues required and drive decisions towards the organization's strategies.
- Technology and digital literacy, to leverage technologies as required.

The training plan should include the following specific components:

- **An exchange to benchmark with another well-established weather service: taking** advantage of the collaboration with the Peer Advisor institution, a visit to WMO and GeoSphere Austria facilities to exchange best practices.
- **Exchange with WMO ETR** to identify training activities on management. Potentially participate in Senior Management Capacity Building courses.
- **Training on project management**: identify a course (remote) to establish basic knowledge of administrative skills for project management and KPIs (also for the senior technical staff).
- **Financing training:** to gather the expertise and tools to handle costing of projects, budgets, and basic day to day operations of a weather service.

4.4. Gender and CSOs considerations

It is well known that disasters affect those most vulnerable, and gender, age and illness are critical factors that may exacerbate the impacts. The integration of gender perspectives with the involvement of civil society is to be included in all aspects, especially when it comes to a government-based institution. This integration should be covered at governance, policy making, development and dissemination and response levels and should have participative approaches to facilitate the engagement and give the voice to those usually unrepresented.

It is therefore important to bring in CSOs in a participative approach to embed the considerations related to gender and specific vulnerabilities right from the start. CSOs will be particularly important at the time of identifying both potential staff, supporting staff and to be included in the training programmes and any related activities. The current situation at the GHS is quite satisfying in terms of gender equality, but it would be also highly recommended to initiate a complete gender assessment at the end of the phase to monitor the progression and success of the implemented actions. This assessment will not only comprise an evaluation of the current staff, but, through exchange with CIMH, an overview of the future gender proportions existing at student level and that will be the pool of potential staff in the future. Gender balance will be encouraged at every procurement and training action with a growing quota with the years.

It will be particularly important to make use of the stakeholder engagement workshops to include a specific dialogue platform for the CSOs addressing gender opportunities while at the same time advocating for the rights of marginalized groups (especially, in the context of Guyana, speaking of indigenous and refugee populations) and more vulnerable individuals (again, in the case of Guyana, the populations residing in the hinterland). The outcomes of the workshops are to be included as formal recommendations for the SOFF activities and be used as guidelines to promote equity and equality. To this aim, an initial dialogue with the International Federation of the Red Cross (IFRC), World Food Programme (WFP), local and international NGOs, etc. and their Anticipatory Actions will be established so that to act as a community liaison for these activities as well as with UN Women.

Last, but not least, an internal quota for the SOFF activities will be sought to ensure as possible that at least 50% of the staff related to SOFF are female and that in the stakeholder's engagement workshops the female contributions are visible. Both at IE and Peer Advisor level this equity will be reinforced at all steps of SOFF related activities. Targets for each year will be included in the Funding Request.

Module 5. Risk Management Framework

5.1 Assess the risks of the observing network and propose mitigation measures

The GHS has only partially a quality management or a risk management framework in place. While ideally the organization should follow the ISO standards, the current state of the institution is still not fully ISO-compliant (with the potential exception of the meteorological services for aviation, as ISO-compliance there is mandatory). However, a proper management of risks is required during and after the SOFF investment phase to prevent potential setbacks and adapt as agile as possible to an emerging risk. In addition, understanding the role of the Implementing Entity, the risk management should follow the internal approaches existing at IE and that will facilitate the execution of the investment phase.

The two main types of risks involved with the future sustainability of the observations network are: a. manpower shortages and high staff turnover rate. b. the harsh environmental conditions in most of the country.

As for the manpower issues, as already mentioned above, the main obstacle lies with the low and insufficient remuneration governmental policy, leading from the one side to very high rate of staff turnover and on the other to major difficulty with the filling in vacancies, especially those related to the technical and IT fields. Considerable political lobbying, together with an engagement of the different stakeholders should push the government to reconsider its policy. In addition, searching for additional potential income sources for the GHS (cost-recovery mechanism for the aviation sector, additional services for the rapidly expanding oil industry, etc.) should also allow the GHS to allocate more resources for the benefit of its employees. One should also take into consideration, that Guyana is expected to become of the world’s major oil producers and hence, considerably increasing its GDP and thus also the possibility of an increased governmental budget and increase of salaries

As for the environmental issues, these include true challenges with accessibility to the stations locations on the one hand, and on the other hand, highly demanding conditions in-situ for the proper operation of the surface stations. These heavy risks will be dealt by: 1. relying on local communities to secure the stations from potential vandalism, but also support the immediate and basic-level monitoring, maintenance, especially during the rainy season, when the roads become much less transable. 2. Making use only of equipment proved to be durable, robust and well operating in these conditions (high humidity and temperatures, insects and birds, etc.). 3. Keeping a larger-than-usual stock of spare parts.

In order to make all the process clearer, more transperant and with a better mechanism dealing with risk management, the entire investment phase will be managed by a special steering committe, headed by the director of GHS and including also members from the IDB, GeoSphere Austria, CIMH as well as a representative from the ministry of agriculture of Guyana, assisted by a technical team core, including members from the GHS, GeoSphere Austria and CIMH. The steering committee will meet on a two-monthly base and/or by need. It will examine, approve and evaluate any activity under the investment phase plan, get periodical and special reports over the activities and in case of changes, adapt the activities to the potential situations.

The table below describes the most critical risks that may be encountered to be added to those presented in the business model selection.

Table 5: summary of risks for a hybrid public-private business (State/National Meteorological and Hydrological Service owned and Private Partner operated model).

Risk	Risk level	Likelihood	Impact	Monitoring and evaluation	Risk Mitigation Measures
Non-compliance with fiduciary and procurement standards in some SOFF activities	Low	Unlikely	Major	Any procurement process, technical specification or change of these will be monitored by the steering committe, with the assistance of the technical core team	Any non-compliance found will be discussed by the steering committee and measures will be taken with the advice of CMO, the SOFF secretariat and with coordination with the other Caribbean SOFF countries
SOFF-funded investments cause environmental or social impacts	Low	Unlikely	Minor	GHS technical and climate staff will use part of their monthly resources to assess these impacts.	These reports will be brought into the immediate knoweldge of the steering committee and in case of an immediate need, the committee will convene ad-hoc and take measures
NMHS staff depart after being trained	High	Likely	Major	At each regular meeting, the Steering Committee is informed by the GHS HR department of any changes to GHS staff, particularly those relevant to the monitoring network.	Through a strong political leverage and advocacy, SOFF, together with CREWS, will help pushing the government of Guyana to recognise the significant importance of the GHS' staff, with the requirement to increase substiantially their salary scales, especially for the junior staff, as this is the main reason for the departure of the staff
Slow implementation and delays in procurement, installation and capacity building activities	Medium	Unlikely	Major	At the kick-off meeting of the investment phase, a clear time schedule for the project will be established, together with milestones. Monthly reports will be issued	The reports would be examined by the steering committee during its fixed meetings. In case of an expected considerabel delay, the steering committee will convene according to the

