The Boeing Bump Index – Additional Methodologies Recommended

By Michael Gerardi

The Boeing Bump Index (BBI) is a tool frequently used to evaluate pavement roughness on an in-service runway. This tool is commonly associated with the FAA Advisory Circular FAA AC-5380-9. This article was written to help readers understand the limitations of the BBI and to demonstrate that relying exclusively on this tool could result in misdiagnosing a potentially serious runway roughness problem. This article will illustrate two examples where the BBI failed to accurately characterize roughness. The first is in a single roughness event that consistently produced pilot and passenger complaints. The second example demonstrates the BBI's inability to accurately characterize multiple-event roughness. While this article illustrates some critical flaws in the BBI, we do appreciate the FAA's attempt to provide the industry with some relevant guidance on runway roughness. However, we believe that the results of the BBI are being accepted without further consideration, and as demonstrated in the following article could lead to additional concerns. When evaluating ride quality issues, the BBI should not be the only method or technology considered.

The basics of the BBI is that it simply compares a roughness event's wavelength verses its amplitude and categorizes that combination as either "Acceptable", "Excessive" or "Unacceptable". This technique was originally used by the Boeing Commercial Airplane Company to help its customers with ride quality issues. In 2009 it was adopted by the FAA as an initial attempt at providing the airport pavement community with guidance on how to characterize airfield pavement roughness.

Due to its nature, the BBI is only effective at characterizing some single-event roughness; single event being a single bump or dip of any wavelength or amplitude. The BBI methodology can be used to categorize that single event in one of the three categories (Figure 1). While this method can be effective in some cases, due of its relative simplicity, it can also misdiagnose roughness events.

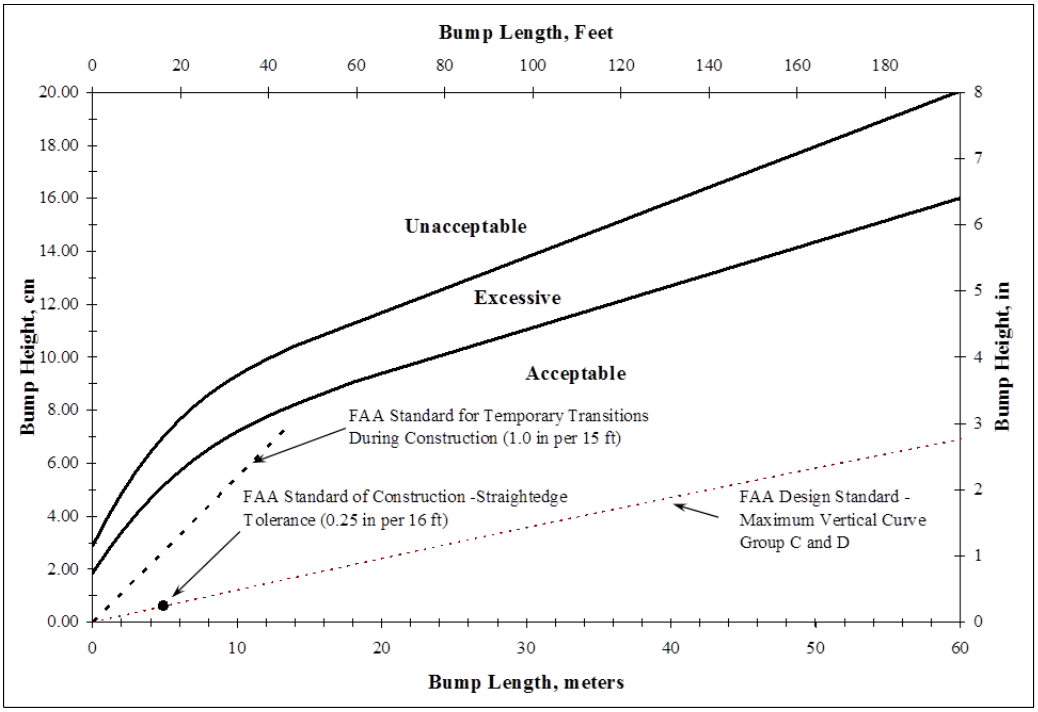

Figure 1. The criteria established by the Boeing Bump Index plotting bump height vs wavelength.

