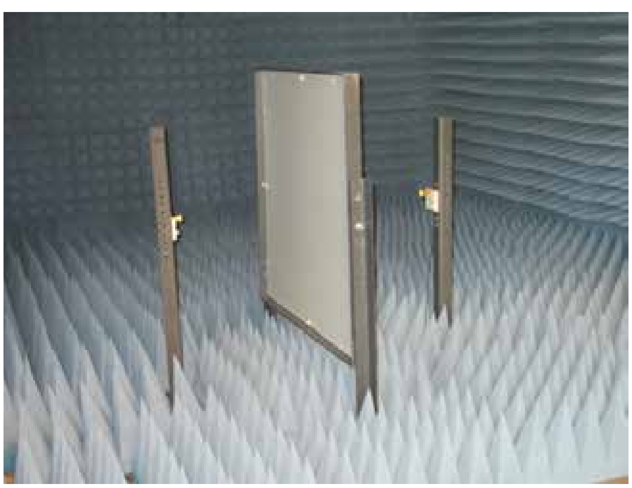
WHITE PAPER

mmWave Performance Behind Fiber Glass Shrouds

Using materials like FRP (fiberglass) to conceal antennas on rooftops is a long-standing practice in the wireless industry. Jurisdictions and wireless operators expect existing concealment materials will work for new mmWave frequencies being used for 5G deployments. This paper addresses how a typical concealment material like FRP performs at mmWave frequencies.

All wireless antennas (panels, cylinders, etc.) come with their own protective cover or radome made of an RF transparent material. When an antenna is hidden behind a concealment material like FRP it acts as a second radome to the antenna. At current sub-6 GHz frequency bands the impact of the FRP to the antenna's performance, transmission loss and antenna pattern distortion, is minimal. With the introduction of mmWave frequencies for 5G, we now need to evaluate the performance impacts of the FRP material on a mmWave antenna.



ConcealFab Testing Capabilities for mmWave

ConcealFab has its own in-house RF test chamber and has developed test methods for evaluating concealment materials from the current sub-6 GHz to the new mmWave frequency bands.

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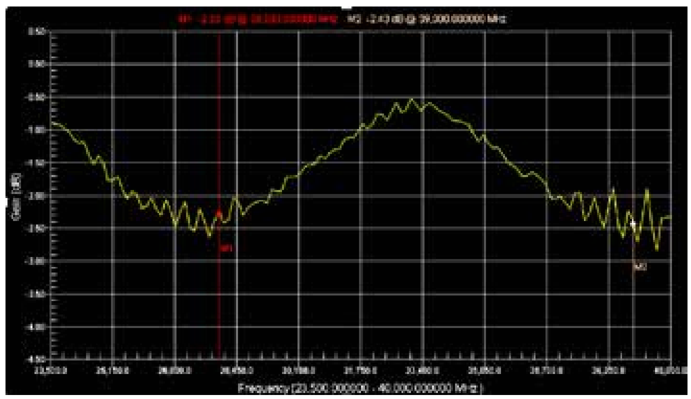
Updated: January 7, 2021

Testing performed at ConcealFab for mmWave includes:

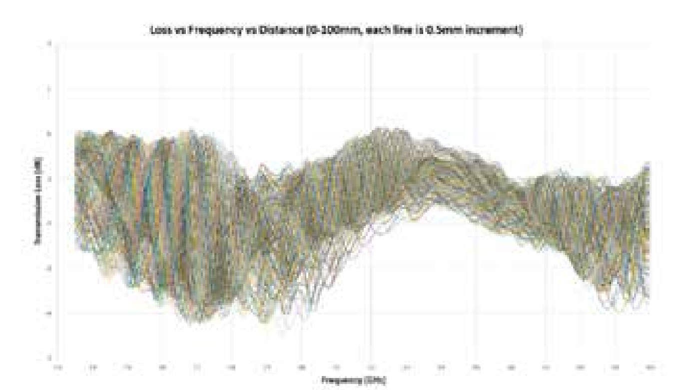
- Far Field Transmission Loss (traditional testing method)
- Near Field Transmission Loss vs Distance
- Array Antenna Patterns

FRP (fiberglass) Test Results at mmWave

The Far Field Transmission Loss plots for FRP at mmWave frequencies (23-40 GHz) show that it may not be suitable as its transmission loss is quite high and dependent on frequency.



