


User Manual

ART-Satellite-Merger

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1. 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)
Controller	does all calculations and generates the data output stream
ARTTRACK (2, 3, 5)	infrared camera
body calibration	teach the system the geometry of a rigid body
body, rigid body	rigid arrangement of several single markers (see also "target")
calibration angle (410mm or 710mm)	belongs to the room calibration set and defines origin and orientation of the room coordinate system
ceiling suspension	equipment to mount an infrared camera to the ceiling
DTrack2	
backend software	Linux-based software which does all necessary calculations
frontend software	graphical user interface to control the Controller
finger thimble	a fixture for the finger tip to hold the active marker(s)
Fingertracking	tracks the orientation of the hand and the position of the fingers
Flystick	wireless interaction device for virtual reality (VR) applications
hand geometry	describes the dimensions of your hand and fingers
hybrid tracking	fusion of optical and inertial data into one consolidated output
inertial sensor	An inertial measurement unit simultaneously measures 9 physical properties, namely angular rates, linear accelerations, and magnetic field components along all 3 axes. This is achieved using solid state gyroscopes and accelerometers for measurement of roll, pitch and yaw and magnetometers (not used) 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
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	one camera sees disturbing reflections caused by the infrared flashes of another one
prediction	predicts output for the specified time in the future to compensate tracking and rendering latency
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 and wand
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 (i.e. mutual blinding may be avoided).
synccard (Synccard2, 3 or SynccardTP)	plug-in card for the controller which serves for synchronizing the cameras

term	definition
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 several single markers (= rigid body)
tracking	position measurement of bodies that move in a defined space
TRACKPACK	infrared camera
TRACKPACK /C	infrared camera especially for multi-sided projections
TRACKPACK	Controller does all calculations and generates the data output stream (compatible to TRACKPACK and TRACKPACK /C)
USB radio transceiver (RT2)	exchange data with Flystick or Tactile Feedback
virtual point cloud	used for calculating the relative positions of the IR cameras
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 system

1. Security advice

1.1. Symbols and their meaning

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



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 operation safety.

These warnings have to be considered, otherwise user and equipment could be endangered, the equipment could be damaged or the function of the equipment is not warranted.



Safety warning for infrared radiation.
These warnings have to be considered, otherwise users eyes could be endangered.

Table 1 Symbols and their meanings

1.2. Safety warnings



Safe operation of the equipment is only warranted if the warnings in this manual and on the equipment are observed.

- Never use the equipment if any part looks damaged.
- Safe operation is not possible, if
 - the housing is damaged,
 - any fluid attains in the housing,
 - objects attain inside the equipment,
 - the equipment shows any visible faults (smoke, sparks, fire, smells, etc.) or
 - the power cord is damaged.
- In any of the cases mentioned above (or similar) pull the power cord out of the power socket immediately. Otherwise, users or environment are endangered. Please contact the **ART** service.
- Never change or alter the equipment, neither mechanically nor electrically. Only the components described by **ART** shall be used. The conformity and the warranty of the producer (**ART**) expire

by non-compliance.

- Never open the equipment! Only personnel authorized by **ART** is allowed to open the equipment. Inside of the equipment there are various hazards like high voltage, electric shocks - even if the equipment is disconnected - which can lead to death on contact. In case of malfunction of the equipment please contact the **ART** service.
- Only peripheral devices which meet the safety requirements of EN/IEC 60950 for extra low voltage may be attached on Ethernet-, BNC- and the DC-circuit of the equipment.
- The cameras emit infrared-light flashes which can pose a threat to human health and the environment. Keep enough distance to the flashes of the cameras or the IR flashes. Never look directly into the IR light sources. Carefully read chapter B.
- Be sure that the cameras are firmly mounted in the correct position.
- Do not touch the front pane of the cameras, since the acrylic pane and the lens are highly sensitive surfaces. Be careful to avoid permanent damages (e.g. scratches). Only touch the housings of the cameras.
- The ventilation holes of the **ARTTRACK2** camera must not be covered. Air circulation is necessary to prevent the cameras from overheating. If the air circulation is restricted overheating will damage the cameras. The minimum distance between equipment and environmental objects has to be greater than 3 cm.
- The equipment has to be attached to a power socket with grounding. If the grounding wire is defective the requirement of the safety and the electromagnetic compatibility (EMC) are not guaranteed. To check the function of the grounding wire ask your regional located electrician.
- Before switching on any device, verify that voltage and frequency of your electric installation are within the allowed ranges of the equipment. The characteristics of the equipment can be found on the appliance rating plate or in chapter A. The appliance rating plates are on the equipment's housing (**ARTTRACK1** on the lower side of the housing; **ARTTRACK2 / ARTTRACK3** on external power supply, controller on the backside of the housing).
- The power switch on the backside does not completely separate the devices from the electricity network. To completely separate the equipment from the electricity network the power plug must be disconnected from the power socket. The power plug has to be accessible freely. The power socket must be close to the equipment.
- The cabling should be realized such that
 - no one can stumble on the cords,
 - the cords cannot be damaged,
 - the cords cannot tear down the cameras.



Install a pull relief!

- Only use original ART (or ART authorized) components and accessories. Using non-original components or accessories may damage the equipment, cause malfunctions or may void operation safety. The provided components and original accessories can be found in chapters 4 and 5. Only use the originally provided external power supply for operating the camera **ARTRACK2** and **ARTRACK3**.
- The equipment must not be dropped and/or knocked.
- Never expose the equipment to high humidity levels or condensating humidity. Protect the cameras against water and chemicals.
- The equipment must not be operated in environments with intensive formation of dust or hot environments where temperatures rise above 40°C (100°F).



ART explicitly denies any liability or warranty if the product is modified in any way or not used according to this manual and the specification labels on the equipment.

2. Introduction

This manual wants to show how the ART-Satellite-Merger software works and how you can set up in your environment.

The main idea behind this program is to be able to continue the tracking of a moving target even if it disappears inside an occluded compartment (e.g. a car). This is accomplished by using two different tracking systems and synchronizing their origins.

The first tracking system is the superior one and the second one is the satellite which has to be set up in the field of view of the first one, even if it is not directly visible. The targets are calibrated in the superior system and will be transferred to the satellite system. A **reference target** is **rigidly connected** to the satellite, making it possible to track its actual position and orientation in the room. The coordinates of a moving target would still be completely different depending on the tracking system due to the different origins. To be able to calculate a single origin for both systems the RS calibration¹ target is necessary. For the synchronization this target has to be visible for both tracking systems at the same time so its coordinates can be recorded simultaneously, creating two separate yet identical three dimensional clouds of dots. Knowing where the satellite is situated in the room, it is now possible to synchronize the two clouds into one coordinate system. Even if a target leaves the sight of the superior tracking system, but can be seen by the second, the program is able to calculate the position of the target according to the superior origin, making it possible to continue tracking, even if the target cannot be seen directly.

