IVS Technology Coordinator Report

Gino Tuccari

Abstract Here the principal activities involving the Technical Coordinator are reported. The main points are related to the signal chain, because in the field there are different methods and approaches to produce the adopted VGOS data, and a harmonization is to be taken into proper account. This is useful for guaranteeing a good degree of compatibility. Advanced automatic or remote controlled observation and correlation could involve a large amount of effort in the future. It will be useful to harmonize the procedures to insert new equipment or existing instrumentation belonging to the signal chain when a new feature is introduced. This role could be covered by the VTC Working Group.

1 Introduction

This report focuses on three items:

1. Signal Chain: current status and evolution.
2. VGOS Tables.
3. Communication with EVN.

The main activity during the 2017–2018 period also included giving advice and assistance to stations, as was reported to the IVS Directing Board.

INAF - Instituto di Radioastronomia, Bologna, Italy
Max Planck Institut für Radioastronomie, Bonn, Germany

IVS Technology Coordinator

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2 Signal Chain: Current Status and Evolution

In the IVS network there is a variety of different solutions consolidated or under investigation. In previous years, on other occasions, definitions for a VGOS signal chain have been discussed in some detail, and this is reported in different previous IVS reports. Under these indications, developments were proposed and experimentally evaluated by the different Development Centers. As a result, there are a number of different solutions which need to be harmonized, along with considering new possibilities and technology solutions which in the meantime have appeared.

There are some elements which can be mentioned as basic points and to summarize:

- The actual frequency broad band, which is determined mainly by the local RFI. The 'official' 2.2–14 GHz VGOS band could actually present some restrictions or limitations to be actually covered as a site dependent element. For a VGOS network, any limitation at a site involves the entire network. In this respect more stations are experiencing increasing problems with the RFI present below 3 GHz. This is due mainly to the fact that no technology is used to limit such a harmful condition. A useful experience could come from the BRAND EVN project, which is covering a wider portion of the frequency spectrum.
- The number of antennas per station and the type of antenna in terms of the speed of the mechanical structure. A number of sites are planning or have available more than one VGOS antenna, which offers a great level of flexibility. Antenna types and

speeds are different, going from the slow legacy ones to the fastest fully VGOS compliant.
- The feed type having linear polarization output, even if the direct generated circular polarization at the feed stage is under investigation. A number of solutions are under study to consider the circular polarization reconstructed at the digital level at the station or at the correlator. The BRAND EVN project is again offering two types of solutions which could find an application for VGOS.
- LNA projects and commercial products. These are available from different sources with good performance. These components need to be further considered.
- Digital process. Mainly two backend systems are in the field, RDBE and DBBC in their different generations. Presently, backend systems developed by the IVS groups can be mainly distinguished as two types:

  1. The broadband input 2.2–14 GHz is flexibly tuned in pieces of 1 GHz afterwards sampled; then a number of 32 MHz channels with a 2-bit resampling are extracted for a maximum data rate of 16 Gbps, but the current common sustained data rate is 8 Gbps. Data representation can be either real or complex.
  2. The input band is fully sampled in pieces of prefiltered 4 GHz chunks, then sampled and available in digital format, from which narrow band channels (ex. 64, 32 MHz) are extracted. A full data rate of 128 Gbps for the entire eight bands of 4 GHz is also possible.

- Recording. For recording we can again distinguish different types:

  1. MK6, which allows a maximum of 16 Gbps per unit, making use of removable disk-packs which can be physically transferred from a station to a correlator and vice-versa.
  2. Flexbuffer-like types, developed or under development, which can permit an even larger sustained recording data rate (up to 32 Gbps), with a fixed pool of disks internally connected. Data transfer to the correlators is then performed asynchronously to the observations.

  Both types of recorders permit the real time transfer of observed data when the network connection between stations and correlator permits.
- Correlation process. The correlation process is currently software-based and performed with different software versions. The standard approach is to move the entire set of data from all the stations involved in an experiment to the correlator appointed for processing it.

