

Restructuring the Intensive Observing Program

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Abstract The main purpose of the IVS Intensive observing program is to provide UT1–UTC measurements on a regular basis with very short latency. A very short turnaround time of 24 hours or less as well as (sub-)daily data points are needed to allow for a reliable forward prediction of this parameter. The observation of daily data points began with the introduction of the IVS observing program in 2002. Given that the Intensive sessions are mostly single baselines observing for one hour, a problem at one of the stations may result in the failure of the entire session. That is, an Intensive is not robust against station failures. Over the years, additional Intensive baselines were introduced to also increase the robustness of the program. However, as the Intensive stations stem from a limited set of stations only, the increased robustness is limited in nature. Further, the majority of the Intensive series were scheduled at convenient local times for the stations. This mostly ignored the needs of our sister services in their use of UT1–UTC. To address these issues, steps are underway to rework and extend the Intensive program.

Keywords Intensives, VGOS, legacy S/X

1 Introduction

One of the most important and unique products of the IVS is the determination of UT1–UTC. To monitor the rapidly changing UT1–UTC value, the IVS introduced the Intensive observing series IVS-INT-1 and IVS-INT-2 in 2002, when the IVS observing pro-

gram began [1]. These single-baseline, one-hour sessions were a continuation and extension of similar sessions that were organized under the auspices of NEOS and other groups before the IVS was established. Over time, several additional Intensive series were added to the observing program so that a daily measurement of UT1–UTC was accomplished. Prior to 2019, all of these Intensive series used legacy S/X stations.

With the advent of the VLBI Global Observing System (VGOS), baselines between VGOS stations were also added to the program. While initially VGOS Intensives were scheduled to coincide with legacy S/X Intensives to better evaluate their quality and performance, the moment has arrived where different times of the day could be sampled.

A limitation of the current Intensive observing program is the small number of stations involved, resulting in a lack of robustness against failures of individual stations. Efforts are currently underway to extend the pool of Intensive stations and baselines and to spread the sessions more evenly over the days. A particular point is to align the midpoints of the Intensives to the epochs of the IGS Rapids at 00 UT, 06 UT, 12 UT, and 18 UT. We give an overview of the current Intensive observing program as well as which changes are being implemented and under discussion.

2 Currently Observed Intensive Series

As of early 2024, there were five Intensive series using legacy S/X stations (Table 1) and six Intensive series using VGOS stations (Table 2). A subset from each group is used operationally by the IERS RS/PC (Rapid Service / Prediction Center). The RS/PC is able to vet

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a series for inclusion in its operational products once a sufficient history of observations (a minimum of 60 sessions spread over at least four months) have been collected. From the legacy S/X group, two Intensive series contribute to the RS/PC, while for the VGOS group it is one Intensive series. A second (and third) VGOS series are being vetted for inclusion.

Table 1 Legacy S/X series of the IVS Intensive program as of late 2023 to early 2024 (bold font indicates availability of a sufficient history; red indicates operational use of S/X series by the IERS RS/PC). That is, the series IVS-INT-1 and IVS-INT-2 are operationally used by the RS/PC. The IVS-INT-3, the midnight Intensive IVS-INT-00, and the southern hemisphere IVS-INT-S series have a sufficient history for operational inclusion by the RS/PC, but they are not used for that purpose yet.

Type	Stations	When	Correl.	Ex.
IVS-INT-1	Kk-Wz	Mo–Fr @ 17:30	WASH	i23003
IVS-INT-2	Mk-Wz	Sa–Su @ 07:30	GSI	q23007
IVS-INT-3	Ns-Sh-Wz	Mo @ 05:30	BONN	q23002
IVS-INT-00	Kk-Wz	Mo+Th @ 23:30	WASH	ii3003
IVS-INT-S	Hb-Ht	Mo @ 06:30	UTAS	z23009

The original Intensive observing series IVS-INT-1 and IVS-INT-2 provided a single data point for UT1–UTC for each day of the week. Subsequent series that were added over time provided additional data points for individual (but select) days; there is significant overlap among those series. For validation and comparison purposes, the initially started VGOS Intensive series (e.g., VGOS-INT-A) were scheduled at the same time as well-established series (e.g., IVS-INT-1).