Merging of the output data of two tracking systems

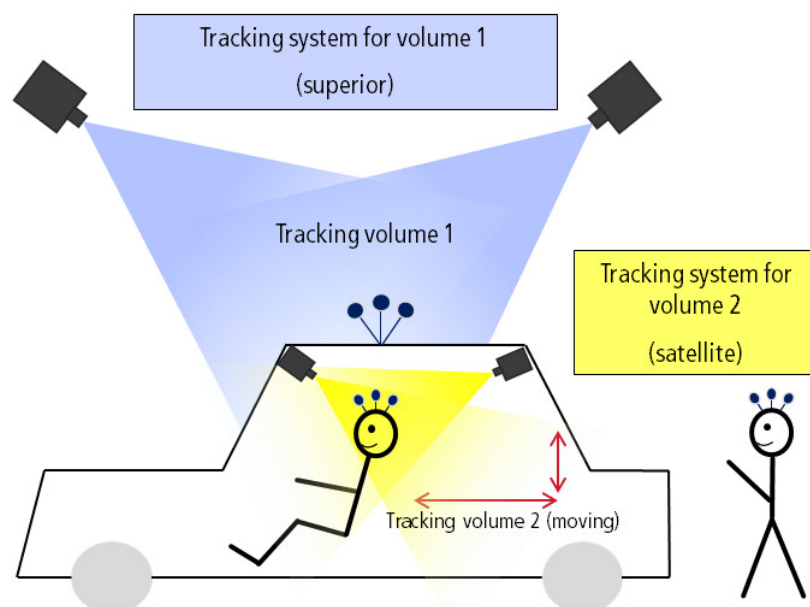


Figure 1: illustration of the ART-Satellite-Merger

¹ Reference Satellite calibration = calibration of the satellite system relative to the superior system

3. System setup

3.1. Hardware

This software only works together with original ART products and the DTrack2 software.

To start with, at least 4 ARTTRACK cameras with 2 different Controllers are needed (alternatively two TRACKPACKs with Controllers or two SMARTTRACKs can be used, combinations are possible). Furthermore the RS calibration target and a reference target are required.

Overview

Data flows and controls

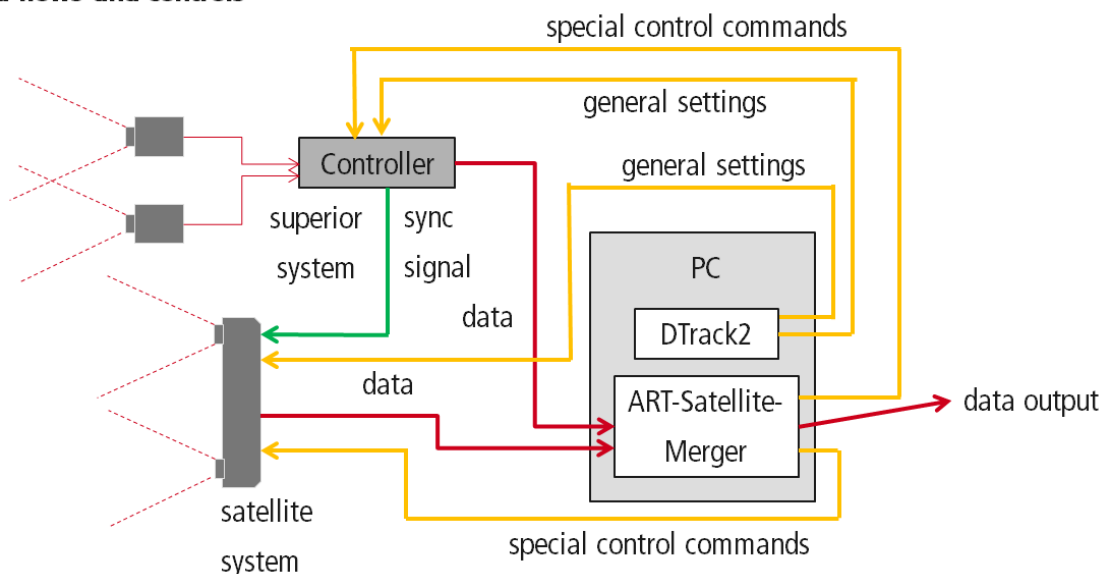


Figure 2: Overview of the ART-Satellite-Merger setup

The first tracking system has to be set up as usual, having the occluded compartment inside which you want to continue tracking in its field of view. Make sure your PC has access to the controller via DTrack2. A valid room calibration is needed to proceed. This setup is now considered as your superior system.

Next you need to decide which targets and/or markers you want to use as reference target. The larger the target gets the better. Therefore the different parts of the target don't have to be connected to each other (e.g. you use a claw target in combination with two single markers, situated in some distance from the target, like this you get a new large target with 6 markers).

Before the next step the reference target must be rigidly attached to the second tracking system, so that single components are unable to move individually (This is very important for the software to

be able to recognize and track the new created reference target). Also make sure that the two tracking systems are connected to the sync output of their controllers via BNC cable.

Calibrate the required targets (reference and RS calibration) and make sure they are tracked correctly. Be aware that all other desired targets you want to work with are also calibrated in the superior system (they will be transferred to the satellite system later). The output data you want to receive from the ART-Satellite-Merger later has to be defined in Channel 1 (output settings) of the superior system. The software will use the settings of the superior system, whereas the port doesn't matter, because it will be set automatically.

Close the DTrack2 software and access the second controller, the satellite system. As before a room calibration is needed.

