

**image**  
SYSTEMS  
**TEMA**  
AUTOMOTIVE

## Product information

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**image**  
SYSTEMS

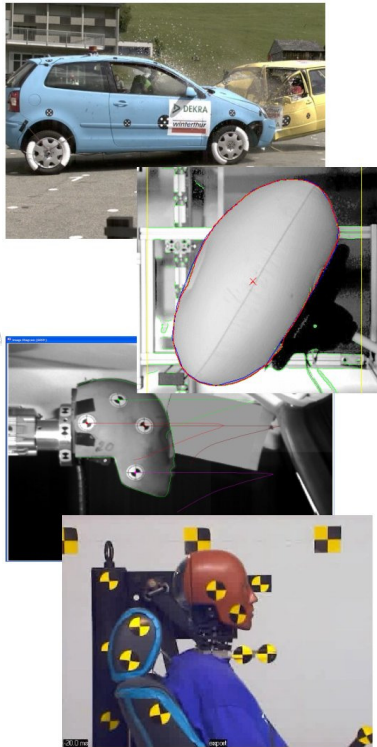
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# Introduction

TEMA Automotive is the world leading system for advanced motion analysis in the automotive industry. Starting with digital image sequences the customer uses TEMA Automotive to track objects in images, make analysis of the movement and present result in tables and graphs.

Typical applications:



- Crash tests in automotive industry using 2D, 3D or 6D analysis.
- Airbag analysis. The inflation process is verified towards simulated modules and the shape, size and position of the airbag is checked towards boundaries. The analysis is based on contour and volume measurements.
- Steering column penetration, Roll-over test or Sled testing using cameras on-board or off-board is just some examples of applications with TEMA Automotive.

The flexible windows based user interface makes it fast and easy to find the best setup for your application. The whole User Interface is fully synchronized: any change of parameters or set-up will directly effect all parts of the tracking session, updating results, graphs and tables.

This implies a fast test performance; all test setup can be done prior to tracking, enabling result data presentation output in real time while tracking. Test templates create an effective work flow working with repetitive tests. Tools for automatic generation of reports makes it possible to present a designed report including tables, graphs and comments with a single command.

The operator can choose between a large number of tracking algorithms and track an unlimited number of points through the image sequence. The system handles all major image formats on the market.

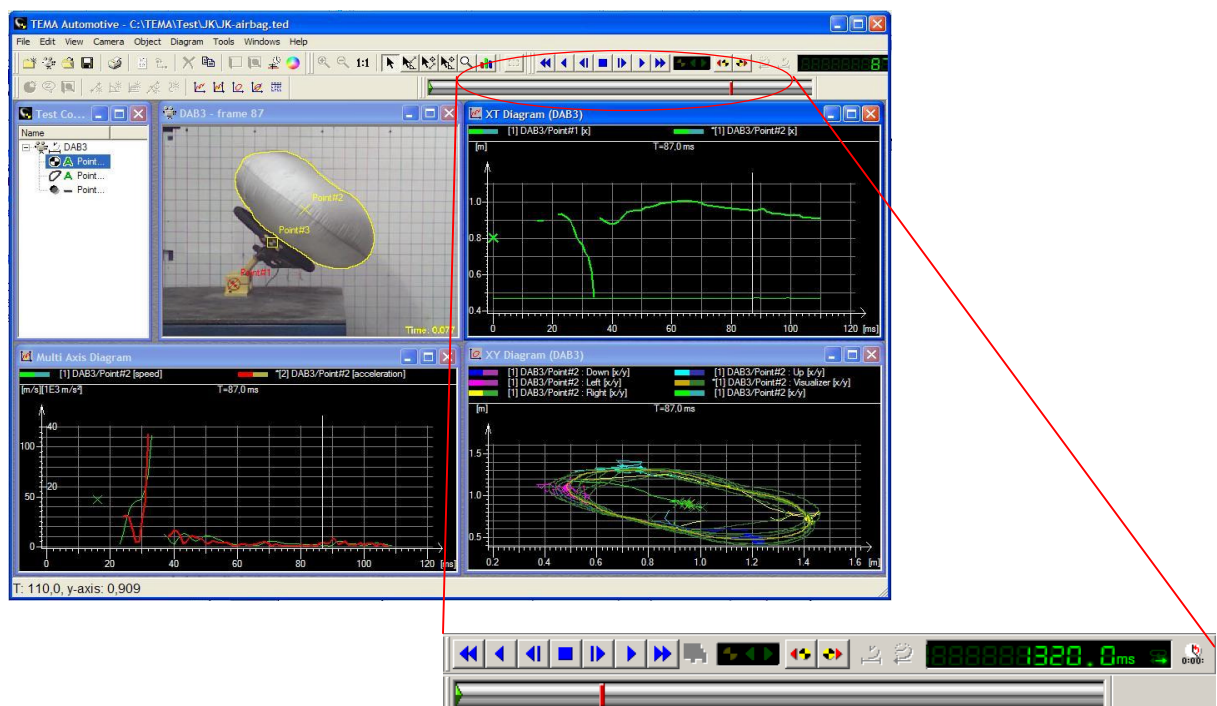
TEMA Automotive has a number of options available, airbag i.e. 3D and 6D analysis and lens calibration.

