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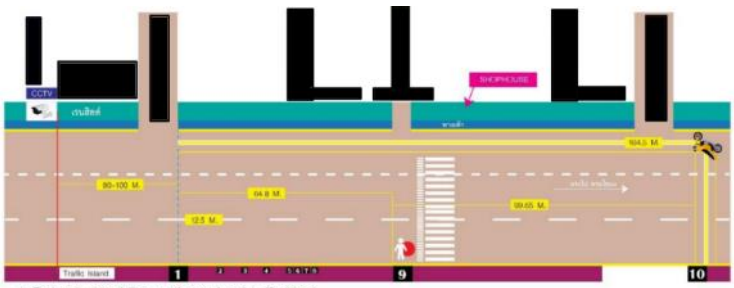
How to reconstruct a motorcycle accident using a combination of numerical simulation validated through crash tests

Back in September 2020, I was asked to provide my expert opinion and reconstruct an accident on a case regarding a traffic accident in Bangkok, Thailand. The accident involved a driver hitting a motorcyclist and killing the motorcyclist, this occurred around 5:20 am and in an area with minimal surveillance and few witnesses. The main point of contention in this case was the speeds of the vehicles at the time of the accident, as there were no speed cameras or any way to access the speedometers to check the exact speeds they were travelling at. Although multiple experts have examined the matter, the quality of the evidence available to them was low and it varied in quality, as some people had access to the original CCTV recordings and others had to rely on a screen recording of the original footage. This led to a variety of results that were inconsistent with one other, as different methodologies were used to calculate speed and some had to compensate for the lower framerate available from lower quality footage.
Because the video analyses were conducted using surveillance cameras, there is a significant risk of misinterpretation, as the time interval between individual images and the distance travelled by the vehicle during this period are difficult to ascertain.
Particularly because the original footage were not available for some of the video recordings, but was filmed with a video camera from the surveillance system's screen, neither the correct time intervals nor the exact time the images were recorded are documented.
Therefore, such analyses are of very limited use. They leave significant sources of error.
In my personal view, information and data applied in a case should be based on the interpretation and application of scientific evidence where in certain cases these are not always given the respect they deserve. The judicial process in certain cases seem to be driven more by the pursuit of outcomes than by a systematic search for truth. Therefore, this study is not intended merely to present a technical analysis, but also to raise critical questions about the reliability and standards of speed determination and forensic evidence assessment in cases where controversial opinions arise through undermining or having disregarded certain scientific findings available. The goal of an accident report must always be to establish objective facts based on physical models and to validate them as best as possible. Only in this way is a reliable, validated reconstruction of the accident possible.

One of the evaluations resulted in a very high speed of 147 km/h for the vehicle, due to wrong interpretation of time and distance travelled.
My approach to this case consisted of analysing the footage, using a computer program to recreate the accident on a simulation basis first.
To validate the simulations, we conducted a real-life crash test using identical vehicles.
I shall explain the approach I took below and what results I arrived at. I should note that reports like these typically aren't often published, due to the confidential nature of such matters, but I am able to share my work with you today on a no name basis as I testified and submitted a report on these matters in court in March 2025.
I would also like to point out that this method of simulating the entire accident scenario is frequently used in both, research and court proceedings. Since this method allows for the detailed reproduction of all movement sequences. All traces left on the vehicles, the roadway, and the bodies can be explained and understood in detail, using this method.
Another advantage of this method is that numerical simulations allow for the variation of various parameters that are not precisely known. This makes it possible to narrow down these unknown parameters through the comparison of the movements of the vehicles and persons.
Once the simulation has produced a result that plausibly explains all damage, injuries, and other traces, this scenario is then recreated using the original vehicles at a scale of 1:1 at an appropriate testing area. Identical vehicles are used and the involved persons are replaced by a so-called dummy. This is a replica of people of similar height and weight who move like humans during the crash test. These dummies are also used in the development of the vehicles safety. They have been validated over many years.
This method has also been used for the reconstruction of many accidents like e.g. the accident of Lady Diana in Paris in August 1997.

