DTRACK3 User's Guide

ARTtrack®, TRACKPACK, SMARTTRACK & DTrack®

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ART▶
Advanced Realtime Tracking

What's new in version 3.1.3?

The following new features are available in *DTRACK3* version v3.1.3:

- Increased number of output channels

- All available HMD targets in target library

- Simplified camera licensing for Cascaded Systems

- Output of system status data via ethernet

What's new in version 3.1.2?

The following new features are available in *DTRACK3* version v3.1.2:

- Support of *SMARTTRACK3/M*

- Approx. 30% increased tracking range for *ARTTRACK6/M*

What's new in version 3.1.1?

The following new features are available in *DTRACK3* version v3.1.1:

- Support of camera *ARTTRACK6/M for Active Markers*

- Support of *Flystick2+* with feedback capabilities

- Easier configuration of stateless firewalls (UDP sending port 50107)

- Early warning for expiring licenses

- Check of DTRACK3-valid license code before upgrading from DTrack2

What's new in version 3.1.0?

The following new features are available in *DTRACK3* version v3.1.0:

- Support of camera *ARTTRACK6/M*

- Tracking with reference target

- Change of licensing *DTRACK3* upgrades

- Output of 6DOF and 3DOF covariances via ethernet

- Adjustment of camera threshold and exposure time

- Time synchronisation using PTP (IEEE1588-2008)

- Optional login with password to *DTRACK3* frontend

What's new in version 3.0.2?

The following new features are available in *DTRACK3* version v3.0.2:

- Support of *ART Controller/M*
- Adjustment of *DTRACK3* for high resolution monitors

What's new in version 3.0.1?

The following new features are available in *DTRACK3* version v3.0.1:

- New 'Service' dialog

What's new in version 3.0.0?

The following new features are available in *DTRACK3* version v3.0.0:

- Support of *SMARTTRACK3* including Cascaded System capability
- Support of up to 70 targets
- Improved target catching algorithm
- New menu structure
- Dark user interface scheme
- Extended licensing models (refer to table 7.2 on page 60)
- Re-positioning of room coordinate system without wand calibration

Contents

Terms and definitions

term	definition
3DOF	three degrees of freedom (i.e. only position)
6DOF	six degrees of freedom (i.e. position and orientation)
5DOF	five degrees of freedom (i.e. one degree less in orientation)
base	imaginary connecting line between two cameras (e.g. the two integrated cameras inside the *SMARTTRACK2/3/M*)
ART Controller	controller for rackmounting, calculates tracking data and generates the data output stream (compatible to *ARTTRACK2* , *ARTTRACK3* , *ARTTRACK5* , *ARTTRACK5/C* , *ARTTRACK6/M* , *TRACKPACK/E*)
ART Controller/M	compact size controller, calculates tracking data and generates the data output stream (compatible to *ARTTRACK2* , *ARTTRACK3* , *ARTTRACK5* , *ARTTRACK5/C* , *ARTTRACK6/M* , *TRACKPACK/E*)
ARTTRACK Controller (discontinued)	calculates tracking data and generates the data output stream (compatible to *ARTTRACK1* , *ARTTRACK2* , *ARTTRACK3*)
ARTTRACK2 (discontinued)	infrared camera
ARTTRACK3 (discontinued)	infrared camera
ARTTRACK5	infrared camera
ARTTRACK5/C	infrared camera dedicated for multi-sided projections
ARTTRACK6/M	infrared camera dedicated for compact environments or multi-sided projections
ARTTRACK6/M for Active Markers	flashless camera dedicated for use with active targets in compact environments or multi-sided projections
body calibration	teach the system the geometry of a rigid body
body, rigid body	rigid arrangement of multiple markers intended for 6DOF tracking (see also "target")
calibration angle	belongs to the room calibration set and defines origin and orientation of the room coordinate system
ceiling suspension	equipment to mount an infrared camera or *SMARTTRACK2/3/M* to the ceiling
DTRACK3	
backend software	software running on the *ART Controller* , *ART Controller/M* or *SMARTTRACK2/3/M* doing all necessary calculations
frontend software	graphical user interface running on customer's computer to control the *ART Controller* , *ART Controller/M* or *SMARTTRACK2/3/M*
Field of View (FoV)	is the area of interest captured on the camera's image
finger thimble	a fixture for the finger tip to hold the active marker(s) (not available for *SMARTTRACK2/3/M*)
Fingertracking (discontinued)	tracks the orientation of the hand and the position of the fingers (not available for *SMARTTRACK2/3/M*)
FINGERTRACKING2	tracks the orientation of the hand and the position of the fingers (not available for *SMARTTRACK2/3/M*)
FINGERTRACKING2 Tactile	tracks the orientation of the hand and the position of the fingers and provides Tactile Feedback
Flystick2/2+/3	wireless interaction device for virtual reality (VR) applications
Flystick feedback	vibrational or acoustic signal that can be triggered in a capable *Flystick*
hand geometry	describes the dimensions of your hand and fingers (not available for *SMARTTRACK2/3/M*)

term	definition
hybrid tracking	sensor fusion of optical and inertial data into one consolidated output
inertial sensor	an inertial measurement unit simultaneously measures 9 physical properties, i.e. angular rates, linear accelerations (unused) and magnetic field components (unused) along all 3 axes. This is achieved using solid state gyroscopes for measurement of roll, pitch and yaw and optical tracking for drift correction.
infrared optical tracking	position measurement of bodies (subjects or objects) based upon infrared light and optical measurement procedures
license code (license key)	software key to unlock certain capabilities of the tracking system or *SMARTTRACK2/3/M*
marker	object either made of retro reflective material or LED for position tracking (3DOF)
Measurement Tool	a pointing device which allows to measure the position of the tool's tip with high accuracy
measurement volume	defines the volume where optical tracking is possible
modulated flash	infrared signal which is used for wireless synchronization
motion capture	track movements of a human body
mutual blinding	at least one camera (also from *SMARTTRACK2/3/M*) sees disturbing reflections caused by the infrared flashes of another camera (or *SMARTTRACK3*)
prediction	predicts output for the specified time in the future to compensate tracking and rendering latency
Radio Transceiver	exchange data with *Flystick2/2+/3* (integrated in *SMARTTRACK2*)
RadioTransceiver2/3	uses USB port to exchange data with *Flystick2/2+/3* or *FINGERTRACKING2 Tactile*
room calibration	teach the system the position of each camera and define origin and orientation of the room coordinate system
room calibration set	consists of angle tool and wand
SMARTTRACK3	fully integrated stand-alone infrared optical tracking system with two cameras and integrated controller, calculates tracking data and generates the data output stream
SMARTTRACK3/M	compact version of *SMARTTRACK3*
syncgroup	cameras being in one syncgroup receive the sync signal at the same time. Syncgroups are distinguished by a short time delay between their sync signals in order to avoid mutual blinding. (not available for *SMARTTRACK2*)
Synccard	unit integrated in *SMARTTRACK2/3/M* which serves for synchronizing the cameras
Synccard2	board integrated in the *ARTTRACK* Controller (discontinued) which serves for synchronizing the cameras
Synccard3	board integrated in the *ART Controller* or *ART Controller/M* which serves for synchronizing the cameras
SynccardTP	board integrated in the *TRACKPACK* Controller (discontinued) which serves for synchronizing the cameras
Tactile Feedback	system for finger-based interactions in immersive virtual reality applications (wires touch the inside of the finger tips and provide an impression when they are shortened)
target	rigid arrangement of multiple markers intended for 6DOF tracking (see also "rigid body")
tracking	position measurement of bodies that move in a defined space
TRACKPACK (discontinued)	infrared camera
TRACKPACK/C (discontinued)	infrared camera dedicated for multi-sided projections

term	definition
TRACKPACK/E	infrared camera
TRACKPACK Controller (discontinued)	calculates tracking data and generates the data output stream (compatible to *TRACKPACK* and *TRACKPACK/C*)
virtual point cloud	used for calculating the relative position of cameras or *SMART-TRACK2/3/M* that cover the measurement volume
wand	precalibrated stick carrying two markers. The wand belongs to the room calibration set and is used to generate a virtual point cloud and to scale the measurement volume

1 Safety

1.1 Symbols and their meaning

You can find the following symbols and signs on the equipment or in the manual:

i	Useful and important notes.
☞	Important notes, which may lead to system malfunction or to the loss of warranty by non-observance.
⚠	Important safety warning to assure user's and operational safety. These warnings have to be observed, otherwise there is a potential risk for health and safety and damaging of the equipment resulting in loss of warranty and liability.
☀	Safety warning for infrared radiation. These warnings have to be observed, otherwise the user's eyes and sight are exposed to a potential hazard.

Table 1.1: Symbols and their meaning

1.2 Warnings

⚠ **All warnings in this manual have to be observed for safe operation of the equipment.**

⚠ *ART* **explicitly denies any warranty and liability if the product is not operated according to this manual or any other authorised documentation (e.g. quick-guides) or not according to the specifications of the equipment.**

1.2.1 Installation

⚠ **The housing may <u>NOT</u> be damaged.**

⚠ **Do not install or use any equipment when it shows signs of damage (e.g. smoke, sparks, fire, smells, etc) or if parts of it show damaging.**

Do not install or use any equipment when the power cord is damaged.

Insert batteries in the indicated polarity !

Some equipment employs connectors of proprietary design. Do not try to connect these to any other computer ports (e.g. COM port or LAN) !!!

Verify that voltage and frequency of your electrical grid comply with the appliance ratings of the equipment. The rating plates are found on the equipment's housing. (*ARTTRACK1* on the lower side of the housing; *ARTTRACK2* / *ARTTRACK3* and *SMARTTRACK2/3/M* on external power supply, all controllers on the rear side of the housing).

The equipment may only be powered from power sockets connected to earth/ground. If the grounding wire is defective the requirement of the safety and the electromagnetic compatibility (EMC) cannot be guaranteed. To check the function of the grounding wire ask your local electrician.

The power switch on the equipment does not separate the device from mains. The equipment must be disconnected from mains.

1.2.2 Mounting

☞ **Do not touch the front pane of the cameras. The acrylic pane and the lens have highly sensitive surfaces. Be careful to avoid permanent damages (e.g. scratches). Grab the cameras only on the housing.**

☞ **Shock and severe vibrations can permanently damage the internal calibration of the cameras. De-calibrated cameras have to be sent in for maintenance.**

☞ **The power cord and plug should be accessible freely. The power socket should be close to the equipment.**

☞ **Install the cables that the line of sight of the cameras or *SMARTTRACK2/3/M* is not obstructed.**

Do not drop the equipment.

Be sure that the cameras are firmly mounted using strong wall plugs / anchors and screws when mounting to walls or ceilings. Loosely mounted cameras may pose a serious hazard to health and safety.

Never unfasten screws that are not designed for mounting. All liability and warranty is void.

Use only accessories for mounting (screws, ceiling suspension) supplied by *ART* .

The ventilation holes of the equipment (particularly of *SMART-TRACK2* , *ARTTRACK2* , *ART Controller* and *ART Controller/M*) must not be covered. Ensure unblocked airflow at all times. The minimum distance between equipment and surrounding objects has to be larger than 3 cm.

Install a strain relief to all cables to avoid damage to the equipment.

Install the cables trip-proof (e.g. cable ducts or fixings). Inappropriate cabling may pose a serious hazard to health and safety.

1.2.3 Operation

Unplug the equipment from mains immediately in any case of damage ! Please contact *ART* service

Removable batteries must be removed before shipping equipment.

Batteries should be removed when equipment is not used for a longer period of time - Risk of damage !

Do not use non-rechargable batteries in rechargable equipment (e.g. *Flystick2*) - Risk of explosion !

Do not crush or puncture batteries and avoid impact that might result in damage, leakage or short-circuiting.

Use only original components and accessories from *ART* or authorized by *ART* . Using unauthorized components or accessories may damage the equipment, may cause malfunctioning and may compromise operational safety.

Only peripheral devices which meet the safety requirements of UL 60950-1 (U.S. only) and EN / UL / IEC 62368-1 (EU, U.S., etc.) for SELV may be attached on Ethernet-, BNC- and the DC-circuit of the equipment.

Do not expose the equipment to high levels of humidity or condensing environments.

The equipment must not be operated in environments with intensive formation of dust.

The equipment must not be operated in environments with elevated temperatures above 40° C (100° F).

Do not use the equipment outdoors (i.e. outside of buildings or potentially moist / wet locations) !

Do not spill fluids over the equipment!

Do not insert objects into the equipment (e.g. ventilation openings) !

Do not change or modify the equipment in any way (e.g. mechanically, electrically). Non-compliance may result in loss of conformity ! All warranty and liability is void.

The cameras and *SMARTTRACK2/3/M* emit infrared light. Keep a distance of min. 20 cm when operating near cameras or *SMART-TRACK2/3/M* . All cameras and *SMARTTRACK2/3/M* are assigned to the Exempt Group according to IEC62471-1 and therefore pose no risk or hazard to the human eye or skin at this distance.

1.2.4 Maintenance

☞ Only the housing of the cameras may be cleaned. Before cleaning shut down the system and disconnect the power cords.

Do not use any solvents, water or chemicals to clean the cameras!

Do not try to repair anything by yourself!

Danger High Voltage inside the equipment ! Do not open the equipment ! Risk of electric shock - even if the equipment is disconnected. Please contact *ART* service.

All warranty and liability is void when the equipment is opened.

In order to replace mains fuses (e.g. *ART Controller*) always unplug the power cord first. Risk of electric shock !

Risk of explosion if removable batteries are replaced by an incorrect type!

1.2.5 Disposal & Recycling

Waste Electronic and Electrical Equipment (WEEE) should never be disposed of along with household waste.

Batteries should never be disposed of along with household waste.

Batteries or rechargeable batteries that are not permanently installed must be removed beforehand and disposed of separately.

To prevent fires due to short-circuits, tape battery terminals and/or place lithium-ion batteries in separate plastic bags.

Do not crush or puncture used batteries and avoid impact that might result in damage, leakage or short-circuiting.

2 General Information

2.1 Cleaning of the equipment

Use a dry, lint-free and antistatic cloth or tissue (e.g. lens-cleaning tissue for optical equipment).

Only the housing of the cameras may be cleaned. Before cleaning shut down the system and disconnect the power cords.

Do not use any solvents, water or chemicals to clean the cameras!

2.2 Maintenance and service

Routine maintenance of the equipment is recommended every three years. If you experience any problems please do not hesitate to contact our support.

Do not try to repair anything by yourself!

Danger High Voltage inside the equipment ! Do not open the equipment ! Risk of electric shock - even if the equipment is disconnected. Please contact *ART* service.

All warranty and liability is void when the equipment is opened.

2.3 Disposal and recycling of equipment

Waste Electronic and Electrical Equipment (WEEE) may contain a complex mixture of materials and hazardous substances. If not managed properly and thus exposed, these can cause serious damage to the environment, wildlife, and human health. In addition, modern electronics contain rare and expensive resources, which can be recycled and re-used to contribute to the circular economy. By ensuring that you dispose of WEEE properly, you are helping to improve sustainable production and consumption, to increase resource efficiency and to preserve our natural resources and protect human health.

The symbol (crossed-out wheelie bin symbol according to Waste Electronic and Electrical Equipment (WEEE) Directive 2012/19/EU, see figure 2.1 (a) or (b) on page 20) indicates

that the product should not be discarded as unsorted municipal waste but must be sent to separate collection facilities for recovery and recycling.

(a) equipment placed on the market prior to 2005

(b) equipment placed on the market after 2005
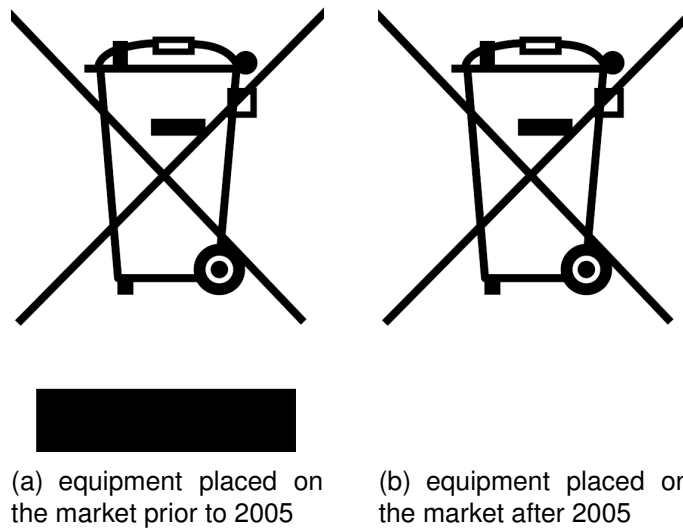
Figure 2.1: WEEE label

When your delivery address is outside of Germany, dispose of WEEE at your local waste facilities or recycling centers available by public waste management authorities only. Please consider that local regulations on the disposal of and recycling of electronic and electrical equipment may apply. Contact your local authority directly for more information.

For deliveries inside Germany only:

- End-users of WEEE are obliged to return the equipment or have it collected within the framework set up by *ART* .

- You are responsible for deleting personal or confidential data from the equipment to be disposed of. You can do this by resetting the device to its factory settings. Please refer to *DTRACK3 User's Guide* → *Connecting to the controller* → *Configuring your controller's network address without network access* for more details. *ART* is not liable for any data on your device. Before resetting your device, you should always back up any sensitive data.

- For further details regarding the WEEE directive, including how *ART* ensures the safe disposal of your electrical and electronic equipment, please refer to our website at https://ar-tracking.com/de/art-geraete-ruecknahmekonzept

> ⚠️ **Waste Electronic and Electrical Equipment (WEEE) should never be disposed of along with household waste.**

2.4 Disposal and recycling of batteries

Batteries are made from important resources, including lead, cadmium, zinc, lithium and mercury. Many of the components of these batteries and rechargeable batteries could be recycled, avoiding the exposure of hazardous substances to the environment. In addition, by recycling your used batteries using the collection and recycling schemes available you are contributing to protecting Earth's natural resources by providing valuable materials to products and production processes.

The symbol (crossed-out wheeled bin symbol according to Battery Directive 2006/66/EC, see figure 2.1 (b) on page 20) indicates that you are legally obliged to dispose of batteries or rechargeable batteries separately from unsorted municipal waste, i.e. that they must be disposed of separately from household waste. If batteries or rechargeable batteries contain Mercury (Hg), Cadmium (Cd) or Lead (Pb), they are marked with the chemical symbols of the metals (Hg, Cd, Pb) for which the limit value is exceeded.

- Pb = battery contains more than 0.004 mass percent Lead

- Cd = battery contains more than 0.002 mass percent Cadmium

- Hg = battery contains more than 0.0005 mass percent Mercury

When your delivery address is outside of Germany, dispose of used batteries at dedicated battery collection points or recycling centers available by public waste management authorities only. Please consider that local regulations on the disposal of and recycling of batteries may apply. Contact your local authority directly for more information.

For deliveries inside Germany only:

- End-users of batteries are obliged to recycle used batteries via dedicated battery collection points or recycling centers set up by public waste management authorities or via retailers directly. Addresses of suitable collection points and recycling facilities in your area can be obtained from your city or by contacting your local authorities.

- For further details regarding the Battery Directive, please refer to our website at https://ar-tracking.com/de/art-geraete-ruecknahmekonzept

Batteries should never be disposed of along with household waste.

Batteries or rechargeable batteries that are not permanently installed must be removed beforehand and disposed of separately.

To prevent fires due to short-circuits, tape battery terminals and/or place lithium-ion batteries in separate plastic bags.

Do not crush or puncture used batteries and avoid impact that might result in damage, leakage or short-circuiting.

2.5 Warranty

General   Please refer to the terms & conditions on our website at
https://ar-tracking.com/en/terms-agb

Hardware   *ART* warrants the hardware to be free from defects in material and workmanship, design and manufacturing for the warranty period set forth in our terms & conditions (see website) after the time of delivery. The time of delivery is defined as the day when the end-user takes possession of the equipment. If *ART* or any third party authorized by *ART* installs the system, the time of delivery is the time of the first installation.
If a defect arises during this warranty period, provided the instructions for returning the hardware are followed, *ART* will, to the extent permitted by law, initially either (i) repair or (ii) replace the hardware or any defective parts. All replaced parts and hardware shall become property of *ART* . This limited warranty applies only to hardware components that have been under ordinary and intended use and service being in their original, unmodified state and thus have not been subject to damage from external causes, alteration or unauthorized repair.

Software   Software supplied is delivered on a tested "As Is" basis. *ART* explicitly does not warrant that the software is error (bug) free. If the user detects bugs and notifies *ART* , *ART* will provide a workaround or bug fix as soon as possible after successfully reproducing the error.

Warranty restrictions   All warranty and liability is void, if the equipment

- is not operated according to this manual or any other authorized documentation (e.g. quick-guides),

- has not been used according to the specifications of the equipment,

- shows damages or signs of improper use,

- has been opened by the user or other non-authorized personnel (non-members of *ART* and third parties not authorized by *ART*),

- has been modified or tampered with by the user or other non-authorized personnel (non-members of *ART* and third parties not authorized by *ART*).

2.6 Liability

General   Please refer to the terms & conditions on our website at
https://ar-tracking.com/en/terms-agb

In no event shall *ART* be liable for any incidental, indirect or consequential damages whatsoever (including, without limitation, damages for loss of business profits, business

interruption, loss of business information, or any other pecuniary loss) arising out of the use of or inability to use the software or hardware.

Measurement results *ART* products are not authorized for use under any circumstance where human life might be at risk due to malfunction, measurement errors or interrupted operation of the system without written approval of a managing director of *ART* .

It is the user's sole responsibility to check the results of the measurement data and to protect any downstream system against malfunction, measurement errors or interrupted operation of the system. Under no circumstances shall *ART* be held liable for any incidental, indirect or consequential damages whatsoever (including, without limitation, damages for loss of business profits, business interruption, loss of business information, or any other pecuniary loss) arising out of malfunction, measurement errors or interrupted operation of the system.

ART **explicitly denies any warranty and liability if the product is not operated according to this manual or any other authorized documentation (e.g. quick-guides) or not according to the specifications of the equipment.**

Do not change or modify the equipment in any way (e.g. mechanically, electrically). Non-compliance may result in loss of conformity ! All warranty and liability is void.

3 Introduction to tracking

The *ART* tracking systems are infrared (IR) optical tracking systems, whereas the *SMART-TRACK2/3/M* are fully integrated stand-alone tracking systems, designed to be used in small volumes (approx. $2m^3$). In this user manual we are going to perceive "tracking" as measurement of positional and rotational information (i.e. orientation) of objects or individuals that move in a defined space.

Concept of optical tracking The cameras send out synchronized IR flashes which are reflected back into the lens by retro-reflective material covering the markers of the target. The reflected IR light is detected by the tracking cameras (integrated in *SMART-TRACK2/3/M*) which create a greyscale image based on the received IR radiation.

In the next step these images are preprocessed by the cameras to calculate the marker positions (2DOF) on the camera sensor with high accuracy using pattern recognition algorithms. Then this 2DOF data is sent to a control unit to calculate 3DOF or 6DOF information.

The simultaneous measurement of spatial position (X, Y, Z) and orientation (three independent angles) is called 'six degrees of freedom' (6DOF) tracking. If only the spatial position (X, Y, Z) is to be measured it is called 'three degrees of freedom' (3DOF) tracking.

Single markers are sufficient if only 3DOF coordinates are needed, but single markers cannot be distinguished in principle. An ID is assigned to a tracked 3DOF marker as long as it can be followed, but after loosing the tracking (e.g. due to occlusions) one would not be able to re-identify the marker and thus a new ID will be assigned. For 6DOF tracking, however, a unique target is mandatory. Targets are rigid arrangements of markers (=rigid bodies) and thus can be identified by their relative marker position. Figure 3.1 on page 25 shows the concept of infrared optical tracking with a two-camera system and a standard target.

The base for this calculation is that the cameras' field of views are overlapping. In a two-step teaching process, the position and orientation of the cameras is made known to the system (the 'room calibration'), after which the system is taught to identify the unique arrangements of markers as targets (the 'body calibration'). Then the paths of the optical rays from the cameras to the markers are calculated to deliver the ray intersections in three-dimensional coordinates. These intersections are the positions of the markers.

Based upon this, one is able to calculate 6DOF data and, finally, knows position and orientation of the target and therefore the object or individual to be tracked.

The *SMARTTRACK2/3/M* make use of the same principle.

Note: In pure optical tracking systems tracking is only possible as long as

- objects or individuals to be tracked are equipped with single markers or targets

- the target is not occluded by any other objects in the cameras' line of sight, which could even be the object itself

- the target is positioned inside the tracking range of the cameras

- at least four markers of a target are visible to at least two cameras (this step enables tracking).
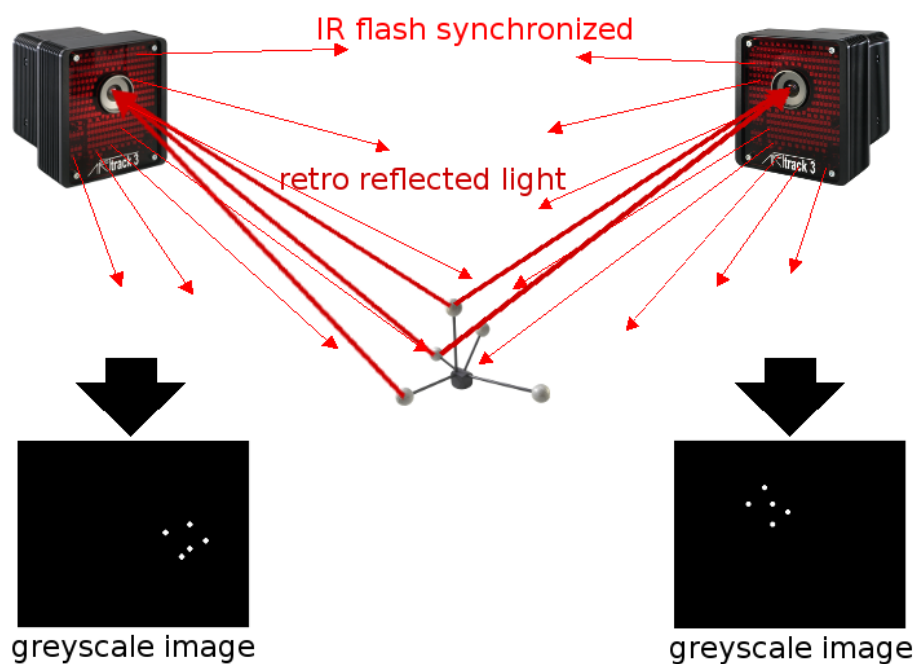
Figure 3.1: Concept of optical tracking (stereo vision)

The *SMARTTRACK2/3/M* have a limited field-of-view and range! It is designed to be used in small volumes. Please refer to the *ART Hardware Installation Guide* for more information on the tracking volume of the *SMARTTRACK2/3/M* .

Marker types   Passive markers are covered with retro reflective material - they act as light reflectors. Active light emitters (i.e. based on infrared LEDs) are called active markers. Please refer to the *ART Hardware Installation Guide* for more information on markers & targets.

Hybrid tracking   In addition to tracking by a pure optical system it is possible to utilize data from inertial measurement units (IMU). These devices usually consist of several components such as gyroscopes, accelerometers and magnetometers. The underlying principle is the combination of solid-state microelectromechanical systems with integrated

circuits and analog or digital outputs to achieve 6DOF rotational information.

Some of the most important advantages of hybrid tracking are:

- tracking data from IMUs offers low noise-levels while running at very high frequencies in combination with low latencies

- IMUs deliver tracking data (i.e. rotational information) even when the optical target is not inside the tracking volume or if the target cannot be tracked due to viewing limitations or occlusions

- drifting of IMUs (i.e. mostly from the 3-axis gyroscope) is compensated by fusing the inertial data with position measurements calculated from the optical tracking system

A hybrid target is basically an optical target additionally equipped with an IMU, which itself is connected to the controller or *SMARTTRACK2/3/M* .
There the tracking data from both worlds (i.e. hybrid) is combined, which also leads to the term 'sensor fusion'. By nature the IMU contains an independent coordinate system which needs to be aligned to the optical tracking system axes. This additional teaching process is called hand-eye calibration or 'hybrid body calibration' in *DTRACK3* .

Tracking with *DTRACK3*   All *ART* systems are based on a controller (stand-alone or integrated controller in *SMARTTRACK2/3/M*) which operates cameras, interaction devices (optional) and targets respectively. The software *DTRACK3* consists of frontend and backend software.
The backend software runs on the controller - all necessary calculations (3DOF, 6DOF data, etc.) are performed there. The data and control commands are interchanged via ethernet (TCP/IP connection) between the controller and the *DTRACK3* frontend software on the remote PC. *DTRACK3* frontend offers a GUI for easy handling that enables the user to control the tracking system at a distance. The benefit is that the system becomes more flexible, i.e. different users can control the tracking system at any one time (but not simultaneously!) from different working places.
Data output to the application or graphics workstation is also done via ethernet (UDP/IP connection).

Furthermore, *DTRACK3* provides the possibility to control the functions in the backend via ethernet (i.e. without the *DTRACK3* frontend software). This is also done by establishing a TCP/IP connection with the controller and exchanging short command strings (refer to the *DTRACK3 Programmer's Guide*).

4 Installing the *DTRACK3* software

The software *DTRACK3* is intended to access any *ART* controller via ethernet and runs on a remote PC (Windows or Linux). *DTRACK3* itself is delivered via USB pen-drive. The latest version can be downloaded from our Download Center at http://www.ar-tracking.com/downloads/

The *SMARTTRACK2/3/M* are integrated tracking systems. Thus for the sake of readability the *SMARTTRACK2/3/M* are referred to as 'Controller' in the following sections.

4.1 Installation under Microsoft Windows

Please refer to chapter A.1 on page 187 for more information on supported operating systems.
Run the installation executable "*DTRACK3_v3.X.Y_win_install.exe*" and the installation wizard of *DTRACK3* starts.
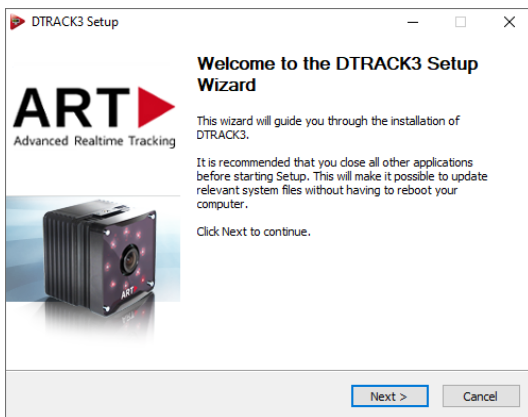
Click *Next* to continue and to start the installation process for *DTRACK3* software. Administrator privileges are not necessary.
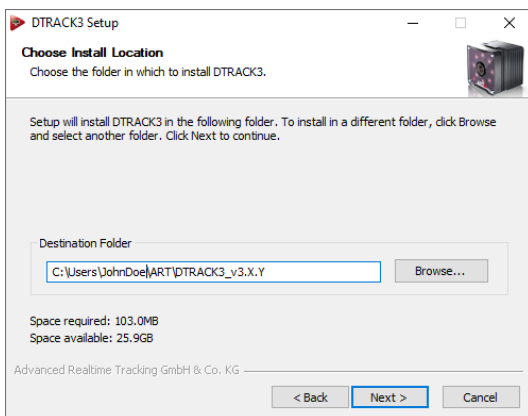
Now, please choose the destination folder in which you want to install *DTRACK3* .

Please read the license terms carefully and press *I Agree* if you agree indeed. A new window shows the installation progress.
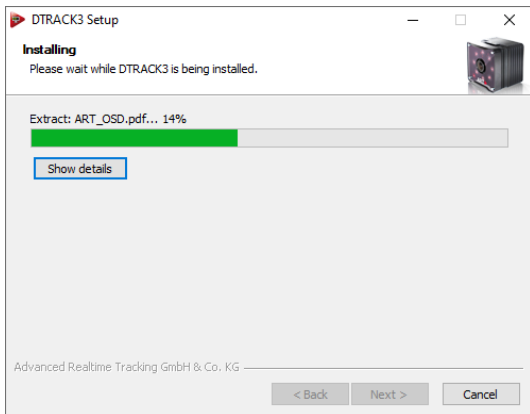
The installation of the **DTRACK3** software is shown using a progress bar.
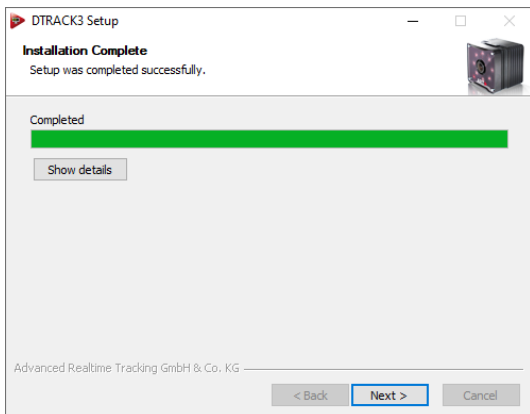
After **DTRACK3** has been installed on your computer click *Next*.
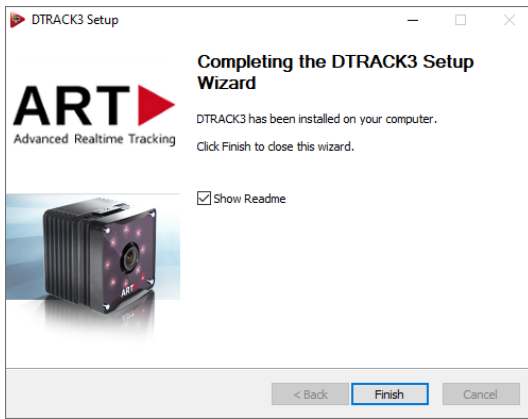
Press *Finish* to complete the **DTRACK3** setup wizard. Now, you can use **DTRACK3** .

> ℹ️ **Information regarding requirements to run *DTRACK3* (operating system, etc.) are opened automatically after the installation is complete. Please read the information carefully.**

> ℹ️ **Newer versions of *DTRACK3* may be installed parallel to the last / current version.**

> ☞ **Recommendation: Do not overwrite previous installations of *DTRACK3* so you can easily revert to the last version.**

4.2 Installation under Linux

The software (64-bit package available only) is packed in an archive. (*DTRACK3_v3.X.Y_linux64.tar.gz*) You do not need to have administrator rights to extract all files to a user-defined folder. In a shell, change to the user-defined folder and type in the command `tar xzf DTRACK3_v3.X.Y_linux64.tar.gz` in order to extract the files. For ease of use, you may create a shortcut on the desktop.

DTRACK3 can be started with the command `./DTRACK3`.

4.3 Software update

The latest **DTRACK3** software is always available from our Download Center at https://ar-tracking.com/en/downloadcenter
For the installation of the frontend update, please proceed as mentioned before in chapters 4.1 on page 27 and 4.2 on page 29. After installing **DTRACK3** on the host PC the controller may be updated after establishing a connection with the new frontend. Please refer to chapter 12.3 on page 162.

> ☞ **All patch releases and updates (e.g. v3.1.0 → v3.1.1 → v3.1.2 → v3.1.3 →...) may be installed without restrictions.**

☞ ***DTRACK3** may only be upgraded to the next version (e.g. v3.1.0 →
v3.2.0) having a valid 'DTRACK3 Upgrade' license. Please double-
check your license status first (see chapter 7.2 on page 59 for more
information).*

5 Connecting to the controller

5.1 Start DTRACK3 frontend software

When you start up *DTRACK3* on the remote PC you will see the following welcome splash screen (see figure 5.1 on page 31) . Using the mouse or shortkeys (2 = down, 4 = left, 6 = right, 8 = up) you can move around the splash screen window, e.g. to a secondary screen. The position of the window is then saved and will be used at the next start-up.
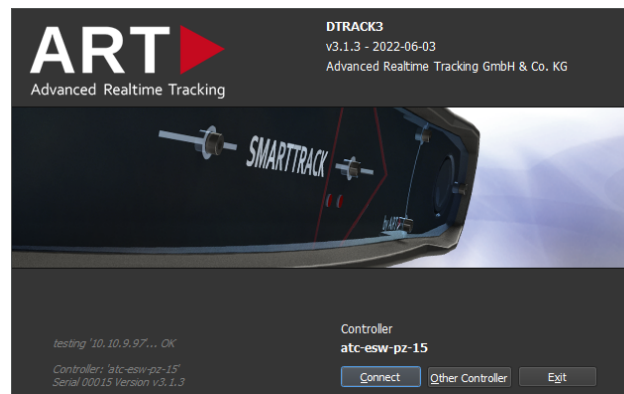
Figure 5.1: Welcome screen of *DTRACK3*

DTRACK3 will always try to connect to the last known or default controller. On the lower left hand corner of the splash screen the current status of connection is shown (refer to table 5.1 on page 32).

status message	Description
testing '*IP-address*'	*DTRACK3* is trying to access the last known controller using the IP address shown
testing '*IP-address*' ... OK	controller is powered-up and is accessible by LAN
Controller: '*hostname*' Serial *DTRACK3* version	*DTRACK3* is able to connect to the last known controller
no connection to controller '*hostname*', accessed by *IP address*	last known controller is being accessed by another client
testing '*IP-address*' ... unsuccessful	*DTRACK3* is unable to access the last known controller (e.g. not powered up / in standby, no DHCP service available)
resolving '*hostname*' ... unsuccessful	
no connection to controller 'hostname'	

Table 5.1: Splash Screen - Description of status messages

If *DTRACK3* is run for the first time the window *Controller Selection* will be opened automatically. Please refer to chapter 5.1.2 on page 33. If the controller is powered up and you would like to connect to the controller shown at this point, just press *Connect*. The main window will open (refer to 6.1 on page 42).

In case you would like to choose a different controller, press *Other Controller*. Please refer to chapter 5.1.2 on page 33.

If the last known controller has been powered down into standby mode, you may wake up your controller using Wake on LAN. Please refer to chapter 5.2 on page 35.

In any other case (i.e. testing '*IP-address*' ... unsuccessful, resolving '*hostname*' ... unsuccessful and Wake on LAN ... unsuccessful), please refer to chapter 13 on page 169.

If the access to the controller has been restricted, you will be prompted to enter the password before the main window will open. In case you have lost the password, please refer to chapter 5.3.1 on page 38 to reset the password feature.

5.1.1 *DTRACK3* **command line parameters**

The following parameters (refer to table 5.2 on page 33) may be added to the command line (i.e. *DTRACK3* icon → properties → shortcut → target) when starting the *DTRACK3* frontend.

Command line parameter	Description
-directstart	Connect with the last used controller (can be combined with -measure)
-help	Shows a window with these command line parameters and additional examples
-host <name or IP>	Connect with given controller (by hostname or IP number) (can be combined with -measure)
-measure	After connecting, start measurement
-wakeup	Wake up the last connected controller (can be combined with -directstart and -measure) (not available for **SMARTTRACK3** & **SMARTTRACK3/M**)
-wakeup <MAC>	Wake up controller with given MAC address (can be combined with -host and -measure) (not available for **SMARTTRACK3** & **SMARTTRACK3/M**)

Table 5.2: Command line parameters

i   **If the access to the controller has been restricted, you will be prompted to enter the password before the main window will open. In case you have lost the password, please refer to chapter 5.3.1 on page 38 to reset the password feature.**

5.1.2 Controller selection

Whenever you would like to select a different controller than the default one, press the button *Other Controller* on the welcome splash screen. A separate window *Controller Selection* will be opened to specify a default controller, see figure 5.2 on page 34.

This is done automatically on the first run of **DTRACK3** .

Specific Controller   In case of LANs without a DHCP server or via direct connection to your remote PC (please refer to the **ART Hardware Installation Guide**) tick the corresponding radio button (*Specific Controller*) and specify the IP-address or host-name of your controller directly by entering it in the field *hostname or IP address*. To connect press *Connect*.
In order to find out the IP address of your controller please refer to chapter 5.3.2 on page 39.

Scan LAN   In case of LANs with DHCP-service you may scan your network for available controllers. Simply tick the radio button *Scan* followed by pressing the button *Update list*. You can also specify the subnet by using the adjacent drop-down menu *subnet address*.

All available controllers in your network will be listed in the table below. Controllers set in grey are used by other remote PCs in your network ($\rightarrow$ accessed by IP address listed at welcome splash screen), whereas available controllers for connection are set in black.

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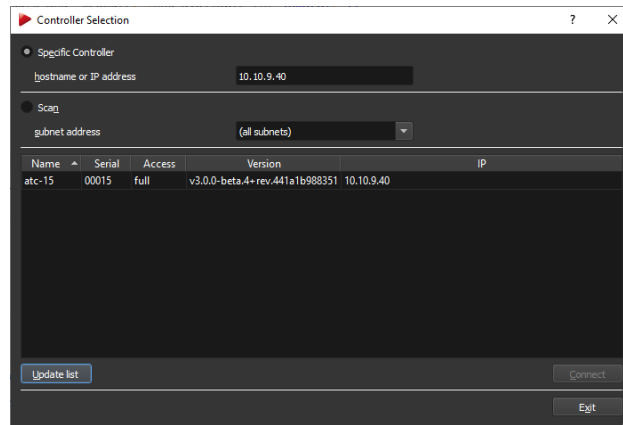
(a) specific controller
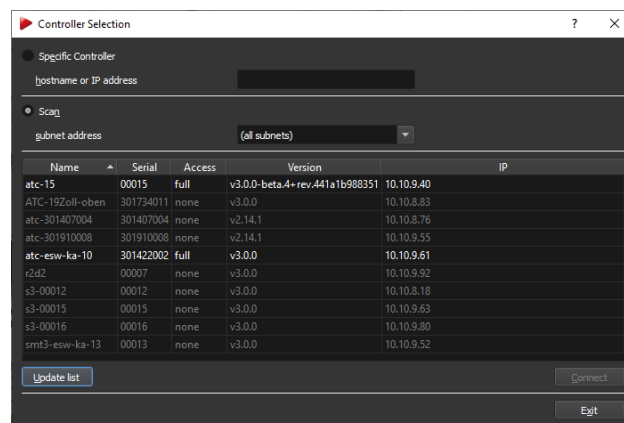
(b) scan the network

Figure 5.2: Controller Selection

You can easily identify your controller by comparing the serial number (e.g. *ART Controller* 301422021 or *SMARTTRACK3* s3-00432 listed in column *Serial*) with the corresponding one printed on the label of the device (rear of the *ART Controller* or *ART Controller/M* and *SMARTTRACK3* & *SMARTTRACK3/M* , please refer to *ART Hardware Installation Guide*). You can also sort the list by host-name *Name* or IP-addresses *IP*. Select the appropriate entry of your controller and press *Connect*.

If nothing is listed, please refer to chapter 13 on page 169.

> **If the Controller is not connected to a LAN or no DHCP server is running, it will use its fall-back IP address (IP 192.168.0.1, subnet mask 255.255.255.0)**

> **If the access to the controller has been restricted, you will be prompted to enter the password before the main window will open. In case you have lost the password, please refer to chapter 5.3.1 on page 38 to reset the password feature.**

☞ **Please make sure that the controller is connected to the local network and that it is powered up !**

☞ **In case of LANs protected by firewalls all necessary ports for** *DTRACK3* **network communication have to be unblocked. Please refer to section A.1 on page 187**.

5.1.3 Setting a static IP address

Please refer to chapter 8.7 on page 96 to set your controller to a static IP address using the *DTRACK3* frontend.

In case you need to specify a static IP address without using the frontend (e.g. installation on network without DHCP service available) please refer to chapter 5.3 on page 36 instead.

5.2 Wake On LAN

The controller is capable of Wake On LAN (WOL) when it has been powered down to standby mode by the user (*DTRACK3* → *Controller standby*).
This function is not available for *SMARTTRACK3* & *SMARTTRACK3/M* .
There are two options for waking up the controller remotely:

1. you may use *DTRACK3* or

2. use a separate tool (Windows: WOL program; Linux: console-based command).

Option 1 - WOL via *DTRACK3*   Start the *DTRACK3* frontend software. It will search for the controller and the '*Connect*' button will be replaced by '*Wake On LAN*' after a few seconds (see figure 5.3 on page 35).

Figure 5.3: Welcome screen of *DTRACK3* with Wake On LAN option

Press the '*Wake On LAN*' button and *DTRACK3* will try to wake up the controller - this may take up to two minutes as the controller has to boot up (see figure 5.4 on page 35).
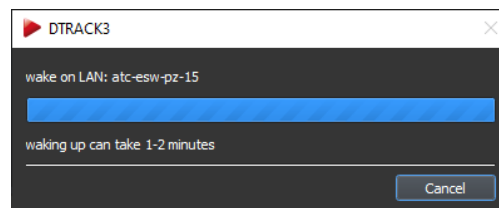
Figure 5.4: Wake On LAN progress bar

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If Wake On LAN is successful **DTRACK3** will automatically establish the connection with this controller and start the frontend software.

☞ **Please make sure that the controller is still connected to the local network and that is in standby-mode! DTRACK3 cannot wake up the controller if no physical connection between remote PC and controller is established or if the controller is powered off!**

Option 2 - WOL via separate tool You will need the '*hostname*' of the controller as well as its MAC address. To get this information, either refer to 5.3.2 on page 39 or enter **DTRACK3** and go to *Hardware → Network*. Copy the '*hostname*' and MAC address ('*ethernet-MAC LAN*').

If you are using Windows you will need a separate WOL program to use this feature. Please refer to the manual of the WOL program you are using to find out how to configure the WOL function.

When using Linux you only need to switch to the console and type in the following command and your controller restarts:

for Linux openSUSE:

```
$ wol <MAC address of your Controller>
e.g.: $ wol 00:1D:92:3A:58:5F
```

for Ubuntu:

```
$ wakeonlan <MAC address of your Controller>
e.g.: $ wakeonlan 00:1D:92:3A:58:5F
```

5.3 Configuring your controller's network address without network access

You can also configure some settings of the controller without the **DTRACK3** frontend software. You will need a standard USB pen drive (FAT32 formatted).

This way you may

- configure the controller to be a DHCP client,

- set a static IP address ,

- reset the password feature for access to the controller and

- carry out a factory reset.

☞ **Carrying out a factory reset will result in the loss of all your settings including your license codes (will be written to USB pen drive during factory reset) ! Backup your configurations or export your systems configuration log file beforehand (please refer to 7.3.2 and 12.4.1 on page 64).**

Proceed as follows:

- Plug-in the USB pen drive in any available USB port of the controller. Controller can be powered up or off

- If necessary start up the controller

- Wait some time for the controller to write two files onto the USB pen drive (approx. 20-30 seconds, signalled by two (2) consecutive beeps)

- Unplug the USB pen drive

- Now plug-in the USB pen drive in a computer and view or edit the setup file (see 5.3 on page 37) with any editor

- After changing the setup file please plug-in the USB pen drive in the controller again afterwards

- Wait some time for the controller to read the setup file (approx. 20-30 seconds, signalled by three (3) consecutive beeps)

- Unplug the USB pen drive

- Reboot the controller for the changes to take effect

Now, your controller is configured according to your requirements.

☞ **Please note that these settings are not part of your personal configuration. Changes will affect all users of your controller! Your controller may become unreachable with wrong IP settings!**

☞ **You can find your current license codes in the file 'ART_Controller_XXXX_licenses.txt' (will be written to USB pen drive during factory reset)**

The setup file Following, a description of the file (e.g. ART_Controller_00117_setup.txt) format:

```
# ART Controller Setup:


# ethernet settings:
#  - uncomment just one of the lines starting with 'SETNET'

# ethernet settings: DHCP
#  - uncomment the following line to activate DHCP
#SETNET="dhcp"

# ethernet settings: fix IP address and subnet mask
#  - uncomment the following line to set a fix IP address and subnet mask
#SETNET="ip 192.168.0.1 255.255.255.0"

# ethernet and routing settings: fix IP address, subnet mask and corresponding gateway
```

```
#  - only use if destination for tracking data or DTRACK3 frontend is in a different network than ATC
#  - note: gateway must be an IP number in same network/netmask as ATC!
#  - uncomment the following line to set a fix IP address, subnet mask and gateway IP address
#SETNET="ip 192.168.0.1 255.255.255.0 192.168.0.253"


# name settings: host name
#  - uncomment the following line to set the host name
#SETHOSTNAME="atc"


# name settings: domain name
#  - uncomment the following line to set the domain name
#SETDOMAINNAME="art.site"


# name settings: domain name server
#  - uncomment one of the following lines to set (or clear) a domain name server
#SETNAMESERVER="192.168.0.254"  # set DNS (IP or hostname)
#SETNAMESERVER="-"              # clear DNS


# reset of frontend password:
#  - uncomment the following line to reset a frontend password
#RESETFRONTENDPASSWORD="yes"


# factory reset of all other settings:
#  - CAUTION: use with care, all your settings will be lost!
#  - uncomment the following line to reset all other Controller settings
#  - additionally your ethernet settings will be set to DHCP if no fix IP is set above
#  - CAUTION: also all license settings will be reset!
#    - export 'system informations' (DTRACK3->Help->Service) to save your license codes;
#      or see 'ART_Controller_X_licenses.txt' (will be written to USB stick during factory reset)
#    - re-enter all license codes after factory reset under DTRACK3->Licenses
#RESETSETTINGS="yes"
```

If you would like to run a command you have to remove the '#' sign and save the changes. Example (set a static IP address, e.g.: 123.123.0.1):

before:

```
#SETNET="ip 192.168.0.1 255.255.255.0"
```

after:

```
SETNET="ip 123.123.0.1 255.255.255.0"
```

5.3.1 Password reset and delete without *DTRACK3* frontend

In case you have lost the password for access to your controller via the *DTRACK3* frontend you can delete the password and reset the feature. You will need a standard USB pen drive (FAT32 formatted).
Proceed as in the previous section (please refer to chapter 5.3 on page 36) described and change the setup file (see 5.3 on page 37).
To reset the password feature, remove the '#' sign in the setup file and save the changes:

before:

```
#RESETFRONTENDPASSWORD= "yes"
```

after:

```
RESETFRONTENDPASSWORD= "yes"
```

Have the controller read the changed file and reboot afterwards.