# System description

## User interface

The windows based user interface of TEMA Automotive provides a very flexible way of setting up a test. The operator can easily load one or multiple camera views and define which points to track in each image sequence.

The user interface is fully synchronized; there is only one current time in a test. Changing a parameter, clicking on an interesting value in a table or moving the time slider to an interesting position on a curve will automatically update all windows and show the corresponding image in the image sequence, curve or table.



The time panel gives a perfect control and overview of playing and tracking the image sequence. Step by step, normal speed or fast-forward: All are supported in both directions.

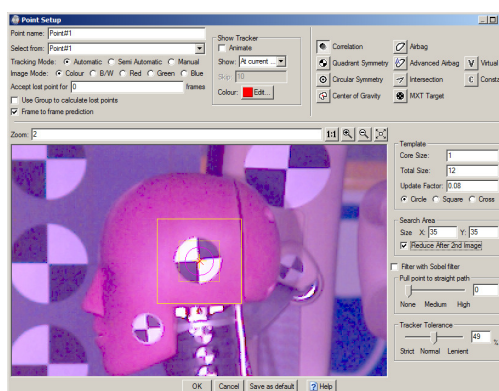
## Tracking

The tracking function operates in two dimensions and produces 2D pixel coordinates for each tracked target point in each image.

Multiple image sequences can be tracked simultaneously and the output plotted in the same graph or spreadsheet.

Different applications have very different requirements on how to track a defined target. The image quality and appearance of the target could vary which means that different algorithms and trackers setups are needed for the tracking.

The setup of the tracking is done per point or per tracking algorithm, multiple points selection.



The operator has full control of the tracking in TEMA with many possibilities to adjust for different applications. The tracking can be made Manual, Semi Automatic or Automatic.

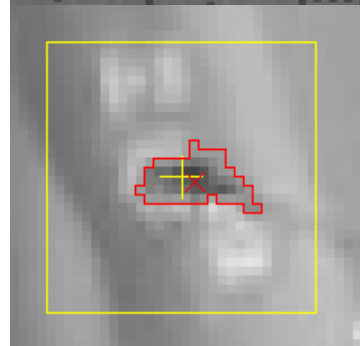
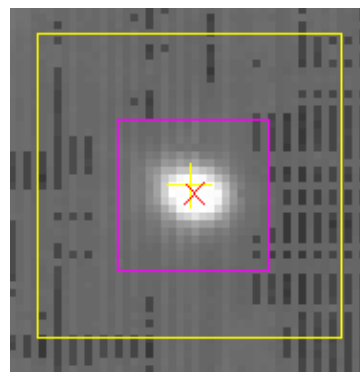
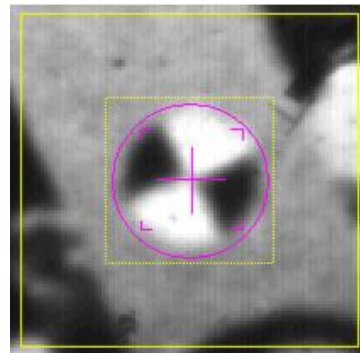
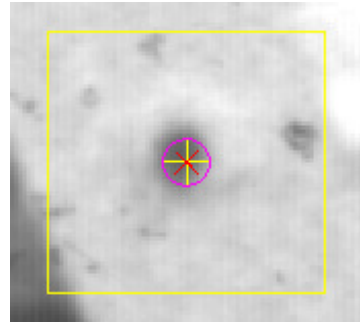
**Automatic tracking** - the operator set a tracker tolerance, which specifies how much variation in the target features that should be tolerated. TEMA Automotive then tracks all targets frame by frame until the end of the sequence. If the tolerance can't be met the tracking stops and the operator is prompted to give the correct position.

**Semi Automatic tracking** - TEMA suggests a position for each target frame by frame and the operator either confirms or adjusts it.

