On the Generation of SLR Output Files at Mt Stromlo

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Abstract

As part of the re-establishment and improvement of the Mt Stromlo SLR station, much of the software systems have been redeveloped, including new post-processing software. With the advent of the new CRD format this has provided an opportunity to consider new approaches to the generation of data products. This paper provides a description of the approach adopted, using XML and XSLT technologies.

Introduction

When considering the redevelopment of the software modules responsible for the generation of output data files resulting from the processing of satellite laser ranging (SLR) data, the following design requirements were established;
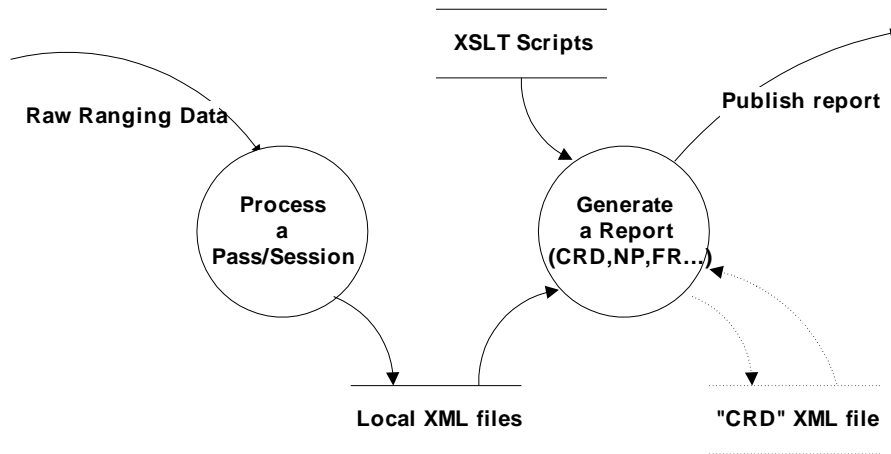
- Raw ranging data should be processed only once.
- All useful data should be extracted and stored in a single data repository/file.
- Output data should be accessible to different users regardless of processing platforms and location.
- Data subsets can be easily extracted for the generation of various reports including current normal point, full rate and new CRD formats.
- Software architecture should easily allow for future functional extensions (eg new data types) with minimal impact on the current software base.

One technology that has recently evolved to meet these types of requirements uses files structured with extensible mark-up language (XML). It was considered that the use of XML files provides a much more flexible solution than alternatives based on, for example, relational databases, unstructured files or proprietary binary files. In fact XML query language provides powerful database-like search and extraction facilities eliminating the need for a conventional database.

There is increasing popularity in the use of XML as a means for data exchange (e.g see Salminsh, 2003) and it is of note that the new ILRS CRD format (Ricklefs and Moore, 2008) has a structure and "mark-up" elements that give some resemblance to an XML document. The CRD format was in fact designed to support an evolutionary path to the adoption of XML and in practice we have found it convenient to create an XML file having a CRD-like format as an intermediary stage in the generation of CRD format reports.

SLR Post Processing

Figure 1 shows an overview of the typical data flow associated with the processing of data obtained during laser ranging sessions. A "raw" file of ranging data collected during a satellite pass is processed to identify and extract true signal data, from which full rate, normal point and other useful data are determined and stored as an XML file in a "local" format. Similar files are generated while ranging to calibration targets. Such

Figure 1. SLR Data Flow Diagram

files contain many other data that are considered to be useful for the station and other users of the data.