				with the progress in the different activities	need, with the mandate to take immediate measures.
After the conclusion of the Investment phase, GBON data are not collected or shared or are shared of insufficient quality	Low	Possible	Moderate	GHS is about to reach a state of real-time reports on the availability and basic quality check tests of its automatic stations	These reports, together with the stations themselves, will be monitored contiously by the technical department, the forecasting department as well as the climatology department, updating the technical department for immediate required actions. The steering committee will examine monthly reports and deal with appearing major issues.
Destruction or theft of SOFF-financed equipment and infrastructure	High	Likely	Major	Continous monitoring by the technical and climate departments. All of the stations will be visited on a fixed base.	The abovementioned reports will allow knowing whether any equipment was damaged or stolen. All of the low-resolution stations are located in governmental facilities.
Countries cannot make optimal use of data, including accessing or using improved forecasts products from the Global Producing Centers throughout the hydromet value chain	Medium	Possible	Moderate	The forecasting and climate departments will report on a monthly base to the director of the GHS, as for the use of this data. In addition, the peer advisor, with the support of CMO, will make external checkes.	GHS, through SOFF, CREWS, EW4All and other initiatives, will seek to constantly improve the knoweldge and know-how of its relevant employees, with the support of CIMH, the peer advisor, as well as future additional partners, such as the university of Guyana, NCEP, the university of the west indies and more.
Meteorological conditions that affect the deployment activities by limiting accessibility to sites and	High	High	Major	The technical staff of the GHS will get continous information from the forecasting and climate departments.	And update the working plan accordingly

constructions as needed.					
Limited availability of potential staff members to be trained to ensure full operations of the network.	High	Likely	Major	Montly reports of the HR department of the GHS to the steering committe.e	A strong political leverage and advocacy with the aim of increasing substiantially the salaries of the staff and addition of new vacancies.
Contractual or financial issues with renewing the working agreement with the private vendor, providing high-level maintenance and calibration	Medium	Possible	Moderate	The contracts and the financial status with the private vendor will be monitored on a constant base by the steering committee.	The initial contract for the investment phase will be constructed with a deep thought on future potential implications and change. The GHS will aspire towards using its own capacities in the most optimal way and relying on the private vendor only in vital issues
Risks related to constant power supply and communication.	Medium	Possible	major	Monthly and realtime automatic reports of the data management system. The climate department will take responsibility of checking the WQDMS website on a continous base, creating direct connections to the Global Computation Centers.	Any alert of untransmitted data, either locally or internationally, will be examined immediately by the technical department of the GHS. The stations will be equipped with the best possible solar power supply and batteries, to be replaced on a yearly base.

The monitoring of the risks and implementation of mitigation strategies are coordinated by the IE, as per description in the Funding Request, but supervised and guided as needed by the Peer Advisor.

Module 6. Transition to SOFF investment phase

The transition to the SOFF investment phase is to be based on the Readiness Phase deliverables and, in particular, this National Contribution Plan which has been drafted in coordination with the beneficiary country and the IE.

Summary of GBON National Contribution Plan

Provide summary of GBON National Contribution Plan by filling this table

Components	Recommended activities
Module 2. GBON business model and institutional development	1. Initiate advocacy actions to promote the finalization of the corresponding legislative framework around the GHS mandate and activities.
	2. Strengthen the cooperation with the CMO and CIMH and explore other potential training providers, outside of the Caribbean Region.
	3. Explore opportunities inside of Guyana for engaging the private national and international private companies operating in the country.
	4. Foster approaches through Early Warnings for all as well as through bilateral discussions of other SOFF and non SOFF countries (Suriname, Brazil, Belize, etc.). Also through other regional associations.
Module 3. GBON infrastructure development	1. Perform a full surface, upper-air and marine stations deployment. This includes all the procurement, preparation, and required ICT actions (tranche 1)
	2. Follow a milestone approach to ensure the capacity is deployed in a robust and sustainable manner to ensure the longevity of the network and its operations.
	3. In case, additional funds will be available, to repeat 1., but with additional 16 surface stations, striving for a GBON high-resolution compliance (tranche 2).
	4. Initiate stakeholder engagement activities to promote engagement, seek for business opportunities and generate an advocacy platform for GHS activities and role as a national critical infrastructure.
	5. Engage local communities for assuring the safety of the surface stations as well as their basic-level maintenance.

	6. Engage the private sector with high-level maintenance and calibration services.
Module 4. GBON human capacity development	1. Through political lobbying, stakeholders engagement and exploring additional income sources, to improve the remuneration for the current and future employees of the GHS.
	2. Establish a tailored technical training plan for the current and expected staff
	3. Strengthen the cooperation and training plan with the CIMH and the University of the West Indies. Explore training opportunities outside of CARICOM.
	4. Initiate training on higher management aspects including an exchange visit at the Peer Advisor facilities and WMO in Geneva
Module 5. Risk Management	1. Through the IE, the CMO and supported by the Peer Advisory and Beneficiary Country, monitor the evolution of the investment phase through the identified risks and initiate mitigation actions as required.
	2. As already mentioned, to positively change the governmental remuneration policy.
	3. To engage the private sector with providing the services, the GHS staff is currently unable to provide.
	4. Procurement of robust and durable stations, adoptable to environmental conditions in Guyana.
Module 6. Transition to SOFF investment phase	Transition performed in a coordinated manner with the beneficiary country, the IE and the peer advisor following the agreed National Contribution Plan. The funding request will be also based on the activities agreed in this National Contribution Plan.

Annex 1. Potential Roadmap for a high-resolution Surface Network

This Annex 1 provides all data for a potential second investment phase to reach target of high density GBON compliance (22) in Guayana. Within two additional years, a second tranche would capitalize upon the already existing operational network created during the first tranche, making it much more dense. Such an approach would demonstrate also the capacities of the SOFF initiative to not only aim at sustainability and robustness, but also at having a wider perspective into GBON compliance towards a high density network that would be more beneficial to both the local and national needs. Guyana could become a showcase of best practice for future steps of SOFF.

If additional funds will become available – we provide a roadmap for this second investment phase:

Aim: Bringing the country into a full high-resolution GBON compliance. During this tranche, the following actions will be necessary:

<u>Technical components:</u>

1. Perform a procurement of additional 16 surface AWSs and 2 marine AWSs (this time, with the full support of SOFF) - as in tranche 1, the procurement, led by the GHS, with the support of the IE and supervised by the peer advisor, should also explore potential maintenance plans and spare parts acquisition. **It is again highly recommended, in the case of the surface stations, the GHS would proceed with purchasing similar stations to the ones installed during tranche 1, to assure sustainability and to avoid the risks associated with a multi-vendor observational network.**
2. Once procurement is achieved for these stations to:
    a. transport, create the necessary local arrangements (fences, etc.) and deploy the 8 new stations, according to table 7 and Fig 4, stations marked in dark green (first year).
    b. transport, create the necessary local arrangements (fences, etc.) and deploy the remaining 8 new stations, according to table 7 and Fig 4, stations marked in dark green (second year).

3. Once procurement is achieved for the additional 2 marine stations, to:

    a. prepare and deploy the anchored buoys, and install the new stations (first year, according to Fig 3).
    b. Perform a series of test observations (three months, at least)
    c. Start sending observations internationally operationally (second year)

4. Perform the procurement and installation of the necessary additional ICT equipment with the corresponding vendor offers and quality control and assurance mechanisms.
   To reassess the services provided by the private company chosen in tranche 1, and use the conclusions derived for a new call for providers of high-level maintenance for the stations' network and calibration services for the single reference surface station. The GHS should re-evaluate the need for outsourcing the high-level maintenance services, before publishing a new call.

<u>Human capacity development:</u>

1. to perform refreshment training for all the relevant staff (technicians, observers, local caregivers) with the support of the CIMH and other potential training providers, already allocated during the first tranche.
2. Support the GHS in locating potential local support staff for the new 16 AWSs and train them to perform basic-level maintenance.

Governance and stakeholder engagement:

1. In case any of the goals mentioned in the previous tranche (thus legislation finalization, increasing governmental support to the GHS and/or salary increase) was not or were not achieved, proceed with the advocacy to paraministry.

2. Continue the dialogues with stakeholders that may have specific actions or interests in the country that can be synergised aiming at a better usage of respective resources and boosting cooperation.