The “Cyclone plot” below developed by ConcealFab for Near Field Transmission Loss vs Distance shows that the transmission loss through the FRP is also highly sensitive to the antenna’s distance from the FRP. Each line on the “Cyclone” plot is a transmission loss sweep from 23-40 GHz taken at 0.5 mm increments as the FRP is moved 0 to 100mm, or approx. 4”, from the measurement antenna. It shows that even slight changes in the distance from the antenna to the FRP can lead to large changes in transmission loss. This makes implementation in the field very difficult to setup and maintain.



Lastly, the ultimate test of the performance of FRP as a concealment material at mmWave is with an actual mmWave array antenna. ConcealFab has acquired its own array antenna and has in-house antenna pattern measurement capability to validate the performance of concealment materials with an antenna of similar characteristics of an OEM antenna.

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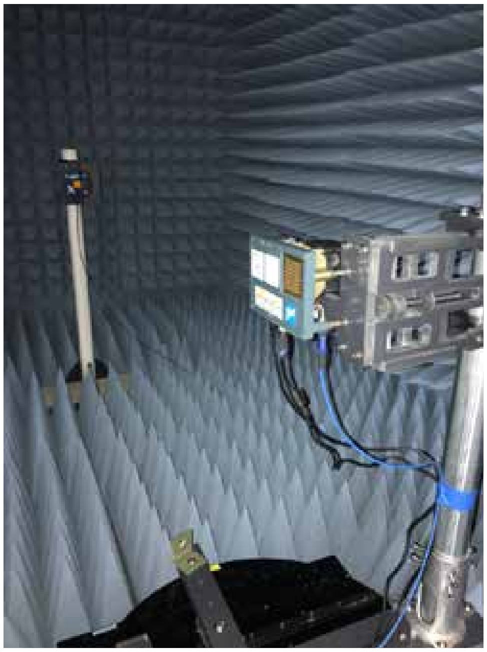
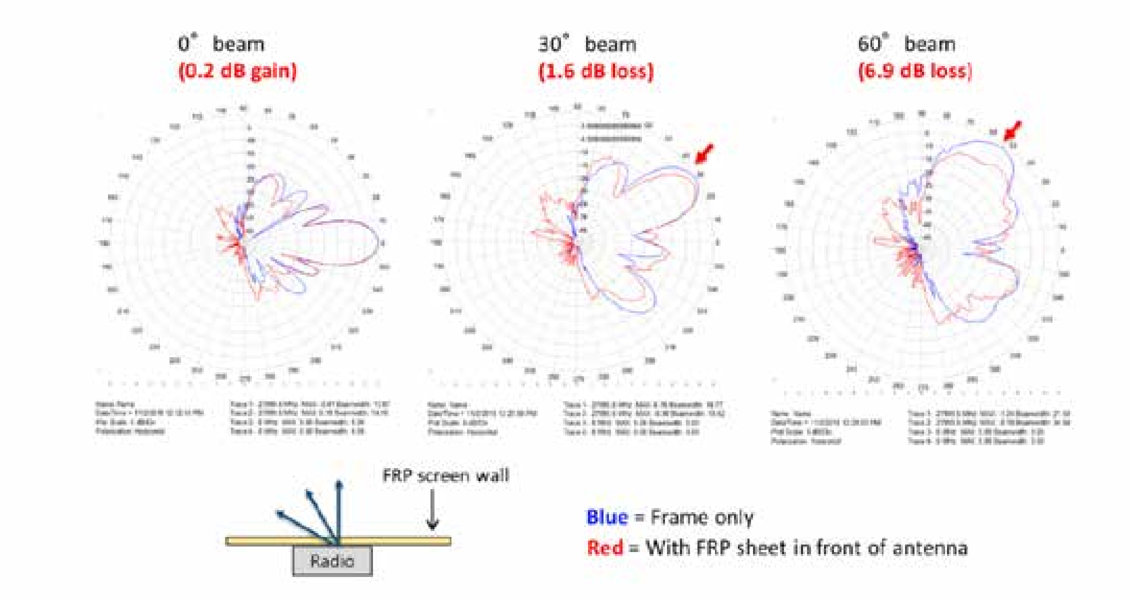


