The frequency standard NICT-Sr1 is an $^{87}$Sr optical lattice clock operated at NICT. Utilizing the method of intermittent evaluation [1], NICT-Sr1 contributed to TAI calibration as published in the Circular T for the following intervals:

MJD 58479 to 58509 (30 days) for Jan. 2019, Circular T 373
MJD 58514 to 58534 (20 days) for Feb. 2019, Circular T 374
MJD 58644 to 58679 (35 days) for June/July 2019, Circular T 379.

The last one in June/July contains three measurements on MJD 58646, MJD 58658 to 58666 and MJD 58675, with an 87% coverage of the central 9 day period.

Measurements of the scale interval use an optical frequency comb to down-convert the optical frequency of 429 THz stabilized to NICT-Sr1 to a signal in the microwave domain. This then serves as a reference to evaluate the frequency of a hydrogen maser (HM). In typical intermittent evaluation, the HM frequency is measured for three hours approximately once per week, and the mean frequency of the HM with respect to the frequency of NICT-Sr1 is determined from several such data blocks distributed over the target period. The uncertainty due to non-operation time of NICT-Sr1 [1-3] is then included in $u_{\text{Lab}}$. Additionally, an average over multiple HMs mitigates the effect of sporadic phase excursions of a specific HM [3]. Intermittent evaluation makes it easier to extend the evaluation interval longer, reducing the uncertainty $u_{\text{Tai}}$ of the satellite link to TAI. The uncertainty $u_{\text{Tai}}$ often limits the overall uncertainty particularly at short evaluation intervals. Table 1 shows uncertainty contributions for such evaluations.

In the evaluation of $u_{\text{Lab}}$, representing the uncertainty of the link between NICT-Sr1 and the local HM, we separately consider and reported Type A and Type B uncertainties, which add in quadrature to give $u_{\text{Lab}}$ as included in the current Circular T.

<table>
<thead>
<tr>
<th>Period of evaluation (MJD)</th>
<th>Evaluation mode</th>
<th>$u_A$</th>
<th>$u_B$</th>
<th>$(u_A/\text{Lab})_{\text{ul/Lab}}$</th>
<th>$(u_B/\text{Lab})_{\text{ul/Lab}}$</th>
<th>$u_{\text{Tai}}$</th>
<th>$u$</th>
<th>$u_{\text{Srep}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>58479 – 58509 (30 days)</td>
<td>Intermittent</td>
<td>0.37</td>
<td>0.77</td>
<td>(3.08)</td>
<td>(0.80)</td>
<td>2.3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>58514 – 58534 (20 days)</td>
<td>Intermittent</td>
<td>0.20</td>
<td>0.73</td>
<td>(2.09)</td>
<td>(0.80)</td>
<td>2.4</td>
<td>3.7</td>
<td>4</td>
</tr>
<tr>
<td>58644 – 58679 (35 days)</td>
<td>Intermittent</td>
<td>0.08</td>
<td>0.71</td>
<td>(2.08)</td>
<td>(0.14)</td>
<td>2.08</td>
<td>2.8</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 1: Reported uncertainty contributions applying the method of intermittent evaluation. The last interval includes an extended center measurement period of near continuous operation. Values are given in units of $10^{-16}$.

The typical systematic corrections and their uncertainties for NICT-Sr1 as previously published [1, 3, 4] are summarized as follows:
Table 2. Systematic corrections and their uncertainties for NICT-Sr1 between MJD 58644 and 58679.

<table>
<thead>
<tr>
<th>Effect</th>
<th>Correction $(10^{-17})$</th>
<th>Uncertainty $(10^{-17})$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blackbody radiation</td>
<td>513.1</td>
<td>3.4</td>
</tr>
<tr>
<td>Lattice scalar / tensor</td>
<td>0</td>
<td>5.3</td>
</tr>
<tr>
<td>Lattice hyperpolarizability</td>
<td>−0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>Lattice E2/M1</td>
<td>0</td>
<td>0.5</td>
</tr>
<tr>
<td>Probe light</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Dc Stark</td>
<td>0.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Quadratic Zeeman</td>
<td>51.2</td>
<td>0.3</td>
</tr>
<tr>
<td>Density</td>
<td>0.4</td>
<td>0.9</td>
</tr>
<tr>
<td>Background gas collisions</td>
<td>0</td>
<td>1.8</td>
</tr>
<tr>
<td>Line pulling</td>
<td>0</td>
<td>0.1</td>
</tr>
<tr>
<td>Servo error</td>
<td>1.8</td>
<td>1.5</td>
</tr>
<tr>
<td>Total</td>
<td>566.6</td>
<td>6.8</td>
</tr>
<tr>
<td>Gravitational redshift</td>
<td>−834.1</td>
<td>2.2</td>
</tr>
<tr>
<td>Total (with gravitational effect)</td>
<td>−267.5</td>
<td>7.1</td>
</tr>
</tbody>
</table>

References