

image
SYSTEMS

TEMA
MOTION

Product information

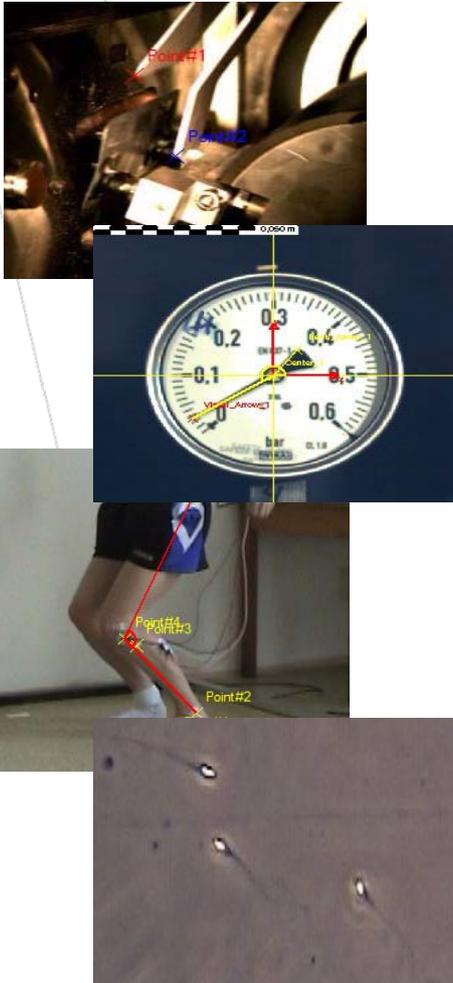
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SYSTEMS

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Introduction

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



Malfunctions in production lines.

The design of modern high-speed production and packaging lines requires high-speed imaging and motion analysis for a cost effective design process.

Drop tests. An important part of product development is the evaluation of mechanical robustness while dropping the product on various foundations.

Biomechanical analysis. Modeling of human body movement for studies of behavior and stress analysis under varying boundary and loading conditions.

Medical research. Studies of sperm activity in microscopy images. The fertility of the sperms are evaluated out of the movement patterns and speed of the sperms.

The flexible windows based user interface makes it fast and easy to find the best setup for your application. 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 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.

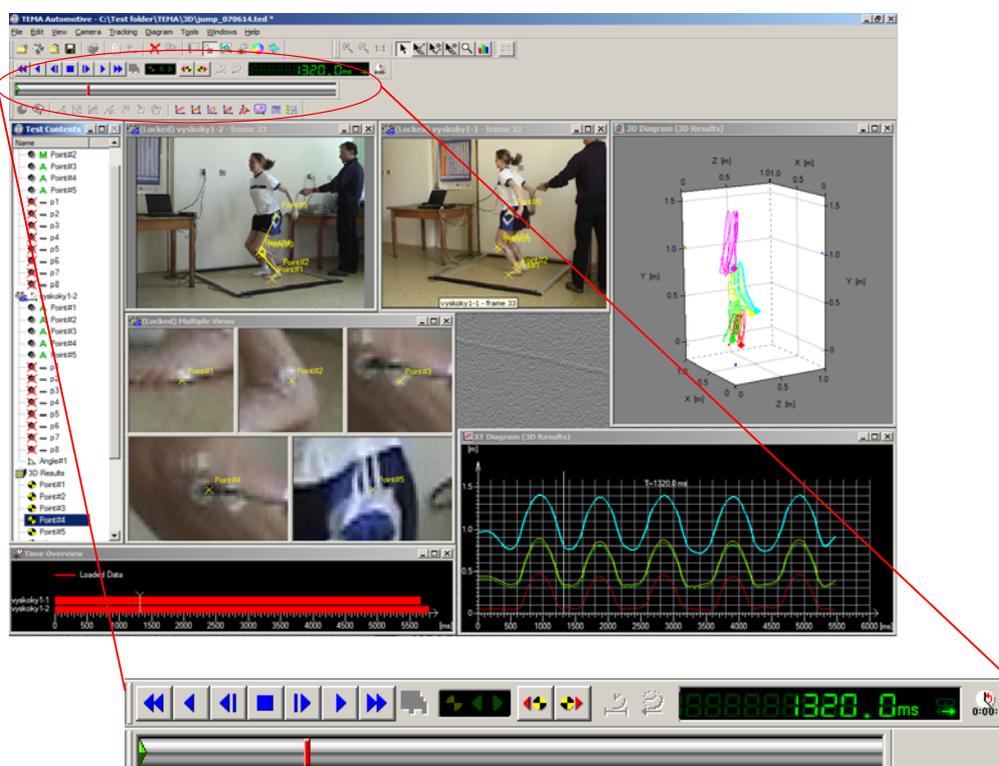
TEMA has a number of options available for 3D and 6D tracking, camera control, lens calibrations and many more.

