TEMA
AUTOMOTIVE

Product information

Introduction

TEMA is the world leading system for camera control and advanced motion analysis in the automotive and many other industries. Starting with digital image sequences the customer uses TEMA to track objects in images, make analysis of the movement and present result in tables and graphs. Typical applications are:

- Crash tests in automotive industry. 2D and 3D analysis.

- Airbag analysis, both contours and volume measurement. (Volume requires at least 3 camera views).

- Fuel injection. Tracking of fluid object development.

- Any other application in different industries, i.e. drop tests, manufacturing, etc..

The flexible windows based user interface makes it fast and easy to find the best setup for your application. Key-bindings to the menu system make the operation very fast. The 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.

The operator can choose between a large number of tracking algorithms (some are options) and track an unlimited number of points through the image sequence. The result can be presented in any of a large number of predefined graphs and tables. Free scaling for print outs makes it very easy to design reports or images.

The system handles all major image formats on the market and has options to control most of the available cameras such as Phantom, Photron, Redlake and others.

TEMA has a very easy installation procedure, with no requirement for dongles. The program can be used on a network installation.

TEMA has a number of options available for Airbag tracking, 3D and 6D tracking, camera control, and lens calibrations. Film digitization, video digitization and tracking using cameras on tracking mounts can be handled in the parent product, TrackEye

System description

User interface

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

The operator has many options to choose a certain function or feature. The Menu bar, tool bar or Key bindings will all give quick access to the wanted feature or function.
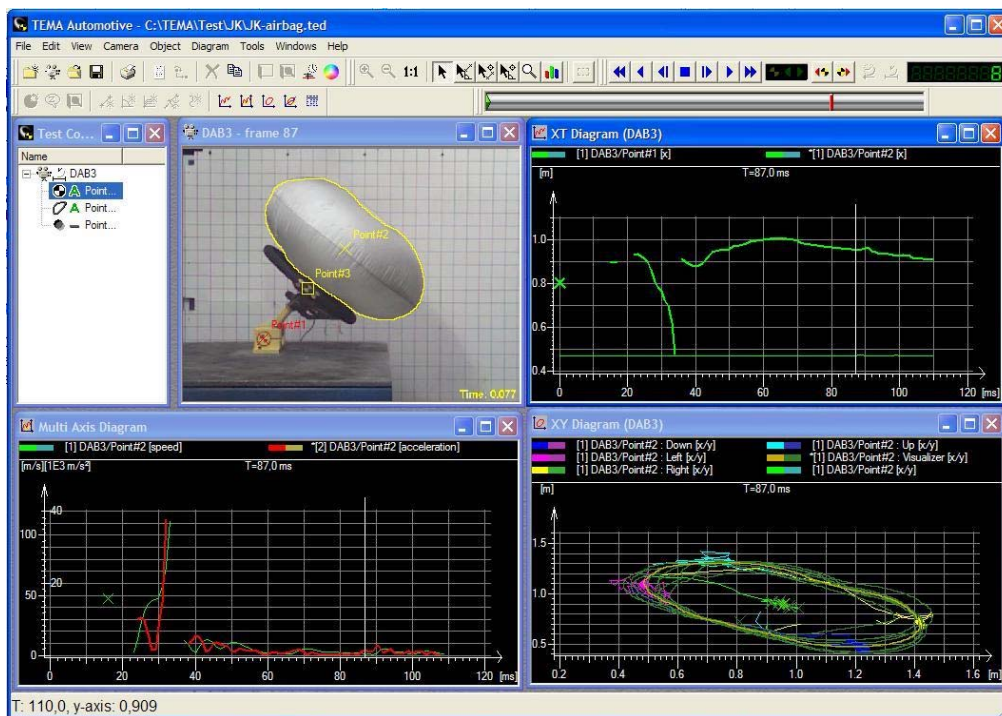
The interface is fully synchronized. Changing a parameter, clicking on an interesting value in a table or moving the time slider to an interesting position on a curve will automatically update all windows and show the corresponding image in the image sequence, curve or table.

