SPH ENGINEERING
SMART PLANES & HELICOPTERS

UGCS DDC

VERSION 2.12

USER MANUAL

Table of Contents

1. UgCS DDC installation

To successfully start using **UgCS Drone Dance Controller (DDC)**, it needs to be installed and configured accordingly.

There are no specific settings required to be changed during the installation. Although it is possible to install only those components which will be used on the specific computer (multimode installation). This is not recommended trough, since each of the components don't take up much disk space and can be used in emergency situations to replace another PC.

If the user would like UCS Server (map and mission data storage, routing, mission calculation) to run automatically with computer start, one must select the following settings during **UgCS DDC**" installation:

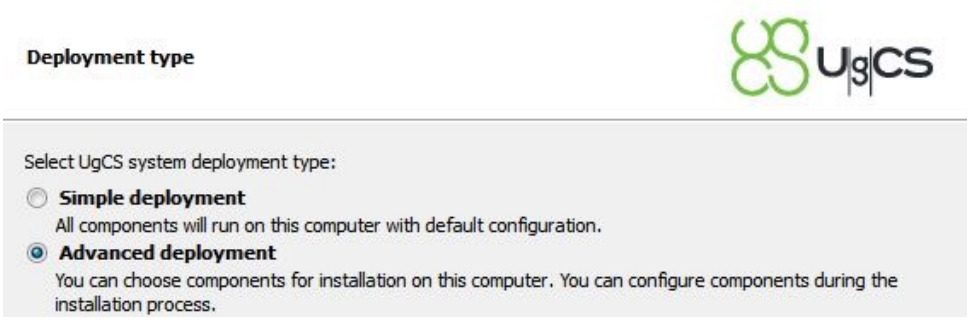


Image 1. *Select "Advanced deployment" if it is necessary to automatically run UCS Server after Windows boot*

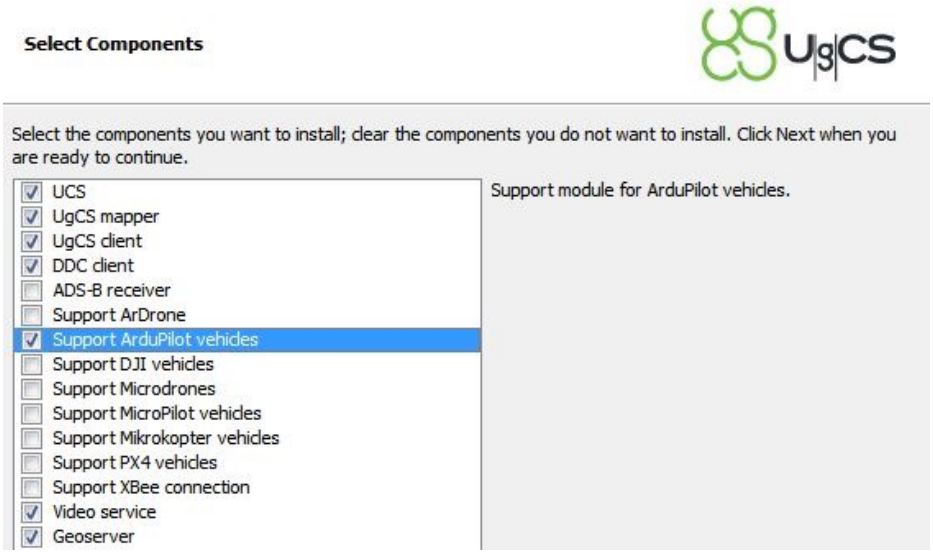


Image 2. *Selecting essential components for installation*

It is also possible to install **UgCS** Server, Pixhawk/APM Vehicle Specific Module (VSM) and Geoserver (used for custom map overlay and elevation data) as system service, if necessary and set server address and port already during installation if is known, that server is or will be running on a different machine.

Additional connection parameters can be set during the installation, but those are meant for Virtual COM Port communication configuration and not TCP/UDP configuration.

2. UgCS DDC configuration and deployment

This section contains information on how to set up **UgCS DDC** for multimode deployment.

For multimode deployment the same **UgCS DDC** version should be installed on all PCs in question. All **UgCS DDC** components should be installed on all PCs, but it is not obligatory to do so (user may choose to not install all of them).

The recommended lay-out would be to have UCS Server and VSM running on one PC and **DDC** Client and **UgCS** Client running on the rest of available PCs.

