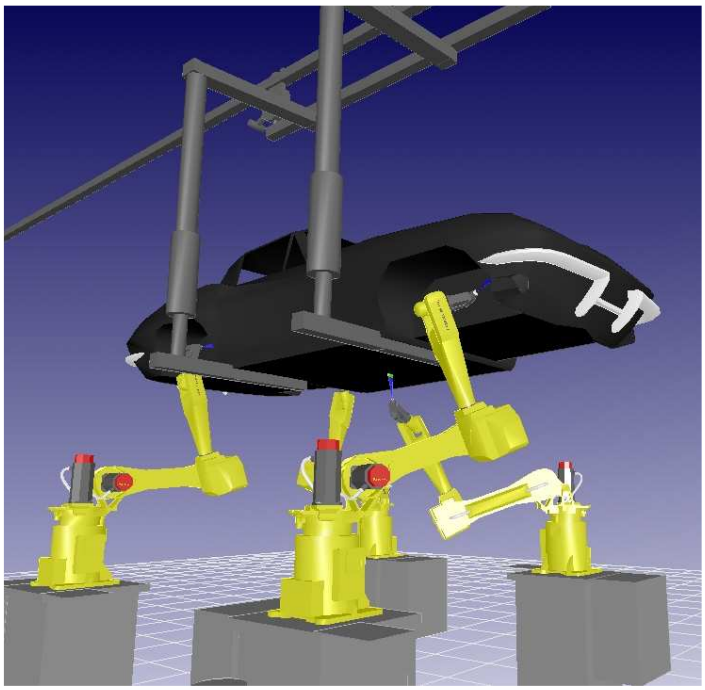
The new version

EASY-ROB™ V4.603



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Version 1.0

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EASY-ROB™

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EASY-ROB™ V4.603

The new EASY-ROB™ V4.6

The new EASY-ROB™ Version 4.6 contains dozens of improvements. The biggest enhancement is a new option to run multiple robots and kinematics (Devices) synchronized at the same time – each with its own program. The new option is called „Multi-Program“.
The programs are running parallel and can communicate by using I/O-variables. There are no changes in the syntax of the programs that programming in EASY-ROB™ is the same than before and existing programs will work without any changes.
The implementation of Multi-Program took a bit more time than expected because deep changes in architecture were required.

To provide better performance regarding the handling of CAD geometry the “merge function” has been improved. It’s just a push of a button to merge geometries which have been identified in „bad condition“ and to optimize the visualization. The method is based on combining objects with the same color to one object. This will increase the length of the polygon- and vertex chain and will reduce the data transfer from and to the graphic board drastically.

Improvements in the dialogs and new ERPL- and ERCL- commands are described in chapter „2. New functions“.

The „Visual File Interface“ – a dialog to pre-view and load a workcell or a robot - has been enhanced as well. A simple function to create a bitmap screenshot („Capture Image“) for the robot or the cell and the possibility to add additional information related to the selected item simplifies the administration of the projects.

To work with EASY-ROB™ in the most efficient way and to make sure that you don’t waste any time while playing with different scenarios, it is important to use the right method of working. Please read more about “How to plan workcells successful with EASY-ROB™” in chapter 5.

We would like to thank our customers and users, who send suggestions and requirements for further development.

Thank you

Stefan Anton

EASY-ROB
3D Robot Simulation Tool

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I. General

EASY-ROB™, Windows Vista, Dual- and Quad-Core Processor

Because of the constant growing request on the computer performance, it is required to enhance the hardware and the operating system. This includes as well drastic changes deep into the system.

To run EASY-ROB™ in a proper way onto operating systems of Microsoft (Windows XP and Vista Business) the new DLL's (Dynamic Link Libraries) Microsoft Foundation Class (MFC), Version 8 are mandatory.

EASY-ROB™ V4.6 was built with the current version of Visual Studio 2005 will need the Service Pack 1 for all DLL's of MFC.

The required DLL's „System MFC Dll Version 8.0 SP1" are available as Zip-file "mfc-dlls-80-SP1.zip" (1.6 mb) in the download area „Software & Updates".

Link: http://www.easy-rob.com/download/easy-rob/software-updates.html

Extract the content of the Zip-file into the start directory of EASY-ROB™ („easyrobw.exe").
With standard installation it will be: „C:/Program Files/EASY-ROB/EASY-ROB".

See also the file: „Readme_mfc-dlls-80-SP1.txt"

The first results on Windows Vista Business are very satisfying. EASY-ROB™ is working - concerning the OpenGL™ visualization – perfect.
A final statement about the performance compared to Windows XP is not present yet, but up to now there is no significant lost of performance.
Finally it depends on the CPU, the graphic board and the available resources like the main memory (RAM).

So we recommend the investment into a graphic board with nVidia Chip with at least 250 MB RAM and a main memory of 2 GB.
The performance of a Dual- or Quad-Core Processor and the capacity of the hard disk in an up-to-date standard computer are sufficient.

A big advantage while working with EASY-ROB™ is the usage of a 22" monitor with a resolution 1650 x 1050 pixel. Because of the great width there is enough room for the 3-D scene even with open dialogs.

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1. Multi-Program

With EASY-ROB™ V4.6 and the new option „Multi-Program“ it is possible to move several robots and kinematics synchronized and at the same time. A function that was required for a long time. It enables the user to build up big and complex workcells. Robots from different brands, user defined kinematics devices like weld guns or gripper can be simulated side by side in one workcell.

„Multi-Program“ is a wise extension to EASY-ROB™ Single- or Multi-Robot Version.

