

HOW IS ASTAZERO DESIGNED AND EQUIPPED FOR ACTIVE SAFETY TESTING?

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ABSTRACT

The Swedish test track AstaZero (Active Safety Test Area) is an open environment where vehicle OEMs, tier one suppliers, research institutes, and universities can come to perform development and research. AstaZero is located just outside the city of Borås in West Sweden and was inaugurated in August 2014. The initiative was taken to create an environment for innovation, testing, and research to develop new active safety functions for road vehicles. The four main environments of the facility are built especially for research and development of active safety functions. A city area for simulation of urban traffic, a multilane road, a 5.7 km long rural road, and an innovative high-speed area facilitate efficient testing. Equipment of different kinds is also at hand; test targets, position measurement and control systems, communication equipment, and driving simulators can be provided. However, the success of the AstaZero test bed is also depending on the existence of leading competence. The Swedish automotive cluster has the ability to perform research, industrial development, and rational production of road vehicles. It is essential for AstaZero to have access to strong competence in its vicinity. The organizations residing in the Gothenburg region can be reached in an hour by car. The Stockholm region is more distant but it is quite possible to travel by road in four hours. The success of AstaZero is built on the track, the competence, and all the partners supporting the facility.

INTRODUCTION

Road safety has improved during the past years, but we are still far from the zero vision that no one should be killed or seriously injured in road traffic. The European Union has set ambitious goals for road safety. According to the 2011-2020 policy the objective is that member countries must together have reduced the number of road accidents by 50 per cent by the year 2020 [1]. Active safety, as well as test facilities where new techniques can be tested, will play an important part in the contribution of making this vision reality.

Active safety functions are regarded as key components to further increase safety on our roads. Due to safety and repeatability requirements, much of the development and research of these functions must be performed in a controlled environment such as a test track. For novel active safety functions many tests cannot be made in real traffic due to the risks of prototype malfunction. In terms of infrastructure, targets and their propulsion systems, as well as measurement systems, what resources are needed to evaluate the performance of active safety functions?

The AstaZero (active safety test area) [2] located just outside the city of Borås in West Sweden was inaugurated in August 2014. The initiative was taken to create an environment for innovation, testing and research to develop new active safety functions for road vehicles. The active safety functions are under rapid development and there are presently, and in contrast to passive safety, few generally accepted testing procedures in place. Performance testing methods for active safety are necessary to improve the safety performance of new safety functions in road vehicles. Suitable test procedures are key enablers. The tests must be repeatable and the results must be relevant to the safety benefits in real traffic. There is still much development and standardisation to be done for test procedures.

AstaZero is an open environment where industry (vehicle OEMs and tier one suppliers) and academia (institutes and universities) can come and perform development and research.

TEST TRACK

The AstaZero has been designed with four main environments. (Figure 1) There is a city area for simulation of urban traffic. Highway scenarios can be simulated at the multilane road. A 5.7 km long rural road is included for monotonous driving with sudden obstacles. Dynamics and fast scenarios can be tested using the high-speed area with acceleration stretches.