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.

Image input

The TEMA software uses digital image sequences as input for the analysis. A large number of digital formats can be read directly during tracking: AVI, TIFF, BMP, JPEG, MPEG2 and many others.

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

Tracking

2D tracking is the basic functionality of TEMA. The tracking is normally done using fixed cameras. The basic tracking function operates in two dimensions and produces 2D pixel coordinates for each tracked target in each image.

Multiple image sequences can be tracked simultaneously and the output plotted on 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.
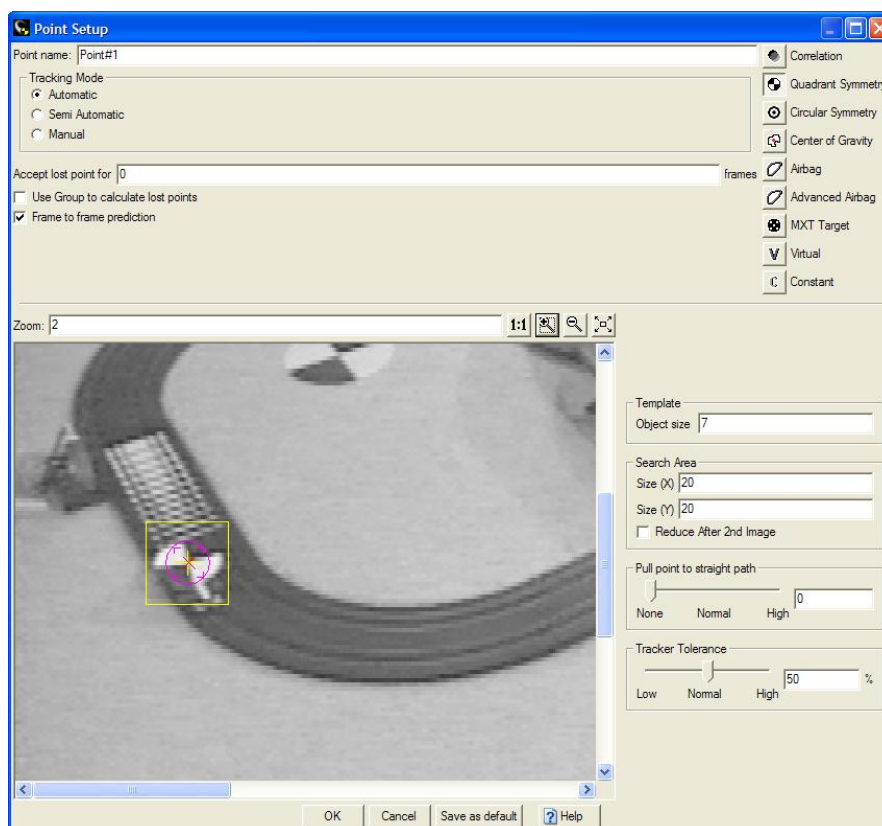

Point set-up window

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.

In manual mode the operator gives the correct position for each target frame by frame. In semi automatic TEMA suggest a position for each target frame by frame and the operator either confirms or adjusts it.

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

TEMA 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.
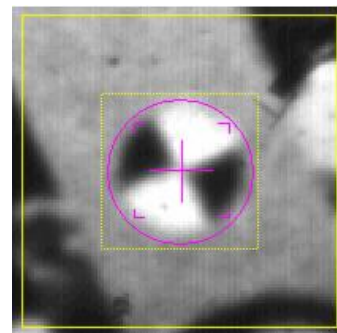
- Circular: finds the symmetry centre of the image within the search area and is applicable to concentric circles, spokes on a bicycle wheel or combinations thereof.

- Center of gravity: tracks a regular, roughly circular shaped object that does not change size and shape during the tracking process.

- 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.

