***Vedyac* stands for Vehicle Dynamics and Crash Dynamics, a flexible computer model which is able to compute and display movements of bodies in space and what happens when they collide. *Vedyac* is able to simulate all sorts of manoeuvres and collisions, not only real-life traffic situations but even situations that exist only on the drawing board, for which full-scale crash tests are not feasible.**

Vedyac computer simulations are generally ten to one hundred times cheaper than crash tests. More variants lead to less cost per variant. Crash tests that would be financially impossible can be carried out with *Vedyac*.

Vedyac combines theoretical principles with information obtained empirically.

Vedyac opens the possibility to use a great variety of input data. The program already contains various data sets defining cars, heavy goods vehicles, road cross-sections, safety barriers, dummy's etc.

Vedyac has already proved its worth to:

- road administrators
- road constructors
- traffic and road consultancies
- traffic police
- manufacturers of street furniture (poles, lamp standards, safety barriers etc.)

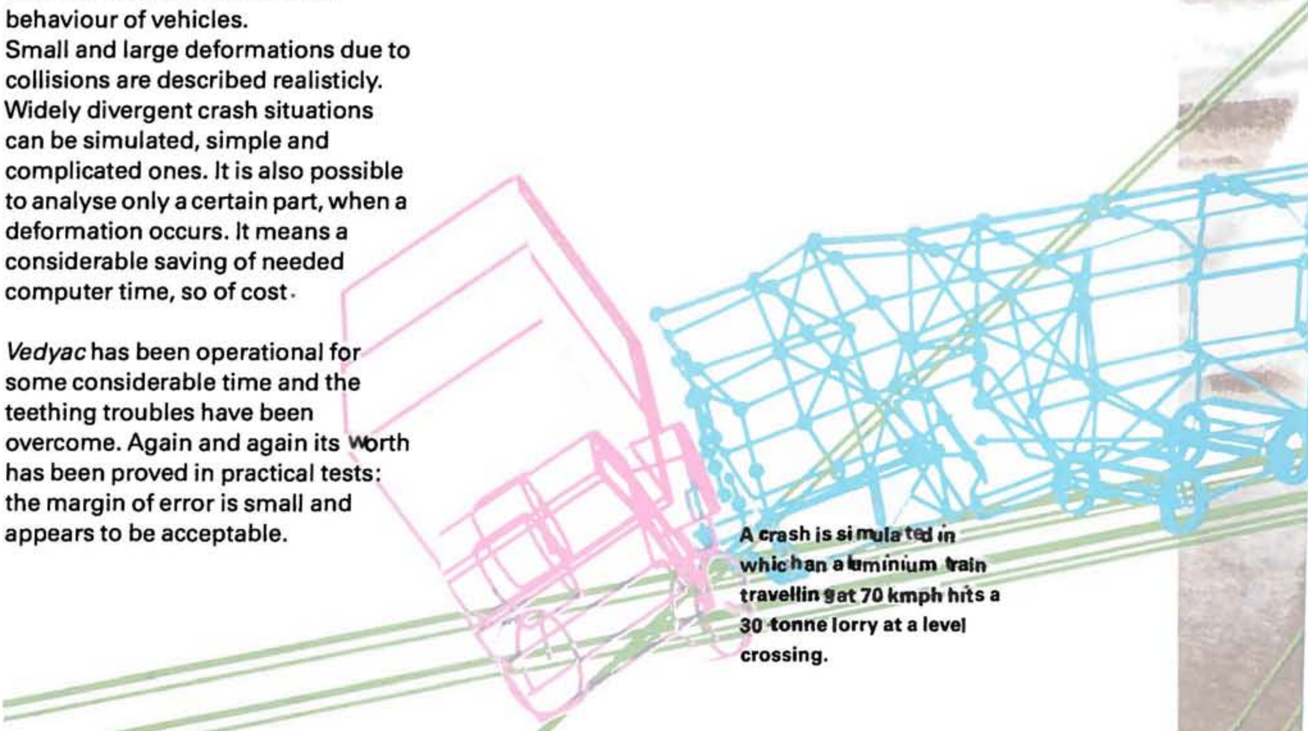
Measuring equipment in test car

The behaviour of a lamp standard in a crash influences the nature and outcome of an accident. A light fitting that becomes detached and falls could cause serious injuries. Vedyac can show what happens to a lamp standard when hit by a medium-sized car at a speed of 40 kmph.