Move robots synchronized and at the same time

In general there are no changes in the handling – the program for the current robot will be created by using the TeachWindow. The difference is, that the user is able now to create additional programs for additional robots, conveyor, positioner, or gripper which are in the workcell as well. Very important is to assign each program explicit to one robot. The program syntax (ERPL/ERCL) hasn’t changed that “old” programs/workcells are still executable in the new version. The maximum number of programs running quasi parallel is limited to the number of loaded robots, which is again unlimited.

Through the TeachWindow the user is able to switch between the programs of each robot. See also chapter „2.2 In the Teach Window“.

How does „Multi-Program“ work?

Target is to get a deterministic manner in the simulation. So we drift off the original approach in which we created one thread per robot to avoid a needless overhead for the synchronization of the threads. And on top we learned our lesson with the (sometimes strange) behavior of threads on Dual- / Quad-Core processors and on graphic boards.

The result is that all robots will be calculated now in a fixed time pattern and at the end the 3-D scene will be visualized in OpenGL™. The time pattern is defined by simulations step size „Sim_Step“. Every program can initialize at a point of time t=0 – that execute the program up to the new command „EndInit“.
Only with this procedure the simulation will be deterministic and independent of the order of the robots defined in the KinematicsWindow. Each robot program will calculate the status (axis values, positions, etc.) of the robot up to a global given moment t=n*SIM_STEP. After the calculation the graphic update with the 3-D visualization follows.
Commands which don’t need time like „SPEED_CP“ or „ERC TRACK ON“ will be processed directly.
Commands like „MOVE tag“ are “time-consuming” commands and will processed bit by bit.

The Formula-Parser enables the user to define own global variables. These variables can be used as I/O-variables and for synchronization of the robots. New commands like „Wait_Until_Signal_Set“ will simplify the synchronization and communication.

The new functions are explained in detail in the following.

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2. New Functions

2.1 CAD Optimization (merge)

1-2 Million Polygons per workcell and a smooth visualization without jerk is the standard nowadays.

The CAD data with many polygons will be loaded direct into the memory (VRAM) of the graphic board to visualize and simulate a workcell in a high level of detail without jerk. OpenGL™ supports the requirement with Vertex Buffer Objects (VBOs) from Version 1.5.

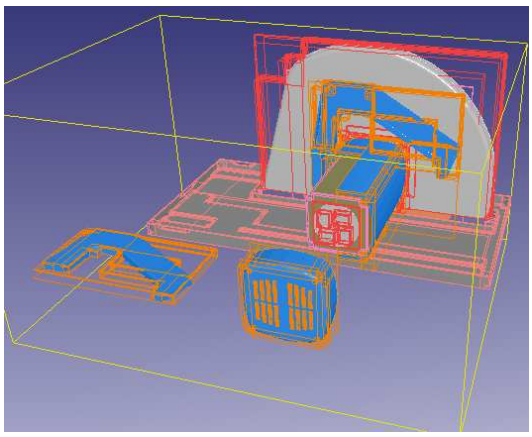
Unfortunately is the internal CAD data structure most times very different and consist of many objects with a small number of polygons per object. We call this state as „bad condition“. CAD data in bad condition will cause a lot of communication with graphic board and that means loss of performance.

Therefore EASY-ROB™ provides now the „Merge-Function“ at the push of a button. From version 4.6 it possible to merge direct into the workcell. The “Merge-Function“ will check the number of polygons per object and the number of objects. Depending on the numbers of the data the system will assign the data in good or bad condition.

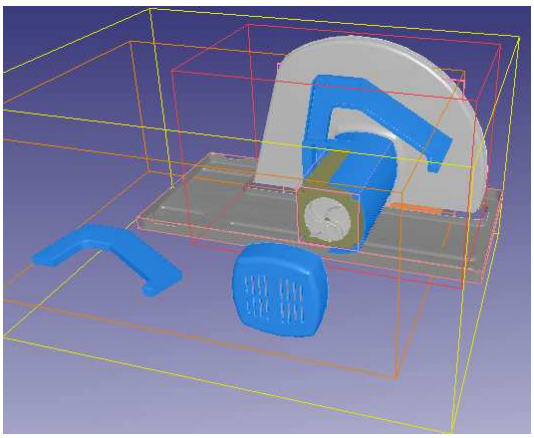
Objects with the same color will be combined to one new object. Those results are less objects and that means a better performance.

The function will overwrite the original data and the user has to reload the data.

The pictures below showing a workpiece in the original and in the optimized state. The bounding boxes are shown as well to make it clear. The number of objects has been reduced from 976 to 5 and the average length of the polygon chain increased from 38 to 5877.



976 Objects, 29386 Polygons, 38 Polygons/Objects
→ CAD model in bad condition



5 Objects, 29386 Polygons, 5877 Polygons/Objects
→ CAD model in good condition

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2.2 In the Teach Window

New program body

When creating a new program (button “New”) a new, extended program body – required by the new functionality for Multi-Program - will be inserted automatically.

The new program body contains a new section for the commands which does not have any effect on the timeline. This section will be executed first of all (point of time t=0) for all programs, before any movement will be proceeded.

