Overflight: OVERFLIGHT PREDICTION AND ANALYSIS SOFTWARE

GMV's ***Overflight*** COTS software is a software application that calculates **overflight events** for a set of satellites over a set of points/zones at Earth's surface. The software presents two main functionalities:

- **estimation of overflight events over regions of interest**: the software computes time intervals in which a point or a polygonal zone over the Earth's surface is visible by the objects defined in a catalogue of satellites of interest.
- **estimation of downlink events at defined stations**: The software also computes the moment in which satellites of interest could send acquired information to downlink stations.

The **estimation of overflight events over regions of interest** is characterized by the following technical aspects:

- analysis is performed for all the satellites defined by the user in a catalogue. Orbital information is taken from an input **TLE catalogue** in which objects are identified using the NORAD ID.
- zones of interest are defined by **latitude-longitude points** over the Earth's surface and they can be a single point or a polygonal region.
- satellite swath can be customized for each satellite, considering a **conical sensor pointing to nadir** in which angles of aperture are defined by the user.
- visibility events can be filtered depending on weather or day/night conditions. User is able to input a file specifying periods in which a region is not visible due to clouds. Three types of sensors could be considered: **optical sensors**, which could not observe zones under cloudy or night conditions; **infra-red sensors**, which are capable of taking images at night conditions, but cannot observe through clouds; **radar sensors**, which are not affected by previously mentioned conditions.

The **estimation of downlink events at defined stations** is performed after the computation of visibility events, so that the user is able to know the time at which the information acquired by the satellite sensor is received by the satellite user. It is characterized by the following aspects:

- downlink events for each satellite are calculated for a list of stations taken from a catalogue in which stations are defined by **latitude-longitude coordinates**.
- a **minimum elevation angle** or an **elevation mask** can be considered for each satellite.
    - In the case of the minimum elevation angle, if the satellite is above that angle with respect to one of the considered stations, it will be considered that the data is being sent to the station.
    - The previous concept can be extended by defining a set of minimum elevation angles for different azimuth values, which are linearly interpolated by the software to generate an elevation mask.
- downlink events will be **associated to corresponding visibility events**. For each visibility event, next downlink event occurring for this satellite will be specified in output XML file (if the next downlink exists within the analysis interval).

In terms of run-time performance, considering a single core of a modern server, ***Overflight*** is able to perform an overflight events analysis for regions defined by points in seconds. If the regions of interest are defined by polygonal zones, algorithm is more complex and computation time may rise to some minutes depending on the number of satellites and zones, the time span and the discretization of the FOV.

As end user products, ***Overflight*** generates the following products:

- **ascii events file**, Including a list of all the detected events: visibility of regions, downlink and weather-related events.

```
2023/06/27-11:03:17.459                             FILE UPDATE TIME
2019/01/30-17:00:00.000 2019/01/31-17:00:00.000 COVERAGE
2019/01/30-19:13:36.648 2019/01/30-19:15:13.917 SPA_MVIA_OPT_GUA          AOS/LOS Point Over Earth for satellite MVIA from the sensor OPT in zone GUA
2019/01/31-10:37:55.323 2019/01/31-10:40:40.405 EZS_MVIB_OPT_SWI          Earth Zone Crossing by Swath of satellite MVIB from sensor OPT of zone SWI
2019/01/30-21:56:46.827 2019/01/30-22:04:53.356 SAX_MVIA_MAR_10.0         AOS/LOS Station Event at 10.0 degree elevation, 139.9 degree azimuth for satellite MVIA from station MAR
2019/01/30-23:34:54.133 2019/01/30-23:39:50.572 SAX_MVIA_MAR_10.0         AOS/LOS Station Event at 10.0 degree elevation, 231.6 degree azimuth for satellite MVIA from station MAR
2019/01/31-09:54:21.331 2019/01/31-09:56:05.361 SAX_MVIA_MAR_10.0         AOS/LOS Station Event at 10.0 degree elevation, 81.3 degree azimuth for satellite MVIA from station MAR
2019/01/31-11:27:37.147 2019/01/31-11:36:09.932 SAX_MVIA_MAR_10.0         AOS/LOS Station Event at 10.0 degree elevation, 0.1 degree azimuth for satellite MVIA from station MAR
2019/01/30-20:23:31.656 2019/01/30-20:31:59.591 SAX_MVIA_MUN_10.0         AOS/LOS Station Event at 10.0 degree elevation, 142.3 degree azimuth for satellite MVIA from station MUN
2019/01/30-22:01:05.356 2019/01/30-22:07:50.345 SAX_MVIA_MUN_10.0         AOS/LOS Station Event at 10.0 degree elevation, 218.1 degree azimuth for satellite MVIA from station MUN
2019/01/31-09:45:54.728 2019/01/31-09:54:40.114 SAX_MVIA_MUN_10.0         AOS/LOS Station Event at 10.0 degree elevation, 20.7 degree azimuth for satellite MVIA from station MUN
2019/01/31-11:23:19.798 2019/01/31-11:29:24.345 SAX_MVIA_MUN_10.0         AOS/LOS Station Event at 10.0 degree elevation, 342.6 degree azimuth for satellite MVIA from station MUN
2019/01/31-02:03:31.247 2019/01/31-02:11:23.672 SAX_MVIB_NY_10.0          AOS/LOS Station Event at 10.0 degree elevation, 132.7 degree azimuth for satellite MVIB from station NY
2019/01/31-03:40:28.545 2019/01/31-03:47:26.533 SAX_MVIB_NY_10.0          AOS/LOS Station Event at 10.0 degree elevation, 213.5 degree azimuth for satellite MVIB from station NY
2019/01/31-15:29:23.963 2019/01/31-15:38:13.977 SAX_MVIB_NY_10.0          AOS/LOS Station Event at 10.0 degree elevation, 17.0 degree azimuth for satellite MVIB from station NY
2019/01/30-19:37:02.569 2019/01/30-19:43:00.049 SAX_MVIB_MUN_10.0         AOS/LOS Station Event at 10.0 degree elevation, 102.9 degree azimuth for satellite MVIB from station MUN
2019/01/30-21:11:41.618 2019/01/30-21:20:28.186 SAX_MVIB_MUN_10.0         AOS/LOS Station Event at 10.0 degree elevation, 178.1 degree azimuth for satellite MVIB from station MUN
2019/01/31-08:58:34.853 2019/01/31-09:05:13.476 SAX_MVIB_MUN_10.0         AOS/LOS Station Event at 10.0 degree elevation, 43.1 degree azimuth for satellite MVIB from station MUN
2019/01/31-10:34:22.424 2019/01/31-10:42:52.635 SAX_MVIB_MUN_10.0         AOS/LOS Station Event at 10.0 degree elevation, 3.0 degree azimuth for satellite MVIB from station MUN
2019/01/30-17:00:00.000 2019/01/30-17:27:46.769 DNT_MVIA                  Day Night Terminator Crossing for satellite MVIA
2019/01/30-18:16:24.213 2019/01/30-19:05:19.308 DNT_MVIA                  Day Night Terminator Crossing for satellite MVIA
2019/01/30-19:53:56.751 2019/01/30-20:42:51.846 DNT_MVIA                  Day Night Terminator Crossing for satellite MVIA
2019/01/30-21:31:29.289 2019/01/30-22:20:24.384 DNT_MVIA                  Day Night Terminator Crossing for satellite MVIA
```