System description

User interface

The windows based user interface of TEMA Motion 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.

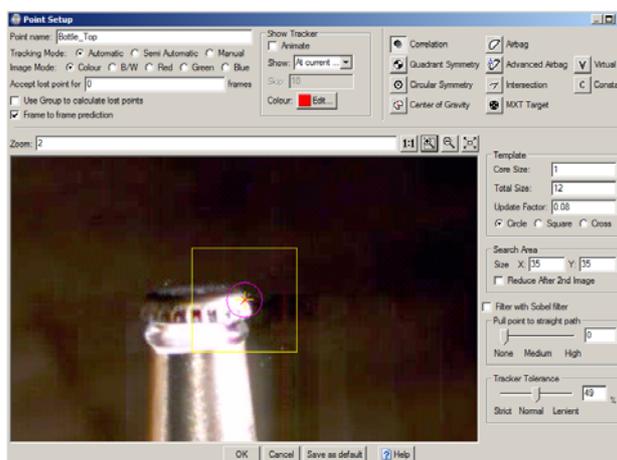
Tracking

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.

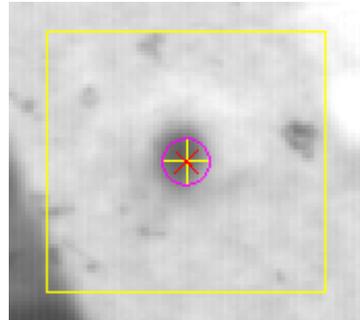
Automatic tracking - the operator set a tracker tolerance, which specifies how much variation in the target features that should be tolerated. TEMA Motion then tracks all targets frame by frame until the end of the sequence. If the tolerance can't be met the tracking stops and the operator is prompted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

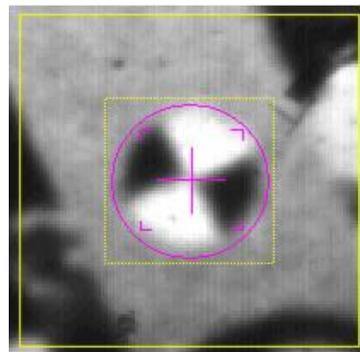
Tracking Algorithms

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

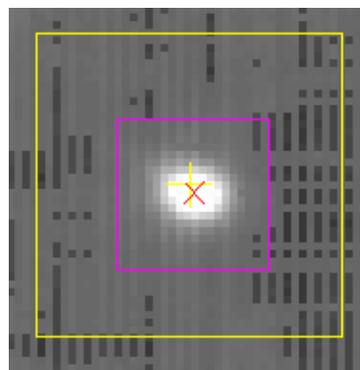
- **Correlation:** looks in each successive image for the area that correlates best with the pattern defined in the first image. This method is applicable to most cases.



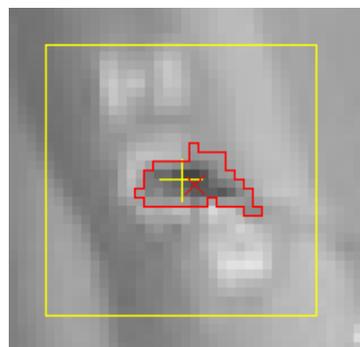
- **Quadrant:** finds the symmetry centre of the Quadrant targets. Quad targets are often used in the automotive industry.



- **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.