3. **To re-assess the capacities of the GHS to perform the required maintenance and operation activities. In case of a change with the situation during the first tranche, to update, with the support of the IE and the Peer Advisor, the contractual agreement with the private sector.**

The investments should include:

- 6 (first tranche) + 16 (second tranche) fully automatic AWS with the corresponding temperature sensor, humidity sensor (hygrometer), atmospheric pressure sensor (barometer), rain gauge and wind speed and direction sensors; All including the Total Cost of Ownership approximation.
- 1 full upper-air manual station with the corresponding temperature sensor, wind and direction sensors, height/pressure sensor (barometer) and humidity sensor (hygrometer); All including the Total Cost of Ownership approximation.
- 2 full marine stations with the corresponding temperature sensor, humidity sensor (hygrometer), atmospheric pressure sensor (barometer), rain gauge, wind speed and direction sensors, wave height and frequency sensor, salinity sensor; All including the Total Cost of Ownership approximation.

The maintenance plan will be drafted in agreement with the manufacturer. The GHS, with the support of the IE and the Peer Advisor, will be in charge of the tendering processes based on the WMO guidance and based on the respective potential agreements under a public-private partnership.

The technical specifications of the stations to be deployed will follow those as specified in the previous procurement tender of the GHS. In this way, maintenance and operations are to be done in a more consistent and cost-efficient manner.

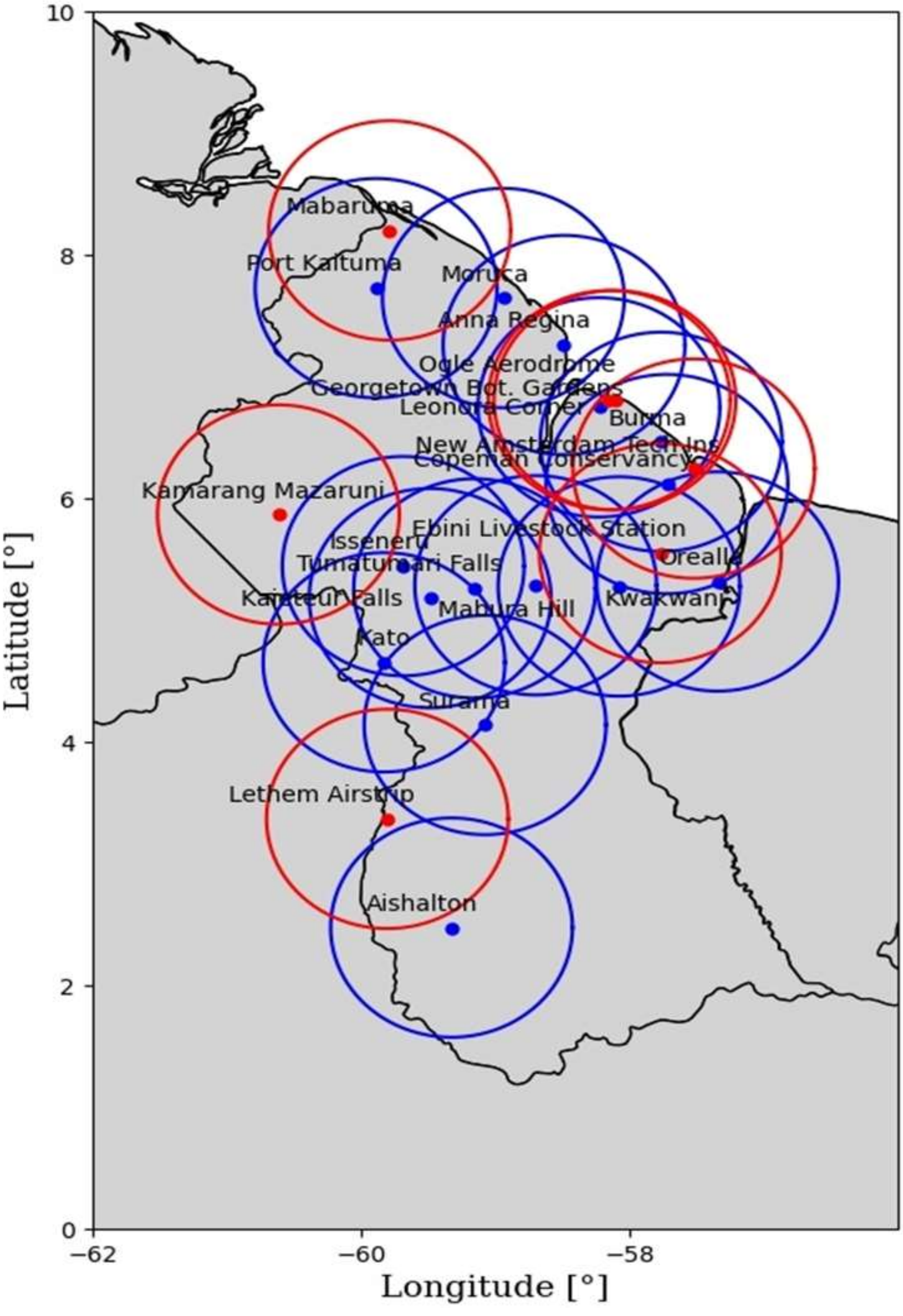

Figure 4: Proposed locations for high-resolution GBON Surface AWSs. Low-resolution stations are marked by red circles; additional stations to reach high-resolution GBON compliance are marked by blue circles).

Table 6. GBON National Contribution Target

Type of station	WMO GBON Global Gap Analysis, June 2023				GBON National Contribution Target	
	Target	Reporting	Gap		To improve	New
			To improve	New		
	[# of stations]				[# of stations]	
Surface	2	1	1	0	6*	0
Surface (high resolution)	n/a	n/a	n/a	n/a	6*	16
Upper-air	1	0	0	1	0	1
Marine	4	0	0	4	0	4

Table 7 and Figure 4 (circle radius of 100 km) show the additional sixteen (16) locations for more AWSs, which together with the previous six (6), will make Guyana fully high-resolution GBON compliant.

Table 7: Proposed locations for GBON low-resolution (light green) and GBON high-resolution (dark green) networks.

Low/High Resolution surface network – GBON target				
Station Num.	**Station Name**	Lat	Lon	Low/High Resolution
1.	**Kamarang**	5.867° N	-60.612° W	Low
2.	**Lethem**	3.367° N	-59.800° W	
3.	**Mabaruma**	8.200° N	-59.783° W	
4.	**New Amsterdam**	6.244° N	-57.517° W	

5.	**Elbini**	5.550° N	-57.767° W	
6.	**Timehri Airport**	6.5035° N	58.2526° W	
7.	**Georgetown (Botanical Gardens)**	6.806° N	-58.147° W	High
8.	**Port Kaituma**	7.726° N	-59.884° W	
9.	**Moruca**	7.645° N	-58.936° W	
10.	**Anna Regina**	7.259° N	-58.484° W	
11.	**Leonora Corner**	6.747° N	-58.224° W	
12.	**Burma**	6.464° N	-57.760° W	
13.	**Copeman Conservancy**	6.117° N	-57.717° W	
14.	**Orealla**	5.317° N	-57.340° W	
15.	**Isseneru**	5.443° N	-59.682° W	
16.	**Kaieteur**	5.180° N	-59.482° W	
17.	**Kato**	4.653° N	-59.825° W	
18.	**Tumatumari Falls**	5.260° N	-59.150° W	

19.	**Aishalton**	2.474° N	-59.322° W	
20.	**Kwakwani**	5.276° N	-58.074° W	
21.	**Mabura Hill**	5.286° N	-58.695° W	
22.	**Port Kaituma**	7.726° N	-59.884° W	

Annex 2. Detailed AWS Network Specifications used for tendering

Specifications for Automatic Weather Station Network

ver. 1.1

1. General

1.1 The Scope of the Specification

The functional and technical specifications described in this document give the requirements for the Automatic Weather Station (AWS) network project under this invitation to tenders.