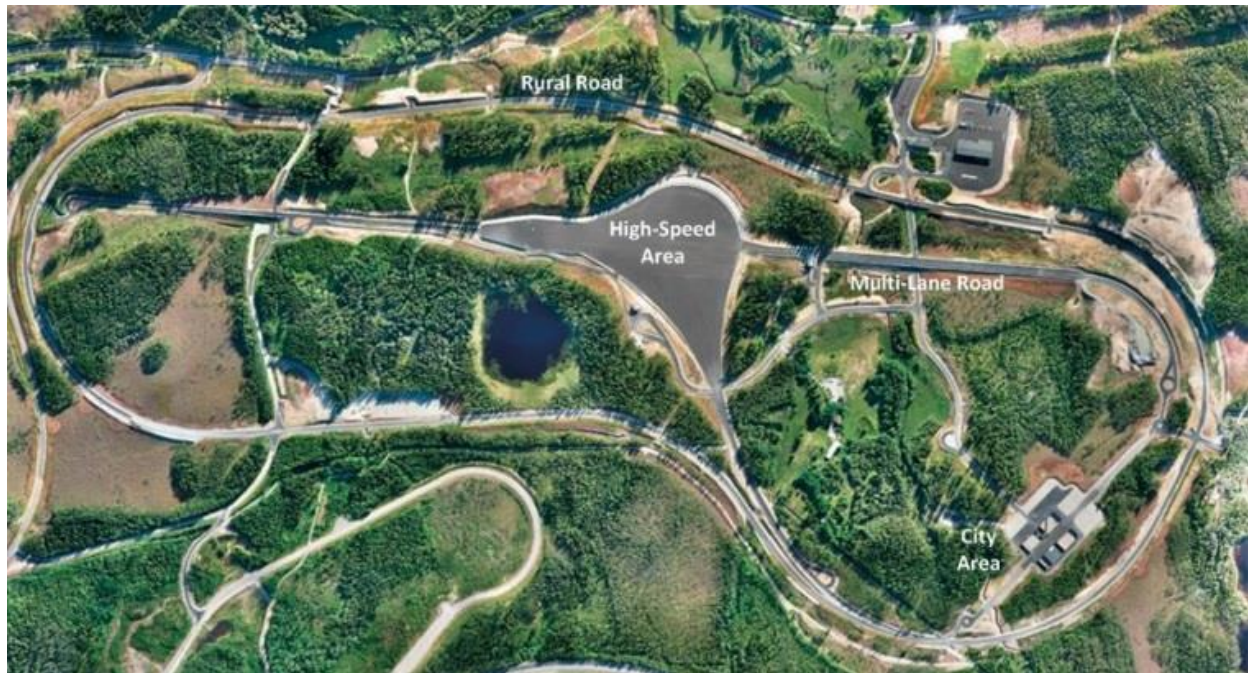


Figure 1. Overview of the AstaZero facility.

All paved surfaces are designed for 60 tons maximum vehicle weight and a 13 ton axel load. This will allow for researching scenarios where trucks with heavy load take part. A maximum vehicle length of 25.25 meters is planned. All internal roads have a width of 7 meters. They are designed for bi-directional traffic driving at the right-hand side of the road. There will be special areas for calibration made out of concrete. The calibration areas are 3 by 15 meters with flatness better than 0.1 degrees in all directions.

The Rural Road

The rural road encircles the facility. It is approximately 5.7 km long. Half of it is designed for travelling at maximum 70 km/h and to other half for maximum 90 km/h. The rural road is specially designed for different tests of driver behavior and is well-suited for the use of hidden or suddenly appearing obstacles. In several places there are scrubs or bushes growing near the road, which make it possible to conceal obstacles before they cross the road in front of the test vehicles. There are also two T-junctions and a crossroad that will be treated as real junctions changeable to suit customer requirements. The rural road will also have bus stops/lay-bys at two locations.

The road is not designed for advanced driving at high speed. It may be used for bi-directional traffic, but the normal setup is one-way traffic driving on the right-hand side of the road. There are some hills at the road, but the maximum incline is 4.5%. Initial feedback from users confirms that the rural road feels and looks like a conventional road and that "it is easy to forget that you are on a proving ground". Communication links via optical fibers are prepared around the track, and it is ready to be populated with road-side units for ITS-applications.



Figure 2. Emergency vehicle driver and platooning research on the rural road

The High-Speed Area

The high-speed area is located at the center of the AstaZero facility. It consists of a circular area with drop-shaped entrances. The circle is 240 meters in diameter and has two acceleration roads. The main acceleration road is approximately 1 kilometer long. This will provide sufficient distance also for accelerating heavy trucks. In addition to the two acceleration roads, it is also possible to use the multilane road for acceleration. As a consequence, vehicles can enter the high-speed area from three different directions.

In this area, focus will primarily be on vehicle dynamics like avoidance maneuvers at very high speeds, but also “near misses” for active safety systems at high speeds. A large open asphalt area like the high-speed area is also useful for cases when virtual reality is combined with driving a real car.

The high-speed area slopes 1% in the lateral direction, but is completely flat in the longitudinal direction, (flatness 1.0 acc. to IRI). Asphalt is provided according to the specification SN75-80. There is a turning loop for long vehicles (25.25m) at the end of the acceleration road and halfway. It has a width of 7 meters. A calibration area is provided at the first turning loop (for gyros).

A separate control tower is overlooking the area. The tower is two stories high for good visibility, and it provides a platform on the roof for visitors. Remote control of targets, balloon cars and driving robots will be performed from the control tower.



