Report on the Results of the Investigation of Motorcycle Racing Rider Daijiro Kato's Accident at the Japan Grand Prix - the First Race of the 2003 Road Race World Championship Series

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Daijiro Kato Accident Investigation Committee

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1. Overview of the Accident

On Sunday, April 6, 2003, during Lap 3 of the Japan Grand Prix – the first race of the World Road Race Championship Series held at the Suzuka Circuit (Suzuka City, Mie Prefecture), Telefonica Movistar Honda team member Daijiro Kato crashed into the barrier on the left side of the track just before the chicane.

Riding in fifth place, Kato entered the area known as 130R. As he reduced speed to enter the chicane, he suddenly lost control and veered out to the left, causing the left side of his bike to violently collide with the tire barrier, after which he crashed into the adjacent foam barrier. His bike finally stopped at a point 48 meters from the point of initial impact with the tire barrier. The impact of the crash threw Kato off the bike and into the air, and his body landed face upwards on the course 33 meters from the point of impact with the tire barrier (Figure 1).

Kato lost consciousness and was transported in critical condition to Mie Prefectural General Medical Center. However, after two weeks of hospitalization and medical treatment, he died at the hospital on April 20 at 12:42 A.M. of a brain stem infarction.

(1) Name of event: Japan Grand Prix - first race of the 2003 Road Race World Championship Series

(2) Class: MotoGP

(3) Name of accident victim: Daijiro Kato
Team name: Telefonica Movistar Honda
Competitor number: 74

(4) Manufacturer of vehicle involved in accident: Honda
Model name: RC211V
Model year: 2003

(5) Time and date of accident: April 6, 2003 (Sunday), approximately 2:08 P.M.

(6) Weather: Sunny

(7) Road surface condition: Dry

(8) Location of accident: Suzuka Circuit (Mie Prefecture, Suzuka City) FIM (Federation Internationale Motocyclisme)-approved racing course, leaving the area known as 130R and moving into the entrance to the chicane (before the 28th surveillance post).

[label:] Sample
Figure 1: Rough layout of accident site

2. Accident Investigation

Following are the details of the investigation conducted by the Accident Investigation Committee.

(1) Onsite investigation conducted at the Suzuka Circuit

① Received a briefing on the course and race administration from the Suzuka Circuit Motor Sports Division's Section Manager, and conducted an investigative interview

② Interviewed the physician and nurses who administered emergency first aid treatment to Kato at the first aid station at the time of the accident covering the emergency medical services system and the details and circumstances of Kato's treatment on that day

③ Conducted an inspection of the accident site

(2) Investigation conducted at the police station

Interviewed the police officer in charge at the Suzuka Police Station (Mie Prefecture)

(3) Investigation conducted at the medical center

Interviewed the attending physician in charge of Kato's case at the Mie Prefectural General Medical Center

(4) Physical check performed on the motorcycle involved in the accident and the riding gear

① Checked the vehicle involved in the accident and all its parts, which are being held at Honda Racing Corp. (HRC)

② Checked the riding gear (helmet, racing suit, gloves, boots, spinal column protector), which is being held at Honda Racing Corp. (HRC)

(5) Analyzed the on-board vehicle data

To ascertain the state of the vehicle during the race, verified vehicle operation and traveling conditions using the following nine vehicle measurements, which were derived from data collected during the race

① Engine speed

② Front wheel speed (rotational speed)

③ Rear wheel speed (rotational speed)

④ Shift load

⑤ Lateral G-force

⑥ Front suspension compression

⑦ Rear suspension compression

⑧ Gear position

⑨ Throttle opening

(6) Image data analysis

The image data shows the spatial placement of the vehicle. Conditions during the race (Kato's vehicle in relation to other vehicles), cruising course position, vehicle inclination (banking), vehicle bearing (yaw angle) and riding position were analyzed using the following four sources of data:

① Image taken from the stands in the 100-meter area before the chicane

② Image taken from the direction of the chicane

③ Image taken from inside of the chicane

④ Image taken by the fixed Suzuka Circuit camera

3. Circumstances of the Accident

3.1 Conditions at the Accident Site

3.1.1 The Accident

Kato veered out in a straight line at approximately 170 km/h from the center-left side of the racing course toward the left side of the course, moved forward diagonally across the grassy area for approximately 17 meters, after which the front left side of his bike struck the tire barrier at approximately 150 km/h at an incident angle of 16.5 degrees. Kato and the bike progressed forward together along the surface of the tire barrier, then crashed into the side of the adjacent foam barrier at approximately 140 km/h.

