Development of a High-Performance and Swiss based Rolex Timescale System including a Unique Optical Atomic Clock

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Abstract— **A high-availability and high-stability timescale system, the Rolex Timescale, designed in collaboration between CSEM and METAS for Rolex, has been developed. This system, targeting state-of-the-art performances, consists of two distinct redundant timescales distant by more than 100 km. In view of the declaration of their constitutive clocks to the BIPM by METAS for their potential participation to the realization of UTC, the two timescales are compared by a calibrated GNSS time link.**

Keywords — timescale, atomic clock, optical clock, time transfer, UTC.

I. Introduction

A high-availability and high-stability timescale system, the Rolex Timescale, designed in collaboration between CSEM and METAS for Rolex, has been developed. This system, targeting state-of-the-art performances, consists of two distinct redundant timescales distant by more than 100 km. In view of the declaration of their constitutive clocks to the BIPM by METAS for their potential participation to the realization of UTC, the two timescales are compared to UTC(CH) by calibrated GNSS time comparison links. Each timescale, alongside redundant timing distribution and control, contains three commercial state-of-the-art atomic clocks, exclusively provided by Swiss manufacturers, as well as a novel rubidium optical atomic clock developed by CSEM for Rolex [1].

II. System description

To optimize temperature control and facilitate maintenance, the two timescales are housed within five racks (Figure 1). Four racks accommodate an atomic clock each, and a central rack hosts the control units and the timing distribution. The atomic clocks chosen for each timescale include an active hydrogen maser from Safran Timing Technologies (iMaser3000), an optically pumped cesium clock (OSA 3300) and a magnetic cesium clock (OSA 3235B) from Oscilloquartz SA. Additionally, a novel rubidium optical atomic clock, developed by CSEM for Rolex [1], will complete the clock ensemble in a near future.

III. GNSS time comparison and UTC

The two timescales are located in different Rolex facilities in Switzerland (Geneva and Bienne), distant by more than 100 km. Their timing accuracy is guaranteed by calibrated GNSS links and, ultimately, by comparison and steering to UTC(CH), individually for each timescale. Significant attention has been directed towards ensuring the optimal performances and reliability of the two timescales and, in particular, of the atomic clocks.

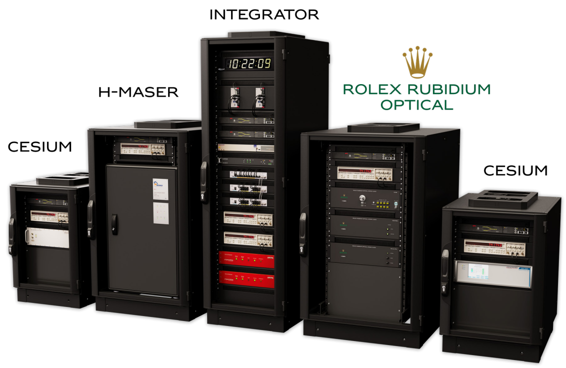

Figure 1: Rolex timescale composed of five racks. From left to right: Cesium OSA 3235B; iMaser3000; Control Unit (Integrator); Rolex Rubidium Optical Atomic Clock; Cesium OSA 3300.

The racks are equipped with secured double electrical power supply, highly precise thermal control and calibrated GNSS receivers. Those stringent requirements open the door for a potential participation of their constitutive clocks in the realization of UTC. Hence, as illustrated in Figure 2, the Federal Institute of Metrology METAS will collect the clock data from both timescales (ET1 and ET2) clocks, will analyze and validate them, before ultimately sending them to the BIPM.

Optical fiber (OF) connections between ET1 and ET2 might allow for resilient and advanced time comparison between the two sites in the future.

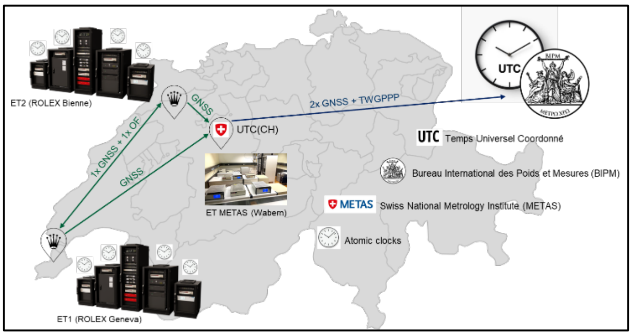

Figure 2: Illustration of the current interconnection between the timescales ET1 (Geneva), ET2 (Bienne) and METAS. The clock data will ultimately be sent by METAS to the BIPM for a potential participation to the realization of UTC. OF: optical fiber.

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IV. Results

The Rolex timescales algorithm is based on a modified AT1 algorithm [2], also used at the Federal Institute of Metrology METAS for the realization of UTC(CH). The clocks physical states are measured by means of time interval counters (TIC). Both timescales are operated continuously since more than 6 months, at Rolex facilities on the one side, and at CSEM facilities on the other side. Figure 3 illustrates the Allan deviations recently measured at CSEM for each of the three commercial clocks versus the Rolex timescale output signal.

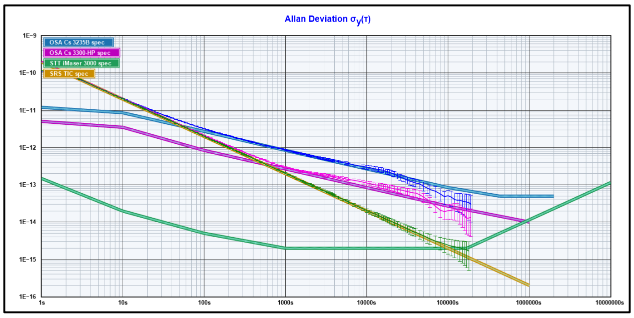

Figure 3: Bold lines: datasheet extracted Allan deviations from the three atomic clocks integrated in the Rolex timescale ET2. The time intervals between the Timescale and the clocks are measured by SR620 frequency counters, the ADEV of which is displayed in gold color. Thin lines: measured Allan deviations.

The fourth and novel Rolex Rubidium Optical Atomic Clock [1] will be integrated in both timescales once validated by METAS and officially listed in the BIPM clock database. Very recent and preliminary measurements realized in the UTC(CH) laboratory [1] with a first 19'' integrated prototype illustrated in Figure 4, confirm the potential use of this clock as the future master clock in the Rolex timescales.

Figure 4: Photography of the 19''integrated Rolex Rubidium Optical Atomic Clock prototype.

V. Conclusion

The very recently installed high-reliability and high-availability Rolex timescales have been presented, with potential future increased resilience thanks to fiber optic connections. Work is ongoing with METAS in view of the declaration of the timescales constitutive clocks to the BIPM for their potential participation to the realization of UTC.

VI. Acknowledgment

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