5.3.2 Information retrieval without *DTRACK3* frontend

It is possible to retrieve some settings of the controller without the *DTRACK3* frontend software. You will need a standard USB pen drive (FAT32 formatted).

Proceed as follows:

- Plug-in the USB pen drive in any available USB port of the controller. Controller can be powered up or off

- If necessary start up the controller

- Wait some time for the controller to write two files onto the USB pen drive (approx. 20-30 seconds, signalled by two (2) consecutive beeps)

- Unplug the USB pen drive

- Now plug the USB pen drive in a computer and view the information file (see below) with any editor

The information file   This file contains the current settings of the controller, e.g. the host-name, serial number and current IP address. Following, a description of the file format (e.g. ART_Controller_0007_info.txt or ART_Controller_301422021_info.txt):

```
ART Controller Information:

Name               : smarttrack-0007 (or atc-301422021)
Serial Number      : 0007 or 301422021

Ethernet (LAN)     : dhcp
Ethernet IP (LAN) : 10.10.99.196 255.255.0.0
Ethernet MAC (LAN): 00:03:1d:0b:0f:36

Gateway (LAN)      : 10.10.0.3

Domain Name        : xyz.site
Domain Name Server: 10.10.0.1
```

Chapter 5

6 Menu Overview

Please refer to the corresponding sections for each of the menus.

DTRACK3	*Shortcut*	page 57
Password		Set a password for access control via the *DTRACK3* frontend
Licenses		License overview → Adding licenses (e.g. higher amount of cameras, Measurement Tool or Cascaded Systems)
Configurations		Select, create new and save different configurations, lock the current configuration and backup & restore all settings
Start/Stop	M	Start/Stop measurement
Controller standby		Force the controller to go into standby mode (shutdown available for *SMARTTRACK3* & *SMARTTRACK3/M*)
Controller reboot		Reboot the controller (not available for *SMART-TRACK2*)
Quit	Q	Quit *DTRACK3*

Hardware	*Shortcut*	page 68
Search hardware	F2	Search for newly added hardware (not available for *SMARTTRACK2*)
Cascaded System		Configure a Cascaded System with available controllers (not available for *SMARTTRACK2*)
Cameras	F7	Camera settings (e.g. flash intensities, sync group assignment)
Synccard	Shift + F7	Synccard settings (e.g. tracking frequency, external synchronisation)
Radio Transceiver		Settings for *ART RadioTransceiver2/3* and devices within your setup
Inertial Sensor		Settings for inertial sensors and hybrid tracking
Network		Configure the IP settings of your controller
Time		Configure the date/time or NTP / PTP settings of your controller

Tracking	*Shortcut*	page 100
Room calibration	F5	Room calibration
Room adjustment	Shift + F5	Adjust / transform the room coordinate system
Single markers		Activate 3DOF calculation, adjust 5DOF central axis
Body administration	F8	General settings for all targets and interaction devices
Body calibration	F6	Body calibration
Body adjustment	Shift + F6	Adjust / transform the body coordinate system

Flystick		Configure your ***Flystick2/2+/3***
Fingertracking	F4	Configure your ***Fingertracking*** (incl. tactile feedback) device and start calibration process (i.e. hand geometry) (not available for ***SMARTTRACK2/3/M***)
Measurement Tool		Configure your Measurement Tool
Measurement Tool tip calibration		Start tip calibration process for the Measurement Tool
Output	F9	Set output channels and configure the data to be transmitted

View	*Shortcut*	page 157
Set to default		Reset the shown displays to default
Monitor 2DOF		Graphical display of markers recognized by the cameras
Data	F10	Display measurement results (6DOF and / or 3DOF)
Flystick		Display ***Flystick2/2+/3*** measurement data
Fingertracking		Display Fingertracking measurement data (not available for ***SMARTTRACK2/3/M***)
Measurement Tool		Display Measurement Tool data
Events		Display event messages generated by ***DTRACK3***

Tools	*Shortcut*	page 159
Measure points		Provides simple measurement acquisition for use with the Measurement Tool

Help	*Shortcut*	page 161
What's this?	Shift + F1	Help
What's new?		Overview of the new features
Controller Update		Start the assistant for the controller update
Service		Service-ID, link to ***ART*** website and export system configuration log
DTRACK3	F1	Software version of frontend & backend
About Qt		Qt toolkit version

Table 6.1: ***DTRACK3*** menu structure overview

Chapter 6

6.1 GUI overview

The graphical user interface of *DTRACK3* can be divided into the following parts (see figure 6.1 on page 42):

- the *menu bar* with access to all settings (please refer to chapter 6 on page 40)

- the *toolbar* with graphical elements regarding the status of the tracking system (please refer to chapter 6.2 on page 43)

- the *docking displays* with graphical information, measurement results and event information (see chapter 6.3 on page 45).
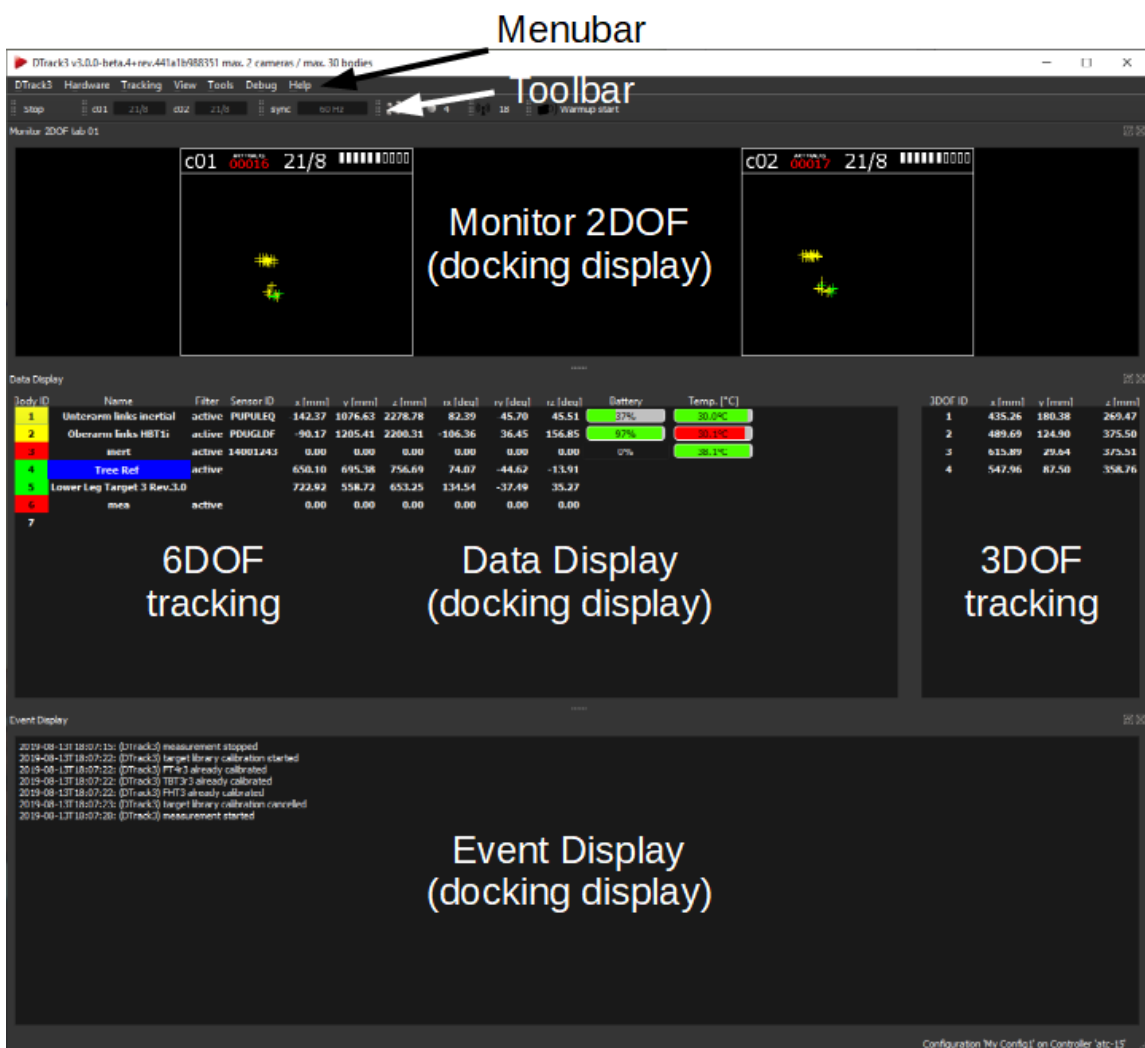
Figure 6.1: Graphical user interface of *DTRACK3* - default layout

Start | c01 | 10/6 | c02 | 10/6 | c03 | 10/6 | c04 | 11/6 | sync | 150 Hz | 1 | 4 | 18 | Warmup stop | Warmup is running 46%...
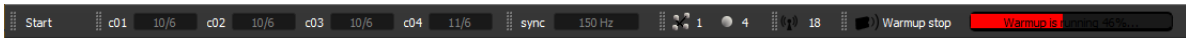
Figure 6.2: *DTRACK3* Toolbar

6.2 Toolbar

By default, the toolbar (see figure 6.2 on page 43) consists of the following elements (from left to right):

Toolbar element	Description
Start/Stop button	Starts and stops the measurement
Camera Status	Shows the number of markers seen (2DOF) / used for tracking targets (6DOF) by each camera
Sync Status	Displays the current tracking frequency
Tracking Status	Shows the number of tracked targets (6DOF) / single markers (3DOF)
Radio Transceiver Status	Displays the currently selected channel of the **ART Radio-Transceiver2/3** (greyed out, if not installed)
Inertial Sensor Status	Displays the currently selected channel of the inertial dongles (wireless only) and the status of the sensor's warm up process (hidden, if not installed)

Table 6.2: Toolbar elements of *DTRACK3*

To change or activate elements right-click anywhere on the toolbar. Drag & drop the elements for re-arrangement by left-clicking.

Start / **Stop button**   Press this button to start the measurement. To stop tracking press it once again.

Camera Status   The *Camera Status* field shows two values for each camera (c01, c02, ...). The first one summarizes the amount of markers that are seen by each camera, wheras the second one only shows the subset which are used for 6DOF tracking.

In the case depicted (see figure 6.3 on page 44), one target equipped with 6 markers is tracked inside the measurement volume by all 4 cameras c01 to c04. As a result the second value equals 6 for all cameras.
At the same time cameras c01 to c04 track 4 single 3DOF markers, while camera c04 sees one more additional marker (presumably a reflection) leading to a total of 10 and 11 markers respectively. This additional marker cannot be tracked because it is not seen by at least one more camera.
One should note that this is a very simple example as multiple targets may be tracked by only a subset of cameras (min. 2) while additional 3DOF markers and reflections do not have to be seen by all cameras at the same time. Compare the *Tracking Status* for more information about tracked targets and single 3DOF markers (see figure 6.5 on page 44).

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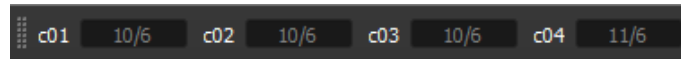
Figure 6.3: *DTRACK3* Camera Status (toolbar element)

Sync Status   The *Sync status* field shows the current tracking frequency in Hz set in *Hardware → Synccard* (Note: *Hardware → Inertial Sensor → Tracking Frequency* when using Hybrid Bodies). The background is changing its colour in case the effective frequency is decreasing due to processing overload (see figure 6.4 on page 44):

(a) black / grey: max. 5 frames per minute lost

(b) yellow: 5 - 10 frames per minute lost

(c) orange: 10 - 15 frames per minute lost

(d) red: > 15 frames per minute lost

Figure 6.4: *DTRACK3* 3 Sync Status (toolbar element) - Visualization of the decrease in effective synchronization frequency

- black / grey: max. 5 frames per minute lost (i.e. 3600 frames per minute are transmitted, not shown)

- yellow: 5 - 10 frames per minute lost

- orange: 10 - 15 frames per minute lost

- red: > 15 frames per minute lost

Tracking Status   In *Tracking status* the amount of tracked 6DOF targets and single 3DOF markers is shown (see figure 6.5 on page 44). The value on the left, next to the icon depicting a target, summarizes all activated and tracked targets (*Tracking → Body Administration* or *mtool*, *Flystick* etc.) inside the measurement volume, in this case only 1. All single 3DOF markers which are not used for 6DOF tracking are shown on the right next to the icon of a marker, in this case 4 markers.
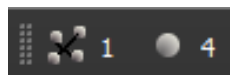
Figure 6.5: *DTRACK3* Tracking status (toolbar element)

Radio Transceiver Status   The *Radio Transceiver Status* shows the currently selected channel (see figure 6.6 on page 45) of the **ART** radio set in *Hardware → Radio Transceiver*, in this case '*Channel 18*'. The toolbar element is greyed out if no **RadioTransceiver2/3** are installed.

Figure 6.6: *DTRACK3* Radio transceiver status (toolbar element)

Inertial Sensor Status   The *Inertial Sensor Status* displays the currently selected chan-
nel (see figure 6.7 on page 45) of the inertial dongles (wireless only) set in *Hardware →
Inertial Sensor*. It also depicts the status of the sensor's warm-up process in the adja-
cent progress bar, in this case approx 50%. The toolbar element is just visible if inertial
sensors are installed.

Figure 6.7: *DTRACK3* Inertial Sensor status (toolbar element)

6.3 Docking Displays

By default the first three of the following docking displays are activated (see table 6.3 on
page 45).

Docking Display	Description
Monitor 2DOF	Graphical display of all markers seen / tracked by the cam-eras. Colour and shape represent the circularity and size of the markers respectively.
Data Display	Displays measurement results (6DOF and / or 3DOF)
Event Display	Displays *DTRACK3* events (e.g. "no valid room calibration")
Flystick	Shows the measurement results (6DOF) of the ***Fly-stick2/2+/3*** and the operation of buttons and joystick
Fingertracking	Shows the measurement results of the hands (not available for ***SMARTTRACK2/3/M***)
Measurement Tool	Shows the measurement results of the Measurement Tool and its reference body, if assigned

Table 6.3: Available docking displays in *DTRACK3*

To change or activate the docking displays right-click anywhere on the *Toolbar* or use
the menu *View* (refer to chapter 10 on page 157). Drag & drop the display windows for
re-arrangement by left-clicking.

6.3.1 Monitor 2DOF display

The *Monitor 2DOF display* is a 2-dimensional graphical display just like a monitor for each
camera equivalent to its field of view (see figure 6.8 on page 46). Essentially the *Moni-
tor 2DOF display* shows a black window with a schematic display of positions, sizes and

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Figure 6.8: **DTRACK3** *Monitor 2DOF display* (docking display)

shapes of all recognized markers / flashes or other IR sources that can be seen inside the field of view of the cameras. It is particularly useful for the adjustment (especially orientation) of the cameras or **SMARTTRACK2/3/M** (please refer to the **ART Hardware Installation Guide**).

Additional *Monitor 2DOF display* **functions**   In the *Monitor 2DOF display* additional functions are assigned to mouse interactions.

- left mouse button
  Drag & drop the camera monitors to move and arrange the position within the *Monitor 2DOF view*.

- middle mouse button
  Click to hide all camera monitors but the one you selected. Click again and all camera monitors will be displayed.

- right mouse button
  Click on a camera monitor to open a context menu for the corresponding camera; see figure 6.10 on page 48 and table 6.4 on page 49 for more details.

Cameras per tab (not available for *SMARTTRACK2* **)**   In case several **ARTTRACK** cameras or **SMARTTRACK3** & **SMARTTRACK3/M** are being used in one system, it may prove helpful to adjust the number of cameras simultaneously shown in the *Monitor 2DOF display* in order to achieve a clear arrangement (see figure 6.8 on page 46).

Move the slider '*cameras per tab*' (in the upper right corner) to the left to decrease the amount of cameras. Tabs containing the remaining cameras will be added below the *Monitor 2DOF display*.

Monitor 2DOF most active tab   The special tab '*Monitor 2DOF most active*' contains only those cameras in which the markers / targets are seen most of the time.

Example: Consider a four camera system with cameras c01 through c04 where you have set the number of '*cameras per tab*' to two. Now if you move a target in front of cameras c02 and c03 most of the time, only these two cameras will be shown in the '*most active cameras*' tab.

Adding/removing cameras (not available for *SMARTTRACK2/3/M*) It is possible to add or remove cameras without restarting the *ART Controller* or *ART Controller/M* . Please refer to chapter 8.1 on page 68 how to dynamically analyse your system for changes in configuration.

> **ℹ️** **When cameras are added to an already calibrated tracking system these cameras will not contribute for calculation and measurement until you perform a room (re-)calibration (see chapter 9.1.5 on page 104). Therefore as as reminder the *Monitor 2DOF display* of the corresponding cameras will show the message (re-)calibration required! in red color.**

> **ℹ️** **The *ART Controller* or *ART Controller/M* will detect all cameras that have been removed from an already calibrated tracking system (e.g. due to a disconnected cable) and mark those as missing until a room (re-)calibration has been performed. The *Monitor 2DOF display* of the corresponding cameras will be disabled (crossed out) and in case of larger systems their corresponding displays will be moved to a new camera tab.**

> **☞** *DTRACK3* **is able to operate when cameras have been added or removed; for best performance it is highly recommended to perform a recalibration**

6.3.1.1 Monitor 2DOF display elements

Each marker is either displayed as a circle or as a cross. This indicates the projected size of the marker on the camera sensor and depends strongly on the distance to the camera, see figure 6.9 on page 48.
A simple color code represents the quality (i.e. circularity) of the markers:

green markers	...	very good tracking quality
yellow markers	...	good tracking quality
red markers	...	bad circularity, unreasonable size of marker and / or low intensities; may result in poor tracking quality
circles	...	big marker (e.g. close to camera)
cross	...	small marker

Recommendation Increase the flash intensity until all markers become yellow or green (*Hardware → Cameras → '*flash intensity*'*. Additionally pay attention to the intensity bar on the top right corner of each camera monitor, see figure 6.9 on page 48. This indicates

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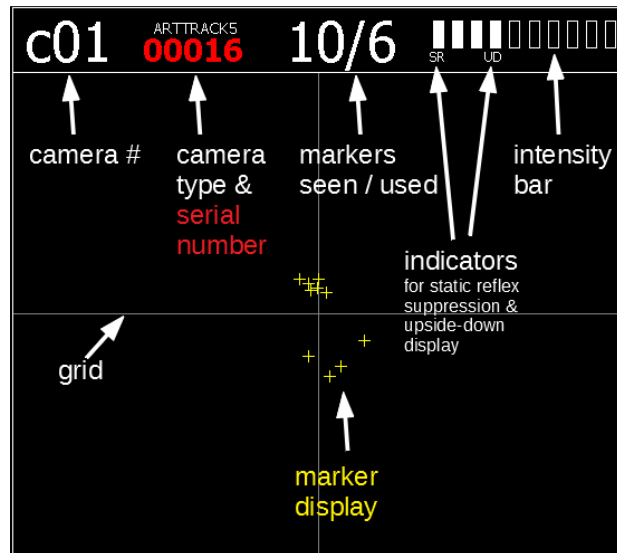
Figure 6.9: **DTRACK3** *Monitor 2DOF display* elements

the intensity of the brightest pixel in the field of view (refer to figure 6.1 on page 42), in this case 4 of 10.

> **As a rule of thumb: For measurement applications with high accuracy requirements the markers should be displayed in green with intensities of min. 4 bars; for VR applications yellow markers with intensities down to 2 bars are still sufficient.**

> **Note: ARTTRACK1 cameras have the bar display integrated into the camera on their front side.**

6.3.1.2 *Monitor 2DOF display* **context menu**

Figure 6.10: *Monitor 2DOF display* context menu (e.g. camera c02)

By right-clicking on the *Monitor 2DOF display* of the corresponding camera monitor the following context menu opens:

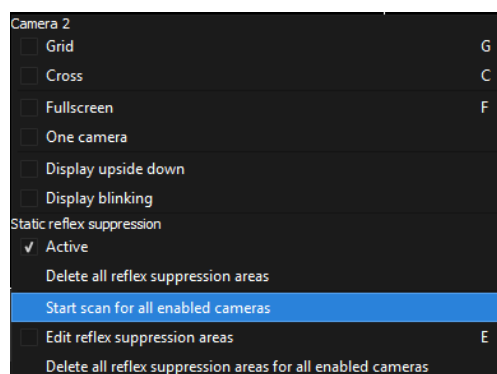| Function	Shortcut	
Grid	G	Shows a grid in the camera monitor.
Cross	C	Shows a cross in the camera monitor.
Fullscreen	F	Resizes *Monitor 2DOF display* to full screen and back.
One Camera		Only show the view of the selected camera.
Display upside down		Rotate the orientation of the camera monitor by 180°. '*UD*' is displayed in the camera monitor.
Display blinking		Activates / deactivates blinking of 2-digit LED matrix and status LEDs on the camera for easy identification (**ARTTRACK5** only).
Static Reflex Suppression		
Active		Enable static reflex suppression functionality for this camera. '*SR*' is displayed in the camera monitor.
Delete all reflex supression areas		Deletes the defined reflection areas for the selected camera only.
Start scan for all enabled cameras		Initiates a scan for static reflections. Enabled only if *Active* is ticked.
Edit reflex suppression areas	E	Enter the edit mode in order to manually select areas to suppress unwanted reflections.
Delete all reflex suppression areas for all enabled cameras		Deletes the defined reflection areas for all enabled cameras at once.

Table 6.4: Context menu of the *Monitor 2DOF view*

Display upside down   The checkbox *display upside down* rotates the orientation of the corresponding camera monitor in the *Monitor 2DOF display* by 180°.

> **ℹ** **Display upside down proves to be useful when mounting the cameras upside down. Note: This setting is for display purposes only. It does not influence the tracking system nor the room calibration.**

6.3.2 Static reflex suppression

Automatic and manual reflection suppression   First the feature has to be enabled either globally for all cameras or individually for each camera. Open *Hardware → Cameras* and mark the checkboxes for each camera you would like to activate the reflection suppression feature or select *global static reflex suppression* to activate the feature for all cameras at once. Please refer to chapter 8.3 on page 71 for details.
Alternatively right-click the *Monitor 2DOF display* on the respective camera monitor and enable the feature directly for each camera by selecting the option '*Active*', see figure 6.10 on page 48.

Hereafter there are two ways to carry out a reflection suppression:

1. run an automatic scan

Open the context menu of the *Monitor 2DOF display* and start the scan by left-clicking *Start Scan for all enabled cameras* (see figure 6.10 on page 48). A scan function will detect and suppress reflections automatically. Cancel the scan at any point by clicking *Cancel*, otherwise wait for completion and accept the detected areas by clicking *OK*. The areas will be stored in the controller and can be edited manually afterwards.

2. set the suppression areas manually
   You can define the areas manually where reflections need to be suppressed. Open the context menu of the *Monitor 2DOF display* and enter the edit mode by selecting '*Edit reflex suppression areas*', see below. You may also use the shortcut ('*E*') listed in table 6.4 on page 49).

☞ **Be sure to remove all targets from the measurement volume before starting the scan.**

☞ **Be aware that reflection suppression leads to decreased field of view / effective measurement volume by blocking the area in which the reflection originated.**
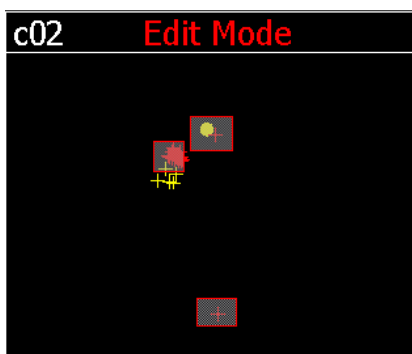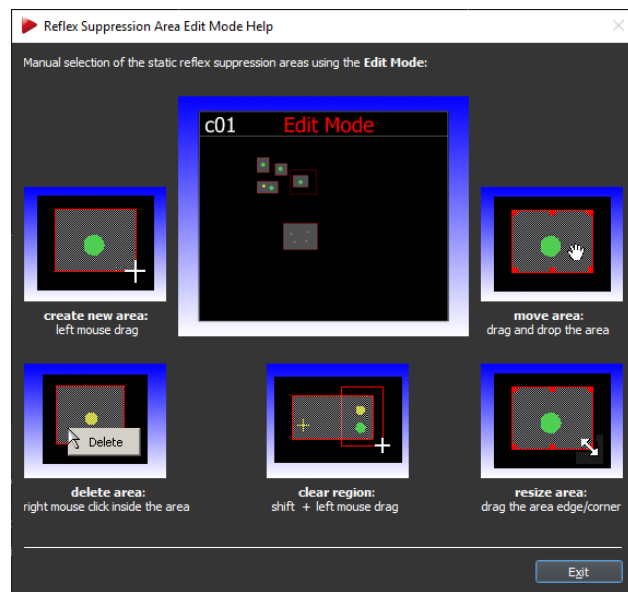
(a) Reflex suppression edit mode   (b) Reflex suppression edit mode help

Figure 6.11: Reflex suppression Edit mode

Edit reflection suppression areas   Within the edit mode (see figure 6.11(a) on page 50) you may:

- create new areas by left mouse button click, hold & drag a rectangle shaped box, then release mouse button,

- delete areas by right mouse button click inside an area followed by pressing the button *delete*,

- clear regions by shift + left mouse button click, hold & drag a rectangle shaped box to create a clearing area, then release the mouse button

- move areas by left mouse button click, drag & drop an existing area.

Leave the edit mode by opening the context menu (right-click the *Monitor 2DOF display*) of the respective camera monitor, then de-select '*Edit reflex suppression areas*'. Reflection suppression areas are enabled as soon as you and accept the changes. The areas will be stored in the controller and can be edited each time you enter this mode.

Configuring reflection suppression If you want to disable the reflection suppression feature for one camera only, open the context menu of the respective camera monitor and deactivate the option '*Active*'.

To permanently delete the reflection suppression areas for one camera, right-click on the respective camera monitor and select '*Delete all reflex suppression areas*' and accept the changes.

You can also delete the reflection suppression areas for all cameras at once by selecting '*Delete all reflex suppression areas for all enabled cameras*'.
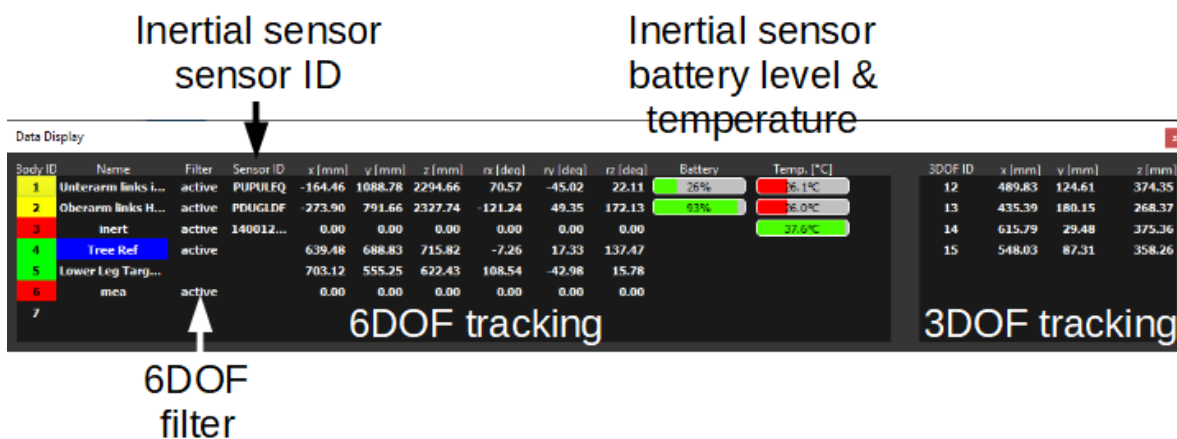
6.3.3 Data Display

Figure 6.12: *Data Display* (docking display)

The *Data Display* is split into two parts, 6DOF and 3DOF measurement results respectively.

6.3.3.1 6DOF measurement results

On the left hand side (see figure 6.12 on page 51), the *Data Display* shows the following measurement results :

1. the *body ID*

2. the assigned *name*

3. the status of an assigned *reference body*

4. filtering status of 6DOF measurement results ('*active*' or ' ')

5. position (*X, Y, Z*) and orientation (*rx, ry, rz*) relative to the room coordinate system

6. additional information for inertial sensors (*sensor ID, battery level, temperature*

Body ID   The bodies are sorted by increasing *body ID*.
A simple colour code indicates the tracking status of the body:

green	...	body is being tracked; tracking data is displayed
yellow	...	body is being tracked only by the means of the inertial sensors (rotational data is displayed only!)
red	...	body is not being tracked; instead of tracking data zeros are displayed
white / black	...	body is not calibrated; columns are left blank

Reference body   The '*name*' of a standard 6DOF body assigned as reference will be highlighted.

reference	...	body is assigned as reference; 'reference' is displayed when no specific name has been assigned

☞   **When a reference body has been assigned, all 6DOF bodies and 3DOF single markers can only be tracked when the reference body is being tracked as well.**

Filtering of 6DOF measurement results   Next to the *body ID* the filtering status is shown (i.e. '*active*' or ' '). Right-click the field *active* in the column *filter* of the corresponding target and press the button *filter* to open the *filter settings* menu. For more information about filtering options please refer to chapter 9.4.1 on page 117.

Position and orientation   The position (*X, Y, Z*) in mm and the orientation (*rx, ry, rz*) in deg °is given relative to the room coordinate system unless a reference body has been assigned. The rotation angles (rx, ry and rz) are rotations around the X, Y and Z axis respectively. The mathematical definition can be found in the *DTRACK3 Programmer's Guide* .

Additional information for inertial sensors   In the *Data Display* additional information is provided for inertial sensors:

- sensor ID

- battery level

- temperature in °C

> **ℹ** **The temperature values between single inertial sensors may vary. The operating temperature is reached as soon as there are no more temperature changes inside the sensors indicated by a green status bar. It is not dependent on the absolute temperature value.**

6.3.3.2 3DOF measurement results

On the right hand side, the *Data Display* shows the 3DOF measurement results. All tracked single 3DOF markers that have not been assigned to a calibrated 6DOF body (i.e. markers of targets not yet calibrated) are shown here.

> **ℹ** **Positional information of single 3DOF markers are shown in the data display only when activated in *Tracking* → *Single Markers* → *calculation of 3DOF markers*.**

6.3.4 Flystick display

Figure 6.13: *Flystick Display* (docking display)

Flystick measurement results   The *Flystick display* shows the following measurement results:

1. the *Flystick ID*

2. the status of buttons *b1...bx*, if applicable

3. the status of the trigger *jt* (**Flystick2+** only)

4. the status of the joystick *jx, jy*

5. filtering status of 6DOF measurement results ('*active*' or ' ')

6. position (*X, Y, Z*) and orientation (*rx, ry, rz*) of the **Flystick2/2+/3**

A simple colour code indicates the status of the *Flystick*:

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green	...	*Flystick2/2+/3* is being tracked; tracking data is displayed
red	...	*Flystick2/2+/3* is not being tracked (e.g. Flystick has not been assigned to ART radio transceiver); instead of tracking data dashes are displayed
blue	...	button is being pressed
white / black	...	*Flystick2/2+/3* is not calibrated; columns are left blank

6.3.5 Fingertracking display
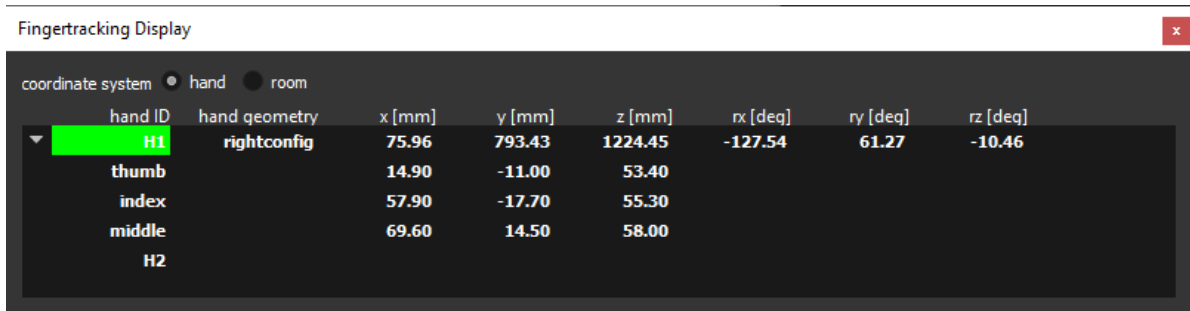
Figure 6.14: *Fingertracking Display* (docking display)

Fingertracking measurement results The *Fingertracking display* (not available for *SMARTTRACK2/3/M*) shows the following measurement results of all hands including each finger (i.e. thumb, index, middle, ...):

1. the *hand ID*

2. the assigned *name* of the hand geometry name (e.g. left or right)

3. position (*X, Y, Z*) and orientation (*rx, ry, rz*) of the hand and fingers relative to the selected coordinate system

The coordinate system of the measurement data may be switched by using the radio buttons *hand* and *room*. You can distinguish between the hands either by the *hand ID* or by the assigned *name* of the hand geometry.
A simple colour code indicates the status of the *Fingertracking* :

green	...	*Fingertracking* device is being tracked; tracking data is displayed
yellow	...	Hand-target is being tracked (i.e. fingers are calibrated, but outside cameras field of view); last known tracking data is displayed
red	...	*Fingertracking* device is not being tracked (e.g. only back of the hand is calibrated); last known tracking data is displayed
white / black	...	*Fingertracking* device is not calibrated; columns are left blank

Figure 6.15: *Measurement Tool Display* (docking display)

6.3.6 Measurement Tool display

The *Measurement Tool display* is split into two parts (see figure 6.15 on page 55):

Measurement Tool measurement results

1. the *Measurement Tool ID*

2. the assigned *reference ID* of the corresponding reference body

3. status of buttons *b1...b3*, if applicable

4. position (*X, Y, Z*) and orientation (*rx, ry, rz*) of the Measurement Tool 's tip

Measurement Tool reference measurement results

1. the *Measurement Tool reference body ID*

2. position (*X, Y, Z*) and orientation (*rx, ry, rz*) of the reference body

A simple colour code indicates the status of the Measurement Tool and the reference body, respectively:

green	...	tool is being tracked; tracking data is displayed
red	...	tool is not being tracked (e.g. tip calibration is missing); instead of tracking data dashes are displayed
blue	...	measurement is being performed and / or button is being pressed
white / black	...	tool is not calibrated; columns are left blank

☞ **A Measurement Tool with an assigned reference body can only be tracked when the reference body is tracked as well.**

6.3.7 Event display

The *Event display* presents the status of the tracking system (see figure 6.16 on page 56). It offers feedback of the operational state regarding errors or warnings. Furthermore, it informs the user about successful room or body calibrations. Each entry is associated with a timestamp and date.
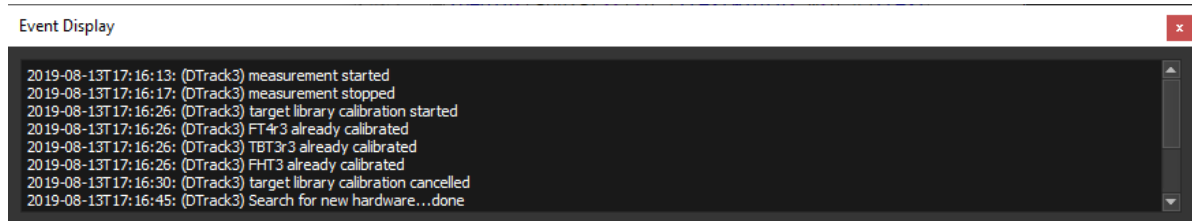
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Figure 6.16: *Event Display* (docking display)

7 Menu DTRACK3 - Basic Configuration

DTRACK3	Shortcut
Password	
Licenses	
Configurations	
Start/Stop	M
Controller standby	
Controller reboot	(not available for **SMARTTRACK2**)
Quit	Q

Table 7.1: Menu *DTRACK3*

7.1 Password

In order to restrict the access to the currently connected controller you may enable password protection of the frontend.

Enable password protection Open the corresponding dialog via **DTRACK3** → *Password* and tick the checkbox *Enable password protection*. Please refer to figure 7.1 on page 58. Next enter your selected password in the entry fields '*New password*' and '*Repeat password*' respectively. If both entrys are matching the fields will turn green and a corresponding message will appear. Press *OK* and a warning message will appear next. If you are sure press *OK* to accept the password for protection. Otherwise press *Cancel* to return to the dialog.

☞ **Please note that these settings are not part of your personal configuration. Changes will affect all users of your controller! Your controller may become unreachable when the password is lost!**

☞ **The password protection only restricts the access via the DTRACK3 frontend. Other control options such as the SDK or the CLI (command line interface tool) still provide full access to all functions and features !**

Disable password protection In the dialog untick the checkbox *Enable password protection* and press *OK*. A warning message will appear next. If you are sure press *OK* to remove the password protection. In the last step you will be prompted to enter the current

Figure 7.1: Enable Access control

password. Enter the password and press *OK* once again. Please refer to figure 7.2 on page 58. The password protection feature is disabled and the previously set password is deleted.

If the entered password is incorrect a corresponding message will appear. You may then try again and enter the correct password.
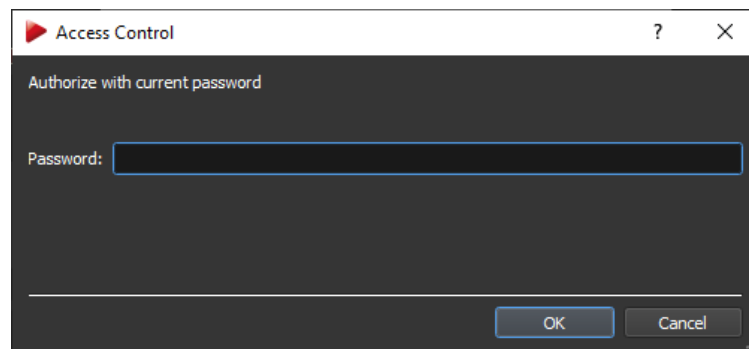
Figure 7.2: Authorize Access control

Change the currently set password   In the dialog enter your new password in the entry fields '*New password*' and '*Repeat password*' respectively, then press *OK*. A warning message will appear next. If you are sure press *OK* to change the password. Otherwise press *Cancel* to return to the dialog. In the last step you will be prompted to enter the curr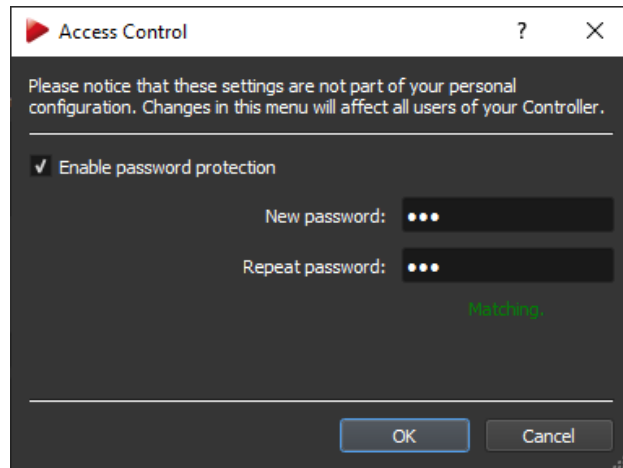ent password. Enter the password and press *OK* once again. Please refer to figure 7.2 on page 58. The password will be changed and the dialog is closed.

If the entered password is incorrect a corresponding message will appear. You may then try again and enter the correct password.

> **In case you have lost the password, please refer to chapter 5.3.1 on page 38 to reset the password feature.**

7.2 Licenses

The capability of the tracking system is defined by licenses which can be managed here, see figure 7.3 on page 59. You can upgrade to any functionality by simply entering a license code. Ask your *ART* representative for pricing.
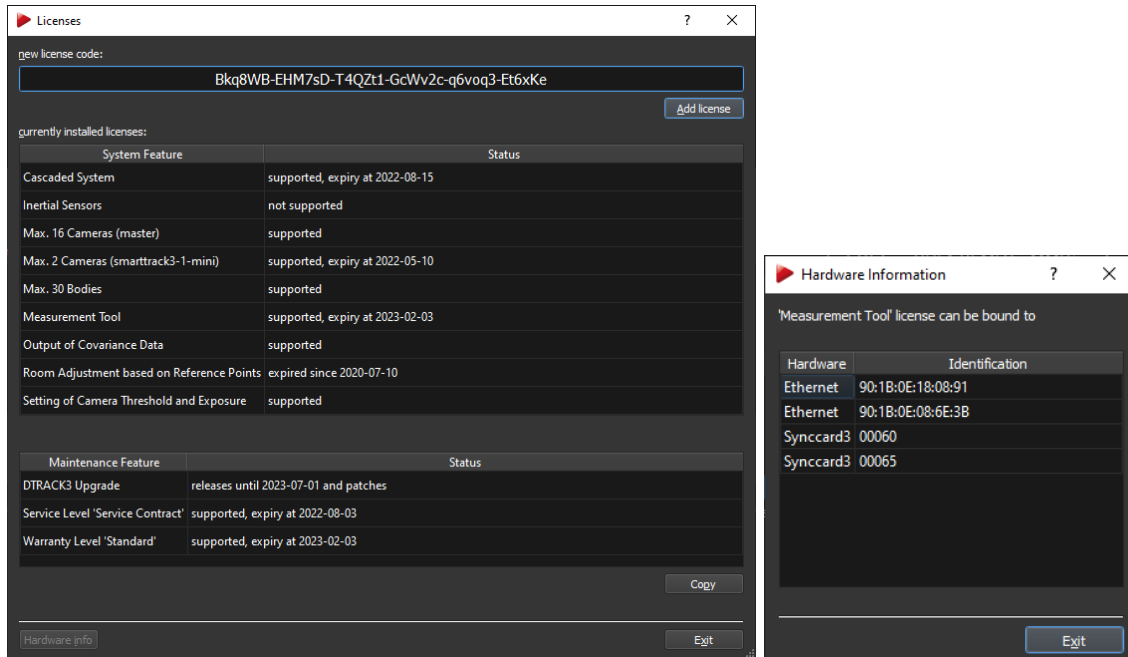
(a) Licenses overview   (b) Hardware information

Figure 7.3: Managing the licenses

> ℹ️ **Some features designed for advanced and experienced users are optional and therefore hidden by default. In order to access these features a license code is necessary. Please ask your *ART* representative for more details.**

7.2.1 Entering a license code

Example: If you would like to add a license, go ahead as follows:

- Select any feature by left-clicking.

- Click on *Hardware Info* to open the *Hardware Information* dialog.

- Contact your *ART* representative and communicate your version of *DTRACK3* together with the serial number of the *Synccard2/3* or alternatively the MAC address of the Ethernet port (=*Identification*) in order to receive a valid license code.

- Exit the window *Hardware Information* and enter a valid license code in the field *new license code*.

- Click on *Add license*.

- Exit the window *Licenses*

7.2.2 License model

Starting with **DTRACK3** version v3.1.0 a new license model has been established:

System Feature	Values	Status
Cascaded Systems		supported / not supported / expiry at *date* / expired since *date*
Inertial Sensors max. I sensors	I = 1, 2, 4, 16	supported / not supported / expiry at *date* / expired since *date*
max. C cameras	C = 2, 4, 8, 16, 32, 50	supported / expiry at *date* / expired since *date*
max. C cameras (master) [1]	C = 2, 4, 8, 16, 32, 50	supported / expiry at *date* / expired since *date*
max. C cameras (slave-hostname) [1]	C = 2, 4, 8, 16, 32, 50	supported / expiry at *date* / expired since *date*
max. B bodies	B = 4, 10, 30, 50, 70	supported / expiry at *date* / expired since *date*
Measurement Tool		supported / not supported / expiry at *date* / expired since *date*
Output of Covariance Data [2]		supported / not supported / expiry at *date* / expired since *date*
Room Adjustment based on Reference Points		supported / not supported / expiry at *date* / expired since *date*
Setting of Camera Threshold and Exposure [2]		supported / not supported / expiry at *date* / expired since *date*

Maintenance Feature	Values	Status
DTRACK3 Upgrade		until releases *v3.X* and patches / until *date* and patches
Service Level	Standard / Extended / Professional / Service Contract	supported / expiry at *date* / expired since *date*
Warranty Level	Standard / Priority / Warranty Contract	supported / expiry at *date* / expired since *date*

[1] available for cascaded systems only. The number of cameras are listed separately for master and slave(s) controllers.

[2] hidden, by default. An optional license code is necessary to unlock these features. Please ask your **ART** representative for more details.

Table 7.2: Licenses overview

Licenses are divided in the categories '*System Feature*' and '*Maintenance Feature*'. '*System Feature*' licenses enable functionalities of **DTRACK3** , while '*Maintenance Feature*' licenses are mainly for informational use. All licenses without expiration date are shown as ('*supported*').

Example *Max. 8 cameras* enables the simultaneous connection of up to 8 **ART** cameras. *Service Level* corresponds to the status of contract for service and maintenance, if

applicable. The minimum level without contract is '*Standard*'. For higher levels the date is shown when the contract will be about to expire. For further information please consult your service agreement.

i **The maximum number of bodies that may be used includes <u>all</u> calibrated interaction devices (*Fingertracking* , *Flystick2/2+/3* , *Measurement Tool*)!**

i **The licensing scheme for the number of cameras in a cascaded system is automatically derived from all licenses available in both master and slave(s) controllers, e.g. 8 *ARTTRACK5* on master + 4 *TRACK-PACK/E* cameras on slave = license showing 12 cameras. Note: *SMARTTRACK3* & *SMARTTRACK3/M* count as two cameras each.**

i **The total number of cameras cannot exceed 50 for any combination of cameras or *SMARTTRACK3* & *SMARTTRACK3/M* systems respectively.**

☞ **The master controller needs to have a dedicated '*Cascaded Systems*' license.**

7.2.2.1 License Expiration

When issued each license may be acquired for a limited period of time ('*supported, expiry at*'). At that point the feature or functionality will stop working and the license status will change to ('*expired since*'). An additional warning message will appear 14 days in advance of expiration at every startup of the **DTRACK3** frontend (see figure 7.4 on page 61).
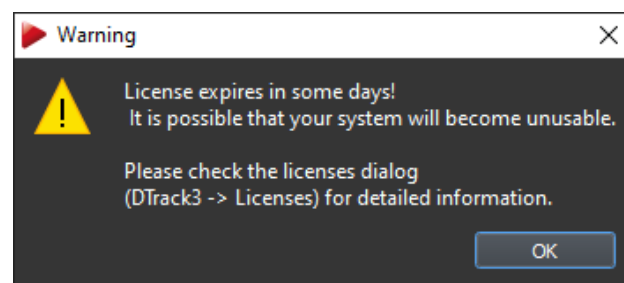
Figure 7.4: Expiry Warning for limited licenses

You may extend your licenses at any time. For further information please contact your **ART** representative.

☞ **When the license for your cameras expires you will not be able to start a measurement at all !**

7.2.2.2 Update & Upgrade Licenses

License *DTRACK3 Upgrade* defines which updates of the **DTRACK3** software are possible. It corresponds either to a version number or the release date of a future release of **DTRACK3** . Updates of patch versions (increasing the third digit of a version number,

e.g. v3.1.0 → v3.1.1 → v3.1.2 → v3.1.3 → ..., may be performed without restrictions at any time.

☞ **All patch releases and updates (e.g. v3.1.0 → v3.1.1 → v3.1.2 → v3.1.3 →...) may be installed without restrictions.**

☞ **DTRACK3 may only be upgraded to the next version (e.g. v3.1.0 → v3.2.0) having a valid 'DTRACK3 Upgrade' license. Ask your ART representative for more information.**

7.3 Configurations

It is possible to create and manage personalised configurations, e.g. with different targets or flash intensity settings (see also figure 7.5 on page 62). Go to **DTRACK3 →** *Configurations* to open the corresponding dialog.