3.1.2 The Chronology of Emergency First Aid Treatment

14:07:59 Accident occurs
(16 seconds elapse)
14:08:15 Rescue team arrives at accident scene
(52 seconds elapse)
14:09:07 Doctor arrives at accident scene
(1 minute, 14 seconds elapse)
14:10:21 Kato transported from the course on a stretcher
(59 seconds elapse)
14:11:20 Kato placed in an ambulance
(1 minute, 15 seconds elapse)
14:12:35 Ambulance leaves accident scene
(1 minute, 12 seconds elapse)
14:13:47 Ambulance arrives at first-aid station
(26 minutes, 3 seconds elapse)
14:39:50 Medevac helicopter leaves first-aid station
(4 minutes, 10 seconds elapse)
14:44:00 Medevac helicopter arrives at hospital (Mie Prefectural General Medical Center)

Kato's emergency first aid treatment began with an initial observation at the accident site, where it was ascertained that he had a pulse and weak respiration. In the ambulance during transport from the accident site to the first-aid station, the doctor and rescue worker immobilized his cervical region, removed his helmet, and performed cardiac massage. At the first-aid station, the doctor and three nurses performed an intubation to secure an airway, started an intravenous drip of lactated Ringer's extracellular-fluid solution, immobilized his cervical region and broken upper left arm, and monitored his vital signs (blood pressure and pulse). At the first aid station Kato was unconscious but breathing spontaneously.

3.1.3 The Tire and Foam Barriers

Safety structures near the accident site include a tire barrier and a foam barrier, separated by a 120 cm gap, that are located on the 200 - 250 cm-wide grassy area on the left edge of the course, along the straightaway that begins near the exit to the 130R and extends to the entrance to the chicane.

The tire barrier consists of two rows of 70 cm-diameter, 20 cm-wide tires, stacked 6-tires high and fixed with bolts, with 1.4 cm-thick, 110 cm-wide rubber belts painted in green, white and red affixed to the surface.

The foam barrier is a large piece of rectangular foam 150 cm high, 200 cm wide and 80 cm thick. The first two foam barriers following the tire barrier are each wrapped in gray vinyl sheeting, followed by seven sets of two foam barriers that are lined up horizontally and wrapped in blue vinyl sheeting advertising "CASIO.". Each of the foam barriers is fixed with thin nylon rope.

Several abrasion marks can be seen running horizontally along the outer surface of the tire barrier Kato struck, as well as blue paint from his motorcycle's cowling and other black matter. The first foam barrier bears the mark where it was struck by his motorcycle (Figures 2 and 3).

[label:] Sample
Figure 2: Tire Barrier and Foam Barrier (Green cone provided for contrast)
Figure 3: Marks of the Collision on the Tire Barrier

3.1.4 Events from the Time of the Collision and Fall until He Came to Rest

Kato remained mounted on his bike as it traveled along the tire barrier, but when his bike struck the adjacent foam barrier he was momentarily caught between the compressed foam barrier and the bike.

As the foam barrier was unable to completely absorb the motorcycle's substantial kinetic energy at that point, the bike flipped forward into the air, springing up higher than the top of the foam barrier, and landing in the grassy area to the left side of the course 48 meters forward from where it initially struck the tire barrier. Following impact with the foam barrier, the bike's fuel tank broke off and landed on the left side of the course near the entrance to the chicane, 12 meters forward and to the right of the final resting position of the bike.

After impacting the foam barrier, Kato was separated from his bike. He plunged head first into the foam barrier, and was then thrown into the air. Rotating horizontally through the air in the manner of a discus, he landed face up in the center of the course 33 meters forward and to the right of the point where he first struck the tire barrier.

After Kato landed in the center of the course, he was not struck or run over by any of the trailing bikes in the race.

3.2 Damage to the Vehicle

The following describes the areas of the motorcycle damaged upon its impact with the tire and foam barriers.

(1) On the left side of the handle bars, at a height 100 cm above the ground, there is a dent and red paint from the tire barrier running towards the back of the vehicle (Figure 4).

(2) There is a palm-sized area of red paint adhering to the left-front part of the front fender at a height 60 cm above the ground (Figure 5).

(3) Red paint from the tire barrier can be seen adhering to various external components on the left side of the vehicle (Figure 6).

(4) Red paint from the tire barrier can be seen adhering to the entire left-side surface of the fuel tank shell (Figure 7).

(5) It is difficult to pinpoint when all damage found on the vehicle occurred apart from the items listed above. Nonetheless, Table 1 includes a general listing of damage caused by the impact and fall.

Figure 4: Vehicle damage (View from above the handlebars)
Figure 5: Vehicle damage (Front fender)
Figure 6: Vehicle damage (Front cowl)
Figure 7: Vehicle damage (Tank shell)

Table 1: Vehicle Damage

	Part Name	External Damage	Remarks
Front Section & Steering	Front tire and wheel	Yes	Abrasion from the impact and fall; tire not punctured
	Front axle	No	
	Front disk	Yes	Damage from the impact and fall; judged to result from impact with barriers
	Front brake caliper	No	
	Front brake line	No	
	Front brake master [cylinder]	Yes	Lever adjuster shift bent from the impact and fall
	Left/right handlebars	Yes	Bent from the impact and fall; no torque down of attachment bolt
	Front stem	Yes	Abrasion from the impact and fall; no torque down of attachment bolt
	Throttle pipe	Yes	Abrasion from the impact and fall
	Throttle cable	Yes	Bent from the impact and fall
	Steering damper	Yes	Abrasion from the impact and fall
	Clutch master [cylinder]	Yes	Banjo bolt damage from the impact and fall
	Left handlebar stopper	Yes	Damage from the impact and fall
Rear Section	Area around the left foot rest	Yes	Bending and abrasion from the impact and fall; no torque down of attachment bolt
	Area around the right foot rest	No	
	Swing arm	Yes	Damage from the impact and fall
	Rear axle	No	
	Rear tire and wheel	Yes	Abrasion marks from the impact and fall
	Rear brake line	No	
	Rear caliper	No	
	Rear disk	Yes	Strike marks assumed to be from the impact and fall
	Drive chain	No	Drive chain play found to be within the limits specified in the vehicle manual
	Throttle body	No	
	Engine	No	Disassembly inspection found no problems
Tires	Front tire air pressure		200 kPa
	Rear tire air pressure		160 kPa