Tools and properties

TEMA has a large set of tools available for the user. The predefined functions make it easy to handle things like image improvement, measurements in images and to perform calculations for the analysis. A sub-set of the available tools is described below:
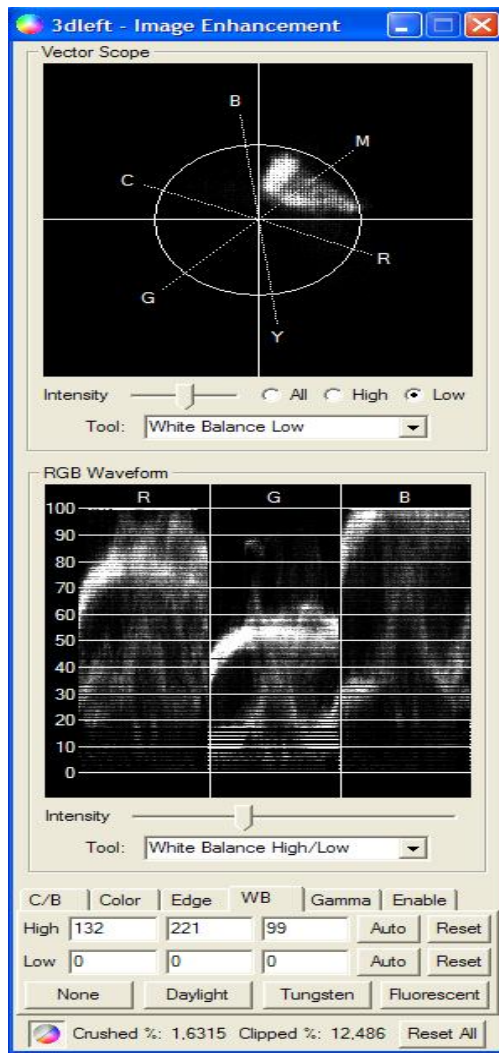
Image enhancement

TEMA uses vector scope and RGB waveform to improve properties like color balance, contrast, brightness and gamma correction in the image. The image sequence can be saved or imported to other image formats after adjustments.

Measurements in the image

Properties like distance and angles can be measured directly in the image. Distances can be given in pixels or dimensions The stick figure tool allows the operator to visualize how a body defined by connected points moves through an image sequence.

Analysis properties

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 points. The system will then automatically calculate distance, angles, angle velocity and angle acceleration for each frame in the sequence.

Presentation

A big benefit with the TEMA system is the possibility to present data and results in customized graphs and tables. It is easy to add comments and add custom graphics and to customize the appearance of a certain view. The main tools for presentations are:

- 2D diagrams: Diagrams where data can be plotted 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.
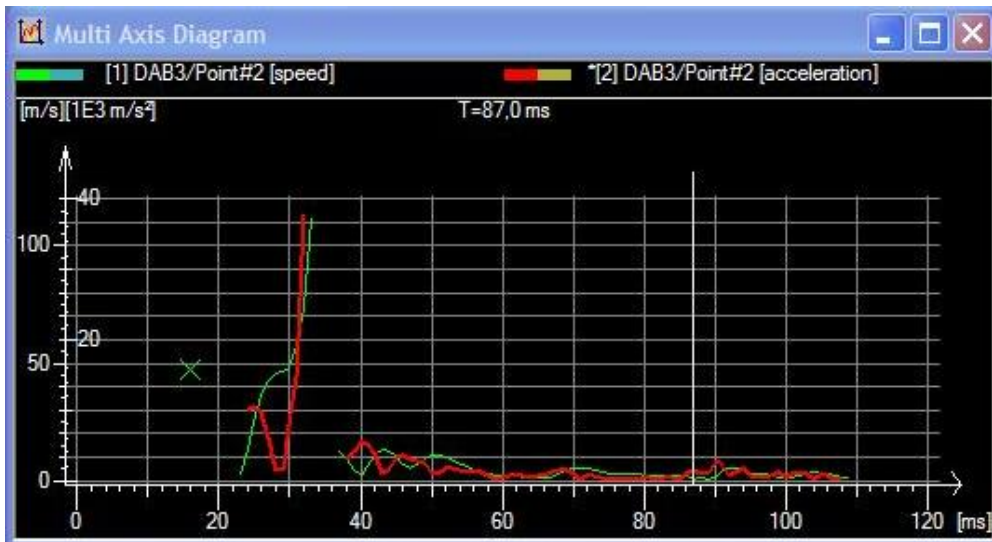