Table 2 VGOS Intensive series of the IVS Intensive program as of late 2023 to early 2024 (bold font indicates availability of a sufficient history; blue indicates operational use of VGOS series by the IERS RS/PC). That is, the series VGOS-INT-A is used operationally by the RS/PC. The VGOS-INT-B/C series have a sufficient history for operational inclusion.

Type	Stations	When	Correl.	Ex.
VGOS-INT-A	K2-Ws	Mo–Fr @ 17:30	WASH	v24002
VGOS-INT-B	Is-Oe-Ow	Sa–Su @ 05:30	GSI	b24006
VGOS-INT-C	Is-Oe-Ow	Sa–Su @ 07:00	BONN	c24006
VGOS-INT-M	Is-Nn-Ws	Mo @ 05:30	BONN	m24113
VGOS-INT-S	Mg-Ws	Tu @ 19:45	WETZ	s24002
VGOS-INT-Y	Gs-Sa-Yj	Tu @ 14:00	YEBS	y24009

A commonality for most Intensive series was that their observing times were chosen to be convenient for the participating stations. The optimal use of the es-

timated UT1–UTC value down the line was a minor consideration at best. An exception was the pilot effort of the midnight Intensives, which we touch on in a later section.

3 Station Pool of Intensives Currently Used by IERS RS/PC

Considering only the stations that contribute to Intensive series that are used by IERS RS/PC (Table 3) we have a very limited set of stations. That implies that problems at any of these stations can have a severe impact on the observing program and the provision of UT1–UTC data points.

Table 3 Station pool for Intensives used operationally by the IERS RS/PC (as of early 2024). The stations Hobart (Hb), Hartebeesthoek (Ht), Ishioka (Is), Ny-Ålesund (Ns), Onsala (Oe, Ow), and Sheshan (Sh) are part of baselines that could be added to the operational work.

Legacy S/X	VGOS	Intensive series
Kokee Park (Kk)	Kokee Park (K2)	IVS-INT-1, VGOS-INT-A
Wettzell (Wz)	Wettzell (Ws)	IVS-INT-1, IVS-INT-2, VGOS-INT-A
Mauna Kea (Mk)		IVS-INT-2

To improve the robustness of the Intensive program and thus to provide UT1–UTC values more reliably, several measures are conceivable:

- increase the number of stations contributing to the Intensives;
- increase the number of baselines used;
- increase the geographic diversity for the baselines;
- observe several Intensives per UT day.

Work is underway to implement some or all of these measures. In addition, further changes to the Intensive program can be done at the same time.

4 Alignment with IGS Rapids

In March 2022, the IVS commenced a new legacy S/X Intensive series that has 00 UT as its midpoint: IVS-INT-00. This effort was a pilot project to assess the