It is expected that new data items will be identified for inclusion over time, but using XML, such data can be easily added without impacting existing users and software applications. As far as this "local" data format is concerned, it is important that the requirements of the station are not inhibited by externally defined formats or restrictions (which may change over time), but this provides a responsibility for the station to capture all necessary and available data to meet both station and external or client requirements. A sample XML file in "local" format is shown in Listing 1. Note that Listings 1 to 3 refer to sample files whose format is expected to change in response to on-going development and user requirements.
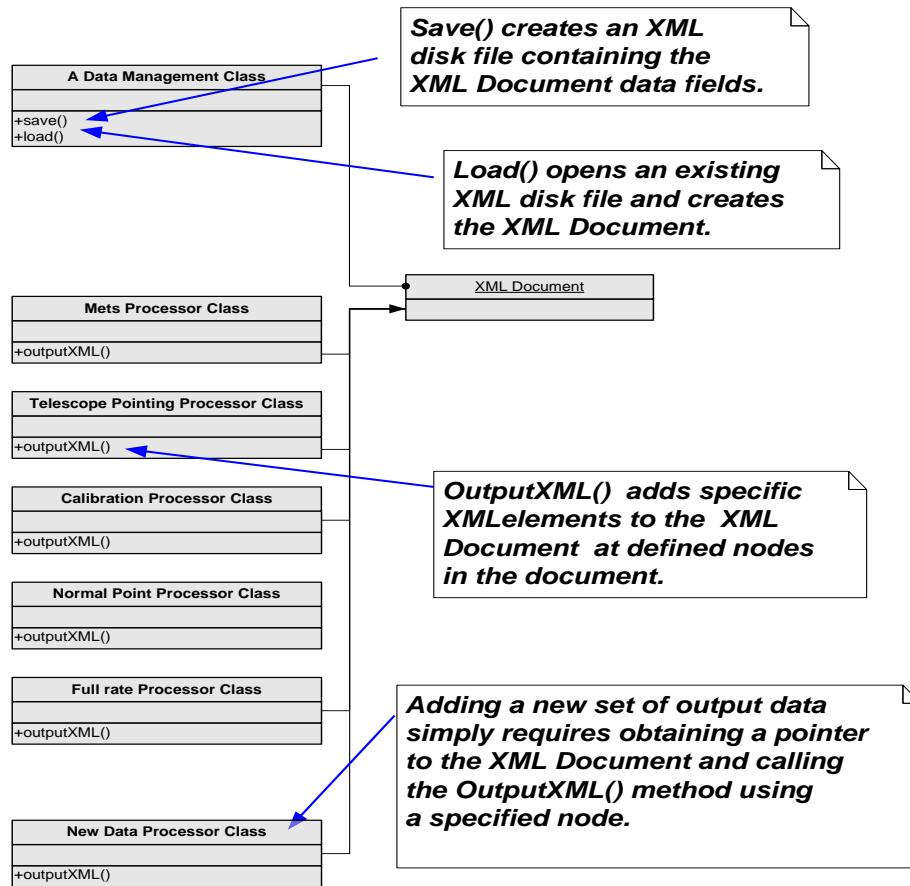
Software Design

The key point with the use of XML files is that additional data fields can be added without impacting on the existing data sets. Also with object oriented software architecture, the addition of new data types can be made at any appropriate node in the XML tree structure, by simply adding additional software classes or modules. The software responsible for generation and formatting of the existing data sets should not require modification. Figure 2 shows a schematic of the software architecture used at Mt Stromlo where independent groups of data sets are identified and associated with their own software classes for processing and storage. If a new set of closely coupled data is identified, then it is simply a matter of writing a new class for these data that will *inter alia* have the responsibility for updating the output XML file.

In this way software design and development can be minimized while maximizing the robustness of the existing code base. Existing and stable third-party XML/XSLT libraries such as the MSXML or Xerxes/Xalan libraries have been adopted to further minimise software development and maintenance.

Report Generation

Once generated, the "local" XML files is used as the data source for the generation of required report files i.e. data files suitable for publication to external bodies or clients using agreed formatting rules. Even quite complex transformations from the local XML structure to such reports can be accomplished using extensible stylesheet language

Figure 2. Typical software classes to append/insert records in an XML document.

transformation (XSLT) transforms. Generation of new reports or modifications to existing reports can therefore be managed without any modification to software binaries.

This approach has been used successfully to create all of the station generated ILRS reports including files in the new CRD format (Ricklefs and Moore, 2007), as well as files in the currently required ILRS normal point and full rate formats. As mentioned, to simplify the transformation process we also generate a temporary CRD-like XML file, currently having a format similar to that shown in Listing 2. This file is then used for subsequent transformation to actual CRD format reports, and to current ILRS normal point and full rate reports. An example of an XSLT transform to complete the generation of an ILRS normal point format file is shown in Listing 3.

File Sizes

One criticism of XML files, given they are in ASCII and contain mark up tags, is that they can be quite verbose. For example a "local" format XML file containing full rate and other data from a Lageos pass at 60Hz fire rate, has a size of about 100 Kbytes and an intermediary CRD-like XML file has a size of about 150 Kbytes. The corresponding combined full rate and normal point CRD File has a volume of about 60 Kbytes. Compression reduces all of these files to about 10% of their original size.

