EXHIBIT G

An Analysis of Cell Tower Ice Falls

(www.symdesign.us/icefall)

Dr. Dennis L. Rogers*

April 16, 2013

Abstract: The following is an estimate of the effects of ice falling from cell towers. The velocity of impact and distance of impact from the tower are calculated for the type of ice fragments expected due to freezing rain on the flat surfaces of the tower and antenna structures. These calculations are not intended to be comprehensive but do show the magnitude of effects to be expected.

Introduction: Freezing rain can cause ice to build up on on the flat surfaces of the antenna elements arrayed around a cell phone tower and also on the tower itself. The photo to the right shows such an antenna array. Since these surfaces are oriented vertically one would expect the ice to form primarily in almost flat sheets oriented vertically to the ground. The thickness of these sheets could be up to 6 cm thick due to freezing rain. In what follows I will consider the fate of such a sheet of ice that has detached from the cell tower surface. This could be due to heat from the antenna currents melting a thin layer next to the tower or antenna element. Indeed such ice falls have been observed.

Cell Phone Tower Antenna array in Kent NY.

The Physics: The sheet of ice will be subject to two forces: the downward force of gravity and the force exerted by wind resistance. The force of gravity is constant and equal to:

Eq 1 $F_{grav} = Mg$

where $g = 9.8 \mathrm{m}/s^2$ is the acceleration of gravity, and M is the mass of the ice sheet in kg. In what follows I will assume the use of MKS units in the calculations.

The force due to wind resistance depends on the actual geometry of the piece of ice but is roughly proportional to the area exposed to the wind, A, the square of the velocity, v, at which it falls and the drag coefficient, C_d, which depends on the exact shape of the ice fragment. Using the EIA-222-C standard for calculating wind forces on antenna structures, the wind force can be written :

Eq. 2 $F_{wind} = F_0 A v^2 C_d$

where $F_0 = 0.26 \frac{nt - s^2}{m^4}$

No Wind: The simplest case is where there is no wind blowing. The wind resistance is then only due to the velocity at which the object is falling. The downward acceleration, a, is then given by:

Eq. 3 $$a=\frac{dv}{dt}=\frac{F_{total}}{M}=\frac{-Mg+F_0Av^2C_d}{M}=-g+\frac{F_0Av^2C_d}{M}$$

For the thin sheets oriented vertically, the second term, the wind resistance force, will be negligible and the ice will fall primarily due to the force of gravity. The cases in which the ice sheet is not oriented vertically will not be considered. Assuming a tower height of 50 meters (about 150 ft) and only gravitational forces, the ice sheet would reach a velocity of 31 m/s or about 67 mph before hitting the ground. Assuming the flat surfaces of the antenna structures are 1 meter sq in size and that the ice is 6 cm thick this would result in a piece of ice weighing approximately 54 kg (119 lbs) striking into the ground with a speed of 67 miles per hour. Since the wind resistance is negligible for vertically oriented sheets, this speed will be independent of the size of the ice sheet.

With Wind: With wind, of course, the ice can move in the direction of the wind before reaching the ground. A sheet of ice can experience considerable force from the wind, especially if the flat side of the sheet is perpendicular to the wind. In this case there is an equation of motion for both the vertical direction and the direction in which the wind is blowing. Vertically the equation is the same as in the no wind case:

Eq 4. $$a_z=\frac{dv_z}{dt}-g+\frac{F_0Av_z^2C_d}{M}$$

while in the direction of the wind:

Eq 5. $$a_x=\frac{dv_x}{dt}=\frac{F_0A(v_w-v_x)^2C_d}{M}-\frac{F_0Av_x^2C_d}{M}$$

where a_x is the acceleration in the direction of the wind, v_w is the velocity of the wind and v_x is the velocity of the ice in the direction of the wind. The first term is the force on the windward side of the sheet and the second term is the force on the opposite side of the sheet due to normal wind resistance. The amount the ice travels in the direction of the wind depends on the thickness of the sheet, with thinner sheets traveling further. These equations have been solved to determine the amount of travel in the direction of the wind that the ice sheet would travel before impacting the ground. Again assuming a 1 meter-sq sheet, the figure below shows the distance from the tower the ice sheet would fall for four different thicknesses and weights:

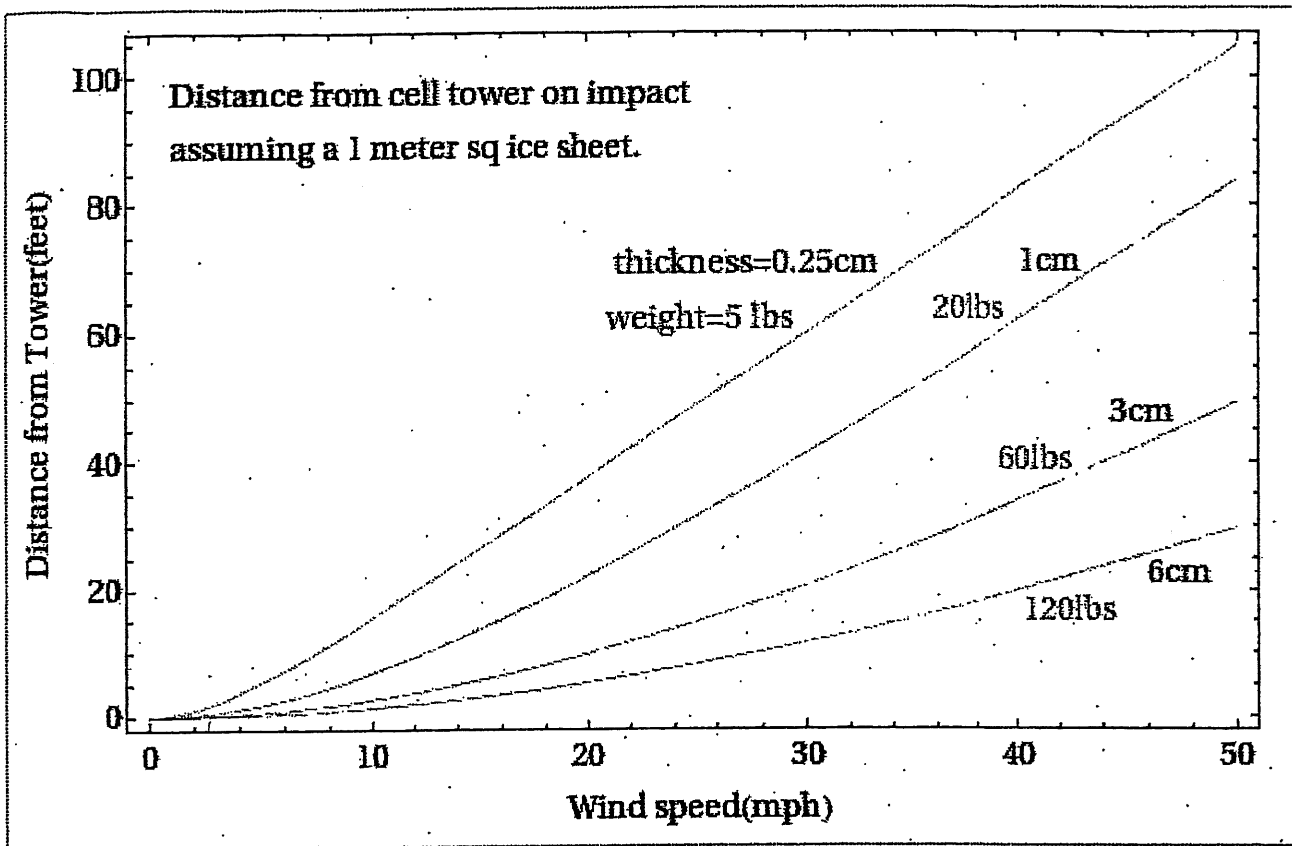

Figure 1. Distance of ice fall from tower vs wind-speed for four different sheet thicknesses

As in the no wind case, the ice sheet would be traveling at approximately 67 mph on impact. Obviously, thinner sheets can travel further from the tower. Note also that, since the weight of the sheet is proportional to it's area, the distance it falls from the tower will be approximately independent of it's cross sectional area.

Summary: This analysis has shown that for one case, that of thin sheets of ice falling from the vertical part of the antenna structures, the ice fall can be a dangerous problem with the ice fragments weighing over a hundred of pounds impacting the ground at almost 70 mph. It also shows that wind conditions can cause these fragments to fall as much as 100 feet from a 150 foot tower with smaller, thinner sheets falling the furthest distances. Of course, as the photo to the right illustrates, in reality the problem can be more complex with the ice fragments being composed of a combination of both snow and ice and the ice build up being more extensive than envisioned in this analysis with possibly even more severe consequences. Therefore care must be taken in positioning these towers to place them sufficiently distant from other structures and places where people may live and work.

Cell Tower Ice build up

* Dr. Rogers received his Phd in theoretical solid stated physics from the University of California at Davis in 1977. Since then he has worked at IBM Research in Yorktown Heights NY for 27 until 2005. Since then he has formed the company Symbiotic Designs and is developing cell phone applications and energy saving devices.