Multi Axes diagram

X/Y Diagram

- Tables: All type of data can be presented in tabulated form using rows and columns. The diagram can easily be customized with different headers or combination of data.

A	B	C	D	E	F	G
Time	3dleft/Point#1 vx[m/s] 3dleft	3dleft/Point#1 vy[m/s] 3dleft	3dright/Point#1 ax[pixels/s²] 3dright	3dright/Point#1 ay[pixels/s²] 3dright	3dright/Point#1 vx[pixels/s] 3dright	3dright/Point#1 vy[pixels/s] 3dright
[ms]						
1620,0	1,3769	0,048450	5259,0	1108,8	331,45	-536,23
1640,0	1,3201	0,14966	5096,8	1419,3	434,43	-510,14
1660,0	1,2547	0,23833	4802,0	1421,8	533,71	-481,45
1680,0	1,2009	0,30943	4380,8	1006,0	625,18	-458,54
1700,0	1,1681	0,36019	3922,5	237,25	708,64	-446,20
1720,0	1,1565	0,39455	3456,3	-568,75	782,93	-448,71
1740,0	1,1656	0,41061	3036,5	-1151,8	846,98	-465,05
1760,0	1,1802	0,41680	2715,5	-1225,0	903,96	-491,79
1780,0	1,1619	0,42497	2541,5	-567,75	957,57	-509,64
1800,0	1,1044	0,43848	2401,5	666,00	1008,6	-505,29
1820,0	1,0064	0,45675	2111,3	1938,8	1051,8	-477,59
1840,0	0,90637	0,46847	1456,3	2380,3	1087,5	-437,66
1860,0	0,81339	0,47002	492,25	1518,5	1106,9	-400,82
1880,0	0,77657	0,44841	-443,75	-83,250	1107,1	-386,93
1900,0	0,76415	0,41753	-1102,8	-1295,0	1092,0	-399,25
1920,0	0,76873	0,38544	-1169,0	-1205,3	1069,2	-422,05
1940,0	0,75167	0,36662	-748,25	410,25	1050,6	-430,18

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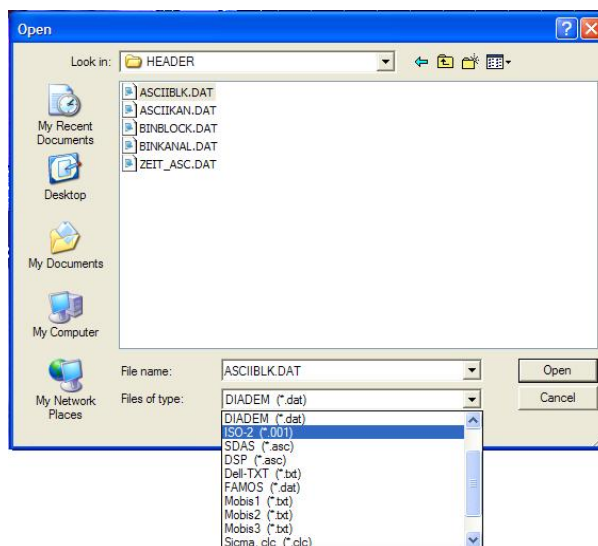
TEMA imports several different standard data formats like DIADEM, ISO13499, ISO-2, SDAS, DELL as well as custom specific ASCII data formats.