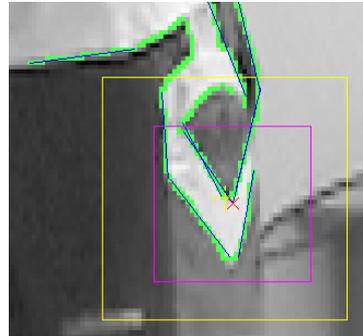


- **Center of gravity:** tracks an object whose form may vary during the sequence. The tracker captures the shape of an area with grey scale values within a user defined interval.



- **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.

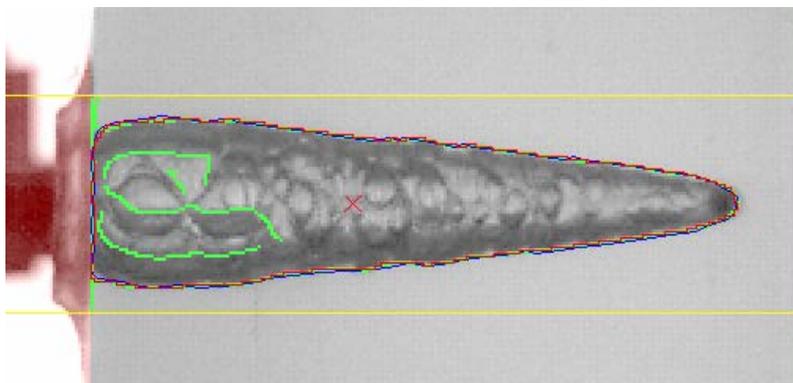
- **Intersection tracker:** tracks intersection points (corners) on any object shape. The intersections are between extrapolated straight lines applied on the object shape.



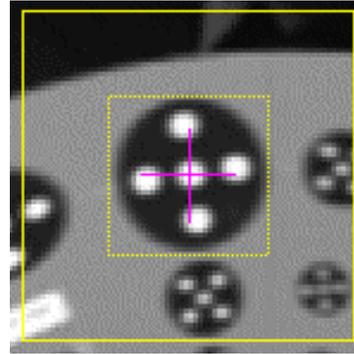
- **Outline tracker (optional):** captures an object boundary to provide an outline around a body. There are two different outline tracker options; one basic and one advanced.

The basic outline tracker analyses threshold values to find the color or grey scale difference between the body 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 outline tracker looks for edges between different surfaces. This is often used when the color or grey scale difference between the object and the background varies.



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 Motion 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 applies 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.

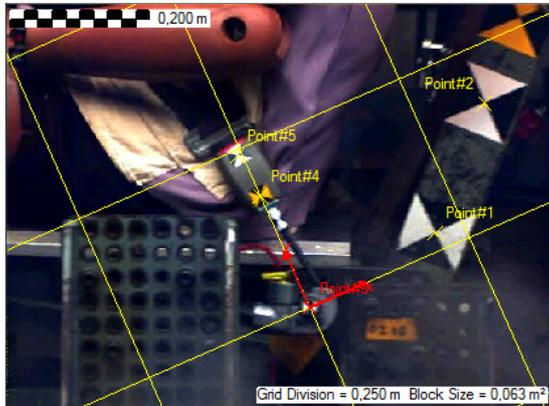
The operator can also define properties like angles and distances between tracked points. The system will then automatically calculate distance, angles, angle velocity and angle acceleration between related points.