## Tracking Algorithms

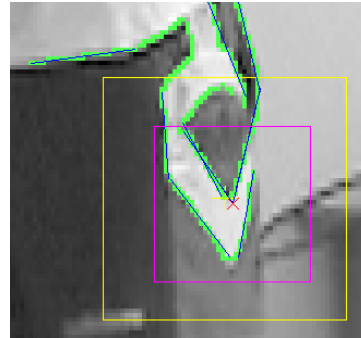
TEMA Automotive has a number of different tracking algorithms available for different applications:

- **Correlation:** looks in each successive image for the area that correlates best with the pattern defined in the first image. This method is applicable to most cases.
- **Quadrant:** finds the symmetry centre of the Quadrant targets. Quad targets are often used in the automotive industry.
- **Circular Symmetry:** finds the symmetry centre of the image within the search area and is applicable to concentric circles, spokes on a bicycle wheel or combinations thereof.
- **Center of gravity:** tracks an object whose form may vary during the sequence. The tracker captures the shape of an area with grey scale values within a user defined interval.



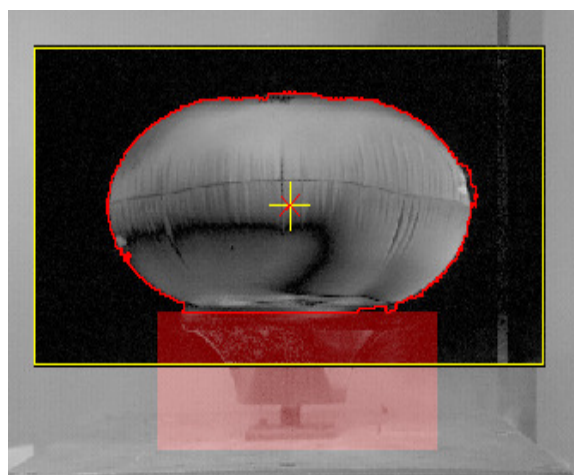
- **Virtual points:** specifies that the point is virtual, i.e. its position in successive images is calculated from the positions of the other points in its target group, rather than by measurement. For instance it can be used to define a part of a rigid body that is not visible in the image sequence.

- **Intersection tracker:** tracks intersection points (corners) on any object shape. The intersections are between extrapolated straight lines applied on the object shape.

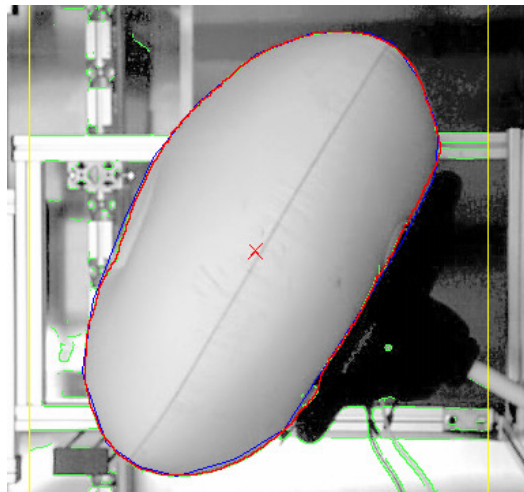


- **Airbag tracker (optional):** captures an object boundary to provide an outline around a body. Typical application is airbag analysis. There are two different outline tracker options; one basic and one advanced.

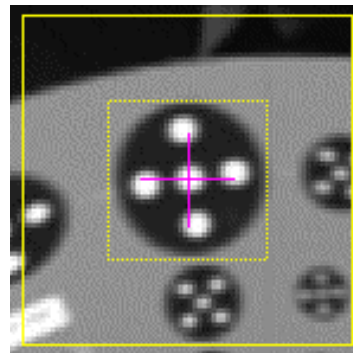
The Basic airbag tracker analyses threshold values to find the colour or grey scale difference between the airbag and the background. To capture object shapes in test setups with a complex background, an image subtraction can be done. This will convert all parts of the image that are non-moving into pitch black.



The Advanced airbag tracker looks for edges between different surfaces. This is often used when the colour or grey scale difference between the object and the background varies; a complex background behind the object.



- **MXT Tracker (optional)** finds the symmetry centre of the target. The user can set the target to 1+4 and 1+5 MXT target tracking.



## **Tracking Features**

### **Suggest target point position**

To be used in an application where the same 2D target model is used at all times. The operator gives the position for one of the target points and TEMA Automotive positions the rest of the target points in the image in relation to the first placed point.