Conclusions

Redevelopment of processing software at Mt Stromlo is well advanced and now incorporates XML technology in the generation of output files. This approach is particularly well suited for the generation of data files in the new CRD format. It is hoped that these developments show that the use of XML files is a suitable and appropriate technology for storage and publication of SLR data.

References

Ricklefs, R.L and C. J. Moore, 2007. Consolidated Laser Ranging Data Format (CRD). http://ilrs.gsfc.nasa.gov/products_formats_procedures/crd.html
Salminsh, K., 2003. XML Applications in SLR, cddis.nasa.gov/lw13/docs/papers/upg_salminsh_1m.pdf

Listing 1: Sample of a "Local" XML File

```xml
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<eos:root xmlns:eos="schemas.eos-aus.com/BrdDataAnalysis/1">
    <MetaData FileCreated="25/02/2009 01:12" RangeUnits="nanoseconds" SchemaName="BrdDataAnalysis" SchemaVersion="1">
        <SourceFiles>
            <BrdFile Filename="ERS2_20060731_232154.brd"/>
        </SourceFiles>
        <Software>
            <Application Built="Thu Feb 19 04:07:24 2009 UTC" Platform="Win32" Name="Profits.exe" Version="5-2-1"/>
            <Library Built="Thu Feb 19 01:13:10 2009 UTC" Platform="Win32" Name="BrdAnalysis.lib" Version="1-0-10"/>
…etc…
        </Software>
    </MetaData>
    <System CdpOcc="01" CdpPadId="7825" CdpSys="90" Height="805.027300" Latitude="-35.316144" Location="Stromlo"
Longitude="149.009880" Name="" Network="Stromlo" TimeScale="GPS">
        <Target CoM="0.000000" Cospar="9502101" NPIndex="3" Name="ERS2" Sic="6178" Signature="0.200" Type="1">
            <Session StartDay="31/07/2006" StartDoY="212" StartMjd="53947.975880" StartSeconds="84329.0" StartYear="2006"
StopDay="31/07/2006" StopMjd="53947.980995" StopSeconds="84758.0">
                <ProcessOptions AmpCorrApplied="FALSE" CoMApplied="FALSE" EpochEventType="Station Laser Fire"
Quality="Good" RangeDataType="2-way" RefractionApplied="FALSE" Release="0" SDApplied="TRUE"/>
                <SystemConfig>
                    <Laser Divergence="30.0" FireRate="60.0" PulseEnergy="20.800" PulseWidth="12.0" SemiTrain="1" Type="Nd-
YAG" Wavelength="532.00"/>
                    <Detector DarkCount="0.0" Polarizer="Linear" PulseType="ECL" PulseWidth="0.0" QE="0.2" SpatialFilter="15.0"
SpectralFilter="1.0" Transmission="100.0" Type="CSPAD" Voltage="0.0" Wavelength="532.0"/>
                    <Timer EpochDelay="232.200" FreqSource="TrueTime_OCXO" TimeSource="TrueTime_XLi" TimerSN="NA"
Type="MRCS"/>
                    <Enclosure AirWindowDiameter="1.362" DomeDiameter="4.5070" GlassWindowDiameter="1.362"
GlassWindowRI="1.474" GlassWindowThickness="0.0190" NormalWindowDelay="0.063" Type="Typhoon"/>
                    <FullRateData>
                        <Segment StartDay="31/07/2006" StartSeconds="84329.0" StopSeconds="84758.0">
                            <EnclosureWindow WindowUsed="GLASS"/>
                            <SystemCal Kurtosis="2.7" MeanDelay="168.306" Method="Post Cal" NumData="26488"
NumDataUsed="14901" PeakOffset="0.000" Rms="0.024" Seconds="29412068.5" Shift="0.117" ShiftType="Peak
To Peak" Skew="0.2" TargetDistance="632.575"/>
                            <Shot Range="8257253.3031" Refraction="25.4315" Residual="25.4510" Seconds="84514.211781815495"/>
…etc…
                        </Segment>
                    </FullRateData>
                    <NormalPoints IntervalSecs="15.00">
                        <NormalPoint Bin="5634" Humidity="69.6" Kurtosis="-0.76" NumTotal="282" NumUsed="19" Peak="0.0000"
Prediction="8224488.6565" Pressure="926.8" Range="8224412.2734" Rate="6.88" Refraction="25.2938"
Residual="0.0016" Rms="0.0113" Seconds="84518.645115210" Skew="-0.03" Temperature="5.30"/>
…etc…
                    </NormalPoints>
                    <SummaryStatistics Bin="637" Humidity="68.4" Kurtosis="-0.73" NumTotal="3678" NumUsed="92" Peak="0.0155"
Prediction="8156254.8181" Pressure="926.9" Quality="0" Range="8156254.8171" Rate="3.88" Refraction="29.6284"
Residual="-0.0009" Rms="0.0138" Seconds="84554.592019940" Skew="-0.01" Temperature="5.26"/>
                </SystemConfig>
                <Mets Origin="Measured">
                    <MetData Humidity="69" Pressure="926.9" Seconds="84469.645115211169" Temperature="5.2"/>
…etc…
                </Mets>
                <Pointing Origin="Measured">
                    <Tel Azim="166.482633" Elev="17.945640" Seconds="84328.899965"/>
…etc…
                </Pointing>
            </Session>
        </Target>
    </System>
</eos:root>
```