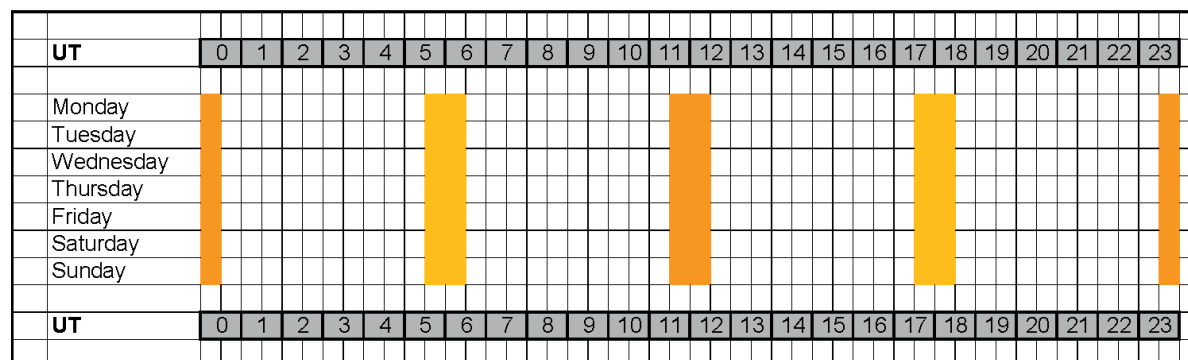


Fig. 1 Alignment goal of the Intensive observing program with the IGS Rapids. Ideally, there would be a data point of UT1–UTC determined at 00 UT, 06 UT, 12 UT, and 18 UT for every day of the week.

practicality of Intensive series that are aligned to “non-IVS-standard” midpoints. The IVS Directing Board had endorsed aligning the Intensives to the needs of our sister services (mostly the IGS). For instance, with a reference epoch of midnight UT (23:30–00:30 UT observing time period) an interpolation step is avoided in the satellite orbit determination.

Following the success of the pilot project, there was further discussion on the alignment of the Intensives to the IGS Rapids (00 UT, 06 UT, 12 UT, and 18 UT) in 2023. Ideally, there would be four Intensives separated by six hours every day of the week (Figure 1). However, with the limited number of Intensive stations as well as limited observational and correlator resources, two Intensives per day seem more easily attainable. From an analysis standpoint, a separation of 12 hours would be an obvious target; but practical constraints will likely necessitate a varying separation of six hours and 18 hours at least initially.

5 Changes to the Intensive Program in 2023 and Plans for 2024–2025

The Observing Program Committee (OPC) started to implement changes to the Intensive program in the latter part of 2023 (Figure 2). Both the IVS-INT-1 and VGOS-INT-A series were shifted to one hour earlier to have an 18 UT midpoint in 2023 Q4, while the VGOS-INT-B series was shifted to be centered on 06 UT.

For 2024, it was considered (1) to shift the IVS-INT-2 and IVS-INT-3 to be centered on 06 UT and

(2) to move the VGOS-INT-A to have a midpoint of 12 UT. These changes were not implemented with the start of the observing year, because a major change was already done to the observing start of the 24-hour VGOS-OPS sessions. Further, it has to be ensured that the IERS RS/PC can take full advantage of the alignment changes.

6 Other Considerations

While it is an essential first step to characterize a new Intensive baseline so that it can be used in the RS/PC combined EOP solution, it is equally important that the turnaround time is fast enough for the data points to contribute to the 0-day UT1–UTC prediction. This implies that the data transport from the stations to the target correlator is to be accomplished quickly and that the correlator has sufficient resources to process the data in a timely fashion. Hence, the characterization period should also be used to optimize the e-transfer as well as the correlation/fringe-fitting steps; a high degree of automation would be highly desirable.

7 Conclusions and Outlook

Efforts are underway to restructure the Intensive observing program to better accommodate the needs of our sister services. The general idea is to align the program with the IGS Rapids. The transition will take time and can only be done in steps. Limitations include sta-