7.3.1 Managing configurations

Any existing configuration may be activated and loaded by selecting the corresponding entry and clicking *Apply*.
All unlocked configurations except the '*standard*' one can be deleted. Select the entry to be deleted and click *Delete*. Quit the dialogue at any time by pressing *Exit*.
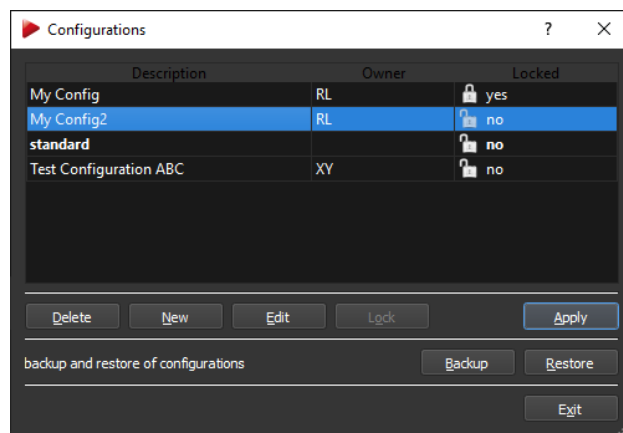
Figure 7.5: Manage configurations

7.3.1.1 Editing configurations

Unless the configuration is locked, it may be changed using the button *Edit*. You can assign a meaningful description ('*description*') and enter your user name ('*owner*'), see also figure 7.6 on page 63. Accept the changes with *OK*.
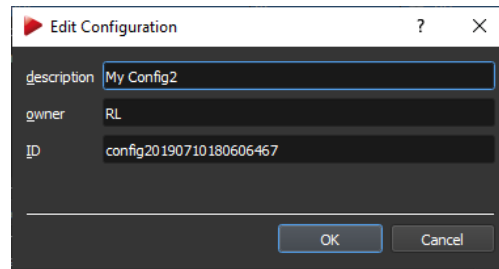
Figure 7.6: Edit configurations

7.3.1.2 Creating a new configuration

Press *New* to create a new configuration using the corresponding window (see figure 7.7 on page 63). You can assign a meaningful description ('*description*') and enter your user name ('*owner*').
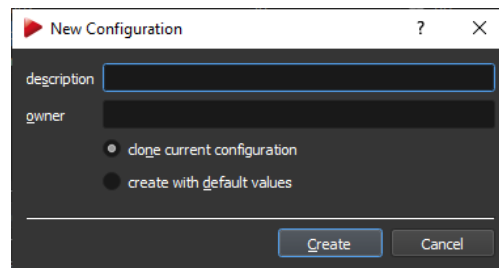
Figure 7.7: Creating a new configuration

Your personal configuration can be created in two ways:

1. '*clone current configuration*'
   all existing calibrations (room and body calibration), settings and values are inherited from the currently active configuration.

2. '*create with default values*'
   default values will be applied (i.e. the system will start from scratch as manufactured). The system will not have a valid room calibration or any body calibrations.

Just press *Create* and the configuration is saved on the controller.

7.3.1.3 Locking configurations

It is possible to protect the settings of any configuration with a password by pressing the button *Lock*. You will be asked to enter and confirm a new password to lock your configuration (see figure 7.8 on page 64).
A locked configuration cannot be changed later on with *Edit*.

> **Locking the configuration does not provide access-control! Only changes in settings / calibrations are disabled.**

> **In case you forget the password please call *ART* for assistance**
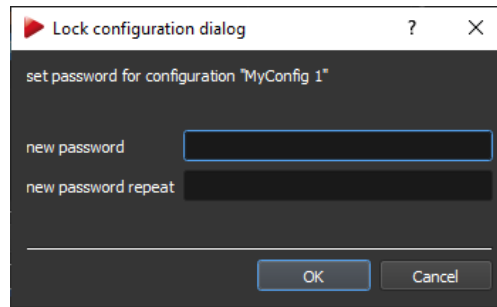
Figure 7.8: Locking a configuration

7.3.2 Backup Configurations

It is possible to export and re-import single configurations or to backup and restore all settings at once.

(a) Select the configurations to save (b) Select the folder on remote PC
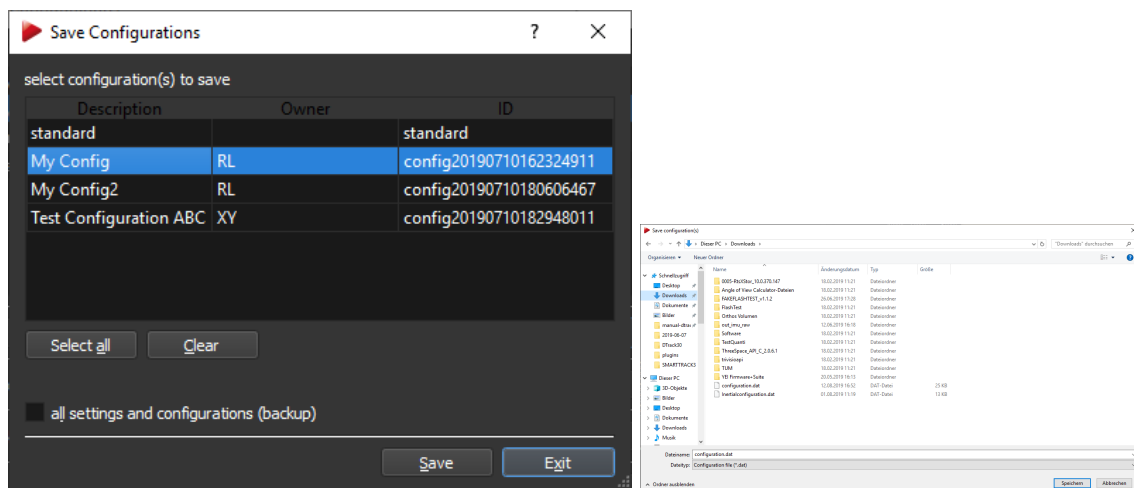
Figure 7.9: Backup configurations
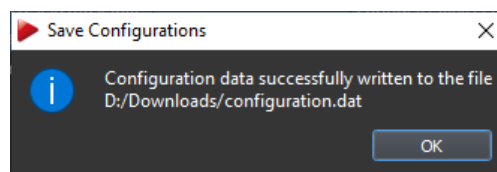
Figure 7.10: Backup configurations - Confirmation Window

Press the button *Backup* to open the corresponding *Save configurations* window for selecting the configuration(s) to export (see figure 7.9(a) on page 64). Either (de-)select individual configurations by left-clicking or click *select all* and *clear* respectively. Tick the checkbox *all settings and configurations (backup)* to save a complete backup of your system's settings. Press '*Save*' to select a destination directory on a remote PC (see figure

7.9(b) on page 64). A confirmation window will inform you of the successful export (see figure 7.10 on page 64).

7.3.3 Restore Configurations

'*Restore*' loads previously exported configuration files or complete backups from a remote PC. First select the folder on the remote PC where you have stored the configuration files (see figure 7.11(a) on page 65), then select the configurations to import (see figure 7.11(b) on page 65). The imported configuration will be activated automatically. It is also possible to import multiple configurations at the same time. A confirmation window will inform you of the successful import (see figure 7.12 on page 65).
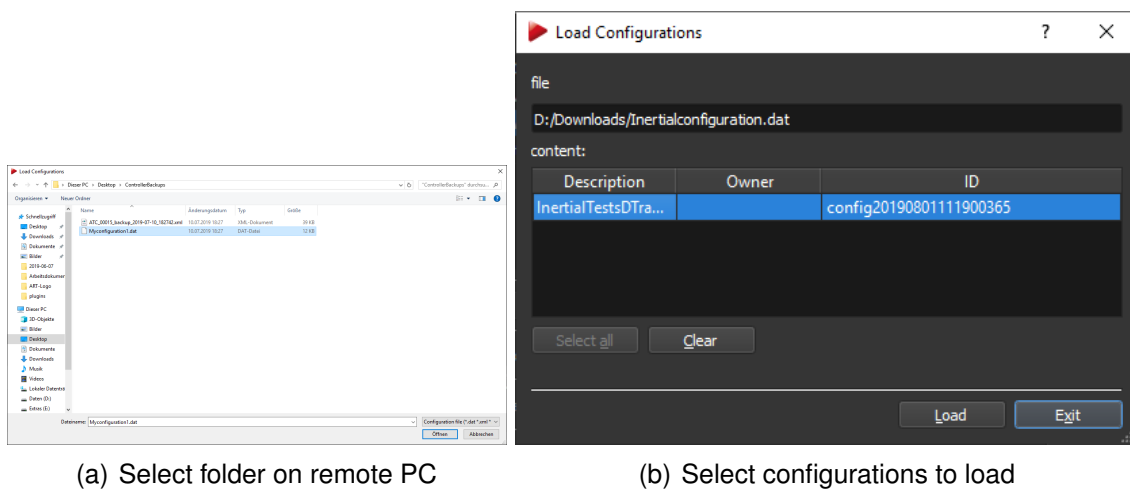
(a) Select folder on remote PC	(b) Select configurations to load

Figure 7.11: Restore configurations
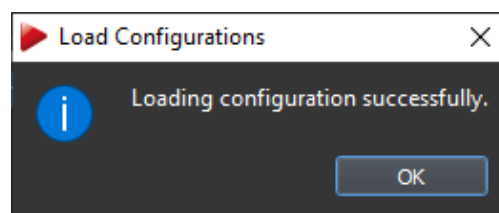
Figure 7.12: Restore configurations - Confirmation Window

Accidentally deleted configurations may be restored presuming an export had been carried out beforehand. In the unfortunate event of repairs this data can also be restored to a replacement controller. Note: A room (re-)calibration might be necessary especially in case the amount of cameras or the camera models should have changed.

☞ **Backup your data by exporting configurations on a regular basis !**

☞ **When exporting single or multiple configurations please assign meaningful filenames (e.g. exporting date 'Standard 07122012'). Configurations using the standard filename (e.g. "Standard") will be overwritten!**

7.4 Start/Stop

Start or stop the measurement by pressing the button *Start / Stop* or by using the keyboard shortcut 'M'.

7.5 Controller standby

Force the controller to go into standby mode with this command. A confirmation window will show up (see figure 7.13 on page 66). You can restart the controller manually or by using Wake On LAN. Please refer to chapter 5.2 on page 35 for more details.
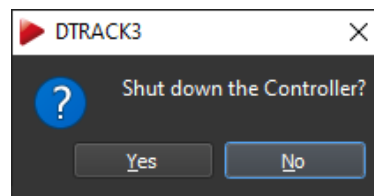
Figure 7.13: Shut down *DTRACK3* - Confirmation Window

7.6 Controller reboot

Reboot the controller with this command. This function is not available for *SMART-TRACK2* . A confirmation window will show up (see figure 7.14 on page 66).
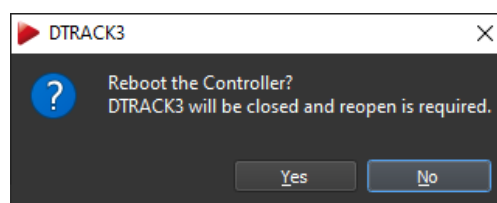
Figure 7.14: Reboot *DTRACK3* - Confirmation Window

7.7 Quit

Quit *DTRACK3* frontend software. In case the system is still in measurement mode, a confirmation window will show up (see figure 7.15 on page 67). You may leave the active measurement running or stop the measurement together with the frontend at this point.
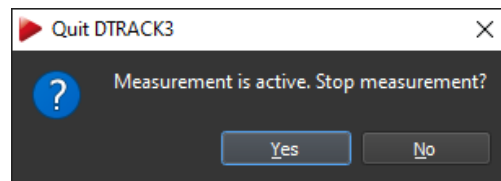
Figure 7.15: Quit *DTRACK3* - Confirmation Window

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8 Menu Hardware - Hardware configuration

Settings	Shortcut
Search hardware	F2 (not available for **SMARTTRACK2**)
Cascaded System	(not available for **SMARTTRACK2**)
Cameras	F7
Synccard	Shift+F7
Radio transceiver	
Inertial Sensor	
Network	
Time	

Table 8.1: Menu *Hardware*

8.1 Search hardware

Without the need for restarting the controller you can dynamically analyse your system for changes in configuration (e.g. added or removed cameras, *ART RadioTransceiver2/3*) This function is not available for **SMARTTRACK2** . Therefore proceed as follows:

- connect a new camera to the controller

- wait until the camera has finished booting

- within **DTRACK3** press the button *Hardware → Search hardware* or use the shortcut '*F2*' to perform a search for new hardware

- check if the camera has been recognized successfully (e.g. by opening *Hardware → Camera* or use the shortcut '*F7*')

- start the measurement, the message (re-)calibration required! inside the *Monitor 2DOF display* of the corresponding camera (see chapter 6.3.1 on page 45 for details)

- perform a room re-calibration 9.1.5 on page 104, added cameras are automatically marked as '*moved*' in the room re-calibration dialog.

ℹ **When cameras are added to an already calibrated tracking system these cameras will not contribute for calculation and measurement until you perform a room (re-)calibration (see chapter 9.1.5 on page 104). As a reminder the** *Monitor 2DOF display* **of the corresponding camera monitor(s) will show the message (re-)calibration required! .**

The *ART Controller* **or** *ART Controller/M* **will detect all cameras that have been removed from an already calibrated tracking system (e.g. due to a disconnected cable) and mark those as missing until a room (re-)calibration has been performed. The** *Monitor 2DOF display* **of the corresponding cameras will be disabled (crossed out) and in case of larger systems their corresponding displays will be moved to a new camera tab.**

☞ *DTRACK3* **is able to operate when cameras have been added or removed; for best performance it is highly recommended to perform a recalibration.**

8.2 Cascaded System Settings

We recommend creating a new configuration for all cascaded systems: *DTRACK3* → *Configurations* → **'New'**

Go to *Hardware* → *Cascaded System* to enter the configuration dialog for the cascaded systems (see figure 8.1 on page 69). This function is not available for *SMARTTRACK2* . There you may select single tracking systems to build a cascade. On the right-hand side of the dialog all '*Available*' controllers are listed (i.e. which can become a slave in the cascaded system).
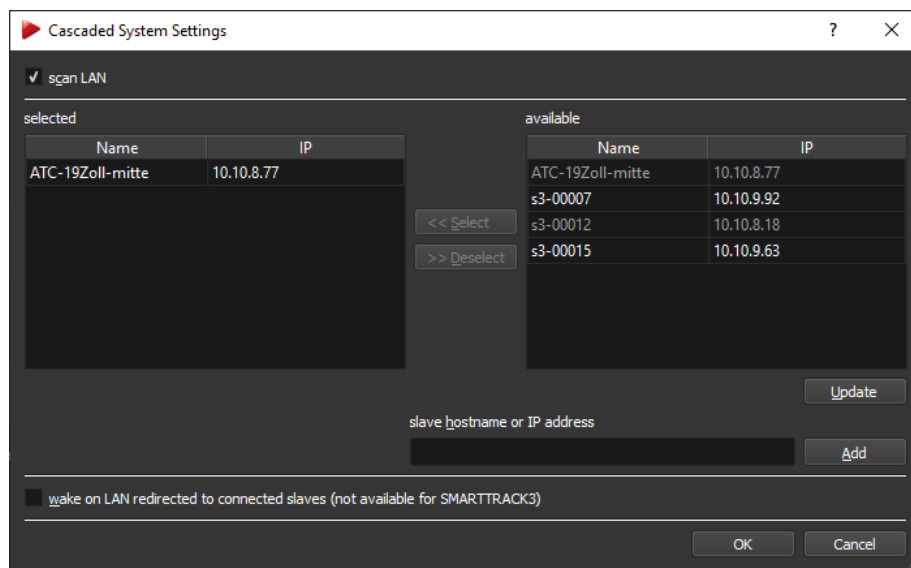
Figure 8.1: Cascaded System Settings

When you have set up your cascaded system using a direct link (via '*Cascaded Network Port*' or *Synccard3* or internal camera network) between master and slave controller the list will be filled automatically.

When using a connection via LAN, you can tick the checkbox '*scan LAN*' and *DTRACK3* will search automatically whether controllers are available for cascading. The button '*Update*'

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refreshes the list.

Mark the desired controller by left-clicking and press '*Select*' to assign this controller to the cascaded system. It will then appear on the left-hand side of the dialog in the list of the '*Selected*' controllers. Repeat these steps if you want to add more slave controllers to the cascade.

To remove controllers from the cascaded system simply select the corresponding controllers in the list of the '*Selected*' controllers by left-clicking and press button '*Deselect*'.

You can also enter a '*slave hostname or IP address*' directly in case you have set a specific static IP address. Please refer to chapter 5.3 on page 36 for more information.

The checkbox '*wake on LAN*' enables synchronized start-up of the master and all slave controllers (not available for *SMARTTRACK3* & *SMARTTRACK3/M*). Starting of the cascade will take 3-4 minutes as the master has to boot up first and then wake up the slave(s).

The changes will be accepted by the system by pressing '*OK*'. Settings (e.g. flash intensity, sync groups) of all cameras inside the cascade can now be edited through the *Hardware → Cameras* dialog. Proceed with configuration of your setup. The next time you start the measurement all cameras inside the cascade can be accessed through the *Monitor 2DOF display*.

In case of using the *ART Synccard3* or internal camera network all slave controllers will acquire their IP addresses automatically.

By default all controllers are set up to support DHCP. When building cascades via LAN the controllers will acquire an IP address automatically given that a DHCP server is running.

If any slave controller is not connected via an ethernet cable or no DHCP server is running, it will use a fall-back IP address (IP 192.168.0.1, subnet mask 255.255.255.0) and you will not able to connect to your slave controllers !

If the cascade is connected via the '*Cascaded network port*' of the *ART Controller* or *ART Controller/M* , all slave controllers must be set to a specific static IP address in the subnet 172.29.xxx.xxx with subnet mask 255.255.0.0. Do not use IP addresses in the range from 172.29.0.1 to 172.29.0.20 ! Please refer to chapter 5.3 on page 36.

Shutdown of master and slave controller(s) is always synchronized. Tick the option '*wake on LAN*' to also start-up the slave controller(s) automatically.

Before starting a measurement, please double-check whether a BNC connection for synchronisation has been established between master *ART Controller* '*OUT1*' or *ART Controller/M* '*OUT*' and slave(s) '*EXT.In*'.

Do not use the PoE injector nor the BNC synchronisation when connecting *SMARTTRACK3* & *SMARTTRACK3/M* slaves to *ART Controllers*.

8.3 Camera Settings

This dialog (see figure 8.2 on page 71) shows a comprehensive list of all cameras currently connected to the system as well as all cameras that have been removed since the last valid room calibration. It allows changes of all camera specific settings (e.g. flash intensity, static reflex suppression, syncgroup assignment, etc.) either for all cameras at once (globally) or for each camera separately by left-clicking and selecting the appropriate entry.

Here you can also toggle *modulated flash* in order to synchronize and trigger an active target.

8.3.0.1 All Cameras tab

By default the window opens up showing the tab *All Cameras*.

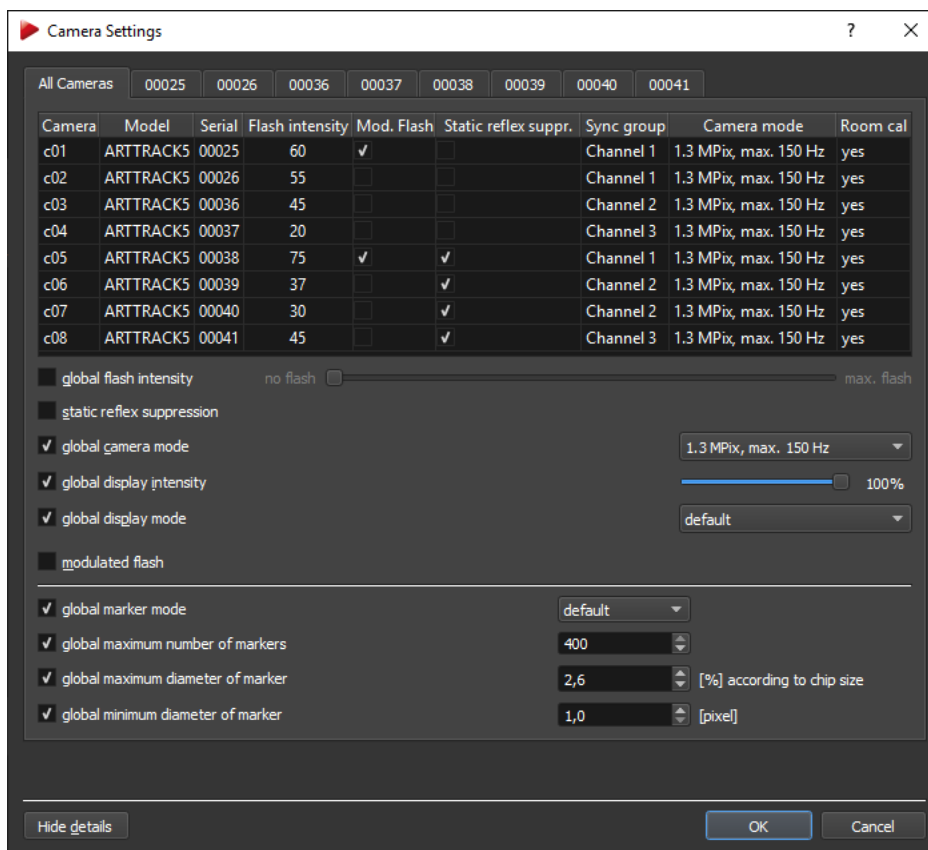| Camera	Model	Serial	Flash intensity	Mod. Flash	Static reflex suppr.	Sync group	Camera mode	Room cal
c01	ARTTRACK5	00025	60	✓		Channel 1	1.3 MPix, max. 150 Hz	yes
c02	ARTTRACK5	00026	55			Channel 1	1.3 MPix, max. 150 Hz	yes
c03	ARTTRACK5	00036	45			Channel 2	1.3 MPix, max. 150 Hz	yes
c04	ARTTRACK5	00037	20			Channel 3	1.3 MPix, max. 150 Hz	yes
c05	ARTTRACK5	00038	75	✓	✓	Channel 1	1.3 MPix, max. 150 Hz	yes
c06	ARTTRACK5	00039	37		✓	Channel 2	1.3 MPix, max. 150 Hz	yes
c07	ARTTRACK5	00040	30		✓	Channel 2	1.3 MPix, max. 150 Hz	yes
c08	ARTTRACK5	00041	45		✓	Channel 3	1.3 MPix, max. 150 Hz	yes

Figure 8.2: Camera Settings - All Cameras Tab

All detected cameras are shown in the table with their corresponding settings (from left to right):

Flash intensity The flash intensity may be changed within an interval from

- 0 .. 6 for *ARTTRACK1* (discontinued),

Column	Description
Camera	Shows the assigned camera ID c01 to ... (compare 2-digit LED matrix display on **ARTTRACK5**)
Model	Shows the type of camera
Serial	Shows **ART** internal serial number of each camera (suffix L / R for **SMARTTRACK3** & **SMARTTRACK3/M** left & right cameras)
Flash intensity	Change the currently set flash intensity (individually)
Modulated flash	(De-)activates the synchronisation signal and trigger for active targets (individually)
Static reflex suppr.	(De-)activates the static reflex suppression for this camera (individually)
Sync group	Select the syncgroup ('*Channel 1*' - '*Channel 3*' for **ART-TRACK6/M** , **ARTTRACK5** , **ARTTRACK5/C** & **TRACK-PACK/E** individually)
Camera mode	Select the camera mode (available modes depend on model, set individually)
Room cal	Shows the status of room calibration (i.e. '*no*' for newly added but not yet calibrated cameras)

Table 8.2: Menu *Camera Settings*

- 0 .. 8 for **ARTTRACK2** / **ARTTRACK3** (discontinued),

- 0 .. 100 for **ARTTRACK6/M** , **ARTTRACK5** , **ARTTRACK5/C** , **TRACKPACK/E** and **SMARTTRACK3** & **SMARTTRACK3/M**

- 0 .. 7 for **TRACKPACK** (discontinued).

- 0 only for **ARTTRACK6/M for Active Markers**

> **The flash setting strongly depends on the working area and range. Increase the flash intensity until all markers become yellow or green using the *Monitor 2DOF display*. Additionally pay attention to the intensity bar on the top right corner of each camera monitor. Please refer to chapter 6.3.1 on page 45 for instructions.**

> **As a rule of thumb: For measurement applications with high accuracy requirements the markers should be displayed in green with intensities of min. 4 bars; for VR applications yellow markers with intensities down to 2 bars are still sufficient.**

> **When using *SMARTTRACK3* & *SMARTTRACK3/M* the flash intensity, the modulated flash and the sync group is changed simultaneously for both cameras.**

> **The *ARTTRACK6/M for Active Markers* cameras do not offer an infrared flash. Thus it is not possible to adjust the flash intensity.**

> **When using *ARTTRACK2/C* cameras it is not possible to adjust the flash intensity of the corresponding external flashes with the *DTRACK3* frontend software!**
> **Please contact *ART* in case you need to adjust the flash intensity of the external flashes.**

> **Keep a distance of min. 20 cm when operating the cameras ! All cameras are assigned to the Exempt Group according to IEC62471-1 and therefore pose no risk or hazard to the human eye or skin at this distance.**

Modulated flash *ART* tracking systems can be used with active markers, i.e. markers consisting of infrared LEDs instead of retro reflective material (please refer to the *ART Hardware Installation Guide → Markers & Targets*). Tick the checkbox *modulated flash* in the table to activate the synchronisation signal (i.e. coded IR flash) that triggers active targets for individual cameras.

> **The effective flash intensity is reduced significantly when the modulation is used in combination with low flash intensities. The influence is negligible at higher flash intensity settings. Simply increase the flash intensity, if necessary.**

> **The range of the modulated flash is significantly higher than the effective tracking distance of the cameras.**

> **All cameras with activated modulated flash have to be assigned to syncgroup #1 (default for *SMARTTRACK3 & SMARTTRACK3/M*) ! ART-TRACK6/M , ARTTRACK5 , ARTTRACK5/C , TRACKPACK/E , & TRACK-PACK systems may be configured via software. ARTTRACK2 & ART-TRACK3 have to be connected to 'OUT1' on the *ART Controller* and 'OUT' on the *ART Controller/M* respectively.**

Static reflex suppr. Tick the corresponding checkbox to activate the support of static reflex suppression. Please refer to the 6.3.2 on page 49 for further information.

Sync group In case of mutual blinding of cameras (see *ART Hardware Installation Guide → Setting up the cameras*) one can assign different syncgroups for opposing or adjacent cameras. You may change the assignment either on the *All Cameras* tab or on the *Individual tab* of the respective camera. Click on the appropriate field in the column 'Sync group' to open a drop-down menu. Possible values are '*Channel 1*', '*Channel 2*' or '*Channel 3*'.

These channels correspond to the three syncgroup outputs (time delays #1: 0 μs, #2: 480 μs, #3: 960 μs on the *ART Controller* or *ART Controller/M*). To change the predefined time delays please refer to 8.4 on page 78.

Please refer to the *ART Hardware Installation Guide → Installation of the Controller* for syncgroup assignment of *ARTTRACK* cameras in backward compatible systems.

> **The *ART Controller/M* offers synchronization output for *ARTTRACK1 – ARTTRACK3* cameras on syncgroup #1 only !**

Camera mode Depending on the model and on your application you can change the camera mode (i.e. the field of view) in order to achieve:

- higher max. frame-rates (refer to **ART Hardware Installation Guide** → *Technical Specifications* for each camera model)

- lower latencies (i.e. time delays for measurement data).

To switch the camera mode, click on the field in the column '*Camera mode*' to open a drop-down menu (e.g. *1.1 Mpix, max. 60 Hz*).

The max. frame-rate is limited by the camera with the largest field of view selected respectively the max. frame-rate of that individual camera. In mixed systems the max. frame-rate is always limited to 60 Hz (*ARTTRACK2* or *ARTTRACK3* with *ARTTRACK6/M* , *ARTTRACK5* or *TRACKPACK/E*) or 120 Hz (*TRACKPACK/E* with *ARTTRACK6/M* or *ART-TRACK5*) respectively.

Note: Higher frame-rates come at the cost of the cameras' reduced field of view.

Room cal This indicator shows whether the corresponding camera was present and running during the last valid room calibration. Hence, *yes* shows that the camera will be used for measurements and will contribute to the tracking. On the contrary *no* indicates that additional cameras have been added to an existing configuration without performing a room (re-)calibration. Thus a (re-)calibration is necessary for the corresponding camera to contribute to the tracking. Please refer to chapter 8.1 on page 68 on how to add new cameras dynamically.

The *ART Controller* or *ART Controller/M* will detect all cameras that have been removed from an already calibrated tracking system (e.g. due to a disconnected cable) and mark those as missing until a room (re-)calibration has been performed. The corresponding entries are greyed out to show that the cameras have been disabled. The only data shown is model and serial number.

DTRACK3 is able to operate when cameras have been added or removed; for best performance it is highly recommended to perform a re-calibration.

Global settings Tick the checkboxes to adjust the corresponding settings for all cameras at once.

- global flash intensity
  Move the adjacent slider to adjust the flash intensities of all cameras globally.

- static reflex suppression
  Tick the corresponding checkbox to activate the support of static reflex suppression for all cameras at once.

- global camera mode
  Set the field of view for all cameras globally by using the adjacent dropdown-menu (e.g. *1.1 Mpix, max. 60 Hz*) on the right.

- global display intensity
  Move the slider to adjust the brightness of the status LEDs and the 2-digit LED matrix display on the **ARTTRACK5** . The brightness can be dimmed from 0...100% if necessary (e.g. in light-sensitive environments).

- global display mode (**ARTTRACK5** only)
  Select *default* to activate the status LEDs and the 2-digit LED matrix display to show the currently assigned camera ID. Alternatively select *number of markers / camera ID* to display the number of detected markers in the camera's field of view instead (only during measurements). The 2-digit LED matrix display can also be deactivated by selecting *only status LEDs*.

- modulated flash
  Tick the checkbox here to activate the modulated flash for all cameras at once.

Show Details   Here you can change the settings regarding low-level marker detection globally (see figure 8.2 on page 71):

Option	Description
global marker mode	configure the marker detection algorithm
global maximum number of markers	set maximum number of markers that a camera is allowed to detect simultaneously
global maximum diameter of markers	set maximum size of a marker that a camera is allowed to detect (in percentage of the camera's sensor size)
global minimum diameter of markers	set minimum size of a marker that a camera is allowed to detect (in pixel)

Table 8.3: *Camera Settings* - Show Details All Cameras Tab

8.3.0.2 Individual camera tabs

Each camera can also be accessed by its individual tab within this dialog (see figure 8.3 on page 76).
In the upper left corner of the tab you will find a depiction of the corresponding camera. To the right the following information is listed:

Info	Description
Model	Shows the type of camera
Serial	Shows **ART** internal serial number of the camera
Version	Shows **ART** internal firmware version of the camera
Focal length	Shows the focal length of the camera lens
Connected at	Shows the controller the camera is connected to (*Cascaded Systems* only)

Table 8.4: *Camera Settings* - Individual Tab Infos

Below you can change the following options (please refer to the former paragraphs for details):
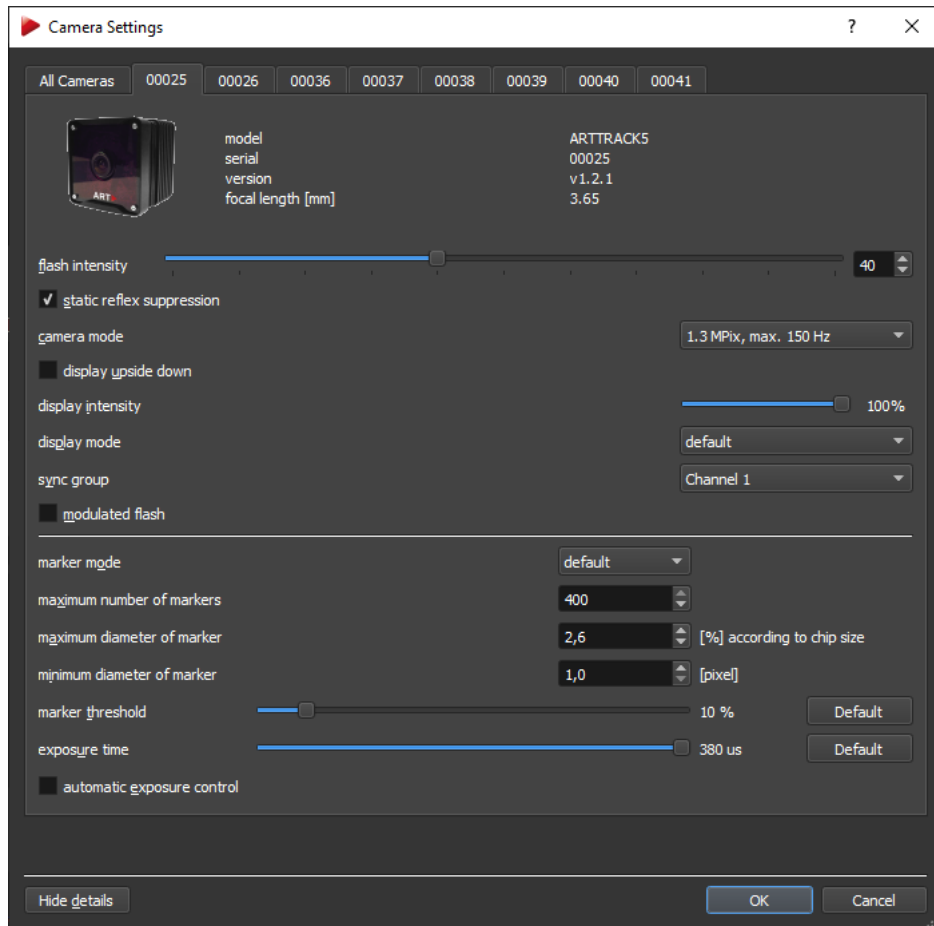
Figure 8.3: *Camera Settings* - Individual Tab

Option	Description
flash intensity	Change the currently set flash intensity
static reflex suppr.	(De-)activates the static reflex suppression for this camera
camera mode	Select the camera mode (available modes depend on model)
display upside down	Rotate the orientation of the camera monitor in the *Monitor 2DOF display* by 180°. '*UD*' is displayed in corresponding camera monitor.
display intensity	Adjust the brightness of the status LEDs and the 2-digit LED matrix display
display mode	(De-)activates the 2-digit LED matrix display (**ART-TRACK5** only)
sync group	Select the syncgroup ('*Channel 1*' - '*Channel 3*' for **ARTTRACK6/M** , **ARTTRACK5** , **ARTTRACK5/C** & **TRACK-PACK/E**)
modulated flash	(De-)activates the synchronisation signal and trigger for active targets

Table 8.5: *Camera Settings* - Individual Tab Options

Show Details Here you can change the settings regarding low-level marker detection for individual cameras (see figure 8.3 on page 76):

Option	Description
marker mode	configure the marker detection algorithm
maximum number of markers	set maximum number of markers that a camera is allowed to detect simultaneously
maximum diameter of markers	set maximum size of a marker that a camera is allowed to detect (in percentage of the camera's sensor size)
minimum diameter of markers	set minimum size of a marker that a camera is allowed to detect (in pixel)
marker threshold	set the sensitivity of the marker detection algorithm (in percent) [1]
exposure time	set the exposure time of the camera manually (in microseconds) [1]
automatic exposure control	set the exposure time of the camera based on the selected flash intensity [1]
Default	return to default values [1]

[1] hidden, by default. An optional license code is necessary to unlock these features. Please refer to section 7.2 on page 59 for more information.

Table 8.6: *Camera Settings* - Show Details Individual Camera Tab

ℹ️ **In certain environments and scenarios (e.g. outdoors, sunlight, other factors that cause high intensities coming from stray light) you may improve marker detection and thus tracking quality by increasing the *marker threshold* and decreasing the *exposure time*. Try to adjust both parameters moderately until improvement is reached.**

ℹ️ **When using passive markers only in scenarios with high intensities coming from stray light it is unnecessary to adjust the exposure time manually. Tick the checkbox *automatic exposure control* and decrease the *flash* until markers can still be tracked in good quality in the *Monitor 2DOF*. Please refer to chapter 6.3.1 on page 45.**

☞ **Active markers by *ART* need a minimum exposure time of at least 30 μs. Do not use *automatic exposure control* in combination with very low flash intensities (i.e. 25).**

☞ **In general do not adjust the *marker threshold* or the *exposure time* to extreme values far from default. The tracking quality may become unreliable and the system may malfunction.**

8.3.1 *SMARTTRACK2* Camera Settings

This dialog (see figure 8.4 on page 78) offers the possibility to adjust the '*flash intensity*', to activate the '*Static reflex suppression*' and the '*modulated flash*'.

Flash intensity The flash intensity may be changed within an interval from 0 .. 7 by moving the slider to left and right respectively or using the adjacent field.
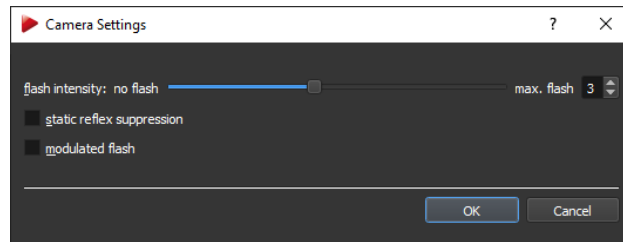
Figure 8.4: Camera Settings - *SMARTTRACK2*

The flash setting strongly depends on the working area and range. Increase the flash intensity until all markers become yellow or green using the *Monitor 2DOF display*. Additionally pay attention to the intensity bar on the top right corner of each camera monitor. Please refer to chapter 6.3.1 on page 45 for instructions.

As a rule of thumb: For measurement applications with high accuracy requirements the markers should be displayed in green with intensities of min. 4 bars; for VR applications yellow markers with intensities down to 2 bars are still sufficient.

Keep a distance of min. 20 cm when operating the *SMARTTRACK2*! It is assigned to the Exempt Group according to IEC62471-1 and therefore poses no risk or hazard to the human eye or skin at this distance.

Static reflex suppr.   Tick the corresponding checkbox to activate the support of static reflex suppression. Please refer to the 6.3.2 on page 49 for further information.

Modulated flash   The *SMARTTRACK* can be used with active markers, i.e. markers consisting of infrared LEDs instead of retro reflective material (please refer to the *ART Hardware Installation Guide* → *Markers & Targets*). Tick the checkbox *modulated flash* to activate the synchronisation signal (i.e. coded IR flash) that triggers active targets.

The effective flash intensity is reduced significantly when the modulation is used in combination with low flash intensities. The influence is negligible at higher flash intensity settings. Simply increase the flash intensity, if necessary.

The range of the modulated flash is significantly higher than the effective tracking distance of the *SMARTTRACK2*

8.4 Synccard Settings

This dialog shows the model and the serial number of the *ART Synccard* . Furthermore you can select the mode of synchronisation (i.e. internal or external source).

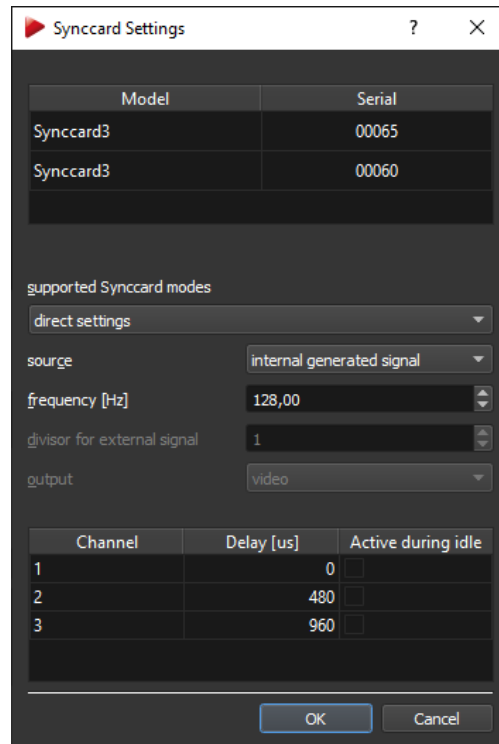The available modes for synchronisation are shown in table 8.7 on page 79.

Figure 8.5: Synccard Settings

supported Synccard modes	field of application
internal generated signal, ... Hz	run the controller without external synchronisation (available values dependent on camera model)
external video signal *external video signal, for validated shutter glasses* [1] *external video signal, for validated shutter glasses, divisor 2* [1,2]	active-stereo projection with an analogue video sync signal (=VGA)
external TTL signal *external TTL signal, for validated shutter glasses* [1] *external TTL signal, for validated shutter glasses, divisor 2* [1,2]	active-stereo projection with a TTL sync signal, triggers on rising edge
external TTL signal both edges [3] *external TTL signal both edges, for validated shutter glasses* [1,3]	see above, triggers on rising AND falling edge
direct settings	advanced custom settings

[1] predefined settings that should be used with the shutter glasses listed in table 8.8 on page 80
[2] use this mode if the frequency of the external synchronisation signal is 2x higher than the max. framerate of the camera or *SMARTTRACK2* (not available for *SMARTTRACK3* & *SMARTTRACK3/M*)
[3] available only for *Synccard2/3* and *SMARTTRACK3* & *SMARTTRACK3/M* (not available for *SMARTTRACK2*)

Table 8.7: Overview of the supported synccard modes

ℹ **The TTL input signal level should be 5 Volt (TTL) and 3 Volt (LVTTL) respectively with a minimum change of 2.5 Volt and duty cycle between 10% and 70 % regardless of input frequency.**

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Brand	Type
RealD	CrystalEyes 1, 2, 3, 5
NuVision	APG6000, APG6100
XPand	X101, X103 (with NuVision Long-Range Emitter), X104LX
NVidia	3D Vision Pro (RF sync'ed)
Volfoni	EDGE (with Volfoni or NuVision LR Emitter)
Virtalis	ActiveWorks 500

Table 8.8: Overview of validated shutter glasses

☞ **The TTL input signal level should show no DC-offset voltage.**

8.4.1 Direct Settings

If you select *direct settings* you may use advanced options for configuring the **Synccard2/3** or **SMARTTRACK3** & **SMARTTRACK3/M** :

Option	Description
source	configure the type of synchronisation to be used (see details below)
output [1]	configure the type of output synchronisation signal '*none, video, TTL*'
frequency [Hz]	enter the tracking frequency manually (max. frequency dependent on camera model and selected camera mode)
divisor for external signal [2]	reduce the external synchronisation frequency by a factor 1 - 10
Delay [us] [3]	configure the delay between the external synchronisation signal and exposure for each syncgroup
Active during idle [4]	configure the output synchronisation signal to be active when system is '*idle*' (measurement stopped)

[1] output signal '*video*' for **Synccard2/3** only ('*none*' for **SMARTTRACK2**)
[2] not available for **SMARTTRACK3** & **SMARTTRACK3/M**
[3] *Channel 1* for **SMARTTRACK2/3/M** only
[4] available for **Synccard2** and **SMARTTRACK3** & **SMARTTRACK3/M** only

Table 8.9: Synccard mode direct settings

source The available options '*internal generated signal*', '*external video signal*', '*external TTL signal*' and '*external TTL signal both edges*' are equivalent to the aforementioned supported synccard modes (see table 8.7 on page 79). Additionally the option '*external inverted TTL signal*' is available, which inverts the external synchronisation signal (i.e. triggers on falling edge).

output The output synchronisation signal can be chosen from '*TTL*' or '*video*' for **SMARTTRACK3** & **SMARTTRACK3/M** . Please refer to the **ART Hardware Installation Guide** → *Synchronisation* for more information.

frequency [Hz] The tracking frequency can be set between 10 Hz and the max. framerate of the cameras or ***SMARTTRACK2/3/M*** in steps of 1 Hz. The max. frame-rate depends on the camera model and the selected camera mode. Please refer to the ***ART Hardware Installation Guide*** → *Technical Specifications* for more information.

divisor for external signal If the frequency of the external synchronisation source is higher than the max. frame rate of the cameras or ***SMARTTRACK2*** (not available for ***SMARTTRACK3*** & ***SMARTTRACK3/M***), a divisor can be set to reduce the frequency accordingly. Set the factor from 1 - 10. The max. frame-rate depends on the camera model and the selected camera mode. Please refer to the ***ART Hardware Installation Guide*** → *Technical Specifications* for each camera model.

Delay [us] When working with external synchronisation a time delay can be set between the external synchronisation signal and the exposure time of all camera syncgroups (*Channel 1* available only for ***SMARTTRACK2/3/M***). The delay for all syncgroups (*Channel 1* to *Channel 3*) is measured relative to the time of the external trigger. If necessary these values can be changed individually. Please also refer to ***ART Hardware Installation Guide*** → *Synchronisation* for detailed information regarding external synchronisation.

> **ⓘ** **Note: The max. delay is dependent on the camera model and camera mode. A difference of min. 300 μs between consecutive channels has to be maintained at all times.**
> **Example: *Channel 1*: 1200 μs, *Channel 2*: 1500 μs, *Channel 3*: 1800 μs**

> **ⓘ** **The TTL input signal level should be 5 Volt (TTL) and 3 Volt (LVTTL) respectively with a minimum change of 2.5 Volt and duty cycle between 10% and 70 % regardless of input frequency.**

> **☞** **The TTL input signal level should show no DC-offset voltage.**

> **☞** **The default values for the different channels (#1: 0 μs, #2 480 μs , #3: 960 μs) are preset for compatibility with active markers by *ART*. Do not increase the delays between the channels beyond 480 μs when using active markers.**

> **☞** **The *ART Controller/M* offers synchronization output for *ARTTRACK1 – ARTTRACK3* cameras on syncgroup #1 only !**

8.5 Radio Transceiver

Here you can configure the settings of the ***ART RadioTransceiver2/3*** . Additionally you will get information about all attached interaction devices (e.g. ***Flystick2/2+/3***).
The following information is offered:

> **ⓘ** **The *SMARTTRACK2* comes with an integrated radio transceiver. There is no need to plug in an additional USB Radio Transceiver (RT3)**

Show details By clicking the button *Show details* the drop-down menu for selecting the radio channel of the ***RadioTransceiver2/3*** is shown.
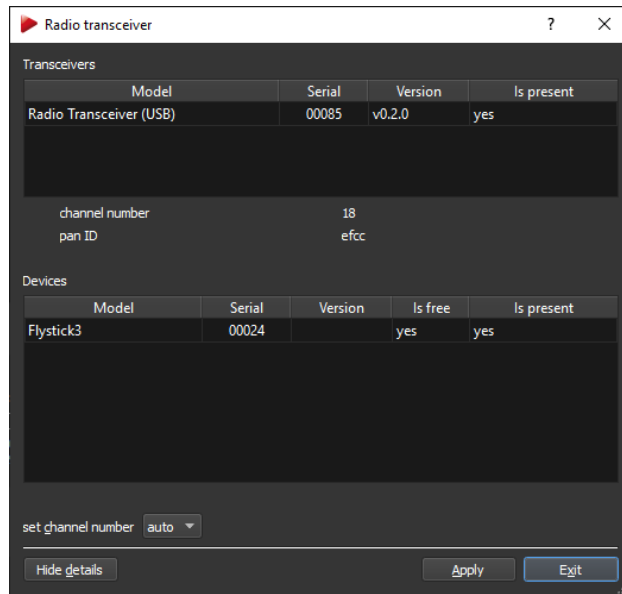
Figure 8.6: ART Radio Info Settings

Info	Description
Model	Shows the model of the transceiver or the device respectively
Serial	Shows the serial number of the transceiver or device respectively
Version	Shows the firmware version of the transceiver or device respectively
Is present	('*yes*'): The transceiver is connected, the device is in range
Is free (only for Devices)	('*yes*'): The device is available for communication and has not been assigned yet
	('*no*'): The device is already assigned to a transceiver

Table 8.10: *ART RadioTransceiver2/3* info settings

Set channel number   By default the *RadioTransceiver2/3* is automatically selecting a radio channel during boot-up, the drop-down menu is preset to ('*auto*'). You may also select a specific channel manually. The selected setting is saved persistently.

8.6 Inertial Sensor

This dialog is the center for configuration and calibration of inertial sensors (license for *DTRACK3* necessary!). When using inertial sensors you can additionally select the pulse generating source for the tracking frequency here. Compatible hybrid targets by *ART* are communicating with the *DTRACK3* system either via wireless 2.4 GHz ISM radio connection or wired USB connection.

8.6.1 Wireless hybrid targets

Wireless hybrid targets are distributed together with an antenna and two wireless transceivers ('Dongles') for communication with the inertial sensors as a part of the *ART* Hybrid Motion Capture suit. Please also refer to the *ART Hardware Installation Guide* → *Markers & Targets*.

> **i** **For *SMARTTRACK2* individual hybrid targets are available only.**

> ☞ **Wireless hybrid targets are not supported for *SMARTTRACK3* & *SMARTTRACK3/M* .**

8.6.1.1 Connecting the wireless transceivers

First connect the USB plugs of the transceivers ('Dongles') to any free USB port of the controller using the supplied extension cables. The dongles are activated after rebooting the controller or *SMARTTRACK2* or calling *Hardware* → *Search hardware*.