This document is divided into sections where:

- Section 1 gives a general description of the station network to be supplied.
- Section 2 lists the minimum requirements for the supplier of the AWS systems.
- Section 3 details the minimum requirements for the electronics and data logger of the system.
- Section 4 describes the minimum requirements for the software.
- Section 5 lists the minimum performance requirements for the sensors to be supplied with the offered system.
- Section 6 sets the requirements for telemetry options.
- Section 7 sets the reliability and maintainability requirements.

1.2 General Description

The Automatic Weather Station (AWS) network consists of automatic observation stations, including electronics and data processing unit, sensors, telemetry and supporting structures further referred to as "stations", and a data collection system consisting of computer hardware and software and communication networks as later specified. The stations automatically measure, log and send the observation data to a central data collection system. The central data collection system collects the data, stores, processes and forwards it further to desired users and systems as later specified. The system must be designed to operate in all environmental conditions, all year round and 24 hours a day. The expected life time of the system must be more than ten years.

The required measurement parameters include:

- Wind direction
- Wind speed
- Air temperature
- Relative humidity

- Atmospheric pressure
- Precipitation

Optional sensor inputs for:

- Global solar radiation
- Soil temperature at multiple levels according to WMO requirements
- Snow depth
- Water level
- Present weather/visibility

- Cloud height

2. Requirements for an eligible bidder

2.1 General Information

2.1.1 This proposed project is a "Turnkey" project, where besides the supply of all components of Automatic Weather Stations (AWS), the integration, installation and training of all installed AWS systems are also considered. For such reasons, the selected Vendor shall provide in an integrated manner all components and constitute each AWS system and services described in this document, as no partial proposals will be accepted.

2.1.2 The Company shall have a long history and proven track record in design, manufacture and after sales support of hydrological and meteorological sensors and data collection systems. The company shall have sufficient and documented financial and technical resources to implement turnkey system deliveries. Together with its technical proposal, the company shall provide written detailed documents at least from five (5) delivery projects of similar size, where the Bidder’s equipment have been used as the standard equipment. In addition, the complete reference list of customers of the offered equipment shall be supplied.

2.1.3 The Company shall have the approved ISO 9001 Quality Assurance System certified by an accreted authority. The copy of this certificate must be attached to the technical proposal

2.1.4 As a manufacturer of products for environmental measurement, the Company shall have a process to minimize the environmental impacts of tits operation, the prevention of pollution and the reduction of waste. This process shall conform to the requirements of the EN ISO 14001 standard. The conformance certificate shall be included with the tender proposal.

2.1.5 As a part of their Quality Assurance System, the Company shall operate the laboratory facilities for sensor testing and calibration. These facilities and the primary standards used shall be traceable to the international standards. Both the quality assurance system and the internationally traceable standards shall be documented in writing in the technical proposal.

2.1.6 The Company shall have a spare parts policy and sufficient financial resources for quarantining the availability of the spare parts for minimum of 10 years after finishing the deliveries of the tendered equipment. In order to show this compliance, the financial statements of the last two (2) years must be included together with the price proposal.

2.1.7 The Company shall have sufficient technical and other resources for supporting the installed system locally. Description of these resources shall be included in the technical proposal or its appendixes.

2.1.8 The interested companies are required to submit detailed description of the proposed hardware and software implementation of the specification of this document.

3. Data Collection equipment

3.1 General requirements

This section presents the AWS system's minimum functional requirements including hardware functions and operating environment.

3.1.1 The design of the system shall make maximum use of the commercial-off-the-shelf equipment with proven operating record and long expected lifetime. A primary characteristic of the system will be high availability and accuracy of the reported data.

3.1.2 The investment of the AWS network extends over many years. The life time of such a network shall be more than 10 years.

3.1.3 The design shall be modular enabling the change of the modules and system components without any special tools. Easy-to-use DIN-rail mounting shall be used in mounting system components.

3.1.4 The following data processing capabilities shall be provided as minimum:

3.1.4.1 Measure the sensors with minimum of 24 bit A/D conversion (ADC).

3.1.4.2 Perform data quality check on the parameters as specified in the section 3.7.

3.1.4.3 Process the data using calculation and statistical functions specified in the section 3.7.

3.1.4.4 Offer to the user freedom to configure multiple output messages.

3.1.4.5 Provide alarm functions based on a measured or calculated parameter exceeding its user set threshold value(s).

3.1.4.6 Log the data at the user configurable formats and intervals.

3.1.4.7 The data logger shall have low power consumption due to solar power operation. The average current consumption of the data logger alone shall not exceed 10 mA from 12 VDC supply.

3.1.4.8 Provide maintenance terminal functions for maintenance technicians to access the internal diagnostics including sensors' data.

3.1.5 The equipment shall support various kinds of communication equipment, including modems, satellite, radio and cellular phone.

3.2 Environmental Specifications

3.2.1 In order to minimize the effects of the environmental and electrical conditions into the quality of the data and reliability of the equipment, the system shall be designed and manufactured to operate within the minimal range of the environmental conditions listed below:

- Operational temperature limits - 50° ... + 60°C
- Operational relative humidity limits 0 ... 100 % RH
- Tolerant to wind speeds up to 60 m/s
- Ingress protection class at least IP66

3.2.2 In order to withstand electrical disturbances and prevent interference with other electronic equipment, the equipment shall fulfill the EN55022 standard for emissions and IEC61000-4 standards for electrostatic discharge immunity, radiated, radio-frequency, electromagnetic field immunity, electrical fast transient/burst immunity, surge immunity and immunity to conducted disturbances, induced by radio-frequency fields.

EMI and ESD Compliance	**Standard**
Emissions:	CISPR 22 Class B (EN55022)
RF field immunity	IEC 61000-4-3
EFT immunity	IEC 61000-4-4
ESD immunity	IEC 61000-4-2
Surge (lightning pulse)	IEC61000-4-5
Conducted RF immunity	IEC 61000-4-6

3.2.3 The system must be compliant with all the applicable CE directives and standards.

3.2.4 The system shall be designed to operate in those conditions 24 hours a day, 365 days a year.

3.3 Device Interfaces

The system must have built-in the support of different sensor and device interfaces listed below.

3.3.1 Analog Interfaces

3.3.1.1 In order to be able to measure several parameters with analog sensors, the system shall have at least ten (10) analog inputs, which are individually and freely configurable by the user. The inputs must be differential type for increased accuracy and avoiding grounding caused errors.

3.3.1.2 The analog interfaces shall have the following features:

- at least 24 bit A/D conversion

- voltage measurement uncertainty less than 0.06 % of FS (Full Scale) over the full temperature range -50 ... +60 °C

- accuracy of resistance measurements (e.g. Pt-100) better than 0.05 % of FS over the full temperature range of -50 ... +60 °C

- measurement interval freely configurable from one (1) second to twenty-four (24) hours in one (1) second intervals independently and separately for each measurement channel

- each sensor input should have independently configurable gain, scaling factors, calibration coefficients and data quality validation parameters

- each sensor interface should have internal over voltage and ESD protection, minimum 5 kV per pin

3.3.1.3 The data logger shall include automatic calibration of A/D converter and the measuring electronics. This calibration shall be based on an onboard temperature measurement: self-calibration shall be initiated automatically whenever there is a change of more than 1 ° C of the onboard temperature or at every 30 minute interval.