3.3 Damage to the Riding Gear

The following describes the main damage to the riding gear caused by the accident.

(1) The face shield fell off the helmet, and the following abrasion marks and types of damage were found on the left and right surfaces, as well as the top and rear of the helmet (Figure 8).

① One strip of abrasion marks approximately 12-14 cm wide with adhering red paint oriented toward the upper rear of the helmet from the lower left to the upper left, believed to have resulted from impact with the tire barrier

② One strip of abrasion marks approximately 15 cm long and 5 cm wide on the top of the helmet continuing from the abrasion marks on the left side, believed to have resulted from impact with the tire barrier

③ Two breakage lines slanted towards one another, one approximately 6 cm in length and the other approximately 5 cm, located on the lower right jaw area of the helmet's chin protector; this deformation damage is believed to have resulted from the strain generated by the impact of the left side of the helmet with the tire barrier (Figure 9)

④ One strip of abrasion marks approximately 16 cm long and approximately 3-5 cm wide on the right rear of the helmet, assumed to have formed secondarily upon impact with the asphalt surface of the course.

⑤ One strip of abrasion marks approximately 11 cm long and approximately 4 cm wide, as well as spiral-shaped abrasion marks measuring approximately 11 x 9 cm, extending from the lower rear to the rear of the helmet, associated with damage from the detachment of a parts-fastening strip on the rear of the helmet; this damage is assumed to have formed secondarily upon impact with the asphalt road surface of the course.

(2) The racing suit has an abrasion mark with adhering red paint from the tire barrier that begins on the left side of the collar and travels down the left sleeve, as well as down the left side of the jacket torso to the hem; the racing suit is not believed to have other accident-related damage.

(3) Nearly the entire palm area of the left glove has adhering red paint from the tire barrier, but is not believed to have other accident-related damage.

(4) The left boot has adhering red paint from the tire barrier from the left side to the dorsal area, but is not believed to have other accident-related damage. The right boot has absolutely no damage or abnormalities.

(5) The upper right interior of the spinal protector has one thumb-sized dark red blood stain measuring approximately 2 x 3 cm, but is not believed to have other accident-related damage.

[label:] Sample
Figure 8: Condition of the Helmet (1)
Figure 9: Condition of the Helmet (2)

4. Investigation Results and Determination

4.1 Events Leading up to the Accident

The following chronology was compiled upon verifying the events leading up to the accident.

(1) Having started out from Grid Row 3, on the back straightaway of the third lap Kato was in the second pack in what was becoming a tight race. Because of his position relative to the other vehicles, he proceeded into 85R from the inside of the curve, and maintained a relatively high speed as he passed through, requiring him to bank sharply.

(2) When passing through 340R, riders moved along the course from the inside to the outside of the curve, but Kato did not brake as hard as he might have, either because he was forced to bank sharply and was unable to do so, or because he was trying to keep the other vehicles at bay.

(3) When braking on the approach to the chicane on the first lap and the second lap, Kato maintained an extremely high rear wheel slip ratio of as much as 35%; on the third lap, however, the ratio climbed to 38%. A sharp reduction in speed reduced rear tire ground contact and caused the vehicle to exhibit unstable behavior.

(4) Due to the conditions outlined in (3) above, the marked slide of the rear tire caused a high side[1]-like phenomenon. The sudden change in banking angle threw Kato out of proper riding position, and, in an effort to support himself, he maintained considerable steering force on the left handlebar. As the rear tire moved from a slide toward a high side, Kato sensed the danger and relaxed the front brake. This increased rear tire contact, which put the bike into weave mode[2]. Since there was considerable steering force on the left handlebar, the weave mode became divergent.

(5) The diverging weave mode began exhibiting strong roll oscillations, generating a maximum lateral force of approximately 1.2 G. As a result, Kato’s body was being thrown off the motorcycle.

(6) It seems that Kato fell over onto the left side of the motorcycle, and, barely able to hang on to the bike, was unable to control its direction and went off the course.

(7) We hypothesize that he was unable to apply the rear brake, that his right foot had come off the footrest, and that he was unable to regain a proper riding position on the bike after it went off the course.

(8) When he crashed into the tire barrier, we believe he contacted the barrier with his left palm first.

(9) After the impact, the left side of the bike and his body scraped along the tire barrier, reaching the boundary with the foam barrier, and he plunged head first into the foam barrier. It was at this point that Kato was separated from the motorcycle, and it is believed that it was at this point that he received the injury to his cervical spine, which seems ultimately to have proved fatal.