First the antenna patterns were taken with a flat sheet of FRP directly against the face of the array.



While the antenna pattern is good at 0° and has some degradation at 30°, the 60° pattern is clearly degraded. The next set of antenna patterns is with a flat sheet of FRP located 3.45” from the face of the array. The plots show significant amounts of reflection that severely distort the antenna patterns at all beam angles.

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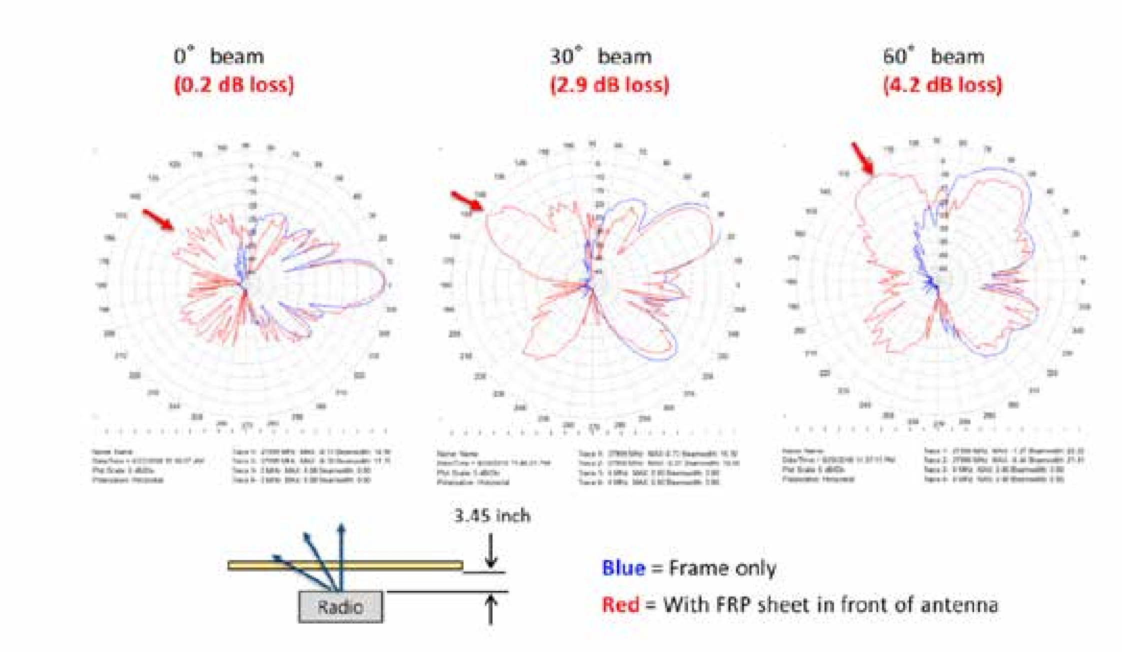
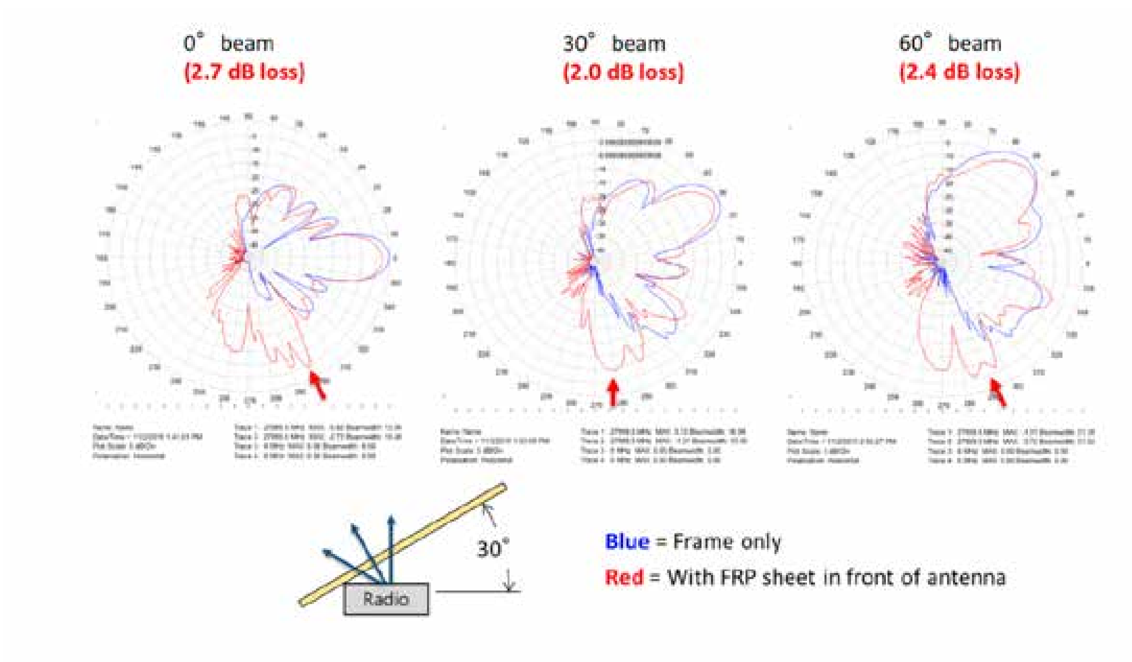
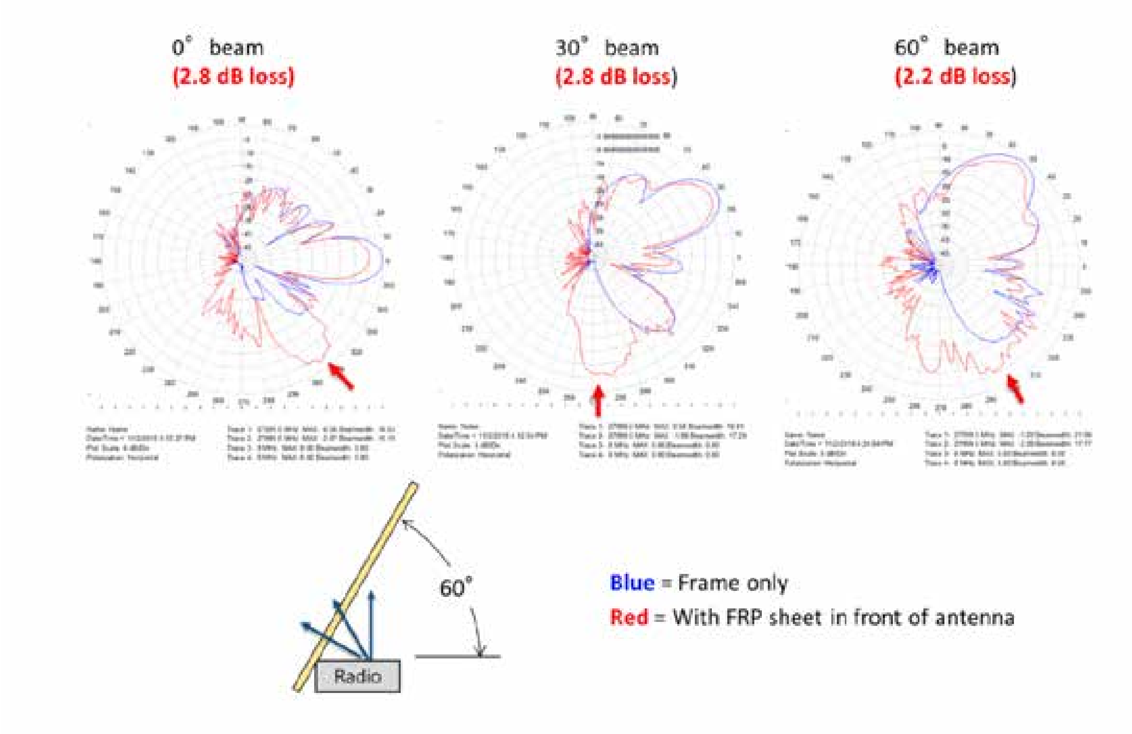
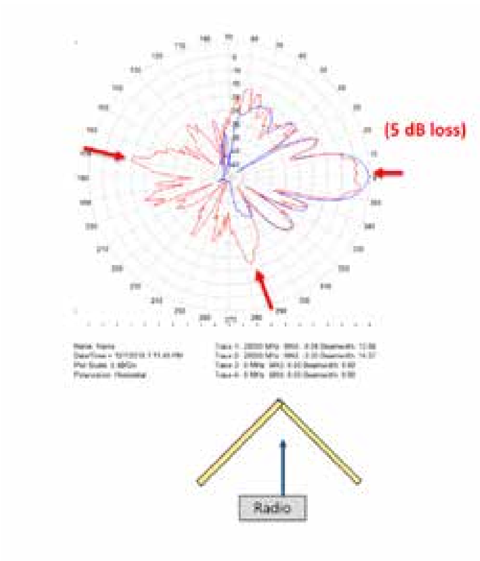