3.3.1.4 The system shall have minimum two frequency inputs with minimum accuracy of 0.005 % of F.S. for sensors such as anemometer or tipping bucket type precipitation sensor.

3.3.2 Digital Interfaces

For enabling the use of sensors with digital interface and device control, an interface for digital I/O channels must be available. The interface shall have at least eight (8) digital input and output channels.

The digital interface shall have the following features:

- have LED indicators for activity; in order to reduce the current consumption, it shall be easily possible to disable the LED if seen necessary

- accept any positive DC voltage from 2V to 25 V

- tolerate negative voltages down to -25 VDC

- the inputs shall have switch debounce and hysteris circuits for reliable operation

3.3.3 Serial Interfaces

The data processing unit shall be able to communicate with smart sensors having a serial communication interface. These communication functions include retrieving data, retrieving self-diagnostic information (if available) and controlling the sensor operation. The serial sensor interfaces shall support the following standards

- RS-232
- RS-485
- SDI-12

The system must have a serial-pass-through-mode which allows direct communication via maintenance line with any smart sensor connected to the system via serial interface.

3.3.4 Network Interfaces

The system must be able to have a 10Base-T Ethernet interface with native TCP/IP support. System shall support connecting an IP-camera, acquiring images from camera either timed or event based, and transmitting acquired images over suitable communication media to a network server.

3.3.5 Maintenance Connection

The system must have a connection port to which a PC can be connected in order to perform system initialization, device software update, configurations, download stored data and monitor the unit operation. Once connected there shall be full access to all programming features. Maintenance connection shall also be remotely accessible as later described.

Operations made via the maintenance port must not interfere with the automatic operation of the data acquisition, registering or transmissions except when this is the user's intention.

In order to prevent moisture or dust to enter the electronics enclosure, the access to the maintenance port shall be available without having to open the enclosure using an external connector. A cable for the service connection shall be included in the delivery.

3.4 Equipment Enclosure

All parts of the electronic and data processing unit must be enclosed in a sealed robust enclosure with easy access to all components with mounting options at least to a mast or a wall. The enclosure shall have the following features:

3.4.1 The enclosure complies with the standards of NEMA-4X or IP-66 as minimum.

3.4.2 The sensor and device connections shall be installed at the bottom side of enclosure to reduce the risks of water or humidity penetration.

3.4.3 Sensor and device connections to the enclosure shall be through cable flange or cable glands. A cable cover shall be provided to protect the cable connections from splashes of water or deep snow cover.

3.4.4. To connect to telemetry antenna cables, the corrosion resistant N type connectors shall be used.

3.4.5 The enclosure shall be properly vented with a device, which will not allow humidity to enter in the enclosure.

3.4.6 The enclosure design and material shall be such that it reduces condensation caused by large daily temperature differences inside the enclosure. The use of regularly changeable desiccant material is not allowed.

3.4.7 The enclosure shall be made of corrosion resistant material with high resistance to UV radiation and chemicals.

3.4.8 All wiring inside the enclosure shall be bundled so that no loose wires or cables exist inside the enclosure.

3.4.9 Whenever a pressure sensor is used there shall be a provision to install a static pressure head for minimizing the error cause by the wind turbulence at the pressure outlet.

3.5 Powering

3.5.1 General

It must be possible to power the system from mains network or with solar panels. In both cases the system should include rechargeable, sealed and maintenance free backup batteries sufficient for keeping the station running at least for seven days without recharging. The backup batteries must have a charge regulator with protection against battery overcharge or deep discharge. The charger must have an indication of the battery condition and charging state.

3.5.2 Grounding and Transient Protection

The station must have a common and secure grounding point for static and safety grounding. The station must be protected against electrical disruptions and lightning induced surges on all input lines. Transient protection of the most vulnerable lines, such as power lines, long communication and sensor lines must be separate and modular so that the protection device can easily be changed.

3.6 Pole Mast

3.6.1 The pole mast shall be sufficient to securely mount the wind sensor(s) 10 meters ± 0.1 meter in height. The structural integrity shall also withstand the load of an optional flight warning light when necessary.

3.6.2 The mast material shall be anodized aluminum and stainless steel.

3.6.3 The mast shall have minimum one set of guy wires.

3.6.4 The mast shall include lightning protection (rod) and electrical grounding. The lightning shall be insulated from the mast and separately grounded.

3.6.5 The mast shall be fully and easily tiltable for sensor maintenance such that the sensor is not more than 1.5 meters above the ground for maintenance.

3.6.6 The mast shall withstand wind speed up to 50 meters/second, optionally up to 75 m/s with optional second guy wire set.

3.6.7 The mast delivery shall include all parts and material, except concrete, for easy installation.

3.7 System Functionalities

3.7.1 Data Acquisition

3.7.1.1 The AWS system must support various data acquisition modes including at least:

- Scheduled acquisition
- On-demand acquisition
- Alarm based acquisition

3.7.1.2 The data acquisition rate shall be individually configurable for each sensor. The rate shall be adjustable from 1 second to 24 hours in steps of 1 second.

3.7.1.3 Data messages shall be sent automatically by the system at the user set intervals. There shall be possibility to configure several data messages to serve different purposes and/or users.

3.7.1.4 It shall be possible to trig any measurement on-demand basis, i.e. whenever the user wants to have the latest data to be made available.

3.7.1.5 Regardless of when the data logger samples, the user shall be able to set a threshold(s) for any measured or calculated parameter to detect whether a threshold has been exceeded. Once a threshold has been crossed the AWS system shall automatically start using a new user set sampling interval until the value returns below the threshold level.

3.7.2 Data Transmission

3.7.2.1 The AWS system shall have capability to be equipped with several different telemetry modules such as UHF radio modems, cellular telemetry, PSTN modems and satellite transmitters.

3.7.2.2 To increase the reliability and redundancy, the AWS system shall have capacity to interface with minimum of two different telemetry devices at the same time.

3.7.3 Data Logging

3.7.3.1 The system must be able to log measured and calculated data into a non-volatile flash memory.

3.7.3.2 The logging interval for each variable must be freely configurable.

3.7.3.3 In case the memory should run out of free space, the system must automatically clear more free memory by deleting the oldest data first, so that the most recent data will always be saved.

3.7.3.4 Primary media for data logging must be an exchangeable external memory card to allow fast local data recovery. The capacity of the memory card must be at least two gigabytes (2 GB). Compact Flash type cards are preferred for being more robust in outdoor use.

3.7.3.5 The filesystem on the memory card must be readable with any PC and commercial card reader.

3.7.3.6 The system must also have internal logging capacity at least for seven days of hourly measurements if the memory card should fail.

3.7.4 Data Quality Control

3.7.4.1 The system must be able to check the measurement data quality to ensure accurate and complete data collection. It must be possible to automatically flag incorrect or missing data with a user-configurable symbol or text.

3.7.4.2 The system must be possible to automatically perform at least the following quality checks for every measurement:

a) For each measured parameter there shall be upper and lower climatological limits that corresponds to the normal operating limits of the sensor in order to prevent the reporting of possibly false values. These parameters must be user configurable to adjust them to the local climatological conditions.

b) For each parameter there shall be a ‘step change’ validation. If the sensor output value changes more that the set maximum value between two consecutive measurements, the value shall be set ‘invalid’ (e.g. erroneous). This parameter must be user configurable to adjust it to the local climatological conditions.

c) For each statistical calculation, there shall be the user configurable parameter for minimum number of the samples available for computing statistical values. If the number of samples is less that the user set value, the value shall be set ‘invalid’ (e.g. erroneous).