Example:

```
ProgramFile
! cRobot 'AX-V6'
! below section is called once at t=0
! add Initialization commands here
EndInit
! below section is called at t>0
! add new ERPL / ERCL commands here
call my_fct_name()
EndProgramFile

fct my_fct_name()
endfct
```

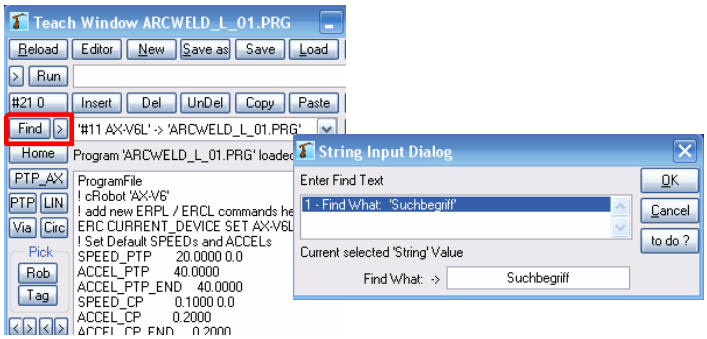
Save As – to store the program

Any time when a program for a robot will be stored in the Teach Window with “Save As”, EASY-ROB™ will suggest a combination of the workcell name + robot name as program name (cellname-robotname.prg)

Find What / Find Next – Searching in the Teach Window

“Find What” and “Find Next” are the new search functions in the Teach Window.

„Find What“ will search for an expression in the Teach Window and „Find Next“ will jump to the next position of the expression. (if it exist more than one time)



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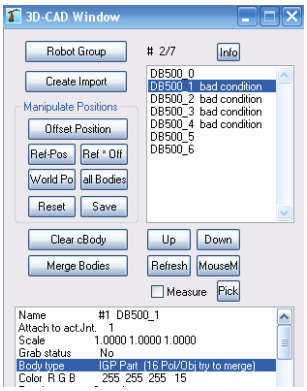
2.3 In the 3D CAD Window



Attribute Body type

Beside the type, the attribute „Body type“ shows now as well the condition of the body and will suggest – if necessary – to merge the object.

Example:
"Body type ... IGP Part (480 Pol/Obj OK)"
or
"Body type ... IGP Part (16 Pol/Obj try to merge)"

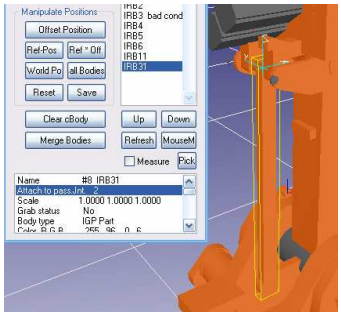
Double click in the list or click onto the button „Info“ will provide detailed information about the body.

Merge Bodies

The „Merge-Function“ will rearrange the internal structure of the body, to improve the graphic performance. The function will overwrite the existing file.

Although the merge will be done in the workcell now (and not in the CAD Preview anymore), a „reload“ is required.

Attribute Attach to act./pass. Jnt.



A CAD-geometry is always assigned to an active or a passive axis of a kinematics. The assignment number will be displayed now more clear in the attribute "Attach to pass. Jnt.".

In case of an assignment to a passive axis, the assignment number will be now from 1 to 12 and not from 13 to 24 anymore.

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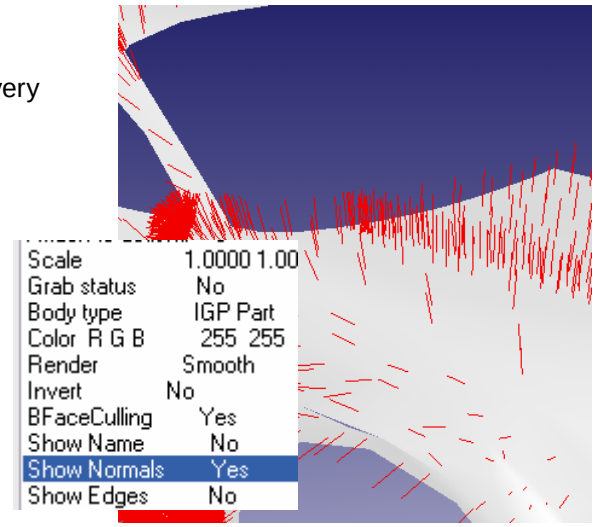
2.4 In the 3D CAD Window

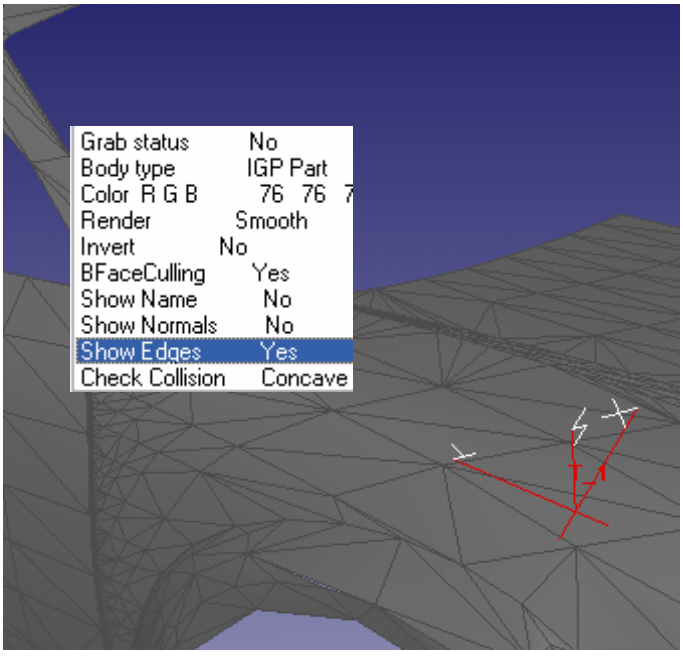
Attribute Show Normals

To simplify the positioning of tagpoints, the normal of every surface area can displayed now.

By double click on "Show Normals" in properties in the 3D CAD Window, the normals for any part / body can be switched on or off separate.



Attribute Show Edges



„Show Edges“ simplifies as well the positioning of tagpoints on the triangles.

The edges can be switched on or off for any part / body by double click on "Show Edges" in properties of the 3D CAD Window .