(10) Kato's body rebounded from the foam barrier and was thrown into the air. It rotated sideways in the manner of a discus and landed on the course.

[1] A high side is the phenomenon of being thrown high and to the side. Caused by the rear tire slippage that can occur during normal banking, a high side occurs when the rear tire suddenly regains its grip on the road surface just after it begins slipping in the direction opposite to that of the banking. The motorcycle exhibits a yaw angle as it moves forward, and the rear suspension compresses suddenly when the rear tire regains its grip. The rebounding of the suspension throws

the rider high up in the direction of forward inertia. This phenomena is strongly linked to the risk of violent overturn.

Riders sense as they travel that the tire is reaching the limit of its grip and is just about to begin slipping. If they are accelerating, they attempt to gain control through operation of the accelerator and try to regain tire grip by banking before a high side can occur. If they are decelerating, they ease up on the front brake to regain rear tire road contact, and use counter steering or shift their body weight to control yaw angle.

[2] An oscillation phenomena particular to two-wheeled vehicles as they travel, weave mode is characterized by complex movement combining lateral motion, yaw motion and roll motion. Since oscillations with a relatively low damping ratio occur, this mode can cause instability (increased likelihood of divergence) at low and high speeds. It has a frequency ranging from 1 - 4 Hz depending on speed, increasing as vehicle speed rises. Not limited to racing motorcycles, it can occur in all two-wheeled vehicles, from bicycles to the largest motorcycles, under certain conditions.

One cause of weave mode instability is a phase lag (tire force-generated timing delay) in the tire force (cornering force). In particular, front tire force phase lag exacerbates weave mode, and has a significant effect on stability. The front tire force phase is controlled by the motion of the steering system to which the front tire is attached. For example, if the rider were to grip the handlebars tightly when weave mode occurs, the movement of the handlebars would be attenuated, causing a phase lag in the movement of the steering system. The phase lag in the movement of the steering system causes a phase lag in the front tire force, which further exacerbates weave mode.

4.2 Accident Verification Results

The facts clarified by the investigation are described from the following five viewpoints, and represent the Committee's view on the causes of the accident.

(1) Verification of the course

(2) Verification of the vehicle involved in the accident

(3) Verification of the rider's psychological state and vehicle operation

(4) Verification of vehicle movement

(5) Verification of medical forensics

4.2.1 Verification of the Course

Just before the race was held, improvements were made to the area around the accident site. The section just in front of the accident site was changed by moving the whole existing high-speed 130R corner to the inside of the curve, transforming it into an 85R/340R compound corner, and significantly expanding the outside run-off area. The section just after the accident site was modified by moving the chicane 65 meters closer to ‘130R’. The 340R corner ascent became gentler, increasing the average speed of the corner exit by about 20 km/h. The entrance to the chicane became closer to ‘130R’, and the reduced distance between 130R and the chicane changed the course, which riders could previously pass straight through in a line, from accelerating to decelerating in the shortened section. The course also became more technical, requiring corner-to-corner switchbacks.

The current configuration of the course is such that a bridge over a road narrows the green area outside the course just beyond the accident site, and this section may not provide sufficient space for deceleration in case a rider veers off the course. Further, there are two types of protective structures placed in this area—a tire barrier that continues to the point where the green area gets especially narrow, followed by a foam barrier beginning at the point where the green area is

narrowest. In addition, there is a 1.2-meter gap between the two protective structures. Kato crashed into the side of the foam barrier next to the gap opening.

Before the course improvements, no serious accidents had occurred at the site of the Kato accident. The improvements resulted in the course becoming a more technically challenging course, but a review of the changes by FIM (Fédération Internationale de Motocyclisme) and IRTA (International Road Racing Teams Association) found only that the safety of '130R' had increased, and they did not designate the accident site dangerous. Even at the occasion of the team's practice runs, the accident site was not seen as dangerous. FIM issued a course certification, and all final checks were completed before the race was held.

4.2.2 Verification of the Vehicle Involved in the Accident

Since Honda Racing Corp. (HRC) had already conducted a disassembly inspection of the motorcycle involved in the accident, the Committee only checked the disassembled parts, and did not directly check for loose nuts or other such problems with part mountings on the motorcycle after the accident.

When HRC disassembled the vehicle involved in the accident, their investigation reported finding no vehicle defects, such as improper assembly or loosened fasteners in the engine or chassis. Showa Corp., which conducted the disassembly inspection of the suspension unit, has not reported any abnormalities. Michelin Tire Japan analyzed the tires, and reported no abnormal findings. HRC, Honda R&D and Brembo Japan analyzed the brakes, performed a finite element method computer simulation to analyze the crash and conducted a bench test of the brakes, and reported that the results of their analysis indicate that the destruction of the front brake disc occurred after impact.

