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Final report, A-TEAM phase 1

FFI Evolutionary steps in passive safety test methodology and test system

1964 → 2000

2000 → A-TEAM

With A-TEAM, Active Safety takes a first step in the same journey

Authors: Peter Janevik, Christian Berger, Magdalena Lindman, Per Gustafsson, Anna Wrige Berling, Mats Petersson
Date: 150427
Sub program: Vehicle Safety

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FFI in short

FFI 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 the following main goals: Reducing the environmental impact of transport, reducing the number killed and injured in traffic and Strengthening

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international competitiveness. Currently there are five collaboration programs: **Vehicle Development, Transport Efficiency, Vehicle and Traffic Safety, Energy & Environment and Sustainable Production Technology.**

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1 Executive Summary

To reach Vision Zero and maintain the competitive edge of the Swedish automotive cluster, research into active safety is crucial. The Swedish automotive cluster also has an ambition to be better than the level that laws and rating, such as EuroNCAP, require. To realize research and development of novel active safety functions to address situations far more reaching than what is required by these organizations, dedicated research activities are needed into new test methods to support the development of the new systems and functions to preserve leading market positions for the Swedish automotive industry.

A-TEAM phase 1 targeted, through research, the development of three method packages for important scenarios where research and development is needed for active safety systems. The research about methods took place in work packages WP4, 5, and 6, where WP4 focused on accidents with oncoming traffic, WP5 contained vulnerable road users research, and WP6 focused on rear-end situations where heavy vehicles closes in on a another vehicle from the rear.

To ensure that the methods would have relevance in real-world traffic, the method work was started after the field data research in WP3 had reached solid results. In WP3, accident statistics and further research projects on European level were used as sources to define the most important scenarios. Thereafter, analytical methods were used to condense the statistical data from WP3 into the test cases that were further researched in WP4, 5, and 6. WP7 was used to exploit the results from A-TEAM phase 1 in a successful way. Its goal was to address the test equipment shortcomings and demonstrate a test system where the methods could be performed. Even taking the work in the scenario, method, and test demonstrator work packages into account, it was clear from the beginning that A-TEAM phase 1 could only address a minor part of the total method research needed. To map out further as well as complementary research needs, WP2 conducted a pre-study focusing on the next few years.

The objectives of A-TEAM phase 1 were:
1. Through research, define accident scenarios within intersection collisions, accidents with heavy vehicles, and accidents with vulnerable road users including requirements
2. Create new knowledge about how other accident and autonomous vehicle scenarios not included in A-TEAM phase 1 can be solved
3. Create test methods for the scenarios
4. Demonstrate a test system where the test methods can be conducted with high quality and efficiency
5. Foster innovation, cooperation, and competence development within all areas above.

During A-TEAM phase 1, the scenarios were defined in WP3, upcoming and related research needs were mapped in WP2, and in WP4, 5, and 6, the methods were defined and demonstrated based on the WP3 scenarios. In WP7 test systems were defined realizing the research of the test methods in WP4, 5, and 6 by initiating the development of a target carrier platform. The project time however, was far too limited to allow for

complete development of the platform within the scope of A-TEAM phase 1. The quality and efficiency targets were reached, but not only thanks to technical research but also through process- and organizational development.

2 Background

Because of the rapid technical development, the number of potential active safety functions has increased at brisk pace. To be able to develop and verify these functions all the way to production-ready solutions, a host of new test methods and test systems is needed. The functions of today mainly address accidents between vehicles in the most common rear-impact situations, but accident types with a high number of injuries such as accidents with cyclists, heavy vehicles, and at intersections are not sufficiently addressed yet. Thus, methods to test these types of situations does not yet exist and thus, a test system is also missing that would fully support the complete variety of velocities, angles, and precision needed to conduct the testing contained in A-TEAM phase 1. Existing equipment is in many cases technically immature and not integrated with other sub systems, something that has been confirmed in AstaZeros and the project team's initial benchmark analysis. Because of the lacking integration, only low efficiency regarding time and resource is possible, something that is already hampering the development rate for active safety systems for the Swedish automotive industry. In A-TEAM phase 1, a pre-study mapping the overall need regarding methods, equipment, and the like was included.

The state-of-the-art for active safety testing is in many ways similar to that of passive safety testing in the seventies and it is clear that the group that first researches the test methods and test systems needed to develop and validate the next generation of active safety systems gets a great competitive advantage. A clear example is EuroNCAP where the rating for intersections and cyclists is aimed to be introduced in the 2018-2020 time frame.

3 Purpose

A-TEAM phase 1 aimed at taking the first few steps within three various scenario types with the research associated to these steps: the methods themselves, the test system, and field data research. The method research also aims to allow the Swedish automotive cluster to develop systems and functions far ahead of the current state-of-the-art, making it possible to maintain and strengthen the world-leading position of the cluster.