NOTE: It is mandatory, that all PCs can access the PC running UCS Server and VSM trough network.

2.1. Configuring UCS Server

On the PC that will be running UCS Server, VSM and Geoserver processes, it is not necessary to run **DDC** Client and **UgCS** Client.

In order to set up the rest of the PCs running **DDC** Client and **UgCS** Client, it is necessary to know the IP address of the PC running UCS Server and VSM. Easiest way to find it out is to use “ipconfig” command from command prompt in Windows or “ip addr” command on Linux machines.

This IP address will be used on the PCs running **DDC** Client and **UgCS** Client to connect to.

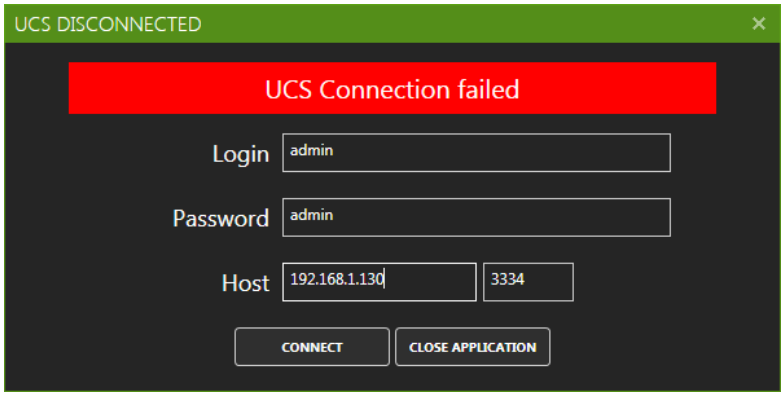


Image 3. *Entering IP address of the Server which connect to and user credentials.*

It is also recommended to change login and password and add new operator users to add another layer of security. To do so, one must open **UgCS** Client on the machine running UCS Server and go to “Users” tab in Main Menu. At first, there is one user – “admin” with the same password (“admin”), change these parameters as preferred and create new users with “Operator” role for ease of use.

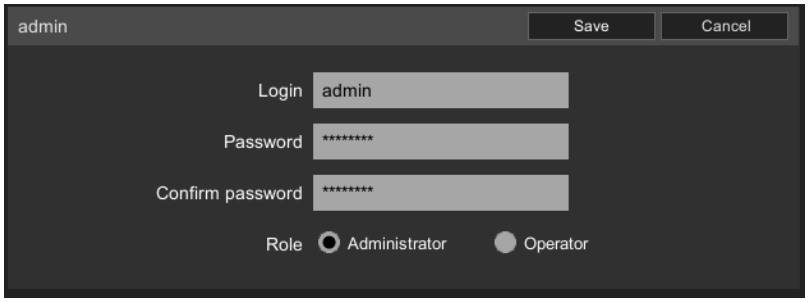


Image 4. *User login and password settings in “Users” tab on Main Menu (UgCS Client).*

2.2. Configuring Vehicle Specific Module (VSM)

Vehicle Specific Module is used to connect to the vehicle and governs advanced routing settings. To configure VSM it is necessary to edit the vsm-ardupilot.conf file which is typically located in

C:\Program Files (x86)\UgCS\bin or the specified installation directory.

2.2.1. Connection related settings

To start connecting the VSM to the available vehicles using UDP protocol, it is necessary to indicate which ports the VSM must listen for available devices (flight controllers).

The lines 36-38 of vsm-ardupilot.conf file contain the following text:

```
# Vehicle can be connected via UDP.
# UDP port which will listen for incoming mavlink messages.
connection.udp_in.1.local_port = 14550
```

To configure the connection to vehicles it is either necessary to set all the vehicles to send messages to the same UDP Port (in which case it will be problematic to connect to one single vehicle only) or to set the local port unique for each vehicle (recommended).

Example configuration for 3 vehicles:

```
connection.udp_in.1.local_port = 14561
connection.udp_in.2.local_port = 14562
connection.udp_in.3.local_port = 14563
```

Notice how both port and number of vehicle (1, 2, 3) changes. Make sure to restart VSM after making any changes to start using them.

2.2.2. Regular GPS and RTK GPS related settings

Within vsm-ardupilot.conf file there are two more very important settings which govern how **UgCS** calculates route altitude. By default these settings are configured for use with regular GPS modules.

