

Active Collision Avoidance System

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1. Nomenclature

ACA	Active Collision Avoidance
ATE	Aerodynamic Test Equipment Ltd.
FOV	Field Of Vision
IP	Intellectual Property
LiDAR	Light Detection And Ranging
OOP	Out Of Position
PTS	Probe Traversing System
TMC	Traverser Motion Control
UUT	Unit Under Test (the test article)
WTCS	Wind Tunnel Control System

2. Introduction

This paper describes ATE's innovative new system for maximising the safe operation of any large probe traversing system, whether supplied by ATE or not. ATE has for many years supplied large probe traversers with passive safety systems that protect the PTS and the wind tunnel infrastructure, including client UUTs.

These systems include:

- 'Teach' routines (both manual and automatic) that allow the operator to record 'exclusion zones' that the PTS cannot enter and,
- CAD model integration of the UUT into exclusion zones.

ATE has developed a novel system that augments these established methods by adding active collision avoidance capability to greatly improve detection and avoidance of unwanted impacts with hard objects or personnel operating inside the test plenum. This additional level of safety is particularly beneficial to protect against impacts with objects in the plenum that are in an unknown position, objects such as vehicles / parts of vehicles in positions unknown to the CAD / surface model, or personnel moving inside the plenum.

The system can be retrofitted to traversing systems not supplied by ATE also.

3. General description

The active collision avoidance system constantly scans the area around the vertically translating carbon fibre Z strut using multiple LiDAR sensors mounted to the PTS at optimal positions to maximise the FOV. These sensors detect any object that can be 'seen' and is in the trajectory of any part of the PTS and warns of a collision. Realtime visual feedback of LiDAR imagery is provided on the control computer display for the operator to monitor, and if the system detects a collision, it automatically slows the motion of the PTS as it approaches an obstacle and ultimately stops the PTS if it comes within a user-defined proximity limit. The system can identify both out of position inanimate objects and personnel operating inside the plenum.

4. Technical proposal

The system incorporates the latest LiDAR transceivers that scan a wide range of the environment around the PTS at a frequency of 20Hz to produce a 'real-time' 3-dimensional representation of the PTS and its surroundings. This 3D image is used to determine the proximity of the PTS from any object and take appropriate control system interventions to maximise safety of personnel and objects inside the plenum.

4.1. Scope of supply

- Quantity 2: 360° by 180° FOV LiDAR transceivers mounted with partial overlap in key areas.
- All necessary wiring
- Software interface to ATE or non-ATE WTCS software (as appropriate).
- Installation and commissioning at the customer site, or delivery and remote support if the client wishes to install and integrate themselves.

4.2. System resolution and accuracy

The system operates at a resolution of 1024 lines (horizontal) by 128 lines (vertical) at 20Hz. The accuracy of the system is dependent upon distance from the target, for example at 10m range accuracy is +/- 40mm.

4.3. Two operation options

4.3.1. Option 1: Fully Integrated into the WTCS

This option provides a fully integrated additional safety level that gives the maximum level of safety for test equipment and vehicles, and more importantly that of personnel inside the plenum.

The following settings can be input by the operator:

- Warning threshold zones
- Speed control parameters
- Exclusion zones / no-go areas
- Estop responsiveness

ATE's software provides the operator with a visual simulation of the physical environment (e.g. the plenum building and features, objects inside the plenum). The following detailed collision checks are performed 20 times every second:

- Full probe shape definition, not just tip position
- Full PTS surface collision detection
- All motion translation and rotation mapped out in simulated environment

On detection of proximity to an object the PTS traverse speed is reduced gradually until reaching the user-defined minimum safe distance at which point the PTS is stopped automatically. In the event of a rapid approach outside of the controlled slow down parameters the PTS will trigger an E-Stop event and prevent further motion until the condition is cleared.

For a WTCS that is not supplied by ATE full Integration into the WTCS may require assistance from the WTCS supplier. ATE will work with the supplier to deliver the maximum benefits described here. For a non-ATE supplied WTCS the following information is required to be made available to ATE:

- Position of all motion-relevant actuators.
- CAD models of the PTS and associated items in the plenum (ATE can produce this for a client if required).
- Either access to control software, or support from current hardware supplier.

4.3.2. Option 2: Standalone

This option supplies the required LiDAR hardware to provide one of the following system feedback options:

- Raw distance and direction of closest object to the PTS probe tip position, or
- Output via either a physical digital I/O or by TCP message, which boundary contains objects, prioritising the closest object.

The operator can specify a range where a specific output will be triggered, which should be handled by the WTCS (e.g. 2-4 ranges, such as 0m-0.4m, 0.4m-1m, 1m-2m).

This option allows for the client to integrate the ATE system into the WTCS themselves. Alternatively ATE can provide this integration (option 1, above).