Listing 2: Sample of a "CRD" XML File

```xml
<?xml version="1.0" encoding="iso-8859-1"?>
<crd xmlns:eos="schemas.eos-aus.com/BrdDataAnalysis/1">
    <format record_type="H1" version=" 0" year="2009" month="02" day="25" hour="01" minute="12">
        <!--Station Header-->
        <station record_type="H2" station_name="Stromlo" cdppad_id="7825" cdp_sys="90" cdp_occ="01" timescale="GPS">
            <!--Target Header (H3)-->
            <target record_type="H3" name="ERS2" cospar_id="9502101" sic="6178" norad_id="000000"
SpacecraftEpochTimeScale="0" TargetType="1" />
            <!--Unique Laser Records-->
            <Laser record_type="C1" unique_id="IDASCXFB" Divergence="30.0" FireRate="60.0" PulseEnergy="20.800"
PulseWidth="12.0" SemiTrain="1" Type="Nd-YAG" Wavelength="532.00" />
            <!--Unique Detector Records-->
```

```
<Detector record_type="C2" unique_id="IDA0CXFB" DarkCount="0.0" Polarizer="Linear" PulseType="ECL"
PulseWidth="0.0" QE="0.2" SpatialFilter="15.0" SpectralFilter="1.0" Transmission="100.0" Type="CSPAD" Voltage="0.0"
Wavelength="532.0" Processing="Profits_5-2-1" />
```
<!--Unique Timer Records-->
```
<Timer record_type="C3" unique_id="IDAGDXFB" EpochDelay="232.200" FreqSource="TrueTime_OCXO"
TimeSource="TrueTime_XLi" TimerSN="NA" Type="MRCS"/>
```
<!--Unique Enclosure Records-->
```
<Enclosure unique_id="IDAMDXFB" AirWindowDiameter="1.362" DomeDiameter="4.5070"
GlassWindowDiameter="1.362" GlassWindowRI="1.474" GlassWindowThickness="0.0190" NormalWindowDelay="0.063"
Type="Typhoon" />
```
<!--Unique Transponder (Clock) Records (not used at Mt. Stromlo)-->
<!--Unique Configuration Records-->
```
<system_configuration_record unique_id="IDARCXFB" record_type="C0" wavelength="532.0">
    <component laser_id="IDASCXFB" detector_id="IDA0CXFB" timer_id="IDAGDXFB" />
</system_configuration_record>
```
<!--Session Header (Full Rate)-->
```
<session record_type="H4" data_type="0" start_year="2006" start_month="07" start_day="31" start_hour="23"
start_minute="25" start_second="29" end_year="2006" end_month="07" end_day="31" end_hour="23" end_minute="32"
end_second="38" >
    <StartDoY>212</StartDoY>
    <ProcessOptions AmpCorrApplied="FALSE" CoMApplied="FALSE" EpochEventType="Station Laser Fire"
    Quality="Good" RangeDataType="2-way" RefractionApplied="FALSE" Release="0" SDApplied="TRUE" />
```
    <!--Summary Statistics-->
```
    <SummaryStatistics record_type="50" unique_config_id="IDARCXFB" Bin="637" Day="31/07/2006" Humidity="68.4"
    Kurtosis="-0.73" NumTotal="3678" NumUsed="92" Peak="0.0000000000155" Prediction="0.008156254818100001"
    Pressure="926.9" Quality="0" Range="0.0081562548171" Rate="3.88" Refraction="0.0000000296284" Residual="-
    0.0000000000009" Rms="0.0000000000138" Seconds="84554.592019940" Skew="-0.01" Temperature="5.26" />
    <Mets record_type="20" Origin="Measured">
    <MetData Humidity="69" Pressure="926.9" Seconds="84469.64511521" Temperature="5.2" /><MetData Humidity="68"
Pressure="926.8" Seconds="84579.578448514367" Temperature="5.3" />
```
...etc...
```
    <segment starting_year="2006" starting_month="07" starting_day="31" start_hour="23" start_minute="25"
start_second="29" end_hour="23" end_minute="32" end_second="38">