NOTE: If the fleet of vehicles has RTK GPS modules, these two lines within vsm-ardupilot.conf file must be uncommented (the "#" from beginning of the line must be removed) and should look like this:

```
vehicle.ardupilot.report_relative_altitude = no
vehicle.ardupilot.set_ground_alt_offset = no
```

- Report relative altitude – assumes that ALT value from flight controller is not absolute
- Set ground altitude offset – assumes that vehicle is on ground level and AGL altitude during route upload is 0

2.2.3. Other routing related settings

Another important routing setting that can be configured within vsm-ardupilot.conf file is enabling and disabling of autoheading. If autoheading is enabled, the route will be created in a way that vehicle always will face the following waypoint. If autoheading is disabled, vehicle will not change its yaw angle unless changed using command "Yaw" using waypoint action. The behavior is governed by changing the following line within vsm-ardupilot.conf file:

```
vehicle.ardupilot.autoheading = no
```

2.2.4. Group Arducopter parameter change using vsm-ardupilot.conf file

It is possible to change one or more Ardupilot configuration parameters by changing vsm-ardupilot.conf file. There is one sample line within vsm-ardupilot.conf file. When parameters are added to this file, they are changed within Ardupilot during route upload. For example, if one would like to set action on loss of RC = N/A, to disable any action when connection to the RC is not available, one could add this line to vsm-ardupilot.conf file and upload routes to all necessary vehicles:

```
vehicle.ardupilot.parameter.FS_THR_ENABLE=0
```

After route has been uploaded to vehicles, the line can be removed from the config file.

2.3. Configuring UgCS Drone Dance Controller

To properly set up **UgCS DDC** one must edit the *DDClient.exe.config* file typically located in *C:\Program Files (x86)\UgCS\client-DDC*. The following settings can be changed in this configuration file:

- Names of the vehicles used
- Default route name for each vehicle
- Geo-fence radius, altitude and polygon
- Edit vehicle groups

```
<add internalid="1" name="APM-101" defaultroute="1" supervisor="User 1"
fenceradius="100" fencealtitude="120" polygonfence="false"/>
```

This is one line from *DDClient.exe.config* containing the vehicle settings for reference.

2.3.1. Names of the vehicles used

It is necessary to specify the names of the vehicles that will be used, before any vehicles are displayed in **DDC**. By default the vehicle names in *DDClient.exe.config* file are set to 1, 2, 3.., etc. (name="1", name="2", name="3",..). It is possible to either set the vehicle names for connected vehicles according to this within **UgCS** client or to change the *DDClient.exe.config* file to match your connected vehicles.

2.3.2. Default route setting

This setting defines the name of default route for the specific vehicle. Usually it is not necessary to change it, but in cases when a vehicle is out of order and needs replacing, using this setting it is possible to assign other vehicles route to be used by default. It is not obligatory to change this parameter, since each route change is saved after closing **DDC** Client meaning that next time when running it, the route settings will remain same as previous time.

2.3.3. Geo-fence radius, altitude and polygon

Geo-fence function consists of two parts:

- Cylindrical fence
- Polygonal fence

The **cylindrical radius fence** is the primary fence function. It can be used separately or together with polygon fence. By changing these two parameters – *fenceradius* and *fencealtitude* it is possible to

define specific flight range limits for each vehicle. These parameters are defined in m (meters) from the home location point – H as shown in Image 5. Position of Home location can be specified in route settings. The action which vehicle will take after fence breach can be defined in Mission Planner.

Additional to the cylindrical fence, it is possible to set **polygonal fence**. To enable polygon fence it is necessary to set parameter polygonfence="true". When the polygonal fence is used together with cylindrical fence, fence breach is triggered as soon as vehicle breaches either cylindrical fence or polygonal fence border. In case of using both types of fence, the permitted flight area is where cylindrical radius fence and polygon fence overlap like shown in Image 5.