Coming back to this accident:

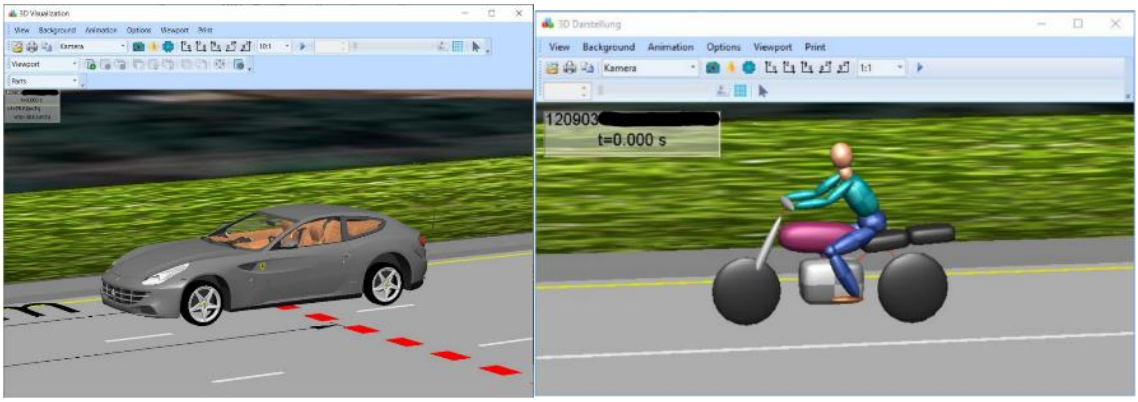
The accident occurred on a stretch of road that was approximately 250 meters long with only one CCTV camera monitoring the area. The motorcyclist was changing from the far left lane (topmost in the diagram) to the far right lane (bottom in the diagram). According to one witness, the motorcycle pulled in front of a car and the witness heard a collision. After this, the car changed lanes from the right lane to the left lane, travelling significantly slower than it did before the collision.



1. Red stain, blood like, on the road and traffic island
2. 2 scrape marks on the road with length of 0.4 metre and 1.2 metre respectively
3. Scrape mark with length of 1.1 metre on yellow street stripes next to the traffic island
4. 1 piece of part of a car bumper
5. Scrape mark with length of 6 metres at the side of the traffic island
6. Scrape mark with length of 1 metre on the road
7. Part of motorcycle's taillight 1 piece
8. Scrape mark with length of 1 metre on the road
9. Body of the deceased with blood pool of approximately 1 litre
10. Motorcycle with shield plate no. [redacted] lying on the road

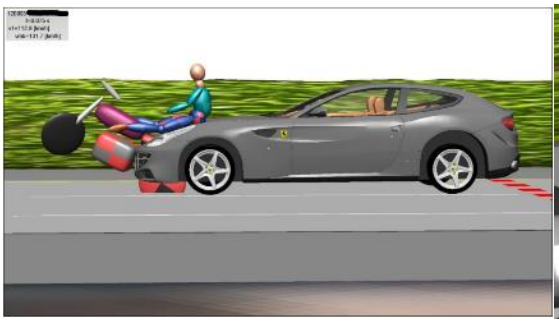
The first step of my analysis was to examine the vehicles involved in the accident. I was provided photos of them and I took note of their respective models, weights and measurements, as well as the height and weight of the motorcyclist. I then analysed the CCTV footage made available to me, which was a screen recording of the original footage. It had a low frame rate of 8 frames, or images, per second, but this was sufficient for me to determine the speeds the vehicles were traveling at. I calculated the motorcycle's speed at 28.944 km/h and the car's speed at 78.5 km/h, this was done by seeing how many lengths a

vehicle moved within a set amount of video frames and dividing it by the amount of time that travel took. The speeds I arrived at were consistent with the accident scene itself, as the first blood splatter on the road was placed where the motorcyclist would have been if he had not been hit by the car. Although this may seem like a conclusive result, this was merely one part of my process and I wished to verify it.
Following this, I used the PC-Crash program to simulate the accident. The model of the car involved in the crash was already present in the program, so it was used as is, but I had to adjust the motorcycle model in the program to fit the shape and weights of the motorcycle in the crash.