Figure 3. Virtual reality and trailer ESC tests on the high-speed area

The City Area

The city area is located in the southern part of the facility and is connected to the rural road at two places. It consists of 4 building blocks (40 x 25 x 4 m), but there are plans to supplement it with additional five blocks. The city area will primarily be used to test the vehicle's capacity to interact with the surrounding environment. Test scenarios will include avoidance of collision with buses, cyclists, pedestrians or other road users. Streets have a 2.0% incline for good drainage into sewage drains. There are acceleration roads, longer than 150 m, before the intersection. The main street equipped with "portals" with traffic signs. The area therefore covers a number of different sub-areas, such as a town center with varying street widths and lanes, bus stops, pavements, bike lanes, street lighting and building backdrops. The city area also has a road system with different kinds of test environments such as roundabouts, T-junction, return loop and lab area (100x30 m). One block contains the control room and warehouse for dummies.



Figure 4. Aerial and entrance view of the city area

The Multilane Road

The Multilane Road is 700 meters long and consists of four lanes. These are connected to the high-speed area, and have an acceleration road that is approximately 300 meters long, 7 meters wide, and a turning loop for long vehicles. Several different scenarios can be tested on the multilane road, such as lane changes and departures, different collision scenarios, as well as crossing scenarios. For example, it will be possible to change the direction of travel in different lanes, as well as to build a temporary central barrier and different types of traffic barrier railings. The road has a 2 % lateral incline for good drainage, split between lane 1 and 2. There is a small intersection with the possibility to create intersection scenarios.

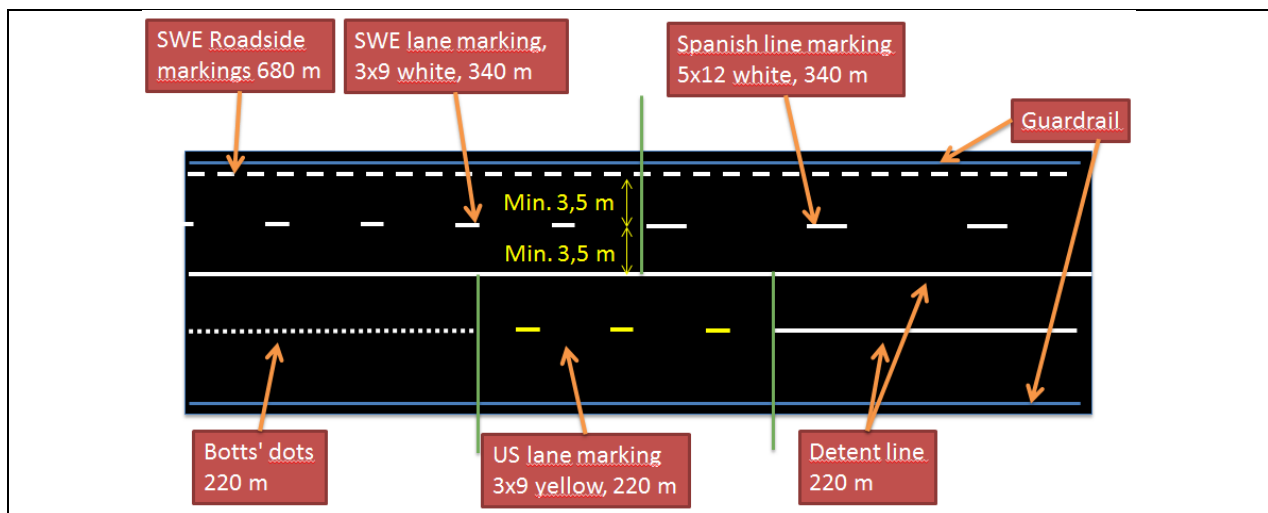


Figure 5. Lane markings available on the multi-lane road

EQUIPMENT

Equipment of different kinds is needed to successfully perform development and research at a test track. Among these are: test targets to be used in different traffic scenarios, equipment for position measurement and control, communication test equipment, data acquisition, and simulation capabilities.

Researchers and engineers visiting the AstaZero facility expect the tests to be repeatable with a high degree of accuracy and efficiency. It is expected that the equipment will be reliable enough to provide a very high availability of the test environment. There are clear requirements for productivity and through-put also at a test track.

All equipment, including the test targets, has to be properly maintained and periodically calibrated. So far, no international practice for calibration of test targets has been established.

Test Targets

The four main environments of the track are well suited to provide for many different traffic scenarios. But many traffic scenarios will also require other vehicles to be present. Safety precautions will in many scenarios require the use of test targets instead of real vehicles. Test targets are needed for cars, trucks, buses, pedestrians, bicycles and powered two-wheelers.