In over 20 years of analysis, we at APR have found that a large number of variables must come together to determine whether or not a runway profile shape can have an adverse impact on aircraft ride quality. For example, let's look at the single bump/dip event that the BBI is capable of categorizing. We have found that the aircraft's response will largely be determined by the location of that event on the runway, and the speed of the aircraft when the event is encountered.

Single Event Roughness

To illustrate this point, let's look at a project in which APR was asked to evaluate an area of roughness that routinely produced pilot and passenger complaints. Figure 2 is a plot of the measured profile of a runway containing a roughness event located approximately 4,800 feet past the runway's threshold. When evaluated with the BBI, it was found to be "*acceptable*" (Figure 3). However, when evaluated using APR's Aircraft Simulation technology, a Boeing 737-800 simulating a 90-knot constant speed taxi found that this event produced .88g at the Pilot's Station and .72g at the aircraft Center of Gravity (Figure 4). Considering that this event consistently produced pilot and passenger complaints, APR's simulation results seem to characterize this event more accurately than the "*acceptable*" rating produced by the BBI.

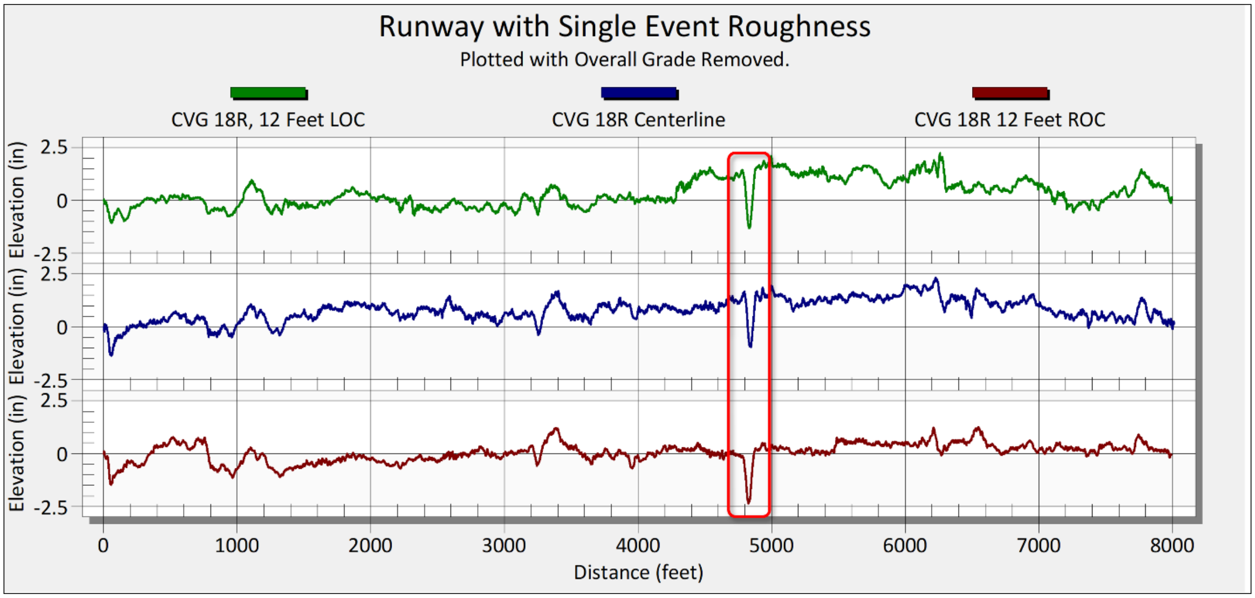

Figure 2. The plotted profile of an event that consistently produces pilot and passenger complaints.