The vehicles were then positioned just immediately before first contact, and I ran the simulation. The results of the simulation were consistent with the damage incurred to the actual vehicles involved in the accident: the motorcycle's rear wheel penetrated the car's body and the motorcyclist's head hit the car's windshield, creating significant cracks.

Some experts who examined the case previously estimated higher speeds of 120 km/h or 177 km/h for the car. These speeds would not be consistent with the accident scene or damage done to the vehicles, as the impact would have been much more severe and the damage to both, car and motorcycle would have been much greater.



Although the virtual simulation helped to confirm the speeds I calculated, I further conducted two real-life crash tests as well to validate the simulations.

Test 1

The first crash test involved a different car for cost reasons (Toyota Celica) and a motorcycle of identical type like the motorcycle at the time the real crash.

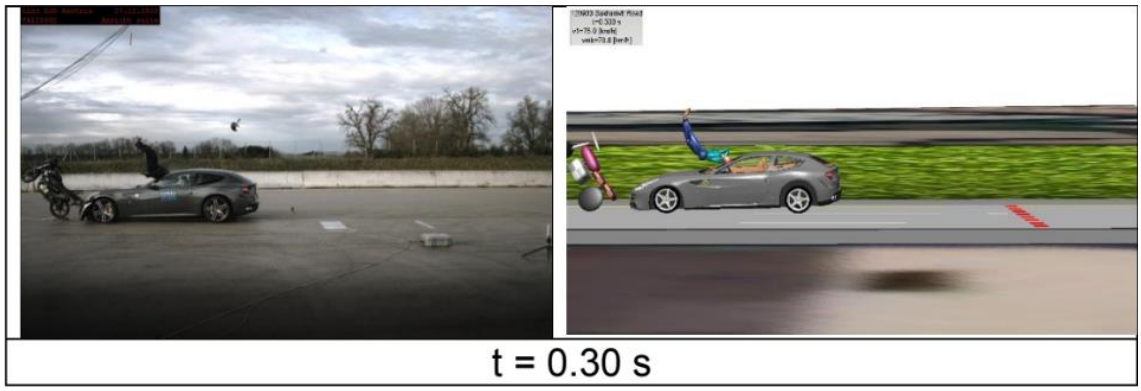
The test was also performed at a speed of 80,1 km/h for the Toyota and 26,7 km/h for the Motorcycle. In the next picture, the head impact of the motorcycle driver on the windscreen can be seen.

The helmet came off because the motorcycle rider did not fasten the helmet strap.

Test 2

In a further step, the test was repeated but with the original Ferrari FF and another identical motorcycle using the same speeds and crash configuration as employed for the first test. Despite the different vehicles, the Toyota Celica had a nearly identical front to the actual Ferrari FF in order to minimise inaccuracy. In this test, the damage was similar to the actual damages, though the motorcycle experienced damage higher up on the rear than in the first test and suffered more damage overall. The damage on the Ferrari was deeper than on the Toyota.

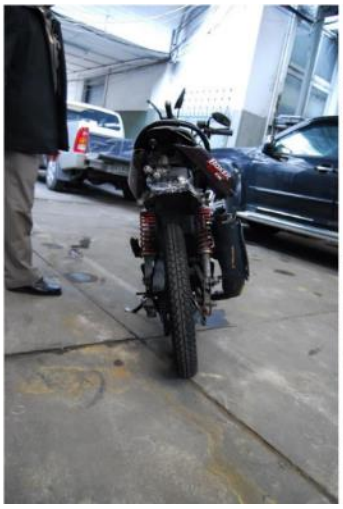
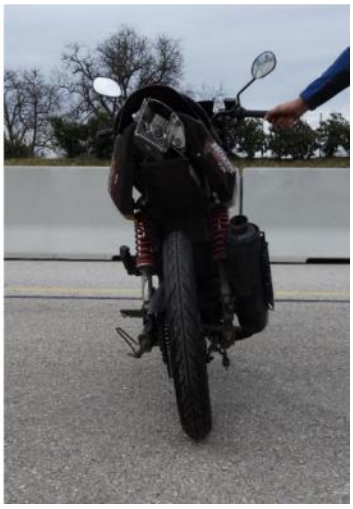
The test involved accelerating the car to 80,1 km/h and the motorcycle to 26,7 km/h. This differs from the speed calculated from the CCTV footage and used in the digital simulation, but this was done to prove the upper limit of the speed the car could have travelled at. The vehicles were placed on a guiding rail and a towing mechanism; the motorcycle was slightly angled to ensure an accurate reproduction of the accident.