### **Auto find similar**

To be used in applications where a lot of similar types of patterns are to be tracked in an image sequence. The operator defines the suitable tracking setup for one of the patterns. TEMA will then find other patterns that apply to the same tracking setup and apply a tracking point to each of those patterns.

### **Auto find new points**

This function is auto find similar but over time in a sequence. To be used in applications where new, static tracking targets appears subsequently in a sequence. The operator defines one such target when visible. At the following tracking, TEMA will apply a new tracking point to each new target that appears that applies to the setup.

## **Analysis**

Analysis properties like position, velocity and acceleration are automatically calculated for all points in the session.

The operator can also define properties like angles and distances between tracked points. The system will then automatically calculate distance, angles, angle velocity and angle acceleration between related points.

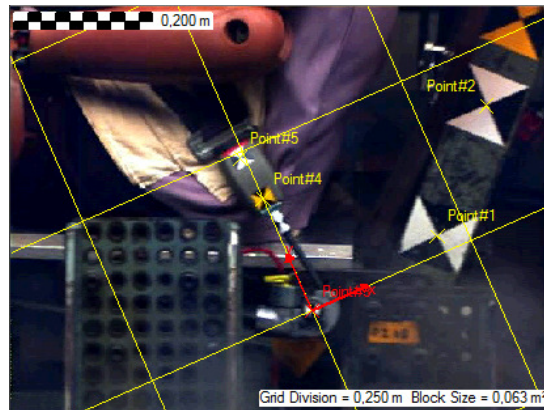
### **Scaling**

The user can at any time rescale pixel data into units of measurement. Thanks to the fully synchronized interface, all data and plots in the entire test will update to the new unit instantly.



## User defined Coordinate Systems

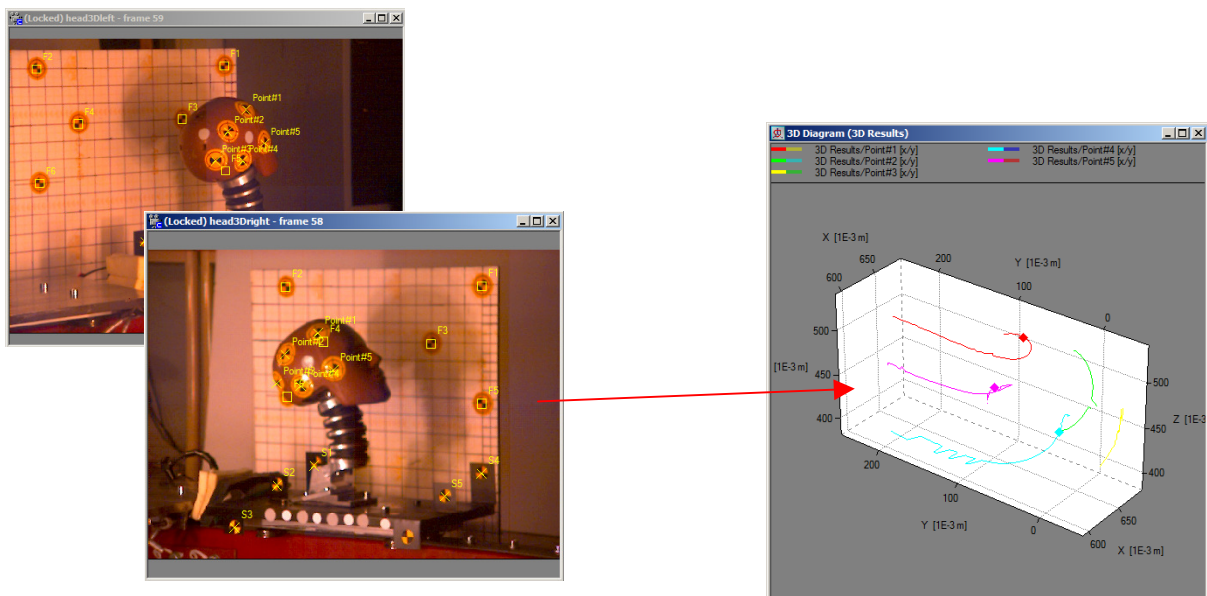
The user can define new coordinate system based on tracked points, used to express tracking data and analysis results. A user defined coordinate system can be dynamic; follow the movements of objects. This will gain new possibilities to analyse otherwise complex movements.



## 3D (Optional)

TEMA Automotive 3D takes the analysis from 2D on the screen to 3D in the real lab.

With two or more fixed cameras and a series of defined fixed target models in any one image, the analysis can be carried out in 3 dimensions. TEMA Automotive takes the observations (tracked 2D pixel coordinates) from each camera, computes the direction from each camera to the target, and finds the target 3D position that is the best fit to the observations.