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

After tracking and analysis can TEMA export the result to several different formats like: Excel, CASDAS, DIADEM, ISO, Matlab or ASCII files.

Hardware requirements

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

	Minimum	Recommended
Operating System	Windows 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
Floppy Drive	1.44Mb	1.44Mb
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 motion analysis software. Higher performance is normally needed if the system is using the TrackEye film scanner software for digitizing cine film, or TEMA camera control for high-speed digital cameras.

Available configurations

TEMA is also offered in a number of different entry levels, where your specific application determines the level of TEMA you require. An entry level can over time be updated to a higher level of TEMA. 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, 6D etc..

TEMA Player: Image viewer and format conversion. It can view all formats that TEMA can view.

Detailed product description	TEMA Starter I	TEMA Starter II	TEMA 2D Lite	TEMA 2D
Tracking				
Correlation	●	●	●	●
Quadrant			●	●
Circular				●
Center of gravity				●
Virtual point				●
Number of points in one session	1	5	5	unlimited
Numerical input of point				●
Simultaneously tracking of multiple images				●
Import / Export				
Import of data files like Diadem, ISO, ASCII				●
Export of data files like Diadem, ISO, ASCII			●	●
Import of images (AVI,TIFF and others)	●	●	●	●
Export of images (AVI,TIFF and others)				●
Export of diagrams and images to Word	●	●	●	●
Scaling				
Correction for depth scaling				●
Dynamic and Static scaling		●	●	●
Manually scaling	●	●	●	●
Co-ordinate system				
Free setting of origin and co-ordinate axes				●
Setting of off-set angle				●
Visualising of grid and scale in image			●	●
Diagram and tables				
X / Y diagram			●	●
X / T diagram	●	●	●	●
Multiple axes (4 axes) X / T diagram				●
Advanced X/Y diagram				●
Data tables free choice of parameters	●	●	●	●
Contour plotting				●
Stick figure plotting				●
Interactivity between time, image, diagrams	●	●	●	●
Setting of horizontal and vertical scale			●	●
Print				
Printing of images and diagrams to printer	**)	**)	**)	●
*** only through cut and paste to Word document*				
Toolbox				
Choice of angles and distances	●	●	●	●
Zoom	●	●	●	●
White balance	●	●	●	●
Setting of cursor, tracking and display mode	●	●	●	●
Setting of default units	●	●	●	●
Presentation, choice of printing parameters				●
Setting of measurable scales of diagrams				●
Printing of logotypes, test comments				●
Filtering of Data CFC / FIR	●	●	●	●
Velocity and acceleration		●	●	●

TEMA options

There are a set of options available for the TEMA 2D product. Below is a summary of these options. Please refer to the TEMA Option description for a more detailed description of these options.

3D Tracking (Option)

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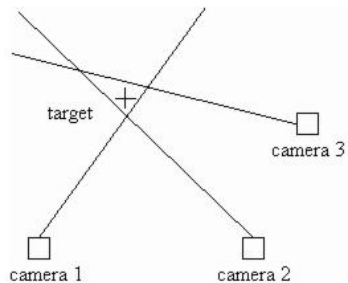
6 Degrees of Freedom (Option)

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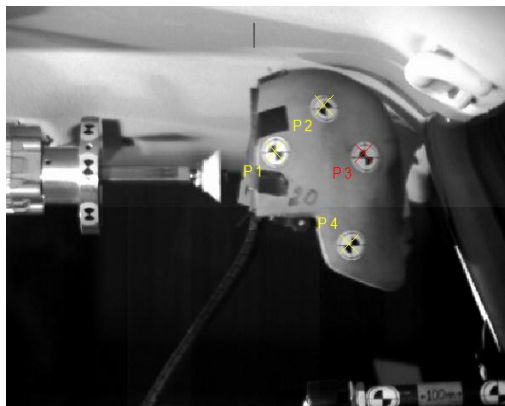
The motion of the rigid body can be described with six parameters: three positions coordinates (x, y and z), which gives the position of a specific point on the body, and three attitude angles (roll, pitch and yaw), which gives its orientation in space.