Vedyac was developed to simulate collisions between cars and roadside safety structures. It is designed in such a fundamental way that *Vedyac* is able to simulate all sorts of manoeuvres and collisions.

Vedyac can simulate collisions between vehicles: cars, buses, lorries, trains, ships or aircraft – even space shuttles. *Vedyac* can also show how vehicles behave in relation to their environment, i.e. road, shoulder, dyke, street furniture, lamp standards, safety barriers, railway lines and runways. *Vedyac* shows both collision and manoeuvre behaviour of vehicles.
Small and large deformations due to collisions are described realisticly. Widely divergent crash situations can be simulated, simple and complicated ones. It is also possible to analyse only a certain part, when a deformation occurs. It means a considerable saving of needed computer time, so of cost.

Vedyac has been operational for some considerable time and the teething troubles have been overcome. Again and again its worth has been proved in practical tests: the margin of error is small and appears to be acceptable.



A crash is simulated in which an aluminium train travelling at 70 kmph hits a 30 tonne lorry at a level crossing.

How Vedyac works

Vedyac is able to compute the movements of a large number of bodies in space. Each body is assigned mechanical properties such as mass and inertia; its shape is delineated by a combination of planes and cylinders. Cylinders have a special function, since they determine the magnitude, point and direction of the impact forces in a collision. Cylinders are filled with a gas at a certain pressure: the higher the pressure, the more rigid the cylinder. The behaviour of these gas-filled cylinders is reminiscent of tyres colliding with surfaces or other tyres. Computations with such cylinders are relatively simple, reducing the amount of computing time needed.

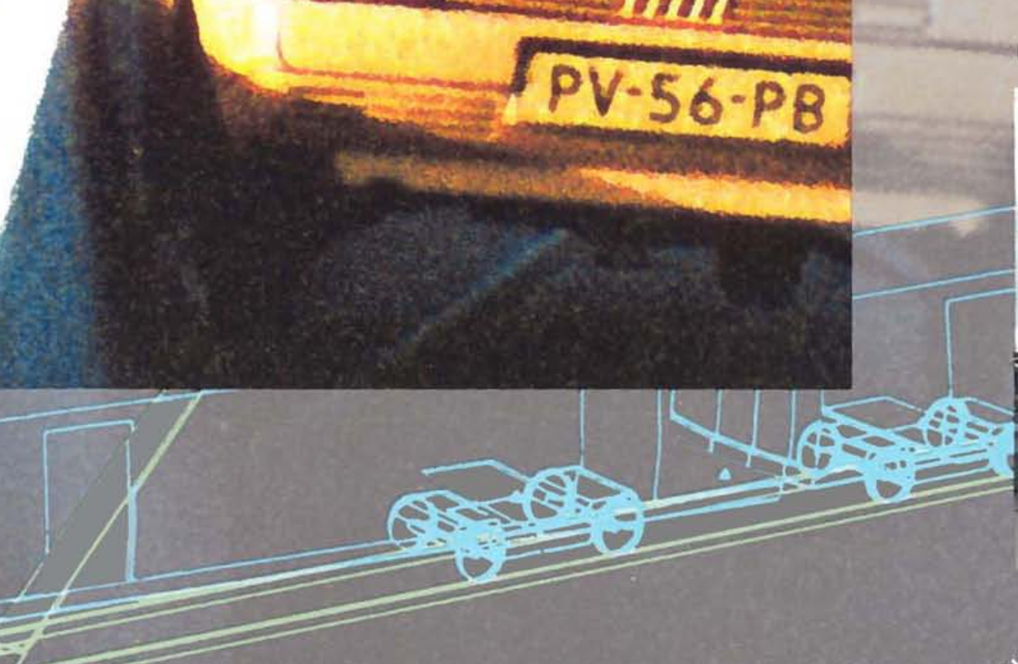
The deformations resulting from relatively gentle collisions are not very large, and the cylinders can be used on their own as a model for the deformability of a body. This does not work in the case of violent collisions, so *Vedyac* employs a different approach to produce a realistic simulation of large deformations: a deformable network is constructed using the finite-elements method, to which cylinders can be attached at various places; the cylinders determine where the forces act upon the network.

The network structure enables realistic models to be constructed, but at the expense of greater complexity and more computing time. We can reduce this factor by using the network to define not the entire body but, say, only the 'crash side' of a body in detail, regarding the remainder of the body as 'non-deformable'.