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

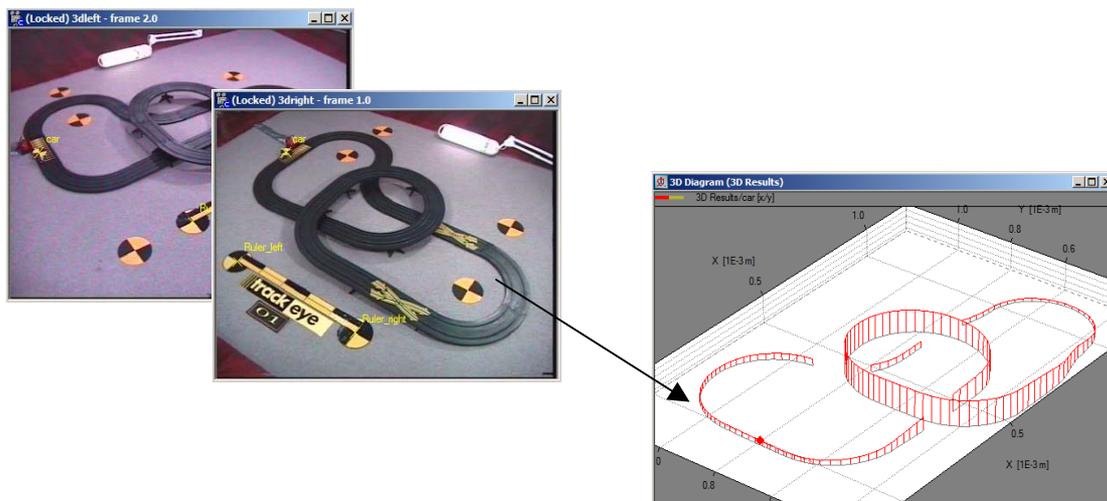
The user can define new coordinate system based on tracked points, used to express tracking data and analysis results. A user defined coordinate system can be dynamic; follow the movements of objects. This will gain new possibilities to analyse otherwise complex movements.



3D (Optional)

TEMA Motion 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 Motion 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.

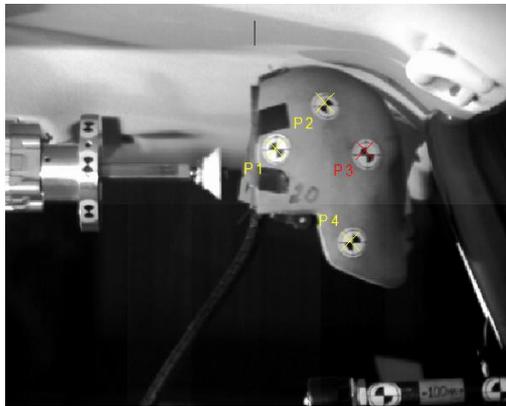


6D (optional)

With the use of only one camera, TEMA Motion 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 Motion 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 center into the program, and tracking each target through the sequence. Based on these measurements, TEMA Motion 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 Motion 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 Motion. 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

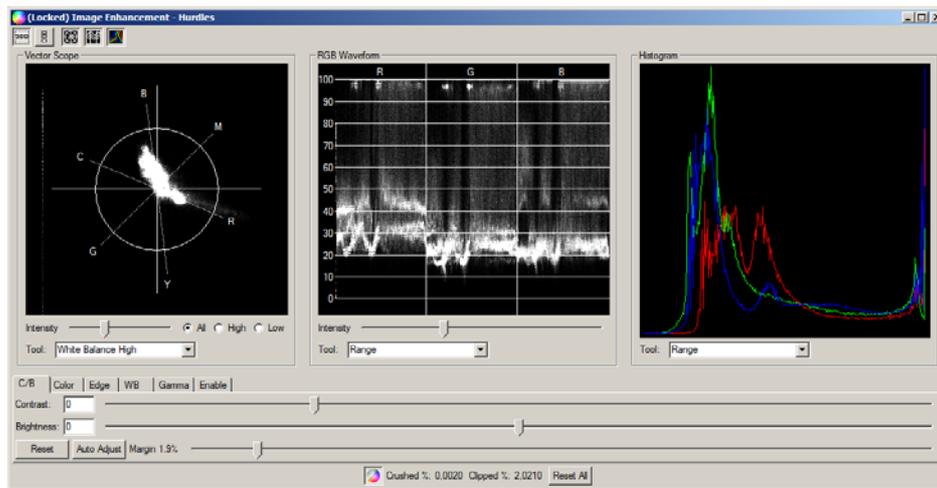
- **Lens calibration Image Systems:** Uses custom calibration boards. The customer presents a target model to the program before calibration. Some customers are using 2 dimensional boards (the Aicon board is 3 dimensional), the distance between camera and the board must then be measured as well.

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 Motion contains a complete Image Enhance functionality. RGB waveform diagram and vectorscope helps to improve properties like color 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.