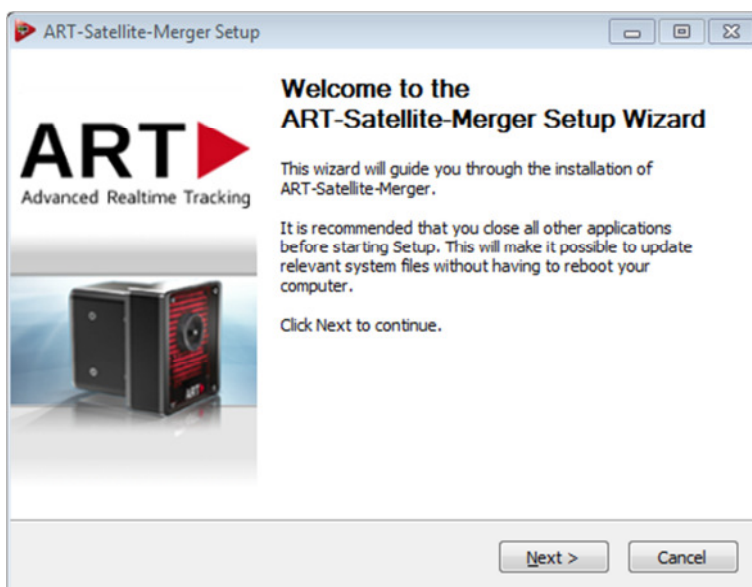


All bodies calibrated in the used configuration of the satellite system will be overwritten by the ones calibrated in the superior system. The software transfers them automatically.

For the next step be sure to close all DTrack2 front ends, in order to make your controllers accessible by the ART-Satellite-Merger.

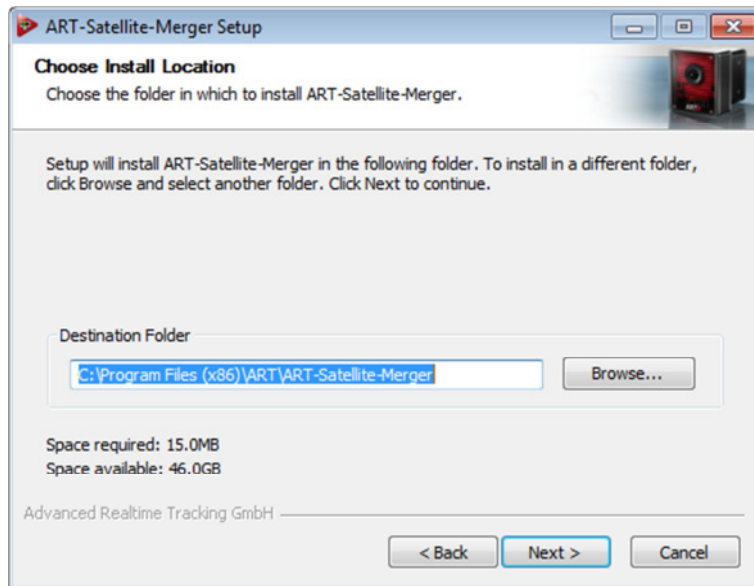
3.2. Software

Having the hardware ready, you now need to install the ART-Satellite-Merger software on your PC. Therefor run the "ART-Satellite-Merger_vX.X.X_win_install.exe" and follow the steps in the setup:



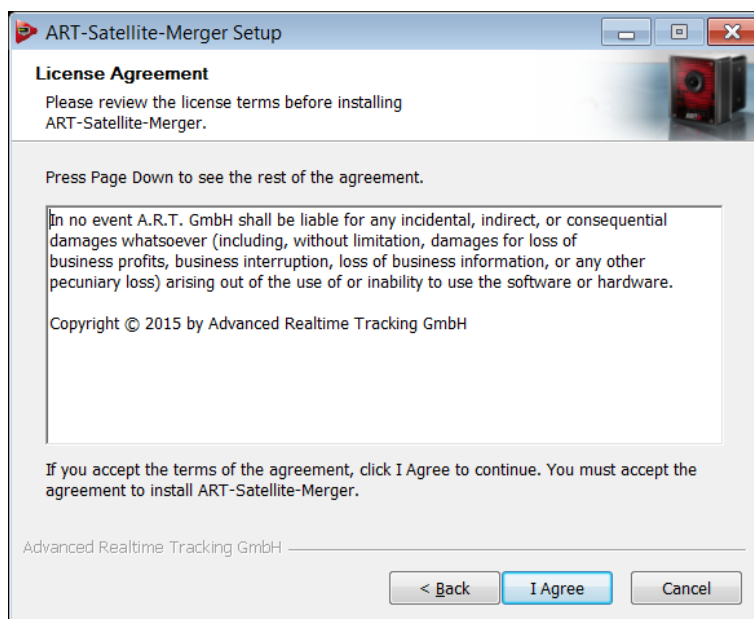
Click "Next >" to continue and start the installation process for the ART-Satellite-Merger software. Administrator rights are needed!

Figure 3: ART-Satellite-Merger setup wizard



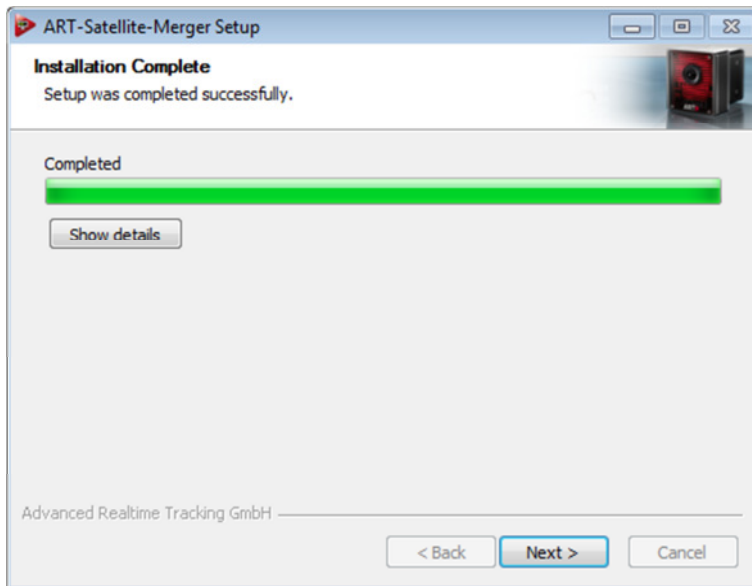
Now please choose the destination folder in which you want to install the ART-Satellite-Merger.

