

## Ionospheric Shock Waves Triggered by Rockets

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This paper present the unprecedented detail of the two-dimensional structure of shock waves resulting from the rocket transit in the upper atmosphere using the time rate change of the total electron content (TEC) derived from dense networks of the ground-based GPS receivers around Japan and Taiwan. From the 2-D TEC maps constructed for the 2009 North Korea Taepodong-2 and 2013 South Korea Naro rocket launches, the V-shape TEC shock wave fronts, with period of 100-600 sec, produced by the propulsive blast of the rocket are seen immediately and propagating perpendicular outward from the rocket trajectory with velocities between 800-1200 m/s. Along the trajectory, clear rocket exhaust depletion of TEC is seen and it propagates northward with a initial velocity of 155 m/s followed by a reduced velocity of 51 m/s, consistent with the background neutral wind predicted by an empirical wind model. After the 10-20 minutes of the rocket transits, the bow and stern waves evolved from the initial blast shock wave front are seen with velocities exceeding 1000 m/s.

Keywords: ionospheric shock wave, rocket exhaust depletion of ionospheric TEC