Current racing bikes continuously record data on their running state, providing investigations with on-board measurement data taken just before the accident. Based on this data, the Committee confirmed the above reports and verified the validity of the analysis results. We found no abnormalities in on-board measurement data for gear shift and throttle operation just before the accident. The data also showed that the front and rear suspension behaved the same way it did on the lap before the accident, and no engine or front/rear suspension malfunctions were found. Examining images provided to the Committee that were taken just before and after the crash, we confirmed the survival of the front brake disc from an image of the motorcycle taken directly after impact with the protective structures. A broken out section of the damaged disc indicated that the brake caliper opened from the inside to the outside, and since it is difficult to imagine that such a break out could occur while the vehicle was traveling, as indicated in the above analysis results, we also determined that the brake disc damage occurred upon collision. Note that there is a mark remaining where the brake pad stuck to the disc surface, but HRC and Honda R&D analysis results indicate that the pad mark was left when the surface of the disc heated up when the brakes locked in his final emergency braking action. The Committee's examination of the tires used on Kato's vehicle revealed no tread surface separation or other abnormalities.

Within the limits indicated above, we determined there were no operational failures in the engine, suspension, drive system, brakes or tires, and no functional problems in the various components of the motorcycle until the time just before impact occurred.

4.2.3 Verification of the Rider's Psychological State and Vehicle Operation

Kato was in 11th place coming out of the preliminary round, and had to start the finals race from the third row of the grid.

On the first lap of the finals he moved up to 7th place, but at that point, the distance began widening between the three bikes in the lead pack and the four bikes in the second pack, which included Kato. On the second lap, images broadcast during the race confirm that he separated from the other riders and entered 130R significantly to the inside, thereby moving into 6th place.

On the third lap, in which the accident occurred, riders Bayliss, Checa, Kato and Ukawa began jockeying for 4th to 7th place, and Kato changed his place in the pack twice. Looking at the aggressive development of the race from the outset, we can surmise that Kato's mindset as a competitor was one of trying to quickly separate himself from the second pack and overtake the lead pack.

Just before the accident, in the midst of braking on the ascent from ‘130R’, we determined that there was a sudden change in the pattern of his movements. Kato first maintained a deep banking angle as he turned left on the ascent from 340R. Normal braking from that position can lead to a loss of balance and overturn. What seems to have happened is that the rear wheel of Kato's motorcycle momentarily slipped to the right, leading to a high side-like phenomenon and, in reaction, we assume that the rear wheel abruptly moved in the opposite direction. In this state, the rear wheel regained its grip and increased contact with the ground, and we can confirm from sources such as images of the scene that this was accompanied by a change in banking angle. This sequence of events caused his vehicle to go into weave mode, where it oscillated sharply (to a maximum of approximately 1.2 G) to the right and left, causing Kato's body to shake off to the left side of the bike. At this point, a racer's mind concentrates on recovery. Having slid off to the left side of the motorcycle, Kato had to focus all his efforts on maintaining his balance, and was not in a position to take sufficient control of the vehicle, causing him to veer sharply off the course to the left. Further, we believe he may not have been in a position to lock his rear brake in order to flip the bike over and thereby minimize damage from a crash. We believe that after the rear wheel speed had recovered, the rear brake was not engaged up to the time of collision.

Red paint, considered to have come from the tire barrier, was found adhering to the surface of the palm on Kato's left glove. We believe that at the moment of impact, his left hand released the handlebars and made contact with the tire barrier as he tried to stem the damage from the collision, and that he made every effort to avoid danger until the moment of impact.

Note that the time elapsed from the start of the oscillations to impact was only about two seconds.

4.2.4 Verification of Vehicle Movement

Although Kato's vehicle veering off course can be directly attributed to the divergence of the weave mode, the results presented below offer a phase-by-phase examination of the causes leading to the accident.

(1) Phase I: From the back straightaway until he passed through 85R

On the third lap, in which the accident occurred, Kato was riding in a line with three other vehicles when he entered 85R from the back straightaway, and therefore could not reduce his speed sufficiently. As a result, the speed of his vehicle as he passed through 85R was higher on that lap than during the previous laps, leading him to take on a sharp banking angle.

(2) Phase II: From his entry into 340R until he began decelerating to enter the chicane

Kato passed through 340R at a higher speed and sharper banking angle than on previous laps. By easing his acceleration slightly in the subsequent acceleration phase, he had achieved normal vehicle speed by the time deceleration was to begin (the end of Phase II). His banking angle did not recover, however, and he maintained a sharp banking angle as he reached the point at which he began deceleration.

(3) Phase III: From the start of deceleration in preparation for entry to the chicane until impact

Since Kato began decelerating while still at a sharp banking angle, the rear wheel slipped to the right, and he experienced difficulty in achieving proper deceleration. He then applied the front brake and, also effecting an engine brake, performed the switchbacks leading to the chicane. Due to the sudden deceleration, rear wheel contact with the ground weakened, and the vehicle

exhibited unstable behavior. A high side-like phenomenon occurred in conjunction with the marked slide of the rear wheel. The sudden fluctuation in the banking angle caused him to lose his balance and, in order to support his body, he applied considerable steering force to the left handlebar. In the progression from a slide to a high side-like phenomenon, Kato, sensing the danger, let up on the front brake. This resulted in increased rear wheel contact with the ground, which induced a prominent weave mode. The considerable force applied to maintain steering suppressed the movement of the steering system (phase lag), which made the weave mode divergent.