Vedyac divides the time that elapses during the course of the crash into small portions of a millisecond or less and computes 'snapshots' of the situation at the programmed intervals. If during the simulation the intervals turn out to be too long to give reliable results, *Vedyac* automatically switches over to shorter intervals, thus improving the clarity and showing the course of the crash precisely. The time intervals can thus be optimalized during the simulation.

Input parameters

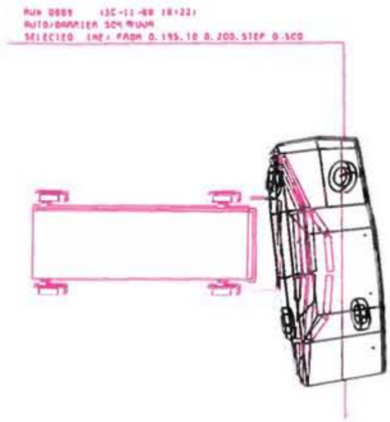
A large number of parameters affecting movement and crash behaviour can be assigned to the bodies and the environment, and each parameter can have a wide range of values. Thus *Vedyac* is able to compute a large number of variants. In addition to movement-related variables such as mass, moment of inertia and initial speed, data on deformation behaviour must also be fed in (e.g. dimensions, properties of materials and friction coefficients).



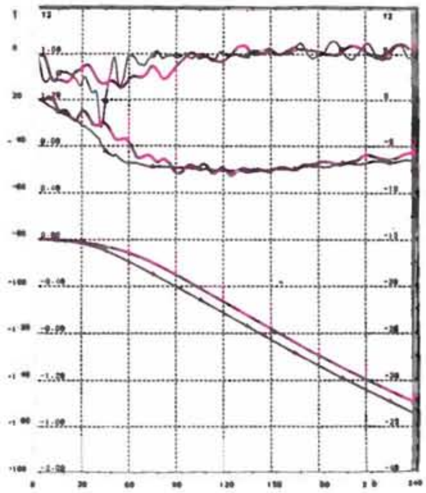
Impact attenuator 'Rimob'

Vedyac crash simulations

A series of simulations shows what deformations occur in a sideways-on collision at different speeds. The simulated deformations were found to give a very accurate representation of the reality, as the diagrams show.



Comparison between Vedyac (red line) and crashtest, acceleration, velocity and displacement of side of car.



Crash test facility

Forces

Vedyac can compute the following forces:

Impact forces
The impact forces which occur when bodies penetrate one another and changes take place in volumes.

Frictional forces
The frictional forces that arise between bodies: these are in effect derived from the impact forces.

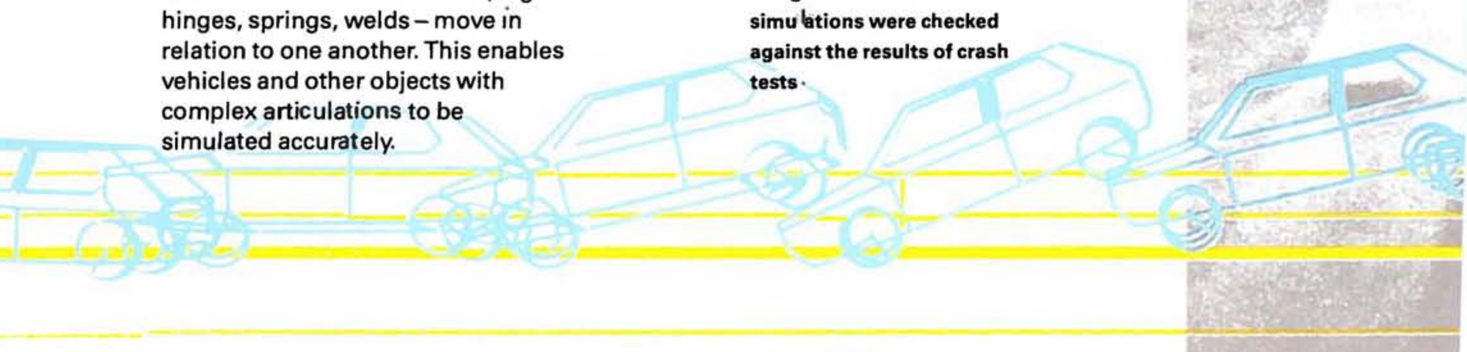
Furrowing forces
The furrowing forces which occur when a cylinder is moved laterally in a much softer surface, e.g. when a wheel of a skidding car enters a soft shoulder.