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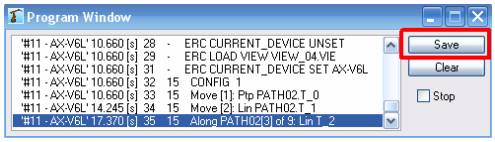
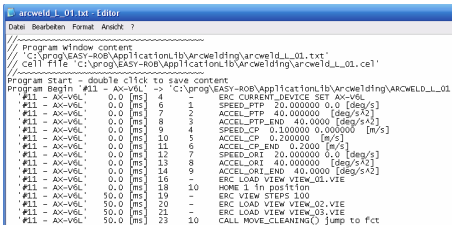
2.5 In the Program Window

While simulation all proceeded commands will be displayed into the Program Window with time stamp, robot name and robot index. Two new features have been implemented into the Program Window.

1.
To get detailed information about the simulated programs the user can store the content of the Program Window by using the „Save-Button“. The content will be stored as a text file with the name of the workcell plus the word ”prgwin”. (workcellname_prgwin.txt).





Example:

```
//~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
// Program Window content
// 'C:\Programme\EASY-ROB\ApplicationLib\ArcWelding\arcweld_L_01.txt'
// Cell file 'C:\Programme\EASY-ROB\ApplicationLib\ArcWelding\arcweld_L_01.cel'
//~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
Program Start - click ‘Save’ to save this content to a file
Program Begin '#11 - AX-V6L' -> 'C:\Programme\EASY-ROB\ApplicationLib\ArcWelding\ARCWELD_L_01. PRG'
  #11 - AX-V6L      0.0       [ms]    6    1    SPEED_PTP  20.000000 0.0 [deg/s]
  #11 - AX-V6L      0.0       [ms]    7    2    ACCEL_PTP  40.000000  [deg/s^2]
  #11 - AX-V6L      0.0       [ms]    8    3    ACCEL_PTP_END  40.0000 [deg/s^2]
  …….              …….       …….     …    …    …….
  #11 - AX-V6L      50.0      [ms]    19   -    ERC VIEW STEPS 100
  …….              …….       …….     …    …    …….
  #11 - AX-V6L      10.700    [s]     29   -    ERC LOAD VIEW VIEW_04.VIE
  #11 - AX-V6L      10.700    [s]     32   15   CONFIG 1
  #11 - AX-V6L      10.700    [s]     33   15   Move [1]: Ptp PATH02.T_0
  #11 - AX-V6L      14.300    [s]     32   15   Move [2]: Lin PATH02.T_1
  #11 - AX-V6L      17.400    [s]     33   15   Along PATH02[3] of 9: Lin T_2
  …….              …….       …….     …    …    …….
  Program End '#11 - AX-V6L' 03:00 [min]
  PRG_ABORT total realtime execution time  01:39 [min] - 36 fps
  1                 2         3       4    5    6
```

Column 1: Index and name of the devices
Column 2: current time stamp respectively begin of the following command
Column 3: unit for time [ms], [s], [min]
Column 4: line in the program respectively line in the Teach Window
Column 5: step of the program (step) = robot command
Column 6: command which is currently proceeded

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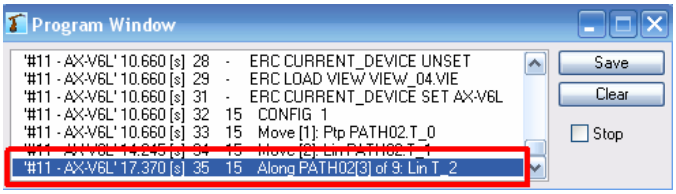
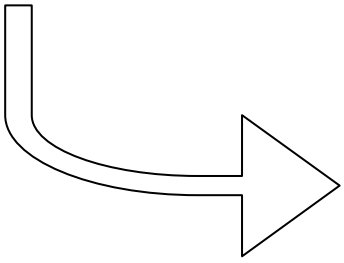
2.5 In the Program Window

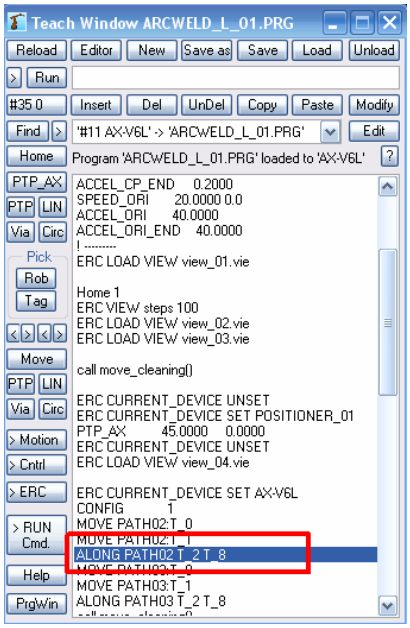
2.
To work in a workcell with many robots and corresponding programs is not an easy task. A double click onto a line in the Program Window will bring the user direct to the corresponding line into the Teach Window. If the Teach Window is closed, EASY-ROB™ will open it automatically.



double click in Program Window



will jump automatically to the line into the Teach Window



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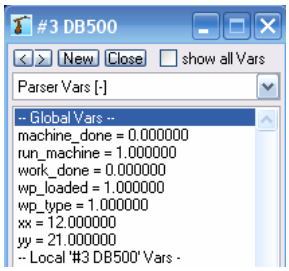
2.6 In the Online Output Window

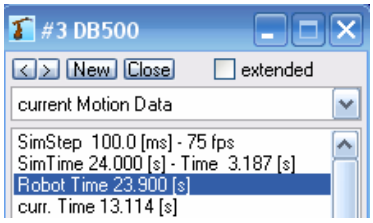


Parser Vars [-]
Global program variables and local device variables can be displayed in the OnlineOutput Window in „Parser Vars“.