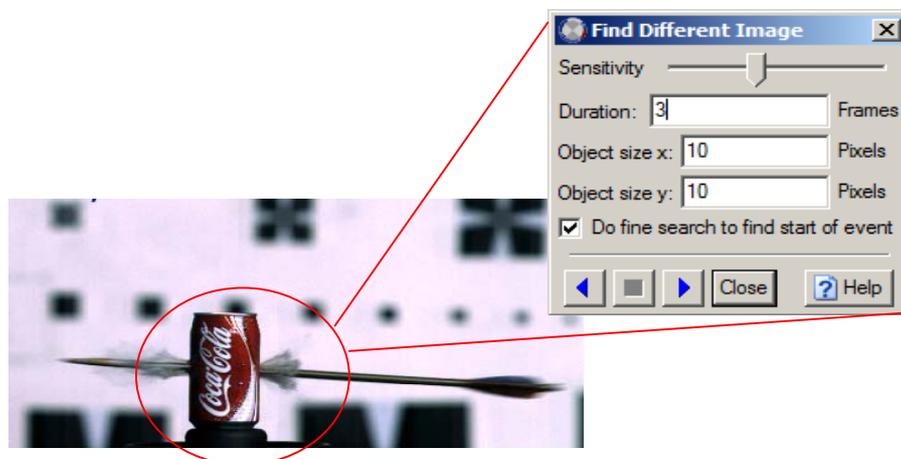


Image input and Export

Image Sequence import

TEMA Motion 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

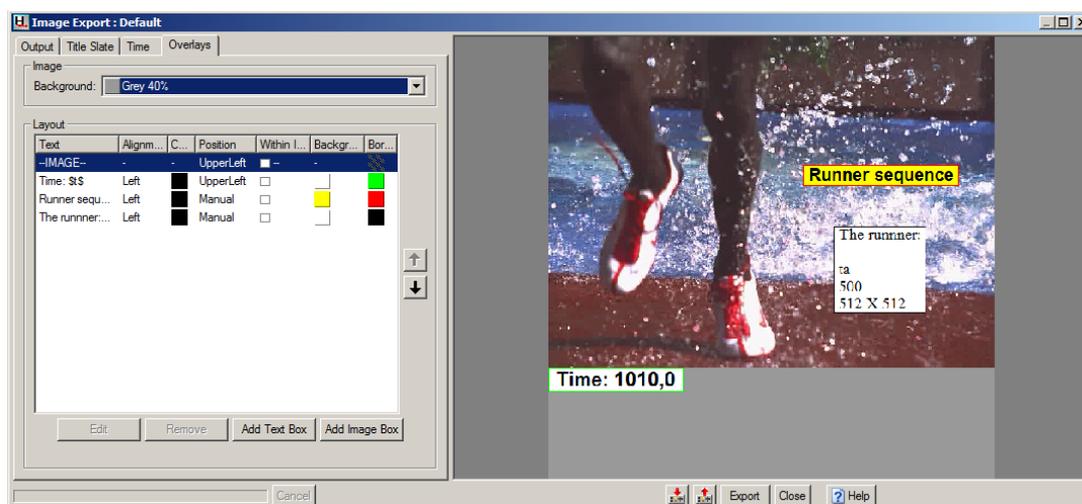
TEMA imports several different standard data formats like DIADEM, ISO13499, ISO-2, SDAS, DELL as well as custom specific ASCII data formats.

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.