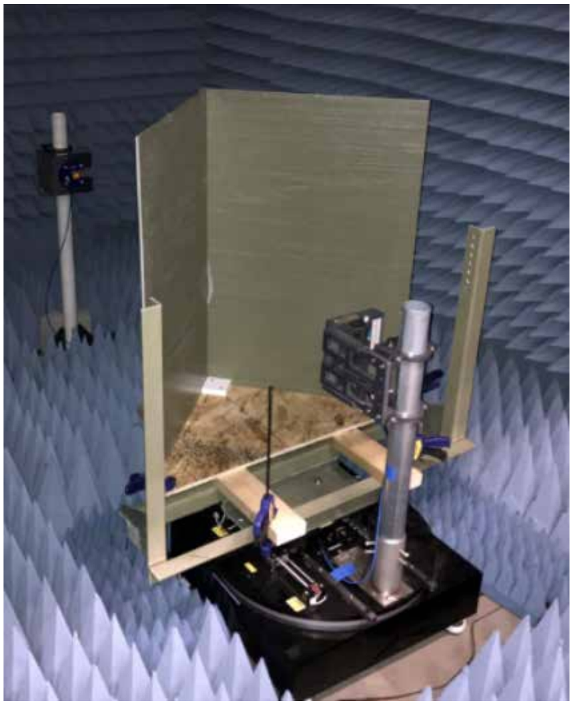
Now the antenna patterns are taken with the flat sheet of FRP at 30° and 60° angles to the face of the array. Again, there is significant distortion of the antenna patterns.