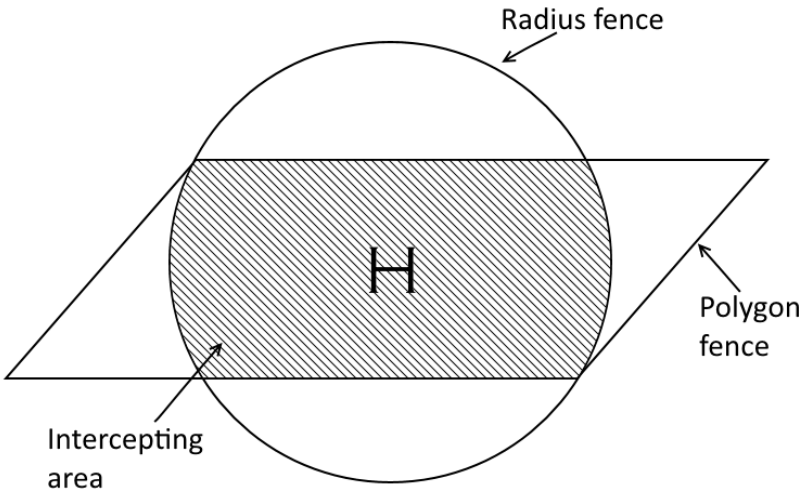


Image 5. *Diagram displaying the permitted flight area within geo-fence*

The setup of polygonal fence requires several steps. First one needs to create a new route in **UgCS** Client and mark the desired fence area using “Perimeter tool”  in **UgCS**. When the area is marked, it is necessary to export the route to a *.XML file and open the file with a text editor. The necessary lines should look like this:

```
<ugcs-List name="points" type="FigurePoint" v0="id" v1="version" v2="order" v3="latitude" v4="longitude" v5="wgs84Altitude" v6="aglAltitude" v7="altitudeType">
<o v2="0" v3="0.5900877312384658" v4="-1.4685816967389724" v6="0.0" v7="AGL"/>
<o v2="1" v3="0.5900910492826061" v4="-1.4685958825188987" v6="0.0" v7="AGL"/>
<o v2="2" v3="0.5900957350709617" v4="-1.4685953519569892" v6="0.0" v7="AGL"/>
<o v2="3" v3="0.5900981341526812" v4="-1.468586617752834" v6="0.0" v7="AGL"/>
</ugcs-List>
```

Next edit the *DDClient.exe.config* file and paste these lines within <polyfence> </polyfence> tags.

Note: fence will work both in Auto mode as well as all Manual modes.

2.3.4. Vehicle group settings

```
<groups>
    <add internalid="1" name="Group-1" vehicles="1,2,3,4,5,6,7"/>
    <add internalid="2" name="Group-2" vehicles="8,9,10,11,12,13, 14"/>
    <add internalid="3" name="Group-3" vehicles="15,16,17,18,19,20"/>
</groups>
```

This sample illustrates how 20 vehicles could be split up to be controlled by three operators. One vehicle can have infinite number of operators (two operators can control the same vehicle) and it is possible to add new groups just by creating a new line by the same pattern, for example:

```
<add internalid="4" name="Group-4" vehicles="7, 10, 14, 19”/>
```

3. Route planning in UgCS Client for use with DDC

General route creation guidelines (described in **UgCS** User Manual) applies for creating routes for use with **DDC** Client with a few exceptions.

3.1. Paying attention to “Action on loss of RC” setting

In order to use 20 vehicles without remote controllers (RC) Action on loss of RC has to be disabled, meaning that there will be no reaction on either enabling or disabling Remote Controller (vehicle can still be taken over using Remote controller at any time). This can be done either from mission planner or using vsm-ardupilot.conf file.

Please note: When planning routes it is necessary to set “Action on loss of RC” within route parameters to “Do not modify”. Otherwise the action will be changed during route upload.