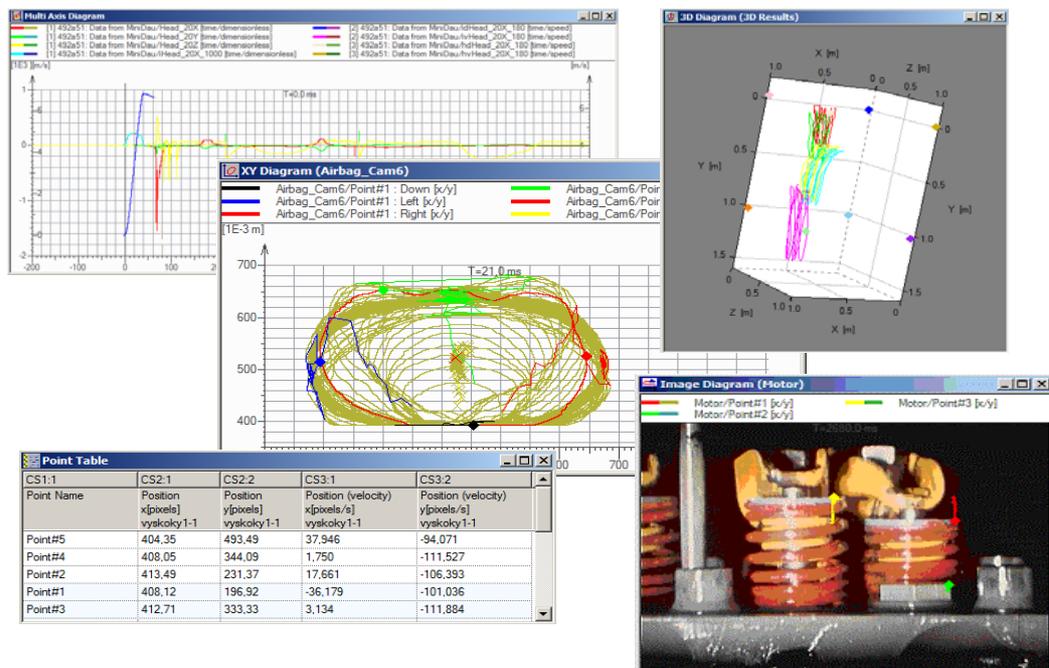
Data Export

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 motion 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:** comes with the optional 3D functionality only. 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.



TEMA Viewer

A TEMA Motion 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 Motion 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 Motion 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
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 TEMA camera control for high-speed digital cameras.

Available configurations

Except TEMA Motion, there is 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 Motion 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, 6D 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 Motion
Tracking Algorithm				
2D Tracking	●	●	●	●
Correlation	●	●	●	●
Quadrant			●	●
Circular				●
Center of gravity				●
Intersection tracker				●
Tracking features				
Number of points to be tracked in one session	1	5	5	Unlimited
Constant tracker				●
Virtual points				●
Image Subtraction (tracking feature)			Included in outline tracker option	Included in outline tracker option
Interpolation of hidden points			●	●
3D moving cameras			Included in 3D option	Included in 3D option

Features	TEMA Starter I	TEMA Starter II	TEMA LITE	TEMA Motion
Import / Export				
Import of data files:Diadem, ISO, ASCII				As Option on request
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	●	●	●	●
Scaling				
Correction for depth scaling				As Option on request
Dynamic scaling		●	●	●
Static scaling		●	●	●
Manually scaling	●	●	●	●
2D coordinate system				
User defined 2D coordinate systems				●
Translation of origin				●
Rotation (axes definition)				●
Rotation (offset angle)				●
Visualizing coordinate system				●
Diagrams and tables				
X / Y diagram			●	●
X / T diagram	●	●	●	●
Multiple axes (4 axes) X / T diagram				●
Advanced X/Y diagram				●
Time Table	●	●	●	●
Image diagram				●
Point Table				As Option on request
3D diagram			(Included in the 3D and 6D option)	
Diagram Features				
Contour plotting				As Option on request
Stick figure plotting				As Option on request
Individual setting of axis			●	●
Corridors				As Option on request
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 Motion
Report				
Report Generator				As Option on request
Analysis and Calculations				
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				As Option on request
Suggest Target Point Position	●	●	●	●
Image handling				
Digital signature				As Option on request
Printing of images to printer	*)	*)	*)	●
Image Enhancement				●
White balance	●	●	●	●
<i>* only through cut and paste to Word document</i>				
Other				
Event Finder				●
Fully synchronized user interface	●	●	●	●
Point zoom	●	●	●	●
Test templates	●	●	●	●
Multi camera views			●	●
Setting of default units	●	●	●	●
Number precision	●	●	●	●
Free setting of Reference Time t0	●	●	●	●

General Options

	TEMA Starter I	TEMA Starter II	TEMA LITE	TEMA Motion
Options				
Dongle licence	●	●	●	●
Floating license			●	●
3D			●	●
6D				●
MXT tracker			●	●
Lens calibration Image Systems				●
Lens Calibration Aicon				●
Viewer				●
Advanced Viewer				●
Outline tracking. Including two tracking algorithms: Basic and Advanced			●	●