This test confirmed both my calculations and the simulation. The damage done to the test car's front bumper matched what was done to the actual vehicle and I confirmed with 100% probability that the car could not have been traveling above 80 km/h at the time of the actual accident. The damage done to the motorcycle was also almost identical to what happened to the actual motorcycle.


The fact that the Ferrari's hood was open after the accident is due to the police opening it during the investigation. No pictures were provided to us, where the hood was still closed. However, it did not automatically open as a result of the collision.

The next pictures show the deformations on the motorcycle (accident vehicle on the left side and motorcycle after the crash test right)

As can be seen on the pictures above, the damages on both vehicles are identical. No deformation of the rear wheel, no wheelbase shortening. Slight deformation of the exhaust system.

Post crash movement of vehicles and victim:

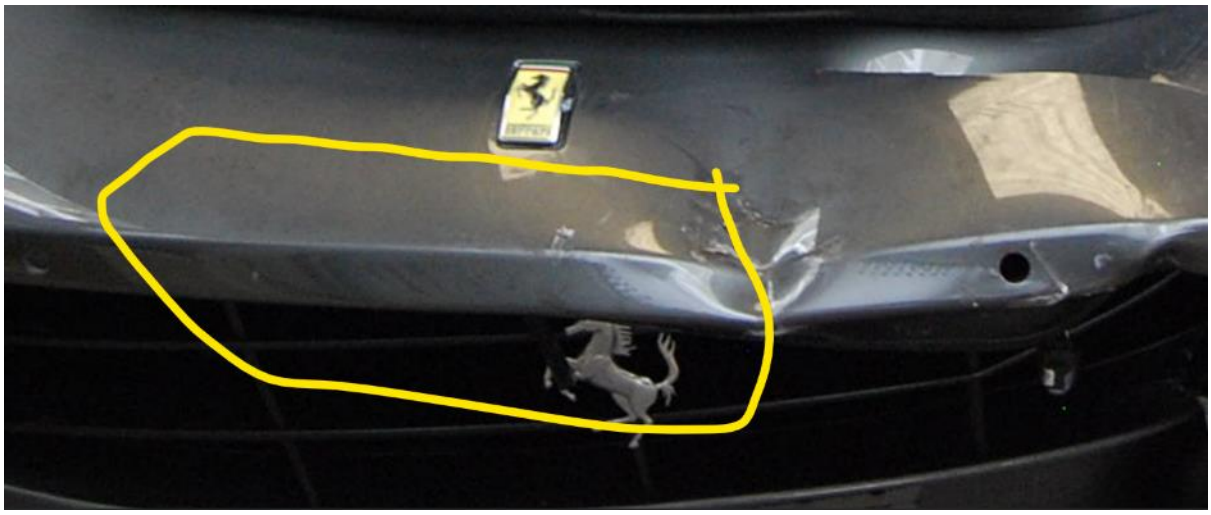
The distance the dummy travelled after the collision was shorter than the post crash travel distance of the motorcycle driver in the accident. But this is likely due to the fact, that the motorcyclist ended up lying on the roof of the Ferrari first.