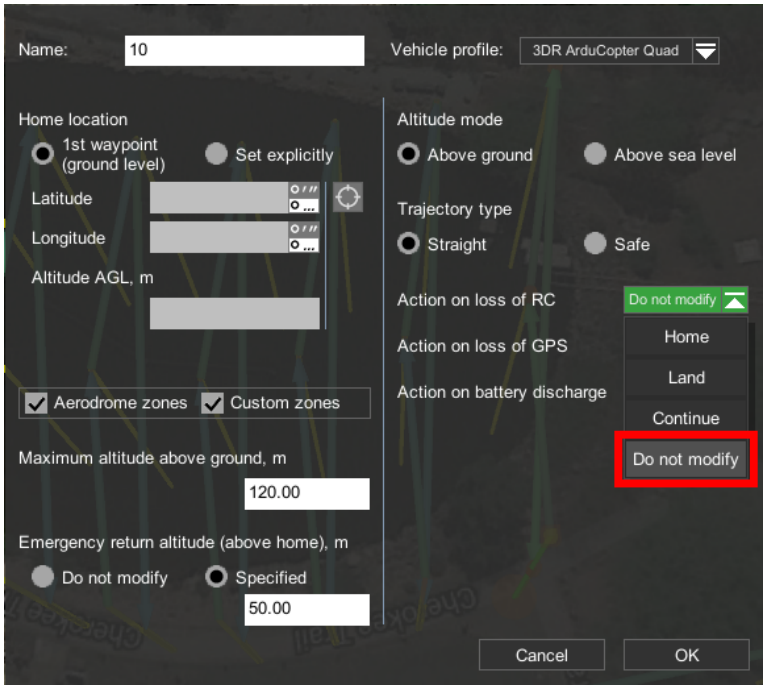


Image 6. *Route settings showing the disabled Action on loss of RC section.*

3.2. Creating a route with “Wait unlimited” actions

Creating a route with “Wait unlimited” actions in every point is necessary to achieve simultaneous execution of the mission from all involved vehicles. By adding “Wait unlimited” action in every waypoint of the route, operator ensures, that after reaching the waypoint, vehicle will stay there and wait for operators command to continue flight to next waypoint.

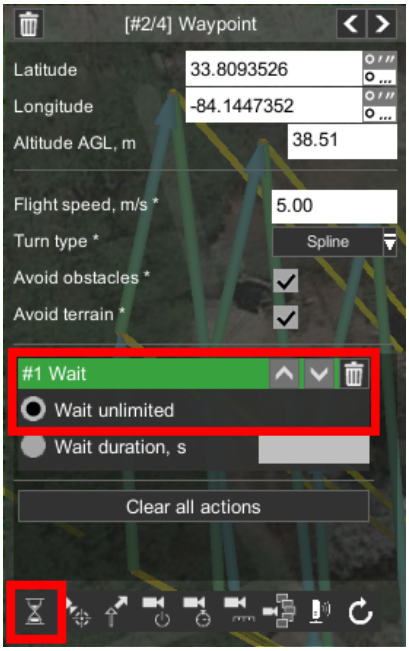


Image 7. *Showing waypoint with added “Wait unlimited” action.*

3.3. Using UgCS to control servo output during flight (for show effects)

For show purposes **UgCS** client with **DDC** features servo output control for Pixhawk autopilots. It can be pre-programmed during planning to be activated autonomously during route execution or can be changed instantly using a command. The output PWM (Pulse-width modulation) signal can be used to operate show elements like lights, smoke, and others.

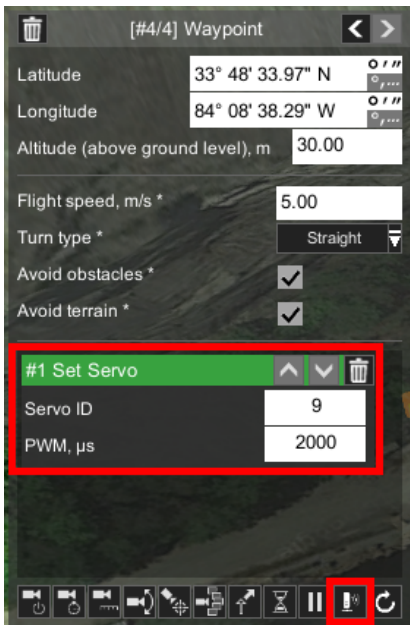


Image 8. *Waypoint with added ‘Set Servo’ action with channel 9 and PWM of 2000µs*

There are two different functions available – Set Servo and Repeat Servo. The functions can be either used as a waypoint action, when the action will be engaged as soon as vehicle reaches the waypoint during route execution or as a command to manually engage the action.

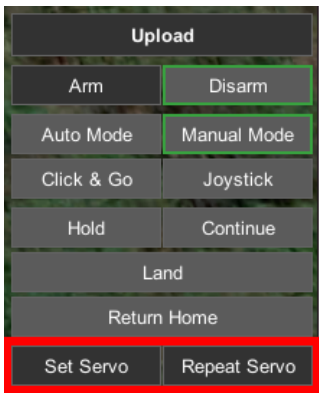


Image 9. *Set Servo and Repeat Servo actions highlighted in the Commands section*