4   Project realization

The project was divided into seven work packages, WP1 to WP7. This section is an introduction to the realization of each work package.

4.1   WP1, project management

WP1 was the project management work package. In this work package, the various other work packages were followed up on a weekly basis with respect to results, reporting, coordination, economy, and others. Reporting, planning of demonstrations, and project prioritizing were also part of the tasks of WP1.

4.2   AP2, pre study

We followed the guidelines from Singer et al. on reporting about field-data collection as published in Shull et al. [2].

Context and Attendees
The workshop was planned to take place on-site at AstaZero [1]. 17 stakeholders were invited to the workshop. The invitees' list included the work package leaders from the seven work packages in A-TEAM representing the entire context of the project; furthermore, the work package leaders were encouraged to further spread the invitations to colleagues and employees from the organization where they saw a matching relation or field of interest. Twelve persons attended the workshop where two came from academia and ten from industry.

Role of the Moderator
The workshop was moderated by the leader of WP2, whose role was (a) to guide the brainstorming process and (b) to provide input from the academia's perspective to the brainstorming and discussion.

Brainstorming Process
The brainstorming process/creativity phase was initiated by setting the frame of reference with the following questions:
- What is missing in terms of concepts, methods, tools, and equipment?
- Where do we see the most urgent and important challenges to better carry out tests for active safety systems?

The moderator distributed sticky notes to the attendees where they could write down their answers and view for the aforementioned questions in a focused session with no interaction amongst each other. After approximately 45 min, the moderator started to collect the sticky notes, read them aloud in front of the audience to first ensure a common understanding among the attendees about the topic mentioned on the note and secondly, to start a discussion about (a) relevance to other industrial or academic partners and (b)

similarity to sticky notes from other attendees. The attendees were not allowed to mark their names or respective organization on the sticky notes; the motivation behind this was (a) to treat all sticky notes equally important in the subsequent discussion without favoring one participant over another over, and (b) to avoid traceability afterwards to reflect the joint character of the results from this workshop.

Data Recording
During this joint discussion phase, several disjunct topics emerged where the sticky notes could be grouped. These topics where adjusted and sharpened a couple of times (a) to well summarize the contained notes and (b) to have a joint understanding of the emerging clusters among the attendees. These clusters where made visible to the audience on a large canvas to also guide the joint discussion. This joint discussion took approximately two-and-a-half hours.

All collected sticky notes were photographed and transcribed for the accompanying minutes to the on-site workshop. These notes were shared with all attendees.

4.3 AP3, accident scenarios

The goal for WP3 was to, based on traffic accident data, identify relevant accident scenarios and also specify these for the development of test scenarios, see Figure 1.

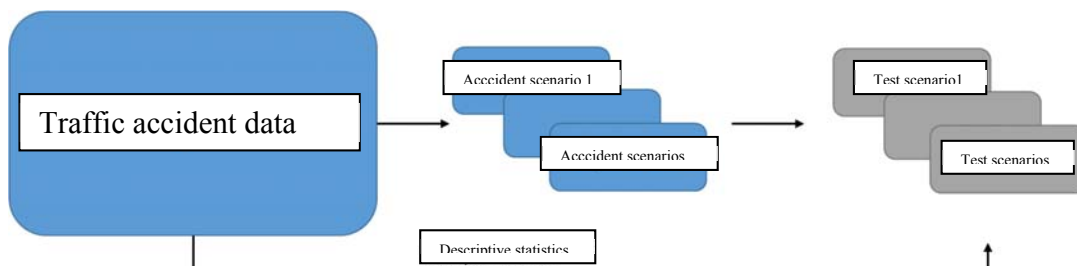*Figure 1. Illustration of substeps in WP3.*

Accident scenarios for the conflict situations:

- LTAP/OD (left turn across path/opposite direction), host vehicle turning left
- Rear-End

and also:

- Vehicle-Cyclist crashes

were identified. Each accident scenario formed the foundation for a test scenario. Then, data analysis supplemented the specification of each test scenario that were defined later in WP 4-6.

4.4 WP4, method development for vulnerable road users

Research of a test platform for testing without the driver in the loop was planned and conducted. This included test scenarios, test methods, test objects with propulsion system, driving robots, measurement equipment etc. From WP3, a number of test scenarios were identified for car-cyclist collisions that formed the base for development of test scenarios and test methods in WP4. The A-TEAM project has adapted this first generation of cyclist test methods to the parallel research activity conducted in Europe; the CATS [6] project, led by TNO. The Austrian company 4A has developed a pedestrian target which will be used in the EuroNCAP rating from 2016 onwards. 4A also develops a cyclist target within the CATS research project. A-TEAM phase 1 has opted to purchase a prototype target from 4A, thus freeing resources for the test method development. For A-TEAM phase 1, the propulsion system used for pedestrian testing was deemed sufficient.