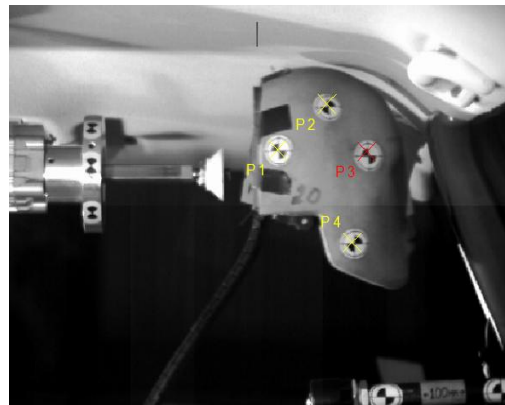


## 6D (optional)

With the use of only one camera, TEMA Automotive 6D can calculate the orientation in 3D space of any real object

The position of a rigid body can be described with six parameters: three positions coordinates (x, y and z), which gives the position of a specific point on the body, and three attitude angles (roll, pitch and yaw), which gives its orientation in space.

The term 6DOF refers to these six parameters. TEMA often refers to these parameters as the *6D position* of the body. Tracking in 6 degrees of freedom (6DOF), also known as 6-dimensional (6D) tracking, is an optional feature that computes the position and orientation of a tracked rigid body from a single camera view.



## Lens calibration (optional)

The inaccuracy of a lens is called **lens distortion**. TEMA Automotive uses a mathematical model of the distortion to correct the image data from the camera.

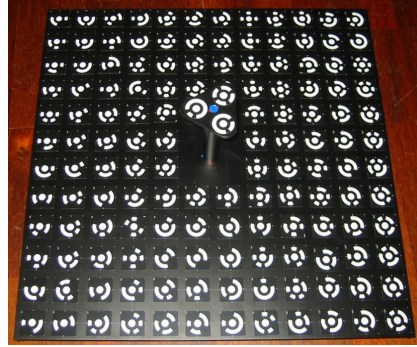
The lens calibration is carried out by taking a sequence of images of a target board, importing the target positions relative to the lens centre into the program, and tracking each target through the sequence. Based on these measurements, TEMA Automotive will calculate the lens distortion parameters and correct the tracking data against lens distortion. If using a short focal length, this will highly increase the overall analysis accuracy.

TEMA Automotive has two options for lens calibration. One is for custom made calibration targets and run with Image Systems Software and the other uses targets and software supplied by Aicon 3D Systems GmbH and integrated into the TEMA software.

- **Lens calibration Aicon:** The calibration board is produced by Aicon 3D Systems GmbH. Parts of the Aicon Software is integrated into TEMA Automotive. The Aicon Lens calibration applies to the German National Bureau of standard requirements. The user just holds the board at random positions in front of the camera and takes an image sequence. The program handles the rest automatically.



Calibrating camera



Aicon calibration board

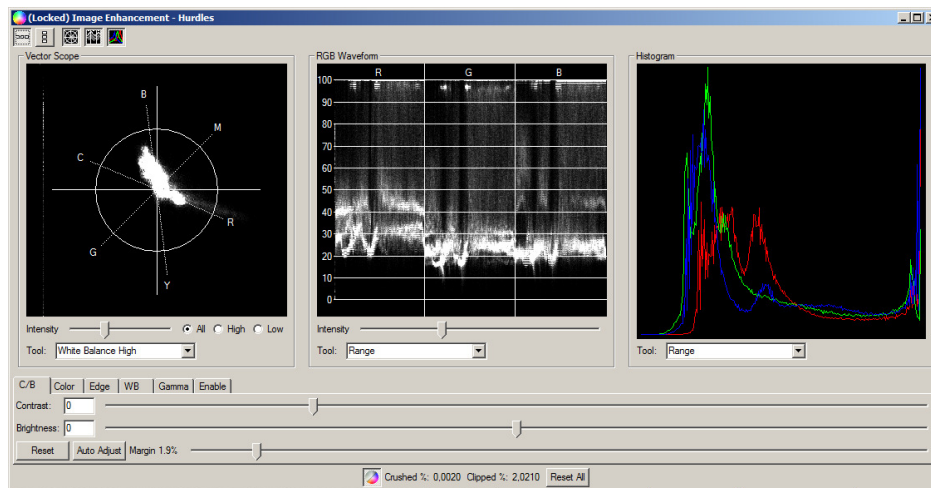
- **Lens calibration Image Systems:** Uses custom calibration boards. The customer presents a target model to the program before calibration. Some customers are using 2 dimensional boards (the Aicon board is 3 dimensional), the distance between camera and the board must then be measured as well.