> ☞ **Note: Use the supplied active (USB 2.0) extension cables (e.g. 'ATEN UE250') to connect the transceivers ('Dongles') to an *ART Controller* or *ART Controller/M* . Otherwise proper function of the transceivers cannot be guaranteed.**

> ☞ **Use an externally powered USB-hub (USB 2.0) for connecting the transceivers ('Dongles') to the free USB port of the *SMARTTRACK2* .**

8.6.1.2 Configuring the wireless transceivers

Now within *DTRACK3* go to the menu *Hardware* → *Inertial Sensor* and open the *Settings* sub-dialog (see figure 8.7 on page 83).
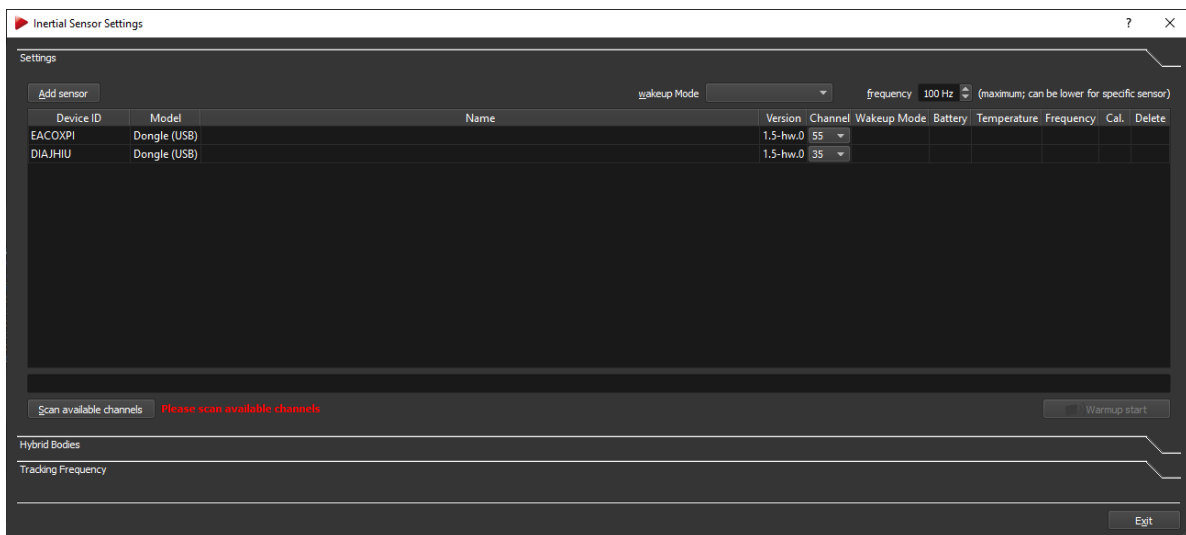
Figure 8.7: Inertial Sensor Settings - Connecting wireless transceivers

Double-check that all attached dongles have been found showing the following Dongle properties:

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Info	Description
Device ID dongle	Shows the serial number of the transceiver
Model	Shows the type of the transceiver (Dongle USB only)
Firmware Version	Shows the firmware version of the transceiver
Currently used radio channel	Shows the radio channel of the transceiver (default: 35 / 55); use the drop-down menu to change the radio channel

Table 8.11: ***ART*** wireless transceivers ('Dongles') settings (only available settings are listed)

At this point only dongles should be listed, otherwise check that all previously added sensors show up together with their corresponding dongle. Please refer to figure 8.10 on page 87.

Next scan the available radio channels by pressing *Scan available channels*. After completion the drop-down menu in the column *Channel* will show a list of all available channels for each dongle (see figure 8.8 on page 84). The currently used channel is marked in bold digits. All channels that are not recommended are greyed out (occupied by other Wi-Fi devices in range), while all recommended channels are marked green.

Please select an appropriate channel for each dongle now. The selected dongle will change its channel accordingly and likewise all assigned sensors.

Figure 8.8: Dongle Configuration - Selection of a radio channel

 The default channels for all dongles and sensors are 35 and 55 (out of 80).

☞ **Do not set both dongles to the same channel or on occupied frequencies from other devices in range..**

☞ **In case channels are already occupied by other devices in range (e.g. WLAN) connection problems may occur. *ART* recommends to scan for available channels and to select free channels accordingly. A minimum distance of 10 channels is mandatory between dongles and recommended from occupied channels for optimum connectivity.**

8.6.1.3 Connecting the wireless inertial sensors

This needs to be done initially - in case the sensors are already connected please skip this step.

All *ART* pre-calibrated targets are delivered with their corresponding optical target geometries stored inside the inertial sensor. Thus when adding the recognized inertial sensors, all corresponding target geometries are automatically added to the tab '*standard bodies*' in the menu *Body Administration* (Shortcut:F8) and the sub-dialog *Hybrid Bodies* of the menu *Inertial Sensor Settings* respectively.

ℹ️ **ART delivers pre-calibrated wireless targets (not available for *SMART-TRACK3* & *SMARTTRACK3/M*) as well as a pre-calibrated hybrid motion capture suit (not available for *SMARTTRACK2/3/M*), i.e. both the optical target geometry as well as the hybrid body calibration are stored directly on the sensor. Unless the hybrid targets are disassembled or become damaged, it is sufficient to identify and add all sensors using the menu *Hardware* → *Inertial Sensor* → *Add Sensors*. There is no need to (re-)assign the inertial sensors on pre-calibrated targets or to calibrate the targets manually.**

☞ **Please ensure that all sensors have been charged or alternatively attach the sensors to the supplied charging hub prior to the following steps.**

Turning on/off wireless inertial sensors Turn on all sensors by pressing their corresponding buttons. The status LED will turn green.

All inertial sensors are turned to stand-by mode after a pre-defined idle time, which corresponds to the selected wake-up mode.

via: *radio* (idle time: 1 min.), i.e. the sensors are switched on as soon as they are addressed by the *SMARTTRACK2* or controller.

via: *tapping* (idle time: 3 min., older sensors only), i.e. the sensors are switched on by tapping on the sensors with your fingertip or tapping the sensors on a hard surface (e.g. table).

via: *USB/button* (idle time: 10 min.), i.e. the sensors are switched on by pressing the button on the sensor for 3-4 seconds or by connecting them to the supplied charging hub.

☞ **For optimal battery life, *ART* recommends to switch all sensors to wake-up mode "USB/button" when not in use for a longer period of time.**

Adding wireless inertial sensors In the menu *Hardware* → *Inertial Sensor*, press *Add sensor* to identify and connect all inertial sensors in range (see figure 8.7 on page 83). In the upcoming dialog (see figure 8.9 on page 86) you should find the *Scan mode* being '*USB*'. Change the mode to '*default channels*' using the adjacent selection box. In this
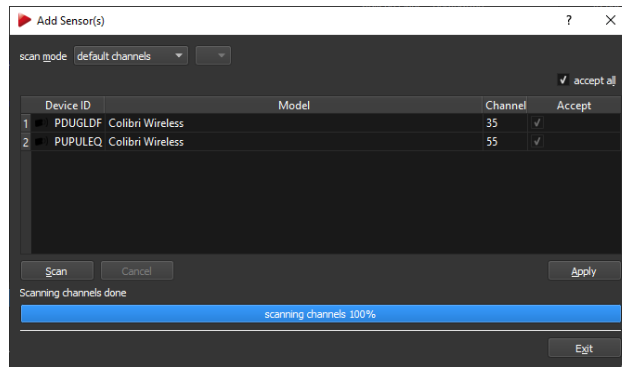
Figure 8.9: Adding wireless inertial sensors

mode **DTRACK3** will search for the sensors on the default channels 35 and 55 even if the current channel of dongles / sensors has been set differently.

In case the dongles / sensor channels have been set manually, please change the scan mode to '*single*' and select the corresponding channels in the adjacent selection box.

Press *Scan* and the system will identify all sensors in range running on the specified channels. Expect 15 inertial sensors for a complete **ART** Hybrid Motion Capture suit (not available for **SMARTTRACK2/3/M**). Tick the checkboxes of all sensors to be added to the configuration in the column *Accept* or add all sensors at once by ticking '*accept all*'. Then press *Apply* and exit this dialog.

> **If you cannot remember the current radio channel of your sensors, you can either choose '*all*' to scan all channels (from 1 to 80, note: this takes some time) or identify the sensors via wired connection. To this end connect all sensors to the controller via a USB charging cable and select the scan mode '*USB*'. All attached sensors will be listed together with their corresponding channel.**

> **Take care that all inertial sensors are assigned to a radio channel of one of the dongles; otherwise such a sensor will not be available for measurement. Also take care that roughly the same number of sensors are assigned to each dongle.**

8.6.1.4 Configuring the wireless inertial sensors

After adding the sensors the dialog *Inertial Sensor Settings* (see figure 8.10 on 87) now shows all available dongles and their assigned sensors with the following sensor properties:

> **The temperature values between single inertial sensors may vary. The operating temperature is reached as soon as there are no more temperature changes inside the sensors indicated by a green status bar. This is not dependent on the absolute temperature value.**
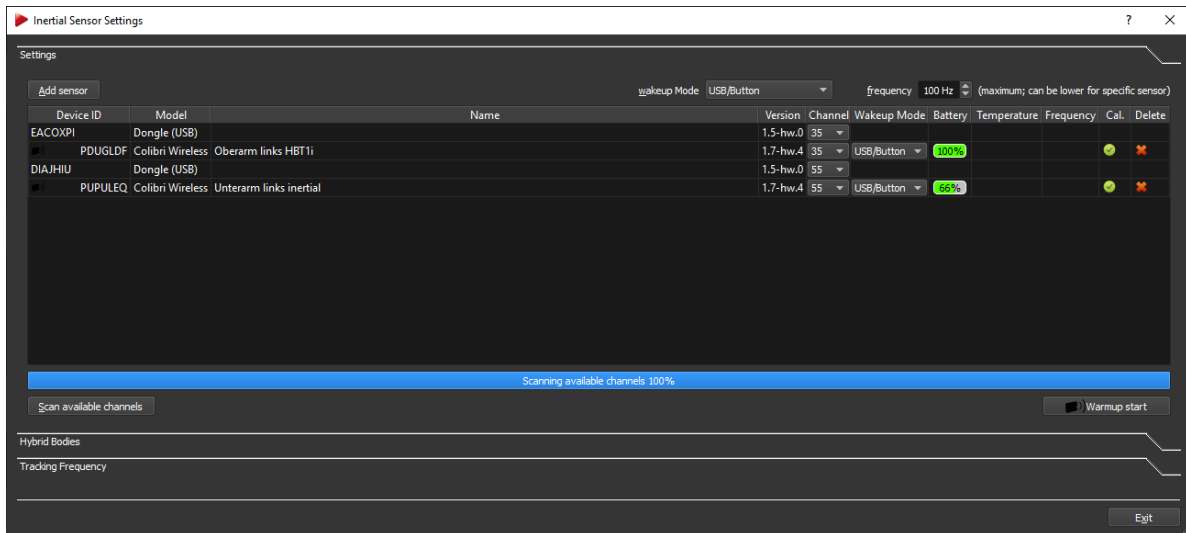
Figure 8.10: Inertial Sensor Settings - Wireless transceivers and sensors added

Info	Description
Device ID sensor + wireless icon	Shows the serial number of the sensor
Model	Shows the type of the sensor (e.g. Colibri Wireless)
Name	Shows the target name (pre-calibrated from Hybrid Motion Capture suit or user-defined)
Firmware Version	Shows the firmware version of the sensor
Currently used radio channel	Shows the radio channel of the sensor (default: 35 / 55); use the drop-down menu to change the radio channel
Wake-up mode	Select the mode to start-up the sensor (radio, tapping, USB/button); use the drop-down menu to change the wake-up mode
Battery level	Shows the remaining battery power in %
Temperature	Shows the sensor temperature (°C, only after a measurement has been started)
Current tracking frequency	Shows the currently set tracking frequency (Hz, only after a measurement has been started)
Calibration status	Shows the calibration status of the associated body (*not calibrated*, *optical only*, *fully calibrated*)
Delete	Deletes the currently selected sensor from the list

Table 8.12: *ART* wireless inertial sensor settings

Tracking frequency Finally check the maximum tracking frequency the inertial sensors are operating at (default for wireless sensors: 100 Hz). Use the spinbox in the upper right corner of the window to select a different value, if necessary.

Selecting the pulse generating source Please refer to chapter 8.6.2.5 on page 95 for further details.

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☞ **It is <u>NOT</u> recommended to select a wireless inertial sensor as pulse generator due to the nature of the connection (i.e. high latencies and timing jitter). Change the default settings in the sub-dialog *Tracking Frequency* only when necessary.**

8.6.1.5 Calibration of custom wireless hybrid targets

Custom wireless hybrid targets will show up as '*not calibrated*' in the column *Calibration* under the tab '*standard bodies*' in the menu *Body Administration* (Shortcut:F8) or in the sub-dialog *Hybrid Bodies* of the menu *Inertial Sensor Settings*. Therefore a multi-step calibration procedure for each body has to be performed analog to wired hybrid targets. Please refer to chapter 8.6.2 on page 88.

☞ **Reassignment or disassociation of inertial sensors and pre-calibrated optical targets will render the corresponding bodies useless. Therefore enter the sub-dialog *Inertial Sensor Settings* → *Hybrid Bodies* only when necessary.**

8.6.2 Wired hybrid targets

Within **DTRACK3** go to the menu *Hardware* → *Inertial Sensor* → *Hybrid Bodies* (see figure 8.14 on 91) and activate the desired amount of bodies . Next assign suitable names by double-clicking the corresponding field *Name* from row '*1...n*' under *selected body*. Now a multi-step calibration procedure for each body has to be performed:

1. A standard optical body calibration needs to be carried out. Alternatively load a body calibration from a file. Start by pressing the button *Calibration*. Please refer to 9.5.1 on 121 for more details.

2. An inertial sensor has to be added and then assigned to an optical target. Please refer to chapters 8.6.2.1 on page 89 and 8.6.2.2 on page 91 respectively for further information.

3. A hybrid body calibration has to be performed to align the inertial sensor with its corresponding optical target by pressing the button *Hybrid Body Calibration*. During this hand-eye calibration process the relative orientation of the two coordinate systems is determined. Please refer to chapter 8.6.2.3 on page 92.

4. An inertial sensor calibration needs to be applied to compensate drift from the inertial sensor. Start by pressing the button *Inertial Sensor Calibration*. Please refer to chapter 8.6.2.4 on page 94.

Repeat all steps for each hybrid target and finally set the pulse generating source that drives the tracking frequency according to your application's requirements. Please refer to chapter 8.6.2.5 on page 95.

ℹ️ **Wired hybrid targets for use with e.g. HMDs are <u>NOT</u> delivered pre-calibrated due to the fact that mechanical changes during assembly on top of the customer's gear would render any pre-calibration useless.**

8.6.2.1 Connecting the wired inertial sensor

This needs to be done initially - in case the sensor is already available please skip this step.
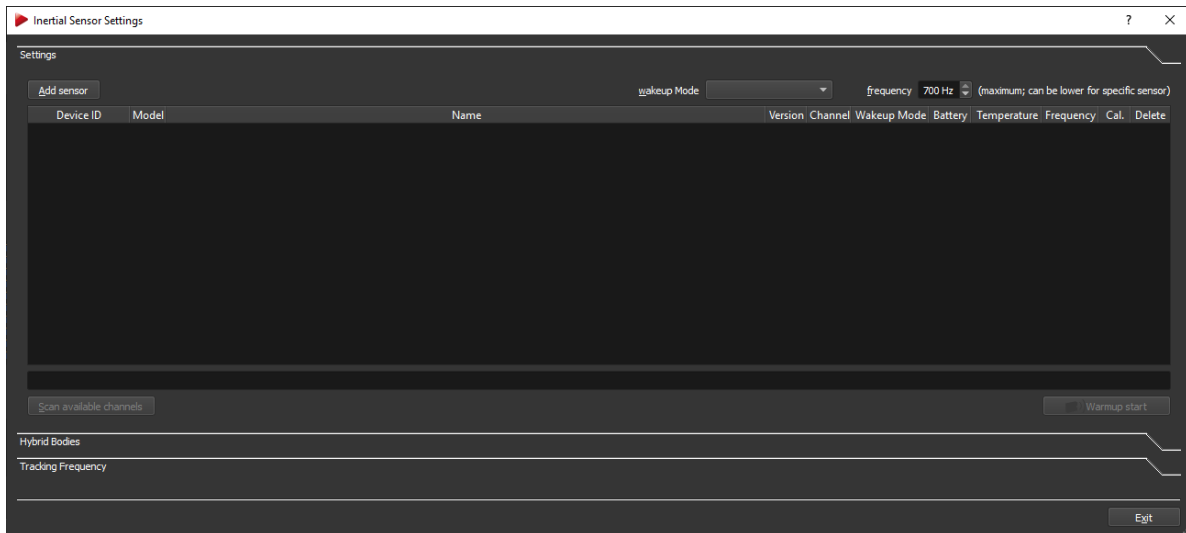Go to the menu *Hardware → Inertial Sensor* and open the *Settings* sub-dialog (see figure 8.11 on page 89).

Figure 8.11: Inertial Sensor Settings - No wired inertial sensor connected

☞ **Never attempt to connect *3-Space* wired sensors / hybrid targets to a personal computer or try to access the sensor using software provided by the original manufacturer *Yost Labs*. This may result in irreversible damage to the sensor.**

☞ **Use an externally powered USB-hub (USB 2.0) for connecting the wires sensor / hybrid target to the free USB port of the *SMARTTRACK2/3/M* . Otherwise proper function of the sensor cannot be guaranteed.**

Adding wired inertial sensor   Please ensure that the sensor has been connected to the controller. Then press the button *Add sensor*.

In the upcoming dialog (see figure 8.12 on page 90) you should find the *Scan mode* being '*USB*'.
Press *Scan* and the system will identify all attached sensors. Tick the checkbox of the sensors to be added to the configuration in the column *Accept* or add all sensors by ticking '*accept all*'. Then press *Apply* and exit this dialog.

The dialog *Inertial Sensor Settings* (see figure 8.13 on page 90) now shows all available sensors with the following properties:

Tracking frequency   Finally check the tracking frequency the inertial sensors are operating at (default for wired sensors: 700 Hz). Use the spinbox in the upper right corner of

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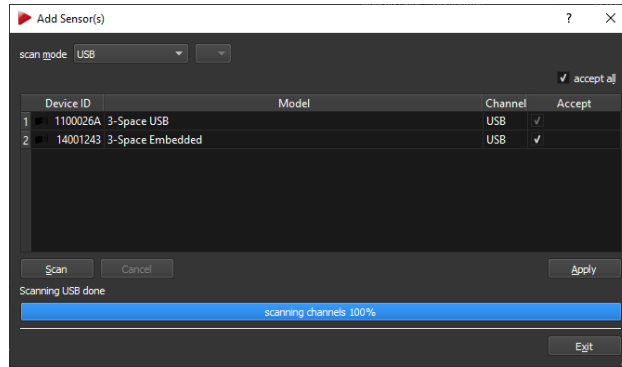
Figure 8.12: Adding wired inertial sensor
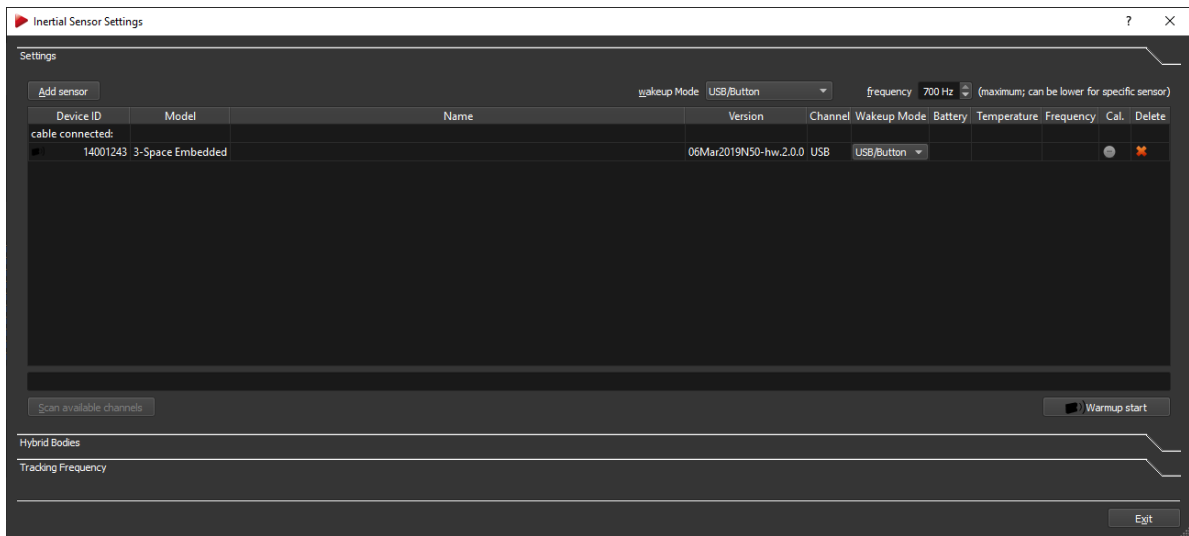
Figure 8.13: Inertial Sensor Settings - Wired inertial sensor added

Info	Description
Device ID sensor	Shows the serial number of the sensor
Model	Shows the type of the sensor (e.g. 3-Space wired)
Name	Shows the target name (empty unless user-defined)
Firmware Version	Shows the firmware version of the sensor
Currently used radio channel	Shows the currently used channel (USB only)
Wake-up mode	N/A for wired sensors
Battery level	N/A for wired sensors
Temperature	Shows the sensor temperature (°C, only after a measurement has been started)
Current tracking frequency	Shows the currently set tracking frequency (Hz, only after a measurement has been started)
Calibration status	Shows the calibration status of the associated body (*not calibrated*, *optical only*, *fully calibrated*)
Delete	Deletes the currently selected sensor from the list

Table 8.13: *ART* wired inertial sensor settings

the window to select a different value, if necessary.

8.6.2.2 Assigning the wired inertial sensor

After adding the inertial sensor it needs to be assigned to an optical target, which has been calibrated beforehand. Change to the sub-dialog *Hybrid bodies* inside the dialog *Inertial Sensor Settings* (see figure 8.14 on 91).
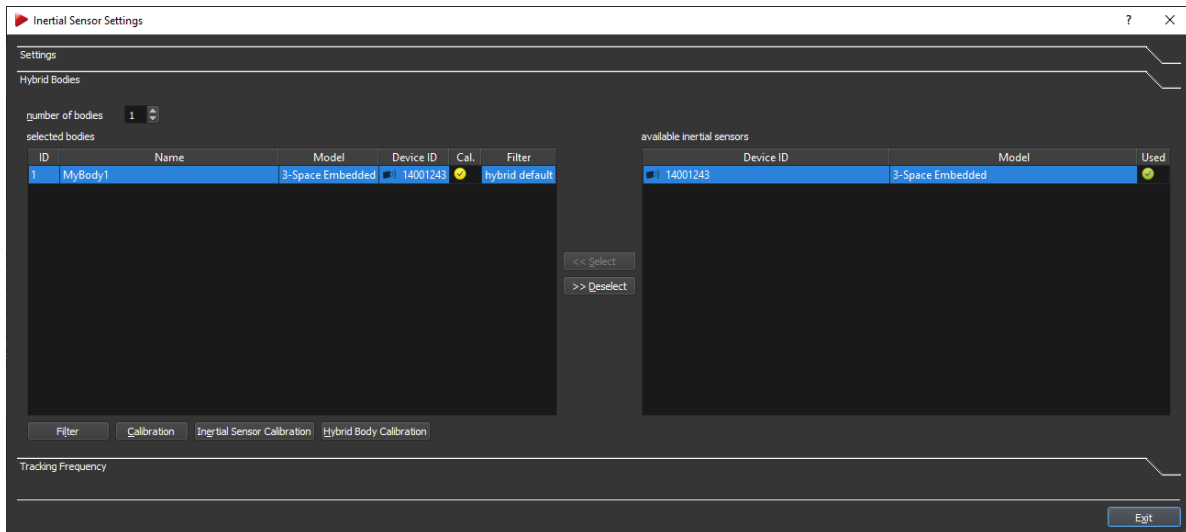
Figure 8.14: Inertial Sensor Settings - Hybrid Bodies sub-dialog

In order to assign an inertial sensor to a optical target follow these steps:

1. mark the respective *Body ID* under *selected bodies* by left-clicking

2. mark the appropriate entry '*Device ID*' under *available inertial sensors* by left-clicking and

3. press *Select*.

You can always delete the assignment by pressing the button *Deselect*. The inertial sensor will be available again for assignment.

After assignment the corresponding body is shown on the left side of the window with the following properties (see figure 8.14 on 91):

> **In order to identify the inertial sensor and to assign it to the corresponding *Body ID* please double-check the serial number on top of the sensor and compare it to the entry in column *Device ID*.**

> **If the inertial sensor is already in use a green tick is shown in the column *Used* on the right side of the window.**

> **For each uncalibrated body the '*Name*' entry will be empty, while the column *Cal.* will show a *No Entry* sign.**

selected bodies	Description
Body ID	Shows the body ID number of the hybrid target
Name	Shows the target name (empty unless user-defined)
Model	Shows the type of the assigned inertial sensor (e.g. 3-Space wired)
Device ID	Shows the device ID of the assigned inertial sensor
Calibration status	Shows the calibration status of the associated body (*not calibrated*, *optical only*, *fully calibrated*)
Filter Status	Shows the currently selected 6DoF tracking filter algorithm (please refer to chapter 9.4.1 on page 117)

available inertial sensors	Description
Device ID	Shows the device ID of the connected inertial sensor
Model	Shows the type of the connected inertial sensor (e.g. 3-Space wired)
Assignment status	Shows the assignment status of the connected inertial sensor body (*not used*, *used*)

Table 8.14: Inertial Sensor Settings - Hybrid Bodies sub-dialog

Body IDs without corresponding hybrid body calibration are marked with a yellow tick on the corresponding *Body ID* row in the column *Cal.*.

A fully calibrated *Body ID* is marked with a green tick.

8.6.2.3 Hybrid Body Calibration

After assigning an inertial sensor , select the respective *Body ID* under *selected bodies* and press the button *Hybrid Body Calibration* (see figure 8.14 on 91).
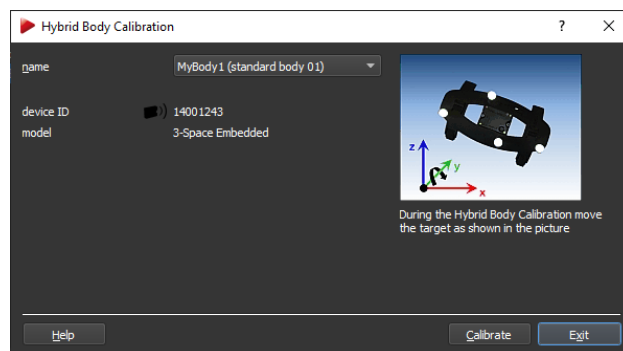
Figure 8.15: Hybrid Body Calibration

In the appearing window (see figure 8.15 on page 92) verify the target by its corresponding '*name*' and '*bodyID*' from the adjacent drop-down menu. Also double-check the '*Device ID*' of the inertial sensor for correspondence with the selected optical target. Then press *Calibrate*.

During the following calibration process the target has to be tilted with moderate speed around all axes of the inertial sensor (please refer to the animation in the dialog see figure 8.15 on page 92). After the countdown disappears the upcoming dialog will show the status of the calibration via a progress bar (see figure 8.16 on page 93.)
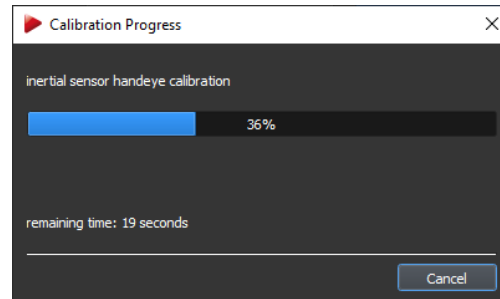
Figure 8.16: Hybrid Body Calibration - Progress Bar

In the upcoming result window (see figure 8.17 on page 93) the residual of the calibration and the sensor delay of the inertial tracking data is displayed.

You can accept the calibration by pressing *OK* to return to the *Hybrid Body Calibration*. Press *Exit* to return to the *Hybrid Bodies* sub-dialog. Now, the sensor should show a green tick in the column *Calibration* under *selected bodies* on the left side of the window.
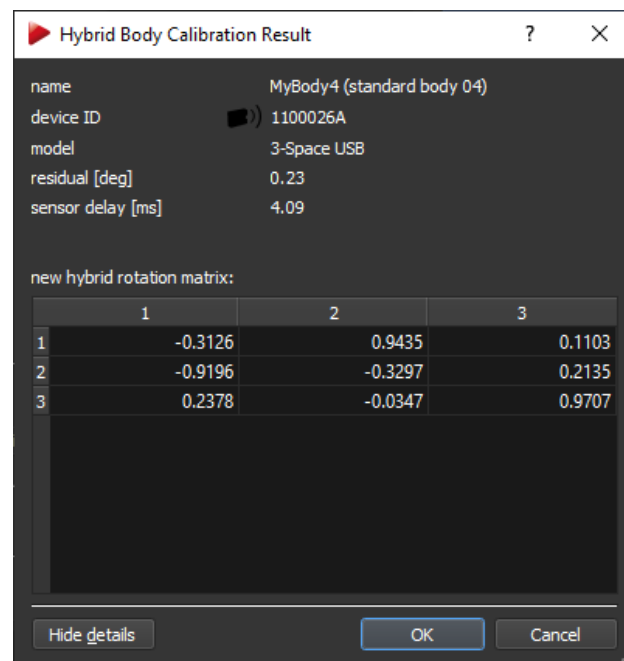
Figure 8.17: Hybrid Body Calibration Result

The residual specifies how well the rotational data from the inertial sensor matches the optical tracking data. Thus it is a measure of the accuracy of the hybrid body calibration. Values up to $1°$ are ideal, while anything less than $3°$ is still acceptable.

> **ℹ** **The sensor delay specifies the latency of the inertial data compared to real-time. This is sensor specific and dependent on the type of connection (wired / wireless). Values up to 5 ms are ideal for HMD applications.**

Show details   You can display the result of the hybrid body calibration as a rotation matrix by pressing the button *Show details*.

8.6.2.4 Inertial Sensor Calibration

After successful calibration of all hybrid bodies , a drift correction for all inertial sensors should be measured and applied. To this end, all sensors have to be warmed-up beforehand. Please refer to chapter 8.6.2.4 on page 95 for more details.

To start the inertial sensor calibration, go to *Inertial Sensor Settings → Hybrid bodies → Inertial Sensor Calibration* (see figure 8.14 on 91). The upcoming window shows a list of all available hybrid targets, i.e. bodies with successful optical calibration and assigned inertial sensor (see figure 8.18 on page 94).
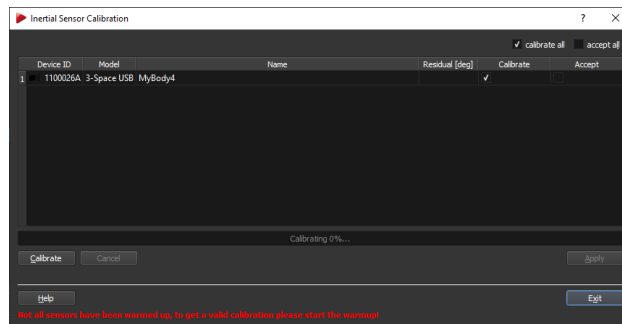
Figure 8.18: Inertial Sensor Calibration

Put the respective sensor (or all at once) inside the tracking volume on a level surface, provided a successful Hybrid Body Calibration for each inertial sensor has been performed beforehand. Tick the checkboxes in the column *Calibrate* of all sensors to be calibrated and press *Calibrate*. Do not move or touch the sensor(s) during the following calibration! In the upcoming result window (see figure 8.19 on page 95 the residual of the drift correction is displayed.

When the calibration is done, you can apply the drift correction either to a single sensor by ticking the appropriate checkbox in the column *Accept* or by ticking '*accept all*' for all sensors in range. Press *Apply* and exit the dialog. A list of all successfully calibrated sensors appears (see figure 8.20 on page 95. Press *Exit* to return to the *Inertial Sensor Calibration* window. Return to the *Inertial Sensor Settings → Hybrid Bodies* subdialog by pressing *Exit* once again.

> **ℹ** **The residual specifies the drift correction for the inertial sensor. Values below 0.1 ° are ideal, while still being acceptable up to 0.2 ° . Higher values indicate possible movement during the calibration.**

> **ℹ** **After the Inertial Sensor Calibration has been performed and applied its result is stored directly on the sensor for future use.**
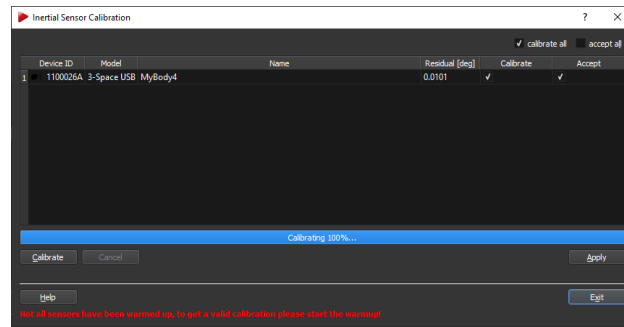
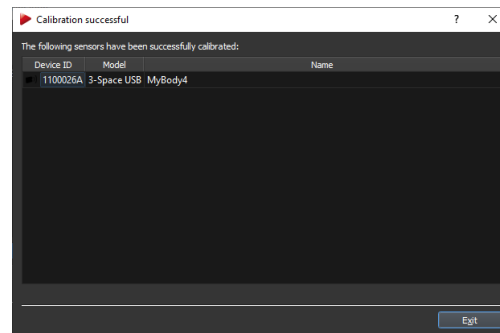Figure 8.19: Inertial Sensor Calibration - Result Window

Figure 8.20: Inertial Sensor Calibration - Result Window Successful

Warm-up of inertial sensors   To start up the procedure simply press the button *Warmup start* in the dialog *Inertial Sensor Settings* (see figure 8.13 on page 90) or in the *toolbar* of **DTRACK3** frontend (refer to chapter 6.2 on page 43) and leave the process running for about 5-10 minutes. The progress bar will stop at 100% (progress bar turns green) even though the warming up of the sensors continues. This shall guarantee that the sensors work continuously and do not cool down until the calibration takes place.

☞ **Please ensure that all sensors have been charged prior to any calibration process.**

☞ **Please perform inertial sensor calibrations with warmed-up sensors at constant ambient temperature prior and during the calibration for optimum tracking performance.**

8.6.2.5 Selecting the pulse generating source

There are several independent pulse generating sources available in a hybrid tracking setup (i.e. combined optical & inertial tracking). Therefore it is necessary to select the appropriate one that drives the tracking frequency.

You can switch between the following sources by ticking the corresponding radio button in the subdialog *Inertial Sensor Setting → Tracking frequency*:

- '*as ART cameras*': The **SMARTTRACK2/3/M** or the controller's **Synccard** is used. The tracking frequency is set according to the *Synccard Settings* menu. Please refer to the corresponding chapters 8.4 on page 78.

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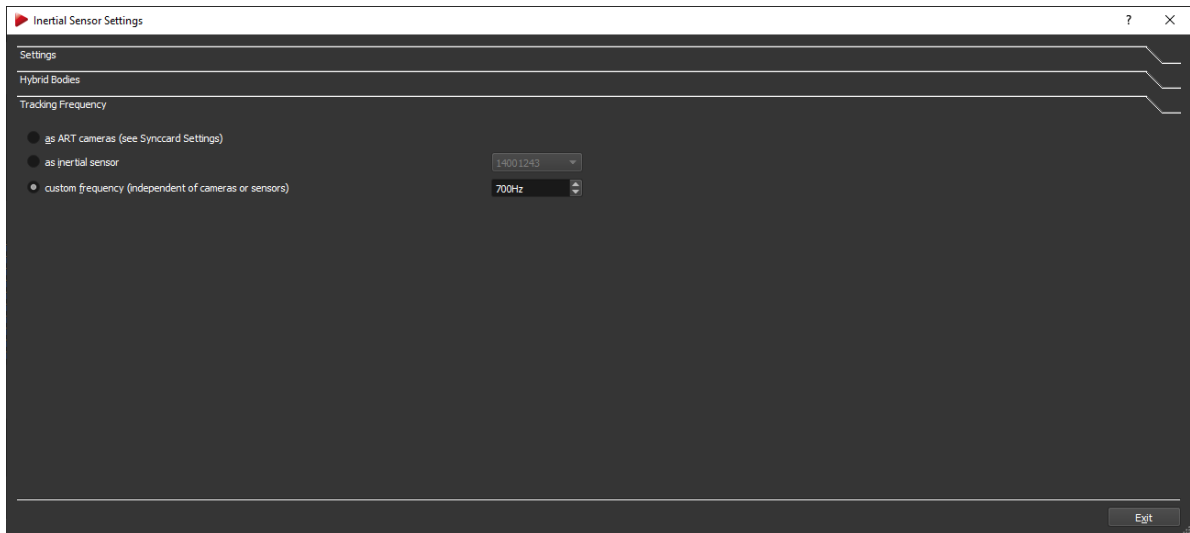
Figure 8.21: Inertial Sensors Settings - Tracking Frequency

- '*as inertial sensor*': An inertial sensor is used (only available, if attached). When using multiple inertial sensors use the adjacent drop-down menu to select the appropriate one. The tracking frequency is set according to the *Inertial Sensor Settings* menu. Please refer to the corresponding chapter 8.6.2.1 on page 89.

- '*custom frequency*': An internal source is used providing a custom frequency. Use the adjacent spinbox in a range from 10 to 1000 Hz (up to 400 Hz with **SMART-TRACK2/3/M**).

> **Selecting a custom frequency higher than the tracking frequency provided by the inertial sensors (e.g. 700 Hz for *3-Space* wired inertial sensors) could lead to minor tracking quality.**

> **Keep in mind that '*send data divisor*' in menu *Output Settings* is also affecting the resulting data output frequency. Please refer to chapter 9.11 on page 154 for further information.**

> **It is <u>NOT</u> recommended to select a wireless inertial sensor as pulse generator due to the nature of the connection (i.e. high latencies and timing jitter). Therefore enter the sub-dialog *Tracking Frequency* only if necessary.**

8.7 Network

On the *Network* window you may change the network specific settings and check the CPU temperatures inside the controller.

DHCP According to your network guidelines it may be necessary to specify *hostname* and the *domain*. Furthermore you can configure the settings for DHCP support.
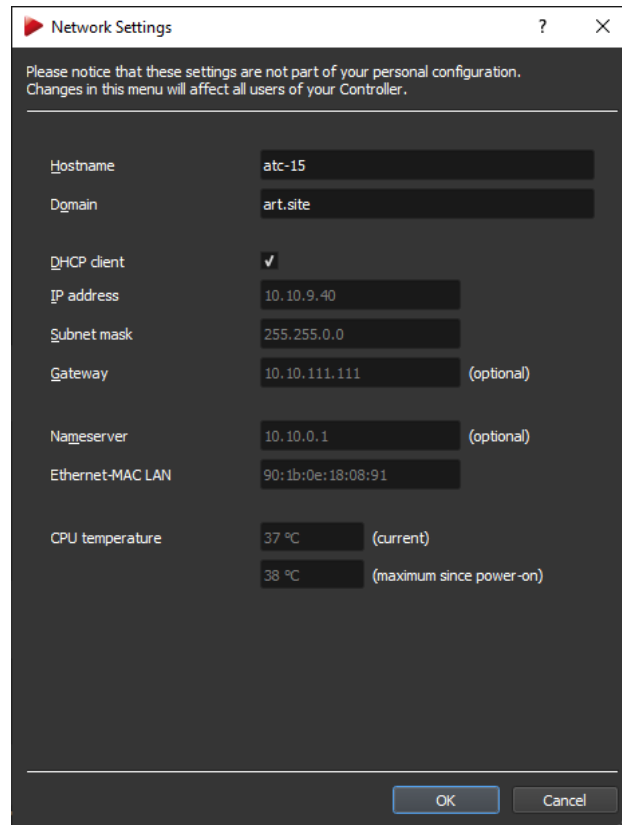
Figure 8.22: Network Settings

When the checkbox *DHCP client* is ticked the controller may be connected to a LAN with DHCP support. The controller then works as a DHCP client. The corresponding *IP address*, *subnet mask*, *gateway* and *nameserver* which have been assigned to the controller by the DHCP server are shown for your information. The MAC address of the controller is printed in the field *ethernet-MAC LAN*.

> **If the network cable is unplugged or the DHCP support is unavailable while booting the controller uses its default IP address (i.e. 192.168.0.1).**

Static IP Address By unticking the checkbox *DHCP client* you may specify a static *IP address*, *subnet mask* by entering the settings in the appropriate fields. Optionally, enter *gateway* and *nameserver*. Accept the changes pressing *OK* and exit the dialog. Reboot the controller for the changes to take effect.

> **Please avoid IP addresses 172.28.X.X and IP addresses in the range from 172.29.0.1 to 172.29.0.20, as they are used for internal communication!**

> **Please note that these settings are not part of your personal configuration. Changes in this menu will affect all users of your controller! Your controller may become unreachable with wrong IP settings! Refer to chapter 5.3 on page 36.**

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Chapter 8

CPU temperature At the bottom of this dialog you can read the CPU temperature inside the controller. The upper value shows the *current* temperature in °C, while the lower value indicates the temperature *maximum since power-on*, i.e. the highest temperature reached since the controller has been started. When reaching elevated or critical levels, the values are highlighted in orange or red color.

8.8 Time

In the *Time* window you can set the controller's internal clock as well as synchronize it with a master clock (i.e. a reference time source) using NTP (= Network Time Protocol) or PTP (= Precision Time Protocol). The supported versions are NTP Version 3 (RFC 1305) and PTP IEEE 1588-2008.

Both protocols are designed to synchronize system clocks among a set of distributed time servers and clients. While NTP is widely used in essentially all general purpose computers to synchronize computer clocks in and over the Internet, PTP addresses the increasingly stringent clock synchronization requirements of spatially localized systems, such as measurement and control systems. Therefore PTP is designed for accuracies beyond those attainable using NTP with PTP devices achieving sub-microsecond accuracy.
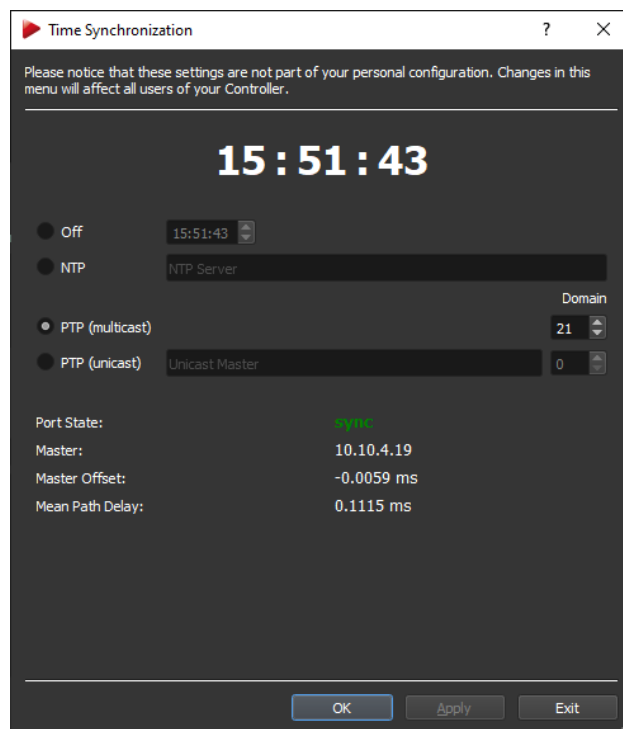
Figure 8.23: Time Settings

The currently set time of the controller is displayed on top of the dialog.

Off The *Off* can be selected to manually set the local time using the entry fields [hh:mm:ss].

NTP In order to activate the NTP synchronisation , select the radio button *NTP* and enter a *hostname* or *IP address* of your NTP server. Please ask your system administrator for further information. Click *Apply* to activate the synchronisation.

While the controller is being synchronised the message '*wait*' is displayed next to the '*state*' at the bottom of the dialog. As soon as the connection has been established, the '*state*' will switch to '*sync*'. Additionally the quality for the connection to the NTP server is measured by its '*reachability*'. The values can range from 0% to 100 %, with higher values indicating good connection quality. Furthermore the quality of the time synchronisation of the master clock and the controller's internal clock is indicated by the '*estimitated precision*' in the unit milliseconds (m̄s).

In case the connection to the NTP server is lost the '*state*' will switch to '*wait*' again.

PTP multicast For synchronisation with a PTP multicast master server select the radio button *PTP multicast* and enter the respective *domain* setting. Please ask your system administrator for further information. Click *Apply* to activate the synchronisation.

While the controller is being synchronised the message '*wait*' is displayed next to the '*port state*' at the bottom of the dialog. As soon as the connection has been established, the '*Port state*' will switch to '*sync*' and the IP address of the master server is shown next to '*master*'. Additionally the quality for the connection to the PTP server is measured by '*master offset*' and '*mean path delay*' with lower values indicating a better connection quality.

In case the connection to the PTP server is lost the '*port state*' will switch to '*wait*' again.

PTP unicast For synchronisation with a PTP unicast master server select the radio button *PTP unicast*, enter the *IP address* of your PTP server and the respective *domain* number setting. Please ask your system administrator for further information. Click *Apply* to activate the synchronisation.

While the controller is being synchronised the message '*wait*' is displayed next to the '*port state*' at the bottom of the dialog. As soon as the connection has been established, the '*Port state*' will switch to '*sync*'. Additionally the quality for the connection to the PTP server is measured by '*master offset*' and '*mean path delay*' with lower values indicating a better connection quality.

In case the connection to the PTP server is lost the '*port state*' will switch to '*wait*' again.

> ℹ️ **NTP is fully supported with Version 3 (RFC 1305), PTP is supported according to IEEE 1588-2008.**

> ℹ️ **Synchronisation with NTP or PTP servers does not affect active measurements, but the timestamps of the tracking results are changed accordingly.**

> ℹ️ **Synchronisation with NTP or PTP servers usually succeeds quite fast (at least in a few seconds). Nevertheless it could be reasonable to give the system some time for complete synchronisation.**

> ☞ **It is highly recommended to synchronize with a local NTP or PTP master clock rather than to a remote time server on the Internet. Otherwise due to network latency and jitter the accuracy of the controller's clock may be degraded too far in order to generate useful timestamps.**

Chapter 8

9 Menu Tracking - Tracking Configuration

Calibration	Shortcut
Room calibration	F5
Room adjustment	Shift + F5
Single markers	
Body administration	F8
Body calibration	F6
Body adjustment	Shift + F6
Flystick	
Fingertracking	(not available for **SMARTTRACK2/3/M**)
Measurement Tool	
Measurement Tool tip calibration	
Output	F9

Table 9.1: Menu *Tracking*

9.1 Room Calibration

Use the room calibration dialog (see figure 9.1 on page 101) to start the calibration process and set parameters therefore. After opening the dialog, the *Monitor 2DOF display* is automatically started in the background. It is possible to transfer a room calibration from one configuration to another (refer to section 9.1.7 on page 106).

☞ **It is recommended to perform a room (re-)calibration on a regular basis (e.g. after a certain operating time of the system) and especially if the system was subject to extreme vibrations or changing environmental conditions (.e.g. high or low temperatures).**

9.1.1 Pre-defined room calibration sets

In the *Room calibration* dialog you can choose from a series of predefined calibrations sets (i.e. a pair of '*calibration angle*' and '*wand*' representing the common **ART** Room Calibration Sets, see table 9.2 on page 101).
Select the calibration set that has been delivered with your tracking system using the dropdown-menu *marker distances*. Verify the wand length or enter it manually in the corresponding field *wand length*, see figure 9.1 on page 101. The wand length is printed on
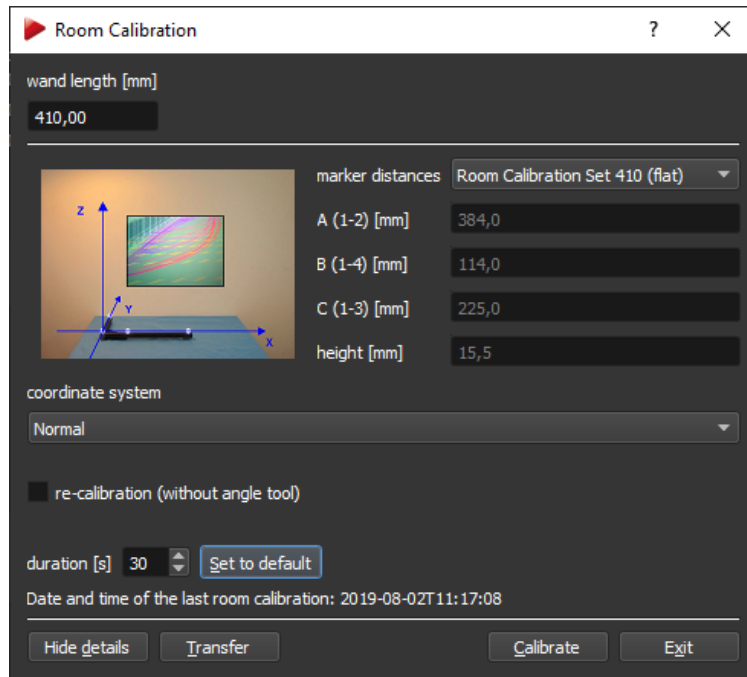
Figure 9.1: Room calibration - using calibration set RCS410

Calibration Set	wand length [mm]	marker dia. [mm]	height [mm] (see Fig. 9.2)
RCS TP (discontinued)	410.0	20	55
RCS 150 (special order)	184.0	16	15.6
RCS 150 active (special order)	204.63	N/A	15.5
RCS 410 flat	410.0	20	15.5
RCS 410 high (discontinued)	410.0	20	43
RCS 710	710.0	20	43
RCS 720 (special order)	720.0	30	48

Table 9.2: Overview of the **ART** Room Calibration Sets (RCS)

the 'wand' .