Figure 4: ART-Satellite-Merger install location



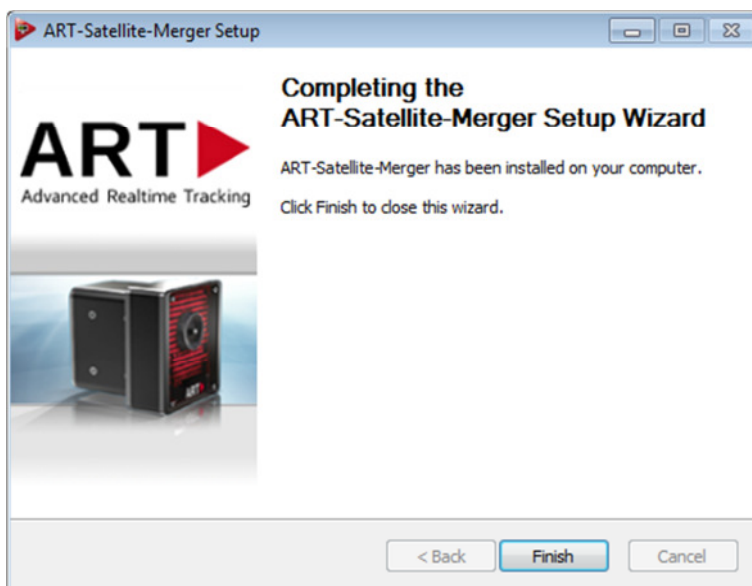
Please read the license terms carefully and press "I Agree" if you agree indeed. A new window shows the installation process

Figure 5: ART-Satellite-Merger License Agreement



The installation of the ART-Satellite-Merger is complete now. The ART-Satellite-Merger has been installed on your computer. Click "Next >".

Figure 6: Installation of the ART-Satellite-Merger is complete



Press "Finish" to complete the ART-Satellite-Merger setup wizard. Now you can use the ART-Satellite-Merger.

Figure 7: Completing the ART-Satellite-Merger setup wizard

After the installation is complete plug the USB dongle to your PC in order to start and use the ART-Satellite-Merger. The drivers for the dongle have been installed automatically together with the software.



The dongle is mandatory for using the ART-Satellite-Merger

4. Settings

If all topics above were done correctly you should now be able to start the ART-Satellite-Merger. In the first window you have to select the two Controllers (superior and satellite system). You may do that by either entering their hostnames or IPs directly or by browsing through your LAN:

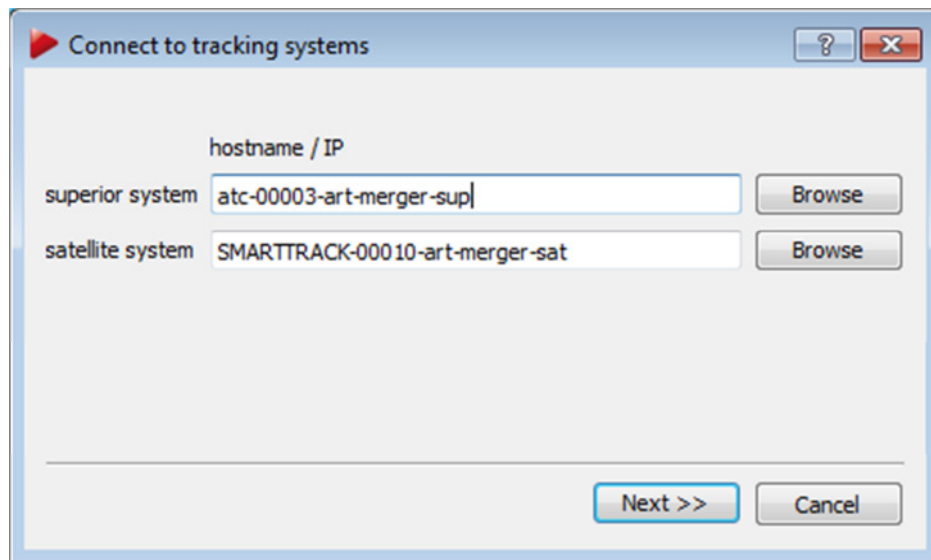


Figure 8: Connect to tracking systems

In the second window you can choose the configurations you want to use for tracking:

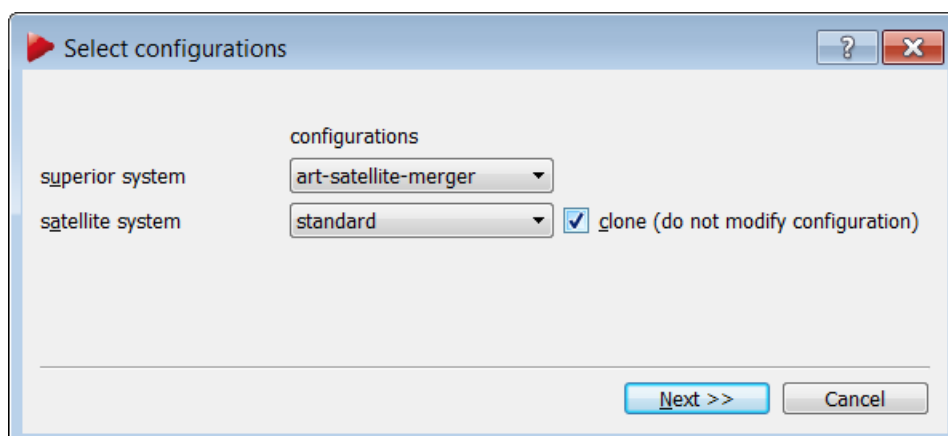


Figure 9: Select configurations

To avoid changes in the configuration of the satellite system activate the checkbox *clone*. The Art-Satellite-Merger will create a temporary working-configuration and delete it again, when the tool is closed.

The next window provides configuration possibilities. The first tab tells you to select your reference target and the RS calibration target. Here you choose the two targets you calibrated earlier from among all your available targets:

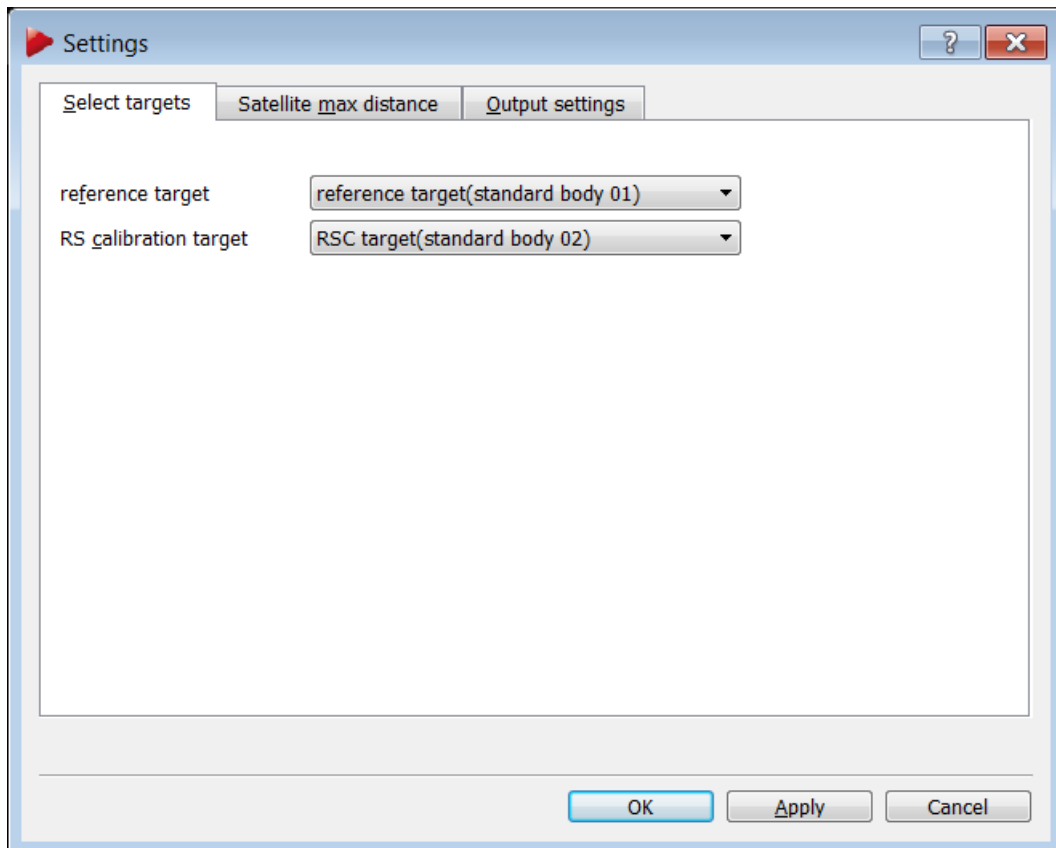


Figure 10: Settings: Select targets

“OK” will save all of your settings in all tabs and launch the program.

“Apply” will just save all the settings.

“Cancel” will close the window, discarding all settings.

These buttons are the same for all following tabs and will save/discard the settings for all tabs, not just the opened one.

It may be possible in certain areas of the room, that a target is visible for both tracking systems at the same time. The program now has to know which tracking information to take and therefore you have the second tab:

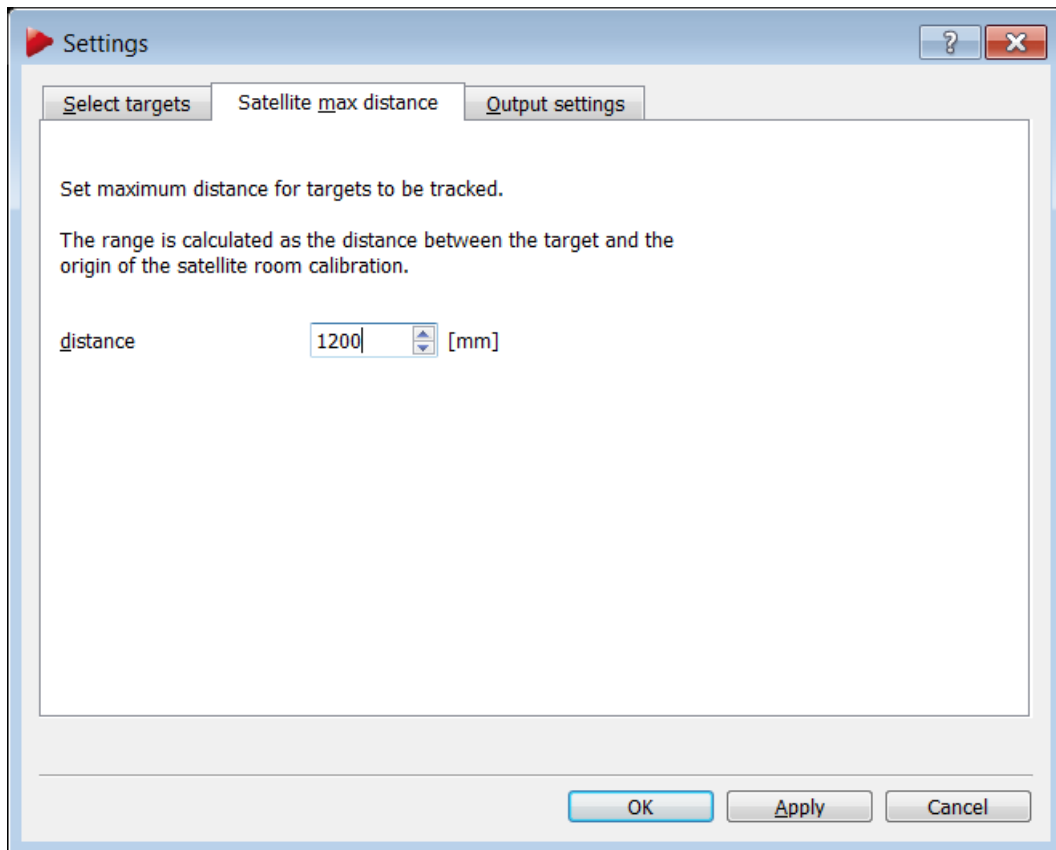


Figure 11: Settings: Satellite max distance

You may choose a maximum tracking range for the satellite system, meaning as long as a target is tracked inside this range, even both systems are able to see it, the information of the satellite system will be used. The range can be set from zero to 5000 mm.

This range is calculated as the distance between a target and the origin of the coordinate system of the satellite system.

In case the satellite is able to track a target outside of the chosen range, this information will be ignored. So as long as there are no signals coming from the satellite system the data of the superior system are used.

In the last tab you can set the destination of the output data (IP and port) for the five output channels of the ART-Satellite-Merger:

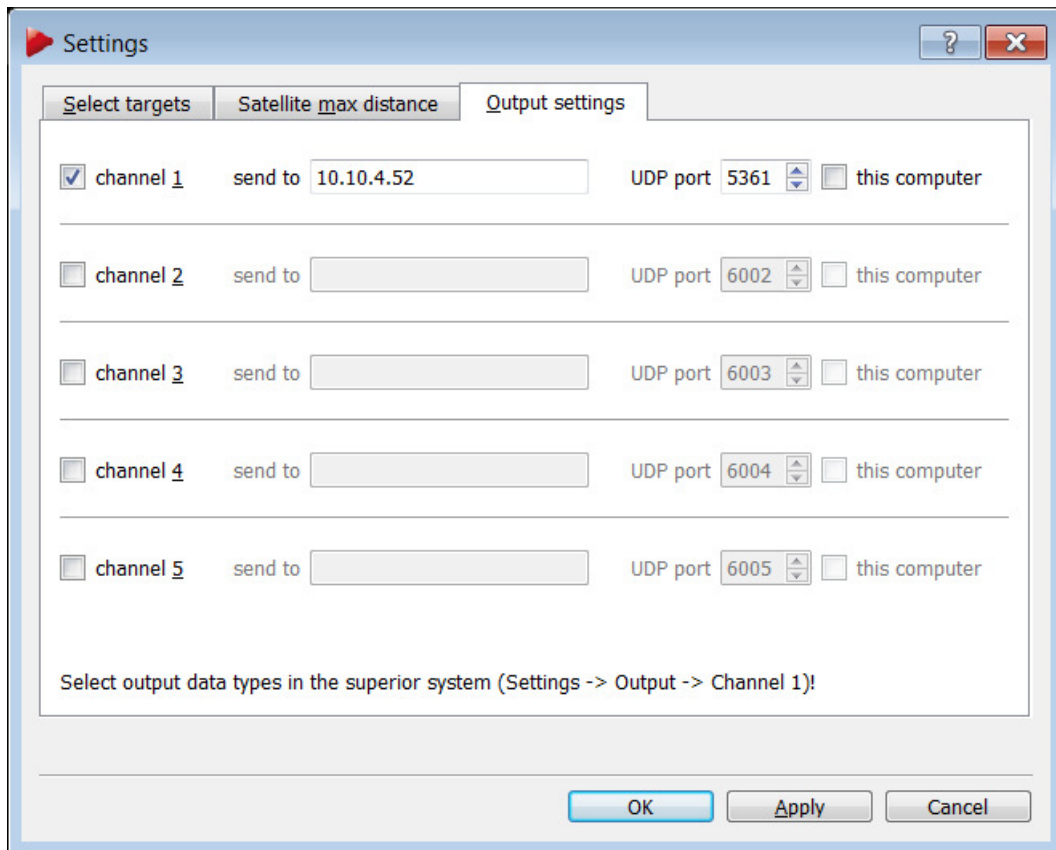


Figure 12: Settings: Output settings

You may either enter IP address(es) on your own, or choose the one of your computer.

 The content (data types) of the output data is defined in the superior system and can be changed using DTrack2 (Settings -> Output -> Channel 1).

After hitting the "OK" button a small progress bar will appear:

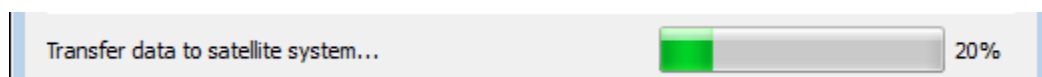


Figure 13: Data transfer to the satellite system

Now all the body files and output settings of DTrack2 channel 1 will be transferred to the satellite system and the ART-Satellite-Merger main window starts.

5. The ART-Satellite-Merger

5.1. Appearance

If everything went fine and no one is already accessing one of the Controllers it should look like this:

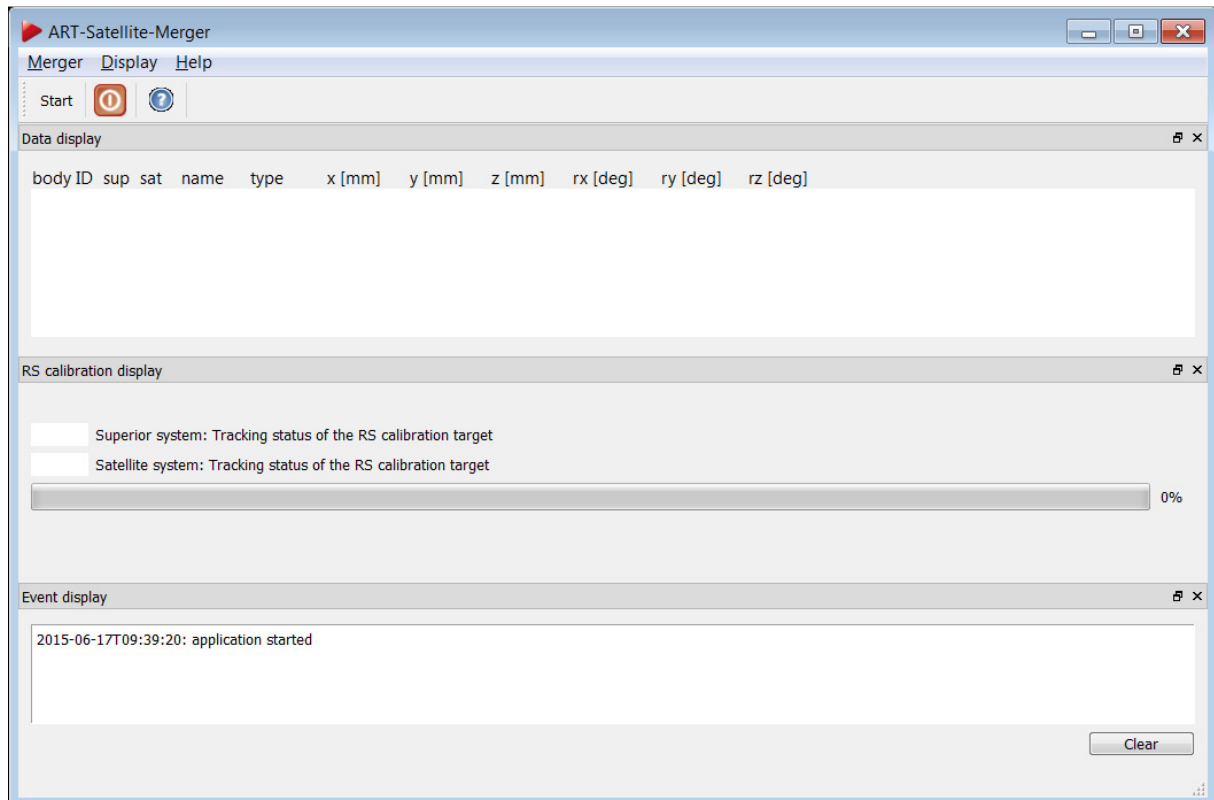


Figure 14: The ART-Satellite-Merger

You can spot almost the same things you already know from DTrack2, except for the Monitor 2DOF tab, which is not part of the ART-Satellite-Merger and the new RS calibration display, giving you the information about the status of the RS calibration.

As in DTrack2 the "Start" button starts the measurement and its label changes to "Stop". Clicking again stops the measurement. The red button closes the window and the question mark gives you some information about the program.