His body just went down from the roof of the car when the car started braking. Due to the length of the proving ground, only a limited travel distance was available for the car. Thus the dummy fell down from the roof earlier than the victim within the accident.
Thus the car was stopped with a hard braking shortly after the collision. Then the dummy fell down from the roof and landed on the ground.
When looking into the test with the Toyota, more or less the same movement of the victim could be seen. The only difference was, that the roof of the Toyota was a lot shorter than the roof of the Ferrari, why the victim landed on the rear windscreen, where he slid down on the backside of the car.
The test showed anyhow, that the victim landed on the roof of the Ferrari in both tests but it is unknown if and when the actual driver braked after the accident. The longer post-crash distances in the real accident can be explained by the victim being transported on the roof of the car for a certain distance before falling off the vehicle.

Regarding the motorcycle's coasting motion, the following results:

The motorcycle continued to slide practically directly in front of the Ferrari.
In the test with the Toyota, the motorcycle continued to slide in front of the car until the car braked. In the test with the Ferrari, the Ferrari braked before contacting the motorcycle again.

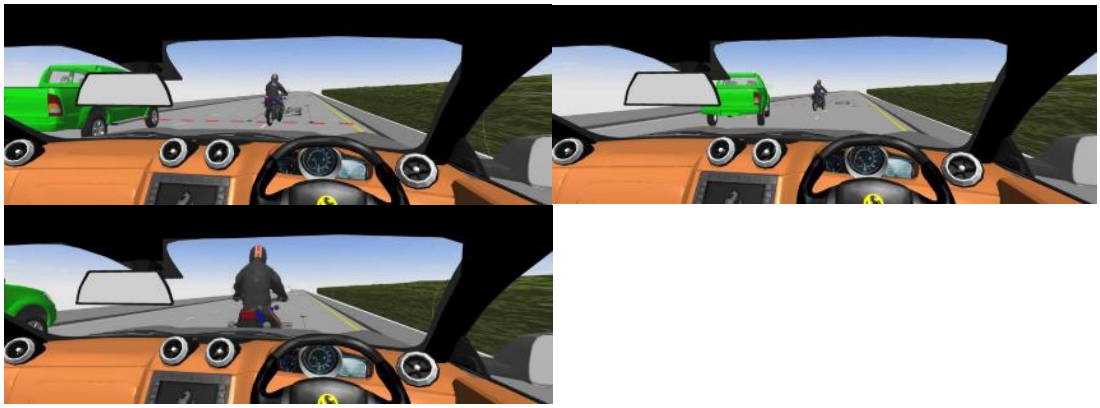
When looking into the pictures of the front of the Ferrari, there were also some contact marks on the right side which could be from the seat bench of the motorcycle.