Place the 'calibration angle' inside the tracking volume of your cameras, double-check that all markers of the 'calibration angle' are seen by the cameras. Start the calibration by pressing *Calibrate*. The room calibration is started with a five seconds delay.

9.1.1.1 Expert settings

Marker distances of the 'calibration angle' can also be set manually using the setting *marker distances → expert*. The numbering of the markers is as seen in figure 9.2 on page 102.

Type	longer arm	shorter arm
'normal'	+X axis	+Y axis
'powerwall'	+X axis	-Z axis

| (a) type 'normal' | (b) type 'powerwall' |
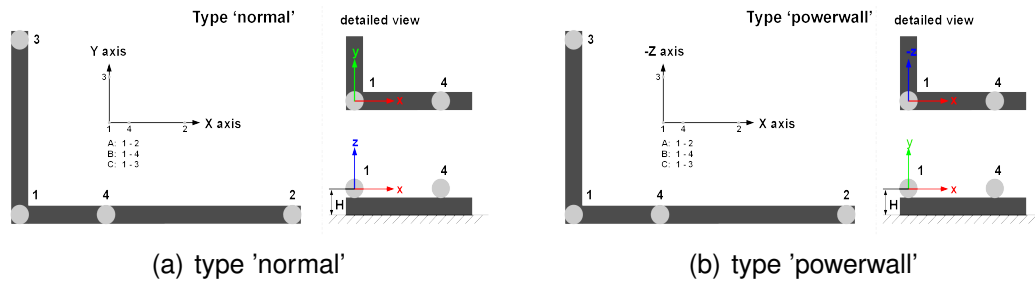
Figure 9.2: Marker distances (including numbering) on the '*calibration angle*' and definition of room coordinate system

The longer arm of the '*calibration angle*' defines the X axis (refer to figure 9.2 on page 102); the shorter one defines the Y axis. The Z axis is added in order to give a right-handed coordinate system. The center of marker #1 defines the origin of the room coordinate system (at a height of see table 9.2 on page 101).

Incorrect input data for this dialog will lead to a poor room calibration, to wrong system scaling, or to an abort of the whole room calibration process.

9.1.2 Coordinate System

With the drop-down menu inside the dialog *Room calibration* you may define how the coordinate system of the room is created relative to the '*calibration angle*' (refer to table 9.3 on page 102).
Select either '*normal*' or '*powerwall*', see figure 9.1 on page 101.

Normal	Powerwall
Normal: The angle defines the X/Y plane (X at the longer, Y at the shorter arm) and Z axis is added upwards.	*Powerwall*: The angle defines the X/Z plane, the Y axis is added upwards. The Z axis points out of the screen. This is the standard screen coordinate system for many VR systems (e.g. OpenGL, TrackD, etc.).

Table 9.3: Defining the coordinate system for the room calibration

9.1.3 Room Calibration Progress

When the room calibration process starts a window showing the progress appears (see figure 9.3(a) on page 103). The progress is shown individually for each camera which is especially helpful for big systems. As soon as enough data for calculation of the camera position has been collected for a specific camera the corresponding progress bar changes its colour to green (see 9.3(b) on 103).

(a) shortly after start   (b) towards the finish
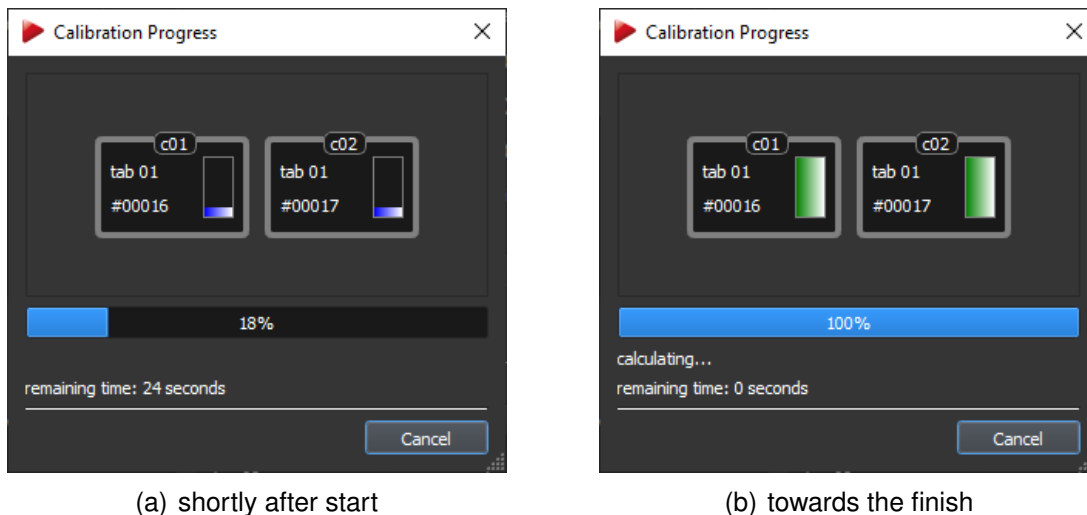
Figure 9.3: Room calibration progress

> **Note: The progress is also displayed individually on the 2-digit LED matrix display of each *ARTTRACK5* camera. After collection of sufficient data the LED matrix display changes back to its defined setting. Please refer to chapter 8.3 on page 71 for detailed information.**

> ☞ **The point cloud should fill at least two thirds of the measurement volume. Moving the '*wand*' in a restricted volume will results in reduced accuracy of calibration or failure.**

9.1.4 Room Calibration Results

After a successful room calibration, the *Room Calibration Result* window is displayed. This window shows measures to estimate the quality of room calibration (refer to table 9.4 on page 104.

The room calibration is confirmed (i.e., the data are stored) by pressing the button *OK*.

> **Try to achieve a low '*wand residual*' up to 1 mm for VR installations while having high values for '*Used Frames*'.**

> **The parameters '*Residual*' for each camera and the '*wand range*' depend on the system geometry and give additional information about the quality of calibration. Please call *ART* for further information.**
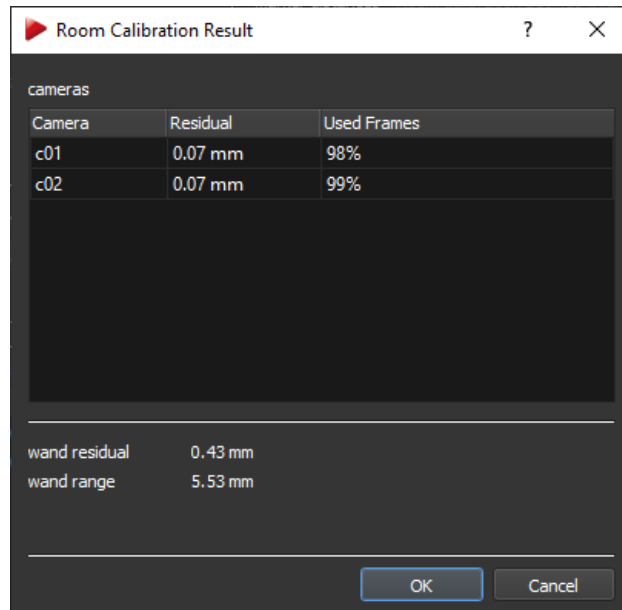
Figure 9.4: Room calibration result

indicator	Description
Residual	mean residual of single cameras (i.e. optical rays during marker detection)
Used Frames	represents the percentage of valid data for each camera (i.e. used for room calibration)
wand residual	mean deviation of '*wand length*'
wand range	max. deviation of '*wand length*'

Table 9.4: Room Calibration Result - Description of quality measures

☞ **The number of '*Used Frames*' should be greater than 70% for each camera. Values under 50% indicate poor room calibration quality.**

☞ **Please note that percentages of more than 70% may not be reached in large and complex measurement volumes.**

9.1.5 Room re-calibration

All camera setups (including **SMARTTRACK2/3/M**) may change after a certain operation time ; if e.g. movement of single cameras due to mechanical instabilities cannot be ruled out or thermal drifts occur it is necessary to perform room calibrations periodically.

DTRACK3 provides a simplified process to revise an existing room calibration without need of an '*calibration angle*', called Room re-calibration.
The '*calibration angle*' does not have to be present in the measurement volume; only the '*wand*' has to be moved the same way as for a standard room calibration. The main advantage of a *room re-calibration* is that **DTRACK3** preserves the origin and orientation of your coordinate system.

To re-calibrate your room tick the checkbox *re-calibration* in the bottom left corner of the room calibration dialog (see figure 9.5 on page 105). The settings *marker distances* and *coordinate system* are disabled / greyed out and thus are not allowed to be changed in comparison to the last valid standard room calibration. Settings regarding the 'wand' may be modified, however.

In case camera positions have changed since the last valid room calibration you have to mark them as 'moved' by unticking the corresponding checkboxes in *select static cameras* (see figure 9.5 on page 105). Start the calibration by pressing *Calibrate*. The room calibration is started with a five seconds delay.
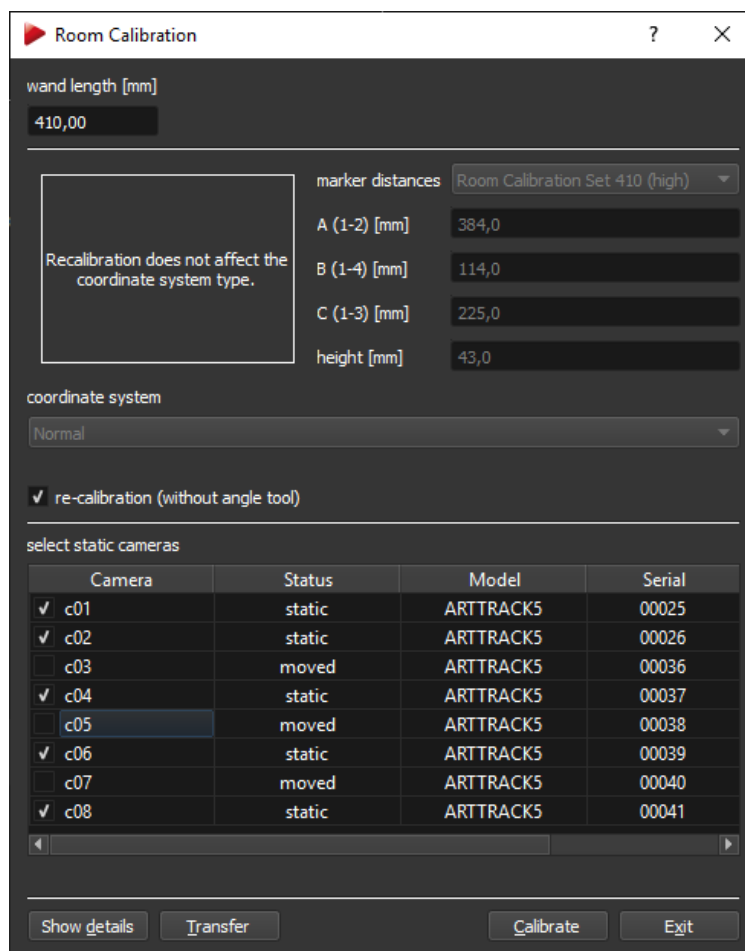
Figure 9.5: Room re-calibration dialog

☞ **Re-calibration is possible as long as camera movements are not too large. It will fail e.g. if the mounting of cameras has been changed completely.**

☞ **The checkbox *re-calibration* is enabled only for *coordinate system* → 'normal' or 'powerwall'. Select *coordinate system* → *middle of cameras* to retain the default orientation and position of the *SMART-TRACK2/3/M* automatically.**

9.1.6 Show Details

ⓘ **The button *Show details* offers information about the date of the latest room calibration.**

Duration   You may adjust the '*duration*' of the room calibration ($\rightarrow$ *Show details*) in a range of 10s - 120s. Reset the value to default by pressing the *Set to default* button (default = 30s).

☞ **Changing the duration of the room calibration towards shorter durations may lead to bad room calibration results! Please make sure that you are able to cover two thirds of the tracking volume within the set time.**

9.1.7 Transfer of room calibration data

In case different configurations need to share the same room calibration data, one can transfer the parameters from the currently running configuration to selected others. Press the button *Transfer* to open the *Transfer room calibration* dialog (see figure 9.6 on page 106). Select the configuration(s) you would like to apply the current room calibration data and press *Apply*.
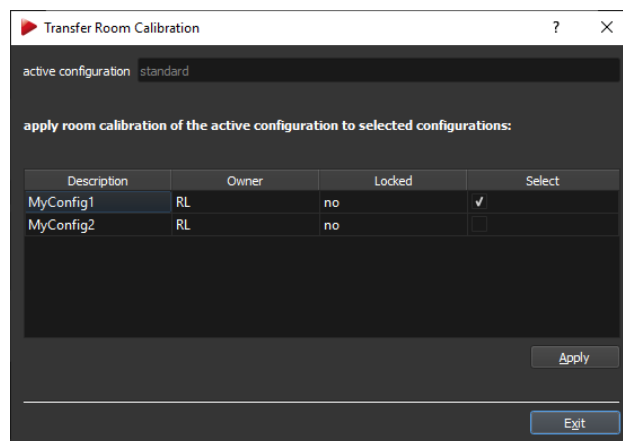
Figure 9.6: Transfer Room Calibration dialog

Accept the transfer by pressing *OK* or discard the changes by pressing *Cancel* (see figure 9.7(a) on page 107).

A status message will appear after the successful transfer (see figure 9.7(b) on page 107). Leave the *Transfer room calibration* dialog by pressing *Exit*.

ⓘ **Room calibration data can only be transferred to an unlocked configuration.**

☞ **Any previously acquired room calibration stored in another configuration will be overwritten during transfer. This process cannot be reverted !**

<table>
(a) Accept the Transfer   (b) Transfer Successful
</table>
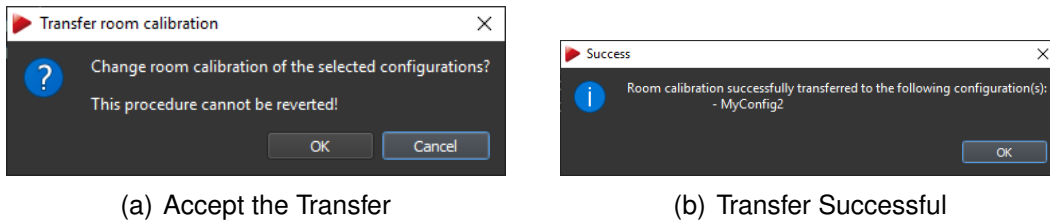
Figure 9.7: Transfer Room Calibration - sub-dialogs

9.1.8 Room Calibration - *SMARTTRACK2/3/M*

By default, the origin of the coordinate system lies approximately in the center between the two cameras . The orientation of the coordinate system is as shown in the *Room calibration* dialog (see figure 9.8 on page 107). If the default orientation and position of the coordinate system is not adequate for your application please choose the appropriate coordinate system (i.e. *normal* or *powerwall* and perform a new room calibration using the provided room calibration set (see table 9.2 on page 101). Please refer to section 9.1 on page 100 for detailed information.

To retain the default orientation and position of the coordinate system of the **SMART-TRACK2/3/M** (e.g. regular re-calibrations) select the *coordinate system → middle of cameras* using the drop-down menu.

The '*calibration angle*' does not have to be present in the measurement volume; only the '*wand*' has to be moved the same way as for a standard room calibration. Please refer to section 9.1.5 on page 104.
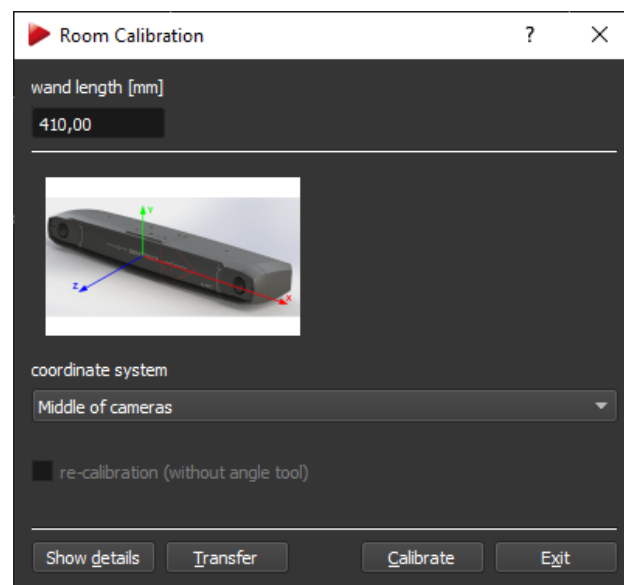
Figure 9.8: Room calibration settings - **SMARTTRACK2/3/M**

> **The SMARTTRACK2/3/M are pre-calibrated, you can start tracking without performing a room calibration.**

9.2 Room adjustment

During a room calibration the marker located in the intersection of the two arms on the '*calibration angle*' defines the origin of the coordinate system (Marker #1), see figure 9.2 on page 102. Oftentimes it might be more suitable to set the origin in respect to a well-known point in space. Use the room adjustment functionality to alter the room coordinate system after calibration.

Possible scenarios for the application of the *Room adjustment* functionality are:

- adjust the origin to the center of a screen,

- align the coordinate system colinear / parallel to a screen (Note: even very small angular deviations might lead to substantial misalignment across the full width of the projection typically 0.1° on 5m length equals 8.7 mm deviation)

- shift and / or rotate the camera coordinate system to match a reference coordinate system, e.g. from CAD models

- maintaining a specific coordinate system / orientation when using mobile installations of cameras, i.e. frequently changing the camera setup locations (suitable reference points provided)

In all these cases the coordinate system must be altered after calibration.

9.2.1 Room adjustment - Coarse

Open the *Room adjustment* dialog where the *Coarse* tab offers a simple way to manipulate the orientation of the room coordinate system with just one click (see figure 9.9 on page 109. On the left hand side of the dialog the current camera coordinates calculated from the room calibration process are displayed. On the right hand side you can define the orientation of two axes using the drop-down menus *Assign axes to room directions* - the third one will be oriented automatically according to the right-hand rule.

Press *Enter* or click *OK* to confirm all changes (i.e. changes are sent to the controller) and the dialog closes. Press *Apply* to accept the current changes but the dialog is left open. Discard all changes by pressing *Cancel*. Press *Reset* to switch back to the unmodified state.

9.2.2 Room adjustment - Fine

More detailed options to adjust the room coordinate system are given in the *Fine* tab (see figure 9.10(a) on page 110). By default a cartesian coordinate system is displayed on the left side of the window. On the right side of the window the room coordinate system may be customized freely, i.e. user-specific.
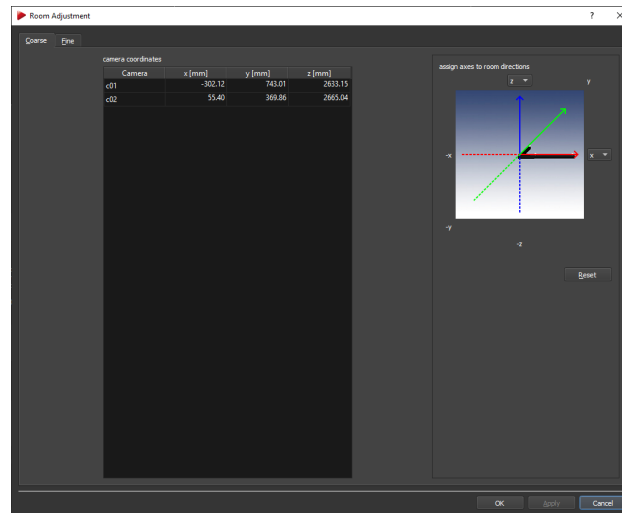
Figure 9.9: Room adjustment dialog (coarse)

9.2.2.1 Graphical display

The room coordinate system is shown as a triplet of arrows with a defined color-coding (x-axis - red, y-axis - green, z-axis - blue), while the xy-plane is shown as a yellow grid. The current and the transformed room coordinate systems are marked with ('*O*') and ('*T*') respectively.

The viewing position and orientation may be changed in two different ways:

1. hold down the "Ctrl" key and the left / right mouse button to change the position / orientation inside the graphical display

2. use the six control dials *View position* and *View orientation* (below the graphical view) to adjust position and orientation along all axes

To center the current room coordinate system, press *Adjust view*. To restore the default view (shift and orientation), press *Reset view*. The visualisation itself can be changed by clicking the right mouse button to open a context menu with the following options (refer to table 9.5 on page 109). (De-)select the appropriate ones by (un-)ticking.

Option	Description
'*Long axes*'	extends the coordinate axes of the body coordinate system by infinite dashed lines
'*Show XY plane*'	shows the XY plane (yellow grid)
'*Show YZ plane*'	shows the YZ plane (cyan grid)
'*Show XZ plane*'	shows the XZ plane (magenta grid)

Table 9.5: Room Adjustment (Fine) - Graphical display context menu
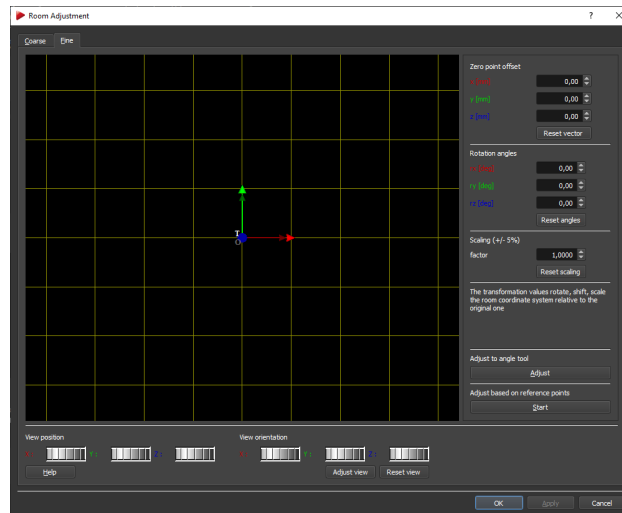
(a) before Transformation
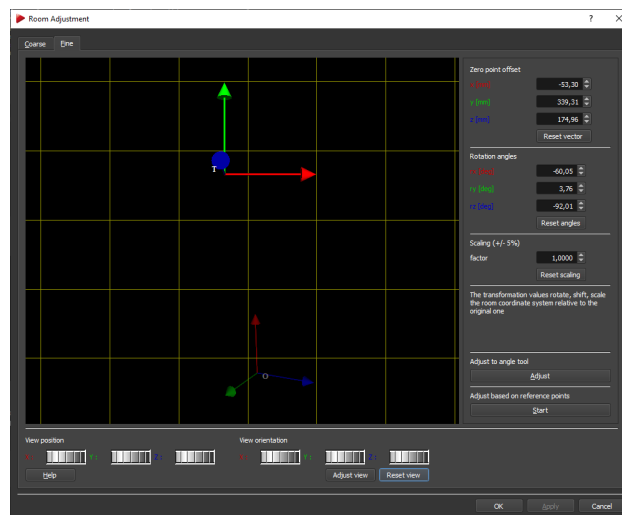
(b) after Transformation

Figure 9.10: Room adjustment dialog (fine)

9.2.2.2 Manually transforming the coordinate system

Several options for transformation of the coordinate system can be selected (refer to table 9.6 on page 111).

Example   All entered transformation values are relative to the original room coordinate system, i.e. in a standard coordinate system (xy-plane on the ground, z-axis facing upwards) the origin is placed 42mm above the ground (due to the height of '*calibration angle*' + radius of spherical marker). If the new desired origin is to be placed 1 m above the ground, then the *Zero point offset* for z is 958mm (1000 mm - 42 mm).

Action	Description
Zero point offset [mm]	translate the room coordinate system along its axes in steps of 1mm
Reset vector	reset the zero point offset to the unmodified state (0.00 mm)
Rotation angles [deg]	rotate the room coordinate system around its axes (from -180 to +180 °)
Reset angles	reset the rotation angles to the unmodified state (0.00 °)
Scaling factor	enlarge / shrink the room coordinate system uniformly by a factor of +/-5 percent
Reset scaling	reset the scaling factor to the unmodified state (1.0000)
Start	start up a module for transforming & matching to a reference coordinate system (**DTRACK3** licenses required)

Table 9.6: Room Adjustment (Fine) - Transform actions

9.2.2.3 Adjust to angle tool

In some cases the room coordinate system needs to be transformed to a specific position and orientation using the *calibration angle* as reference. There is no need to use the *wand* in this process. Open the dialog *Adjust room coordinates to angle tool* (see figure 9.11 on page 112) and place the *calibration angle* inside your tracking volume to define the new origin and orientation. Please refer to figure 9.2 on page 102.

Double-check that all markers of the '*calibration angle*' are seen by the cameras and start the calibration process by pressing *Calibrate*.

A progress bar shows the current status (see figure 9.12(a) on page 112) after which a result window will be opened (see figure 9.12(b) on page 112).

Press *OK* to return to the dialog *Adjust room coordinates to angle tool*. Press *OK* to accept or *Cancel* to discard the changes.
Back in the *Fine* tab of the *Room adjustment* dialog (see figure 9.10(b) on page 110) press *Enter* or click *OK* to confirm the resulting transformation and to close the dialog. Pressing *Apply* accepts the current changes and leaves the dialog open. Discard all changes by pressing *Cancel*.

☞ **Incorrect selection of the *calibration angle* will result in failure of calibration.**

☞ **The calculated transformation is applied on both *zero point offset* as well as *rotation angles* in *Fine* tab.**

9.2.2.4 Adjust based on reference points

The purpose of the coordinate transformation is to convert the origin and orientation of the initial camera coordinate system (indicated with '*O*') into a reference coordinate system (indicated with '*T*'), e.g. given by a certain object or CAD model. All measurement data will be transformed with respect to the reference coordinate system ('*T*'). Press *Start*
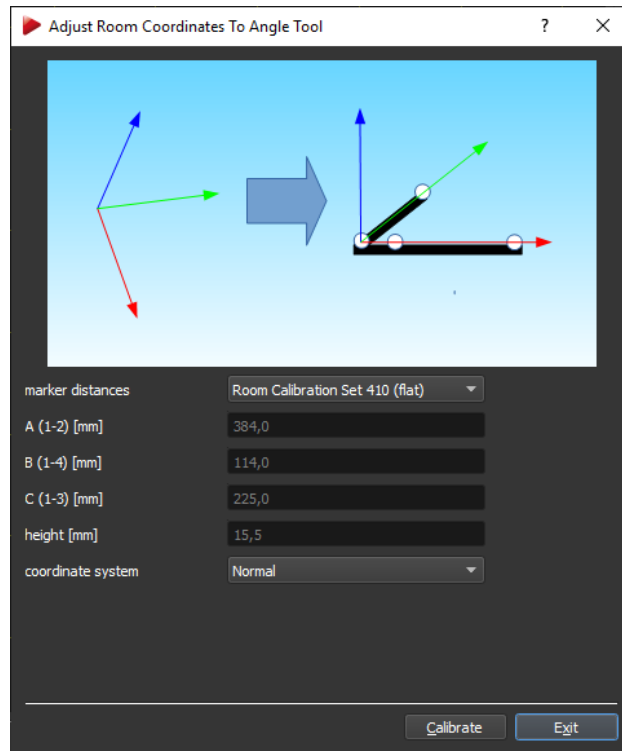
Figure 9.11: Room adjustment - Adjust room coordinates to angle tool
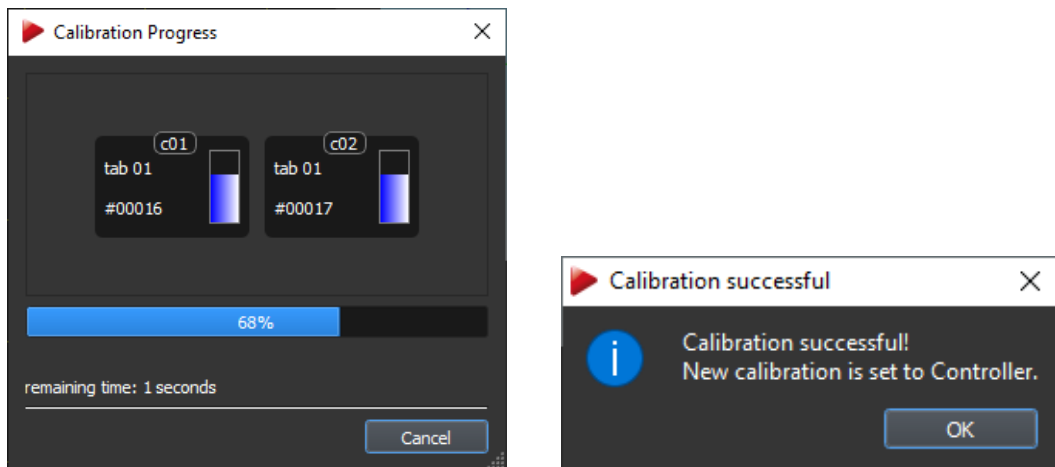
(a) Progress bar   (b) Success Window

Figure 9.12: Adjust room coordinates to angle tool - sub-dialogs

in the *Fine* tab to open the room matching dialog (see figure 9.13 on page 113). This functionality depends on licenses (refer to chapter 7.2 on page 59).

> **If the Measurement Tool is not tracked (calibration required) matching cannot be performed. Use an authorised Measurement Tool by *ART* for best results.**
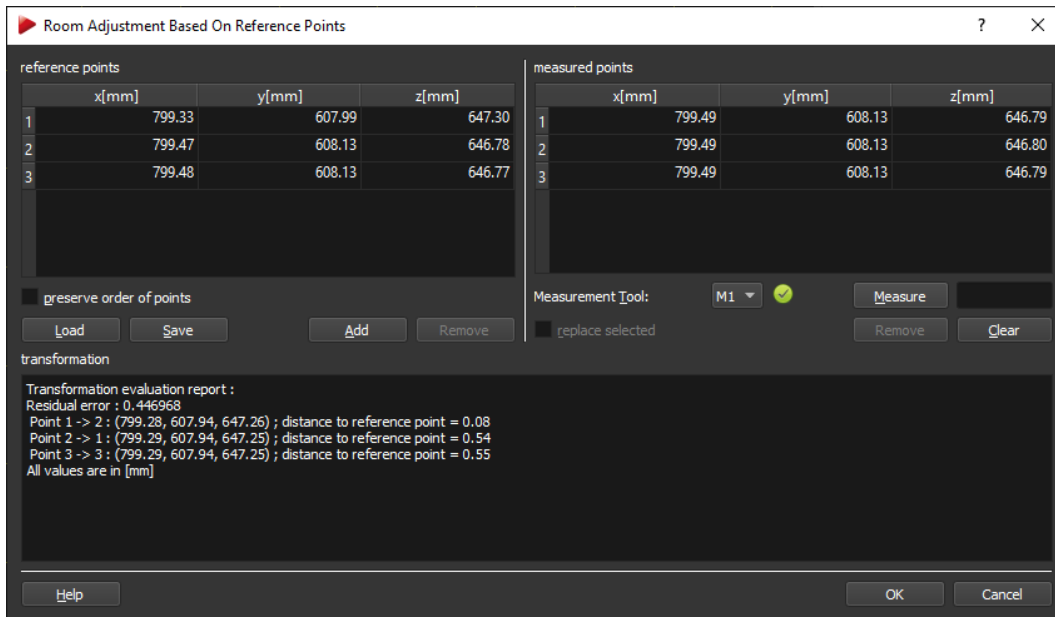
Figure 9.13: Room transform & matching dialog

☞ **Deselect any previously assigned Measurement Tool References prior to matching of the coordinate systems. Otherwise matching results will be erroneous.**

Procedure A three-step process has to be performed:

1. Add measurement data from the reference coordinate system ('*T*') by manually entering the coordinates into the table *reference points* using the button *Add*. A minimum of three (3) data points is necessary for calculations.
   The current set of reference points can be saved by pressing *Save*.
   Delete single data points by selecting the corresponding row and press *Remove*.
   Alternatively load the coordinates from a text file (ASCII) using the button *Load*. The text file must comply to the following format:

   ```
   1 1.00 20.00 300.00 <CRLF>
   2 4.00 50.00 600.00 <CRLF>
   3 7.00 80.00 900.00 <CRLF>
   # x    y    z      <CRLF>
   ```

   The import strictly follows the sequence from the ASCII text file. Still in some cases the data might be ambigous regarding its 3-D orientation. Toggle the tickbox *preserve order of points* to lock the order in the table *reference points*.

2. Select a calibrated and tracked Measurement Tool from the drop-down menu and measure all points (e.g. on the corresponding object) which directly relate to the reference points (e.g. from a CAD model) defined in step 1.
   Each measurement can be started by:

- clicking the button *Measure*

- clicking the start button on the Measurement Tool (if applicable)

- using the start button simulation of the Measurement Tool (refer to 9.9 on page 150)

- clicking a button of an assigned *Flystick2/2+/3*

3. After having measured all corresponding points the calculation is started automatically and the result of the transformation is displayed in the textbox *transformation*. Double-check that all measured data points correspond to the correct reference data points.
   Delete single data points by selecting the corresponding row and press *Remove* or delete all data points to start all over by pressing *Clear*.

   The residual error (standard deviation) is a measure of the transformation quality, i.e. how well the measured data fit the corresponding reference points. It may be influenced by the quality of data acquisition and by differences in scale of the camera and reference coordinate systems. Press *OK* to accept this transformation and to close the dialog box.

Back in the *Fine* tab of the *Room adjustment* dialog (see figure 9.10(b) on page 110) press *Enter* or click *OK* to confirm the resulting transformation and to close the dialog. Pressing *Apply* accepts the current changes and leaves the dialog open. Discard all changes by pressing *Cancel*.

> ☞ **If automatic matching between reference and measured points fails, acquire the data points in the exact sequence of the reference data and tick the checkbox preserve order of points .**

> ☞ **The calculated transformation is applied on both *zero point offset* as well as *rotation angles* in *Fine* tab.**

9.3 Single Markers

In this dialog you can enable / disable the calculation of 3DOF markers. Here you can also define the central axis for all 5DOF targets globally.

3DOF single markers   By default the calculation of single markers is disabled. By enabling '*calculation of 3DOF markers*' the tracking data appears on the right hand side of the data display (refer to chapter 6.3 on page 45).

Axis 5DOF central   Select the axis using the drop-down menu '*axis 5DOF central*'. Please refer to chapter 9.5.3 on page 123 for details.
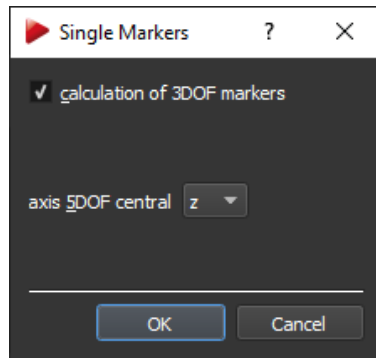
Figure 9.14: Single Marker Settings

9.4 Body administration

This dialog (see figure 9.15 on page 115) allows for managing all targets (e.g. Standard, Flystick, Measurement Tool , etc.) in the system. The number and types of bodies to be tracked may be configured in here. You can also assign names, delete or reset target calibrations, activate filtering of 6DOF tracking data or change the order in which the targets appear in the data display (refer to chapter 6.3 on page 45.
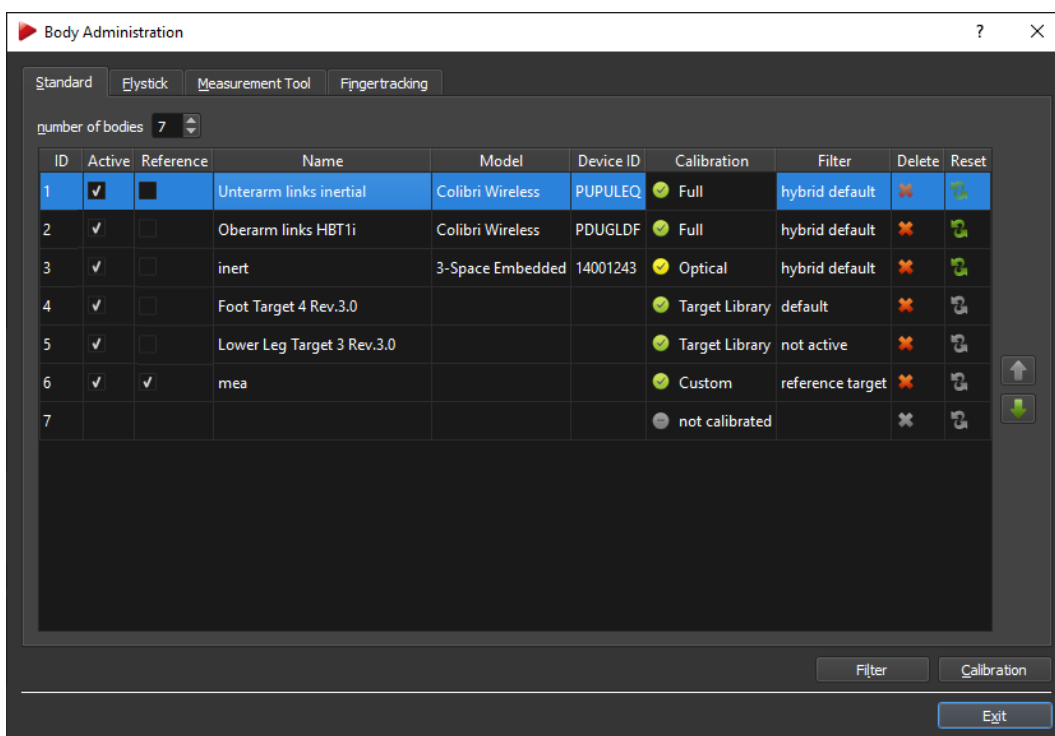
Figure 9.15: Body Administration

Using the different tabs on the top you can configure standard bodies or interaction devices. Please use the tabs *Standard*, *Flystick*, *Measurement Tool* and *Fingertracking* respectively.

In the bottom right of the dialog (see figure 9.15 on page 115) you will find two buttons. You may switch to the Body Calibration dialog and perform the optical calibration for the selected target via *Calibration* (see chapter 9.5.1 on page 121). Press *Filter* to deactivate the filtering of tracking data for each target. Filtering is activated by default. A detailed description of the filtering options can be found in chapter 9.4.1 on page 117.

Table 9.7 on page 116 shows a detailed description of the functions in the dialog.

Info / Action	Description
number of bodies	Increase / Decrease the number of accessible slots (i.e. body IDs) for calibration of targets.
ID	The targets are sorted in ascending order (i.e. increasing body ID).
Active	Activate or deactivate a target by ticking. Data of deactivated targets will not be transmitted in the data stream. The target sequence will not be affected.
Reference	Activate or deactivate the assignment as reference body by ticking.
Name	Assign a description or name to the body.
Device ID	The device ID of an assigned inertial sensor (hybrid targets only).
Calibration	Provides information about the target calibration status.
Filter	Deactivate the filtering of tracking data for each target, filtering is activated by default. A detailed description of the filtering options can be found in chapter 9.4.1 on page 117.
Delete	Delete the calibration data of a target - effective immediately after confirming the query. The target sequence will not be affected.
Reset	Reset the calibration to predefined '*Target Library*' values (only available after the geometry has been re-calibrated by the user manually after inital recognition via the '*Target Library*' function).
Change order	With the arrows on the right-hand side of the window you may re-arrange the order of the targets. The data output will change accordingly.

Table 9.7: Body Administration - Detailed description of tabs

The maximum number of bodies depends on your license and includes ALL calibrated interaction devices (e.g. 4 body license: 1 standard body + 1 set of Fingertracking (left + right) + 1 Flystick). Hybrid targets are listed as standard bodies, with additional info about the model of the inertial sensor and its device ID.

Reference body   Any standard 6DOF body may be assigned as reference upon which all 6DOF and 3DOF tracking data is calculated relative to this body coordinate system instead of the room coordinate system. Only one reference can be assigned at a time by ticking the checkbox in the column *Reference* of the respective body.

When a reference body has been assigned, all 6DOF bodies and 3DOF single markers can only be tracked when the reference body is being tracked as well.

Calibration status The column *Calibration* (see table 9.8 on page 117) provides information about the target calibration status:

Calibration Status	Description
not calibrated	a customized target has not been calibrated yet
Target Library	the predefined calibration file from the system is being used
Target Library, re-calibrated	the predefined calibration file has been used, but the geometry has been re-calibrated manually
Custom	a manual body calibration has been performed
Optical	an inertial sensor has been disassociated from a fully calibrated hybrid body (hybrid targets only).
Full	a hybrid body calibration has been performed or that predefined calibration data stored inside the hybrid inertial sensors is being used (hybrid targets only).

Table 9.8: Body Administration - Description of calibration status

9.4.1 Filtering options for 6DOF tracking data

DTRACK3 incorporates advanced filtering options for enhanced 6DOF tracking performance. One can choose between recommended presets or customize filtering options in order to optimize tracking behaviour individually for each target. For example in applications where reference targets are used to calculate the position of a seating buck it is possible to apply a strong filter for these targets which results in practically noise-free tracking data.

On the contrary tracking (e.g. of HMD units) oftentimes calls for a compensation of system intrinsic latencies. Here *DTRACK3* is able to deliver tracking data that incorporates probabilistic prediction up to tens of milliseconds ahead in time.

Access the filtering options for each target either via the menu *Body Administration* or directly through the main GUI docking window *Data Display*. Please refer to table 9.7 on page 116 and 6.3.3 on page 51 to open the menu *Filter Settings*.

☞ **When using third-party hybrid tracking solutions (e.g. LP Research's LPVR-CAD) turn off filtering for the respective HMD target altogether in order to achieve the best performance and immersive experience.**

9.4.1.1 Filter Settings

Filtering of 6DOF tracking data is activated by default. Untick the checkbox '*active*' to deactivate filtering for the respective target or choose from several recommended presets shown in the following table:
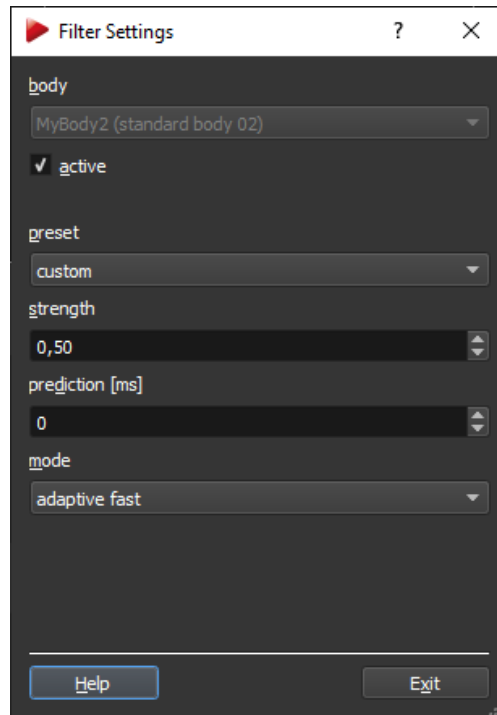
Figure 9.16: Filter Settings

Presets optical tracking	Description
custom	Customizable preset. A detailed description of the parameters can be found in table 9.10 on page 119.
default	Standard filtering without prediction or smoothing.
Flystick	Recommended setting for use with **Flystick2/2+/3** (responsive filtering, designed for fast to slow motions).
HMD-1	Recommended setting for tracking of a HMD without hybrid tracking (down-tuned filtering with prediction, designed for fast motions).
medium prediction	Filter with prediction of tracking data (less responsive filtering, designed for slow to medium motion).
reference target	Filter with smoothing for tracking of stable reference positions (strong non-responsive filter, designed for occasionally moving objects).
smoothing (delayed)	Filter with strong smoothing and high averaging (responsive filtering with high latencies, designed for recording of tracking data).
Presets hybrid tracking	**Description**
hybrid custom	Customizable preset. A detailed description can be found in table 9.10 on page 119.
hybrid default	Standard filtering for hybrid targets without prediction or smoothing (designed for e.g. Hybrid Motion Capture).
hybrid HMD medium prediction	Filter for hybrid targets with prediction of tracking data. (designed for e.g. HMDs)

Table 9.9: Filtering of 6DOF tracking data - Detailed description of the presets

It is also possible to customize the tracking behaviour to the requirements of the applica-

tion using the following tunable settings:

Settings		Description	Usage
Strength		Sets the strength of the filter. Low values lead to faster reaction but higher jitter. High values result in smoother output but slower reaction. Note: Not available for hybrid tracking.	A higher strength may be ideal for tracking seating bucks
Prediction		Predicts output for the specified time into the future (ms) in order to compensate tracking and rendering latency. Note: Too high positive values can increase jitter and reduce precision. Negative values can be used for smoothing the output at the cost of higher latency.	A negative prediction may be ideal for recording data and offline analysis.
Mode optical tracking		Specifies the elementary behavior of the filter. Several options are available:	for optical tracking only
	'*Adaptive fast*'	Automatically adapts to the observed motion.	Moving targets that change between fast and slow motions, such as **Flystick2/2+/3** .
	'*Adaptive slow*'	Automatically adapts to the observed motion, with stronger filtering of fast motions.	Moving targets with slow and medium motions
	'*Fast*'	Optimized for fast motions without special filtering of slower motions.	Targets where quick reaction is important, such as HMDs.
	'*Slow*'	Optimized for medium motions without special filtering of slow motions.	Targets where quick reaction is important, but motions are slow.
	'*Static*'	Optimized for targets that are known not to move at all.	Reference targets attached to non-moving objects
	'*Reference target*'	Optimized for generally static objects, with automatic detection of occasional motions.	Reference targets attached to occasionally moving objects.
Mode hybrid tracking		Specifies the elementary behavior of the filter. Several options are available:	for hybrid tracking only
	'*Hybrid target*'	Optimized for non-HMD hybrid targets incorporating an inertial sensor unit.	Hybrid Motion Capture
	'*Hybrid HMD*'	Optimized for HMD hybrid targets incorporating an inertial sensor unit	HMDs and similar projective units (e.g. AR glasses).

Table 9.10: Customizable preset 6DOF filtering - Detailed description of the parameters

9.5 Body calibration

The process of teaching a target's geometry to the tracking system is called body calibration. For a body calibration, the target (= rigid body) to be calibrated has to be in the field of view of the IR cameras.

The body may be moved during body calibration always considering that the cameras should see each marker of the body.

If the body is not moved during body calibration it should be considered that each marker of the target has to be seen by at least two cameras and generally should be seen by as many cameras as possible.