The Variables are editable by double click.

Current Motion Data

The headline Current Motion Data in the OnlineOutput Window contains among other items the following time related Values:



SimTime	: cycle time (total)
Time	: current elapsed time (the real time)
RobotTime	: time of the device working
curr. Time	: current time of the current motion
Realtime ON	: real time

Remark:
While a simulation with „REALTIME = ON“ the *SimTime* = *Time* and the simulation step size will be adapted by the computer to its own performance. The higher the performance of the computer is the smaller the *SimStep* becomes and the more frames per seconds can be displayed.

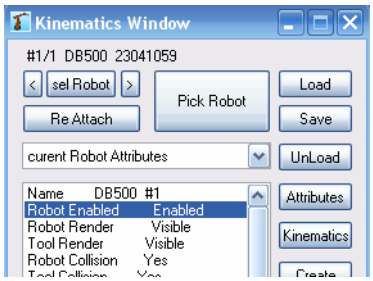
2.7 In the Kinematics Window

Enable / Disable Robot

With this version it possible to activate and deactivate single robots. That means that a **de**activated robot with a loaded program will not move while simulation.

Double click onto "Robot Enabled" in the properties of the Kinematics Window switches the function ON or OFF.

Tipp: While creating the programs it might be helpful to disable the robots that the user does not need to keep a better overview.



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2.8 Other Enhancements

- **ne- and eq- function with epsi 1e-5 for query with floating point numbers**
  If a device will be moved to the position xx=5, the real position is because of small inaccuracies not exact 5.
  The ne- and eq function have been improved to avoid trouble while doing queries using “equal” and “not-equal” functions.
  With an accuracy of 0.00001 the user will get:

  eq (5.00001,5) is 1 = true ne (5.00001,5) is 0 = false

  but
  eq (5.00002,5) is 0 = false ne (5.00002,5) is 1 = true

- **Index of the robot**
  The index of the robot respectively the robot name will be displayed for a better overview. The index of the robot is a number for the order which can be changed in the Kinematics Window.

  Example: '#1 DB500' with Index 1

- **Stop ON …..**
  To examine the simulation the user has to activate the „Stop ON“ commands one after the other while running the simulation.
  The „Stop ON“ will stop/pause the simulation („STOP Program“) that the simulation can be continued.

  This works for the following Stop ON commands:
  - Limit Switch
  - Speed Limits
  - Accel Limits
  - Collision
  - Unreach Pose

- **Global program parameter**
  To synchronize robots/devices global program parameter can be defined and used now.

- **Tool offset for Scara-Robots**
  Adaptation of the inverse kinematics for Scara-Robots: any tool offset can be used now.

- **ERC CURRENT_DEVICE SET <robot_name>**
  Due to the fact that every robot can have his own program now, the ERC-command „ERC CURRENT_DEVICE SET <robot_name>“, which has been used up to now to set the current device, is not required anymore.

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3. New ERPL-commands

EndInit

The *EndInit* command is required for the new functionality ***Multi-Program.***

In Multi-Program mode it is absolutely necessary to set all signals and to initialize all variables in the beginning of the simulation.
This will be done in the initialization area in the beginning of the program before the *EndInit*.
It does not make any sense to put move commands into the section.

Example: The signal wp_loaded will be initialized and set to false.

```
ProgramFile
! cRobot 'DB500'
! below section is called once at t=0
! add Initialization commands here
wp_loaded=0
EndInit
! below section is called at t>0
! add new ERPL / ERCL commands here
! Set Default SPEEDs and ACCELs
…….
……..
```

Before any movement will be proceeded, the simulation will proceed (at point of time t=0) first of all the initialization commands for all programs.

Zone

The command „Zone = 0“ allows to move exact to a target position.

Remark:
To move to a target position the needed time for the movement will be calculated. The calculated time is typically not a multiple of the step size (*SimStep*).
By the Zone value the robot knows how to move to the target: exact or cross the target.
Default is Zone = 0.1
That means that if the remaining time towards the first target is less than the *SimStep*, the robot will continue and will move to the second target.
Target positions with Zone=0 are called Fine-Point.

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4. New ERCL-commands

4.1 „Reading signals“ for Multi-Program

The new option ***Multi-Program*** requires new commands for the communication between the devices to work synchronized while simulation.
The commands are checking a condition on „True“ and „False“. The condition is a mathematical expression, which is true if greater than 0.5.

A conveyor for instance can wait until the robot put the workpiece onto it..

4.2 WAIT_UNTIL_SIGNAL_SET

Will wait until the signal is set.

```
WAIT_UNTIL_SIGNAL_SET my_signal
!  continues when the signal „my_signal“ is set
!  will wait as long as the signal „my_signal“ is not set
```

Example:

robot program	conveyor program
……..	…….
LIN Tag01	…….
ERC RELEASE DEVICE WP_01	…….
rob01_out = 1	WAIT_UNTIL_SIGNAL_SET ***rob01_out***
……..	MOVE TO Tag02
……..	……..

4.3 WAIT_UNTIL_SIGNAL_UNSET

Will wait until the signal is **not** set anymore.

```
WAIT_UNTIL_SIGNAL_UNSET my_signal
!  continues when the signal „my_signal“ is not set anymore
!  will wait as long as the signal „my_signal“ is set
```

4.4 WAIT_FOR_CONDITION

Will check for a given condition.

```
WAIT_FOR_CONDITION gt( my_signal ,0)
!  continues if condition is true
!  will wait if condition is false
```


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5. Successful workcell planning – Method of working with EASY-ROB™

To work with EASY-ROB™ in the most efficient way and to make sure that you don't waste any time while playing with different scenarios, it is important to use the right method of working.