4.2.5 Verification of Medical Forensics

Sixteen seconds after the accident occurred, members of the chicane entrance 28th surveillance post rescue squad rushed to the accident site, waving large flags and taking other preventative measures to avoid a secondary accident. One minute and eight seconds after the accident occurred, the standby physician also attended at the accident scene. Kato was then transported by ambulance to the first aid station, received emergency first aid treatment, and was transported by Medevac helicopter to Mie Prefectural General Medical Center. The time elapsed from the point the accident occurred until he was admitted to the Medical Center was approximately 36 minutes.

In our judgment, the emergency first aid Kato received from the time immediately after the accident occurred until he was transported to Mie Prefectural General Medical Center can be considered entirely appropriate from the standpoint of Japan's first aid treatment and emergency transport protocols. The results of the various tests performed at the medical center indicate that Kato suffered a life-threatening cervical spine injury as a result of the accident. It is also our judgment that Kato may have experienced clinical brain death immediately after receiving his injuries.

Kato was momentarily caught between his vehicle and the foam barrier. The barrier compressed from the shock of his collision with its side surface, and he was momentarily buried, head first, in its side surface. The intense forward momentum of his body from the neck down caused it to flip upwards, and this launched his whole body into the air. From this we conclude that the forward occipitoatloid dislocation directly responsible for the brain stem infarction that caused his death occurred during the hyperextension of his cervical region when his head was momentarily held immobilized while the rest of his body flipped upwards. Evaluating the fact that his body flew through the air rotating laterally like a discus and landed face up in the middle of the course, having been launched into flight by the force of impact with the foam barrier, we have also concluded that the fall and landing was not the cause of the forward occipitoatloid dislocation.

According to images broadcast during the race, four rescue workers took hold of Kato, who lay collapsed face up in the middle of the course, held him by the right shoulder, the torso and both legs, and moved him sideways just a few dozen centimeters onto the stretcher. It certainly appears that sufficient care was taken to immobilize his head and neck area. However, when the stretcher was moved Kato's head drooped markedly, and it cannot be denied that this might have additionally injured his neck.

4.3 Summary of the Causes of the Accident

Generally speaking, accidents occur as a result of multiple factors, and Kato's accident is no exception. We believe that events may not have led to such a serious accident had several factors not occurred concurrently.

4.3.1 The Cause of Kato's Vehicle Traveling Off-Course

The Committee took great care in considering what caused his vehicle to travel off the course, and was led to draw detailed conclusions on the factors directly involved in triggering the accident. The following summarizes the final circumstances of the accident.

Our evaluation of front suspension stroke, rear wheel speed, rear suspension stroke, and engine speed data collected on-board Kato's motorcycle indicates that the motorcycle was traveling in first gear with the front brake engaged as it decelerated on the approach to the chicane. We surmise that when the rear wheel slip neared approximately 30%, he performed a switchback to bank to the right while moving forward in preparation to enter the chicane. We believe that the rise in the rear wheel slip ratio reduced the cornering force needed to maintain vehicle stability, and this caused the bike to begin exhibiting unstable behavior.

According to the on-board data, we conclude that the engagement of the front brake abruptly changed the load on the rear wheel, which lifted almost entirely off the ground, causing a lateral skid. From data on the change in suspension and acceleration sensors that followed, we can confirm that the vehicle entered a high side-like condition. We also referred to images and on-board measurements taken during the high side that caused Gibernau's fall on the second day of Round 12 of the World Grand Prix in Brazil.

From on-board data, we understand that Kato eased up on the front brake in an effort to handle the instability caused by the aforementioned abrupt deceleration. This caused the rear wheel to regain cornering force, which generated lateral acceleration in the rear wheel that caused a sudden yaw, sending the vehicle into weave mode. Of particular note is that Kato lost his balance in the progression from rear wheel lateral skid toward high side, and maintained considerable steering force on the left handlebar to support himself. However, it is known that if a vehicle enters weave mode while such intense steering force is maintained, a delay in the movement of the steering system will cause the weave mode[2] to diverge. We can confirm from surveillance images taken from the direction of the chicane that Kato lost his balance in conjunction with the above sequence of movement changes.

Analysis of on-board data also indicates that the clutch was disengaged at that time, but we do not know if Kato deliberately disengaged the clutch or if this was caused by the back torque limiter[3]. It is possible that the disengagement of the clutch exacerbated the weave mode divergence, but the extent to which it may have affected the divergence is unclear.

Based on our verification of the above information, it is conceivable that divergence of the weave mode was the ultimate trigger that sent his motorcycle off the course.

We also verified on-board data from other competitor's motorcycles to answer the important question of whether the occurrence of weave mode was due to a characteristic of Kato’s particular motorcycle. On-board data from competitor Ukawa's motorcycle shows a clear weave mode occurring after he passed through ‘130R’ and began decelerating on the approach to the chicane, but it did not reach divergence in his case, and has not been considered problematic since.

