TECHNOLOGY TRANSFER, CAPACITY BUILDING, TRAINING AND DEVELOPMENT OF RICs.

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ABSTRACT

Recent CIMO training initiatives and capability surveys have highlighted a number of inconsistencies in traceability within the NMHS. A plan for future development of capability must be developed to enable the developed NMHS to decrease the measurement uncertainty of the less developed nations.

CIMO sponsored workshops in RA-I and VI have provided metrology training for NMHS staff and information on the status and abilities of the various NMHS in terms of instrument calibration and traceability.

Interaction between the Australian RIC and RA-V will be used as a model to generate discussion. In this model the Bureau assumes responsibility for the traceability of all NMHS within the Region that do not pursue traceability through their National Measurement Institutes. This involves the circulation within the Region of a kit of transfer standard instruments to the less developed NMHS, and laboratory inter-comparisons for the developed NMHS.

TEXT

Background

Recent workshops and surveys sponsored by CIMO have alerted the RICs in the developed laboratories to the shortcomings in the traceability of many NMHS. It is clear that many of the RICs do not have state of the art instrumentation and can offer little support to the NMHS within their regional associations. It is also clear from the surveys that most of the working reference instrumentation in use in the less developed countries is mercury based and unsuitable for transportation to an advanced RIC for calibration.

Current State of Traceability

There was a significant issue with respect to the calibration of reference instruments within most of the NMHS surveyed. For example, several of the RA-I members reported that their working reference instrumentation had not been calibrated or checked since the 1960s. Many of the NMHS in RA-I, V and VI linked their traceability to the manufacturers of instruments rather than their National Measurement Institute or an RIC.

It is clear that very few inter-comparisons are being performed between the RICs and very few calibrations are done by RICs for NMHS within their region. There are several reasons for this. Firstly, the majority NMHS have mercury based reference instruments, such as barometers and thermometers that can not be shipped to an RIC. For this reason inter-comparison using transfer standards is the only viable strategy for verifying the NHMS instruments, however inter-comparisons are time consuming. Typically, an inter-comparison for pressure will take approximately 6 to 8 weeks from start to finish – due mostly to shipping and customs clearance times. Given this time frame an RIC would be able to complete a cycle of inter-comparisons with the whole region once every 5 years. Alternatively, many transfer standards would have to be purchased to enable the inter-comparison cycle to be completed within 1 year

Currently the greatest impediment to RICs supporting their regions is the lack of suitable transfer standards – especially in humidity. There is a critical need for an expert team to identify transfer

standard instruments that are suitable for interchange between the RICs and the NMHS within the region.

Current State of the Instrument Laboratories within NMHSs

There was a significant gap between what the participants believed the role of the RIC was, and what CIMO/WMO intended their role should be. The view of the majority of participants from NMHSs was that the WMO should fund a central metrology laboratory that would provide traceable calibrations for the regional associations free of charge. The WMO view that laboratories should volunteer to be RICs and that their host meteorological service should provide staff and infrastructure for regional support was not widely understood.

During CIMO sponsored metrology workshops at Cairo, Bratislava and Ljubljana each national meteorological service (NMS) represented was asked to make a presentation and outline their current capabilities and needs. It was apparent from these presentations and conversations that few of the NMHS that attended the workshops possessed facilities necessary to carry out traceable calibrations of meteorological instrumentation to the level recommended by the CIMO Guide.

There was a degree of co-operation shown between some of the RA-I nations with Botswana taking a leadership role in Southern Africa. The laboratories in RA-V and VI are substantially better, with some laboratories possessing primary standards for temperature and pressure and several inter-comparisons have been performed.

Capacity building

Most of the NMHS surveyed claimed that instrumentation and traceability were given a low priority by their organizations. This has led to a lack of staff and resources for instrument calibrations and their traceability. There was a clear divide between the less developed laboratories which have people and time, and the more developed laboratories which have state-of-the-art instruments, but few staff. Developed RICs have expended considerable resources on automating calibration processes using electronic instruments and standards. Lower staffing levels imply that the manual calibration of instruments is avoided in developed RICs. However, manual inter-comparisons have a place in the less developed services. For example, a 2 week manual inter-comparison between a transfer standard instrument and a thermo-hydrograph would be unthinkable in the Bureau, but for a RA-I RIC it may make sense.

Another method for capacity building in the less developed RICs would involve the donation of obsolete or retired instruments from developed RICs to less developed RICs. However, this may not be a panacea. The devices are by definition old and may require continuing maintenance; the RIC or NMHS may not have the funds or trained staff to maintain or operate the instruments; and parts or consumables may no longer be available. Again, the problem is the ongoing funding of the metrology laboratory not the one of cost of purchase of reference instruments. For example, if a funding organization provided instruments and systems, most NMHS would be ill-equipped to service and maintain them. The cost of maintaining the current generation of electronic calibration equipment is beyond the reach of many nations.

The model that RICs would become the source of excellence for one measured parameter and that the combined expertise of the RA-I RICs would be employed to provide calibrations in P, T, U and wind speed may not be workable. Firstly, in order to produce a calibration in one parameter to a low level of uncertainty the others must be measured to high accuracy, which would require the RIC to hold standards for other parameters which was what the strategy sought to avoid. Secondly, the system proposed would require a high level of co-operation between disparate RICs and involve significant freight and customs costs.

