What is a good brake pressure profile?

Aggressive application of the brakes is something that separates good drivers from average drivers. Most driver inputs to the car should be smooth, but in big braking zones, like the approaching the front straight chicane at Montreal, a driver should be very aggressive with the brakes. This is especially important in aerodynamic cars. In an aerodynamic car, the higher speeds mean more downforce and more load on the tires. This means that at higher speeds, the car is capable of larger braking accelerations. In order to make use of this, a driver needs to achieve his peak braking pressure very quickly and then release the pressure as the car slows and the downforce decreases. A good brake pressure profile looks like the one pictured below.

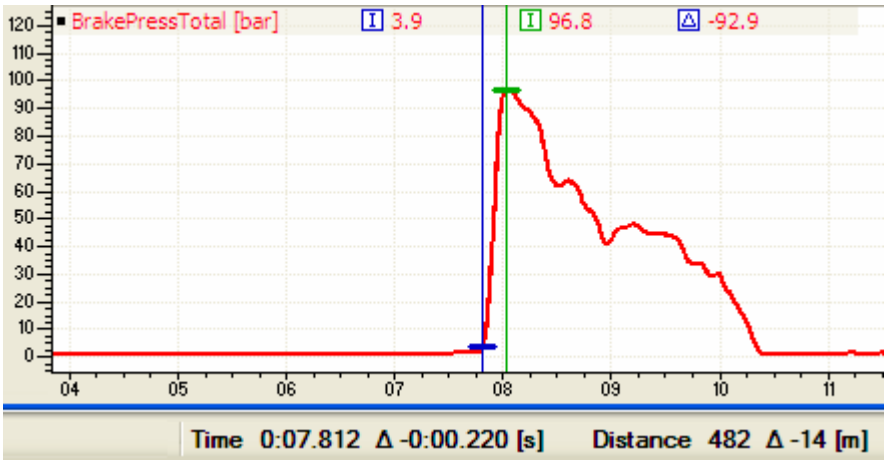


Figure 1 - Good

Notice that this driver takes 0.22s to build maximum pressure. There is still some room for improvement as there are many drivers who are able to build maximum pressure in 0.20s or less. The trace below is an example of bad application and release of the brakes. Notice how the peak pressure is less and it achieved over a longer time period, 0.33s. Also notice that the driver doesn't use the aerodynamic advantage in braking. He holds a constant pressure around 40bar instead of smoothly releasing pressure.

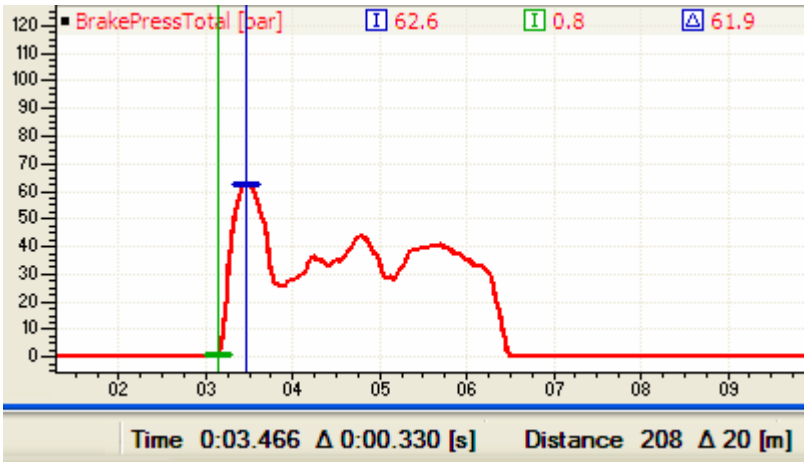


Figure 2 - Bad

How do I measure this using i2 math channels?

To measure how aggressively a driver applies the brakes we can use the Brake Aggression Number. The Brake Aggression Number is derived from the speed at which the driver builds pressure in the brake system. This number is nothing more than the derivative of the Total Brake Pressure channel which gives us the slope of the brake pressure in a unit of [bar/s] or [psi/s].

The Brake Aggression Number channel below reports the slope of the brake pressure gated only in the sections where the brakes are being aggressively applied.

BrakeAggressionNumber

choose((derivative('**BrakePressTotal**' [bar],0.2)>20),derivative('**BrakePressTotal**' [bar]),1/0)

- Look at only sections where over a 0.2s time frame the brakes are being applied with a rate bigger than 20 bar/s
- If the brakes are being applied, return the application rate in units of bar per second
- If the brakes are not being applied, return N/A

To measure how smoothly a driver releases the brakes we can use the Brake Release Smoothness channel. The Brake Release Smoothness is derived from the difference between a smoothed brake trace and the actual brake trace. This channel is gated so that it only returns values when the driver is releasing the brakes so it doesn't penalize a driver who is aggressive with brake application.