4.5 WP5, method development for LTAP/OD

Test platform for tests without the driver in the loop
A test platform has been researched for system testing without the driver in the loop, in a left turn in the LTAP/OD situation, based on the input from WP3. The test platform has both been integrated into the internal processes used for test scenario development in use by the partners, both for CAE-based test-scenario development and direct programming of steering robots. Test matrices with left- turning test subject vehicle (SV) compiles testing with varying SV speeds and on the test vehicle and Principal Other Vehicle (POV) in intersections with varying geometries.

Tests with driver in the loop
Further research has been carried out on a test platform for testing with the driver in the loop in the LTAP/OD scenario based on results from the FFI project DCBIN regarding driver reaction and kinematic influence on the driver at autonomous braking interventions at left turn. The test platform has also included the handling of test persons. In this part of the test platform, AstaZero has planned and conducted the recruitment of the test persons based on requirements from VCC. VCC were then responsible for carrying out the testing. This part was carried out in an exemplary way and will form the foundation for upcoming testing with the driver in the loop.

4.6 WP6, method development for heavy vehicles

Mapping of test method need for heavy vehicles
To secure that all needs are taken into account and that as much synergies as possible are identified between different test scenarios in order to maximize the equipment and method development coming (planned and foreseen) functions and systems were mapped. As input to the mapping, accident statistics, external influences, and company strategies were considered.

Experiment design – heavy vehicles

From the above survey, the scenario chosen for this first phase of the A-TEAM project is an "extended rear end scenario". By extended, we mean that we go beyond the requirements for our current advanced emergency brake system and cover also foreseen requirements for future advanced emergency brake systems.

The rear-end scenarios were grouped into three categories (the sketches should be seen as examples – not describing the entire need for scenarios in the category) as shown in Figure 2.

– Straight
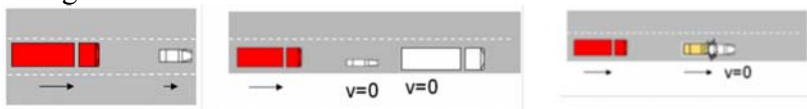
– Lane change / cut-in
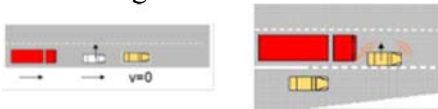
– Curve/Intersection

Figure 2: Categories for rear-end collision scenarios.

Regardless of scenario – the method approach is similar;

(i)   Virtual Simulation Environment: Used to generate scenarios with details of the real environment where the vehicle will also be represented with dynamics and functions as in the real vehicle. In this project, PreScan is used as the simulation environment.

(ii)   Component level: Driving robots with the same profile as the virtual simulation environment will be able to run the same scenarios as in the virtual world in simulated tracks

(iii)   Test Drives: Based on the input received from the virtual verification and validation productive test drives will be carried out in real vehicles in targeted environments.

Experiment implementation – heavy vehicles

As equipment and tool development is part of the project and carried out in parallel with the method development, the experiment implementation at this stage is limited to the use of existing equipment. This means, that we try to carry out the testing with existing driving/steering robots (ABD and Autoliv) and targets (Autoliv rail balloon car).

Focus has been both on the ability to reproduce the wanted scenarios on the test track and on the efficiency and safety of the testing. This work will continue in the upcoming A-TEAM II project.

Scenarios:
The following 2 scenarios were tested on the ASTA multilane test track as shown in Figure 3.
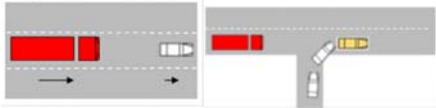
Figure 3: Scenarios tested on AstaZero proving ground.
(Due to the availability of only 1 target and to the inflexibility of the rail that guides the balloon car, it was not possible at this stage to test more scenarios)

Efficiency / Safety:
To improve the efficiency (time per run) and also reduce the need for acceleration stretch (which impacts the possibility to run tests on different tracks), the acceleration profile was optimized. This was done by running tests with and without load and with and without trailer.
To increase the safety in the testing with driving/steering robots, the impact of function intervention on the robot action was investigated.