Test targets representing cars have been developed for rear-end collision scenarios [3,4,5]. Such a target must have a high fidelity of being perceived as a car both by the driver and by the sensor systems (radar, lidar, and/or camera) of the vehicle under test. At the same time, it must be possible to crash into without safety risks. The development of test targets for cars is towards correct representation of a car in all viewing angles, not only from the rear. Existing “balloon cars” have a three-dimensional structure, but do not provide a true 360 degree impression of the car. “360-targets” are under development and expected to be needed in future research and development.

Usually these car targets are towed or carried by a self-propelled flat platform such as the UFO [6] or LPRV [7]. However, being overrun by a heavy truck with full braking is a challenge for the platform-based solutions. It is also important to remember that the sensors on trucks could be placed in such a way that they “look down” at other road users which affect the design of targets.

Position Measurement and Control

Testing of vehicles in traffic scenarios requires the possibility to measure and control the position with high accuracy. The accuracy possible to reach varies depending on the type of scenario, especially the speed of the vehicles involved, but ± 20 mm is a state-of-the-art accuracy often mentioned. AstaZero is equipped with an RTK GPS base station which covers the entire test area. State-of-the-art GPS equipment is available as well as driving robots for driverless testing [8].

With the advent of automatically driven vehicles there will be a need for more complex traffic scenarios involving many road users. Here it will be necessary with interoperability between driving robots, target platforms, and overall scenario control. Standardized open communication interfaces will thus be needed. The trajectories of all targets and the test vehicle need to be synchronized, and the positioning of each actor needs to be sufficiently accurate. This calls for cost-efficient positioning based on local anchors and/or intelligent data fusion. In areas with poor GNSS reception, it might be necessary to augment the GNSS-based systems with a ground-based one [9].

Controlling test vehicles at high speed implies both safety risks for test engineers on the test track and the risk to severely damage expensive and unique prototype vehicles. All risks must be observed and the control system must be designed to provide adequate functional safety, i.e. to reduce all risks associated with malfunctioning of the control system to an acceptable level.

Vehicle Communication Testing

Communication between vehicles ("V2V") and communication between vehicles and the infrastructure ("V2I") will soon be offered in cars, trucks, and buses. The wireless communication facility will help to exchange data for safety applications, autonomous driving, traffic management and other applications. Communication facilities have to be offered by AstaZero.

The ETSI G5 standard defines a Basic Set of Application (BSA) for cooperative ITS. These applications are associated to a different number of use cases. Application classes have also been defined showing the potential of cooperative ITS for active safety as well as for efficiency and mobility. Among active road safety applications, three main blocks are also being defined by ETSI which group different applications: Road Hazard Signaling, Longitudinal Collision Risk Warning and Intersection Collision Risk Warning.

Communication nodes for application at AstaZero are under development. AstaZero has to be flexible and adopt the communication units since the test track will be used by several suppliers and vehicle OEMs.

Test Data

During product development testing a lot of test data is generated, especially raw data from sensors. Large amount of video data is not uncommon. In many cases the data collection is not centralized and integrated. Instead data is collected in different devices and tiresome post processing is needed to aggregate and align test data which in the worst case is out-of-sync. A secure and centralized data repository which collects test data in almost real-time could significantly improve the efficiency of proving ground testing.

The test track is used by several research groups and many companies. All partners need to know that the data collected from their test sessions is accessible only to them. Proper measures for IT security are deployed to ensure confidentiality of the data. Also the integrity of data and the availability of recorded data can be assured.

Analysis of the executed traffic scenarios will as good as always be performed off-line when the test is completed. Test data from several data loggers is synchronized and stored. One issue to handle is when data formats differ between the loggers used.

Simulating the Test Track

The use of the test track is considered as one of the tools to develop the automotive technology of the future. Research and development may start by simulation at a computer and then continue by simulation in a driving simulator. Vehicles will be driven at the test track and later in real traffic environments. Several tools will be needed to provide efficient research and development.

AstaZero has developed a model of the track to be used in driving simulators. The researchers and engineers have the possibility to try the test scenarios in a simulator before driving at the real test track. (Figure 6.) This will make it easier to plan the tests and run the most essential test cases on the track.

There is also a high-resolution three-dimensional model of the track which has been realized by on-site scanning of the four main environments. This precision model may be used for further enhancements of the driving simulations and planning of the test.



