Crash course

Test collision control with advanced ABB technology

Börje Johansson

Two cars – approaching from different directions, but heading for exactly the same spot. Seconds later there is a chilling, dull thud, followed by harsh metallic screeching, as they collide and come to a standstill. An eerie silence descends on the scene and bystanders move forward to investigate the badly battered cars, in which the passengers seem to have escaped serious injury.

This narrative fortunately does not describe a real traffic accident, but a car crash, complete with dummies, staged by engineers at Volvo's new crash test laboratory in Gothenburg, Sweden. In this center, in which ABB technology controls the collisions with high precision, tests are carried out that could have consequences for road safety in the future.

The new facility 1, which started operating this summer, is designed especially for the purpose of crash-testing vehicles and checking the safety of new model designs. At least three different types of test are possible at the center: non-destructive testing by computer; simulation with a car-crash simulator; and crash-testing in the laboratory.

Non-destructive testing is used to check the crash safety of new car models at an early design stage. The facility's computer – which has supercomputer capability – allows basic data to be easily changed, enabling, for example, a component part to be re-dimensioned and the part quickly tested again. When the right technical solution has been found, the details are fed back to the designers for incorporation into the new car model being developed.

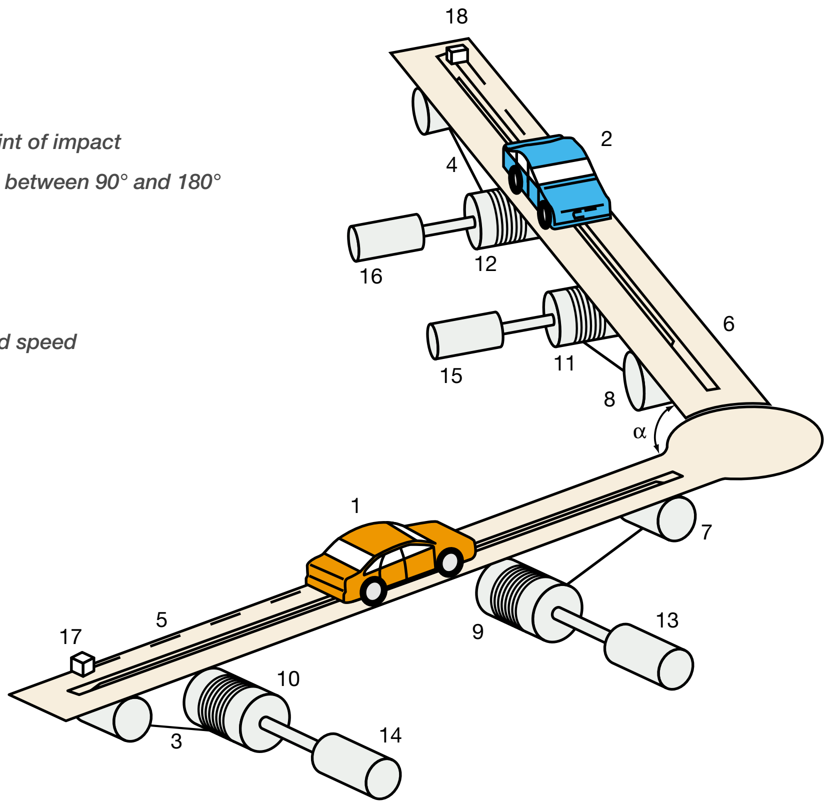
The car-crash simulator is a gigantic contraption in which Volvo's safety engineers test how seat belts, air bags and other safety solutions work in frontal collisions. With pumped-up power, immense hydraulic pistons 'kick' a car body so that the 'passengers' – crash-test dummies – are thrown forwards and caught by the safety equipment, while high-speed cameras record the sequence of events down to the last detail.

The advantage of the simulator is that crashes can be replayed as often as required, with only very specific changes

1 The slewable test track weighs 700 tonnes and extends 108 meters from the main building of the crash test laboratory. It is lifted by air cushions and can be turned 90 to 180 degrees to facilitate different kinds of collision tests.

2 Basic diagram of the crash-test facility

1–2	*Vehicles being crash-tested*
3–4	*Steel ropes pulling vehicles towards point of impact*
5–6	*Test tracks, can be set up for any angle between 90° and 180°*
7–8	*Pulleys*
9–12	*Rope drums*
13–16	*Electric drive motors*
17–18	*Laser meters for measuring position and speed*



made from one cycle to the next. The simulator is therefore ideal for testing and identifying the safety solutions that work best.

As each of the above-mentioned testing aids is based on simulating reality, some other, more realistic way is obviously also needed to verify that the safety solutions built into cars actually do work as intended. This is where the *crash-test laboratory* – and ABB technology – comes in.

Track facts:		
Length of car tracks	fixed track slewable track	154 m 108 m
Max slewing angle (slewable vs fixed track)		90°–180°
Max vehicle speed	fixed track slewable track	passenger car 120 km/h truck 80 km/h passenger car 70 km/h
Max deviation from set impact point		25 mm
Rated power of rope system drive motors		2 x 900 kW (peak power 2 x 1750 kW)

The crash-test laboratory – final confirmation

The new laboratory has two car tracks, one fixed and one slewable. In the floor of each track, a small trolley attached to a steel rope pulls the car towards the point of impact. The tracks, which may be used separately or jointly, can be run in either direction, making it possible to stage collisions not only with a heavy barrier or another vehicle but also with other objects placed around the facility.

With such a range of features, virtually every kind of collision between motor vehicles and natural obstacles, such as rock faces, poles and trees, as well as other motor vehicles, can be set up. It is even possible to test how well vehicles are able to withstand rollovers. All basic parameters, such as speed, point and angle of impact, etc, can be set and controlled accurately. The vehicles can be either passenger cars, trucks or buses.