The target orientation can be checked using **DTRACK3**'s *Monitor 2DOF display*, which is opened automatically in the background after starting the body calibration. The following figure 9.17 on page 120 shows a rigid body with five markers that are all correctly seen by the IR camera.
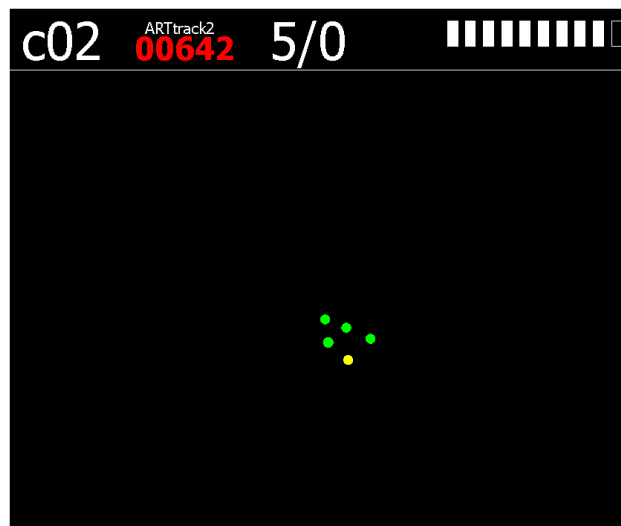
Figure 9.17: Recognized target in **DTRACK3** *Monitor 2DOF display*

☞ **Do not calibrate the body geometry for a HMD clip-on targets manually ! Always use the built-in target library and re-calibrate afterwards to compensate for mechanical bending or twisting due to mounting. Otherwise the tracking pivot point cannot be determined resulting in poor immersive experience.**

☞ **If two markers, seen from one camera's point of view, are merging to one reflection, body calibration may be affected. These "merging marker situations" should be avoided during body calibration, i.e. the target should be oriented in a way that reduces merging markers to a minimum.**

☞ **Ensure the absence of any additional markers in the measurement volume during body calibration. If additional markers that are not part of the target are in the field of view of the IR cameras during body calibration these markers will be assigned to the target. Hence the target will not be correctly calibrated and therefore tracking problems may occur.**

9.5.1 Selecting the body type

Open the dialog *Tracking → Body Calibration → Custom Tab* to start a body calibration .
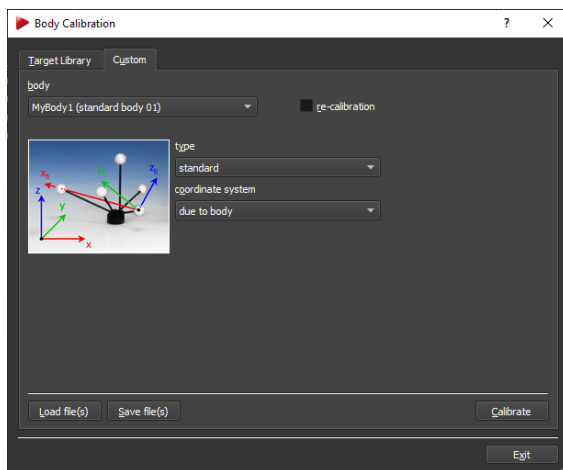
(a) Target type "standard"
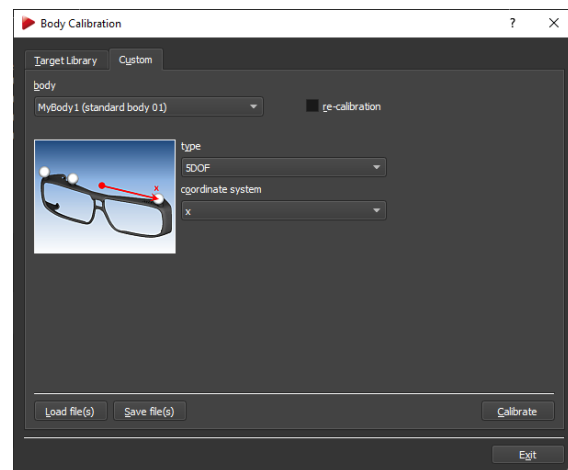
(b) Target type "5DOF"
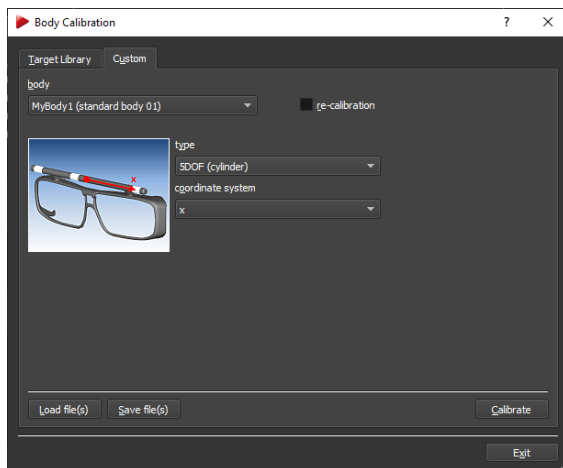
(c) Target type "5DOF (cylinder)"
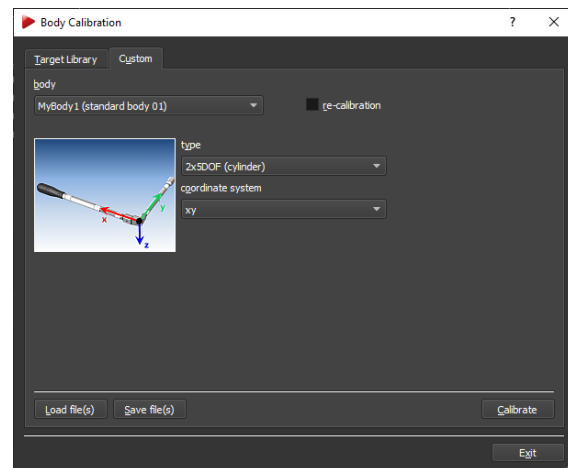
(d) Target type "2x 5DOF (cylinder)"

Figure 9.18: Body calibration dialog

First select the target that should be calibrated in the select list *Body*. By default the *type* is set to '*standard*' which allows for calibrating a 6DOF target with spherical, flat or active markers. When you are using a 5DOF target or a target made of ring markers you would select the '*type*' according to the geometry of the target:

- '*5DOF*' .. a target made of spherical markers which are aligned along one main axis. The rotation around that axis cannot be detected by the system - you loose one dimension of freedom. Therefore only 5 dimensions.

- '*5DOF (cylinder)*' .. a target made of ring markers which are aligned along one main axis.

- '*2x 5DOF (cylinder)*' .. an L-shaped target made of ring markers which delivers complete 6DOF data.

Next select the type of body calibration (refer to section 9.5.2 on page 122 then press *Calibrate* to start the body calibration with a delay of five seconds.

To re-calibrate a body tick the checkbox *re-calibration* next to the drop-down menu. For more information about body re-calibration please refer to chapter 9.5.7 on page 128.

After a new room calibration or room re-calibration it is not necessary to perform a new body calibration. Only if the body itself has been changed you have to calibrate the body again.

The previous body calibration will be lost if you carry out a new body calibration. If you want to save the previous body calibration please use the '*Save file(s)*' option in the *Body calibration* dialog.

9.5.2 Selecting the coordinate system for 6DOF targets

During body calibration, **DTRACK3** defines a local coordinate system (body coordinate system) for each target .

The type of body calibration can be set as '*due to body*', '*due to room*' or '*due to room (zero in marker)*' (see figure 9.19 on page 122. The difference between these types is to be found in the orientation of the body coordinate system relative to the body itself.

(a) Body calibration "due to body"

(b) Body calibration "due to room"

(c) Body calibration "due to room (zero in marker)"
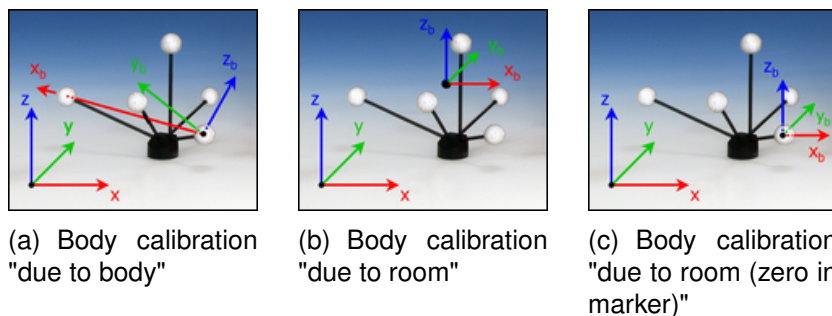
Figure 9.19: Defining the target coordinate system

9.5.2.1 Body calibration setting due to body

The body coordinate system is fixed by the markers of the rigid body according to a set of rules (refer to 9.19 a) on page 122):

1. Search for the largest distance between two markers of the rigid body. These two markers (# 1 and # 2) will define the x-axis.

2. Search for a third marker (# 3) with the shortest distance to one of the two markers # 1 and # 2. The marker that is closest to marker # 3 becomes marker # 1. It will define the coordinate origin. The other marker will become # 2. The positive X axis is directed from marker # 1 to marker # 2.

3. Marker # 3 defines the x/y-plane, together with markers # 1 and # 2. Marker # 3 has a positive Y coordinate.

4. The z-axis is added resulting in a right-handed coordinate system.

9.5.2.2 Body calibration setting due to room

The origin of the body coordinate system is set to the center (center of gravity) of all markers building the rigid body (refer to 9.19 b) on page 122). The axes of the body coordinate system are parallel to the axes of the room coordinate system in the beginning of the body calibration. The result of this type of body calibration will depend on the angular rotation of the target during calibration.

Without moving the body a 6DOF measurement right after the calibration will give the angular coordinates 0°/ 0°/ 0°.
If the target was moved during calibration instead **DTRACK3** will use the direction of the target at the beginning of the calibration.

9.5.2.3 Body calibration setting due to room (zero in marker)

This is a combination of the methods '*due to body*' and '*due to room*' (refer to 9.19 c) on page 122). The direction of the axes of the body coordinate system will be set parallel to the room coordinate system in the moment of body calibration - analog to the setting '*due to room*'. The origin of the body coordinate system is set to a marker of the body according to the rules for '*due to body*'.

9.5.3 Selecting the coordinate system for 5DOF targets

In contrast to 6DOF bodies all markers are aligned along one main axis (body axis).

9.5.3.1 Coordinate system setting for type '*5DOF*' and '*5DOF (cylinder)*'

The origin of the body coordinate system is in the middle of the body axis, i.e. between the two markers with the largest distance to each other (refer to 9.18 b) and c) on page 121). The orientation is defined by the marker with the shortest distance to the origin. Its position has a negative sign. The other two directions are undetermined due to the missing degree of freedom. Therefore the rotation around this axis cannot be measured

by the tracking system.

This is where the '*5DOF central axis*' comes into play. The '*5DOF central axis*' defines the missing degree of freedom if you intend to use the tracking data for 6DOF scenarios nonetheless. Effectively the body axis (X, Y or Z) is aligned towards the corresponding room axis (X, Y or Z), thereby minimizing the angle in between. If a '*5DOF central axis*' is chosen with a negative sign, the body axis (X, Y or Z) is aligned to the opposite room axis (-X, -Y or -Z) respectively.
Please refer to chapter 9.3 on page 114 to set the central axis in the menu *Tracking →
Single Markers*.

Setting the 5DOF central axis in a VR setup with head tracking   It general it is recommended to choose the '*5DOF central axis*' by using a direction in your setup which is perpendicular to the tracked body axis most of the time. For example when using a target for shutter glasses do not set the '*5DOF central axis*' parallel to the floor or ceiling but rather use the vertical axis instead.

☞ **Note: For orientations of the '*5DOF central axis*' close to the body axis (i.e. the two axes are driven into a parallel configuration) the rotation angle for the '*5DOF central axis*' will show strange behaviour, e.g. large odd-looking changes.**

9.5.3.2 Coordinate system setting for type '*2x 5DOF (cylinder)*'

The body is expected to consist of two connected 5DOF targets with a roughly perpendicular and constant angle in between (refer to 9.18 d) on page 121). These are placed on the two axes. The origin is placed at the intersection of the two 5DOF targets. The first axis is assigned to the 5DOF target which includes the marker with the largest distance to the origin. The other 5DOF target is placed in the plane created by the two axes.

ℹ **A click-type torque wrench is one the most prominent members of this class of bodies. Due to the engineering backlash and other high mechanical tolerances in these devices often times the resulting body calibrations are error-prone.**

ℹ **Due to the L-shaped geometry in the case of 2x5DOF tracking the data provided consists of complete 6DOF information. Therefore the data is not affected by the 5DOF central axis chosen.**

9.5.4 Body calibration progress

During the body calibration the current status is shown using a progress bar (see figure 9.20 on 125). Verify that all markers of the target are recognised properly.
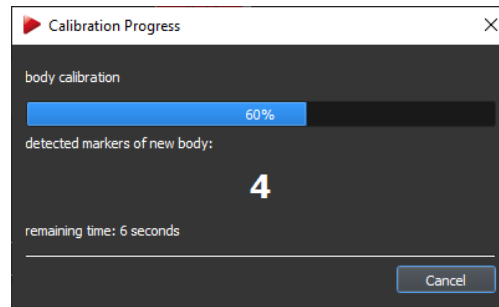
Figure 9.20: Body Calibration Process - Progress bar

9.5.5 Body calibration result

After successfully calibrating a body the result window is displayed (see figure 9.21 on 125).
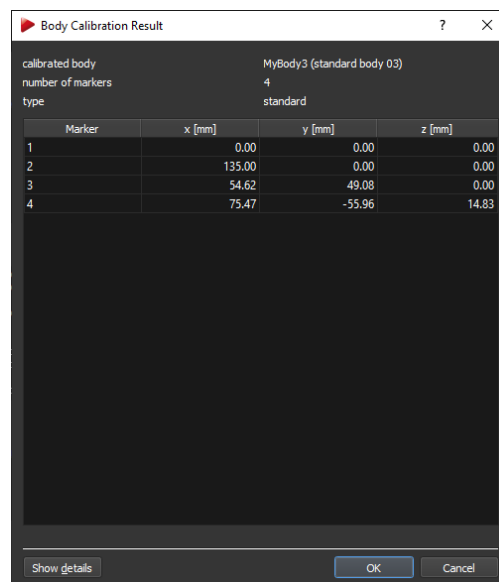
Figure 9.21: Body Calibration Process - Result Window

All markers of the rigid body that have been recognized during calibration are listed. Confirm the result with *OK* or discard the calibration with *Cancel*. The information (i.e. geometry data) of the calibrated target will be stored inside the controller in your personal configuration (see also section 7.3 on 62).

☞ **Please double-check the number of markers and compare to the rigid body that all markers have been recognized properly.**

9.5.5.1 Show Details

By clicking *Show details* additional information can be displayed (see figure 9.22 on page 126:

(a) Distances between markers   (b) Emission vector & aperture information   (c) Cylinder Information
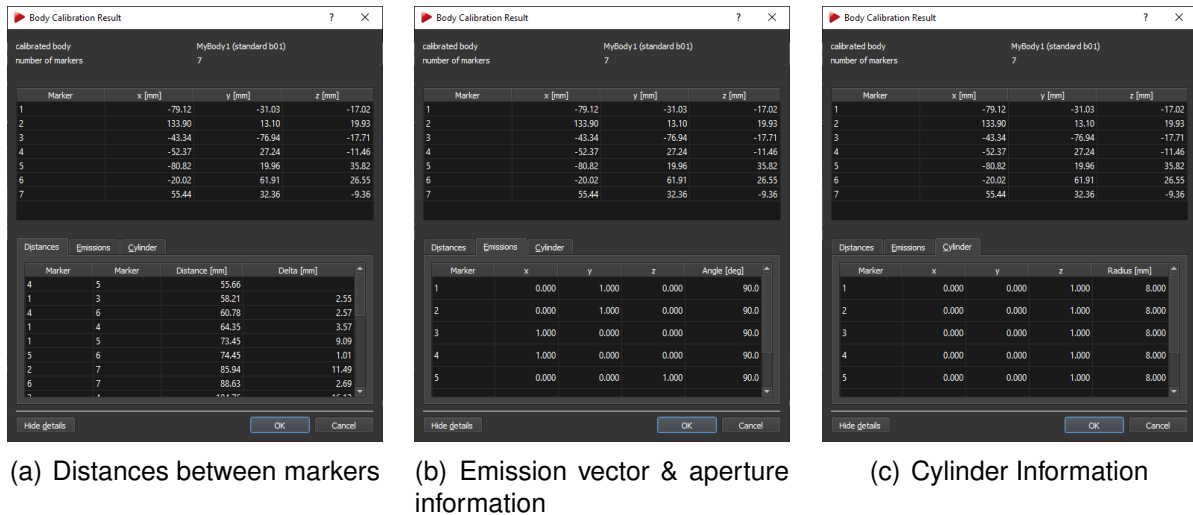
Figure 9.22: Body calibration Result

- 'Distances' shows all possible combinations of distances for all markers (min. distances are important for customer-specific geometries, call **ART** for further information)

- 'Emissions' shows normalised emission vectors x, y, z and emission aperture for bodies with restrictions of visibility (only for calibration files available on request by **ART**)

- 'Cylinder' shows coordinates and radii for bodies with (cylindrical) ring markers

9.5.6 Calibration files

To easily create backups of calibrated bodies, calibration files can be saved and restored from files. These files contain the dimensions of the target and the distances between all markers. Each file is specific for just one type of target.
Just click *Load file(s)* and select the appropriate calibration file(s) or click on *Save file(s)* respectively.

9.5.6.1 Save a body calibration file

Press 'Save file(s)' option in the *Body calibration* dialog to store the calibration file(s) of the currently used bodies.
Select the individual bodies by left-clicking or all ot once by pressing *select all* (see figure 9.23(a) on page 127). Press *Save* and in the upcoming window select a folder on your remote PC for storage (see figure 9.23(b) on page 127). After successful saving a confirmation window will show up (see figure 9.24 on page 127). Press *OK* then exit the dialog.
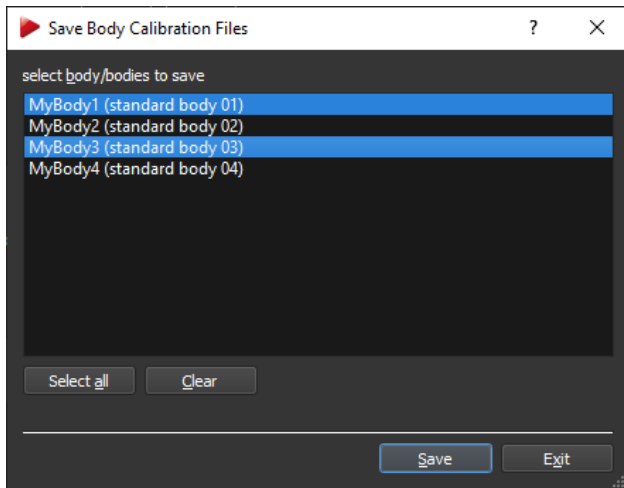
(a) Selecting the body file(s) to save
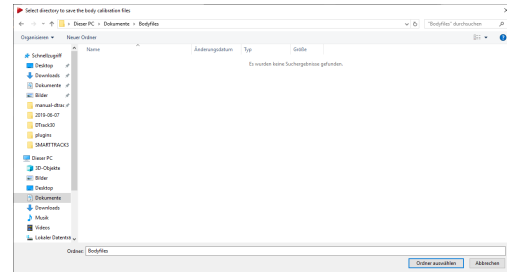
(b) Select the folder on the remote PC

Figure 9.23: Saving calibration files
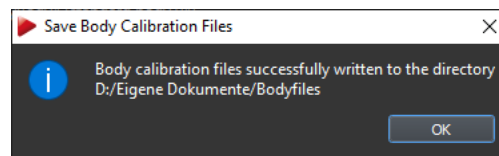
Figure 9.24: Saving calibration files - Confirmation Message

> ℹ **The format of the file name will be according to "*standard b01.txt*" with "*b01*" being the identifier which refers to the ID of the target.**

9.5.6.2 Load a body calibration file
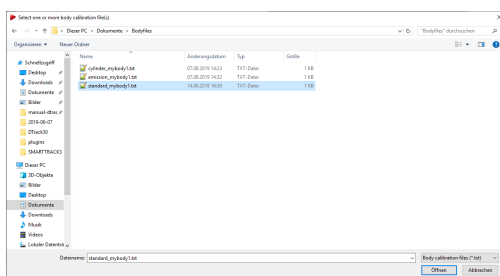
(a) Select the body file(s) to load
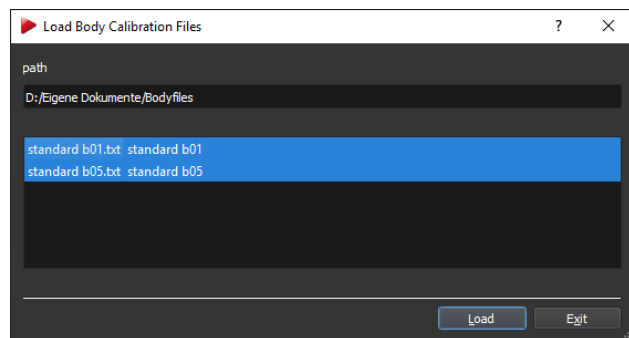
(b) Confirmation window for multiple files

Figure 9.25: Loading calibration files

You can load calibration file(s) by pressing *Load file(s)* and choose the calibration file(s) for your targets. Select the corresponding body *body ID* and load single calibration files one after the other by pressing *Load* (see figure 9.25(a) on page 127).

Alternatively you can load multiple files simultaneously when the corresponding body calibration files comply to the *DTRACK3* file name convention (i.e. "*standard b01.txt*" with "*b01*" being the identifier which refers to the ID of the target). *DTRACK3* automatically assigns the calibration file to the respective *body ID* by using the identifier in the file name. Select multiple files and press *Load*.

A confirmation window will open, press '*Load*' again to import of the body calibration files (see figure 9.25(b) on page 127).

In the upcoming window the coordinates of all identified markers are listed together with the body's label as well as the number of markers. It is analog to the body calibration result window (see figure 9.21 on page 125).

☞ **Any previous body calibrations will be overwritten when you load calibration files.**

ℹ **Invalid or corrupt files are not loaded by *DTRACK3* . This is indicated by an error message in the confirmation dialog.**

9.5.6.3 Restricted Visibility / Emission Cones

Optionally a restricted visibility can be defined for each marker of a body. This is performed setting up so called 'emission cones'; in essence, a 2DOF observation from a camera has to be inside this cone so that tracking data can be used later for pose estimation. Currently the only way to equip markers with emission cones is to import an appropriate calibration file which are available on request. These files are created at *ART* on site performing a body calibration in a defined environment or measurement volume respectively.

9.5.7 Body re-calibration

DTRACK3 provides a possibility to re-calibrate a rigid body without losing the body's coordinate system. This function may be used in case the body geometry is affected due to e.g. mechanical impact. Tick the checkbox *re-calibation* and perform a routine body calibration as described in 9.5 on page 120.

☞ **Only during a body re-calibration the origin and orientation of the initial coordinate system as well as specific information (tracking pivot point, predefined emission vectors, cylindrical marker info) are preserved.**

☞ **Re-calibration is possible as long as changes in the body geometry are not too large (e.g. replacement of markers). It will fail e.g. if the body has been modified completely.**

9.5.8 Target Library

It is also possible to make use of an integrated library that contains calibration data for most *ART* standard targets (e.g. HMD clip-on targets, Motion Capture, 3D glasses, etc.).

An automatic target recognition identifies the body geometry and loads the corresponding information.

Go to *Tracking → Body Calibration* and choose the tab 'Target Library' (refer to figure 9.26 on page 129). By default the complete library is used for target recognition, the drop-down menu *filter* is set to 'Found Targets'. You can also use specific subsets of the library by changing to a different option (e.g. Motion Capture), if only targets of this type are to be identified.
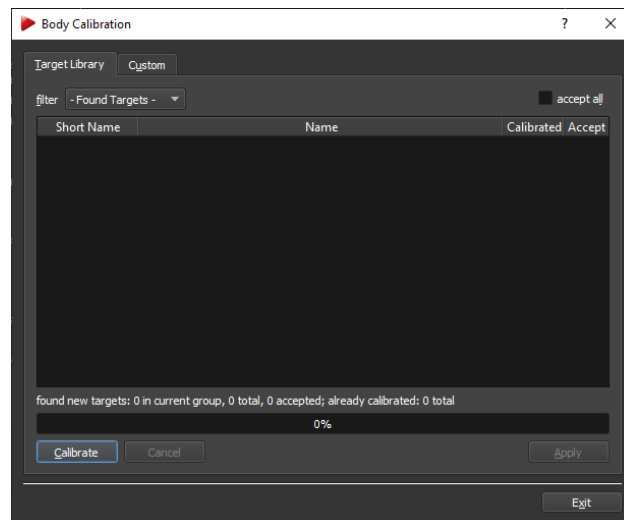
Figure 9.26: Body Calibration - Target Library

Make sure that all targets to be identified are visible in the tracking volume. Start the identification by pressing *Calibrate*.
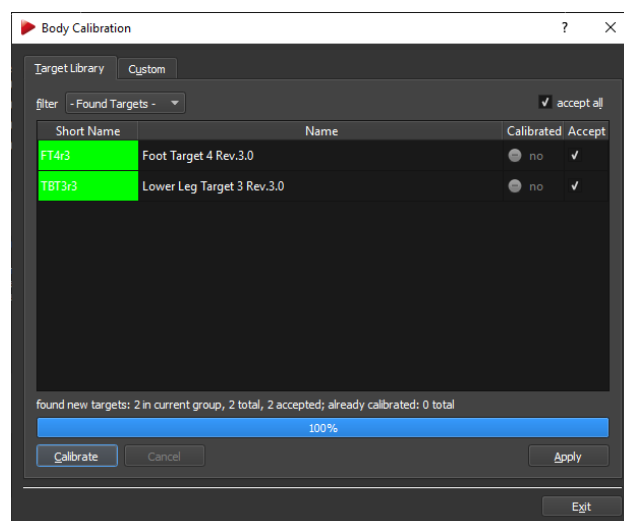
Figure 9.27: Body Calibration - Target Library progress bar

The current status is shown by a progress bar while the amount of 'found new targets' is listed (see figure 9.27 on page 129). The *Short Name* of all identified targets will be

marked green. The body calibrations for all found targets can be loaded all at once or one at a time by either ticking the checkbox *accept all* or each individual checkbox in the column *Accept*. Finalize the assignment of the targets by pressing *Apply*.

(a) Automatic increase of number of bodies in Body Administration

(b) Confirmation Window
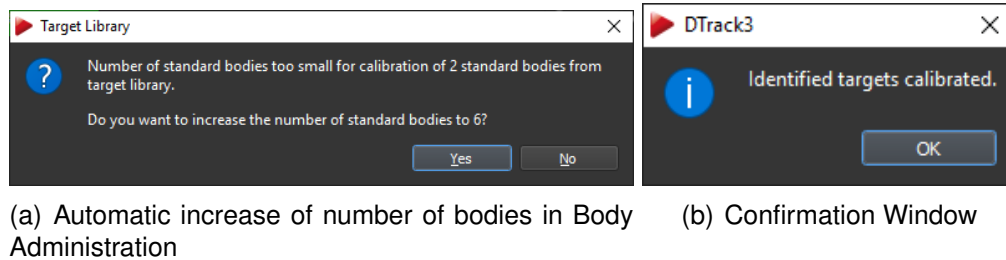
Figure 9.28: Body Calibration - Target Library calibration process

If you have not yet increased the *number of bodies* inside the *Body Administration* the system will ask you to adjust the setting automatically (see figure 9.28(a) on page 130). Accept by clicking *Yes*. Press *OK* to accept all imported bodies from the target library (see figure 9.28(b) on page 130) and exit the dialog.

☞ **_DTRACK3_ compares the geometry of the physical target with the calibration data of the target library. In some cases a re-calibration might be necessary, i.e. bending and twisting is possible when a clip-on target is mounted on a HMD casing or 3D glasses.**

☞ **In the unlikely case that a target is not found by the system use the standard body calibration.**

9.5.8.1 Identification of Motion Capture targets without Inertial sensors

For this example it is assumed that a setup with at least eight cameras has been calibrated properly and that all necessary licenses are present.

First, fit the targets to the test person and make sure that the person is inside the tracking volume. Then, start the calibration (*Tracking → Body → 'Target Library' → 'Calibrate'*) and allow the test person to move around. While this movement the targets must be visible for the tracking system. Next, all targets, one after the other, should be recognized and will appear in the list of '*Found Targets*'. Tick the checkbox *accept all* and press *Apply* load all body calibrations. In case you need to adjust the order of the targets please go to *Tracking → Body Administration*. Finally, start the measurement in order for your application to receive tracking data.

9.6 Body adjustment

The *Body adjustment* function is a tool to visualise and manipulate calibration data of rigid bodies , i.e. the body coordinate system may be changed relative to the markers of the

body.

ℹ️ **Body adjustment is not available for 5DOF targets or measurement tools.**

The main features of *Body adjustment* are:

- adjusting the body position and orientation of each target manually,

- use predefined body coordinate systems,

- move and set the origin of the body coordinate system (e.g. into a selected marker or the center of gravity),

- aligning the axes of body and room coordinate system without changing the origin,

- delete selected markers from the target geometry,

- "live" mode (i.e. the 3D-representation of the target in the '*Graphic view*' is depicting movements / rotation of the target in "real time"),

- (optionally) visualise predefined emission cones due to restrictions of visibility (directional and angular dependence) for all markers

9.6.1 Body Adjustment - Graphic View

Open the menu *Tracking → Body Adjustment* and select the desired body from the drop-down list *Body* at the top of the window (see figure 9.29 on page 132).

By default a cartesian coordinate system is displayed on the left side of the window depicting the selected rigid body's geometry ('*Graphic view*'). On the right hand side the body's coordinate system can be manipulated.

The body coordinate system is shown as a triplet of arrows with a defined color-coding (x-axis: red, y-axis: green, z-axis: blue), while the xy-plane is shown as a yellow grid. All markers are visualised by sequentially colored spheres (RGB) for better identification.

In case the selected rigid body features visibility restrictions (optional), emission cones may have been predefined. Direction of visibility (emission vector) is depicted as an arrow (white) for each marker, while the angular restriction (emission aperture) is shown as a cone (grey).

The viewing position and orientation may be changed in two different ways:

1. hold down the "Ctrl" key and the left / right mouse button to change the position / orientation inside the graphical display

2. use the six control dials *View position* and *View orientation* (below the graphical view) to adjust position and orientation along all axes
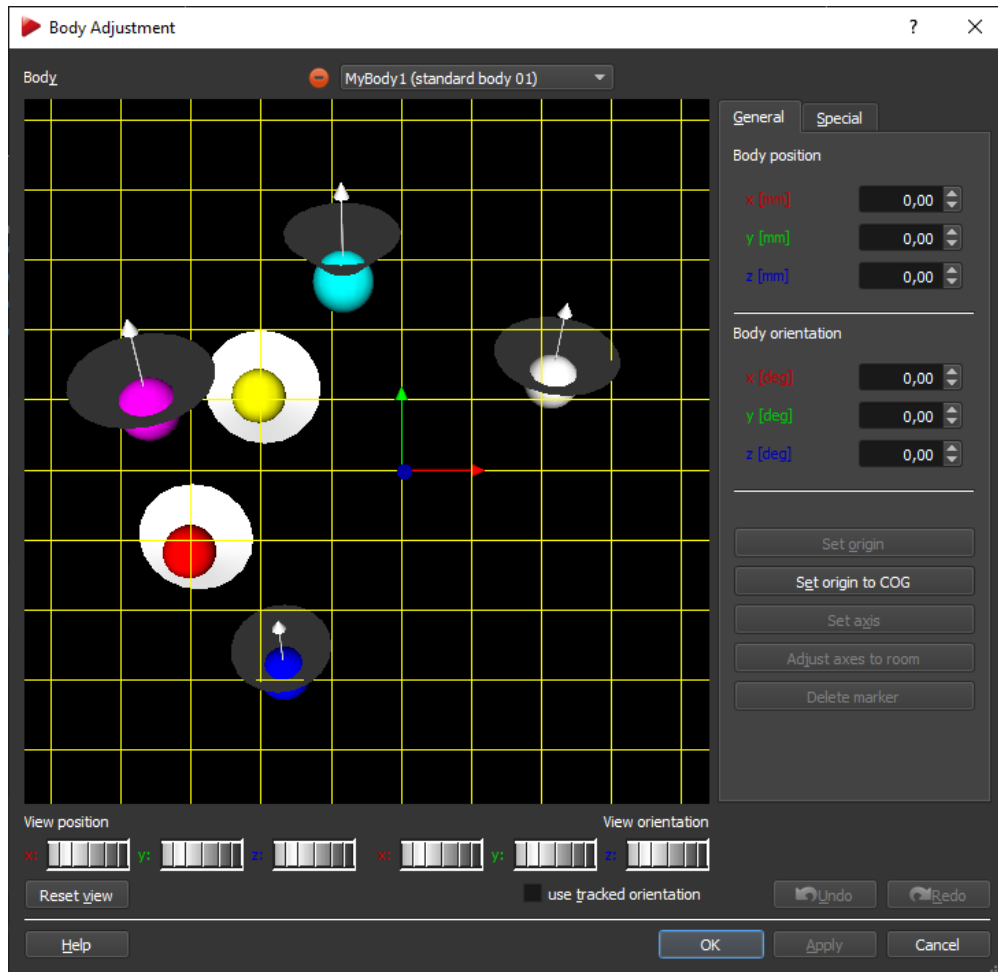
Figure 9.29: Body Adjustment

To restore the default view press *Reset view*.

Press *Enter* or click *OK* to accept all changes for all bodies (i.e after confirmation the changes are sent to the controller) and to close the dialog. Press *Apply* instead to change the currently selected body only - the body will be redrawn and the dialog will be left open.

Press *Undo* to switch back to the unmodified state or *Redo* to repeat the last action. Discard all changes by pressing *Cancel*.

Context Menu The visualisation can be changed by clicking the right mouse button to open a context menu with the following options. (De-)select the appropriate ones by (un-)ticking.

Live View Tick the *use tracked orientation* checkbox to switch to live mode. The 3D-representation of the target in the 'Graphic view' will depict movements / rotation of the target in the "real time"). This also enables the function *Adjust axes to room* (see table 9.12 on page 134 in order to align the body coordinate system collinear to the room

Option	Description
'*Small markers*'	reduces the size of the marker spheres
'*Colored markers*'	shows the markers in RGB colors (untick: greyish)
'*Emissions*'	shows emission vectors (arrows) and emission aperture (cones) (if applicable)
'*Long axes*'	extends the coordinate axes of the body coordinate system by infinite dashed lines
'*Show COG*'	shows the body's center of gravity (white square)
'*Show XY plane*'	shows the XY plane (yellow grid)
'*Show YZ plane*'	shows the YZ plane (cyan grid)
'*Show XZ plane*'	shows the XZ plane (magenta grid)
'*Show room orientation*'	shows the room coordinate system (only available when checkbox '*use tracked orientation*' is ticked)
'*Add line between markers*'	adds a line between two selected markers (option greyed out until two markers are selected)
'*Delete line between markers*'	removes a line between two selected markers (option greyed out until line is selected)
'*Data view*'	switches to the data view

Table 9.11: Body Adjustment Graphic View - Context Menu

coordinate system.

9.6.2 Changing the body geometry

For manipulating the body geometry you have the choice between *General* or *Special* options:

General The body coordinate system may be customized user-specific (see table 9.12 on page 134):

Special Choose from the following predefined transformations (see table 9.13 on page 134):

> ℹ️ **Predefined visibility restrictions (emission vectors and emission apertures) are retained along all body transformations.**

> ☞ **If the MultiUser function for *Flystick2/2+/3* is enabled the *Body Adjustment* module will load standard bodies only - a label *'MultiUser function should be disabled!'* will appear at the bottom of the dialog. To adjust the body calibration data of your *Flystick2/2+/3* , make sure that the MultiUser function is disabled (*Tracking → Flystick*).**

Action	Description
Body position [mm]	translate the body coordinate system along its axes in steps of 1mm
Body orientation [deg]	rotate the body coordinate system around its axes
Set origin	activate and highlight a marker in the '*Graphic view*' by left-clicking the mouse. the button *Set origin* is activated. press the button to translate the origin of the body coordinate system into the center of the selected marker.
Set origin to COG	translate the origin of the body coordinate system into the target's center of gravity
Set axis	activate and highlight two markers sequentially in the '*Graphic view*' by left-clicking the mouse. the first marker is highlighted in white, the second one in grey. the button *Set axis* is activated. press the button to open a dialog to configure the transformation.
Adjust axes to room	press this button to align the body coordinate system collinear to the room coordinate system
Delete marker	activate and highlight a marker in the '*Graphic view*' by left-clicking the mouse. the button *Delete marker* is activated. press the button to remove the selected marker from the target geometry.

Table 9.12: Body Adjustment (General) - Transform actions

Action	Description
due to body	the body coordinate system is defined by the target geometry (see section 9.5.2.1 on page 122)
due to room (origin in COG)	the body coordinate system is rotated and aligned collinear to the room coordinate system with the origin set in the center of gravity (COG) (see section 9.5.2.2 on page 123). tick the checkbox *use tracked orientation* to use this function.
due to room (origin in marker)	the body coordinate system is rotated and aligned collinear to the room coordinate system with the origin set in one specific marker (see section 9.5.2.3 on page 123). tick the checkbox *use tracked orientation* to use this function.

Table 9.13: Body Adjustment (Special) - Transform actions

9.7 Flystick

Open the *Tracking → Flystick* dialog to manage the *number of Flysticks* (max. 20) and to configure the corresponding settings to be used, see figure 9.30 on page 135.
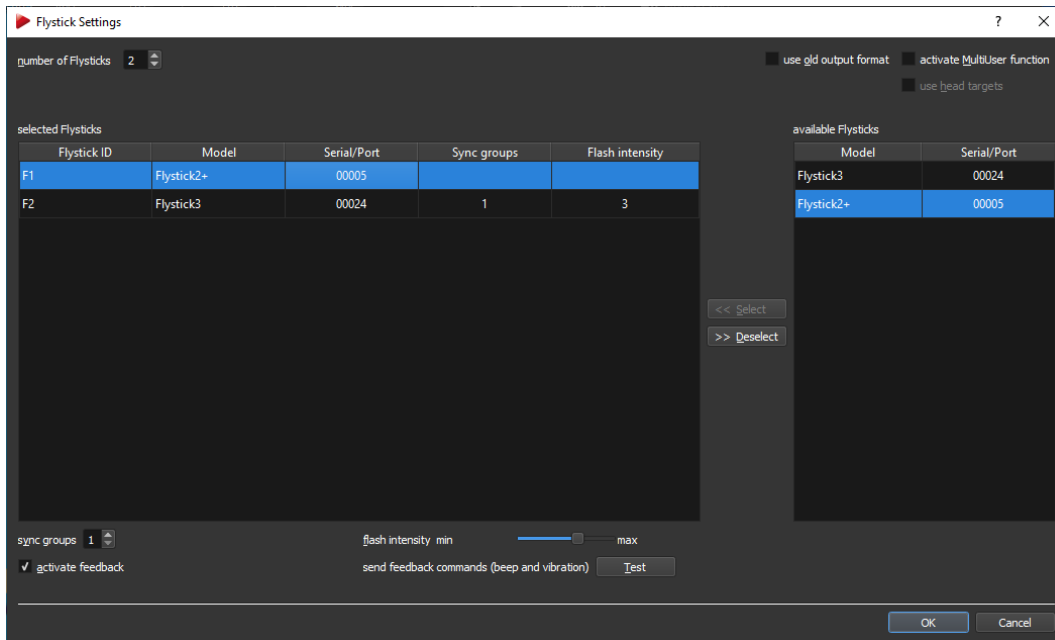
Figure 9.30: Flystick Settings

Checkbox	Description
use old output format	use the legacy output format of the Flystick1 (refer to the **DTRACK3 Programmer's Guide**)
activate MultiUser function	activate the use of multiple **Flystick2/2+/3** (refer to section 9.7 on page 136)
use head targets	the data pair (**Flystick2/2+/3** and head target) of one user is made available as output data (MultiUser enabled only)
active Flystick3 only	**Description**
sync groups	configure your active **Flystick3** (discontinued) for use with syncgroups (syncgroup #1, syncgroups #1 and #2, . . . ; default = syncgroup #1)
flash intensity	change the flash intensity of the active target of the **Flystick3** (discontinued) by moving the slider (default = 3)
Flystick2+ only	**Description**
activate feedback	activate feedback functionality of **Flystick2+**
Test	start feedback vibration test run

Table 9.14: Flystick settings - Description of the checkboxes and options

MultiUser option   The MultiUser option is an enhancement especially for VR/AR applications when working with more than one *Flystick2/2+/3* . Tick the checkbox '*activate MultiUser function*' to activate the function. Please refer to the *DTRACK3 Programmer's Guide* → *Output of Measurement Data via Ethernet* for more details.

Use head targets   In order to use a *Flystick2/2+/3* and a head target as data pair tick the checkbox '*use head targets*' as well. Up to ten users can be equipped with a *Flystick2/2+/3* and a head target (usually mounted on glasses). *DTRACK3* is able to track them all but only the data pair (*Flystick2/2+/3* and one designated head target) of one user is available as output data. Switching between the single users can be done by pressing one of the *Flystick2/2+/3* buttons.

9.7.1 Flystick Configuration

Enter the *number of Flysticks* '*0...20*' directly or use the numeric updown button. The corresponding entries in the list of *selected Flysticks* will show up. The fields *Model*, *Serial / Port*, *Sync Groups* and *Flash Intensity* are empty by default.

Make sure that your *Flystick2/2+/3* are listed under *available Flysticks* - compare the serial number listed here to the one printed on the battery compartment of the *Flystick2* or on the back cover of the *Flystick3* . Detach the upper marker compartment of the *Flystick2+* to gain access to the serial number.

Now assign your *Flystick2/2+/3* to a *Flystick ID*:

Therefore,

- mark the respective *Flystick ID*, e.g. '*F1*', by left-clicking the corresponding entry from the list of *selected Flysticks*

- mark the desired *Flystick2/2+/3* from the list of *available Flysticks* by left-clicking

- press *Select* to finalize the assignment.

Repeat these steps if you want to use another *Flystick2/2+/3* .

> **ℹ** **If the list of *available Flysticks* does not contain your *Flystick2/2+/3* press any button of the *Flystick2/2+/3* to register it at the *RadioTransceiver2/3***

9.7.2 Flystick2+ Feedback

This function is only available after assignment of at least one *Flystick2+* device to a corresponding *Flystick ID*.

Tick the checkbox *activate feedback* in the lower left corner of the dialog to activate the feature globally on all **Flystick** devices providing feedback functionality. Mark the respective *Flystick ID* (e.g. 'F1') under *selected Flysticks* by left-clicking and press the button *Test* to send a series of feedback commands to test beep and vibration of the **Flystick2+** . The corresponding status LEDs will light up to indicate radio communication. Please refer to the **ART Hardware Installation Guide** → *Interaction devices* → *Flystick2+* → *Control Elements*.

9.7.3 Flystick Calibration

After assigning the **Flystick2/2+/3** to the **ART RadioTransceiver2/3** , close the *Flystick Settings* dialog and open *Tracking → Body calibration*. There select the body *Flystick body 01* for calibration. Define the orientation of the body coordinate system relative to the body (default: *due to body*). Make sure that all markers of the **Flystick2/2+/3** are seen by the cameras using the *Monitor 2DOF display* which appears in the background. Press *Calibrate* and the calibration will start within 5 seconds. Please refer to chapter 9.5.1 on page 121 for more information concerning the body calibration procedure.

9.7.4 Flystick Output settings

The last step is to define where the **Flystick2/2+/3** data has to be sent to. Open *Tracking → Output*. There either select *this computer* (= remote PC) or enter an IP address of another client you want to send data to. Tick the checkbox '*6df2*' to transmit the **Flystick2/2+/3** data.
Please refer to chapter 9.11 on page 154 for more details.

9.7.5 Flystick Display

Press *Start* to start the measurement. In order to view the tracking data enable the *Flystick display* by clicking *View → Flystick*. Please refer to chapter 6.3 on page 45 for details.

9.8 Fingertracking

This dialog is the center for configuration and calibration of **Fingertracking** hardware (optional with tactile feedback). This feature is not available for **SMARTTRACK2/3/M** .

The following steps describe a full calibration of one hand using non-customized **ART Fingertracking** hardware:

1. Select the number of hands you want to use with your tracking system (up to 4).

2. Assign body calibrations for all hand targets (using the target library). When using

customized hand targets please refer to the corresponding chapter 9.8.3 on page 143 for further details.

3. Calibrate the complete hand geometry (i.e. the position and orientation of the finger tips in respect to the hand target).

4. (optionally) Install an **ART RadioTransceiver2/3** when using **FINGERTRACKING2 Tactile** devices (refer to the **ART Hardware Installation Guide** → *Other equipment* → *Radio Transceiver* and section 8.5 on page 81 for details).

5. (optionally) Assign tactile devices for all hand targets, if applicable

Simply repeat all steps for each tracked hand in your system.

9.8.1 Fingertracking Settings

First, open the dialog *Tracking → Fingertracking* and configure the *number of hands* you are using. Enter the *number of hands '0...4'* directly or use the numeric updown button.
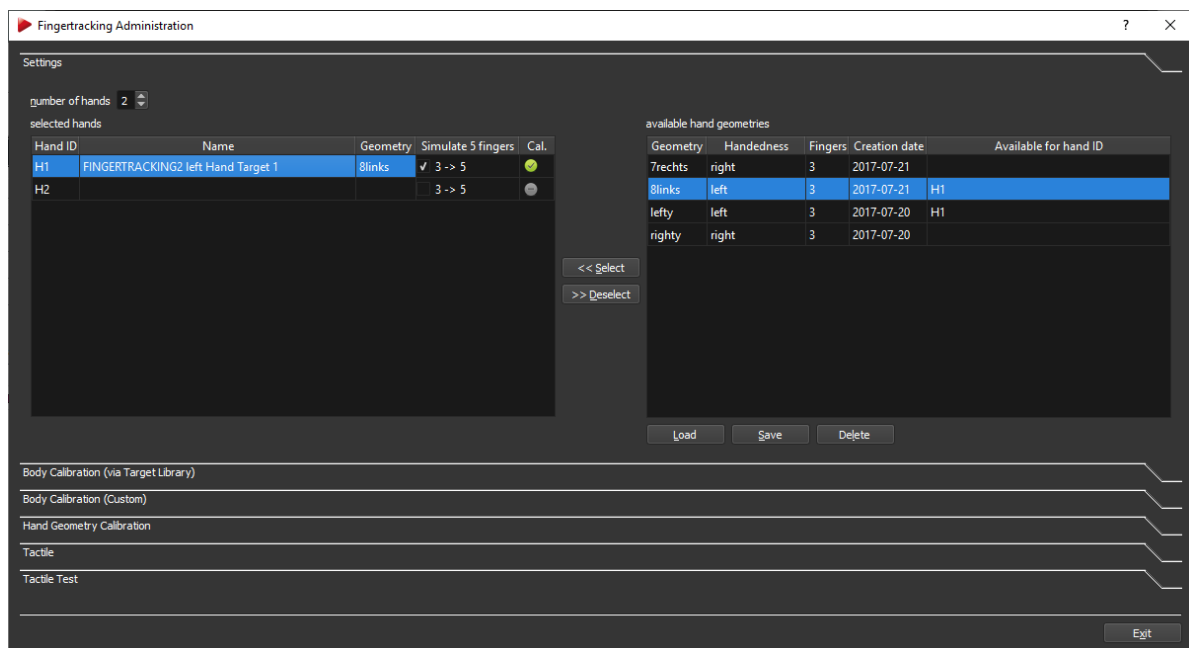
Figure 9.31: Fingertracking Administration - Settings

For each *Hand ID* a row from '*H1...H4*' will show up correspondingly on the left side of the window under *selected hands*. The '*Name*' and '*Geometry*' entries will be empty, while the column *Cal.* will show a grey *No Entry* sign.

Next a body calibration for the hand target has to be assigned using the target library (refer to chapter 9.8.2 on page 141).

Hand target calibrations without corresponding hand geometries are marked with a yellow tick on the corresponding *Hand ID* row under selected hands. A fully calibrated *Hand ID* is marked with a green tick.

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9.8.1.1 Available hand geometries

It is also possible to (re-)assign previously calibrated hand geometries (i.e. position and orientation of the finger tips) to existing hand target calibrations . This way one set of **Fingertracking** hand targets can be used by several different users and, most importantly, one needs to calibrate the hand geometry only once for each person during first installation.

A hand geometry listed on the right side of the window under *available hand geometries* can be assigned to a selected *Hand ID* the following way:

- mark the respective *Hand ID* from row '*H1...H4*' under *selected hands* by left-clicking

- mark the appropriate entry '*Available for hand ID*' → '*H1...H4*' under *available hand geometries* by left-clicking and

- press *Select*

- (optionally) confirm to overwrite the assignment by pressing *OK*. This confirmation will only show up when the assignment to a specific *Hand ID* is to be changed.

If the hand geometry is already in use (multiple assignment) a warning message will be shown instead. You can always delete a previously assigned hand geometry by pressing the button *Deselect*. The geometry will be available again for assignment.

> ℹ️ **In order to identify different hand geometries under *available hand geometries* and to assign it to the corresponding hand target please use meaningful names for the '*geometry*' and double-check the column '*Available for hand ID*'.**
>
> ☞ **In case of multiple assignments (i.e. one hand geometry is to be assigned to more than one hand target calibration) a warning message will pop up. Delete the current assignment prior to re-assigning.**

9.8.1.2 Managing hand geometries

Exporting hand geometries In order to export hand geometries just press '*Save*' and select the hand geometries you would like to export in the upcoming window (see figure 9.32(a) on page 140). Press '*Save*' again, select the location of the respective folder and choose an appropriate file name (see figure 9.32(b) on page 140).

A confirmation window will show the successful import (see figure 9.33 on page 140).

Importing hand geometries You can also import previously saved hand geometries by pressing the button '*Load*'. A window will open to select the respective folder (see figure 9.34(a) on page 140). Choose the appropriate file and press '*OK*'. Then select the individual geometries to import by left-clicking or select all geometries at once by clicking
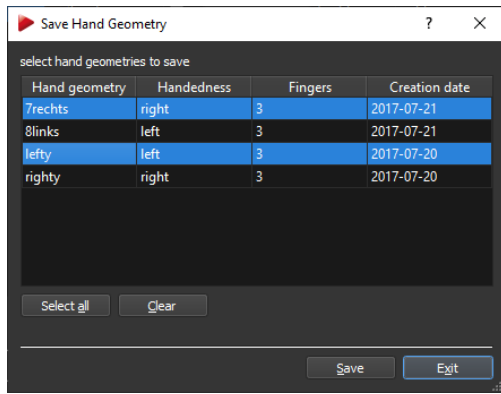
(a) Select the hand geometry file(s) to save
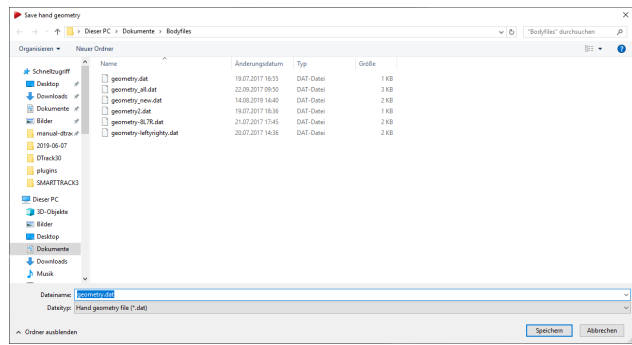
(b) Select the folder on the remote PC

Figure 9.32: Fingertracking Administration - Saving hand geometry files
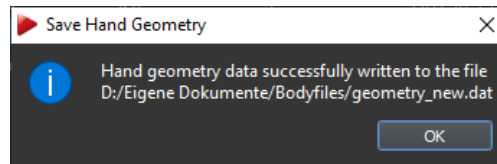
Figure 9.33: Fingertracking Administration - Saving hand geometry files - Confirmation window

select all (see figure 9.34(b) on page 140). Press *Load* to import.