4.7 WP7, test equipment demonstrator

WP7 received input on what is needed in terms of future test equipment from WP4, WP5, and WP6; this input was used to define clear requirements of a concept solution. Top speed of 80 km/h, maximum run-over height of 90 mm and waterproof were set as the most important criteria. Several different concept solutions were evaluated through different comparison matrices. Once the final concept solution was chosen as a stand-alone platform with on-board propulsion, calculations and physical tests were performed to find input to the design of the platform.
To determine the power needed in order to reach the platform requirements, a calculation model was used. This took into account the different forces acting on the platform; rolling resistance due to mass and aerodynamic properties due to body shape of target. Both propulsion force and resistance force was considered and the results gave input to the drivetrain. The calculation model was evaluated through physical tests of a passenger vehicle.
To determine the risk of injury or damage to equipment in case of a collision between platform and test vehicle, crash tests and run-over tests were performed. Crash testing was performed through a lateral impact of platform into passenger vehicle's tire/wheel. Run-over tests were performed by driving over the 90 mm tall platform with a passenger vehicle as well as a truck. Finally a concept of the final platform solution was presented.

5 Results and deliverables

5.1 Results per work package

5.1.1 WP2

In the following, the resulting topics from the on-site workshop planned and conducted as described in the methodology for WP2 are reported as shown in Figure 4. Further details as well as the raw data are available in the complete final report for WP2.
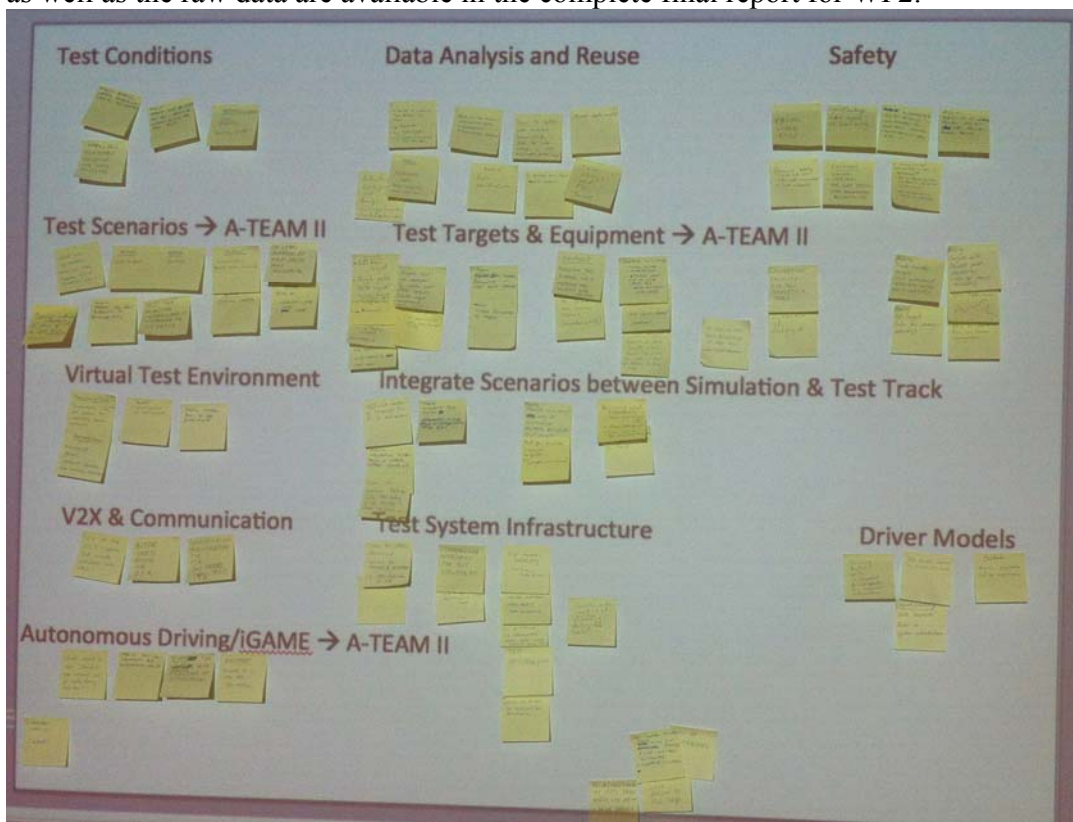

Figure 4: Resulting topics map from the on-site workshop.

Identified topics:
- Topic 1: Test Targets & Equipment
- Topic 2: Data Analysis & Reuse
- Topic 3: Safety
- Topic 4: Integrate scenarios between simulation & test track
- Topic 5: Driver Models
- Topic 6: Test System Infrastructure
- Topic 7: Test Scenarios

- Topic 8: Autonomous Driving/iGAME
- Topic 9: Virtual Test Environment
- Topic 10: V2X
- Topic 11: Test Conditions

5.1.2 WP3

In WP3, the accident scenarios for selected conflict situations were identified in traffic accident data. Also, statistical analysis specified the scenarios for test development in WP4, 5 and 6.

LTAP/OD, host vehicle turning left

For LTAP/OD, host vehicle turning left, a literature study and a review of fatal accidents in Strada for the accident years 2011-2013 was conducted. A statistical analysis of data from the accident years 2007-2013 on 86 accidents with modern cars in the Volvo Cars Accident Database (VCTAD) was also performed.