Coupling forces
The coupling forces which are produced when separate bodies attached to one another – by whatever kind of connections, e.g. hinges, springs, welds – move in relation to one another. This enables vehicles and other objects with complex articulations to be simulated accurately.

Suspension systems

Vedyac approaches suspension systems as separate components which can be attached to any point of a body. It computes the wheel movements separately and passes on the resulting forces to the body. *Vedyac* recognizes various types of suspension, with a variable number of wheels: steerable wheels, driving wheels and braked wheels. Different elasticities and damping properties can be assigned to each suspension system.

The shape of a safety barrier affects the outcome of crashes. Collisions between small cars and the concrete New Jersey Barrier are simulated to provide data for the purpose of improving the design of the barrier. The simulations were checked against the results of crash tests.



Comparison between Vedyac and crash tests

Vedyac computer simulations and crash tests can be compared on four points.

Parameters

Not only can *Vedyac* simulate crashes, it can also measure effects that cannot be measured in crash tests: measuring equipment can scarcely be attached to the point of impact, since it would not survive the crash. More variations can be investigated, since simulations cost much less than practical trials. In other words, more parameters can be measured and in greater numbers. Also, *Vedyac* can simulate situations which exist only on the drawing board.

Accuracy

A crash test shows the reality, a computer simulation a close approximation to the reality. Comparisons with crash tests have shown that the margin of error in *Vedyac* is usually no more than 10%, with an occasional exceptional 15-20%. *Vedyac* is regularly updated to incorporate the latest developments and data; the teething troubles have long been overcome.

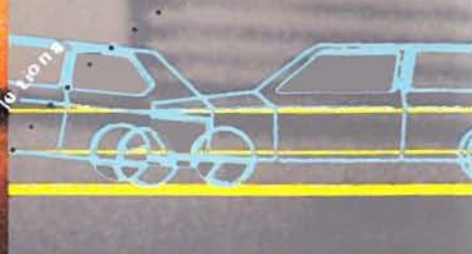
Time

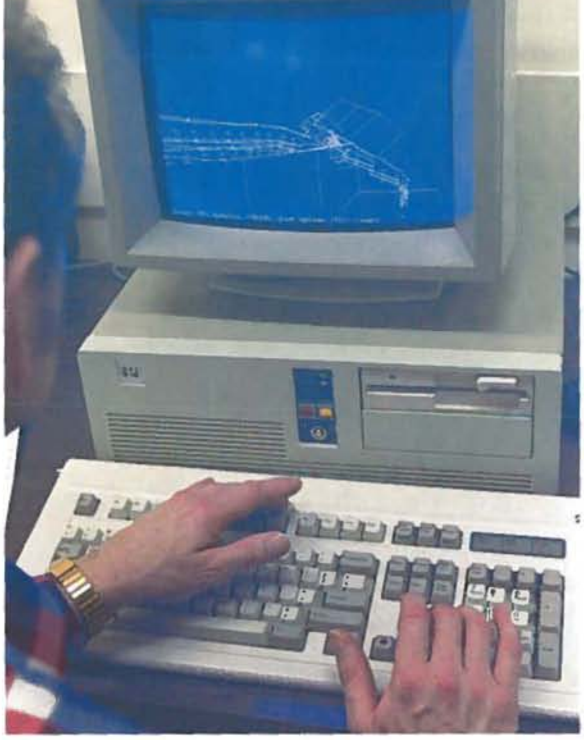
A certain amount of time is needed to plan a crash test, and there is often only one opportunity to collect data. Time is also needed to plan a computer simulation, especially if the problem requiring analysis is a new one. Deciding what questions the simulation needs to answer and feeding in the data is something that needs to be done in consultation and with great care.

The advantage of *Vedyac* is that, once the planning is complete, series of simulations with different variations can be completed in a short period of time. Supplementary computations can also be carried out quickly. Over the years a variety of situations have been simulated with *Vedyac;* consequently a large number of data sets are already available, which, with minor modifications, can be used to answer all sorts of questions. If these are used the planning can be done fairly quickly, taking much less time than would be needed for a crash test.

Cost

Vedyac simulations cost much less than crash tests. As a rule of thumb, a series of ten *Vedyac* simulations costs about the same as one practical trial. If carried out in large numbers, the cost of simulations can often be less than a hundredth of that of a single practical trial.