```
        <!--Calibration Record-->
```
        <calibration record_type="40" seconds_of_day="29412068.5" type_of_data="0" unique_config_id="IDARCXFB"
        data_points_recorded="26488" data_points_used="14901" one_way_target_distance="632.575"
        cal_sys_delay="0.00000016830" cal_delay_shift="0.000000000117" Rms="0.000000000024" Skew="0.2"
        Kurtosis="2.7" sys_delay_peak="0" cal_type="2" cal_shift_type="3" detector_channel="0" />
        <EnclosureWindow WindowUsed="GLASS" />
        <data record_type="10" seconds="84514.211781815495" epoch_event="2" unique_config_id="IDARCXFB"
        Range="0.0082572533031" />
```
...etc...
```
    </segment>
```
    <!--Pointing Angles Records-->
```
    <Pointing record_type="30" Origin="Measured">
        <Telescope seconds_of_day="84331.94495" Azimuth="165.059559" Elevation="16.809546" TxRxDirection="0"
RefractionCorrected="0" />
```
...etc...
```
    </Pointing>
</session>
```
<!--Session Header (normal points)-->
```
<session record_type="H4" data_type="1" start_year="2006" start_month="07" start_day="31" start_hour="23"
start_minute="25" start_second="29" end_year="2006" end_month="07" end_day="31" end_hour="23" end_minute="32"
end_second="38" >
    <StartDoY>212</StartDoY>
    <ProcessOptions AmpCorrApplied="FALSE" CoMApplied="FALSE" EpochEventType="Station Laser Fire"
    Quality="Good" RangeDataType="2-way" RefractionApplied="FALSE" Release="0" SDApplied="TRUE" />
```
    <!--Summary Statistics-->
```
    <SummaryStatistics record_type="50" unique_config_id="IDARCXFB" Bin="637" Day="31/07/2006" Humidity="68.4"
    Kurtosis="-0.73" NumTotal="3678" NumUsed="92" Peak="0.0000000000155" Prediction="0.008156254818"
    Pressure="926.9" Quality="0" Range="0.0081562548171" Rate="3.88" Refraction="0.0000000296284" Residual="-
    0.0000000000009" Rms="0.0000000000138" Seconds="84554.592019940" Skew="-0.01" Temperature="5.26" />
    <Mets record_type="20" Origin="Measured">
        <MetData Humidity="69" Pressure="926.9" Seconds="84469.645115211169" Temperature="5.2" />
```
...etc...
```
    </Mets>
```
    <!--Calibration Record-->
```
    <calibration record_type="40" seconds_of_day="29412068.5" type_of_data="0" unique_config_id="IDARCXFB"
    data_points_recorded="26488" data_points_used="14901" one_way_target_distance="632.575"
    cal_sys_delay="0.0000001683" cal_delay_shift="0.000000000117" Rms="0.000000000024" Skew="0.2" Kurtosis="2.7"
    sys_delay_peak="0" cal_type="2" cal_shift_type="3" detector_channel="0" />
```
    <!--NormalPoints-->
```
    <NormalPoints DoY="212" Year="2006">
        <normal_point record_type="11" seconds="84518.645115210" Range="0.008224412273400001"
        Prediction="8224488.6565" Residual="0.0016" unique_config_id="IDARCXFB" epoch_event="2"
```

```
                    WindowLength="15.00" Day="31/07/2006" RawRanges="19" BinRMS="0.0000000000113" BinSkew="-0.03"
                    BinKurtosis="-0.76" ReturnRate="6.88" Peak="0" Humidity="69.6" Pressure="926.8" TemperatureC="5.30"
                    Refraction="25.2938" />
...etc...
                    </NormalPoints>
               </session>
          </station>
     </format>
</crd>
```