It can be seen from the fact that other competitors experienced weave mode in the same race in which Kato's accident occurred that it is a common oscillation phenomenon. In the case of this accident, however, Kato's vehicle was operating at its performance limits, and tracing back the events in Phase III, we see that several overlapping factors led to the divergence of the weave mode.

[3] The back torque limiter is a mechanism that reduces rear wheel hop by automatically disengaging the clutch to decrease back torque generated by sudden down-shifting.

4.3.2 Causes Contributing to the Seriousness of the Accident

In examining what caused such a serious accident to occur, we of course know that the direct cause of death was the high-speed collision with the barriers and, in particular, the fact that having been dragged along the tire barrier, Kato received a cervical spine injury when he momentarily plunged into the side of the foam barrier in the area where the tire barrier and foam barrier meet. Viewed from the results, we can see that he flew off the course in the S-curve zone, and it is very possible that, if he had been able to decelerate sufficiently once he left the course, the incident might have ended as a simple course departure. Further, if there had not been a gap

between the two barriers, Kato would not have crashed into the side of the foam barrier, which would have changed the extent and type of injury he received.

There had never before been a fatal accident at the site of this accident, and although course improvements had made it a more technical venue, the accident site was not identified as hazardous when each of the competing teams held their practice meets. The course was also certified by FIM, all final checks were completed for staging the race, and no one, including the riders, perceived that the area was dangerous.

5. Recommendations of the Accident Investigation Committee

5.1 Vehicle Oscillation Characteristics and Rider Operation

This Committee's examination of the high side-like phenomenon and weave mode from the perspective of vehicle behavior does not necessarily bring the whole story of the accident to light. For example, phenomena arose during the race that would present no problem at all under normal circumstances, but in this case occurred as part of a variety of overlapping factors that caused the serious problem of oscillation divergence. The various factors are not just limited to the characteristics of the motorcycle, but also include rider handling of the vehicle. However, clear identification and handling of these particular oscillation phenomena by a rider is itself thought to be quite difficult at present. In that sense, it is important to further investigate the factors and circumstances involved in oscillation phenomena particular to motorcycles, including rider handling of vehicle operation, under various conditions.

5.2 Research and Development into Protective Equipment

From the perspective of the medical forensics investigation, future measures to ensure rider safety include an examination of the layout, shape and materials of protective structures on the course. In the first place, as in ordinary accidents, racing accidents each have different causes and occur with different modalities. It would therefore be of value to improve the effectiveness of protective structures to reduce by even a small amount the shock of impact in an unforeseen collision.

In Kato's case, it was his crash into the foam barrier rather than the collision with the tire barrier that resulted in the forward occipitoatloid dislocation that proved fatal. Therefore, if we limit our examination to his accident alone, we can say that if the protective structures at the accident site had been of a more uniform structure, the way in which he would have been injured would have been different, and may not have led to such a serious outcome.

In addition, the way in which the barriers were laid out, such as the gap between them, may also have exacerbated the accident. FIM presently does not have a uniform standard for the safe installation of protective barriers. To reduce safety risks even minimally, we hope that FIM will proactively promote research and development in the area of protective barrier safety, and create such standards.

5.3 Attention to the Safety of Rider Equipment

There have been significant improvements recently in riding gear, which even in Kato's accident provided nearly perfect protection to his head and body. It did not, however, protect the vital cervical area connecting his head and body, and the cervical hyperextension that occurred when his head and torso (chest and abdomen) were traveling in different directions resulted in an ultimately fatal forward occipitoatloid dislocation. Normally, freedom of neck movement is preserved to avoid any hindrance to motorcycle operation, but we hope to see the development of protective equipment that could momentarily immobilize the head and torso firmly if the body is subject to abnormal shock, such as a violent fall. Such equipment would also be useful in preventing the cervical spine dislocations frequently seen in forensic autopsies of victims of fatal accidents on ordinary motorcycles, and could contribute significantly to rider safety.

Appendix: Daijiro Kato Accident Investigation Committee

1. Objectives of the Daijiro Kato Accident Investigation Committee

The Daijiro Kato Accident Investigation Committee is an independent body that Honda Motor Co., Ltd. established on April 25, 2003 to investigate the cause of Daijiro Kato's motorcycle accident on April 6 at the Suzuka Circuit (Mie Prefecture). Its mission is to task a multidisciplinary team of specialists to fairly and impartially analyze the accident from a broad range of perspectives, and to objectively clarify its causes.

2. Committee Composition

On April 25, Honda resolved to establish the Daijiro Kato Accident Investigation Committee and appointed the Committee Chair. In May, Honda nominated the Committee members and secured their consent to participate, finalizing the Committee composition at the end of May. The following lists the Committee members.

Daijiro Kato Accident Investigation Committee

Committee Chair

Ichiro Kageyama

Position
Professor, College of Industrial Technology, Nihon University

Specialization
Automotive engineering, mechanical dynamics, control engineering

Principal Fields of Research
Mechanical dynamics and control systems (particularly related to vehicular motion and motion control). Presently, Kageyama is conducting research into control systems, such as evaluating man-machine systems, evaluating mental stress using biological reactions, analyzing traffic flows, safety, motion analysis of automobiles and motorcycles, and automatic steering of vehicles.