4.4. Control system integration

The system can be integrated into ATE's WTCS or into a WTCS supplied by others.

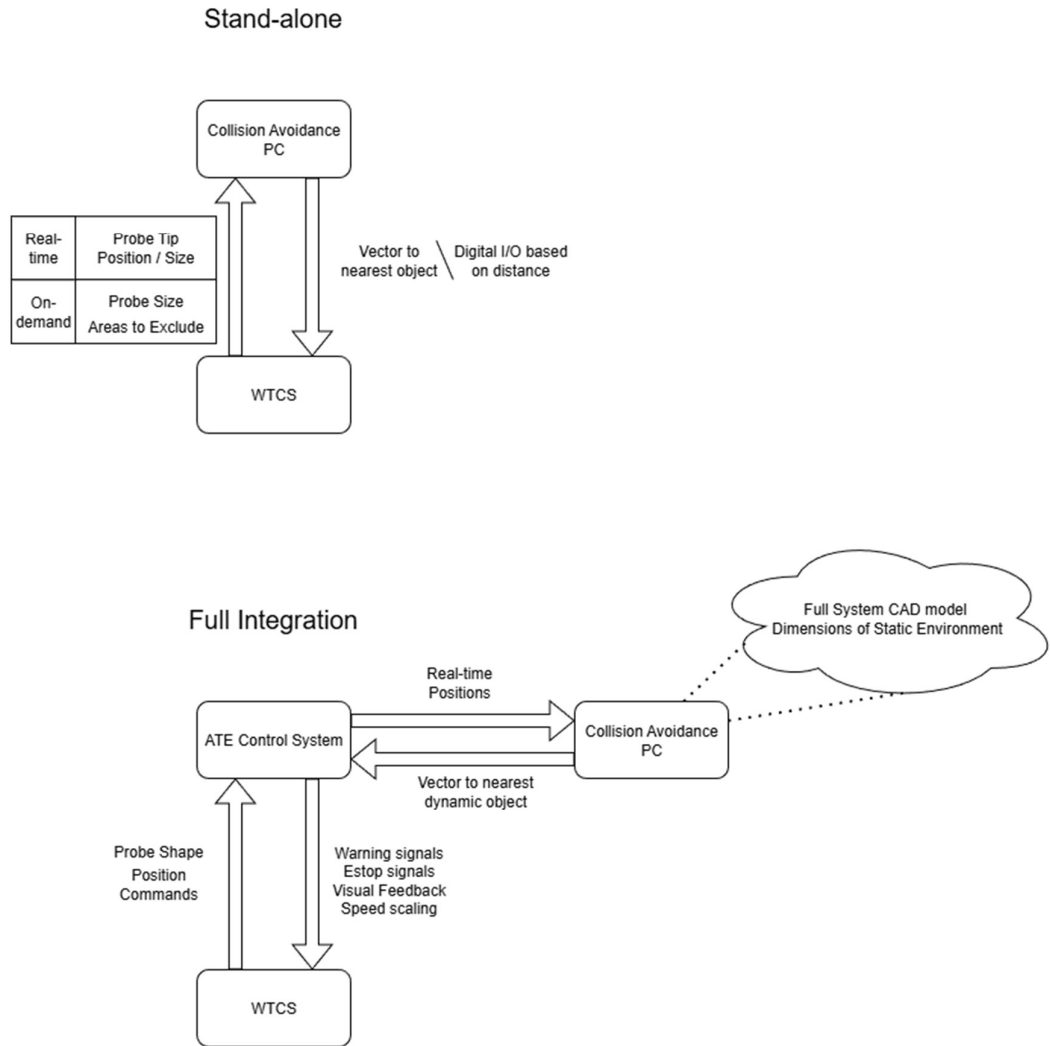


Figure 1 Control system integration schematics

5. Benefits

- Increased safety of personnel operating inside the plenum.
- Minimises the likelihood of damaging instrumentation devices, the PTS, UUT/model, etc.
- Finer positioning control when approaching model, with automatic speed reduction.

This system greatly improves the safety of the overall wind tunnel operation.