Animation as visual check
of simulation

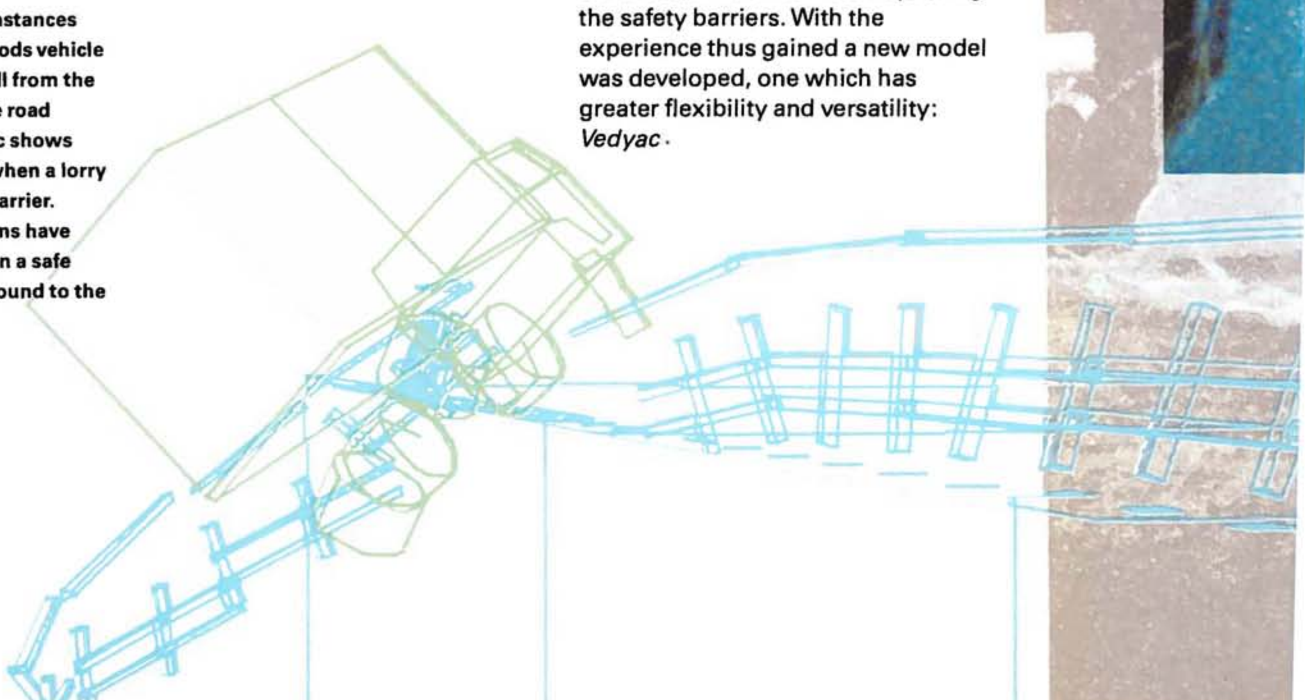
Preparation of test car

Vedyac – the product of 25 years of experience

The SWOV Institute for Road Safety Research began research into a safe design for safety barriers in 1964. This study, commissioned by the Ministry of Transport and Public Works, produced provisional guidelines in 1970, and these are still widely used.

The research project was in two parts. The first part entailed some 150 crash tests involving different types of cars with different masses impacting at different speeds and different angles. These produced a large number of 'practical data'. The second part involved developing a mathematical model to simulate tests of this kind.

In 1970 SWOV began collaborating with Professor V. Giavotto, Professor of Aircraft Design at the University of Milan, on a computer model, the forerunner of *Vedyac*. With this model over 1,000 simulations were carried out with the aim of improving the safety barriers. With the experience thus gained a new model was developed, one which has greater flexibility and versatility: *Vedyac*.



Under no circumstances must a heavy goods vehicle be allowed to fall from the viaduct onto the road beneath. Vedyac shows what happens when a lorry hits the safety barrier. These simulations have finally resulted in a safe solution being found to the problem.

In the meantime the capacity of small computers had grown considerably. This facilitated its application a great deal.

Vedyac clearly works according to the laws of mechanics. On this basis *Vedyac* analyses situations and calculates the consequences. *Vedyac* also stores the data collected in the course of years of experiments and crash tests. It is justified to call *Vedyac* a hybrid system.