3.7.4.3 The system must be able to indicate the status of the connected sensors. This indication shall include both analog sensors as well as sensor with digital serial interface. For each sensors, there shall be value in the variable status, which can be included in the report(s) and/or monitored in order to produce an alarm e.g. for maintenance purposes.

3.7.5 Calculations

3.7.5.1 Statistical calculations

The station must be able to perform statistical calculations for any of the variables. The period over which the calculations are made must be adjustable from 1 second to 24 hours. At least the following operations must be supported:

- Average
- Minimum
- Maximum
- Standard deviation
- Cumulative sum
- Arithmetic operations

3.7.5.2 Other calculations

The system must have built-in operations for calculating various weather parameters following WMO recommendations, including at least:

- Dew Point Temperature
- Frost Point temperature
- Effective temperature sum
- QNH, QFE and QFF pressure
- Pressure tendency and pressure trend
- Wind calculation: it shall be possible to make the calculation in scalar and vector formats.
- Evapotranspiration
- Calculation of Sunshine Duration based on data from the global solar radiation sensor (pyranometer).

3.7.5.3 The AWS system shall include unit conversion module with multiple scale unit selection (e.g. m/s to knots or m/s to km/h). Unit selection shall be selectable/configurable by the user.

3.7.6 ALARM Function

In order to enable early warnings for severe weather or system malfunction, the station must support the alarm functions described here.

3.7.6.1 The system shall be possible for the user to freely set threshold limits for any of the measured or calculated parameters. It must be possible to configure an alarm to be launched whenever a parameter:

- exceeds a set upper limit (e.g. when the precipitation intensity exceeds 30mm/h),
- goes below a set lower limit (e.g. water level goes below 2.4 m),
- is between a set range (e.g. wind direction is between 90 and 180 degrees),
- is out of a user set reference range (e.g. 10 minute precipitation rate is 7 mm over the average hourly rate),
- changes faster than a user set rate, selectable both descending and/ or ascending value.

3.7.6.2 The possible actions to be taken automatically when an alarm is launched shall include:

- sending a message to the user configured destination
- storing the alarm event together with the measured value
- triggering the logging of user defined data group
- triggering an external signal e.g. a relay contact, light switch etc.

3.7.6.3 The user shall be able to configure the alarm action to be taken:

- only once on the first occasion an alarm is detected,
- always when the alarm condition stays effective
- when the alarm condition disappears, i.e. the parameter return to its normal value

3.7.7 System Clock

3.7.7.1 The station must have a Real Time Clock (RTC) protected against power losses.

3.7.7.2 The system must be able to operate in UTC or local time.

3.7.7.3 Daylight saving time must be enabled to be adjusted automatically.

3.7.7.4 For supporting real-time messaging and alarm generation, the internal real-time clock's accuracy must be better than twenty (20) seconds per month.

3.7.7.5 In addition, it must be possible to adjust RTC using at least the following methods:

- locally via terminal commands
- remote commands over a network
- automatically from a central data collections system or an NTP server
- using a GPS (Global Positioning System) signal if such a receiver is connected to the system

3.7.8 Power Saving Mode

3.7.8.1 When there is a power failure at a remote station, this shall enter into low power mode. When in low power mode, the AWS system shall switch off the communication module (PSTM modem, satellite transmitter etc) for most of the time, and will switch it on at user defined time(s) for narrow time window. Example: Communication module is switched off. It is switched on for 5 minutes at the beginning of the full hour.

3.7.8.2 After the user set period in low power mode, the AWS system shall be capable to switch off the communication device to save the battery. The AWS system shall continue to work as data logging station only.

3.7.8.3 Similarly, in low power mode the AWS system will start using a new time schedule for data transmission. After the power failure, the AWS system shall automatically revert to its original time schedule.

4. Software

4.1 Terminal software

The AWS system shall be delivered with an easy to use terminal software. The software shall be Windows 2000 and XP compatible.

It shall be menu-driven and automate everyday functions such as read, recovery, archive and display observation data, and monitor the AWS system through communication port, remotely via modem or TCP/IP connection.

4.2 PC based setup program

The system shall be shipped with a PC based setup software to allow an easy configuration and modification of all the system parameters and operation. This software shall be Windows 2000 and XP compatible.

The software must have a graphical user interface. The software must be able to configure at least the following features and functions:

- sensors to be connected into the system
- measurement intervals freely for each sensor
- sensor powering
- calculations
- data logging
- output and messages
- communications
- alarms

5. Sensors

5.1 General Requirements

All the sensors must be interchangeable. All sensors shall be independently operated by the electronics and data processing unit so that a possible failure of any of the sensors shall not affect the performance of the remaining sensors. The sensors must be tested to correctly operate in the system. All sensors must be able to operate in environmental conditions as specified in 3.2 and the required performance must be reached over the whole measurement and operational temperature range.

5.2 Air Temperature

Air temperature must be measured using an 1/3 Class B IEC 751 standard Pt-100 resistance temperature detector (RTD) or a better sensor. To minimize the effect of sensor line resistance, the Pt-100 element shall be measured using the 4-wire resistance measurement technique.

The air temperature sensor shall comply with the following specifications:

Feature	Specification

Sensing element	Platinum resistance element Pt-100
Accuracy	1/3 DIN 43760, better than 0.1 °C at + 20 °C
Resolution	0.1 °C
Operating temperature	-80...+60 C

5.3 Relative Humidity

Relative humidity shall be measured with a thin film type capacitance sensor. The sensor must be protected from pollution by an appropriate, exchangeable filter. The sensor shall be easy detachable to allow quick replacement in the field.

The relative humidity sensor shall comply with the following specifications:

Feature	Specification
Sensor type	Capacitive humidity sensing element
Measuring range	0..100 %
Accuracy	±2 % below 90 % of RH and ±3 % between 90..100 % of RH
Long term stability/year	±1 % or better
Operating temperature	-80...+60 C

5.4 Radiation Shield for Temperature and Humidity Sensors

(RG13)

5.4.1 Temperature and humidity sensors shall be installed inside a naturally vented radiation shield at 1.5-2 m above the ground, protecting measurement result from effect of direct solar radiation.

5.4.2 The radiation shield (stacked plate structure) shall be made of a UV stabilized fiber-glass filled polyester with outer surface painted white to reflect the sun radiation. The inner surface shall be painted black to absorb accumulated heat preventing reflections to the temperature sensor. Shields made of metal are not allowed.

5.5 Alternative Radiation Shield for Temperature and Humidity Sensors

(DTR503)

5.5.1 Temperature and humidity sensors shall be installed inside a naturally vented radiation shield at 1.5-2 m above the ground, protecting measurement result from effect of direct solar radiation.

5.5.3 The radiation shield (stacked plate structure) shall be made of a UV stabilized thermoplastic material with white outside finishing. Shields made of metal are not allowed. Underside of the shield plates shall be black colored to ensure that any heat is emitted off the radiation shield.

5.6 Atmospheric Pressure Sensor

(BARO-1)

Atmospheric pressure shall be measured by an intelligent digital silicon solid-state pressure sensor. The sensor shall have a minimum drift and long term stability over the whole operating temperature range. The sensor shall have in-built temperature compensation to guarantee the required accuracy over the whole operating temperature range.