24 published reports that studied LTAP/OD accidents or LTAP/OD situations in driving data in real traffic were compiled per geographical region (North America, Asia, Sweden and the rest of EU) and selection criteria (accidents reported by police, fatal accidents etc.). Results from the reports were organized in categories: velocity-related measures, posted speed limits, traffic control, state of the road surface, precipitation, driving lanes and road geometry, lighting conditions, obscured view, counterpart/other, traffic elements, collision, and driver-related pre-crash parameters. Examples of relevant information for the project were: variety in intersection geometries, counterpart types in serious accidents and details such as travel and turn speed in driving data.

In a cluster analysis based on data from VCTAD three accident scenarios were defined that are described using four variables in Figure 5.

1. Main deformation side of turning car (kollisionstyp LTAP-bilen)
2. Initial lateral offset (Y)
3. Width of the crossing road (B)
4. Combination of estimated velocities for each vehicle (hastigheter)

kollisionstyp LTAP-bilen	sida	front	sida
Y (se fig)	7 m	4 m	18 m
B (se fig)	14 m	8 m	25 m
hastigheter (LTAP-bilen vs OD-bilen)	10-20 km/h vs 21-40 km/h	10-20 km/h vs 41-60 km/h	41-60 km/h vs 41-60 km/h

Figure 5: Cluster for LTAP/OD –accident scenarios (Swedish, unit key in table above).

Based on these accident scenarios, the test scenarios for AP5 were subsequently developed.

<u>Car-cyclist</u>

For cyclists-car crashes, accident data analysis reports that was published in other test development projects [6,7], were compiled. Also, a review of results from studies on cyclist accidents with heavy vehicles was performed. A statistical analysis was conducted on data from the accident years 2005-2013, with a total of 311 accidents with modern cars in the Volvo Cars Cyclist Accident Database (V_CAD), which is presented in greater detail in [8].

Prioritized conflict situations for the CATS project [6] based on analysis in various European traffic accident databases were:

- Straight Crossing Path, cyclist from right (SCPcr)
- Straight Crossing Path, cyclist from left (SCPcl)
- Straight, cyclist Same Direction (SD)

For this project, further situations were also prioritized:

- Left Turn, cyclist from Opposite Direction (LT/OD)
- Right Turn, cyclist from Opposite Direction (RT/OD)

The conflict situations are schematically illustrated in Figure 6. In total, these situations summed up 56% of all the car-cyclist situations regardless of personal injury to the cyclist (MAIS0+) in V_CAD and more than 54% of all the accidents with serious personal injury (MAIS2+).

SCPcl   SCPcr   SD   RT/OD   LT/OD
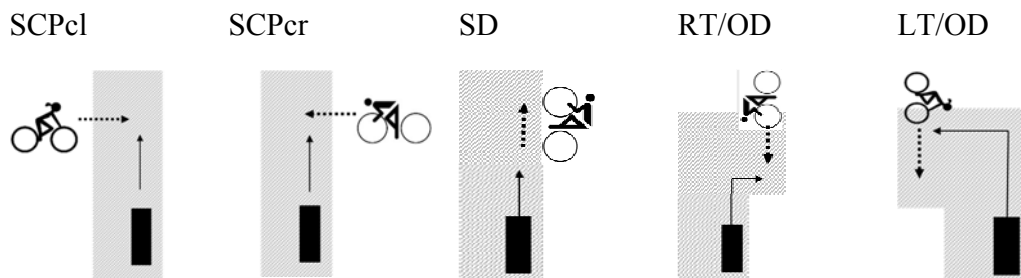
Figure 6: Prioritized conflict situations for car-cyclist accidents.

Altogether, this results in three accident scenarios for development of test scenarios in WP4;

1. Straight Crossing Path
2. Same Direction
3. Host vehicle turning, cyclist from Opposite Direction

Descriptive statistics were then presented for each accident scenario. Important parameters to take into account were e.g. the car and the cyclist velocities, obscured views, initial offset (for Host vehicle turning, cyclist from Opposite Direction), collision type and the size of the cyclist.

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Rear-end Frontal

For Rear-end Frontal-accidents, four studies presenting accident data analysis were compiled where at least one heavy vehicle was involved in a traffic accident. A major part of the accidents is represented by two accident scenarios, see Figure 7:

1) Same Direction: The vehicles are travelling in the same direction and the heavy vehicles drives into the vehicle ahead of it. The vehicle ahead of it is either standing still or driving slower than the heavy vehicle.

2) Vehicle going straight – opponent from left or right: the heavy vehicle is driving straight ahead and the counterpart is turning out into the path of the heavy vehicle

Same Direction   Vehicle going straight –
                        opponent from left or right

Figure 7: Accident scenarios for Rear-end-situations with heavy vehicle.

