Development of a methodology for deriving Plasmaspheric Total Electron Content from In-Situ electron density measurements in highly eccentric equatorial orbits

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Total Electron Content (TEC) measurements yield very high values in the Near-Equatorial regions, which extends approximately ± 20^0 - 25^0 on either sides of the magnetic equator. Ironically, the bulk of the research on TEC profile and behaviour has been carried out with respect to mid-latitude regions. Recently, efforts have been undertook by the scientific community in the equatorial belt as well as the international community to carry out research in this area, especially so after the advent of the GNSS such as GPS and their widespread usage. Nevertheless, much more studies need to be done.

The contribution of the Upper Plasmasphere (the altitudes above semi-synchronous orbit height up to the Plasmapause height) to the TEC at any given location has been and continues to be an un-quantified component. So far, as TEC could not be measured directly and needs to be derived from other parameters, it has not been possible to derive this component from traditional methods such as incoherent scattering radars, ground based ionosondes, satellite sounders and GNSS dual frequency measurements. Dual frequency measurements from GNSS such as GPS, GLONASS and Galileo cannot be employed as the Upper Plasmaspheric altitudes are above the satellite orbit altitudes of these GNSS.

The PEACE instrument in the Chinese – European Space Agency Double Star TC1 (Tan Ce 1) satellite and its highly eccentric equatorial orbit provide an excellent opportunity to build Upper Plasmaspheric TEC components in the Equatorial region from empirical in-situ measurements of electron density along the orbit in the 20000km to 40000km altitude range.

The high eccentricity and the low perigee, high apogee of the TC1 orbit and the resulting smaller incident angle the orbital trace makes while in the above altitude range resulting from it provide the ideal geometric opportunity to build the methodology and utilise the in-situ electron density measurements for the calculation of the Upper Plasmaspheric TEC component.

Furthermore, the suitability of the variation of the Inclination Angle of the mission makes TC1 an equatorial mission that was very much confined to the Near-Equatorial region approximately ± 20^0 - 25^0 on either sides of the magnetic equator. As the most pronounced absolute TEC values and variations are within this region, TC1 data offers an excellent opportunity to build a TEC database of this region.

The methodology developed and presented in this research generates a first time ever (comprehensive) database of Upper Plasmaspheric TEC components along the orbital path of the TC1, using a methodology of approximation equating arcs of the orbits to straight-line TEC Bars, which utilizes highly complex and advanced mathematics. This research aims to develop this methodology as such that the Plasmaspheric TEC component can be determined by applying it on the in situ measurements of electron density measured by any satellite having an eccentric elongated orbit.