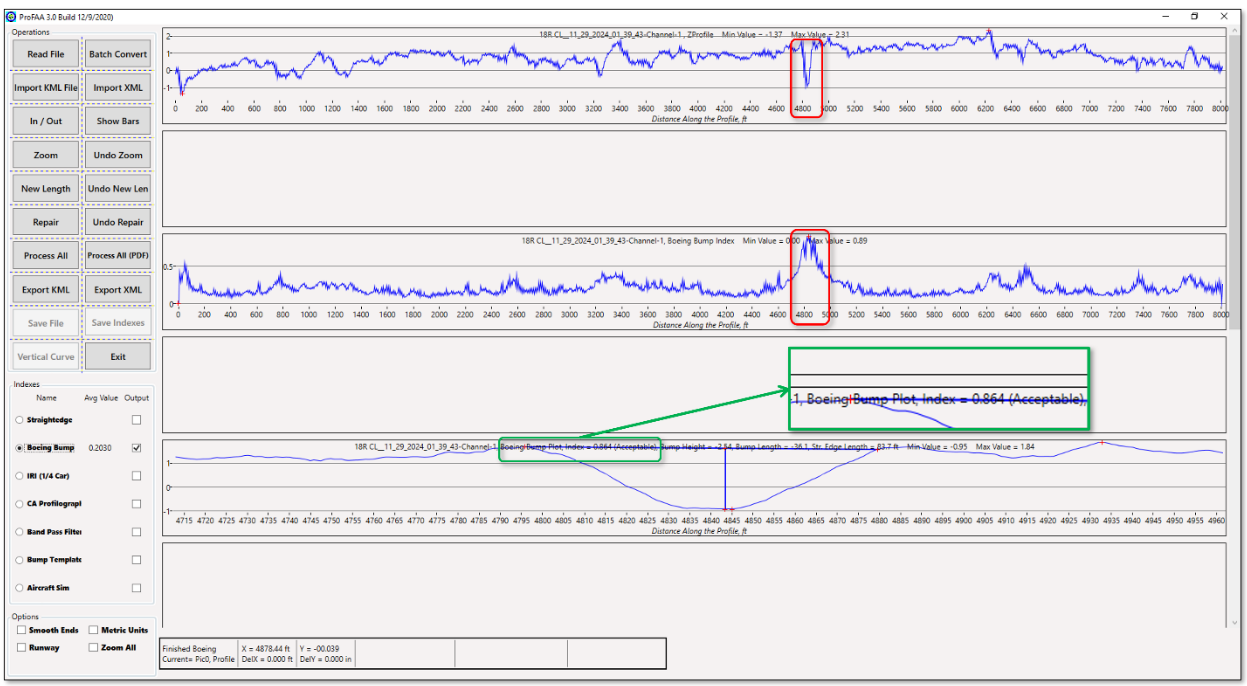

Figure 3. The Boeing Bump Index as computed within ProFAA characterizing this runway as "acceptable".

It is APR's belief that, if possible, this area should be repaired. Every aircraft that encounters this event will impart dynamic loads onto the pavement, which will lower the useful life of the pavement and increase wear and tear on the aircraft that regularly operate from this runway.