Technology transfer

The developed laboratories of RA V and VI have largely replaced manual and mechanical instruments with electronic devices and this severely limits the amount and type of support they can offer less developed services. The developed RICs are cash-rich, but staff-poor, and have systematically replaced their manual and mechanical systems in order to save on human resources. This has led to a situation where developed laboratories have difficulty calibrating manual instruments. This is exacerbated by the procurement of ad hoc instrumentation by NMHS through foreign aid programs which limits the ability of the developed laboratories to train and support these systems.

These two processes above have also led to a situation where developed laboratories are not able to provide training, maintenance or advice on the older meteorological instruments since these instruments have not been used for some time. The obsolete instruments are generally not available in the developed laboratories.

Training and development

As stated in the previous sections the disparity in capabilities between the developed laboratories and most of the NMHS limits the types and levels of training available. For example the Australian Bureau of Meteorology often takes RA-V members for training on radar maintenance – however most RA-V members do not have radars. The Bureau does not offer training in maintaining barographs and precision aneroid barometers since these devices are not longer supported by the Bureau – however most of the RA-V members use these devices and have requested training in their maintenance.

It is also clear from the CIMO training workshops that the metrology training offered by the developed labs is not well aligned with the needs of the developing laboratories. The training in future may need to be more prescriptive – rather than descriptive. That is; the training should be more 'this is how you will calibrate barometers' rather than 'barometers work on these principles'. A descriptive approach to training may lead to less developed RICs falling behind as they search for a way to apply the knowledge transferred to their particular instruments.

Having said that, the training of the CIMO metrology workshops have provided a method for rapidly disseminating metrology knowledge to the members of the regional associations. The preparation of course materials has led to the creation of a set of unique resources that can be used in the future. Future courses will further refine this material.

Suggestions by Workshop and Survey Respondents

1. WMO should scrutinize workshop applications with more rigor as some workshop attendees were not involved in the calibration or maintenance of instruments.
2. The workshop training should be more practical in nature with more demonstrations and ‘hands-on’ experience.
3. The WMO should support a central calibration laboratory within each Regional Association which would calibrate working standards for the regional members at no charge.
4. More training in calibration techniques should be given to member countries.

Discussions and Suggestions by Workshop Staff

1. It was noted that there was a wide range of capabilities within the RA-I, V and VI with little co-operation between laboratories.
2. Most of the reference barometers used are mercury based and therefore transportation to a central facility was not possible. It is therefore necessary to establish calibration using inter-comparisons with traveling standards.
3. There is a critical need to estimate the uncertainties of measured parameters in the NMHS to enable rational decision making and planning by the WMO in the future.
4. It is clear that the many NMHS are not capable of calibrating or maintaining modern

meteorological measurement systems and therefore thought should be given to second tier systems in line with paragraph 3 above.

5. Traveling metrology standards should be purchased or developed for circulation between the less developed NMHS. Calibration of the standards must be routinely performed by one of the more advanced RICs.
6. An efficient and rapid system of traveling standard instrument transportation between member laboratories needs to be developed.

One approach - ARIC Interaction with RA-V

The ARIC has adopted a two tiered approach to supporting the NMHS within RA-V. For the more developed laboratories inter-comparisons are made using transfer standard instruments (for example Malaysia, Philippines). This is a time consuming process taking approximately 8 weeks per inter-comparison, but it maintains a low overall uncertainty. For less developed laboratories, or NMHS that do not have an instrument laboratory the ARIC has developed a calibration kit. The kit is comprised of stable and transportable instruments that are 'stand alone'. The minimum set of parameters, Pressure, temperature and humidity do not require external power or computers. The inter-comparison method is manual or if facilities exist automated. The instruments are capable of serial data output if the laboratory has the expertise and facilities to utilize serial output streams.

Figure 1. Contents of the RA-V calibration kit.

The contents of the kit are shown in Figure 1 and listed in Table 1. The kit comprises a precision electronic barometer, working reference temperature indicator and Pt100 temperature probes , a rain gauge calibrator and a humidity probe. The kit, including instructions for use, is then shipped to the RA-V member and used to verify the working references at the NMHS. The kit is calibrated at the ARIC before being shipped to the NMHS for inter-comparison, upon completion the kit is return to the ARIC and recalibrated. Any drift or offsets are then communicated to the NMHS. The instruments used and their associated uncertainties are given in Table 1.

Table 1. Uncertainties Associated with the RA-V Calibration Kit

Parameter	Device	Interfaces	Approximate U95
Pressure	Paros Scientific Digi Quartz 765	RS-232, USB	0.08 hPa
Temperature (in liquid bath)	Instrulab 3312 + 2 Pt100s	RS-232	0.05 ^{o}C
Temperature (in air)	Dostmann P650 Pt100	RS-232	0.15 ^{0}C
Humidity	Dostman P650	RS-232	3.0 % RH
Rainfall	Hydrological Services Field Calibration Device (20mm into 203 mm gauge)	Nil	0.1 mm

The greatest difficulty is the transportation of the devices and clearance through the relevant customs agencies in a timely manner. Various companies and strategies have been attempted but the turn around time is about 6 to 8 weeks per NMHS making it impossible to cover all the RA-V members in a two year period. The cost of each cycle is approximately €1000 in transport and customs charges. The ARIC is currently building up a second kit to increase the number of services that are addressed each year.

Metrology Training in RA-V

The ARIC will host a metrology training workshop in late 2007. The workshop will divide the training into two streams with some common subjects. One stream will be for laboratory staff from NMHS possessing calibrations laboratories, while the second stream will involve technical staff from NMHS not possessing a metrology or instrumentation laboratory.

Stream 1 participants will be trained in inter-comparison techniques and the calibration of reference instruments. Stream 2 participants will be trained in the use of traveling standards and the calibration of field instruments.