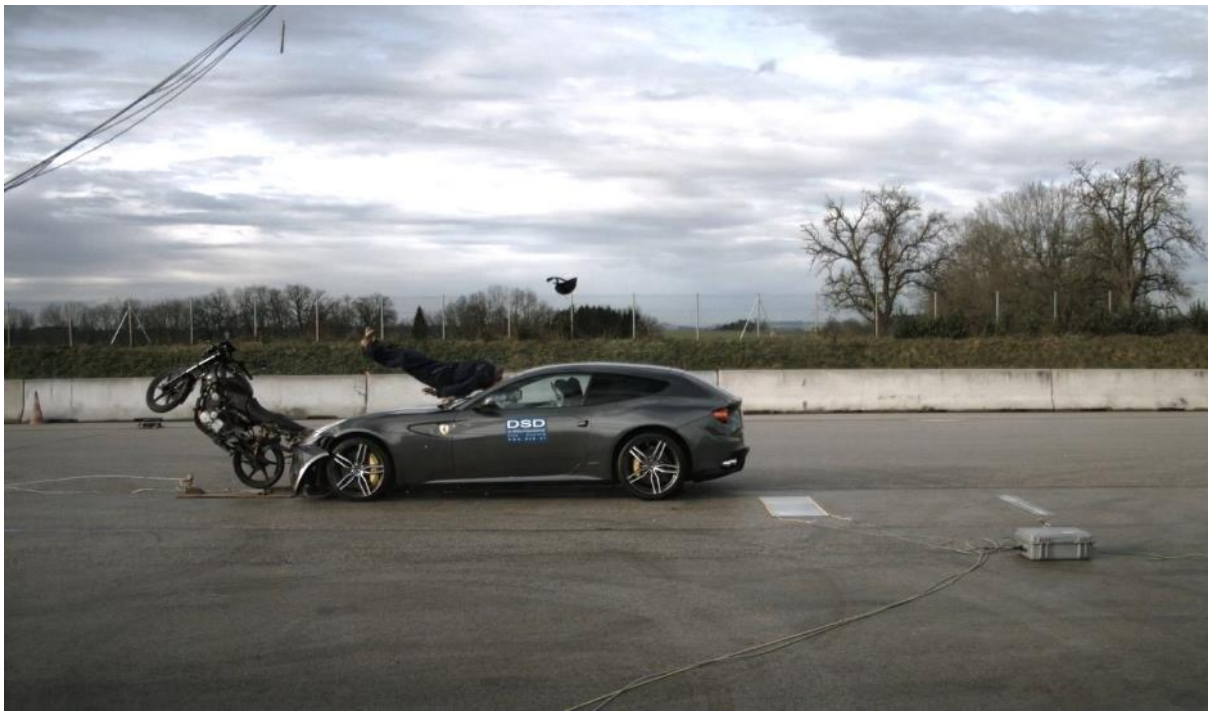
Prevention analysis

There is also the question of whether the crash could have been avoided in the first place. I created a simulation of the traffic at the time of the accident to determine when the driver could have first seen the motorcyclist. There were other vehicles on the road at the time of the accident and it occurred late at night, so the driver's vision would have been limited by these factors. I determined that the motorcyclist would only have been visible about 1.5 seconds before impact, even in good lighting conditions, and would have changed into the driver's lane only 1 second before impact. This accident would have been unavoidable, as there would have been no way for the driver to react in time to this.

The accident could have only be avoided by the driver of the motorcycle by checking, if the lane is free, before he steered his motorcycle into the lane of the Ferrari.



Summary:
The results of my calculations, the virtual simulation and the crash tests were consistent with each other. The damage done to the vehicles in the crash test was consistent with my calculated speeds based off CCTV footage, despite the slight differences in speed between my calculations and the actual speed used in the tests.
Based on the comparison of the deformations of the 2 involved vehicles between crash test and real accident the speeds of the motorcycle and Ferrari can be seen to be less than 80 km/h for the Ferrari and approximately 29 km/h for the motorcycle. Simulations and the crash test show identical results.
The differences between the actual accident and the crash tests regarding post-crash travel of victim and motorcycle can be explained by the driver of the Ferrari not braking in the accident, as he would not have had time to react to the motorcyclist pulling in front of him. He also did not apply a strong brake to his car after the accident, as in such a case the victim would have fallen from the roof of the Ferrari earlier.
As the post crash movement of the motorcycle is 2,5 times longer than the post crash movement of the victim there must have been an external force applied to the motorcycle after the collision to push it further forward.
These crash tests and accident reconstruction are, to my experience, close to perfect in showing how the accident occurred and I can conclude with confidence that the speed of the car and the motorcycle are maximum 80 km/h and 30 km/h.
This case study demonstrates the possibilities available today for reliably reconstructing a traffic accident and validating the results. This makes it possible to demonstrate the exact course of events to the court. The effects of alternative behaviour by the people involved in the accident, from a legal perspective, can also be analysed.
Based on these results, the court has the opportunity to analyse the influence of any misconduct by those involved and to apply the relevant laws.
The responsibilities of the technical expert and the court's jurisprudence are thus clearly separated.
The court can thus make its legal decisions based on sound and validated physical principles. The effects of alternative behavior by those involved are also excellently demonstrated.
One can only hope that such scientific evidence will not be replaced by any reasons, including social or political pressure.
The physical principles for describing such mechanical processes date back to the 17th century and have not yet been refuted.
The current case will be one of the case studies I will definitely address in my lectures at TU Graz and some international Conferences.
It shows the most effective but expensive methods to reconstruct a car to motorcycle accident using latest state of reconstruction technology.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