Under "Merger" you may also start and stop the measurement or exit the program.

"Display" lets you choose which displays will be shown in the ART-Satellite-Merger window.

And under "Help" you may get version information about the ART-Satellite-Merger itself or Qt.

Note that all important actions will be reported in an event log file which is generated in:

- Windows: C:\Users\%username%\ART\artsatmerger\logs
- Linux: /home/%username%/ART/artsatmerger/logs

If you have any problems with the software and the customer support tells you to send your log file, you should send the one called "events-yyyy-mm-dd.log" or zip the complete logs directory and send it to A.R.T.

5.2. Starting the measurement

After you start the measurement you should see a window similar to this one:

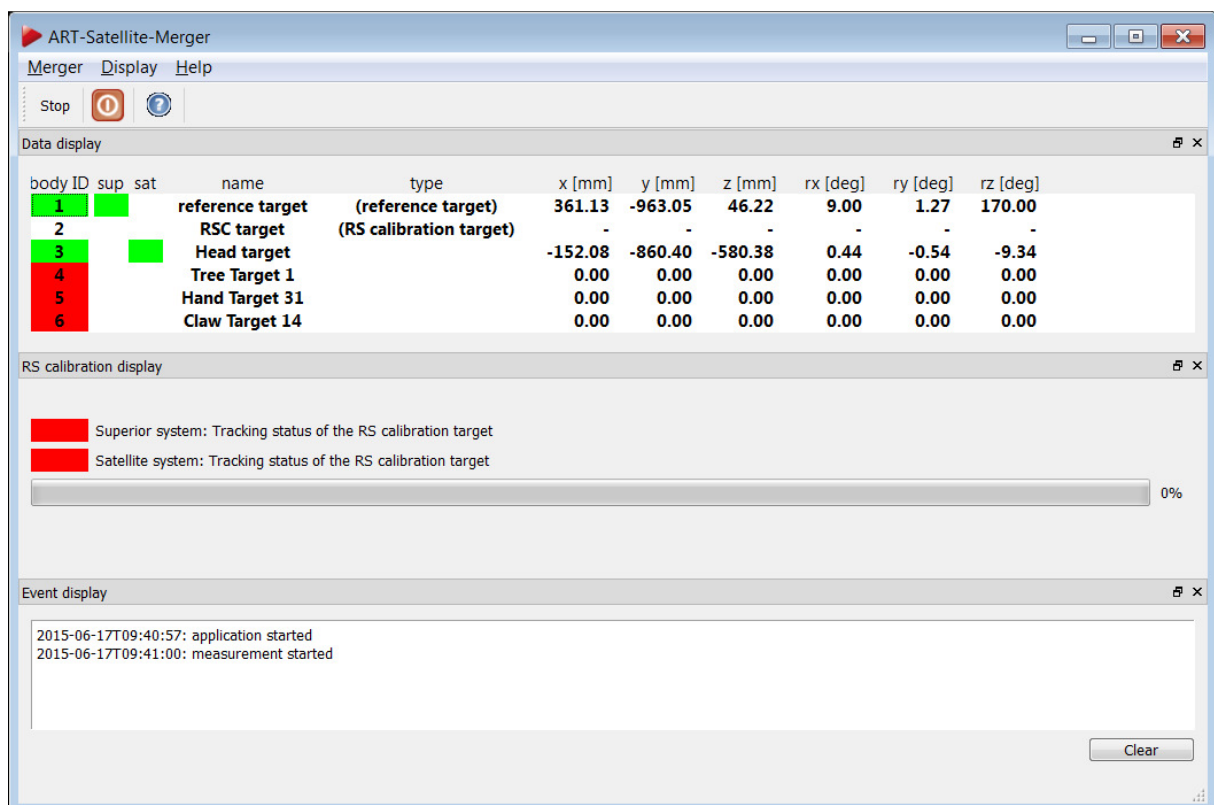


Figure 15: ART-Satellite-Merger running

The data display shows all your earlier calibrated targets. There are the two mandatory ones, the reference and the RS calibration target (here ID 1 and 2), but you may also calibrate a self-selected number of targets you wish to work with.

The background of the body IDs shows whether the target is tracked (green) or not (red). The RS calibration target has a white background, because it has its own display below.
If inertial targets are used there is a third tracking status 'inertial tracked' (yellow) possible.

The columns "sup" and "sat" (meaning superior and satellite system) indicate which of the two tracking system's data is being used right now (here: body 1 → "sat" and body 5 → "sup").

Calibrated Flysticks, Measurement Tools and Fingertracking devices will be shown in the corresponding display after activating it in the menu.

The RS calibration display is the most important one of this program. Moving a target through the room, would still lead to completely different coordinates, depending on which tracking system is tracking the target at the moment. This can be seen because the RS calibration is still missing. In order to synchronize those two origins both systems need to see the RS calibration target at the same time.

The last display is just the usual event display, showing important information, like errors and start/stop of measurements.

5.3. RS calibration

To set one origin for both tracking systems you need to get the RS calibration tool in range of both of them at the same time, which, if done correctly, is shown by two green lights. As soon as this happens and the reference target is tracked by the superior system, the RS calibration process will start automatically.

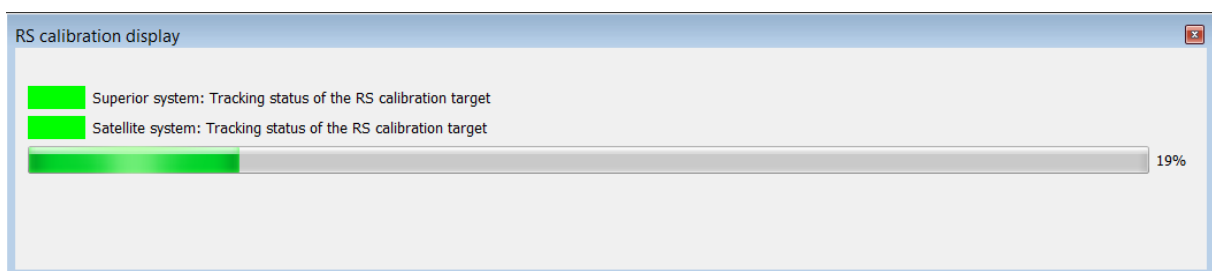


Figure 16: RS calibration display



The reference target has to be tracked during the whole RS calibration process

In order to provide a good transformation the program needs a number of frames in which the RS calibration target is tracked by both systems. To get a sufficient number of points for the calculation, the target has to be moved. A progress bar shows the progress of the RS calibration and you can see when you are done collecting points.