In a majority of the accidents, the collision object was a car or another heavy vehicle and in the Same Direction scenario, a significant share of the collision objects was stationary. Further analysis was conducted in WP 6 in which the test scenario was developed and defined.

5.1.3   WP4

Experiment design
During phase 1, experiment design for chosen test scenarios has been conducted and the test equipment and propulsion system has been modified for these scenarios. In Figure 8, an example of one of the specified test scenarios is shown including a velocity matrix for SV and POV.
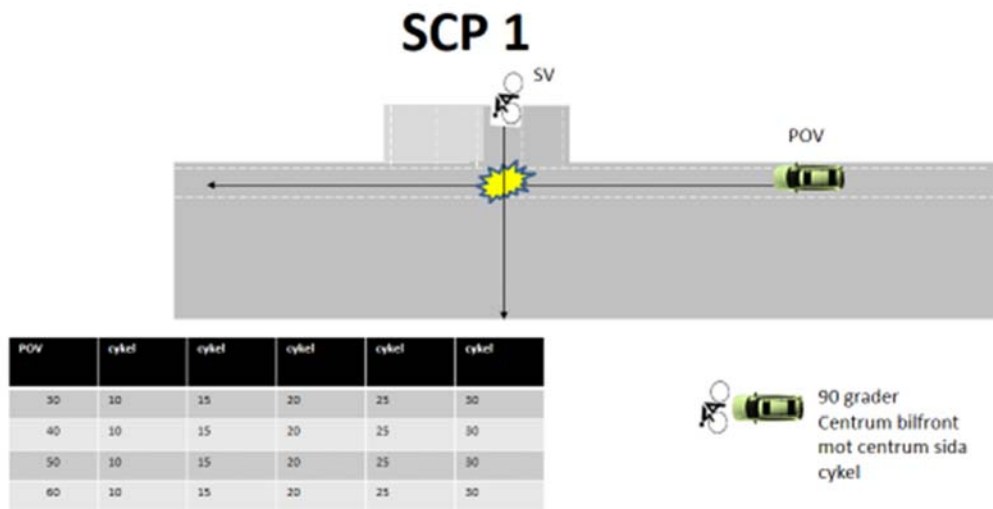
SCP 1

POV	cykel	cykel	cykel	cykel	cykel
30	10	15	20	25	30
40	10	15	20	25	30
50	10	15	20	25	30
60	10	15	20	25	30

90 grader
Centrum bilfront
mot centrum sida
cykel

Figure 8: Example of a cycle test scenario.

Carrying out of experiments
Pilot testing has been conducted for lower velocities. Due to the state-of-the-art for the propulsion system, the propulsion system needed to be modified for higher velocities by the supplier ABD, which caused time loss that made full completion of the experiment matrix during A-TEAM phase 1. These experiments will be carried out in A-TEAM phase 2 instead. The requirements for accuracy are similar to those for pedestrian testing and are judged to be met in the lateral test cases- +/-5 cm without autonomous braking of the test vehicle.

5.1.4 WP5

Experiment design
The experiment design and method development has taken place in three iterations and has been adapted to the limitation existing with respect to available test objects and test equipment. The test scenarios and their velocity matrices were based on results from WP3

Carrying out of experiments

In iteration 1, tests in left hand turns of SV in LTAP/OD were performed using the Autoliv driving robot in combination with the Autoliv test target and propulsion system for POV. In iteration 2, tests of left hand turn of SV in LTAP/OD using an Anthony Best Dynamics (ABD) driving robot in combination with and Autoliv platform without target for POV. Because of the problems and risks with the current state of the art platform during LTAP/OD, only low velocity up to 20 km/h in SV and POV not resulting in

collisions were permitted. The platforms will be further developed to handle these collision scenarios within the complete velocity matrix. Development of platform technology is done concurrently in WP7, and A-TEAM also follows the development of platform technology in the US and EU. In iteration 3, tests in left hand turns were conducted by SV in LTAP/OD using ABD driving robot in SV in combination with an Autoliv target as a POV. The tests were constrained to the maximum allowable delta velocities between the target and the subject vehicle.

In A-TEAM phase 2, new designs for test method, test object and propulsion system needs to be found to allow for testing of the complete velocity matrices for each test scenario.

The quality and accuracy of the test results have been high, even though the testing in LTAP/OD has been conducted in open-loop control mode between the ABD driving robot and the Autoliv target. During the method development and verification of the test methods in the LTAP/OD scenarios in WP5, the requirements for joint cooperation, planning and coordination have been very high. The research work has identified that many competences are needed, both related to the carrying out of tests but also support for test vehicles, functions and sensors, handling of test objects, measurement equipment, and CAE competence.