Presently, we can envisage directions from which an evolution could come, bringing benefit to the VGOS network. Here are the main ones I would like to report:

- Direct full VGOS band sampling
  This method performed in multi-bit representation could be a quantum leap in the signal chain. A very advanced implementation comes from the BRAND EVN project where a 16 GHz full band direct 8-bit sampling has been implemented. This mode opens the possibility of having a simplified approach to broadband VGOS experimental observations, which could greatly simplify the signal chain with all the benefits broadband (1 GHz, 2 GHz, etc.) channels could offer.
- System interoperability
  As reported earlier, different systems developed and available in different stations are a reality in the VGOS scenario. Compatibility between those systems is an element involving not only each system in its individual structure, but also the capability of the entire system to accommodate different solutions offered to the community. In this respect, a normalization process has to deal with such capability under the supervision of the VTC Working Group. Such a group is going to be enlarged, including all the parts willing to actively cooperate for VGOS progress, in a fully shared and coordinated fashion.
- Broadband coverage / RFI status
  As mentioned earlier, the actual use of the entire band is problematic due to the presence of RFI, varying at different sites. On the other hand, for compatibility with the legacy S/X stations, observing the lower part of the band would be important. An effort is then to be dedicated to RFI handling and mitigation, as opposed to the trend to simply cut this portion of the band and move the lower observation edge of the band to higher frequencies. An important contribution could come from ad-hoc

HTS (High Temperature Superconducting) filters placed in front of the LNAs in order to limit the worst case unwanted signals able to saturate such an amplification stage.

- 24-hr/day continuous observation sessions must require a reduced contribution from the operators, so the efforts to introduce automatic and remote controlled observation sessions cover a fundamental aspect.
- The data rate as was planned since the initial phases of the VGOS project has to be increased to move the network at the planned goals. A first limitation looks to be the recording capability, with different others following immediately after, such as data storage capability, transfer data speed, and correlation capability.
- A distributed correlation is considered an important task to be explored, in perspective, to have an always-increasing amount of data to be correlated. Two test runs were organized involving a number of small correlators. Recently a new test run was performed, inviting all the correlators interested to join the experiment under the coordination of Laura La Porta. Useful evaluation and encouraging results available at the time of the General Meeting were reported. Additional small and standard correlators are expected to join additional test runs.

3 VGOS Tables

The VGOS tables indicating the detailed information about any relevant equipment in the existing and under construction VGOS stations are relevant for promoting compatibility in the IVS network and are guides for newcomer stations. The amount of information is relevant, and the form in the initial phase used, an Excel spreadsheet, was proved to be inadequate for a fast consultation and, in particular, for an easy and useful comparison. Dedicated Technology Coordinator Web pages have been suggested to place and maintain such data with the information provided by the single station personnel, using a write access and password protection.

An important functionality for such a database consultation would be the possibility of implementing an advanced search capability in order to be able to select a number of parameters and stations to view; then it will be easy to be able to perform comparisons in those elements of interest under the search. Such a functionality is pretty complex in principle to be performed under a Web site belonging to a research institution, for different reasons, e.g. where they have the most rigorous Web site security. Therefore, a dedicated server was envisaged to be appropriate, with links indicated in relevant Web pages where this information can be easily found.

Different solutions were evaluated, and a professional Web server was finally selected to support such a functionality. Then in order to accommodate such information, the Web sites ‘www.ivs-coordinator.info’ and ‘www.ivs-coordinator.cloud’ were registered, and some databases began to be uploaded.

4 Communication with EVN

It was formally stated to maintain regular communication and contacts on technical issues between the IVS and EVN networks as defined in the agreed document which reports: “The EVN and IVS explicitly wishes to engender and stimulate convergent technological developments and innovative projects, and to aim for compatible or shared operational procedures between them. Structural contacts at a technical level will be maintained by the chair of the EVN Technical Operations Group (TOG) and the IVS Technology Coordinator.” In this respect the IVS Technology Coordinator and the EVN TOG chair have begun periodic contact with the aim of sharing the relevant information of common interest for the best coordination of the technical efforts within the two VLBI networks.