The calibration is normally performed prior to the test and the result is saved to file. It is possible to save calibration results for many different camera/lens combinations. During the actual analyze the operator chooses which lens calibration to apply.

# Tools and Accessories

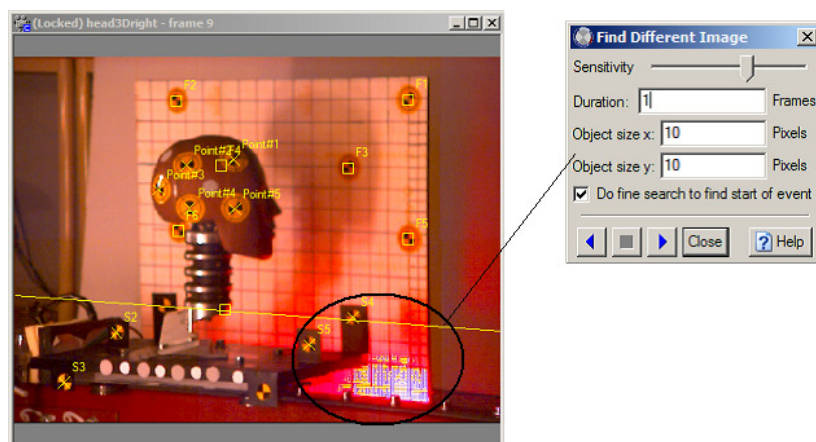
## Image enhancement

In order to enhance tracking and/or reviewing an image sequence, TEMA Automotive contains a complete Image Enhance functionality. RGB waveform diagram and vector scope helps to improve properties like colour balance, contrast, brightness and gamma correction in the image. The enhanced image sequence can be saved or imported to other image formats after adjustments.



## Event Finder

The Event finder identifies and finds one image or an interval of images of interest out of a whole sequence.



## Image input and Export

### Image Sequence import

TEMA Automotive software uses digital image sequences as input for the analysis. Most raw formats from high speed cameras and a large number of compressed digital formats can be read: AVI, TIFF, BMP, JPEG, MPEG2 and many others.

TEMA is continuously updated to support new image formats when they became available.

### Data import

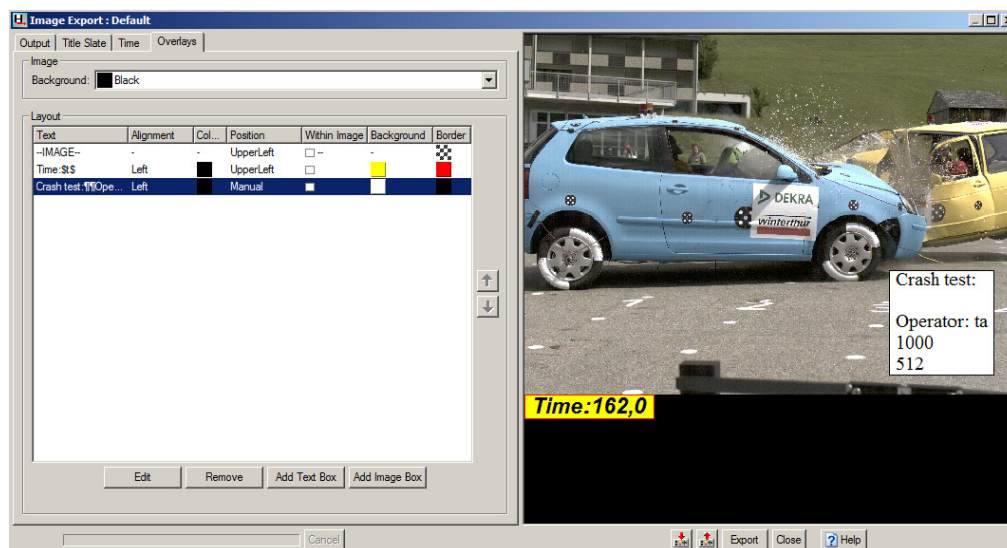
TEMA imports several different standard data formats like DIADEM, ISO13499, ISO-2, SDAS, DELL as well as custom specific ASCII data formats.

The imported data is available for all parts of the program and can be used in calculations, graphs and tables.

### Image Sequence export

All image sequences can be exported from TEMA , with or without overlaid tracking data. The Image Export can be extensively customized:

- Settable image size, format, sequence time range and skip count.
- A title slate can be added, acting as the first frame of the exported sequence. This can be specified with any describing text.
- Text box overlays on the exported sequence, including text and interactive information like the time for each frame, operator name etc.