We like to show step by step the whole process from empty cell to final simulation.

What is the target ?

To plan the layout of the workcell and to prove the feasibility of the project; to place the robots in a way that all positions are reachable without collision and without violation of axis limits. And finally the estimation of the cycle time.

The customer will hand over CAD data from the design department – sometimes only in 2D – with the remark: That's how I roughly planed it – will it work ?

What to do now ?

Step 1: First of all you have to create the needed Devices (rob-files) by using the CAD Data. The Devices will be stored in special project folder. This step is time consuming work – but its worth in the end.

Step 2: Load all Devices into the workcell, position them and connect the together belonging Devices. A gripper for instance will be attached to the flange of the robot.
Save the workcell.

Step 3: Create the paths and tags. Make sure that the path is ‚attached' to corresponding Device that the path will follow if the Device will be moved. Check if the tags are reachable.
Save the workcell.

Step 4: Select the first robot, create a new program and teach the process. Verify with "single step mode" if the target is reachable. If needed rearrange the positions of the workpiece or the robot. „Disable" all robots that you don't need at the moment. Create the programs for every single robot and save them.

Step 5: Simulation. Start the simulation with „RUN" and observe the robots to make sure that they act like expected. Optimize the process. Verify axis limits and check for collision. Use the „Stop ON" commands.

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Step 6: Reducing the cycle time. To improve the cycle time you have to increase the programmed speed while checking the speed and acceleration limits to avoid limit violations. Optimize the process.

Step 7: Create with the AVI-Recorder and the VRML-Export the result as output files.

The following page will show the single steps in a block diagram.

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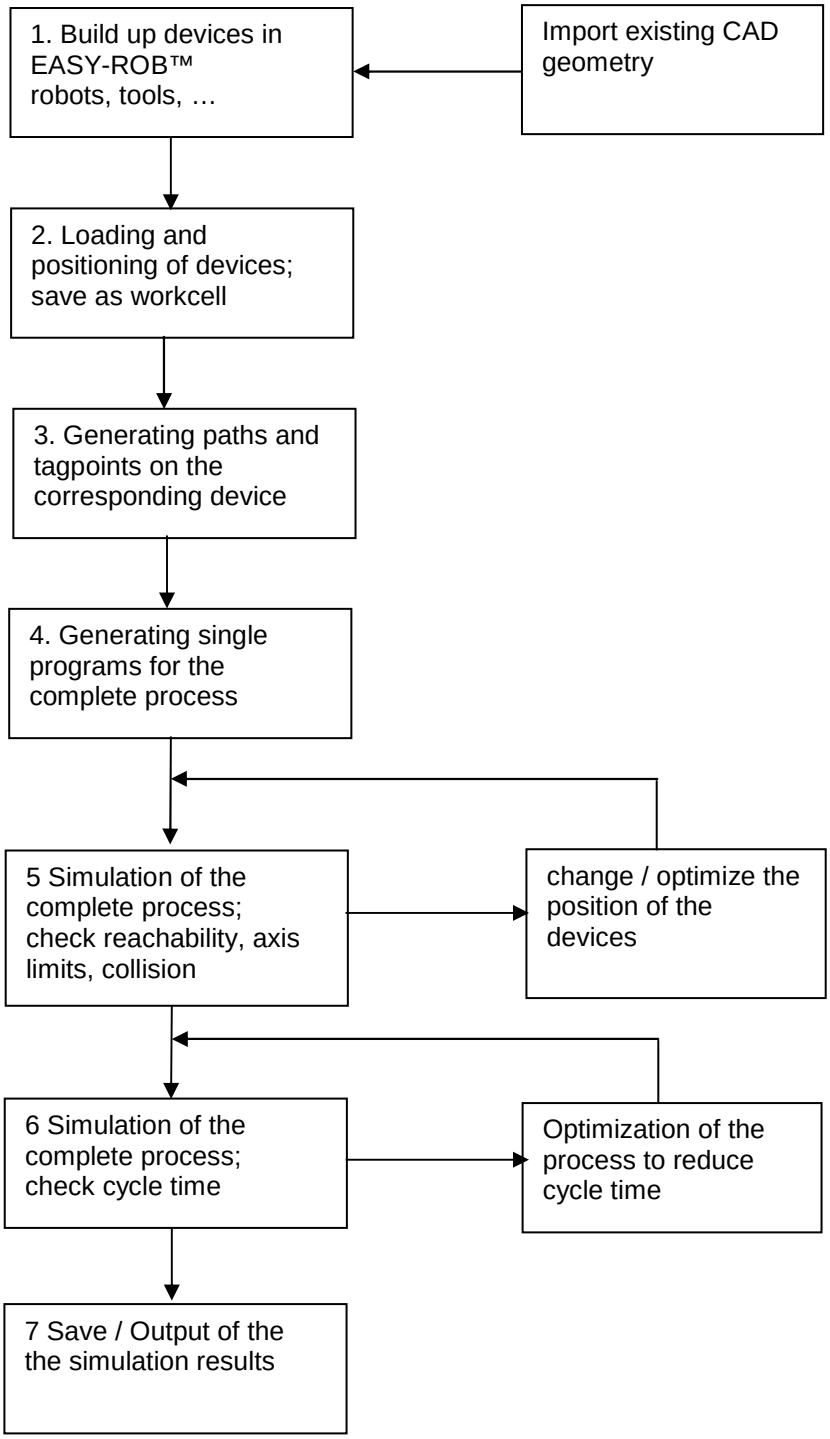
Block diagram