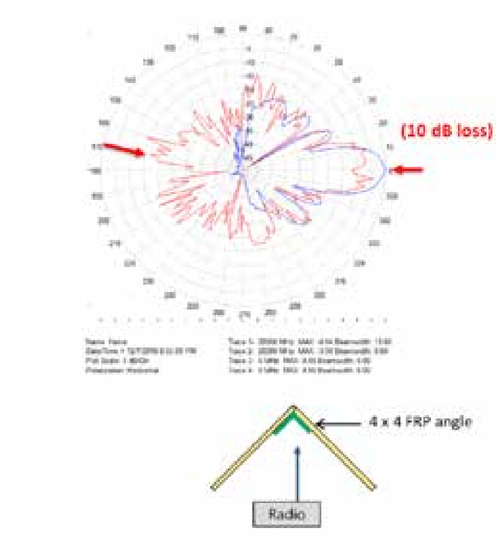


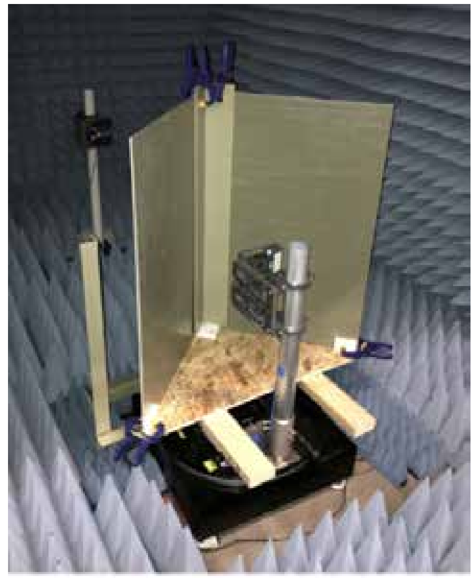


In some instances, an antenna might be shooting out through a corner of the rooftop concealment to maintain the desired azimuth. Below are antenna patterns with the antenna shooting through the FRP joined at a 90° angle, first with the corner unreinforced and then reinforced by a 4x4 angle. Again the antenna patterns show significant degradation.









Conclusions on the performance of FRP (fiberglass) at mmWave

It is clear from this data that FRP exhibits poor performance at mmWave frequencies. So, what is the difference between sub-6 GHz frequencies and mmWave frequencies that leads to such a significant degradation in the RF performance of the antenna? The principal change with the introduction of mmWave is that the wavelength of the RF wave is significantly shorter than for sub-6 GHz frequencies. Typical wavelengths at sub-6 GHz are 2-17" and at mmWave they are 0.3-0.4". A key property that makes for a good RF transparent material is when its thickness is less than 0.1 (10%) of a wavelength which is considered "electrically thin". For ¼" thick FRP, the table below shows its "electrically thin" for sub-6 GHz but not at mmWave.

Frequency (MHz)	600 - 700	850	1900 - 2100	3500	5500	28000	39000
Wavelength (in)	17.00	14.00	5.00	3.30	2.15	**0.42**	**0.30**
FRP thickness (in)	0.25	0.25	0.25	0.25	0.25	**0.25**	**0.25**
Ratio of thickness/wavelength	0.01	0.02	0.05	0.08	0.12	**0.6**	**0.8**

Another factor to consider for RF transparent materials is the antenna beamwidth and radio propagation environment. At sub-6 GHz frequencies, the impact of FRP is less noticeable due to the wide antenna beamwidths (50-90°) and the more favorable propagation environment. At mmWave frequencies, where narrow antenna beams (10-20°) are deployed and the propagation environment is less favorable, the pattern distortion and increased loss of FRP is severe.

In summary, "off-the-shelf" concealment materials like FRP that have been used in the wireless industry for decades will often not be suitable for 5G deployments. Concealments need to be custom designed using "mmWave friendly" materials to prevent unwanted pattern distortion and loss. ConcealFab offers a wide selection of optimized mmWave concealments fabricated using its proprietary clearWave™ material. Designs are available to conceal mmWave OEM radios for street level deployment on light poles or for roof-top installations. Please visit ConcealFab's website at www.concealfab.com for additional information on available solutions.