Vedyac now has 25 years of experience behind it. With scenarios available for a wide variety of situations, new experiments can be designed, and results obtained, quickly.

SWOV has produced *Vedyac* simulations for various clients at home and abroad.

What Vedyac could do for you

Careful formulation of the problem

If you wish to know whether *Vedyac* is able to solve a problem for you, we at SWOV will analyse it in consultation with you. It is essential that the problem be properly formulated, and this requires a good deal of care and attention: without precise formulation it is impossible to find the correct solution. Close consultation between the client and SWOV is essential at this stage.

In many cases the research project can be simplified with the aid of previous experience. A good deal of time, computation work and money can be saved then.

Once you have agreed the formulation with us, SWOV will submit a quotation for the work.

Computation

If you accept the quotation SWOV will draw up the programs and feed in the data required so that the computer can carry out the simulations.

Results

The results of the simulations can be shown in three different forms.
a. Numerical series that can be presented in the form of graphs.
b. Printed computer graphics showing the course of a crash, for instance, in visual form.
c. A videotape recording showing the course of a crash and the behaviour of the vehicles and objects involved in its entirety.

The results are always accompanied by a report which interprets the data in relation to the problem as formulated.

Safety barrier and safety fence

Positioning of test car

Crash test

The SWOV Institute for Road Safety Research

At the beginning of the seventies over 3,000 people a year died in road accidents in Holland. The figure has now been more than halved, and this country now has one of the lowest accident rates in the world. The knowledge acquired over the years by SWOV has helped to make this reduction possible.

The SWOV Institute for Road Safety Research was set up in 1962 at the instigation of the then Minister of Transport and Public Works and a number of non-government organizations. SWOV's aim is and always has been to contribute to improving road safety by means of research. It applies the basic principle that it is not enough to solve individual problems; the working of the traffic system must be examined as a whole. This requires an understanding of the mechanical, economic and psychological factors behind the traffic system and the interrelations between them. In other words, road safety research requires an interdisciplinary approach, with technical, legal and medical experts, statisticians and psychologists all playing their part.

Over the years SWOV has developed into an organization employing some 70 staff from various disciplines.

Initially SWOV worked mainly for government departments. In recent years, however, more and more commissions have been carried out for industry. Commissions have also come in from abroad. SWOV is increasingly operating as an independent business in competition with other organizations.

SWOV carries out research of its own, but it also acts as a coordinating body for all the research into road safety carried out at universities and other institutions in the Netherlands. It also maintains close contacts with fellow research bodies in other countries.

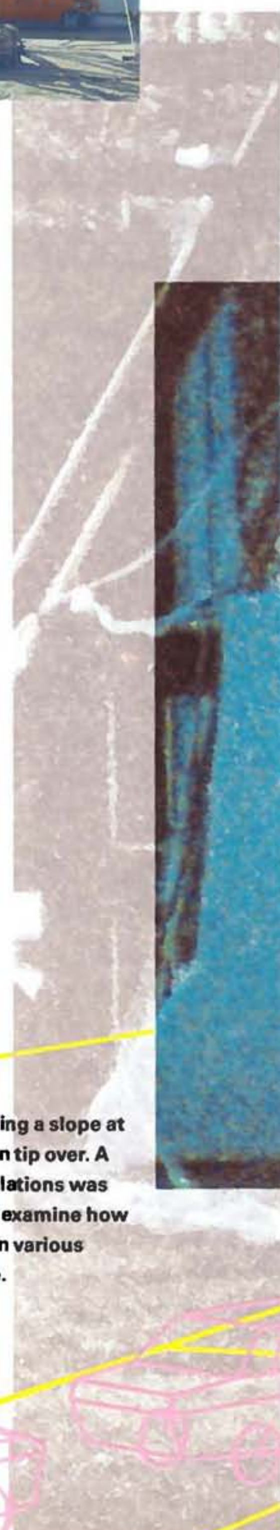
During the quarter-century of its existence, SWOV has carried out and commissioned numerous research projects, issued a large number of publications and organized meetings and conferences.

SWOV
Institute for
Road Safety Research

Duindoorn 32
2262 AR Leidschendam

P.O. Box 170
2260 AD Leidschendam
The Netherlands

Telephone international
3170209323
From December 1989:
31703209323
Telefax 3170201261
From December 1989:
31703201261



A car descending a slope at high speed can tip over. A series of simulations was carried out to examine how cars behave on various types of slope.