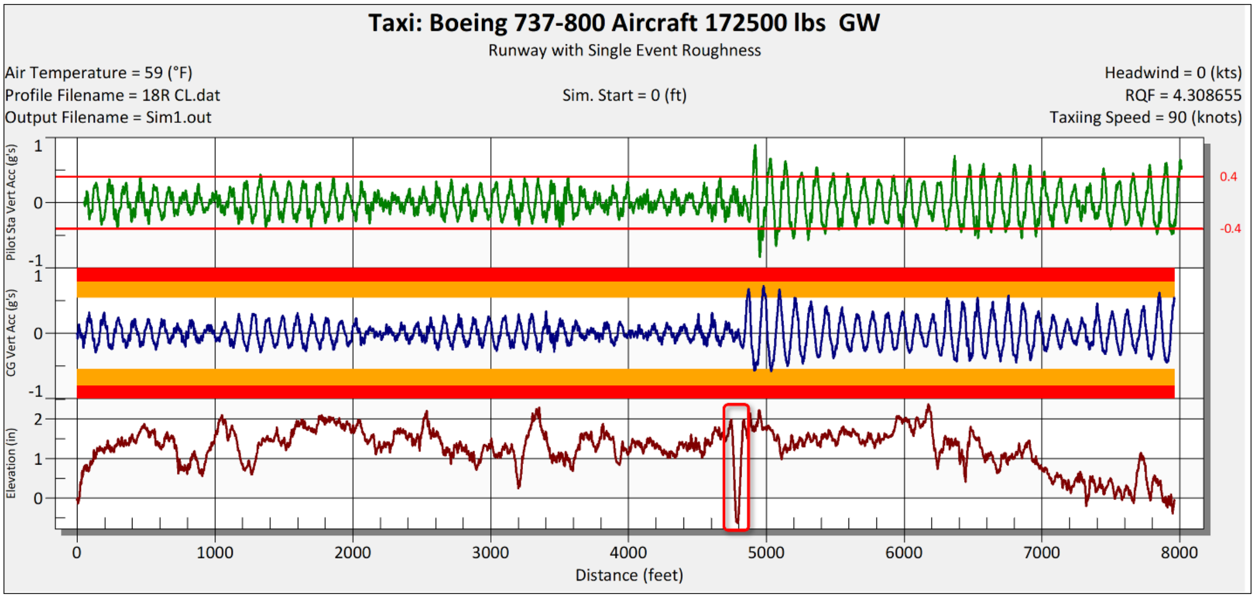

Figure 4. Aircraft simulation of a 737-800 performing a 90-knot constant speed taxi.

Multiple Event Roughness

It has been APR's experience that in most cases where aircraft response is most severe multiple event roughness exists whereby there are multiple bumps and or dips in succession. In this example, two bumps are located in quick succession starting at 2,250 feet from the beginning of the runway. When evaluated with BBI, you can see that this area is characterized as "*acceptable*" (Figure 5).