EuroNCAP have decided to postpone the intersection scenario until 2020 which highlights the challenges in this test-method branch. However, full focus is still needed to be able to field robust methods including test targets and propulsion systems at this point in time.

The validation of the test method with the driver in the loop went well and the testing was conducted in an efficient manner in a cooperation between AstaZero and VCC, where AstaZero were responsible for the test persons, proving ground and test equipment while VCC were responsible for the test completion.

5.1.5 WP6

A high-level summary of the method need for heavy vehicle methods and tools is shown in Figure 9 (for secrecy reasons this table does not give very detailed scenario descriptions and refers to traffic situation rather than function).

Traffic situation		Run off road	Instability on road	Oncoming head on collision	Rear end collision	Intersection	Lane change	Low speed VRU accidents	Intersection VRU	VRU crosses path	Automated driving / Numerous traffic situations
Priority (1-3)		2	2	3	1	3	2	2	1	2	1
Speed range	Truck	0-80	0-80	0-80	0-80	0-80	0-80	0-20	10-40	0-80	0-80
	Target	-	-	0-80	0-80	0-80	same as truck	0-10	0-20	0-30	All speeds
Target	Trucks/buses			x	x						x
	Passenger cars			x	x	x	x				x
	VRU			(x)				x	x	x	x
Moving path	Truck	Straight	Curve	Straight, curve	Straight, curve	Straight, turn	Straight, lane change	Straight, turn	Straight, turning	Straight, curve	Straight, turning, curve, lane change etc.
	Target	-	-	Straight, curve, lane change, turn	Straight, curve, lane change, turn	Straight, turn	Straight	Straight	Straight, turning	Straight	
Multiple targets		No	No	Not in first stage	Yes - at least 2	Not in first stage	Yes - at least 2	Not in first stage	Not in first stage	Not in first stage	Yes - multiple vehicles/targets needed
Road characteristics		Lane markings	Normal and slippery	Lane markings	Lane markings		Lane markings		Urban intersection, zebra crossing, bicycle path		Multiple - all of the above and more

Test method gaps											
	Test vehicle control	A flexible and efficient method to identify critical scenario parameters (speed, offset, distance etc). Existing robots fulfill accuracy and ability needs.									
	Target control	-	-	Possibility to freely design target path. Crashworthiness of target (for heavy vehicle scenarios)							
	Target features	-	-	V2V	Target sensor fidelity (radar and camera primarily) - from front, rear and side						
	Other	Synchronization and control of test scenarios with multiple objects.									

Figure 9: High-level summary of the method need for heavy vehicle methods and tools.

As seen in the table, there are many similarities between different traffic situations, in terms of test vehicle control and target needs, so there are good chances to cover many scenarios with only a few variations in target and vehicle control.

The experiment design resulted in a number of requirements for equipment and tools:
- Truck speed: 0 - 80 km/h
- Truck controlled with robot (drive files)
- Robot should accelerate truck smoothly also at higher acceleration
- Target controlled with drive files
- Possible target paths must include: straight, lane change, curve driving and turn around corner.
- Target acceleration/deceleration up to $7 m/s^2$
- Target speed 0-80 km/h
- Truck, target, and logged data synchronized
- Target must withstand collision with truck
- At least 2 targets needed

- Logging of data
  - Position on the track and relative to each other.
  - Test object and targets/dummies.
  - Motion direction and speed relative to the vehicle
  - Sampling frequency, different requirement depending on speed.
- Safety
  - The test environment must be designed in a traffic safe manner that allows for the test vehicle to run off the road or that prevents the test vehicle from running off road – without danger for the driver.
    => Emergency stop for test vehicle and target
    => Possibility to set "boundaries" for driving robot.

Main results from physical testing of the test method:
- High accuracy and repeatability for all speeds tested.
  (Checked through "closed loop analysis" PreScan – test track – PreScan)
- Acceleration time shortened for truck
- Safety of function intervention when truck controlled by robot secured.

This gives a solid ground for A-TEAM phase II where we will extend the method to include more scenarios and – most important – include more vehicles in a synchronized setup.

5.1.6 WP7

The comparison between test vehicle and calculation model showed a difference of 7%, this may be due to incorrect mass measuring of the test vehicle and is not considered to be a major issue. The run-over testing showed that it is very low risk of injury for a healthy passenger to drive over a 90 mm tall platform at velocities up to 130km/h, given that the platform has side-ramps with 8.5 degrees inclination. The crash testing showed that occupant(s) in the car being struck by the platform might experience acceleration levels leading to large lateral movement under a short period of time, therefore yielding a risk of passenger(s) hitting the inside of the test vehicle. It is at this point uncertain if any occupants may be in the test vehicle at test scenarios where there is a risk of the platform hitting the vehicle laterally at 50 km/h; at 90 km/h no person may be inside the test vehicle.