If for any reason the RS calibration is interrupted for longer than 10 seconds, the process will reset to zero.

Completing the RS calibration will lead to a 100% bar, a message in the event display that you finished the RS calibration. A standard deviation is calculated. If the standard deviation is smaller than 25mm the RS calibration is accepted and activated. In addition you will see that the RS calibration will be disabled for 10 seconds to avoid any inconvenience. After these 10 seconds it will be enabled automatically.

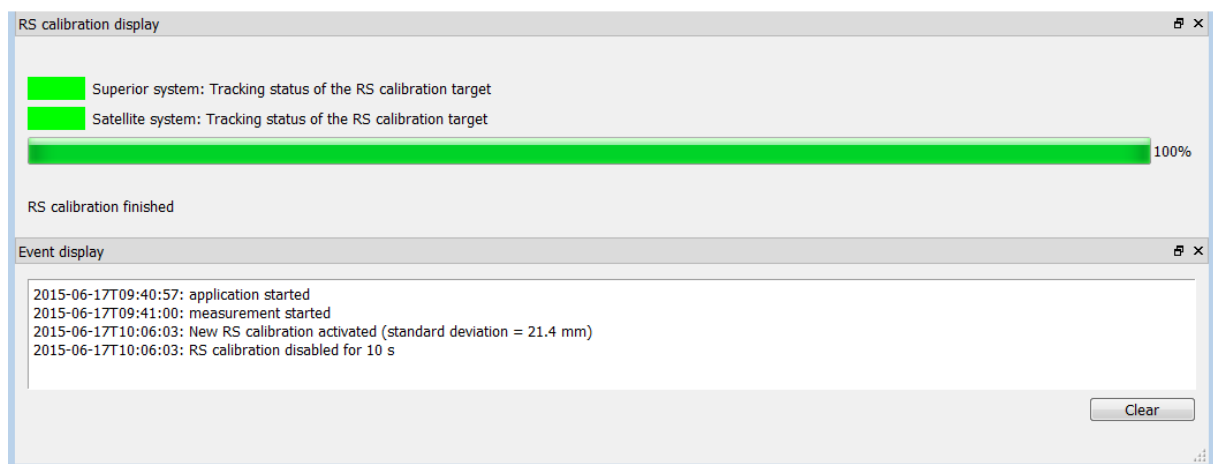


Figure 17: RS calibration successful

The RS calibration can be repeated as often as you wish and will start over automatically as soon as the RS calibration target is seen again by both tracking systems.

5.4. One single origin

After you successfully completed the RS calibration process (as seen in the picture above) the software will automatically calculate a single origin for both camera systems. This won't be a random one, but will be the origin of the superior system, meaning that all information coming from the satellite will simply be transferred into the coordinate system of the superior system.

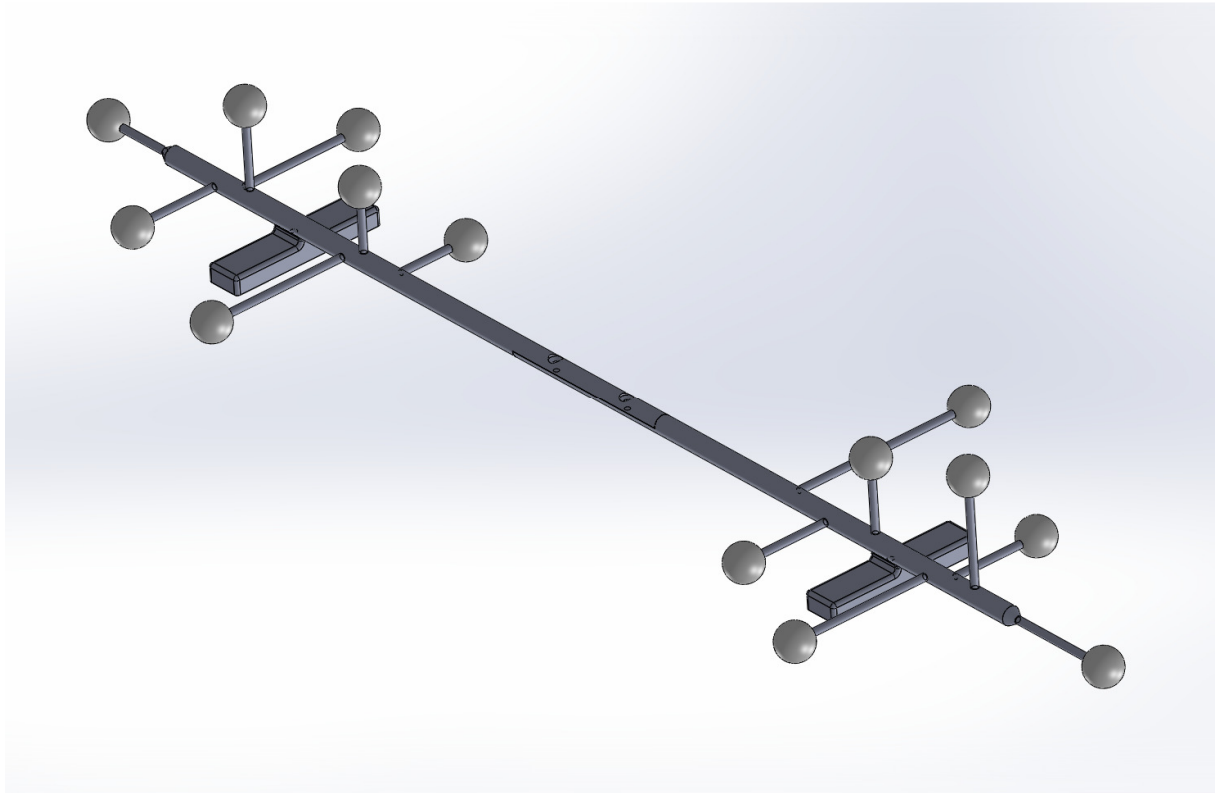
You may now proceed to move targets through the field of view of both systems, without seeing any difference no matter which system is tracking the target right now, because there are no different origins anymore.

5.5. Accuracy of the satellite system

Please be aware that the accuracy of the satellite system depends on several factors and is in any case less than the accuracy of the superior system.

The depending factors are:

- Setup of the complete system
 - Number of cameras of the superior and the satellite system
 - Structure and size of the reference target
- Quality of the room calibration of superior and satellite system
- Quality of the RS calibration
- Visibility of the reference target
- Visibility of the tracking target during tracking by the satellite system



Appendix 1: RS calibration target

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