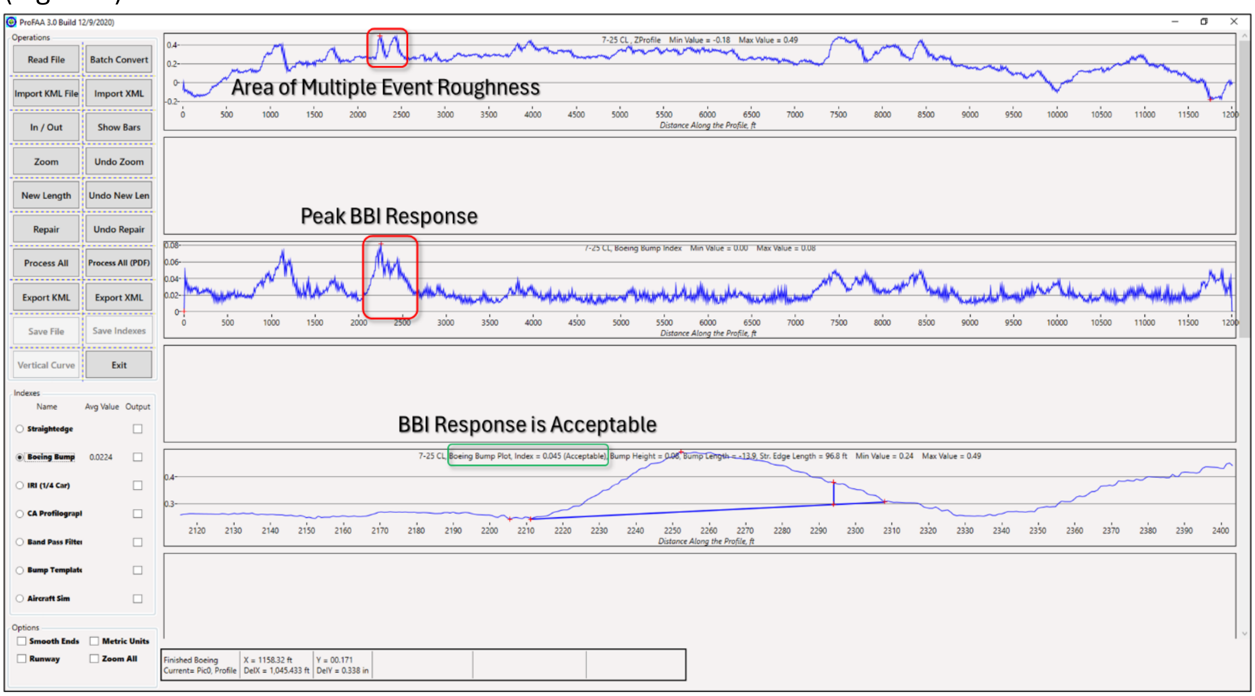

Figure 5. Multiple event roughness of a runway determined as *Acceptable* by BBI.

However, as you can see in Figure 6, aircraft simulation tells a very different story. Here, the cockpit is predicted to experience .82g and the aircraft's center of gravity is predicted to experience .80g of vertical acceleration, considered *Unacceptable* by Boeing's Report on Runway Roughness (Boeing Document D6-81746).

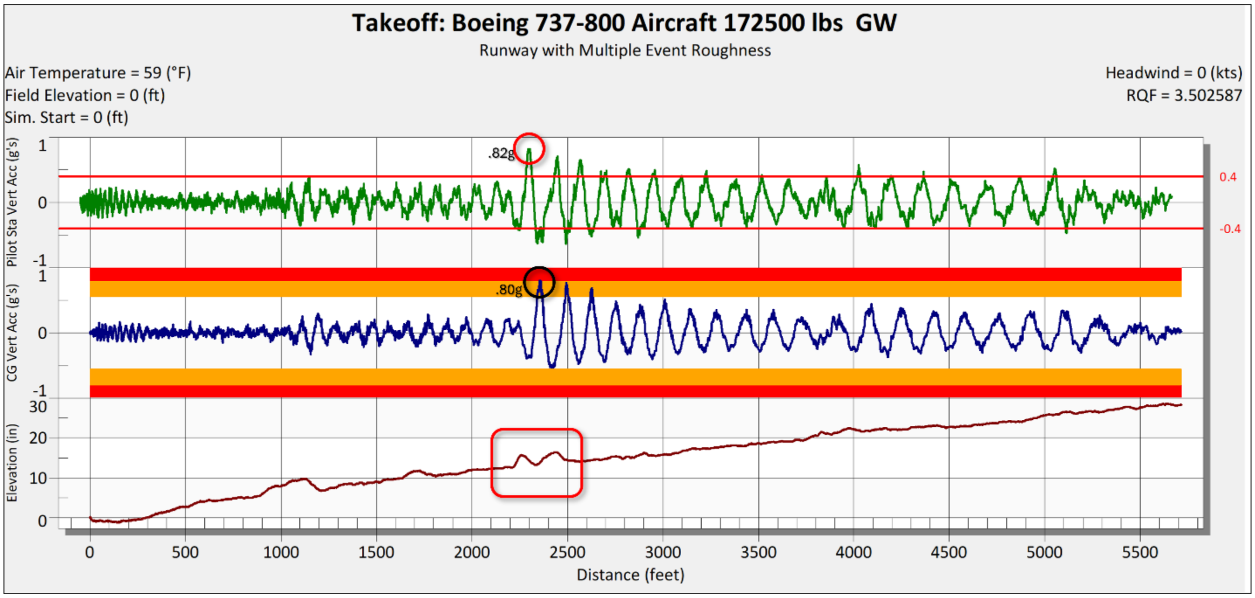

Figure 6. Aircraft simulation predicts excessive responses to this area of multiple event roughness.

As this article illustrates, there are some significant issues to consider when using the BBI to accurately assess a ride quality problem. It is our opinion that the BBI should not be the *only* evaluation method used to quantify suspected ride quality concerns. As demonstrated here, due to its nature the BBI is not effective at accurately characterizing some types of pavement roughness. We applaud the FAA for taking this first step at developing some criteria for roughness, even though it is not the final solution.