Based on the calculations and testing the following list displays the keys to producing test equipment capable of reaching the requirements set by WP4, WP5 and WP6.
- Recommended propulsion power: min. 25kW
- Recommended platform height: max. 90mm
- Recommended top speed: min 80km/h
- Recommended inclination of ramps at side of platform: 8.5°

- Recommended vertical stiffness of platform chassis: min. 60 000N

It was decided within WP7 that a stand-alone platform is what is needed for future active safety testing based on the input criteria from WP4, WP5, and WP6. There is no platform on the market capable of running tests at velocities above 80km/h and/or having a height limitation of 90 mm. It was therefore deemed necessary to develop something there is a strong need for, even though the time in A-Team Phase 1 was not enough, rather than creating something quick with low desirability within active safety testing. The output from WP7 will be used as foundation for the development of a stand-alone platform within A-Team Phase 2.

5.2 Delivery to the FFI goals

The combination of a proving ground and the new tools and methods that this project aimed at developing contributes to many of the general FFI goals. Swedish industry has, thanks to the test methods, a unique platform for research and innovation and thus access to new tools in the work to remove accidents resulting in serious injuries and deaths. These test methods are needed also to support the development of autonomous vehicles since autonomous vehicles must be able to handle these situations.

The methods and test system addressed four out of six research areas in the strategic roadmap for the vehicle and traffic safety:
- Vehicle and traffic safety analysis including other facilitating technologies and knowledge
- Basic safety attributes of vehicles
- Driver support and related interfaces between driver and vehicle
- Intelligent collision-avoiding systems and vehicles

Through the mapping of the potential future method and test equipment steps, a plan was indirectly created for further contribute to the roadmap in many steps. Swedish vehicle industry is in the absolute cutting edge of active-safety development and the new possibilities in the new methods combined with the testing efficiency improvements will allow the industry to maintain and increase the leadership. Accidents in intersections are already mentioned as a domain where active safety can contribute [4]. Within this scope, cooperating systems based on vehicle to vehicle and vehicle to infrastructure is contained. As shown by Lefévre [5], the number of involved parties in combination with their various types is increasing the dynamics and complexity of the traffic model. By using suitable warnings- or other active safety systems that e.g. informs parties in intersections in time, the associated risk for this traffic type can be lowered. The decision by EuroNCAP to develop a rating method for the scenario type further shows the focus dedicated to this traffic environment.

The increased method and equipment competence will allow the Swedish companies, institutes and universities to play a greater role in the EU Horizon 2020 programs.

Within the SAFER framework, there is already a strong cluster that now has gotten more nourishment to further strengthen the cooperation between the triple helix parties. Swedish vehicle industry have gotten new possibilities to develop new vehicle based active safety systems that supports the driver in taking the right actions in situations involving various cognitive driver loading and possibility to strengthen driver initiated actions such as braking.

Similar scenarios will be designed for driving simulators and this will create a need to validate simulator tests using proving ground testing. The knowledge is used to develop driver models to CAE tools utilizing the potential of shorter development times of technology.

6   Dissemination and publications

Within the frame of A-TEAM phase 1, no major publication was undertaken due to the short time span of the project running only about a year. Dissemination was created by means of demonstration of a chosen scenario type during AstaZero Researchers Day, when the scenario was shown to about 80 researchers and industry representatives from Sweden, Germany, and China among other countries.

In A-TEAM phase 2, publications are planned by means of the PostDoc that will join the project. A-TEAM phase 1 is connected to a host of other projects and product launches that will help spread the results further. The results will also be spread through participation in European research projects such as ASPECSS and CATS, cooperation in the development of rating methods and standardization of target types in the ISO setting.

7   Conclusions and future research

A-TEAM phase 1 has delivered validated test methods, scenarios, and demonstrated them in test systems with performance levels necessary for validation of the methods. To reach higher velocities and to create more complex scenarios, the platform development that was defined and initiated in A-TEAM phase 1 must be completed among others.

Research into more scenarios, methods, equipment, and test infrastructure will continue in A-TEAM phase 2. A number of other applications are also planned that originate from the ATEAM phase 1 WP2 pre study. iTRANSIT and MIRAGE are two examples of such applications.

8 Participating parties and contact persons

Peter Janevik, peter.janevik@astazero.com, 010-5166143

Contact persons:

VCC: Anders Axelson, anders.axelson.ii@volvocars.com

AB Volvo: Anna Wrige Berling, anna.wrige@volvo.com

Autoliv: Christian Svensson, christian.svensson@autoliv.com

SP: Henrik Eriksson, henrik.eriksson@sp.se

Chalmers: Christian Berger, christian.berger@chalmers.se

AstaZero: Peter Janevik, peter.janevik@astazero.com

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