Committee Members

Hirohide Imaizumi

Position
Assistant Professor, Nihon University
Former Research Associate, Graduate School of Engineering, The University of Tokyo

Principal Fields of Research
Analysis of motorcycles using multibody systems, and CAE analysis

Tsuyoshi Katayama

Position
Senior Researcher, Safety and Information Research Department, Japan Automobile Research Institute

Principal Fields of Research
Vehicle maneuverability and safety theory

Shigeyuki Tsunenari

Position
Professor of Forensic Medicine, Graduate School of Medical and Pharmaceutical Sciences, Kumamoto University

Specialization

Forensic medicine

Principal Fields of Research

In the field of forensic medicine at the Kumamoto University Graduate School of Medical and Pharmaceutical Sciences, Professor Tsunenari is making a social contribution to the region through forensic medicine activities, such as the performance of all forensic autopsies conducted in Kumamoto Prefecture (approximately 100/year), as well as paternity testing. He is also conducting research from the viewpoint of advancing knowledge through the study of forensically autopsied corpses.

Kyoji Namba

Position

President, Action Crew Co.
WGP race commentator
Former GP rider

Main Activities

Began racing in earnest in 1985 as a Yamaha Factory rider, and took 5th place in the 500 cc class at the WGP Suzuka Circuit in 1998. Currently employed as a WGP race commentator at NHK.

Committee Office Personnel

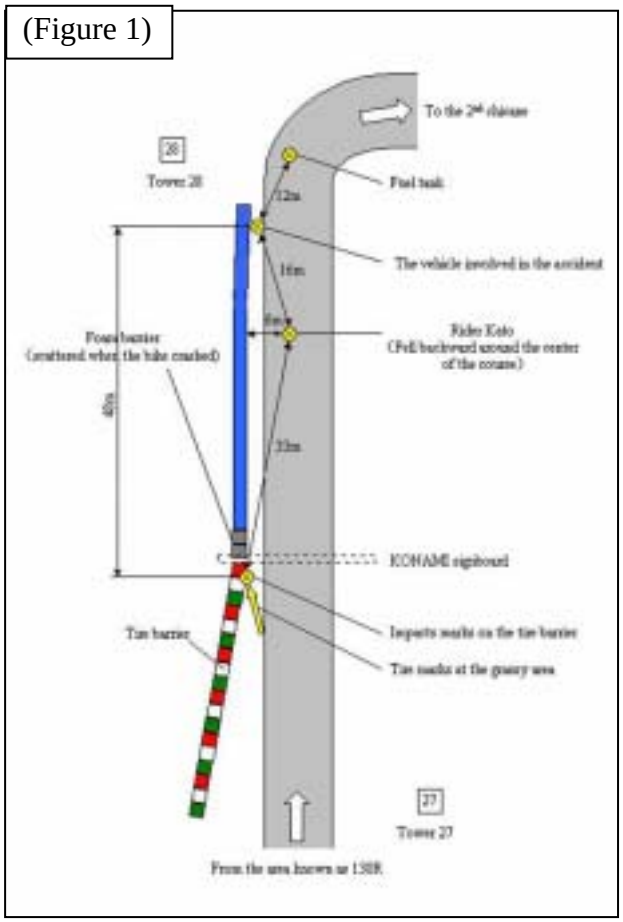
Satoshi Kakumasu (Honda R&D Co., Ltd.)
Keiko Seki (Honda Motor Co., Ltd.)

3. Chronology of Committee Meetings

Meeting	Date	Remarks
1	6/3/03	
2	6/10/03	
	6/20/03 *	Onsite investigation at Suzuka circuit
	6/21/03 *	Verification of accident motorcycle and accessories
3	6/24/03	
4	7/1/03	
	7/5/03 *	Medical investigation at Mie Prefectural General Medical Center
5	7/8/03	
6	7/15/03	
7	7/30/03	
8	8/4/03	
9	8/28/03	
10	9/20/03	
11	10/6/03	
12	10/16/03	

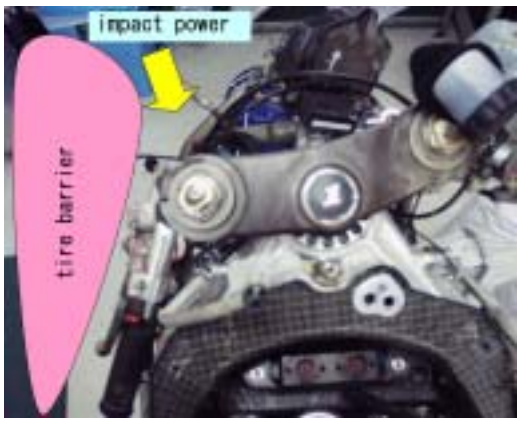
【Sample figures】

(Figure 1)



(Figure 2) Tire barrier and foam barrier (the green cone is a counterpart)

(Figure 3) Impact marks on the tire barrier



(Figure 4) Damage of the vehicle (view from above of the handle)

(Figure 5) Damage of the vehicle (front fender)

(Figure 6) Damage of the vehicle (front cowl)

(Figure 7) Damage of the vehicle (tank shell)