A confirmation window will show the successful import (see figure 9.35 on page 141).
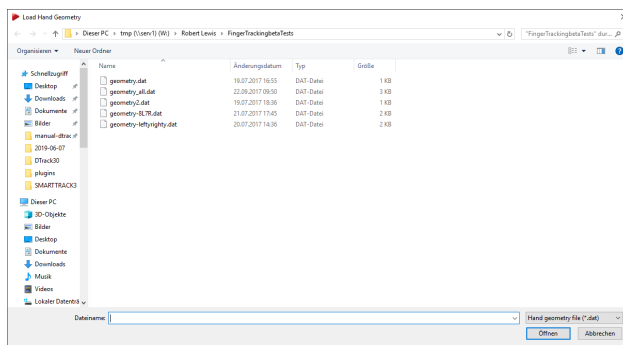
(a) Select the folder on the remote PC
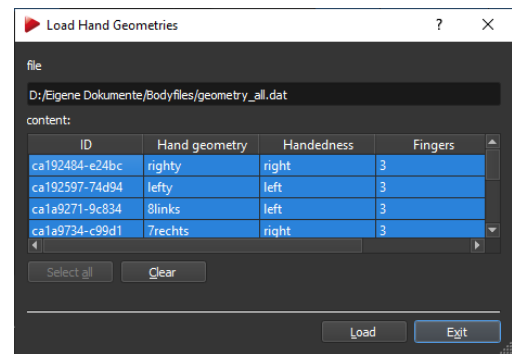
(b) Select the hand geometry file(s) to load

Figure 9.34: Fingertracking Administration - Loading hand geometry files

Deleting hand geometries   You can also remove entries from *available hand geometries* by left-clicking and pressing '*Delete*'. Select the hand geometries you would like to delete in the upcoming window (see figure 9.36(a) on page 141). Press '*Delete*' again to
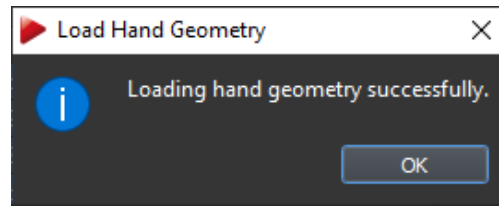
Figure 9.35: Fingertracking Administration - Loading hand geometry files - Confirmation window

remove the corresponding entry.

A confirmation window will show up to confirm the removal (see figure 9.36(b) on page 141).
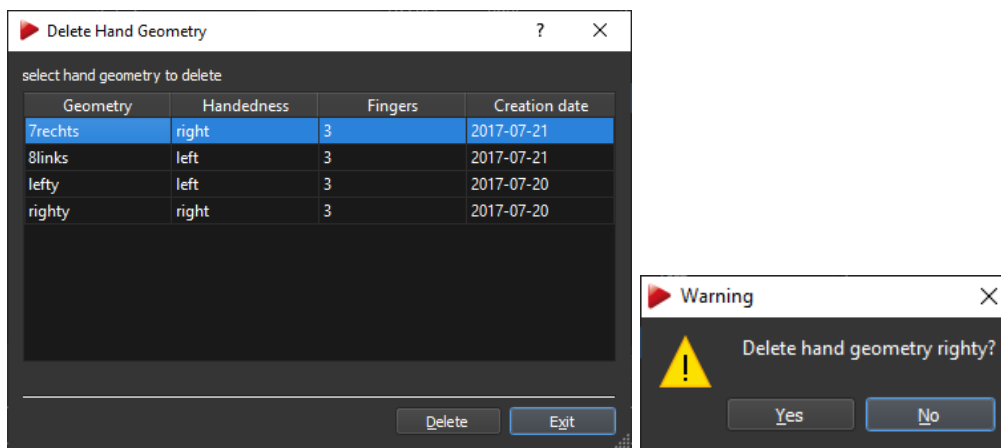
(a) Select the hand geometry file(s) to delete   (b) Confirm the removal

Figure 9.36: Fingertracking Administration - Deleting hand geometry files

9.8.2 Fingertracking Body calibration via Target Library

Open the sub-dialog *Fingertracking → Body Calibration via Target Library* to assign the corresponding body calibration of each hand target to a selected *Hand ID*. All hand target body calibrations stored in the target library are shown on the right side of the window.

> ℹ **The integrated target library contains most hand target calibrations of *ART* Fingertracking hardware. Perform a custom body calibration only when the hand target cannot be identified automatically.**

The body calibration can be assigned to a selected *Hand ID* the following way:

- turn on one *Fingertracking* device and place it inside the tracking volume

- run the target library identification by pressing *Calibrate*. The *Short Name* of the corresponding hand target will be marked green
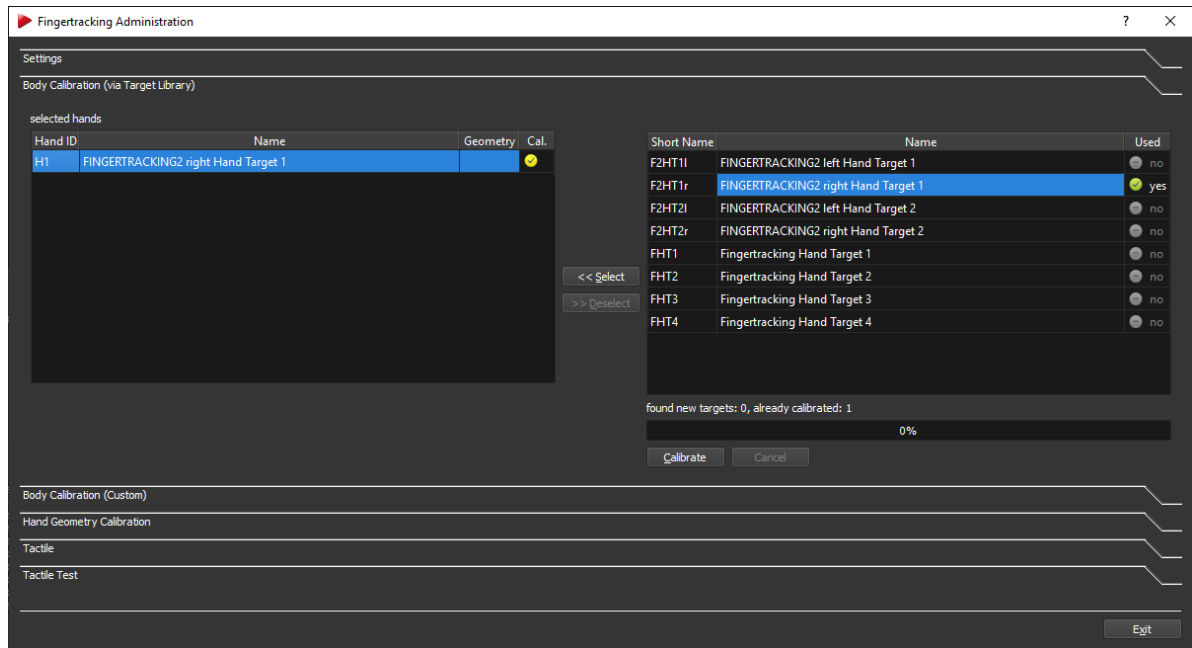
Figure 9.37: Fingertracking Administration - Body Calibration Target library

- mark the respective *Hand ID* from row '*H1...H4*' under *selected hands* by left-clicking

- mark the appropriate entry in the target library (e.g. '*FINGERTRACKING2 left Hand Target 1*') by left-clicking and

- press *Select*

The '*Name*' and '*Geometry*' entries will be updated. The entry in the column *Cal.* will turn into a yellow tick. On the right side of the window the corresponding entry in column *Used* will turn into a green tick and will change to '*yes*'.

You can always delete the assignment by pressing the button *Deselect*. The body calibration will be available again for assignment to a different *Hand ID*.

The next step is to calibrate the handedness as well as the position and orientation of the finger tips (refer to chapter 9.8.4 on page 143).

☞ **The *Fingertracking* without tactile support is delivered with different hand target geometries when using two pair of sets, whereas *FINGERTRACKING2 Tactile* devices have to be set up properly. Refer to the *ART Hardware Installation Guide* → *Interaction devices* → *FINGERTRACKING2 Tactile Hand Targets* how to switch the configuration.**

☞ **Select the Set *1* or *2* configuration of the *FINGERTRACKING2 Tactile* handtargets during first-time installation only. Do not change the setting during routine operation or tracking will fail !**

9.8.3 Fingertracking Body calibration Custom
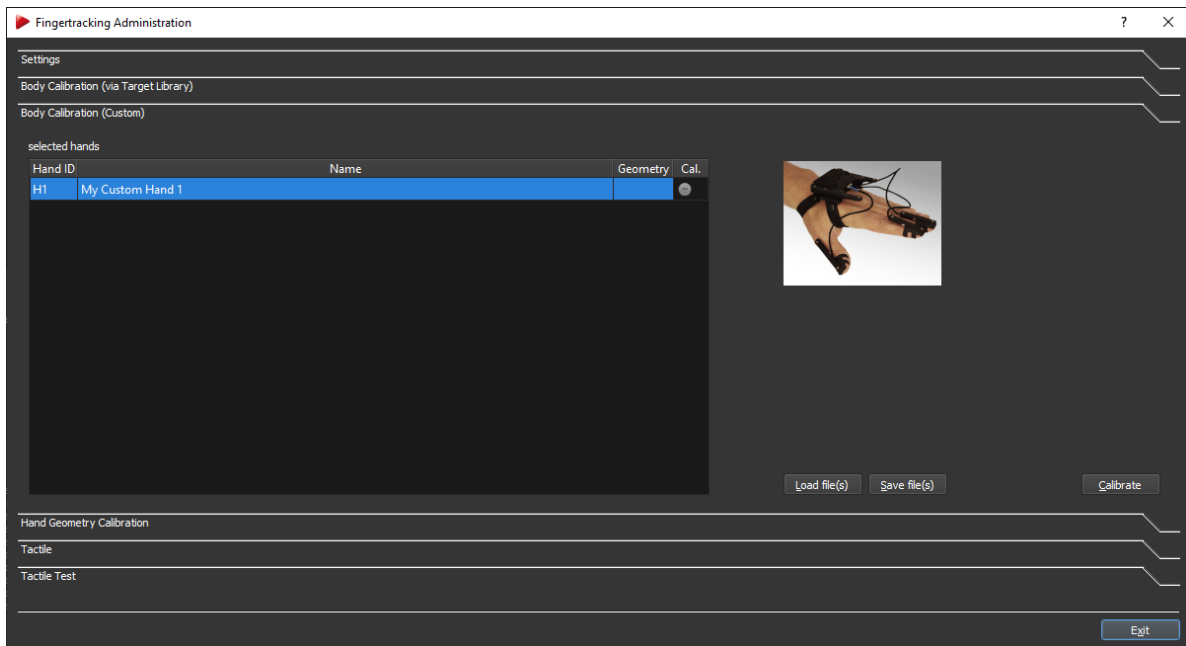
Figure 9.38: Fingertracking Administration - Body Calibration Custom

When using hand targets not found inside the target library (e.g. customized) a standard body calibration has to be carried out. The process of calibrating a 6DOF body is described in chapter 9.5.1 on page 121.

Mark the respective *Hand ID* from row 'H1...H4' under *selected hands* by left-clicking and start the calibration by pressing the button *Calibrate*.

You can also load a calibration from a calibration file instead by pressing '*Load*' after marking the corresponding *Hand ID*. Please refer to chapter 9.5.6 on page 126 for details.

9.8.4 Fingertracking Hand geometry calibration

Open the sub-dialog *Fingertracking → Hand Geometry calibration* to calibrate the handedness as well as the position and orientation of the finger tips . The respective *Hand ID* is selected automatically during the calibration process.

The hand geometry calibration is performed the following way:

- enter a meaningful name for the geometry (e.g. username-left) in the field *new hand geometry name*

- select the handedness by ticking the corresponding radio button for *left* or *right* hand

- select the appropriate thimble set from the dropdown-menu *fingerset*
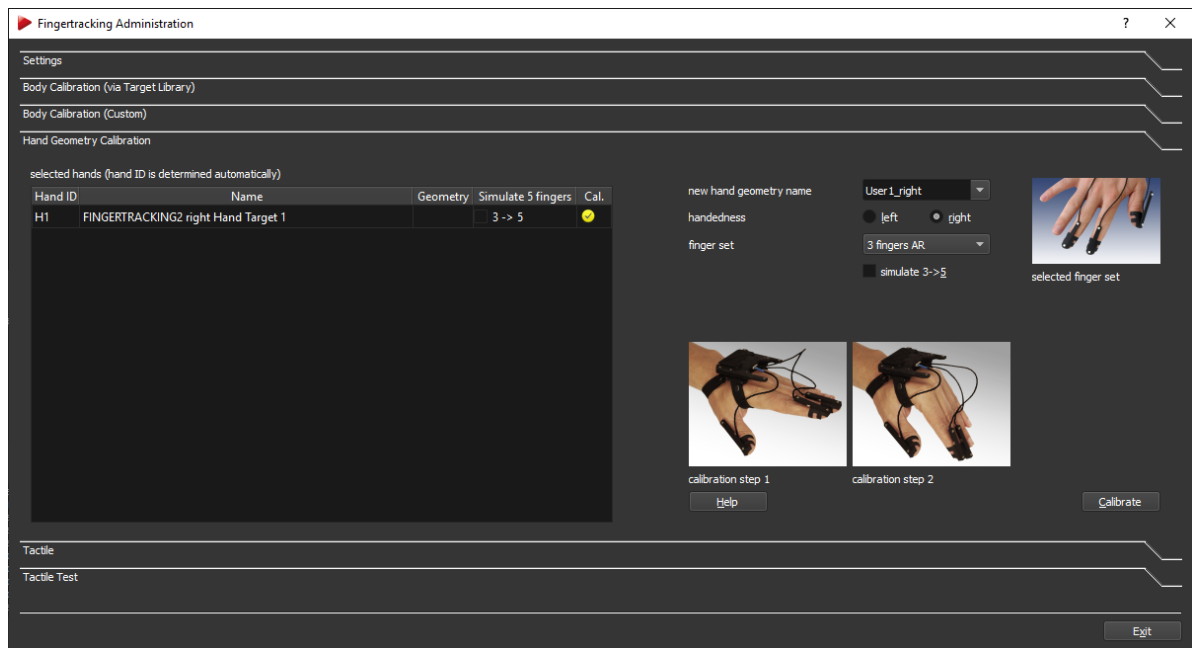
Figure 9.39: Fingertracking Administration - Hand Geometry Calibration

- (optionally) activate the 5 finger simulation (only available for 3-finger thimble sets) by ticking the checkbox *3 -> 5*

- press *Calibrate* to start the two-step calibration process

> ℹ️ **For easy identification and assignment of the correct hand geometry for different users please use meaningful names for the '*geometry*'.**
>
> ℹ️ **Click on the button *Help* to open a window where the calibration process is additionally explained and visualized.**

9.8.4.1 Hand geometry calibration process

After pressing *Calibrate* a countdown for the first step of the calibration process begins.

In the first phase (calibration step 1)

- all fingers have to be stretched out (see left picture in dialog, refer to figure 9.39 on page 144)

- the thumb has to be spread away from the hand

- do not spread the other fingers, keep them together. Take care, that there is no space between them

- do not move any finger nor the thumb during the first calibration phase

- you may move the entire hand slightly
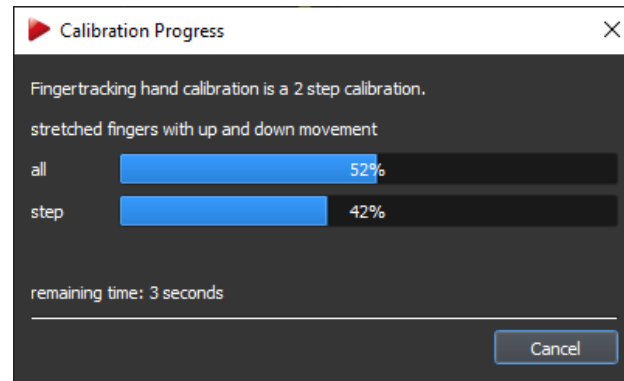
Figure 9.40: Fingertracking Administration - Hand Geometry Calibration progress bar

A progress bar shows the status of the calibration (see figure 9.40 on page 145).

☞ **If calibration step 1 fails, please check if modulated flash is activated for at least one camera and if the correct handedness and thimble set are selected.**

☞ **It is important that the hand is held inside the tracking volume and all markers are visible to at least two cameras when starting the calibration process.**
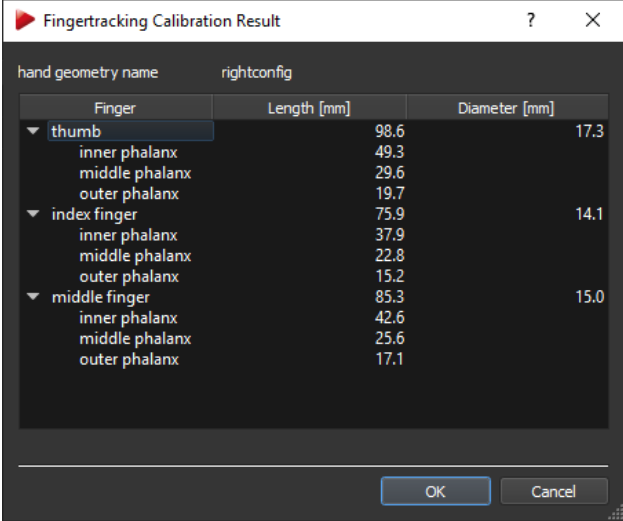
After the first step has been completed a new countdown for step 2 is started.

During the second phase (calibration step 2)

- keep the fingers stretched out (see right picture in dialog, refer to figure 9.39 on page 144)

- keep the thumb spread away from the hand

- keep the other fingers close together

- gently move all of your fingers up and down at the same time until the calibration process is finished. The thumb is still spread away from the hand and should not be moved during this phase.

- do not bend or cross your fingers

ℹ **Try to achieve an angle of approximately 60°between up and down position of the fingers.**

ℹ **If the calibration terminates with an error message, double-check the calibration procedure by clicking the button *Help*.**

☞ **If calibration step 2 fails, please take care not to bend your fingers, and not to move the thumb too much**

After data collection a process is started which calculates the finger sizes from the movement of the finger tips (see figure 9.41 on page 146. The length of the thumb is derived by the finger lengths.

Figure 9.41: Fingertracking Administration - Hand Geometry Calibration result window

After successful calibration the '*geometry*' entry under *selected hands* will be updated. The entry in the column *Cal.* will turn into a green tick.

When using **Fingertracking** without tactile support, the next step is to activate the data output. Please refer to chapter 9.8.7 on page 149. When using **FINGERTRACKING2 Tactile** you need to assign the tactile devices, see to chapter 9.8.5 on page 147 for details.

9.8.4.2 5 Finger Simulation

If you are using a three finger thimble set but would like to get data for five fingers, tick the checkbox *simulate 3 -> 5*. **DTRACK3** will simulate the data of the two missing fingers by putting them parallel to the middle finger. By default, the checkbox *simulate 3 -> 5* is unticked until you have carried out a hand geometry calibration.

9.8.4.3 Resetting finger tip sequence

When the **Fingertracking** device has been removed from the hand and afterwards is put on again by the same user, the system needs to reset the correct order of the finger tips. To regain the correct sequence, the hand must be kept still with all fingers stretched out and the thumb spread to the side (see first phase of calibration process). When using two hands, both hands have to be separated by at least 50 cm during this procedure.

> **ℹ** **Fingertracking devices will compensate short synchronization losses internally.**

☞ **In the rare case when the *Fingertracking* devices have lost synchronization use the reset procedure to regain synchronisation. Refer to the *ART Hardware Installation Guide* → *Interaction devices* → *Fingertracking* → *Description of the hand targets*.**

9.8.5 Fingertracking Tactile Assignment

Open the sub-dialog *Fingertracking* → *Tactile Assignment* to assign a tactile device to the corresponding *Hand ID*. All *available tactile devices* will show up on the right side of the window. This function is only available with **FINGERTRACKING2 Tactile** devices.
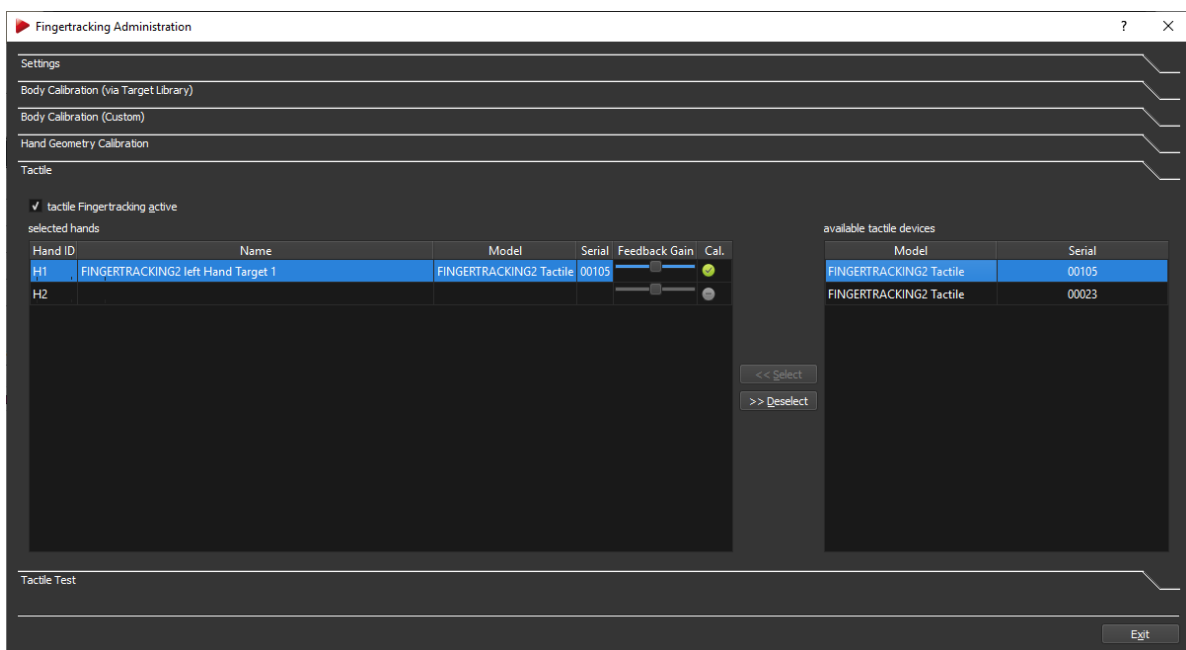
Figure 9.42: Fingertracking Administration - Tactile Device Assignment

Tactile devices are assigned the following way:

* activate the support for tactile devices by ticking the corresponding checkbox *tactile Fingertracking active*

* mark the respective *Hand ID* from row 'H1...H4' under *selected hands* by left-clicking

* mark the appropriate entry under *available tactile devices* (e.g. 'FINGERTRACKING2 Tactile' with 'serial number' XY) by left-clicking and

* press *Select*

The 'Model' and 'Serial Number' entries will be updated accordingly.

You can always delete the assignment by pressing the button *Deselect*. The tactile device will be available again for assignment to a different *Hand ID*.

Feedback Gain   The feedback strength can be adjusted using a global gain setting, i.e. the feedback used inside the application is multiplied by this value. By default, this feedback gain is set to average. Activate the slider *Feedback Gain* by double-clicking, then move it to the right to increase the gain setting, move the slider to left to decrease it respectively.

Please refer to the **DTRACK3 Programmer's Guide** → *Input of Control Data via Ethernet* for more information about setting the feedback strength.

You can also test the feedback strength (refer to the next chapter 9.8.6 on page 148).

> **The serial number of the tactile device can be found on the bottom of the hand target, e.g. 8L means tactile device #8. Refer to the *ART Hardware Installation Guide* → *Interaction devices* → *Fingertracking* → *Description of the hand targets***

> **Please install an *ART RadioTransceiver2/3* when using FINGERTRACKING2 Tactile devices (refer to the *ART Hardware Installation Guide* → *Other equipment* → *Radio Transceiver* and section 8.5 on page 81 for details).**

9.8.6 Fingertracking Tactile Test

Open the sub-dialog *Fingertracking* → *Tactile Test* to test the feedback on the thimbles. This function is only available after assignment of a **FINGERTRACKING2 Tactile** device to a corresponding *Hand ID*.
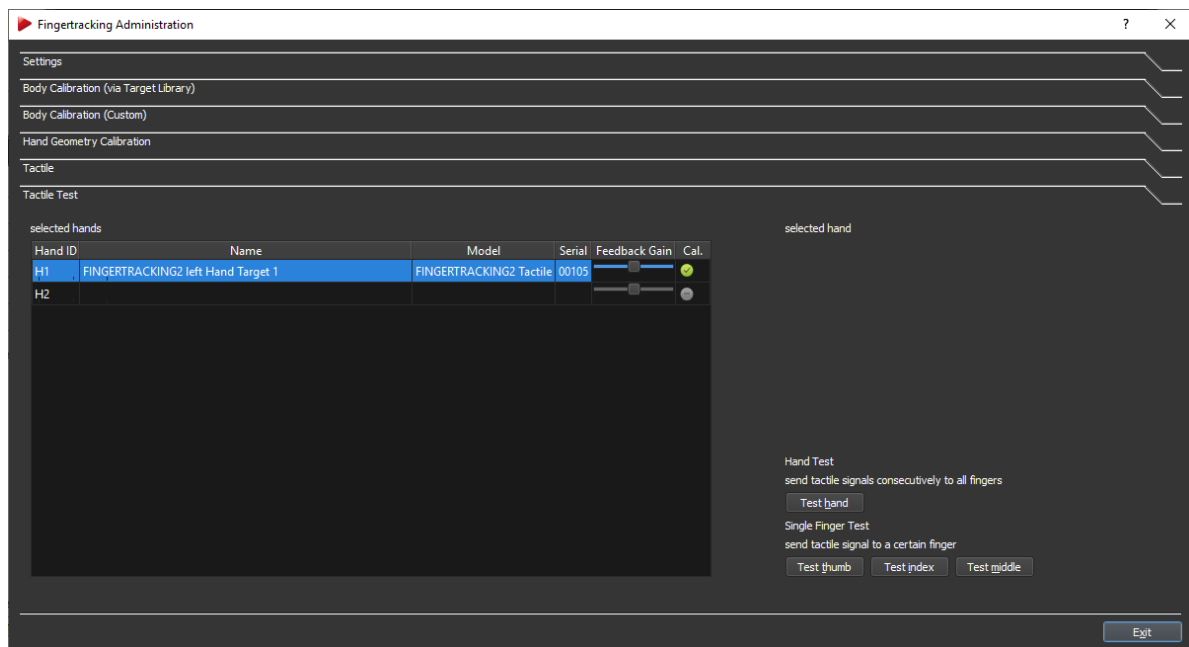
Figure 9.43: Fingertracking Administration - Tactile Device Test

Mark the respective *Hand ID* from row 'H1...H4' under *selected hands* by left-clicking.

Then press the button *Test hand*. The tactile thimbles will be activated sequentially from thumb over index finger to middle finger.

You can also test one finger after the other by pressing the corresponding buttons *Test thumb*, *Test index* or *Test middle*. The corresponding status LED will light up to indicate radio communication. Refer to the **ART Hardware Installation Guide** → *Interaction devices* → *Fingertracking* → *Description of the hand targets*.

9.8.7 Fingertracking Output settings

The last step is to define where the **Fingertracking** data has to be sent to. Open *Tracking* → *Output*. There either select *this computer* (= remote PC) or enter an IP address of another client you want to send data to. Tick the checkboxes '*gl*' and '*glcal*' to transmit the **Fingertracking** data.
Please refer to chapter 9.11 on page 154 for more details.

9.8.8 Fingertracking Display

Press *Start* to start the measurement. In order to view the tracking data enable the *Fingertracking display* by clicking *View* → *Fingertracking*. Please refer to chapter 6.3 on page 45 for details.

9.8.9 External Add-On - Fingertracking Viewer

The Fingertracking Viewer is a tool for visualisation of the hand and finger positions. It is available free of charge for demonstration and testing purposes to be installed on the PC that receives **DTRACK3** data.

After starting the viewer, proceed the following way:

- specify the **ART Controller** or **ART Controller/M** to connect to by defining the host name or IP address

- specify the UDP data port the viewer has to listen to

- press the *Go Online* button

- press *OK* to connect the viewer to **DTRACK3**

- choose the *Hand ID* you want to display

The indicator adjacent to the *Hand ID* setting shows whether this hand is tracked or not (green=tracked, red=not tracked). Finally click on one of the buttons featuring a hand to see your tracked hand and fingers.

You can also start a small demo showing the handling of a virtual object by opening the *Demos* menu. There is a limited number of demos available, e.g. you can handle a virtual sphere or cube. To insert the virtual object into the tracking volume, place the tracked hand at a convenient position and press the *Grab object* button.

9.9 Measurement Tool

Within this dialog you can manage the *number of Measurement Tools* and the *number of references* (max. 4 each) and configure the corresponding settings to be used (see figure 9.44 on page 150).
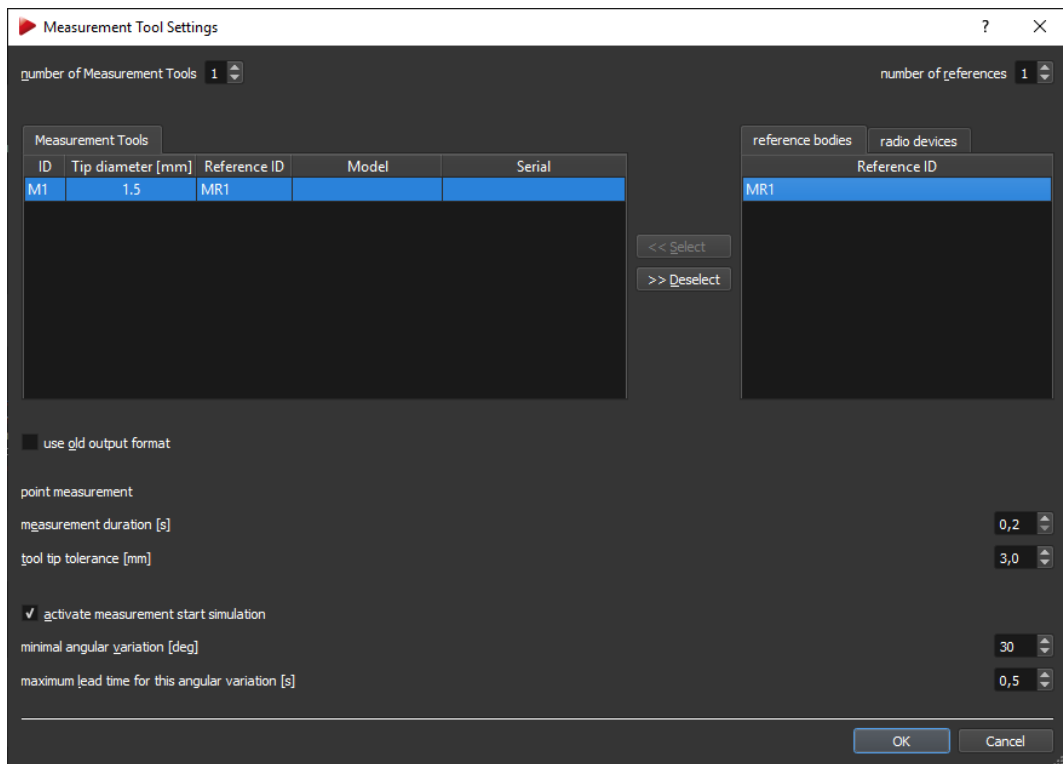
Figure 9.44: Measurement Tool

Additionally several other parameters can be changed to suit your application:

Enter the *number of Measurement Tools* '0...4' directly or use the numeric updown button. The corresponding entries in the list of *Measurement Tools* will show up. The fields *Model*, *Serial* are empty by default. Double-click the corresponding entry *Tip diameter [mm]* and enter a value (in mm) when using ball-shaped tips. The diameter will be included in the data output (refer to the **DTRACK3 Programmer's Guide** → *Output of Measurement Data via Ethernet*).

Control	Description
number of Measurement Tools	configure the number of devices to be used
number of references	configure the number of reference bodies to be used
Tip diameter [mm]	define the diameter of the tip (ball-shaped)
use old output format	use the legacy output format (refer to the **DTRACK3 Programmer's Guide**)
measurement duration [s]	configure how long a measurement with the Measurement Tool (valid range: 0.2 - 10.0 sec) should take
tool tip tolerance [mm]	specify the range within the tip is assumed to be static (valid range: 0.1 - 5.0 mm)
activate measurement start simulation	activate the gesture detection and enable the respective controls
minimal angular variation [deg]	specify the minimum angle that the Measurement Tool has to be tilted over to start a measurement (valid range: $10°$ - $120°$)
maximum lead time for this angular variation [s]	waiting time before the measurement start after gesture detection

Table 9.15: Measurement Tool settings

Measurement Duration   It is possible to define the duration of a point measurement. A compromise has to be found between the amount of data collected and the convenience of holding the Measurement Tool . Enter the value in seconds in the field *measurement duration [s]*.

Tool Tip Tolerance   The tracking system will take measurements up to a defined jitter in millimeter around the tool tip. Configure this tolerance to suit your needs for accuracy. Enter the value in millimeters in *tool tip tolerance [mm]*.

Start Simulation   In certain applications and use cases it might be more convenient to start the measurement by a gesture rather than pressing a button on your PC. Tick the checkbox *activate measurement start simulation* to enable the gesture detection.

The gesture is simply tilting the Measurement Tool along the tip axis similar to waving. You can configure the minimum angle of tilt that is necessary to detect the gesture. Enter the value in $°$[deg] in the field *minimal angular variation [deg]*. Additionally you can specify a waiting time until the measurement starts after detection of the gesture. Specify the time in seconds in the field *maximum lead time for this angular variation [s]*.

9.9.0.1 Reference bodies

If you are working with a reference body you may assign it to a specific Measurement Tool :

- mark the respective *Measurement Tool ID* by left-clicking,

- mark the reference body *Reference ID* and

- press *Select*.

The '*Reference ID*' entry will be updated accordingly. Repeat these steps if you want to assign references to other Measurement Tools .

If you are working with reference bodies you will need to calibrate them as well. This is done using a standard body calibration of e.g. *Measurement Tool reference body 01*. Please refer to chapter 9.5.1 on page 121 for more information concerning the body calibration procedure.

☞   **A Measurement Tool with an assigned reference body can only be tracked when the reference body is tracked as well.**

9.9.1 Measurement Tool Calibration

The calibration of the Measurement Tool is separated into two steps:

1. body calibration of the Measurement Tool and

2. calibration of the tip (refer to section 9.10 on page 153.

9.9.1.1 Measurement Tool Body Calibration

First, calibrate the Measurement Tool using a standard body calibration. Close the *Measurement Tool Settings* dialog and open *Tracking → Body calibration*. There select the body *Measurement Tool body 01* for calibration. Define the orientation of the body coordinate system relative to the body (default: *due to body*). Make sure that all markers of the Measurement Tool are seen by the cameras using the *Monitor 2DOF display* which appears in the background. Press *Calibrate* and the calibration will start within 5 seconds. Please refer to chapter 9.5.1 on page 121 for more information concerning the body calibration procedure.

9.9.2 Measurement Tool Output settings

The last step is to define where the Measurement Tool data has to be sent to. Open *Tracking → Output*. There either select *this computer* (= remote PC) or enter an IP address of another client you want to send data to. Tick the checkboxes '*6dmt2*' and '*6dmtr*' to transmit the Measurement Tool data.
Please refer to chapter 9.11 on pag 154 for more details.

9.9.3 Measurement Tool Display

Press *Start* to start the measurement. In order to view the tracking data enable the *Measurement Tool display* by clicking *View → Measurement Tool*. Please refer to chapter 6.3 on page 45 for details.

9.10 Measurement Tool Tip Calibration

After a successful body calibration, you have to calibrate the tip of the Measurement Tool by opening *Tracking → Measurement Tool Tip calibration* (see figure 9.45 on page 153) .
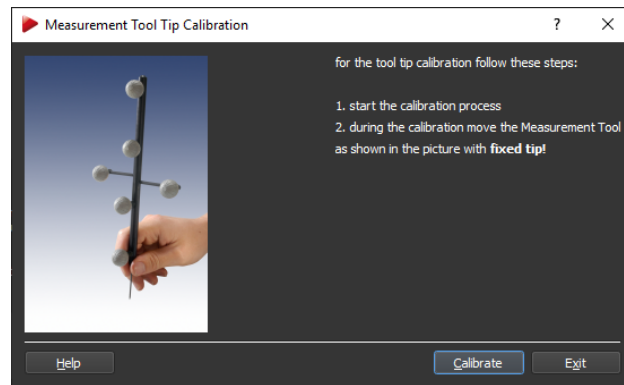
Figure 9.45: Measurement Tool Tip Calibration

Place the Measurement Tool in front of the cameras with the tip fixed at exactly one position (e.g. on a hard surface). Press *Calibrate* to start the calibration process.

Gently move the Measurement Tool while tilting it around its tip in all axes. A progress bar will show the current status (see figure 9.46(a) on page 153. *DTRACK3* will calculate the position of the tip relative to the markers of the Measurement Tool , i.e. the origin of the body coordinate system is transformed into the Measurement Tool 's tip.
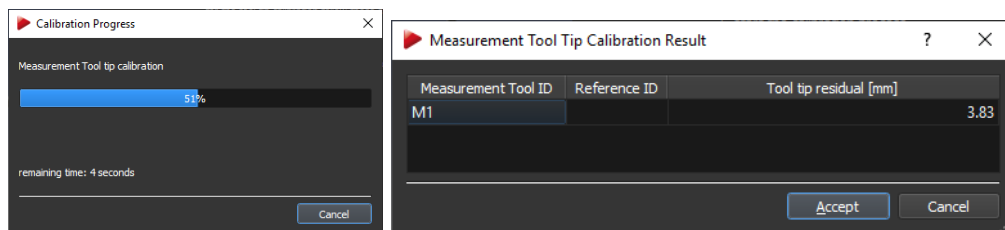
(a) Progress bar
(b) Calibration Result

Figure 9.46: Measurement Tool Tip Calibration Process

After successful tip calibration the result is presented in the dialog *Measurement Tool Tip Calibration Result* (see figure 9.46(b) on page 153. Please check the information and either '*Accept*' or '*Cancel*' the tip calibration.

> **A tool tip calibration result below 0.2 mm is recommended for measurements with high accuracy.**

> **Keep the Measurement Tool positioned at exactly one point, i.e. do not lift it from the surface.**

☞　**The progress bar will stop if the Measurement Tool is not moved suffi-ciently.**

9.11 Output Settings

In this dialog you can manage the settings for data output via ethernet (see figure 9.47 on page 154). You can send data to any computer within your local network with a total of up to 10 individual channels for UDP data.

Figure 9.47: Output settings

First tick the checkbox *active* on the corresponding tab to enable data output for each channel. Next enter the IP address of the receiving client in the box *send to* and choose a UDP port number in *UDP Port*.
Alternatively tick the checkbox *this computer* instead to send the data to the remote PC from where you started the **DTRACK3** frontend.

You can also send the data to a multicast IP address (in the range of 224.0.1.0 to 239.255.255.255) by ticking the checkbox *multicast*.

By clicking on the tab $+$ you can add one channel at a time up to 10 channels. Set-up each channel on the corresponding tab as described above. Scroll horizontally using the *left / right arrow button* or simply resize the dialog window using the mouse. Click the button *Close tab* to remove the selected output channel configuration. A warning message will appear to confirm the action. Press *Exit* to close the *Output Settings* dialog.

send data divisor   In order to reduce the amount of data from the data stream you can define a divisor from 1 to 10. The divisor works the following way:

- 1 .. every frame is transmitted,

- 2 .. every second frame is transmitted,

- ...

- 10 .. every tenth frame is transmitted.

selection of UDP output data

Identifier	Description
fr	frame counter
ts	timestamp
6dcal	number of calibrated bodies
6d	6DOF standard body
3d	3DOF marker
6df	Flystick (old format) [1]
6df2	Flystick
6dmtr	Measurement Tool reference
gl	Fingertracking hand
glcal	number of calibrated Fingertracking hands
st	system status
6di	6DOF inertial body (extended format)
6dmt	Measurement Tool (old format) [2]
6dmt2	Measurement Tool (also for ball probes)
6dcov	6DOF standard body covariance [3]
3dcov	3DOF marker covariance [3]

[1] only available if activated in Tracking $\rightarrow$ Flystick $\rightarrow$ checkbox '*use old output format*'

[2] only available if activated in Tracking $\rightarrow$ Measurement Tool $\rightarrow$ checkbox '*use old output format*'

[3] hidden, by default. An optional license code is necessary to unlock these features. Please refer to section 7.2 on page 59 for more information.

Table 9.16: Description of UDP output data

Please refer to the **DTRACK3 Programmer's Guide** $\rightarrow$ *Output of Measurement Data via Ethernet* for the format of the data output.

☞ **Double-check the currently used pulse generating source in the menu** *Inertial Sensor Settings → Tracking***. Please refer to chapter 8.6.2.5 on page 95 for further information.**

☞ **When using the identifier '***timestamp***' please refer to the** *DTRACK3* *Programmer's Guide → Output of Measurement Data via Ethernet* **regarding the accuracy of timestamps.**

☞ **Please double-check that output channels are activated only for connected clients ready to receive data. De-activate all output channels when clients have been disconnected or IP addresses have become invalid.**

9.11.1 Act as router for tracking output

This functionality may be used when it is not allowed to connect the controller to your local network due to IP security reasons. The UDP output data can then be routed to your local network via *DTRACK3* . The mandatory requirement for this function is that the PC running the *DTRACK3* frontend is equipped with two ethernet LAN ports. One is necessary for connecting the controller and the other for connection to your local network (see figure 9.48 on page 156).

Tick the checkbox *act as router for tracking output* to activate the function.

(a) *act as router* disabled (default)   (b) *act as router* enabled
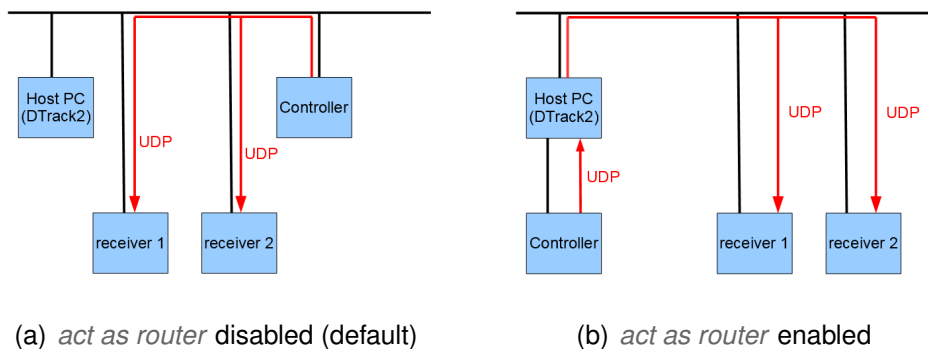
Figure 9.48: Depiction 'act as router' functionality

ℹ **Using** *DTRACK3* **to forward the UDP data output will add a short delay / latency.**

☞ **Do not use this function if the application PC and the controller are in the same network!**

10 Menu View - Frontend configuration

Display	Shortcut
Set to default	
Monitor 2DOF	
Data	F10
Flystick	
Fingertracking	
Measurement Tool	
Events	

Table 10.1: Menu *View*

Set to default   This function resets the appearance of the **DTRACK3** frontend, i.e. all views and the size of the windows are reverted to default values. Only the *Monitor 2DOF* and the displays *Data* and *Events* are shown.

Monitor 2DOF   The *Monitor 2DOF display* is a graphical display of the field of view of the cameras to visualise all markers that are seen by the cameras. It is activated by default. A more detailed description can be found in chapter 6.3.1 on page 45.

Data   On the left hand side the *Data Display* shows the 6DOF measurement results (i.e. position and orientation of the body relative to the room coordinate system). Additional information for inertial sensors are also shown, if applicable. On the right hand side the results for 3DOF calculation of single markers (e.g. from not-calibrated targets) are shown, if activated.

Measurement Tool   The *Measurement Tool* display shows the measurement results of the position and orientation of the Measurement Tool .

Events   The *Event Display* shows the status of the tracking system. All messages and entries shown here are also stored in event logs on the remote PC. These files are necessary for tech support by **ART** (please refer to chapter 7.3 on page 62).

Fingertracking (not available for *SMARTTRACK2/3/M*)   The *Fingertracking* display shows the measurement results for the hands - i.e. of back of the hand + each finger (thumb, index, middle, ...).

Flystick   The *Flystick* display shows the measurement results of the position and orientation of the Flystick.

11 Menu Tools

Tools	Shortcut
Measure points	

Table 11.1: Menu *Tools*

11.1 Measure Points

This tool (see figure 11.1 on page 159) provides a simple acquisition method for measurements with the Measurement Tool .
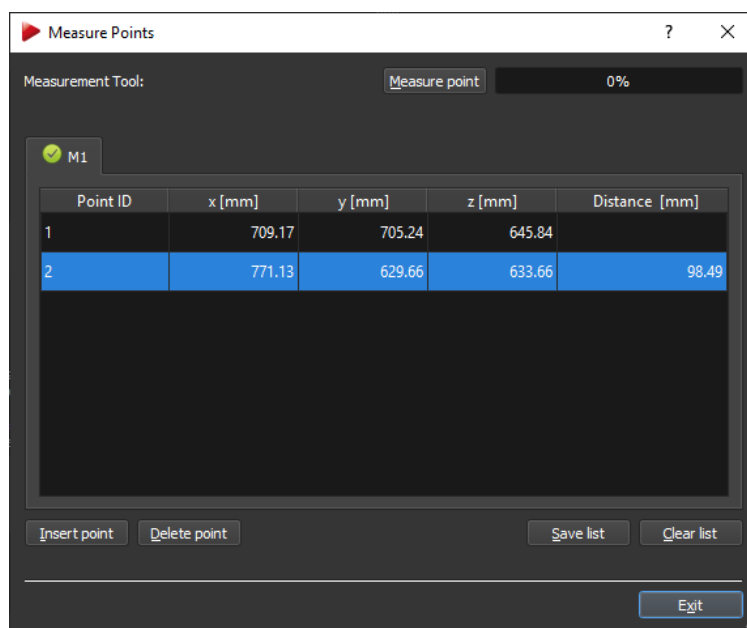
Figure 11.1: Measure Points

The dialog shows the following informations:

The measurement of a point is started either by pressing the button *Measure point* or by performing a gesture with the Measurement Tool . Tilt over the Measurement Tool as defined in 9.9 on page 150. The distances between adjacent points are computed automatically. You may insert or delete points from the list and you may save the list to a file.

Control	Description
Measure point	Place the Measurement Tool at the position you want to measure and press this button.
Insert point	Add an additional measurement to the list (above the selected point).
Delete point	Remove the selected measurement from the list.
Save list	Export the list of measurements to a file (e.g. for import in a spreadsheet program).
Clear list	Delete all entries of the list.

Table 11.2: Measure Points - Description

i   **If the Measurement Tool is not tracked a measurement cannot be performed!**

12 Menu Help

About	Shortcut
What's this?	Shift + F1
What's new?	
Controller Update	
Service	
DTRACK3	F1
About Qt	

Table 12.1: Menu *Help*

12.1 What's this?

By clicking *What's this*, you may use the context-sensitive help function within the **DTRACK3** frontend software. Just point the mouse cursor over any feature of the **DTRACK3** GUI, then left-click to receive additional information.