The resulting unit is pressure multiplied by 100. In essence the unit is not very meaningful, but the number is good for comparison between drivers.

BrakeReleaseSmoothness

Look at only sections where over a 0.75s time frame the brakes are being released with a rate of 5 bar/s or more

Multiplication by 100 to scale the result for visualization

Choose((derivative('**BrakePressTotal**' [bar],0.75)<-5),
abs('**BrakePressTotal**' [bar]-'**BrakeSmoothed**' [bar]),1/0)*100

If the brakes are being released, return the difference between a BrakeSmoothed channel and the BrakePressureTotal trace. In this case BrakeSmoothed is smoothed using a 0.2s moving average.

Otherwise Return N/A

Do These Channels Really Work?

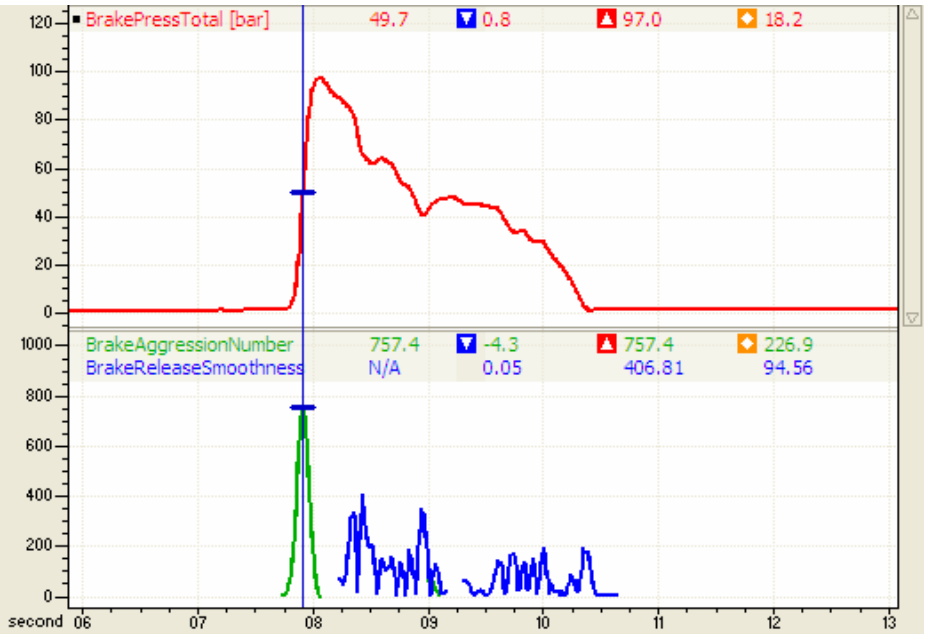


Figure 3 - Good

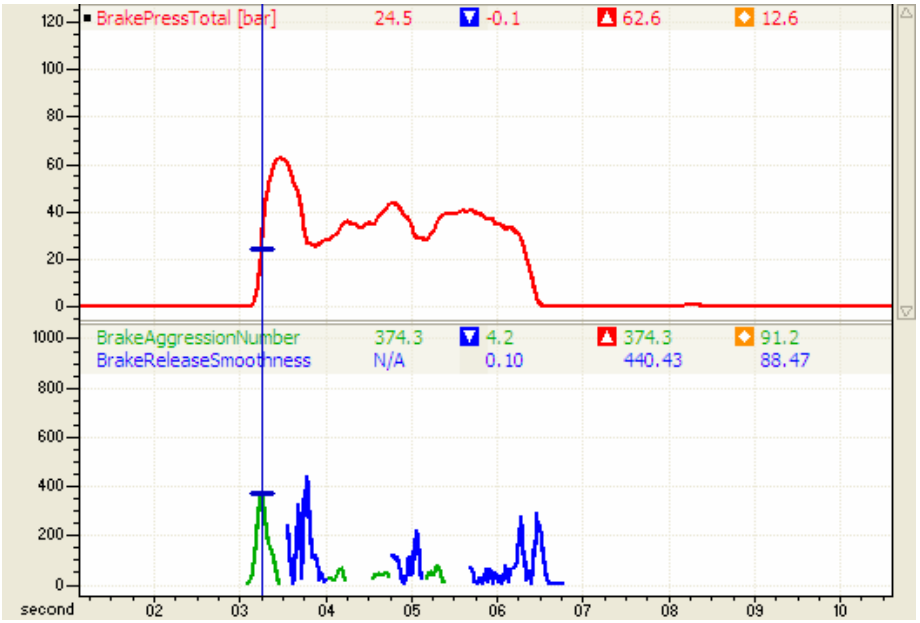
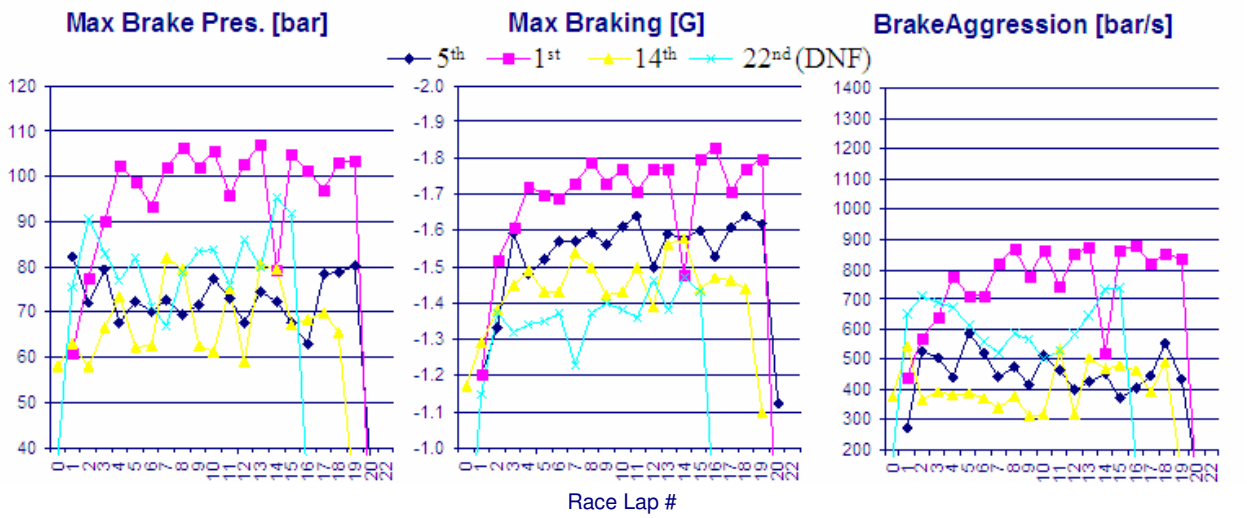


Figure 4 - Bad

Comparing these single braking zones, it is easy to see that the Brake Aggression Number clearly gives a higher value for the better braking profile. The average of the brake release smoothness is 94.5 for the good profile and 88.4 for the bad profile. This is opposite because the smoother the release, the lower the number should be. However, the bad profile is so poor that it is actually broken up into 3 different release sections. The Brake Release Smoothness needs to be used with some caution.

The charts below show the Brake Aggression Number for 4 drivers in the same race. See how the driver with the largest brake aggression number consistently achieves higher accelerations in braking and also achieves higher maximum braking pressure.