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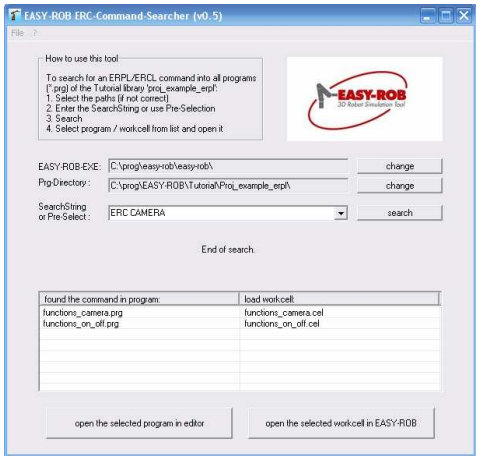
6. The ERC Searcher

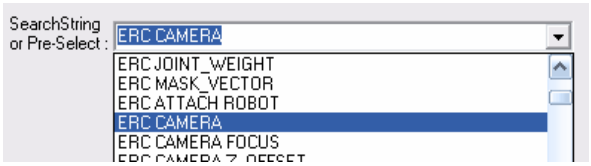
The ERC Command Searcher will support the user to search for a specific ERC command in the example library "Proj_example_erpl", which is normally installed in the directory:

".\EASY-ROB\Tutorial\Proj_example_erpl"

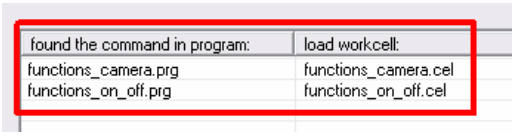
The library contains many short example programs with different ERC commands to give an impression how the commands are working.



The user can insert the command manual or can use the pre-selection to search for it:



All results/hits will be shown in the list.



Select by mouse the program or the workcell, to load the program in an editor respectively run the simulation to see how the command works and how to use it.

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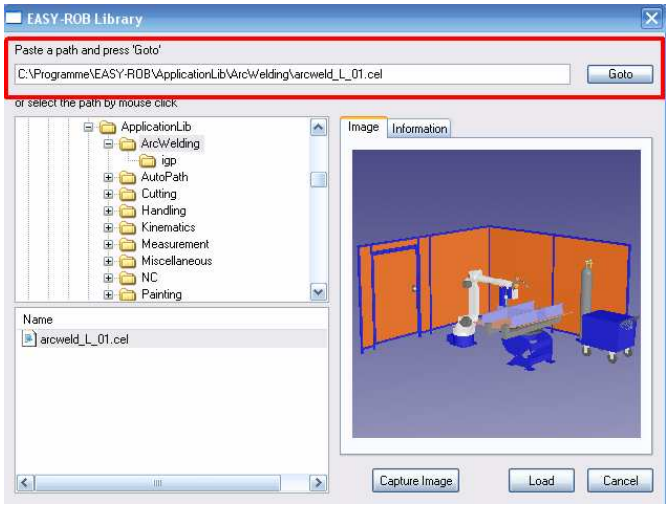
7. The Visual File Interface

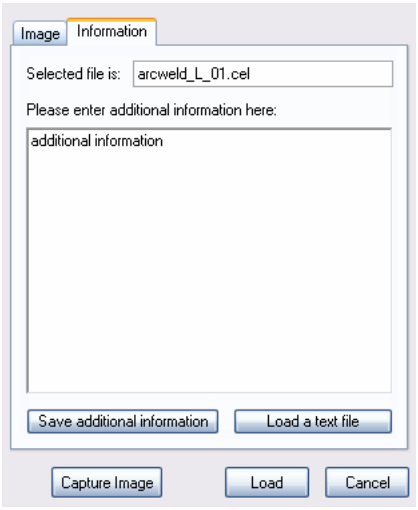
The Visual File Interface of the library has been revised to become more user-friendly and to provide new functions.

Open the library with the button „Load from Library“:



In addition to the tree structure (to click through to the file) there is an input field now to insert the target directory by writing or copy and paste. „Return key“ or mouse click onto „Goto“ will display in the list all workcells and robots from the given directory.

Additional information to the selected file can be displayed or added by the user into the panel „Information“.