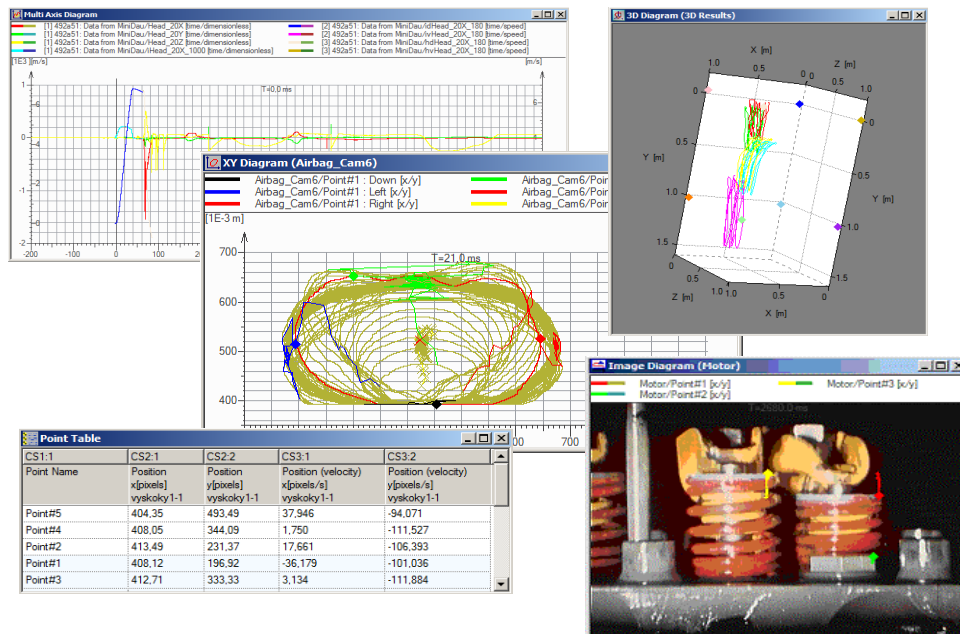
## **Data Export**

After tracking and analysis, the result can easily be exported to several different formats like Excel, CASDAS, DIADEM, ISO, Matlab or ASCII files.

## Presentation

TEMA Automotive can present the analysis data and results in a variety of customized graphs and tables. It is easy to add comments and add custom graphics to customize the appearance of a certain view or plot. The main tools for presentations are:

- **3D diagrams:** (included in 3D option). Enables plot of 3D data according to 3 axes in a rotatable 3D box. The 3D plot can also be equipped with curtains to enhance the understanding 3D data.
- **2D diagrams:** plots data against time or other data (X/Y-diagrams). All data, whether tracking data, or data input separately, can be plotted in single or multi axis X/T or Y/X plots with many options to customize.
- **Time tables:** All type of data can be presented in tabulated form using rows and columns. The rows will be time indexed. The diagram can easily be customized with different headers or combination of data. The row of the current time will always be highlighted.
- **Point tables:** All type of data can be presented in tabulated form using rows and columns. The rows will be indexed per point added to the table. The data in each cell will then update according to the current time. The diagram can easily be customized with different headers or combination of data.
- **Image Diagrams:** Plots data as overlays on top of image sequence from the tracking view.



- **Report Generator:** Framework to populate a whole set of graphs and tables from a test that can be output using one single command.

## TEMA Viewer

A TEMA Automotive test can be exported to a self-running CD that allows the recipient to rerun the tracking with the images, graphs and spreadsheet data synchronized. Just like in TEMA Automotive itself. Data from the viewer can in its turn be copied into another document. The TEMA Viewer does not require any extensive program installation to run. Also, the same Viewer can be loaded onto a network for shared use. There are two versions of the Viewer, basic and advanced.

**Basic Viewer** – The user can only review the data using the current graphs and tables. He can also export the result.

**The Advanced Viewer** has all the functionality as the basic, but the user can also add new graphs and tables to the setup. Still, no new data can be added.

## Hardware requirements

The TEMA Automotive system runs on standard stationary PC or a Laptop. The minimum requirements are:

	<b>Minimum</b>	<b>Recommended</b>
Operating System	Windows Vista/XP/2000 Professional	Windows XP Professional
CPU	2.0 GHz	3.0 GHz
RAM	1GB	1GB
System disk	100 GB	100 GB
Image disk	Not required	200 GB
Graphics	>19" @ 1280 x 1024	>19" @ 1280 x 1024
CD / DVD	CD	CD / DVD

Please note that the required performance specified above only apply for running the TEMA Automotive analysis software. Higher performance is normally needed if the system is TEMA camera control for high-speed digital cameras.