Using the channel report function of i2 is easy to create a table showing the following parameters for each lap. These key performance indicators help you keep tabs of the braking performance of your car and driver package.

Channel Report - Braking Key Performance Indicators

		Lap 1	Lap 2	Lap 3	Lap 4	Lap 5	Lap 6	Lap 7	Lap 8	Lap 9	Lap 10	Lap 11
BrakeBias [%]	Avg	54.8	54.7	54.5	53.9	53.7	53.2	53.5	54.4	55.0	55.7	56.7
BrakePressTotal [bar]	Max	97.4	81.5	88.0	97.9	96.7	87.0	97.0	97.0	99.3	94.0	94.4
BrakeAggressionNumber	Max	756.9	665.8	685.5	772.1	770.7	696.2	750.6	757.4	720.7	712.2	760.1
BrakeReleaseSmoothness	Avg	44.52	65.39	76.66	71.57	77.63	90.89	81.88	75.64	80.05	72.86	62.96
BrakingAccel [G]	Min	-1.59	-1.70	-1.70	-1.74	-1.77	-1.65	-1.75	-1.75	-1.74	-1.69	-1.70

Figure 5 - Braking KPIs

Conclusion

Aggressive use of the brakes is important for getting the best performance out of a car. It is also important in races because most passing occurs in the braking zones. The Brake Aggression Number is a channel that you can use to evaluate a driver and keep track of their performance. This channel also helps to determine how the setup of the car effects the ultimate braking performance. Smooth release of the brakes is important to keep the load on the tires consistent and prevent the chassis from moving violently. The Brake Release Smoothness channel helps to coach the driver and track their performance as well as track how setup changes on the car enable the driver to release the brakes more smoothly.

If you found this useful, or have comments, let us know at TechTips@optimumg.com. Our other tech tips are available on the web at www.optimumg.com.