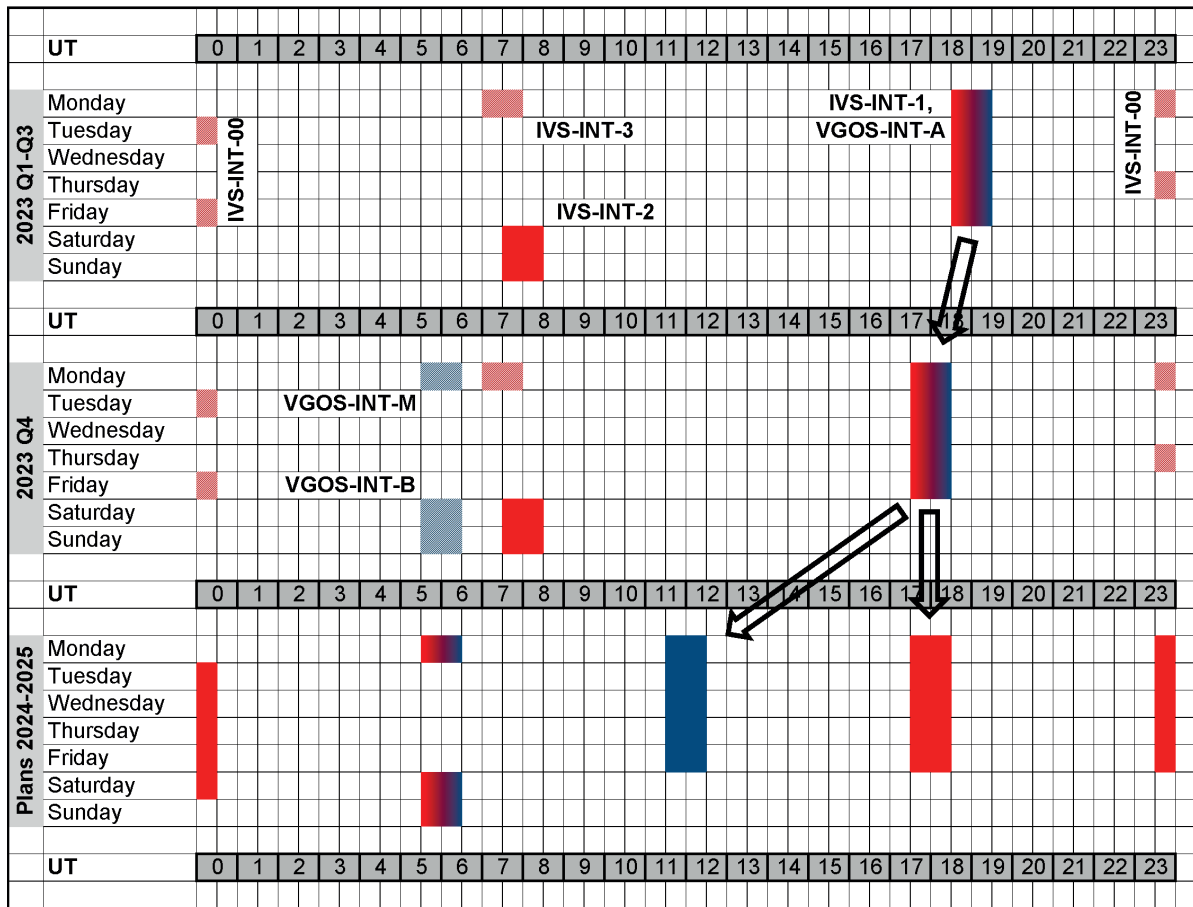


Fig. 2 Overview of the Intensive observing program, including updates (done and planned) from 2023 to 2025, depicting the series that are used by the IERS RS/PC in production (solid colors) or are being evaluated for use in production (colored hatch patterns). A major alignment step in 2023 Q4 was the centering of the IVS-INT-1 and VGOS-INT-A series on 18 UT.

tion and correlator resources. Further, the robustness of the program can be improved by increasing the number of validated baselines (and stations) with the IERS RS/PC.

The VGOS-INT-A series yields better UT1–UTC results than the equivalent legacy S/X series IVS-INT-1; e.g., the RMS scatter w.r.t. the R1/R4 estimates reduced from 25.3 μ s (S/X) to 16.7 μ s (VGOS) [2]. For that, it seems reasonable to favor VGOS baselines over S/X baselines when possible. However, operational constraints may make the utilization of additional legacy S/X Intensives a pragmatic approach.

With the Intensive program moving towards an alignment with the IGS Rapids, it may be appropriate to change the naming convention (e.g., session type) of the Intensives. A possibility includes to embed the UT midpoint into the name; for instance: IVS-INT-00,

IVS-INT-06, IVS-INT-12, and IVS-INT-18. As this would change long-standing standards and habituations, further discussions are needed to evaluate the impact of such a change.

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