Figure 6. Ambulance drivers have trained at AstaZero both by driving on the track and in a desktop simulator

COMPETENCE AND RESEARCH

A Competence Cluster

A successful environment for automotive research and development certainly requires tools and equipment. In addition, the competence and the knowledge of the domain will be equally important. The Swedish automotive cluster has the ability to perform research, industrial development and rational production of road vehicles. The two major truck manufacturers Scania and Volvo Truck are together with the car manufacturer Volvo Cars the best known vehicle companies. There are also suppliers of world-leading reputation such as Autoliv. Research institutes offer possibilities for applied research together with all these industries, but also attract technology from small and medium sized enterprises (SMEs) in the automotive cluster. Several universities educate engineers for the automotive industry and provide automotive research together with European and international partners.

It is essential for AstaZero to have access to strong competence in its vicinity. The organizations residing in the Gothenburg region can be reached in an hour by car. The Stockholm region is more distant but it is quite possible to travel by road in four hours.

SAFER Vehicle and Traffic Safety Centre at Chalmers is a joint research unit where 30 partners from the Swedish automotive industry, academia, and authorities cooperate to make a center of excellence within the field of vehicle and traffic safety. The cooperation with authorities and local government is also essential for the development of AstaZero as a complete environment for automotive development and research.

The success of AstaZero is built on the track, the competence, and all the partners supporting the facility.

Research to Develop Testing

Test and development of novel technology requires state-of-the-art test methods and equipment. AstaZero is cooperating with research institutes, universities, and industry to develop both equipment and ways of working.

Future road transport will be different from what we are used to today. The global urbanization and the aging population are two of the main factors driving the change. Perhaps the most important factor is to mitigate the consequences of the climate change. Reduction of the emission of greenhouse gases will require a change in the way we use the roads.

AstaZero must also be prepared to work with new types of road vehicles. Electric powertrains and hybridization has influenced the types of vehicles we find on our roads. Electrification and smart charging of electric vehicles will require facilities for test and demonstration.

Automatic and autonomous driving will require a lot of development effort. All autonomous functions will have to be carefully tested; at first in a controlled environment such as AstaZero and later in real traffic. Research to facilitate testing with optimized coverage of the shifting factors of the traffic environment is

important. It is also important to understand how much of the previously performed verification and validation that has to be repeated when a design is modified.

Sweden has a long tradition of supporting national research in vehicle technology and transport. The largest Swedish program for automotive research is called FFI - Strategic Vehicle Research and Innovation. This is a partnership between the Swedish government and automotive industry for joint funding of research, innovation and development concentrating on Climate & Environment and Safety. FFI has R&D activities worth approx. €100 million per year, of which half is governmental funding. The background to the investment is that development within road transportation and Swedish automotive industry has big impact for growth. FFI will contribute to three main goals: reducing the environmental impact of transport, reducing the number killed and injured in traffic, and strengthening international competitiveness.

Standardization

The automotive industry is depending on standardization. Standardization will reduce costs by making it possible to re-use solutions from one vehicle to another vehicle. Standardized features will enable drivers to easily drive vehicles of different type and manufacture. It will also make it possible for road vehicles to interact and use the same roads.

Passive safety testing has been developing up to a point where results are comparable between different test sites and different vehicles. Crash test dummies have been developed and test procedures to represent the important crash types have been agreed. Testing of active safety and road automation is far from this goal.

AstaZero is participating in the standardization work of ISO (the International Standardisation Organisation) as convener of the working group ISO/TC 22/WG 16 for Active Safety Test Equipment. Active safety and the related standardization subjects is of interest from both an ITS and a vehicle perspective. Both perspectives have to be considered when allocating the various aspects and work items. A first step in the standardization is expected two-dimensional vehicle targets and pedestrian targets. That may be followed by targets representing bicycles and other vehicles in a more three-dimensional way.

CONCLUSIONS

The AstaZero facility has been designed and constructed according to plan. Operation started in the summer of 2014. New users of the proving ground are coming to join the competence cluster. There are already partners using AstaZero on a regular basis; vehicle manufacturers, suppliers and researchers come to AstaZero.

Equipment has been gathered and is still developing through several projects by industrial users and researchers. Also the competence network of AstaZero is under rapid development. Seminars have been held with researchers and two special “AstaZero Researchers Day” have been organized to make the research community in Sweden and internationally aware of the possibilities offered.

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