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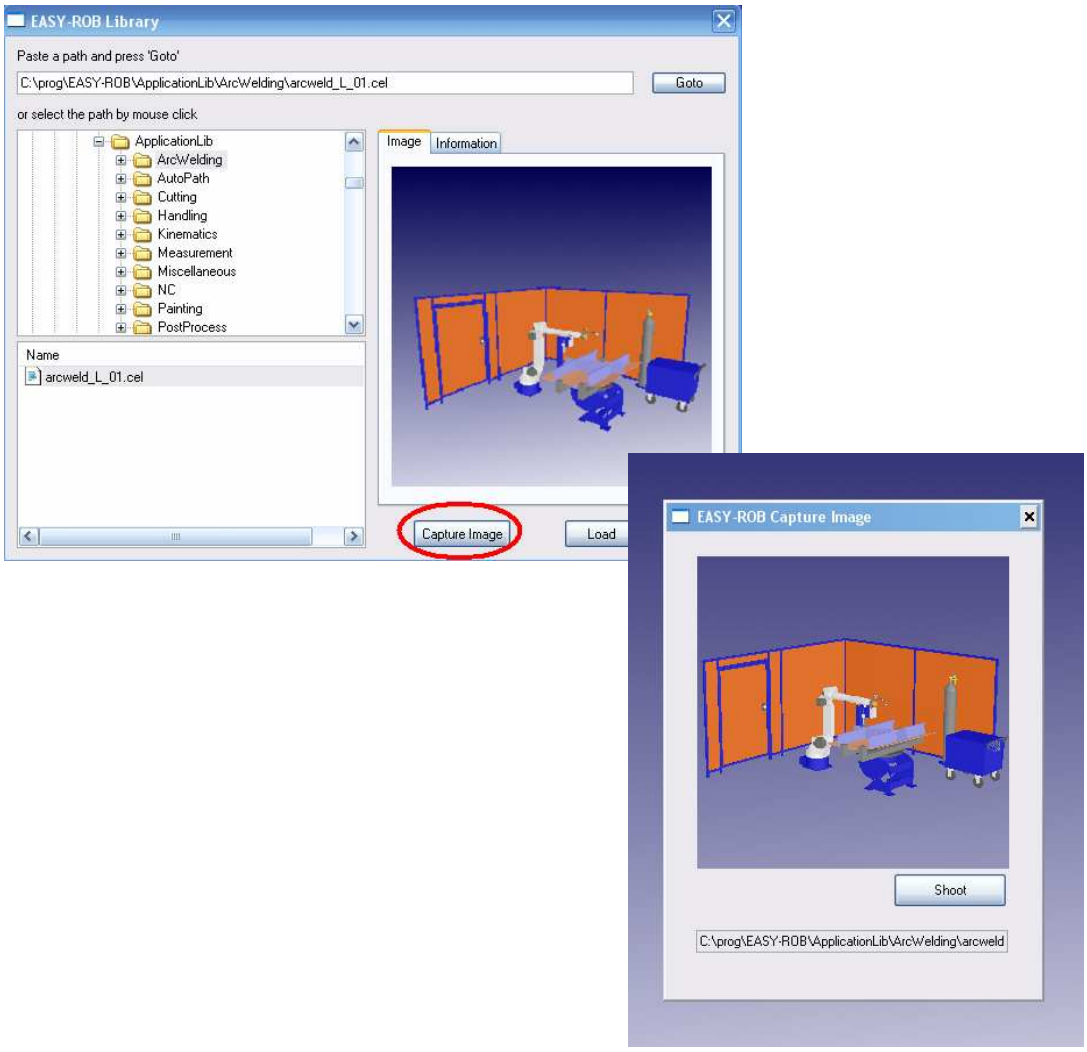
7.1 EASY-ROB™ Capture Image

The new function ***EASY-ROB™ Capture Image*** enables the user to create snapshots in the right size for the Visual File Interface of the library.

After loading the workcell or the robot the function „Capture Image“ can be called through the EASY-ROB Library.
Then it’s up to user to place the motif in the right position to take the snapshot.



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8. New API-Commands

Many new API functions have been added. Please see the header-files „`./er_dvlp/er_dvlp.h`“ and „`./er_dvlp/er_dvlp_ext.h`“.

- er_dvlp.h

* System Routines (API-UserDLL -> er_vad.dll *)
const int AUX_UPDATE_IDX_OPENGL
const int AUX_UPDATE_IDX_OPENGL_POST
Function: To draw into the 3-D scene and to set OpenGL™ commands.

* ERC ON/OFF Commands
const int ERC_ENABLE_CROBOT
Function: Activates respectively deactivates the current robot

* kinematics & dynamics *
EXPORT_C int *inq_robot_enabled(void);
Function: Activates respectively deactivates the current robot

* motion planner *
typedef enum {JOINT, CP, CIRC, WAIT, IPO_AUX_1, IPO_AUX_2, IPO_AUX_3, IPO_AUX_4,
UNDEF} IPO_MODE;
Function: new TypeDef

* Collision Routines *
EXPORT_C int * inq_show_collision_line(void);
Function: Activates respectively deactivates the Min-Distance-Line while collision

* Routines *
EXPORT_C int *inq_prgwindow_show_auto(void);
EXPORT_C int *inq_msgwindow_show_auto(void);
Function: disables the automatic function to open the program- or message windows

- er_dvlp_ext.h

* Body CAD Routines *
EXPORT_C int *er_vad_inq_body_show_edges(void *body_handle);
Function: Shows the edges of a geometry with the handle ‚body_handle’

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9. Plans for the future

We've got quite a few items on our ToDo-list and there is still a lot to develop – but we are already working on that.

9.1 Additional CAD import interfaces

The current EASY-ROB ™ Version 4.6 is another very important milestone on our way. One of the next targets will be the extension of the import interfaces. Beside the already existing neutral formats like STL, VRML and IGP, EASY-ROB ™ will be able to read STEP, IGES, VDA - FS and JT-Open.
Furthermore it will be possible to read native data formats such as CATIA V4 and V5, UG and ProE.
To realize it we decided to use the solution „3D_Evolution© API" of CT Core Technology GmbH and connect it to EASY-ROB ™. A first version will be available in January 2008.

The 3D_Evolution © Conversion Engine allows to change the triangulation to get a proper level of detail.

9.2 Other functions

- Save Export Cell file
- Report at the end of a simulation
  Which robot needed how long (RobotTime).
- Clone IGP file
  First step top to load same CAD files just one time per workcell
- transparent geometry
- Tag on Triangle:
  with selectable approach direction x,y,z,-x,-y or -z,m (at the moment always z)
- mirror Tagpoints
- several / different HomePos and Tools
- save the current view when loading – "ESC-Button" will activate / set the view
- save the environment settings within the workcell.
  While loading the workcell the user can decide which environment will be loaded – the saved one or the default.
- different RotView for CADPreView <-> Sim
- Device types:
  Robot, Conveyor, Positioner, Track, Fixture, FlangeDevice (Gripper, Gun, Torch), Accessory, Miscellaneous

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10. Notes

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