The pressure sensor shall comply with the following specifications:

Feature	Specification
Type	Silicon capacitive pressure sensor
Measuring range	500...1100 hPa
Resolution	0.1 hPa
Accuracy	± 0.15 hPa over the whole temperature range

Operating temperature	-40...+60 C

5.7 Alternative Atmospheric Pressure Sensor

(PTB330AWS)

5.7.1 Atmospheric pressure shall be measured by an intelligent digital silicon solid-state pressure sensor. The sensor shall have a minimum drift and long term stability over the whole operating temperature range. The sensor shall have in-built temperature compensation to guarantee the required accuracy over the whole operating temperature range.

5.7.2 The pressure sensor shall have the option to incorporate one, two or three sensor element. When two or three sensor elements are used, the barometer continuously compares the readings of the pressure sensor elements against one another and provides information on whether these are within the set internal difference criteria. The redundancy in pressure measurement is desired in climatological stations.

5.7.3 The pressure sensor shall comply with the following specifications:

Feature	Specification
Type	Silicon capacitive pressure sensor
Measuring range	500...1100 hPa
Resolution	0.1 hPa
Accuracy	±0.15 hPa over the whole temperature range
Operating temperature	-40...+60 C

5.7 Ultrasonic Wind Sensor

The Ultrasonic Wind Sensor shall use ultrasound to determine horizontal speed and direction of the wind. To avoid the possible errors caused by orthogonal incidence angle, the sensor must use the three transducer principle. The sensor should be available in two models: Standard and Heated. The observation height shall be 10 meters.

The ultrasonic wind sensors shall comply with the following specifications:

Feature	Specification
Measuring range	Wind speed: 0...75 m/s Wind direction: 0...360 °
Starting Threshold	Virtually zero
Resolution	Wind speed:0.01 m/s Wind direction:1 °
Accuracy	Wind speed: ±0.2 m/s or 3% of reading, whichever is greater Wind direction: ±2°
Operating temperature	Standard: -55 ... +70 °C

5.8 Alternative Wind Sensor: Anemometer and Wind Vane

The sensors used for the measurement of wind speed and direction shall be separate sensors and shall be light-weight sensors. The wind observation height shall be 10 meters.

Anemometer

Wind speed shall be measured with an optoelectronic anemometer installed in the same cross-arm with a wind vane on the instrument mast. The anemometer shall be a fast response, low-threshold anemometer. The sensor shall provide excellent linearity over the entire operating range, up to 75 m/s so the cup wheel shall be consisting of three light-weight conical cups. The sensor shall be equipped with a thermostat controlled 10W heating element in the shaft tunnel to keep the bearings above the freezing level in cold climates.

The anemometer shall comply with the following specifications:

Feature	Specification
Measuring range	0.4...75m/s
Starting threshold	< 0.5 m/s
Accuracy	± 0.17 m/s (Within 0.4…60 m/s)
Operating temperature	-50...+55 °C (with shaft heating)

Wind Vane

Wind direction shall be measured with a counter-balanced, low-threshold optoelectronic wind vane installed in the same cross-arm with an anemometer on the instrument mast. The sensor shall output wind direction using 6-bit GRAY code. The wind direction shall be measured by infrared LEDs and phototransistors mounted on six orbits on each side of a rotating GRAY-coded disc. The sensor shall be equipped with a thermostat controlled 10W heating element in the shaft tunnel to keep the bearings above the freezing level.

The wind vane shall comply with the following specifications:

Feature	Specification
Measuring range	0...360 °
Starting threshold	0.4 m/s or better
Resolution	2.8°
Accuracy	Better than ± 3°
Operating temperature	-50...+55 °C (with shaft heating)

5.9 Precipitation

The precipitation shall be measured by a tipping bucket type of sensor. The rain gauge shall be fabricated of corrosion resistant and rugged material. The rain gauge shall be installed on a leveled metal platform whose height is such that the rim of the rain gauge is at 1.5 meters from the ground.

The sensor shall comply with the following specifications:

Feature	Specification
Type	Tipping bucket
Sensitivity	0.2 mm per tip
Accuracy	1 % (at 25 mm/h)
Area of aperture	400 cm2

5.10 Ground/Soil Temperature Probe

Soil temperature must be measured with a water-tight and corrosion resistant Pt-100 sensor. It shall be used to measure the temperature at different levels beneath the surface. The housing of the platinum resistance (Pt-100) sensing element shall be made of stainless steel, located in the tip part of the assembly. To minimize the effect of sensor line resistance, the Pt-100 element shall be measured using the 4-wire resistance measurement technique.

The sensor shall comply with the following specifications:

Feature	Specification
Sensing element	Platinum resistance element (Pt-100)
Accuracy	¼ DIN 43760 B; (±0.08 °C at 0 °C)
Sensitivity	0.385 ohm/°C

Measurement range	-50 °C...+60 °C
Ingress protection	IP68 (connector)

5.11 Solar Radiation Sensor

Solar radiation must be measured using an ISO-9060 certified First Class pyranometer. The sensor must have a double glass dome and a drying cartridge to avoid moisture and built-in level to ease the installation.

The sensor shall comply with the following specifications:

Feature	**Specification**
Spectral range	285...2800nm (50% points)
Sensitivity	5...20 µV/Wm^{-2}
Response time	18 s
Maximum solar irradiance	2000 W/m^2
Operating temperature	-40...+80 °C

5.12 Snow Depth Sensor

Snow depth must be measured using an ultrasonic sensor with internal temperature correction. The sensor must be manufactured of non-corrosive materials.

The sensor shall comply with the following specifications:

Feature	**Specification**
Measurement range	0…at least 10 m

Resolution	2.5 mm
Accuracy	± 0.25% of detected range
Operating temperature	-40 to 60°C

5.13 Visibility and Present Weather Sensor

5.13.1 The sensor shall combine the both functions of a forward scatter visibility meter and a present weather sensor in the same device.

5.13.2 The sensor must be measured using downward-looking forward scatter principle.

5.13.3 The sensor must be able to differentiate between different types of precipitation (both liquid and solid precipitation) and indicate the reason for reduced visibility.

5.13.4 The must be possible to measure also precipitation intensity and accumulation with the sensor.

5.13.5 There shall be an extensive self-diagnostic procedures continuously monitor the sensor status. Dirt and foreign particles on the lens shall be detected automatically in order to minimize the risk of false high values.

5.13.6 Reports must be available in WMO 4680 and 4678 code table formats for automatic messaging.

5.13.7 The sensor device shall have traceable calibration with reference to highly accurate transmissiometers.

5.13.8 A special calibration kit shall be provided as an option for carrying field calibration under all weather conditions.

5.13.9 The sensor must have heating for icy conditions.

5.13.10 The sensor shall comply with the following specifications:

Feature	**Specification**
Measurement range	10 ... 35000 m
Accuracy	±10 %, range 10 m ... 10000 m

	±20 %, range 10 km … 35 km
Precipitation detection sensitivity	0.05 mm/h or less, within 10 minutes
Weather type identification	7 different types of precipitation (rain, freezing rain, drizzle, freezing drizzle, mixed rain/snow, snow, ice pellets) Fog, mist, haze (smoke, sand) or clear
Weather type reporting	WMO code table 4680
Operating temperature range	-40 ... +60 °C
Operating humidity range	0 … 100 % RH
Protection class	IP66

5.14 Cloud Height

5.14.1 Cloud height sensor must be an eye safe laser ceilometer using single lens technology.

5.14.2 The sensor must be possible to tilt the sensor for better protection of the optics and enhanced performance during a precipitation event. Tilting angle must be automatically measured and corrected.

5.14.3 The sensor must have a heated window cleaning system and self-diagnostics.

5.14.4 The sensor must report cloud hits, backscatter profile and status information. An algorithm to automatically report cloud coverage must be available.