The term 6DOF refers to these six parameters. TEMA often refers to these parameters as the *6D position* of the body.

TEMA Lens calibration (Option):

The inaccuracy of a lens is called **lens distortion**. TEMA 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 into the program the coordinates of the target positions relative to the lens center, and tracking each target through the sequence. From these measurements the lens distortion and focal length is calculated.

TEMA has two options for 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. 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 TEMA 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 choose which calibration to apply.

Airbag Contour tracker
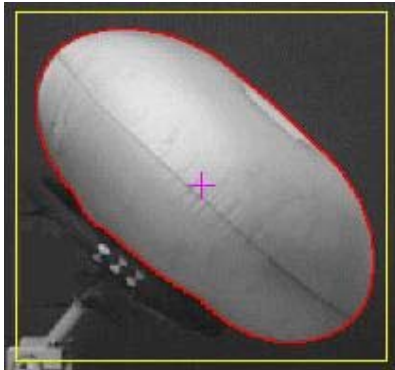
In Airbag contour TEMA searches the object boundary to provide an outline around a body, for instance an airbag.

TEMA offers two methods to find the outline. Method one uses threshholding to find the color or grayscale difference between the body and the background.

Method two looks for edges between different surfaces. This is often used when the color or grayscale difference between the object and the background varies. The airbag contour tracker is also used in applications like fuel injection development.
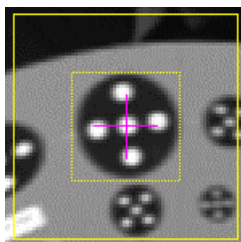
Airbag Volume
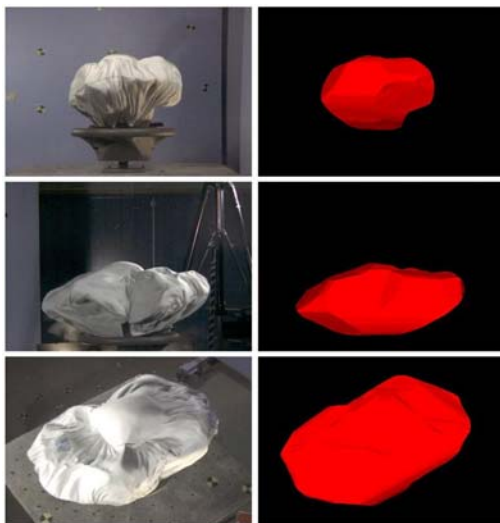
In TEMA Airbag Volume a full 3D model of the airbag is reconstructed from multiple video sequences.

The volume is calculated out of the reconstructed 3D model. The accuracy of the volume estimate depends on the number of cameras used in the set-up.

With 3 or more cameras the error is less then 10%.

MXT Tracker

MXT Targets is a special target used in the German Automotive industry. The tracker algorithm finds the symmetry centre of the target.

TEMA Viewer

The results of a tracking session can be exported to a self-running CD that allows the recipient to rerun the tracking with the images, graphs and spreadsheet data synchronized. Data from this can be copied into another document. This viewer does not require any program installation to run it This same viewer can be loaded onto a network for shared use.

CD Viewer

Required configurations

The different TEMA options require different basic functionality and are therefore not available to all configurations of TEMA. Below is a list of which configuration that is required for a certain TEMA option.

	TEMA Starter I	TEMA Starter II	TEMA 2D Lite	TEMA 2D
Options				
3D			●*	●
6D				●
MXT tracker			●	●
Airbag Contour tracker		●	●	●
Airbag Volume		●	●	●
Lens calibration Image Systems			●**	●
Lens Calibration Aicon			●	●
Viewer			●	●
At least 10 points are recommended				
** Unlimited number of points are recommended*				