Precision is paramount

High control precision is essential, especially for angled collisions between two cars. To analyze the damage to vehicles and passengers accurately, it is necessary to have absolute control over

3 Each test track is equipped with two rope drives to facilitate control of the rope tension and bi-directional running of the track. The electric motors are controlled in terms of both speed and car position, and are able to deliver as much as 2x1750 kW of power during acceleration.

the angle of impact, point of impact and speed. ABB's expertise and experience in controlling the movements of heavy loads in applications such as mine hoists, rolling mills and paper machines, came in useful here. For some tests it is necessary to control the two vehicles with half-inch precision right up to the point of impact.

The two computer-controlled test tracks – one 154 m long and fixed, the other 108 m long and slewable – allow exact setting of the desired collision angle 2. The 700 t heavy slewable track is moved on air cushions.

To stop the cars – literally – in their tracks, the facility also has an 800-tonne collision barrier of steel and concrete. This was also supplied by ABB and can be moved to wherever it is required quickly and precisely on an air-cushion. The ease with which ABB technology makes this colossus movable is spectacular.

ABB mine-hoist technology in a new role

Each of the car tracks is driven by an underfloor steel rope conveyance system, featuring two electric motors, which keeps the rope taut and the car in the right position and at the right speed 3. The rope drives a trolley fitted with a steel pin that pulls the car forward. This pin is the only part of the trolley that is visible above floor level. ABB was able to draw on its know-how and experience with mine-hoists during development of this system.

The test car(s) is/are accelerated to their full speed just a second or two before impact. Smooth acceleration is essential since the dummies, which are packed with sensors, are not allowed to move out of position. Shortly after full speed is reached, the trolley releases both the car and the rope. A fraction of a second later the car crashes, releasing tremendous dynamic forces.

4 The crash test laboratory is controlled from this room by means of an Advant OCS control system. The general-purpose ABB system is used throughout industry to control and monitor a wide range of processes.

The crashes take place on a glassed-over floor section (see page 6) to allow video and high-speed cameras to record the sequence of events from every conceivable angle. Floodlights are installed to light up the crash area with an intensity three times greater than that of normal daylight. Thanks to this feature, the high-speed cameras can take pictures at rates as high as 3000 frames per second.

Laser technology ensures precise measurement

High impact accuracy is critical for angled collisions between two vehicles since the vehicles move as much as 30 mm in 1 millisecond. The actual point of impact is not allowed to deviate by more than 25 mm from the setpoint. Accurate positioning and speed control therefore provided the pivotal challenge during this project.

Laser technology provided the solution. The laser equipment, which measures the distance to the cars on the

ABB has supplied crash-test equipment to the world's most advanced car safety center, owned and operated by Volvo Cars in Gothenburg, Sweden. The new center was inaugurated in the presence of King Carl XVI Gustaf of Sweden in the spring of this year. Almost every conceivable kind of car crash can be performed or simulated in the facility, which includes a crash-test laboratory featuring advanced ABB controls and laser technology for high-precision collisions.

ABB companies in Sweden, Switzerland, Germany and Finland were involved in supplying the crash-testing equipment for the new facility, among them ABB Automation Systems, who led the project, ABB Contracting and ABB Service.

tracks, is connected to the facility's computer control system. Polled a thousand times per second, with both the speed and position calculated each time, the equipment takes measurements simultaneously for both vehicles. This high scanning frequency, which takes account of the fact that the cars can move approximately 30 mm between polls, guarantees the specified impact accuracy. The software that synchronizes the measurement of the speed/position of the two vehicles was developed by ABB.

5 The collision barrier weighs 800 tonnes and is moved on air cushions. Protrusions can be fitted on the four sides of the barrier to simulate different kinds of common obstacles.

A perfectly standard control system

The computer-based control system that was installed is basically a general-purpose Advant OCS system **4** of the kind used to control a wide range of industrial processes – from mine hoists to bottling lines. The application-specific solutions for this project were implemented in software developed in AMPL, the graphic programming language created by ABB specifically for industrial control applications. The solutions that were developed, including the drive control, are largely unique, and patents for them have been applied for.

In addition to the drives, the system also controls the lighting, the measuring equipment, and the video and high-speed cameras.

The collision barrier: another challenge

Tests involving the collision barrier **5** presented technical challenges of another kind. First, it had to withstand hits without moving or sustaining damage; second, it had to be movable to allow it to be set up in different positions and at different angles and off-sets, as well as moved completely aside for two-car crashes.

The first requirement was met by bringing into the project mechanical design engineers who were expert in military defense structures and had worked before with exceptional dynamic stresses; the second requirement was met by employing air-cushion technology – it takes about 15 minutes to move the barrier to a new position and carry out adjustments.

The collision barrier is made of steel and special-grade concrete. With a weight of 800 tonnes – as much as fifteen heavy battle tanks – it stands as steady as a rock when required to do so, yet glides effortlessly across the floor when being moved.

A contribution to safety

By allowing better and more realistic collision tests than in the past, Volvo Car's new crash-test facility may well lead in time to even safer cars and fewer injuries to passengers. In the shorter term, it could prompt authorities and consumer groups to pressure the automotive industry as a whole to adopt higher crash-test standards. ABB has the satisfying feeling that, through this project, it has shown itself to be capable of making an important contribution to safety on our roads.

Author

Börje Johansson
ABB Automation Systems AB
SE-721 67 Västerås
Sweden
borje.r.johansson@se.abb.com
Telefax: +46 21 18 58 90