## Available configurations

Except TEMA Automotive, there are also a number of different entry levels, where your specific application determines the level of the program you require. An entry level can over time be updated to the complete TEMA Automotive product. A summary of the functionality is described below.

- TEMA Starter 1:** Allows tracking of single point with correlation tracker. Possible to plot one point and make table of positions.
- TEMA Starter 2:** Allows tracking of 5 points with correlation tracker. Possible to plot points and make tables of positions, velocity and acceleration. Some additional scaling functionality.
- TEMA Lite:** Starter 2 plus quad tracking, X/Y diagrams and export of data. A TEMA Lite user has also possibility to upgrade to the major TEMA options like 3D, etc..
- TEMA Player:** Image viewer and format conversion. It can view all formats that TEMA can view.

## Configuration vs features

Features	TEMA Starter I	TEMA Starter II	TEMA LITE	TEMA Automotive
<b>Tracking Algorithm</b>				
2D Tracking	●	●	●	●
Correlation	●	●	●	●
Quadrant			●	●
Circular				●
Center of gravity				●
Intersection tracker				●
<b>Tracking features</b>				
Number of points to be tracked in one session	1	5	5	unlimited
Constant tracker				●
Virtual points				●
Image Subtraction (tracking feature)			Included in Airbag analysis option	
Interpolation of hidden points	●	●	●	●
3D moving cameras			Included in 3D option	

Features	TEMA Starter I	TEMA Starter II	TEMA LITE	TEMA Automotive
<b>Import / Export</b>				
Import of data files: Diadem, ISO, ASCII				●
Export of data files: Diadem, ISO, ASCII			●	●
Import of images (AVI, TIFF, MPEG, JPEG and others)	●	●	●	●
Export of images (AVI, TIFF and others)				●
Export of diagrams and images to Word document	●	●	●	●
<b>Scaling</b>				
Correction for depth scaling				●
Dynamic scaling		●	●	●
Static scaling		●	●	●
Manual scaling	●	●	●	●
<b>2D coordinate system</b>				
User defined 2D coordinate systems				●
Translation of origin				●
Rotation (axes definition)				●
Rotation (offset angle)				●
Visualizing coordinate system				●
<b>Diagrams and tables</b>				
X / Y diagram			●	●
X / T diagram	●	●	●	●
Multiple axes (4 axes) X / T diagram				●
Advanced X/Y diagram				●
Time Table	●	●	●	●
Image diagram				●
Point Table				●
3D diagram				●
<b>Diagram Features</b>				
Contour plotting				●
Stick figure plotting				●
Individual setting of horizontal and vertical axis range	●	●	●	●
Corridors				●
Text Boxes in diagram				●
Setting of measurable scales in diagram printouts				●
Legends in diagram	●	●	●	●
Printing of diagrams to printer				●
Printing of logotypes, test comments				●

Features	TEMA Starter I	TEMA Starter II	TEMA LITE	TEMA Automotive
<b>Report</b>				
Report Generator				●
<b>Analysis and Calculations</b>				
Angles between points			●	●
Distances between points			●	●
Filtering of Data CFC / FIR	●	●	●	●
Velocity and acceleration		●	●	●
Exclude Areas				●
Autofind similar point				●
Autofind new points (point generator)				●
Automatic point group finder				●
Suggest Point Position				●
<b>Image handling</b>				
Digital signature				●
Printing of images to printer	*)	*)	*)	●
Image Enhancement				●
White balance	●	●	●	●
<i>* only through cut and paste to Word document</i>				
<b>Other</b>				
Event Finder	●	●	●	●
Fully synchronized user interface	●	●	●	●
Point zoom	●	●	●	●
Macros				●
Test templates	●	●	●	●
Multiple camera views				●
Setting of default units	●	●	●	●
Number precision	●	●	●	●
Free setting of Reference Time t0	●	●	●	●

## Options

	TEMA Starter I	TEMA Starter II	TEMA LITE	TEMA Automotive
<b>Options</b>				
Dongle licence	●	●	●	●
Floating license			●	●
3D			●	●
6D				●
MXT tracker			●	●
Airbag analysis (TEMA Automotive Option). Including algorithms: Basic Airbag and Advanced Airbag tracker			●	●
Airbag Volume			●	●
Lens calibration Image Systems			●	●
Lens Calibration Aicon			●	●
Viewer			●	●
Advanced Viewer			●	●