6. System images

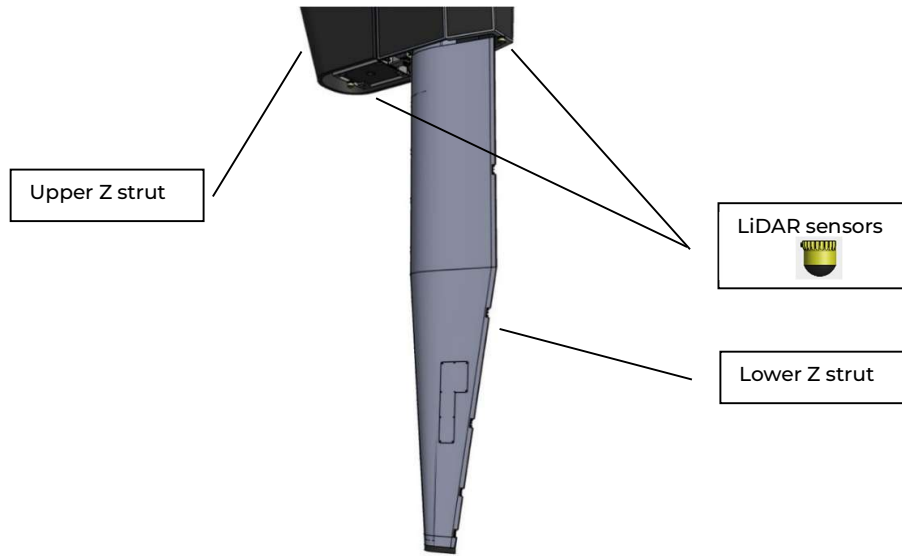


Figure 2 LiDAR sensor locations (typical)

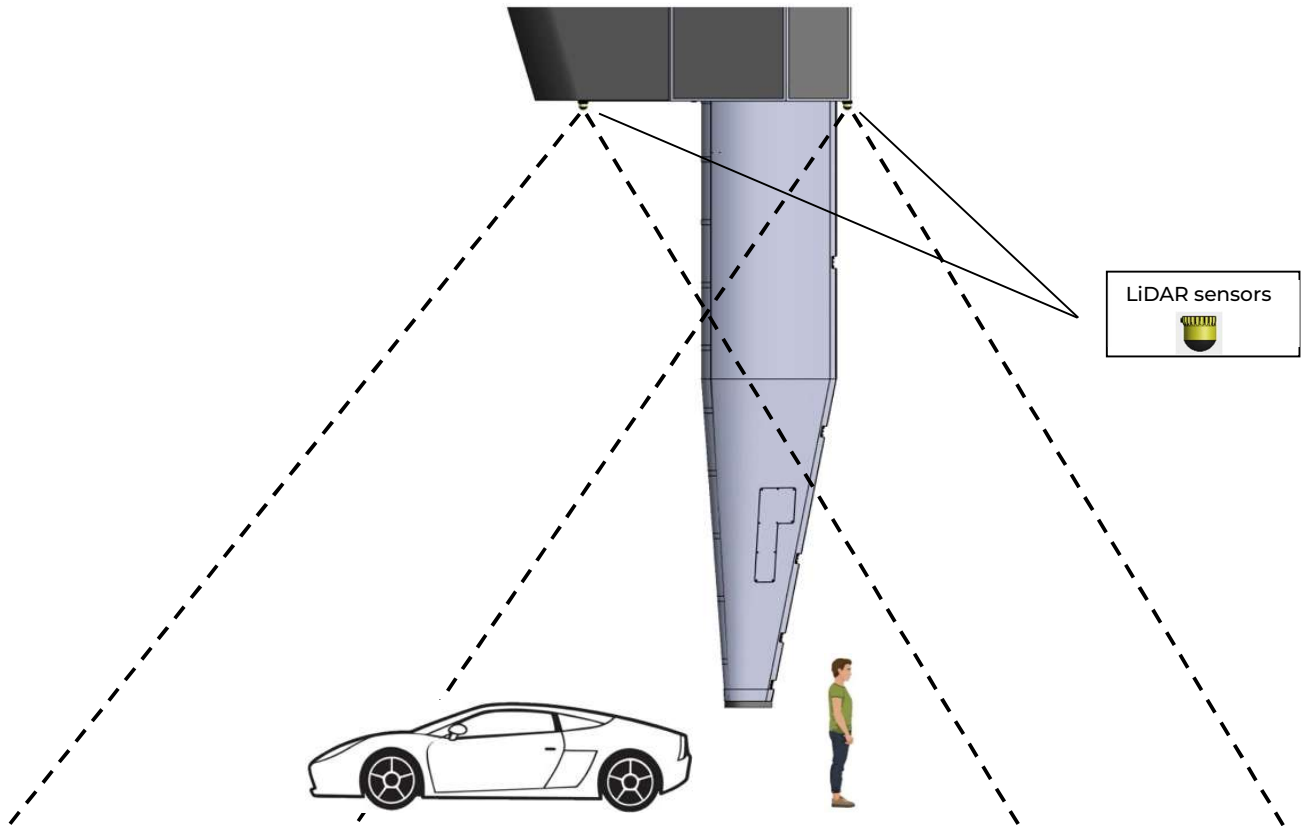


Figure 3 Representation of LiDAR scanning zones

7. Appendix

Video of LiDAR sensor operating in real-time (courtesy of LiDAR manufacturer – try the link below if your PDF reader cannot open the video directly):



Figure 4 Video of LiDAR example

Link to YouTube video: <https://youtu.be/o5o5PZ0UKkY>