5.1.5 The sensor shall comply with the following specifications:

Feature	**Specification**
Measuring range	0...7.5 km

Resolution	5 m
Accuracy (against hard target)	Greater of ±1 % or ±5 m
Laser	Pulsed diode, InGaAs Diode Laser
Wavelength	910 ± 10 nm
Eye safety	Class 1M IEC/EN60825-1
Measurement cycle	Programmable 2 seconds or faster
Operating temperature	-40...+60 °C
Protection class	IP65

5.15 Water Level Sensor: Submersible Pressure Transmitter

With the hydrological stations water level is measured by absolute pressure based sensor. Reference atmospheric pressure for determining the water level will be obtained from the station. Pressure sensor shall comply with following specifications:

Feature	**Specification**
Measurement Ranges	0 - 1/3/10/30 bars (= 0 - 10/30/100/300 meters)
Resolution	0,002 %FS
Accuracy	Digital: 0.1%FS (= 0.010 m) Analog: 0.15%FS (= 0.015 m)
Operating temperature	-20...+80 °C
Protection class	IP68, ice proof

6. Telemetry systems

6.1 General Requirements

The AWS shall be capable to interface with a wide range of modern telemetry systems. As a preferred choice for communications, the system shall support bi-directional TCP/IPv4 based connections with cly available media, including at least:

- Ethernet (10Base-T). Allowing connection via

- LAN

- ADSL/DSL

- Satellite broadband

- Wireless LAN

- Cellular networks
- Point-to-point connection over full duplex serial link

The system shall also support the use of conventional media including

- Point-to-point serial links
- Serial links in bus mode (RS-485, SDI-12)
- PSTN and Cellular (CSD, SMS) modems
- Radiomodems
- Satellite transmitters

6.2 TCP/IP Based File Transfer and Communication

To enable interfacing with different network infrastructure the system shall support at least the following protocols:

- Point to Point Protocol PPP with authentication (PAP/CHAP)
- Address Resolution Protocol ARP
- Internet Control Message Protocol, ICMP
- Dynamic Host Configuration Protocol, DHCP
- Domain Name Services, DNS
- Internet Protocol, IP
- Transmission Control Protocol, TCP
- User Datagram Protocol, UDP

For utilizing commonly available network services, the following application level protocols shall be supported.

- Hypertext Transfer Protocol, HTTP
- File Transfer Protocol, FTP
- Simple Mail Transfer Protocol, SMTP
- Network Time Protocol, NTP
- Virtual Communication Ports, i.e. serial links using TCP sockets
- Dynamic Domain Name Service, DDNS

6.3 Error Recovery and Connection Redundancy

The system shall have functionality for detecting and automatically recovering from any non permanent connection malfunction. During temporary communication failures, the system shall buffer outgoing messages up to user defined limit so that when communications are restored, the buffered messages are transmitted to the destination system. The system shall allow configuring backup servers and/or media, which are taken into use when user configurable number of sequential communication failures has occurred.

7. Reliability and Maintainability requirements

7.1 Reliability

7.1.1 The system shall have a demonstrated operational data availability of over 95 % for correct, complete and error-free reporting of data. This requirement is exclusive of any third party equipment supplied by the Purchaser.

7.1.2 The systems shall be designed and fabricated so that the Mean Time Between Failures (MTBF) shall not be less than 20,000 hours for the entire system. The MTBF value (reliability prediction) shall be calculated using the MIL-HNDB-217F standard and shall assume 'ground fixed' glass of operation. The documented calculation of the MTBF shall be included as a part of the technical proposal.

7.2 Maintainability

7.2.1 The Mean Time To Repair (MTTR) of a system failure shall not exceed 1 hour. It is preferable that the MTTR is less than 30 minutes. MTTR shall include failure detection time, remove and replace the faulty FRU and perform a checkout and any necessary calibration, once the parts, tools and manuals are available. The repairs shall be accomplished by a single person.

7.2.2 In order to accomplish the ease of maintenance at the field:

- the system shall have the equipment enclosure with hinged door
- all sensor, power and communication cables shall have ready made, waterproof connectors.
- connectors and fasteners shall be readily accessible to allow for easy field replaceable unit (FRU) removal.
- all Field Replaceable Units (FRU) shall be easily accessible and exchangeable without any special tools. Mounting on the DIN- rails is preferred over parts and printed board held in place by screws.
- all connectors, fasteners and screws shall be readily available without need to remove other parts/units to gain an access to these.
- the technician shall not have to perform preventive maintenance more than once annually.

7.3 Remote Maintenance

7.3.1 In addition to the local maintenance port, the AWS system shall have capability to access the terminal and diagnostics mode remotely via a modem line or wirelessly using GSM network.

7.3.2 The system shall be capable to produce, at the user set interval, a maintenance message containing as minimum the following information:

- internal temperature

- door status: if the equipment enclosure is open
- battery voltage
- voltage of the solar panel, when solar panel is used.
- status of the mains power supply voltage (ON/OFF), when the mains power is used

7.4 Calibration and Preventive Maintenance

7.4.1 The system shall be designed to eliminate or minimize the need for equipment adjustment, alignments, calibrations and preventive maintenance.

Annex 3. Detailed Marine AWS Network Specifications used for tendering

No.	Items	Specification
1	2.4m Integrated Observation Buoy	- Marine Lantern, - mooring system, - buoy body, ϕ2.4m - watertight cable and connector.
2	Power Management System	Include: solar panel, battery group, charging controller, discharge controller, multifunctional power management module.
3	Data logger and sensor power management system	Contains 15 digital sensor synchronous acquisition cards and supports 3 analog sensor synchronous acquisition cards, including data acquisition, storage and sensor power management
4	Data compression software module	Online data is compressed once a day, and the compression rate is not greater than 75% of the data transmitted in hexadecimal or ASCII code. The optimal compression rate is not greater than 35% of the data transmitted in hexadecimal or ASCII code.
5	Communication System	Iridium communication system (Includes 1 year service charge)
6	Sensor	Weather station, GMX600
7	Sensor	Temperature Sensor
8	Sensor	Wave sensor

9	GPS	GPS location system
10	AIS	AIS
11	Detection and early warning system	Including water inlet alarm system and opening alarm system
12	Shore station processing system	Shore station processing system
13	Labor cost	Two (2) Engineer to guide deployment, including air ticket, accommodation and meals cost for 15 days
14	ADCP	RIV 300K
15	Communication cost	Iridium service cost for ADCP, hourly data transit back frequency, 4m/cell, 100m water depth, 25 cells to measure.
16	Integration Cost	Integrate ADCP to the buoy

Annex 4. A list of observation instruments and systems, required for an upper-air station

No.	Items	Single/continous
1	Preperation of the GHS‘ designed space to house the upper-air consumables, cleaning materials, the required ICT infrastructure and a workstation for the observer to be able to follow the ballons	Single Purchase/activity
2	A local display for the radiosonde profile and access to sensors for ground check data (T/RH/WS/WD/pressure)	
3	H_2 Hydrogen generator and storage	
4	H_2 Hydrogen storage tank, piping, valvs	
5	Ground Monitoring System hard-/software - Upper-air Ground System - UPS and Desktop PC	
6	Ground System lease Contract for 2-years	
6	Balloons+parachoutes	800 per year (including a redundancy)
7	Radiosones	800 per year (including a redundancy)
8	Helium gas cylinder (backup)	1 per year

9	Personal Protective Equipment (PPE) suitable for dealing with explosive environments	As required

Report completion signatures

Peer Advisor signature Andreas Schaffhauser
Beneficiary Country signature
WMO Technical Authority signature