Figure 1: Example of ascii events file generated by *Overflight*

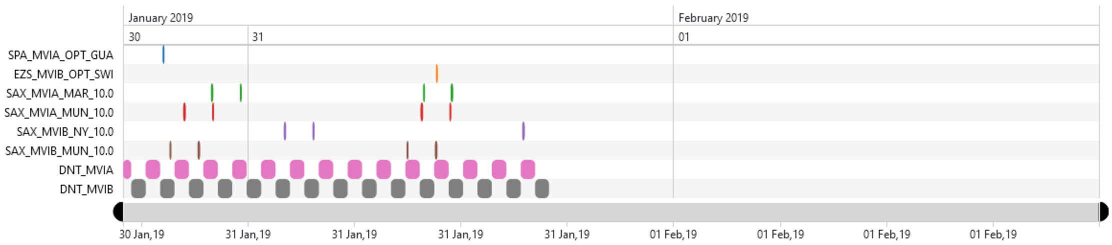

Figure 2: Gantt visualization of the ascii events file generated by *Overflight*

- **Overflight XML file** including a summary of all the relevant information of the analysis in XML format.


```
<Data>
  <START>2019/01/30-17:00:00.000</START>
  <END>2019/01/31-17:00:00.000</END>
  <OVERFLIGHTS lenght="2">
    <record index="1">
        <OVF_ZONE>GUA</OVF_ZONE>
        <OVF_COORDS lenght="1">
          <point index="1">
            <COORD_LON>   4.005705</COORD_LON>
            <COORD_LAT>   0.709476</COORD_LAT>
          </point>
        </OVF_COORDS>
        <OVF_SAT>MVIA</OVF_SAT>
        <OVF_COUNTRY>MOROCCO</OVF_COUNTRY>
        <OVF_TYPE>Optic</OVF_TYPE>
        <OVF_START>2019/01/30-19:13:36.648</OVF_START>
        <OVF_END>2019/01/30-19:15:13.917</OVF_END>
        <OVF_DS stat="MAR">2019/01/30-21:56:46.827</OVF_DS>
    </record>
    <record index="2">
        <OVF_ZONE>SWI</OVF_ZONE>
        <OVF_COORDS lenght="4">
          <point index="1">
            <COORD_LON>   0.106465</COORD_LON>
            <COORD_LAT>   0.837758</COORD_LAT>
          </point>
          <point index="2">
            <COORD_LON>   0.104720</COORD_LON>
            <COORD_LAT>   0.785398</COORD_LAT>
          </point>
          <point index="3">
            <COORD_LON>   0.191986</COORD_LON>
            <COORD_LAT>   0.785398</COORD_LAT>
          </point>
          <point index="4">
            <COORD_LON>   0.191986</COORD_LON>
            <COORD_LAT>   0.837758</COORD_LAT>
          </point>
        </OVF_COORDS>
        <OVF_SAT>MVIB</OVF_SAT>
        <OVF_COUNTRY>MOROCCO</OVF_COUNTRY>
        <OVF_TYPE>Optic</OVF_TYPE>
        <OVF_START>2019/01/31-10:37:55.323</OVF_START>
        <OVF_END>2019/01/31-10:40:40.405</OVF_END>
        <OVF_DS stat="NY">2019/01/31-15:29:23.963</OVF_DS>
    </record>
```


Figure 3: Example of XML file generated by *Overflight*