**6.6 Interoperating and Interworking with Other Wireless Solutions**

**6.6.1 Satellite Communications**

Satellite communications technologies have features which can be used for many of the use cases identified for the Smart Grid. For example, satellite services are available throughout North America and cover 100% of the conterminous United States. This means that the same user terminal can work anywhere in any rural or urban location.

Furthermore, since satellite communications is independent of any local infrastructure it is ideal for emergency response and restoration, as well as for a redundant path to support highly reliable communications.

Satellite communications systems all operate in licensed-band spectrum. Mobile Satellite Services (MSS) spectrum is available in L-band and S-band and includes both Geostationary Earth Orbit constellations as well as Low Earth Orbit constellations. Fixed Satellite Services (FSS) spectrum includes C-Band, Ku-Band, and Ka-Band. Fixed satellites are generally in the Geostationary Earth Orbit. FSS is becoming a misnomer as portable, transportable and fully mobile terminals are routinely supported.

The one way path delay between a user terminal and a geostationary Earth orbit satellite is between 117 ms and 135 ms. The round trip latency due to propagation between a remote terminal and a gateway hub station is between 468 ms and 540 ms. In addition to propagation there are processing and queuing delays which are dependent on the specific implementation. This delay is acceptable for most Smart Grid applications. While some latency is tolerable, certain events have to be logged with an accurate time stamp. The mobile satellite technologies are completely integrated with the GPS system for routine functions like spot beam selection and paging area location and many terminals are required to have GPS receivers. The fixed satellite technologies are not required to have a GPS receiver but are routinely integrated with GPS depending on the application. Therefore, accurate GPS time is available for time stamp.

The ubiquitous nature of satellite communications means that repair crews can use satellite terminals or handsets anywhere in the United States where such crews may be dispatched in the event of emergencies. Mobile terminals in both MSS and FSS bands can be used at speeds up to 1,200 km/hour with Doppler compensation but are more routinely used below 100 mph (160 km/hr).

In order to close the link and provide adequate margin, MSS satellites all deploy on the order of hundreds of spot beams throughout their coverage areas. Not only do spot beams provide improved satellite EIRP and G/T but also increased capacity with frequency reuse. New fixed satellites feature similar numbers of spot beams.

Several MSS terminal types are small handheld devices similar to a cell phone having low antenna directivity. These are ideal for emergency crew dispatch. Both data and voice are supported, though the available bandwidths are commensurate with the antenna gain performance and terminal type.

Satellite communications typically rely on line of sight propagation. Fading from foliage and imperfect terminal orientation is tolerated in low directivity handheld terminals used in MSS. Some MSS terminals have several dB of directivity and operate best when oriented properly and may really be considered transportable. These terminals can support up to 590 kbps of data in the forward direction or downlink direction from satellite to terminal and 186 kbps in the return or uplink direction from the terminal to the satellite. These data rates exceed the required rates.

Many MSS networks employ the 3GPP Iu-interface between the radio access stratum and the core network non-access stratum. The physical and media access control layers are optimized for the satellite radio propagation characteristics but the higher layers are integrated. MSS terminals can be dual-mode satellite/terrestrial and have a single shared protocol stack above the radio resource control layer so that mobility management and session management are the same for both modes. Core networks can also be fully integrated sharing the same 3GPP Serving GPRS Support Node (SGSN).

FSS terminals use highly directive offset parabolic dish antennas, between 0.5 and 1 meter in diameter. But they support data rates up to 440 Mbps in the forward link and 16 Mbps in the return link. These terminals are intended for fixed transportable and mobile applications.