12.2 What's new?

The upcoming window provides information about the new features that have been released with the current version. By clicking on '*Show more*' you can access the history of introduced features (see figure 12.1 on page 162).
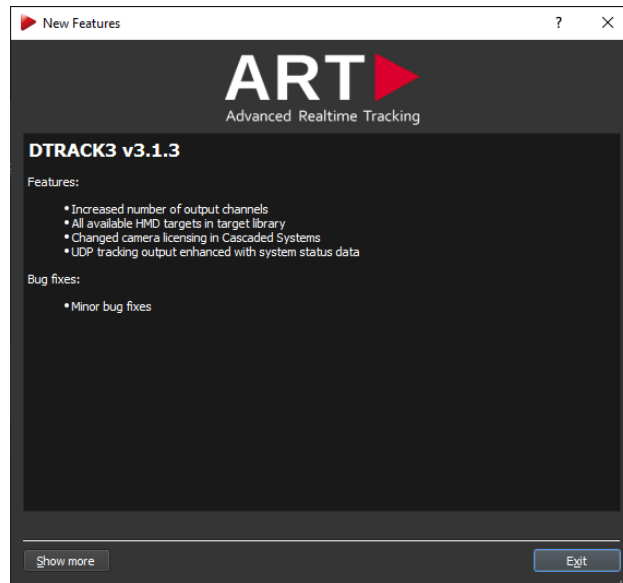
Figure 12.1: What's new Information

12.3 Controller Update

After updating the *DTRACK3* frontend software an automatic update of the controller and cameras is started, if necessary. In case you have aborted this process during first run you can re-open the update assistant here (see figure 12.2 on page 162).
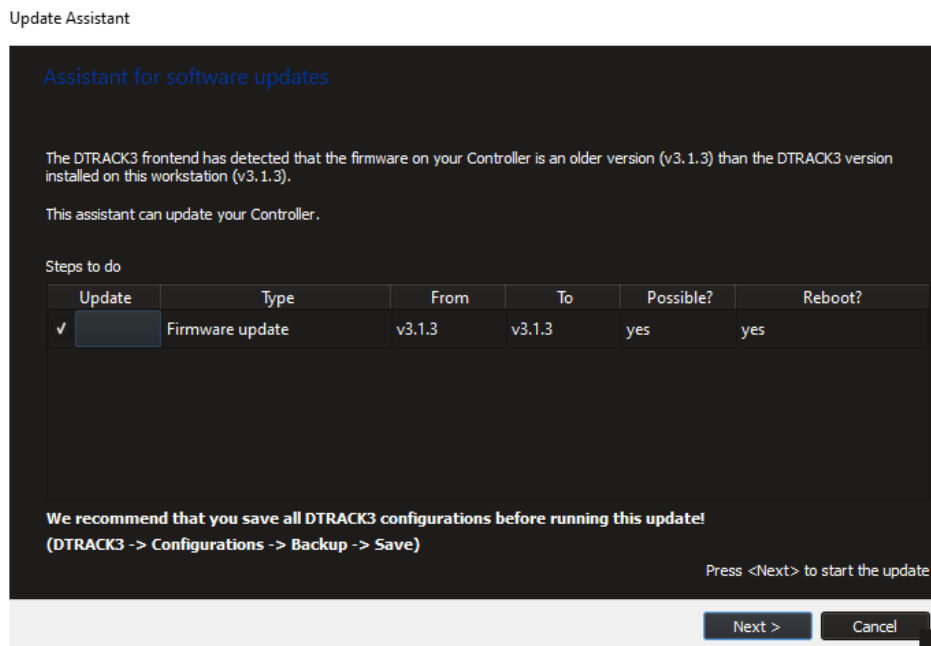
Figure 12.2: Update Assistant

Click *Next* to start the update process. Confirm by clicking *Yes* in the upcoming dialog (see figure 12.3(a) on page 163). A final warning will open after which the update is started (see figure 12.3(b) on page 163). Do not stop the process afterwards.

(a) Confirmation window

(b) Confirmation warning
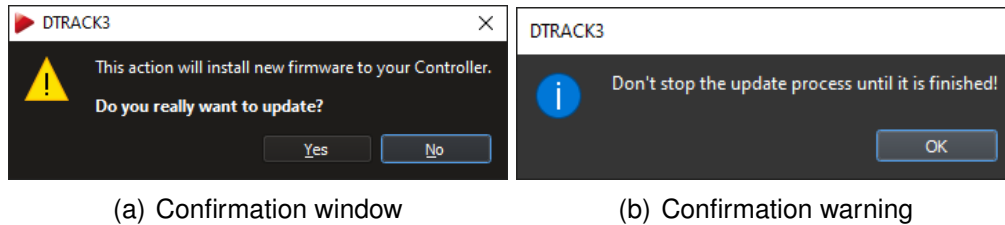
Figure 12.3: Confirming the update

The update assistant will then show the current status using a progress bar (refer to 12.4(a) page 163). Depending on the update this may take several minutes.

(a) Update Assistant progress bar

(b) Restart warning
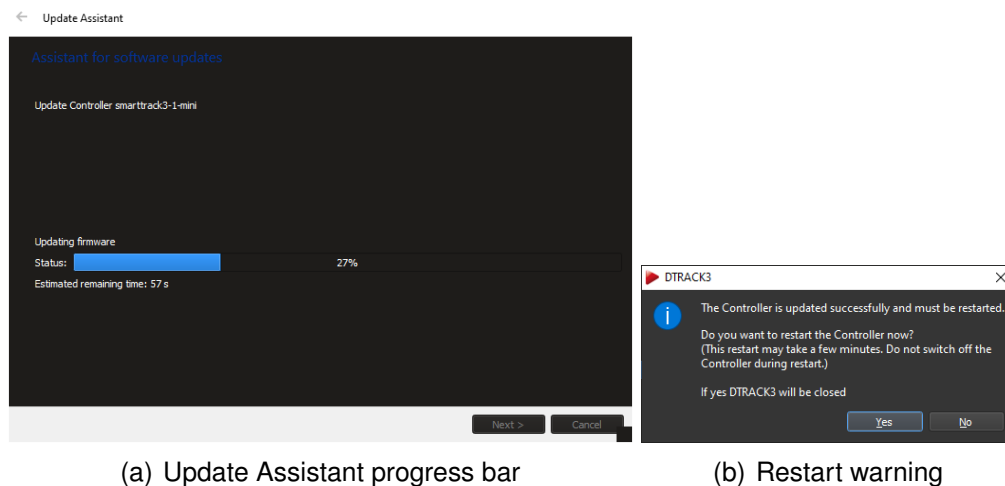
Figure 12.4: Running the update

After the update has been completed the controller has to be restarted to finalize the update process. In order to restart directly click *Yes* in the upcoming dialog (refer to 12.4(b) page 163).

You may also continue with your measurement by clicking *No*. The update assistant will show that your controller is up-to-date (refer to 12.5 on page 164). Click *Finish* to close the update assistant. Please remember to restart the controller later on.

> **ℹ** **Personal settings and configurations (e.g. room and body calibration, output settings, etc.) will be preserved during update!**

> **ℹ** **Updates of the camera firmware are installed in a seperate run after the controller has been updated completely.**
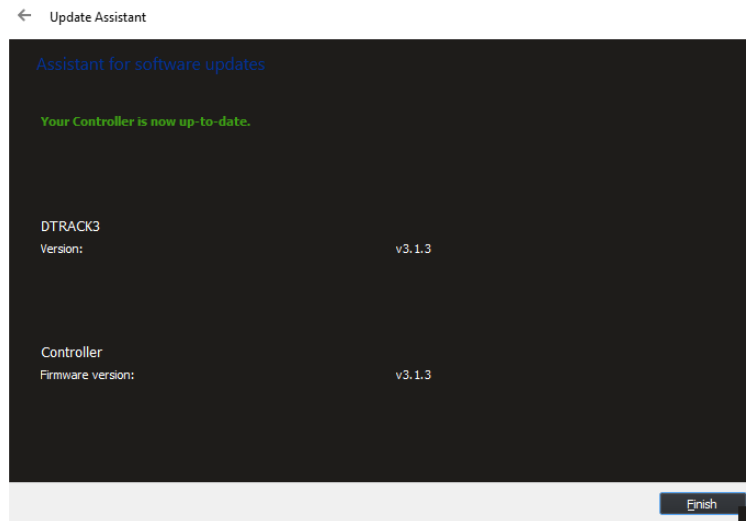
Figure 12.5: Update Assistant Completed

In case you have not updated your system on regular basis the update assistant may open repeatedly to run incremental updates of the controller (e.g. v2.10.0 → v2.14.1 → v3.1.0) followed by updates of the camera firmware when applicable. The whole process may take several minutes.

The controller may be restarted automatically to finish the update process. In case of updating the camera firmware the cameras need to be turned off separately.

Please remember to manually restart the controller if you cancelled the automatic restart.

All patch releases and updates (e.g. v3.1.0 → v3.1.1 → v3.1.2 → v3.1.3 →...) may be installed without restrictions.

***DTRACK3* may only be upgraded to the next version (e.g. v3.1.0 → v3.2.0) having a valid 'DTRACK3 Upgrade' license. Please double-check your license status first (see chapter 7.2 on page 59 for more information).**

12.3.1 Upgrading from earlier versions

When upgrading versions earlier than *DTRACK3* (e.g. *DTrack2 2.14.1*) you will be prompted with an additional warning message (see figure 12.6 on page 165). Please double-check that your system meets the specified requirements.

In case the requirements are not met the upgrade will be denied (see figure 12.7 on page 165).

As an additional measure against invalid upgrades a dialog will appear next in order to check for a valid *DTRACK3* license code (see figure 12.8 on page 165).
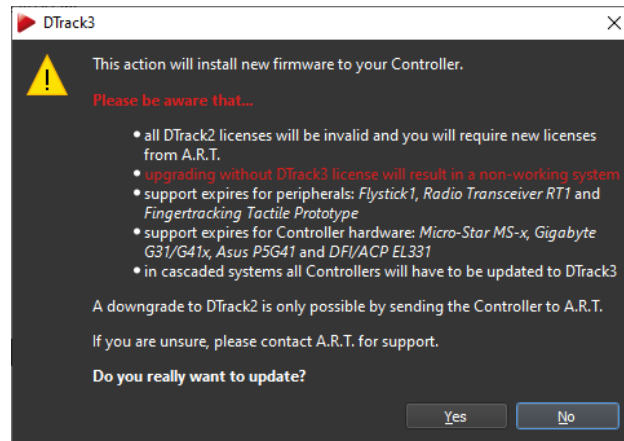
Figure 12.6: Upgrade Warning

Figure 12.7: Upgrade Denied
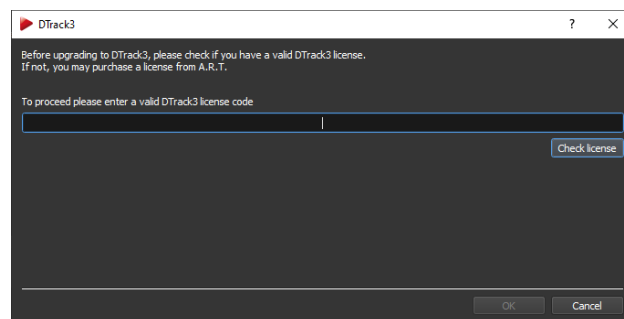
Figure 12.8: Upgrade Valid License Code Entry

After entering the code press *OK* and the upgrade will be started. Please refer to the previous section and figure 12.4(a) on page 163.

12.4 Service

The service dialog shows important information when contacting *ART* technical support (see figure 12.9 on page 166).

The *Service-ID* is a unique identifier of your controller. Next the current software version on your controller (i.e. backend) is shown next to *DTRACK*. You can select both entries to copy & paste.

The following entries show the *Service Level* and *Warranty Level*. These levels correspond to the status of your contract for service and maintenance, if applicable. The minimum level without contract is 'Standard'. Depending on your *Service Level* contact details of **ART** are provided here. For further information please consult your service agreement.

You can also access the **ART** website directly using the link below. The *Service-ID* is attached automatically at the end of the link.

At the bottom of the dialog the export system information window can be opened (please refer to section 12.4.1 on page 166).
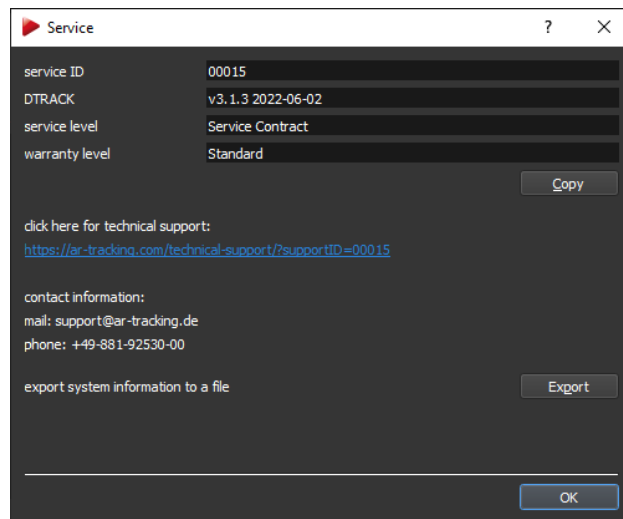
Figure 12.9: Service Information

> **Please have your Service-ID and current software version ready when you contact the *ART* technical support.**

12.4.1 Export system information

This dialog is intended for saving a current system information file as well as recent event logs in case you need to contact tech support at **ART** (see figure 12.10 on page 167). Information is included such as number and types of cameras, validity of room calibration, number and types of targets, current settings, warnings and error messages etc.

Select the appropriate *Event log files* by left-clicking the entries or by moving the slider below the table to the left or right respectively. You can also enter the number of *last days* manually (max. 30 days). Press *Export* to save the selected event logs together with the system information file in (ASCII-)TXT format on any remote PC in your local network.
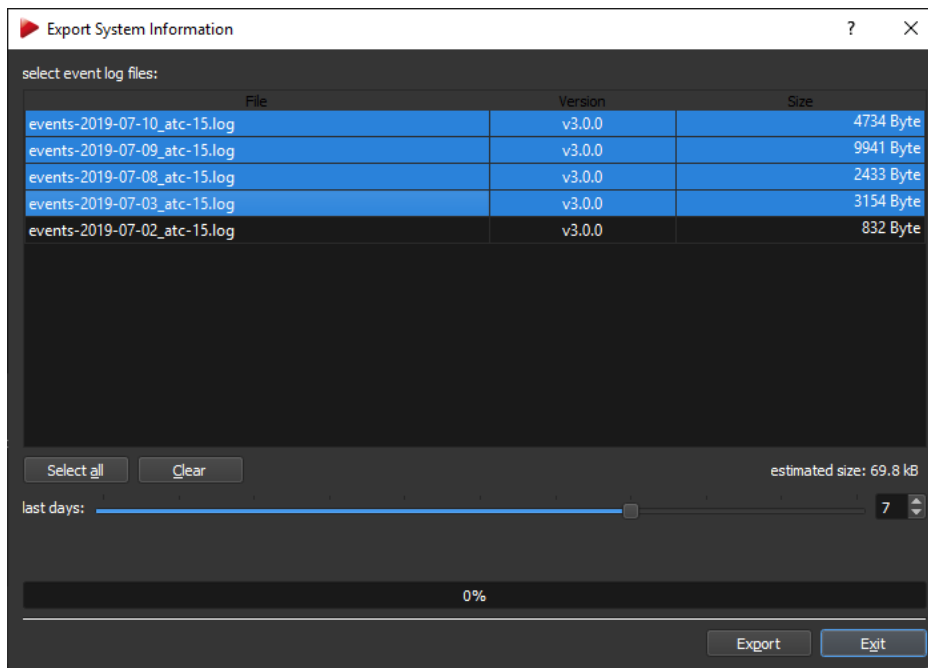
Figure 12.10: Export System Information

12.5 DTRACK3

This dialog offers information about the software version and release date of the **DTRACK3** frontend and backend software running on the controller (see figure 12.11 on page 168). Additionally hostname and serial number of the controller are shown. By clicking on the button *Show details* a list of all included software modules is shown together with their respective software versions. Information regarding licensing of **DTRACK3** can be found under *Open-Source software*.
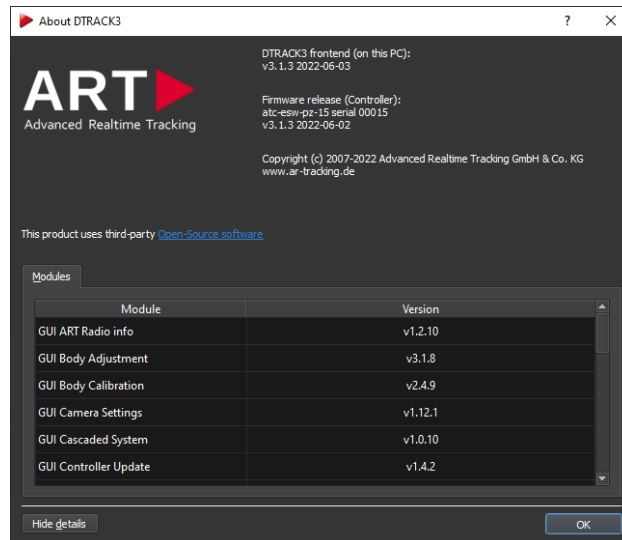
Figure 12.11: About *DTRACK3* Information

12.6 About Qt

This offers information about the Qt software toolkit used within *DTRACK3* .
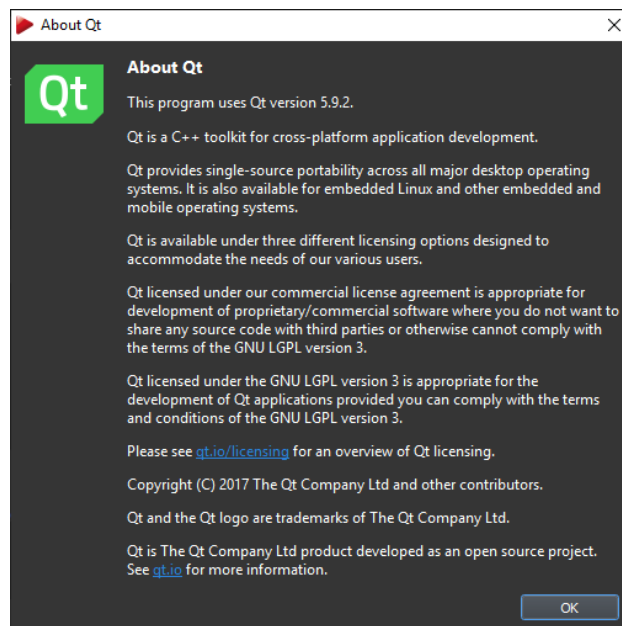
Figure 12.12: About Qt Information

13 Frequently asked questions (FAQ)

Within this FAQ chapter we are offering solutions for easy-to-solve questions that our support encounters from time to time. The questions are grouped into specific topics to make it more convenient for you to find a solution.

In case you do not find a proper solution for your specific problem, please do not hesitate to contact us.

Our goal is to offer the best support possible. Therefore, we ask you to have the system running and that you have internet access when you call us. Additionally we will need details about your system. Please refer to the **DTRACK3 User's Guide** → *Menu Help* → *Service* → *Export System Information File* for details how to export a system information file. Please include it in your mail when you contact tech support.

13.1 Backup

⇨ **How do I create a backup of important configurations?**

It is possible to export and import configurations. Please refer to chapter 7.3.2 on page 64 for details how to export and backup your configurations. In case of an accidental deleting of a configuration it will be possible to restore it presuming that an export had been carried out before. In the unfortunate event of repairs this data could also be restored to a replacement controller.

Please note that a room (re-)calibration might be necessary especially in case the amount of cameras or the camera models have changed.

13.2 Cameras

⇨ **How many cameras may be connected to the tracking system?**

Starting with **DTRACK3** version v3.0.0 a new license model has been established.

You may use 2, 4, 8, 16, 32 or up to 50 cameras in any combination with 4, 10, 30, 50 or up to 70 targets depending on the license purchased.

Please refer to table 7.2 on page 60 for a complete license overview.

13.3 Controller

▷ **What are the possibilities to start the controller?**

The controller is equipped with a switch that you have to press for the initial start-up. If you want to power up your controller remotely, you may use Wake On LAN (WOL).

Please refer to chapter 5.2 on page 35 for more information.
The *SMARTTRACK3* & *SMARTTRACK3/M* are PoE powered device, so they do not have a power switch. They do not feature Wake On LAN either. Simply connect the *SMARTTRACK3* & *SMARTTRACK3/M* to the provided PoE-injector and plug the PoE-injector into a mains socket.

▷ **I cannot find my controller. What can I do?**

- Please make sure that the controller is connected properly to the Ethernet network.

- Switch on the controller.

- It is possible that your controller has become unreachable due to wrong IP settings (wrong IP address or IP address area, etc.). Please refer to chapter 5.3 on page 36.

- In case you are using a firewall, please do not block *DTRACK3* communication. Please refer to chapter A.1 on page 187.

For more information, please also refer to the *ART Hardware Installation Guide* → *Installation of the Controller* or → *Installation of the SMARTTRACK3* or → *Connection to local network LAN*.

▷ **What is the IP address of my controller?**

You may use a standard USB pen drive and plug it in to the controller at any time. If not running yet, please switch on the controller. Its settings (IP address, etc.) will be saved to a information file on the USB drive. This file may be opened and modified in any editor.

Please refer to chapter 5.3.2 on page 39 for more information.

▷ **How can I assign a specific IP address to my controller?**

You may configure a static IP address the following ways:

- using *DTRACK3* (refer to chapter 5.1.3 on page 35)

- without the *DTRACK3* frontend (refer to chapter 5.3 on page 36)

13.4 *DTRACK3* and shutter glasses

⇨ **What types of shutter glasses can be used with the *ART* tracking system**

Please to refer to table 8.8 on page 80.

⇨ **When I start tracking, the shutter glasses don't work correctly.**

Most shutter glasses use infrared signals to synchronize the glasses with the image. The tracking cameras produce a strong infrared flash, which interferes with this communication. By synchronizing both systems, the cameras emit their flash in a way that does not interfere.

Please refer to the *ART Hardware Installation Guide* → *Synchronisation*.

⇨ **When I connect the "ExtIn", the shutter emitters stop working.**

Some projectors create only a weak sync signal (TTL), which is not strong enough to drive the *Synccard2* . Please contact *ART* to get a special high-impedance version or synchronize against the video signal (if available).

⇨ **Tracking stops when no stereo image is displayed**

Some graphics adapters only create the shutter image when a stereo image is displayed. If available, use video synchronization. This is a known behavior for NVidia adapters.

13.5 *DTRACK3* and interfaces

⇨ **I'm using VRPN. Which output identifiers have to be activated?**

It is absolutely mandatory that you activate at least the '*6d*' and '*6dcal*' output identifiers (refer to table 9.16 on page 155). Activate other output identifiers depending on your application (e.g. if you're using *Flystick2/2+/3* you have to activate '*6df2*').

⇨ **I'm using VRPN and TrackD but I only succeed in receiving data via just one of them.**

Please make sure that you are using two separate output channels with different port numbers. Please refer to chapter 9.11 on page 154.

⇨ **I'm having problems with the *Flystick2/2+/3* data transmission via TrackD.**

Please make sure that you are using the latest version of the TrackD module - *ART* will provide information upon request. Versions of trackd 5.5 which are older than February 2007 do not support data transmission for *Flystick2/2+/3* .

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If you don't want to change the module you may also use the '*old output format*' for legacy Flystick1. Please refer to chapter 9.7 on page 135 for more details.

13.6 Software *DTRACK3*

⇨ Where do I get the software *DTRACK3* from?

The software *DTRACK3* is delivered on a USB pen drive with the tracking system. Furthermore, you may register for the *ART* Download Center (`http://www.ar-tracking.com/support/`) in order to always have access to the latest patch release of *DTRACK3* .
Please refer to chapter 7.2 on page 59 for more information about *DTRACK3* release policy.

⇨ Why is my frontend not starting up?

- Please refer to chapter A.1 on page 187 for a list of supported operating systems.

- Windows XP is not supported. Please update to Windows 7 or newer.

- Linux 32-bit is not supported. Please upgrade to a compatible 64-bit Linux distribution.

- If using Linux: some newer Linux distributions do not install the library `libpng12.so.0` by default, although it is part of the distribution. Please install it using an appropriate package installer.

⇨ Some of my menu items are missing. What can I do?

- Please check if the latest updates for your operating system are installed.

- Please refer to chapter A.1 on page 187 for a list of supported operating systems.

⇨ Some of my menu items are greyed out / disabled. What can I do?

- Please check if your configuration is locked. In case unlock your configuration.

- Please refer to chapter 7.3 on page 62 how to manage your configurations.

⇨ Where is the Monitor 2DOF display?

- Please check if the latest updates for your operating system are installed.

- Please make sure that your firewall is not blocking *DTRACK3* , even partly.

- Please refer to chapter A.1 on page 187 for a list of supported operating systems and communication ports.

⇨ **Why is the Monitor 2DOF display crossed out for some cameras?**

- Please check if all the cameras used during room calibration are connected.

- Please refer to the *ART Hardware Installation Guide* → *FAQ* for the common reasons of disconnected cameras.

- Please refer to section 6.3.1 on page 45 for more information about Adding / removing cameras.

⇨ **Why does the "(re-)calibration required" message appear in Monitor 2DOF?**

- Please make sure you have performed a correct room calibration using all connected cameras.

- Please refer to section 6.3.1 on page 45 for more information about Adding / removing cameras.

⇨ **My target is not visualized within the Monitor 2DOF display.**

- Please make sure that the target is inside the tracking volume and within tracking range of the cameras.

- Double-check the settings for the flash intensities of the cameras (refer to chapter 8.3 on page 71).

- In case you are using active targets, please make sure that you have activated the modulated flash. Please refer to chapter 8.3 on page 71 for further details.

⇨ **There are greyish areas in my Monitor 2DOF display. What do they indicate?**

The static reflex suppression is currently active. This is indicated with these greyish areas. Markers in these areas will not contribute to tracking.

Please refer to chapter 6.3.2 on page 49 for more information.

⇨ **What do the abbreviations "SR", "DR" and "UD" mean?**

SR ... static reflex suppression active
UD ... display orientation is upside down

Please refer to chapter 6.3.1 on page 45 for more information on the additional *Monitor 2DOF display* settings.

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➪ **The display bar in the Monitor 2DOF display is indicating very high intensities although no markers are illustrated. Where's the light coming from?**

Please check that the cameras are not in the field of view of each other to avoid mutual blinding. Furthermore, remove other strong IR radiation sources from the tracking volume or, at least, prevent them from interfering with the tracking system. Please refer to the *ART Hardware Installation Guide* → *Setting up the cameras* for more information.

➪ **Monitor 2DOF and/or Data Display are 'freezing' after some time, although tracking didn't stop.**

This can be caused by a firewall that is running on the *DTRACK3* PC and blocking (UDP) output data.
Check your firewall settings and ensure that it is not blocking *DTRACK3* application, even partly. Please refer to chapter A.1 on page 187.

➪ **How do I define the number of targets to be tracked?**

Go to *Tracking* → *Body Administration* and change the '*number of bodies*'. Please refer to chapter 9.4 on page 115.

➪ **What is the maximum number of targets?**

The maximum number of targets (including *Flystick2/2+/3* and *Fingertracking* devices) is depending on the license type.
Starting with *DTRACK3* version v3.0.0 a new license model has been established.
You may activate and calibrate 4, 10, 30, 50 or up to 70 targets depending on the license purchased.

Please refer to table 7.2 on page 60 for a complete license overview.

➪ **Where do I get a license code from?**

You may purchase additional licenses for your system. Please contact your *ART* representative in case you need consultation.

Please refer to chapter 7.2 on page 59 for further details.

➪ **Where do I enter a new license code?**

Go to *DTRACK3* → *Licenses* and enter the code in line '*new license code*'.

Please refer to chapter 7.2 on page 59 for further details.

⇨ **Where do I get a software update from?**

The latest patch release of ***DTRACK3*** is always available at the ***ART*** Download Center (`http://www.ar-tracking.com/support/`).
Please refer to chapter 7.2 on page 59 for more information about ***DTRACK3*** release policy.

⇨ **I want to run a software update. How do I preserve my data and my configurations?**

Your data and your configurations are automatically preserved when running a software update. But it is recommended to regularly create backups of your configuration(s). Please refer to chapter 7.3.2 on page 64 for further details.

⇨ **How do I run a software update?**

Please contact ***ART*** to receive the latest patch release and follow the instructions in chapter 4.3 on page 29 and chapter 12.3 on page 162.

⇨ **Do I have to update the *DTRACK3* frontend software and the software of the controller at the same time?**

Yes, this is mandatory.

⇨ **My specific settings have been lost.**

Please check if the correct configuration is selected:
go to *DTRACK3 → Configurations* and select the correct configuration.
Please refer to chapter 7.3 on page 62 for further details.

⇨ **Is it possible to automatically start the measurement after booting the controller?**

No, this feature is not available as customer surveys have provided negative feedback.

⇨ **May I close the *DTRACK3* frontend software window after starting the measurement?**

Yes, the measurement continues even if the ***DTRACK3*** frontend software is not active.

⇨ **What's the version of my *DTRACK3* software?**

Go to *Help → DTRACK3* to find out the version of your ***DTRACK3*** frontend software and the backend software on the controller. Please refer to chapter 12 on page 161 for further details.

13.7 Calibration

⇨ **How can I find out when the room has been calibrated last time?**

Please go to *Tracking → Room calibration* and click *Show details*. The date of the last room calibration is shown.

⇨ **How do I define position and orientation of the room coordinate system?**

The calibration angle defines position and orientation of the room coordinate system depending on how you place it within the tracking volume. Please refer to table 9.3 on page 102.

DTRACK3 offers the possibility to adjust the room coordinate system after the room calibration. Please refer to chapter 9.2 on page 108 for more information.

⇨ **How do I have to move the wand?**

Move the wand gently within the measurement volume, in order to generate a virtual point cloud. This point cloud should fill at least about two thirds of the measurement volume. Please refer to the ***ART Hardware Installation Guide*** *→ Setting up the cameras → Room Calibration - Overview* for more information.

⇨ **I do not succeed in performing a room calibration.**

- Please make sure that the calibration angle is placed within the measurement volume such that it is seen completely by at least two cameras (→ verify with *Monitor 2DOF* display). If not all cameras see the angle be sure that a sufficient volume connects each camera to the others. No other marker except for the ones belonging to the calibration angle should be visible.

- Please make sure that the correct calibration set is selected in the settings for room calibration. Please refer to chapter 9.1 on page 100 for details.

- Please make sure that no reflections are seen by the cameras. If it is not possible to eliminate the reflections you may use static suppression of reflections to remove them. Please refer to the ***ART Hardware Installation Guide*** *→ Setting up the cameras* for more information.

- Please make sure that the markers positioned on the calibration angle are not damaged or misarranged.

- Increase the flash intensities of the cameras until all markers are of good quality (i.e. at least yellow). Please refer to chapter 8.3 on page 71.

- Restart the room calibration. Move the wand gently within the measurement volume, in order to generate a virtual point cloud. This point cloud should fill at least about two thirds of the measurement volume.

Please refer to the ***ART Hardware Installation Guide*** → *Setting up the cameras* → *Room Calibration - Overview* for more information.

➪ I cannot cover two thirds of the measurement volume within the set time for the room calibration. How do I extend the time for the calibration process?

Please open the dialogue *Tracking* → *Room calibration* and click *Show details*. There you can extend the duration for the calibration process. Please refer to chapter 9.1 on page 100 for more information.

➪ How shall I evaluate the room calibration results?

Please refer to chapter 9.1.4 on page 103 for a detailed explanation.

➪ *DTRACK3* reports the error message "*no angle tool detected*". What went wrong?

First of all, please double-check if all markers are visible and that there are no disturbing reflections. Sometimes, it might help to move the calibration angle a little bit.
Please always verify the settings for the room calibration before repeating:

- wand length is printed on a label on the wand;

- select the correct calibration set.

➪ The progress bar of the room calibration stopped.

Please double-check in the *Monitor 2DOF* display whether the calibration wand is recognized by the cameras during its movement.

➪ What is a "re-calibration" and when do I have to perform one?

DTRACK3 provides simplified room and body calibrations, called room and body re-calibration. The main advantage of a re-calibration is that *DTRACK3* preserves the origin and the orientation of your coordinate system as well as specific information (predefined emission vectors, cylindrical marker).

You may perform a room re-calibration from time to time or if a camera moved slightly (e.g. due to mechanical instabilities).Please refer to chapter 9.1.5 on page 104.

If your body fell down or if the structure is bent you should carry out a body re-calibration. Please refer to chapter 9.5.7 on page 128 for more information.

⇨ **What does '*scaling factor*' mean?**

Performing a room calibration results in a certain scaling error. This might be a problem when applications do have very high accuracy requirements (e.g. when performing measurements with the Measurement Tool).
The scaling error can be determined, for instance, by measuring points on a defined scale (e.g. tape measure). The determined scaling error can thus be adjusted with the *DTRACK3* '*scaling factor*' (refer to chapter 9.2 on page 108).

Please contact *ART* if you require further information.

⇨ **I cannot calibrate my target.**

- Please check if the markers of the target are seen by the cameras in good quality (i.e. at least yellow) - a slight change of the target position might help. If necessary increase the flash intensities of the cameras. Therefore, go to *Hardware →️ Cameras*.

- Make sure that when starting the body calibration every marker of the target is visible to the cameras.

- A body calibration can be carried out only if a valid room calibration has been carried out before. Check in the *Event Display* if there is a warning saying 'no valid room calibration', additionally the button *Calibrate* is greyed out and cannot be clicked. In that case, please carry out a new room calibration.

- Please make sure using the *Monitor 2DOF* display that no marker is overlapped (i.e. merged) by another one. If necessary rearrange the target and restart the body calibration.

- Try to carry out the body calibration with a moving target. Therefore, shift the starting position of the target for calibration (often a shift of 10 or 20cm is enough to enable calibration again).

- Make sure that no other markers or targets are inside the tracking volume other than the one you want to calibrate.

- Please carry out a new room calibration.

⇨ **I'd like to save all my body files for backup reasons but I receive less files than configured bodies.**

DTRACK3 only creates body files for calibrated bodies. For example: if you have configured 15 targets for tracking but only 4 of them are calibrated, you will only receive 4 calibration files.

⇨ **I'd like to calibrate a body but the body calibration dialogue is greyed out.**

Please ensure that you have performed and accepted a valid room calibration prior to body calibration. Check in the *Event Display* if there is a warning saying 'no valid room calibration'.

⇨ **What is the difference between '*due to body*' and '*due to room*'?**

When selecting '*due to body*', the body coordinate system is determined by the arrangement of the rigid body itself. When '*due to room*' is used the origin of the body coordinate system is set to the center of gravity of all markers building the rigid body.

Please refer to chapter 9.5.2 on page 122 for more information.

⇨ **Do I have to move the target while performing a body calibration?**

If possible we recommend to perform moderate movements because accuracy can be improved doing so. However, the body has to be visible to the cameras all the time.

⇨ **May I change the position and the orientation of the body coordinate system later on?**

Yes, you may use the dialogue *Body adjustment* to alter position and orientation of the body coordinate system. Please refer to chapter 9.6 on page 130 for more information.

⇨ **How do I define a name for a target?**

Go to *Tracking → Body Administration (F8)*. Double-click into the name field and enter a name for the respective body. Please refer to chapter 9.4 on page 115 for more information.

⇨ **I cannot increase the number of targets anymore.**

The maximum number of targets to be tracked (including **Flystick2/2+/3** and **Fingertracking** devices) depends on the license that is installed. Go to *DTRACK3 → Licenses* to see which license you have.

Starting with **DTRACK3** version v3.0.0 a new license model has been established. You may activate and calibrate 4, 10, 30, 50 or up to 70 targets depending on the license purchased.
Please refer to table 7.2 on page 60 for more information.

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⇨ **How shall I evaluate the body calibration results?**

Verify that all markers of the target have been recognized during the **DTRACK3** body calibration. Further, you may check if the single distances between the markers are correct (refer to chapter 9.5.5 on page 125).

As a special service you may send us the calibration file and we are going to check it.

13.8 Tracking

⇨ **My target (active or passive) is not recognized sporadically or only partly or even not at all.**

- Go to *Hardware → Cameras* and tick the checkbox '*modulated flash*'. Alternatively select the ones that have unobstructed view of the whole tracking area. Furthermore all cameras with activated *modulated flash* have to be assigned to syncgroup #1 ! **ARTTRACK5** , **ARTTRACK5/C** , **TRACKPACK/E** , & **TRACKPACK** systems may be configured via software, while **ARTTRACK2** & **ARTTRACK3** have to be connected to '*OUT1*' on the controller's **Synccard2/3** .

- Also, take into account that the distance between active target and cameras should not the tracking range of the camera model.

- Active targets cannot be used near or in front of plasma screens. The IR emission of the plasma screen overdrives the IR receiver in the active target. See also the FAQ section: Operation near plasma screen.

- Please perform a new room calibration.

- Double-check if the marker surface is not dirty or dusty and that it doesn't appear to be worn out.

⇨ **Tracking does not work.**

- Please make sure that the measurement has been started and that the target is within tracking range of the cameras.

- If marker recognition is poor then increase the flash intensity.

- Check the number of markers that are used for calculation. If all markers of the target are seen by the cameras, but some are not used for calculation, then execute a new room and body calibration.

- Go to *Tracking → Output*. Define a receiver for the tracking data and configure the type of data to be transmitted.

- Activate the tracking functionality within your graphics application.

⇨ **I'm having too many heavy reflections.**

- Please double-check that the flash intensities of the cameras are not too high. In general, a flash intensity of approx. 50 % might be sufficient.

- Make sure that no other strong infrared radiation sources (e.g. sunrays or halogen lamps) are present in the tracking volume. If they cannot be removed you may use the reflex suppression feature of *DTRACK3* .

- If mutual blinding is possible please either try to adjust the cameras differently or try to arrange them in different syncgroups.

⇨ **Does *DTRACK3* send data if no target is being tracked?**

No tracking data is sent except for the frame number ('*fr*').

⇨ **The application PC does not receive tracking data.**

- Go to *Tracking → Output*. Define a receiver for the tracking data and configure the type of data to be transmitted.

- Check the network connection physically and try to address the controller with a 'Ping'.

- Double-check whether a firewall is blocking communication.

- Activate the tracking functionality within your graphics application.

⇨ **May I use passive and active targets at the same time?**

Yes, of course, there are no restrictions on using passive and active targets simultaneously. But you will need an external modulated flash if you are using *ARTTRACK1* (discontinued) or *ARTTRACK2* (SN < 320, (discontinued). Please contact *ART* in that case.

⇨ **I am moving my target upwards but within the Monitor 2DOF display it moves downwards.**

The camera is set to display data upside down. In the Monitor 2DOF display, right-click on the respective camera window and disable *Display upside down*.

13.9 Flystick

⇨ **The *ART* radio transceiver cannot be found.**

Please make sure that the *ART* radio transceiver is plugged in. Then, simply press '*F2*' in order to perform a search for new hardware. The radio transceiver should be detected now.

13 Frequently asked questions (FAQ)

⇨ **My** *Flystick2/2+/3* **is not listed under the available Flysticks list.**

- Make sure that the battery is charged. Press any button of the *Flystick2/2+/3* and the orange status LED should be switched on.

- Go to *Hardware → ART Radio Info* to see if the **ART** radio transceiver has been recognized.

- Go to *Hardware → ART Radio Info → Show details* and set the channel number manually.

⇨ **Why is the pressing of the** *Flystick2/2+/3* **buttons not recognized (within** *DTRACK3* **)?**

- Make sure that the battery is charged. Press any button of the *Flystick2/2+/3* and the orange status LED should be switched on.

- Double-check whether the button pressed events are recognized by *DTRACK3* . Therefore:
    - enable the Flystick Display (*View → Flystick*)
    - blue rectangles should light up on each button pressed event in the Flystick Display.

- Go to *Hardware → ART Radio Info* to see if the **ART** radio transceiver has been recognized.

- Go to *Hardware → ART Radio Info → Show details* and set the channel number manually.

- Go to *Tracking → Flystick* and assign your Flystick (to be found in the available Flysticks list) to any '*Flystick ID*'.

⇨ **Why is the pressing of the** *Flystick2/2+/3* **buttons not recognized (within the graphics application)?**

- Make sure that the battery is charged. Press any button of the *Flystick2/2+/3* and the orange status LED should be switched on.

- Go to *Tracking → Flystick* and assign your Flystick (to be found in the available Flysticks list) to any '*Flystick ID*'.

- Go to *Tracking → Output* and check if the data output is configured correctly:
    - data receiver defined ('*send to*'),
    - identifier '*6df2*' selected,
    - if you are using the legacy *old output format*: identifier '*6df*' selected.

⇨ **What is the maximum number of *Flystick2/2+/3* to be used simultaneously?**

type	max. number
Flystick2	5
Flystick3	2

Please double-check that the targets of the *Flystick2/2+/3* , that are used simultaneously, are not identical. If in doubt please contact *ART* .

⇨ **What is the MultiUser option for *Flystick2/2+/3* ?**

The MultiUser option is an enhancement especially for VR/AR applications when working with more than one *Flystick2/2+/3* .

Please refer to chapter 9.7 on page 136 for more information.

⇨ **The Flystick output data is not transmitted.**

Go to *Tracking → Output* and check if the data output is configured correctly:

- data receiver defined ('*send to*'),

- identifier '*6df2*' selected,

- if you are using the legacy *old output format*: identifier '*6df*' selected.

13.10 Fingertracking

⇨ **The *Fingertracking* hand target is not recognized sporadically or even not at all.**

- Make sure that the battery is charged and the hand target is switched on.

- Go to *Hardware → Cameras* and tick the checkbox '*modulated flash*'. Alternatively select the ones that have unobstructed view of the whole tracking area. Furthermore all cameras with activated *modulated flash* have to be assigned to syncgroup #1 ! *ARTTRACK5* , *ARTTRACK5/C* , *TRACKPACK/E* , & *TRACKPACK* systems may be configured via software, while *ARTTRACK2* & *ARTTRACK3* have to be connected to '*OUT1*' on the controller's *Synccard2/3* .

- The configuration dial has to be turned to the proper position. Please refer to the *ART Hardware Installation Guide → System setup → Interaction devices*.

- Increase the brightness of the LEDs on *FINGERTRACKING2* devices. Please refer to the *ART Hardware Installation Guide → System setup → Interaction devices*..

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⇨ **When using Fingertracking, there are always some markers that are flashing alternately in the Monitor 2DOF display.**

This is not bug, but rather it is due to the sequential activation of the finger thimble markers in order to achieve a separation of the fingers.

⇨ **What's the meaning of the status LEDs on the Fingertracking hand target?**

Please refer to the ***ART Hardware Installation Guide*** → *System setup* → *Interaction devices* for more information.

⇨ **What is being configured when turning the configuration dial?**

Please refer to the ***ART Hardware Installation Guide*** → *System setup* → *Interaction devices* for more information.

⇨ **What's the maximum number of hands to be used?**

You may use two ***Fingertracking*** sets (i.e. four hands) in your tracking system at the same time. However, the targets of the hand devices must be different.

⇨ **How do I assign a hand geometry to a hand ID?**

Go to *Tracking* → *Fingertracking*. Please refer to chapter 9.8 on page 137 for further details.

⇨ **The finger calibration fails. What do I do wrong?**

- The configuration dial has to be turned to the proper position. Please refer to the ***ART Hardware Installation Guide*** → *System setup* → *Interaction devices* for more information.

- Go to *Hardware* → *Cameras* and tick the checkbox '*modulated flash*'. Alternatively select the ones that have unobstructed view of the whole tracking area. Furthermore all cameras with activated *modulated flash* have to be assigned to syncgroup #1 ! ***ARTTRACK5*** , ***ARTTRACK5/C*** , ***TRACKPACK/E*** , & ***TRACKPACK*** systems may be configured via software, while ***ARTTRACK2*** & ***ARTTRACK3*** have to be connected to '*OUT1*' on the controller's ***Synccard2/3*** .

- Please observe the calibration procedure defined in chapter 9.8.4 on page 143.

- Make sure that you selected the correct handedness and type of fingerset in *Tracking* → *Fingertracking* → *Hand geometry calibration*.

- Double-check that the diffusor spheres (not applicable for ***FINGERTRACKING2***) are not broken or missing.

⇨ **The *Fingertracking* output data is not transmitted.**

Go to *Tracking → Output* and check if the data output is configured correctly:

- data receiver defined ('*send to*'),

- identifiers '*gl*' and '*glcal*' selected.

⇨ **Is it possible to upgrade to the 3-finger or the 5-finger version?**

Yes, if you are currently using the non-tactile 3-finger version you may also use 5-finger thimble sets and vice versa. Tactile thimbles are available for 3 fingers only. Please contact *ART* to receive more information.

13.11 Measurement Tool

⇨ **I'm using the *Measure Points* tool but I cannot measure any points.**

Please check whether both, the Measurement Tool and the Measurement Tool reference body (if assigned), are tracked.

⇨ **It is not possible to perform a tip calibration.**

Please check whether both, the Measurement Tool and the Measurement Tool reference body (if assigned), are tracked.
Then, try to keep the tip in the same position while doing the tip calibration. Therefore, tilt the Measurement Tool in both room directions, not only in one direction (i.e. left and right, as well as back and forth). When rotating around one axis only, a tip position cannot be defined.

13.12 Active Targets

⇨ **Operation near plasma screen**

A plasma screen is a very strong IR source which overdrives the IR receiver in the active target (e.g. active *Flystick3* (discontinued), *Fingertracking*). Thus, active targets may not work properly near plasma screens. If possible use passive targets as alternative.

13.13 *ART* tracking and 3D TVs

⇨ **Synchronization**

3D TVs are primarily consumer products which have not been designed to fulfill the requirements of professional users. In fact, this especially applies when it comes to synchronizing the 3D TV and the tracking system. Typically, there's no defined synchronization output which could be used easily. In some rare cases, *ART* might be able to assist.

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⇨ **Shutter glasses**

IR synchronized shutter glasses might not work with *ART* tracking systems. Due to the increasing variety, *ART* only validated a few of these shutter glasses. However, we may support customers who are performing tests with shutter glasses that have not been validated yet.
Please contact *ART* to receive information on this issue.

13.14 Radio transceivers used in *ART* products

⇨ **Can *ART* radio transceivers pose any security issue ?**

Radio transceivers for *Flystick2/2+/3* , Measurement Tool or *FINGERTRACKING2 Tactile* use a protocol based on IEEE 802.15.4 which was developed in-house at *ART* specifically for these devices. The protocol is proprietary, no other devices should work with this protocol. The design of all controllers by *ART* ensures that use of this protocol is limited to transfering measurement data (like button-pressed events) and configuring devices.

A Technical specifications

☞ **The specifications are subject to change without notice.**

A.1 Overall system

System parameters

number of cameras	2 - 50 (max. 16 for *TRACKPACK/E* and *TRACKPACK* systems)
max. number of targets	70
max. number of hands	4
max. number of Flysticks	
- Flystick2	5
- Flystick2+	5
- Flystick3	2
Scalability	*ARTTRACK* system: fully scalable (2 - 50 cameras)
	TRACKPACK/E system: cascadable up to 16 cameras (additional controller necessary)
	TRACKPACK systems (discontinued): cascadable as slave(s) only
Accuracy	
- of the timestamp	with a Synccard2/3: $\Delta t_{err} \sim \pm 0.01 ms$
	with a SynccardTP: $\Delta t_{err} \sim \pm 0.5 ms$
	with a *SMARTTRACK3* & *SMARTTRACK3/M* : $\Delta t_{err} \sim \pm 0.01 ms$
	with a *SMARTTRACK2* : $\Delta t_{err} \sim \pm 0.5 ms$
	with a 3-Space wired inertial sensor: $\Delta t_{err} \sim \pm 0.1 ms$

Compatible shutter glasses

NuVision APG6000	$\times$
NuVision APG6100	$\times$
NVidia 3D Vision Pro	$\times$, radio synchronization
RealD CE1	$\times$
RealD CE2	$\times$
RealD CE3	$\times$
RealD CE4	-
RealD CE5	$\times$
Volfoni EDGE	$\times$, with Volfoni or NuVision Long-Range Emitter
XPand X103	$\times$, with NuVision Long-Range Emitter
XPand X101	$\times$
XPand X104LX	$\times$
Virtalis ActiveWorks 500	$\times$

DTRACK3 frontend software

System requirements

A Technical specifications

- Free disk space	$\geq$ 200MB
- Processor	Intel: $\geq$ P4 2GHz
	AMD: $\geq$ K6 1.6Ghz
- RAM	$\geq$ 1GB
Operating systems	Windows 7 32/64 Bit with Service Pack 1
	Windows 8/8.1 32/64 Bit
	Windows 10 32/64 Bit
	Linux openSUSE $\geq$ 15.0 64 Bit
	Linux Ubuntu $\geq$ 18.04 64 Bit
	Linux CentOS $\geq$ 7.5 64 Bit
	Linux Debian $\geq$ 10.0 64 Bit

Used IP ports in Controller

Controller		*DTRACK3* fron-tend	purpose
TCP 50105	$\leftrightarrow$	TCP dynamic	general communication
UDP 50105	$\leftrightarrow$	UDP dynamic	general communication
UDP 50107	$\rightarrow$	UDP dynamic	measurement data (6DOF, timestamps, etc.)

Controller		user's application (e.g. DTrackSDK)	purpose
TCP 50105	$\leftrightarrow$	TCP variable	remote commands (optional)
UDP 50107	$\rightarrow$	UDP user-defined (default: 5000)	measurement data (6DOF, timestamps, etc.)
UDP 50110	$\leftarrow$	UDP variable	control commands (optional; for *FINGERTRACKING2 Tactile* or *Flystick* feedback devices)

List of Figures

Appendix A

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