Listing 3 – Example of an XSLT transform to convert a CRD-XML file to ILRS NP format.

```
<?xml version="1.0" encoding="UTF-8" ?>
<xsl:stylesheet version="1.0" xmlns:xsl="http://www.w3.org/1999/XSL/Transform" xmlns:eos="www.eos-aus.com">
          <xsl:output method="text" version="1.0" indent="no" encoding="ISO-8859-1" />
          <xsl:template match="/">
                    <xsl:apply-templates select="//NormalPoints" />
          </xsl:template>
          <xsl:template match="NormalPoints">99999
<xsl:value-of select="format-number(../../target/@cospar_id, '0000000')" />
<xsl:value-of select="substring(@Year, 3, 2)" />
<xsl:value-of select="format-number(@DoY, '000')" />
<xsl:value-of select="../../@cdppad_id" />
<xsl:value-of select="format-number(../../@cdp_sys, '00')" />
<xsl:value-of select="format-number(../../@cdp_occ, '00')" />
<xsl:value-of select="format-number((../../Laser/@Wavelength * 10), '0000')" />
<xsl:value-of select="format-number((../../session/segment/calibration/@cal_sys_delay * 1000000000000.0), '00000000')" />
<xsl:choose>
          <xsl:when test="(../../session/segment/calibration/@cal_delay_shift &lt; 0)">
                    <!-- force the negative number, positive -->
                    <xsl:value-of select="format-number((../../session/segment/calibration/@cal_delay_shift * 1000000000000.0) * -1.0,
'000000')" />
          </xsl:when>
          <xsl:otherwise>
                    <xsl:value-of select="format-number((../../session/segment/calibration/@cal_delay_shift * 1000000000000.0),
'000000')" />
          </xsl:otherwise>
</xsl:choose>
<xsl:value-of select="format-number((../../session/segment/calibration/@Rms * 1000000000000.0), '0000')" />
<xsl:choose>
                              <xsl:when test="normal_point[1]/@WindowLength='5.00'">1</xsl:when>
                              <xsl:when test="normal_point[1]/@WindowLength='15.00'">3</xsl:when>
…etc…
                              <xsl:when test="normal_point[1]/@WindowLength='300.00'">9</xsl:when>
                              <xsl:otherwise>0</xsl:otherwise>
                    </xsl:choose>
<xsl:choose>
          <xsl:when test="//crd/format/station/@timescale = 'GPS'">4</xsl:when>
</xsl:choose>
<xsl:text>0</xsl:text>
<xsl:text>4</xsl:text>
<xsl:choose>
          <xsl:when test="../../session/segment/EnclosureWindow/@WindowUsed='AIR'">1</xsl:when>
          <xsl:when test="../../session/segment/EnclosureWindow/@WindowUsed='GLASS'">2</xsl:when>
</xsl:choose>
<xsl:value-of select="format-number((../SummaryStatistics/@Rms * 1000000000000.0), '0000')" />
<xsl:text>0</xsl:text>
<xsl:text>00</xsl:text>2
<xsl:apply-templates />
          </xsl:template>
          <xsl:template match="normal_point">
<xsl:value-of select="format-number((@seconds * 10000000.0), '000000000000')" />
                    <xsl:value-of select="format-number((@Range * 1000000000000.0),'000000000000')" />
                    <xsl:value-of select="format-number((@BinRMS * 1000000000000.0),'0000000')" />
                    <xsl:value-of select="format-number((@Pressure * 10.0), '00000')" />
                    <xsl:value-of select="format-number(((@TemperatureC + 273.15) * 10.0), '0000')" />
                    <xsl:value-of select="format-number(@Humidity, '000')" />
                    <xsl:value-of select="format-number(@RawRanges,'0000')" />
                    <xsl:text>0</xsl:text>
                    <xsl:text>0</xsl:text>
                    <xsl:text>0</xsl:text>
                    <xsl:text>00</xsl:text>00
</xsl:template>
</xsl:stylesheet>
```