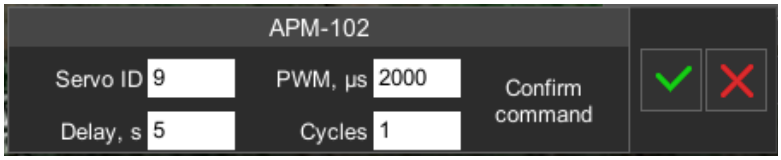


Image 10. *Showing 'Repeat Servo' command parameters*

- Set Servo – sends the PWM signal continuously until different PWM is set, has two parameters:
    - **Servo ID**
    - **PWM, µs**
- Repeat Servo – periodically changes PWM output to the set one and back to default has the following parameters:
    - **Servo ID**
    - **PWM, µs**
    - **Delay, s** – period of time after which servo level changes
    - **Cycles** – after completing the number of cycles signal returns to default

It is recommended to connect the appliance, which needs to be controlled the following way:

- Power (+ and -) are connected to RC port of Pixhawk
- Signal pin is connected to port 1 of Aux Out

Image 11. *Showing the recommended Servo output ports*

3.4. Adding “Landing” waypoint

To safely and effortlessly run flights with **DDC**, it is necessary to add “Landing” waypoint in the end of each route. This will assure, that by executing “Adjust last point” action (described in later paragraphs) the landing point will be moved to current location (while vehicle is located in starting point) of the vehicle assuring, that the vehicle will land exactly where it took off from.

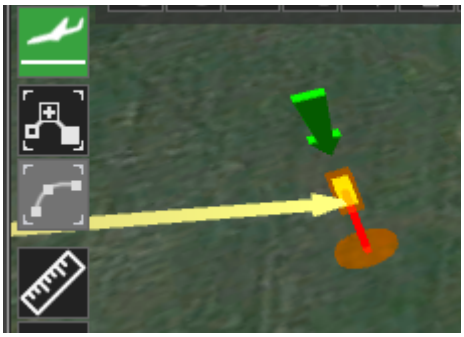


Image 12. *Showing selected “Landing” tool and landing waypoint placed on map.*

3.5. Additional options that are available in UgCS for DDC

There are two additional functions added in **UgCS** for ease of use with large number of drones:

- Ability to save 3 different camera viewpoints and quickly switch between them
- User is allowed to change the size of drone on display – Real size or upscaled Auto size

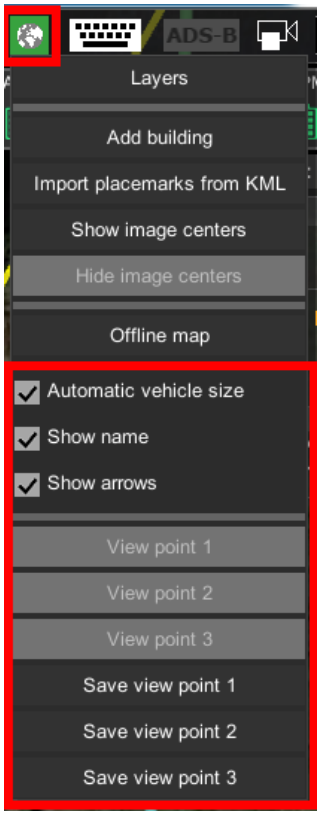


Image 13. *Showing highlighted Camera and Drone size options*

The settings are located under Map Options (globe icon between search field and keyboard field in upper right corner).

4. UgCS Client and DDC Client show operation guide

Image 14. DDC Client main view with marked control areas

The **DDC** Client consists of 6 main control areas and a spreadsheet type list of vehicles. Each of the areas serve a different kind of purpose.

4.1. Actions and Options tab

Following commands are in “Actions” tab (Nr. 1 in the Image 14):

- **Reload Vehicle list** – will refresh the vehicle list and check for any changes
- **Load new mission** – opens up context menu to change to different mission
- **Manual mode** – sets the selected vehicles to Manual mode
- **Adjust last point** – sets the last route point of selected vehicles to current vehicle location
- **Reboot vehicles** – Restarts the flight controller to re-initialize all sensors
- **Exit** – Close this menu

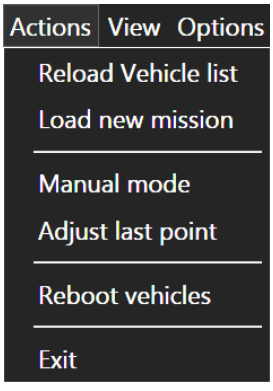


Image 15. “Actions” menu content

In“View” tab button “View server logs” displays the window with UCS Server log messages.

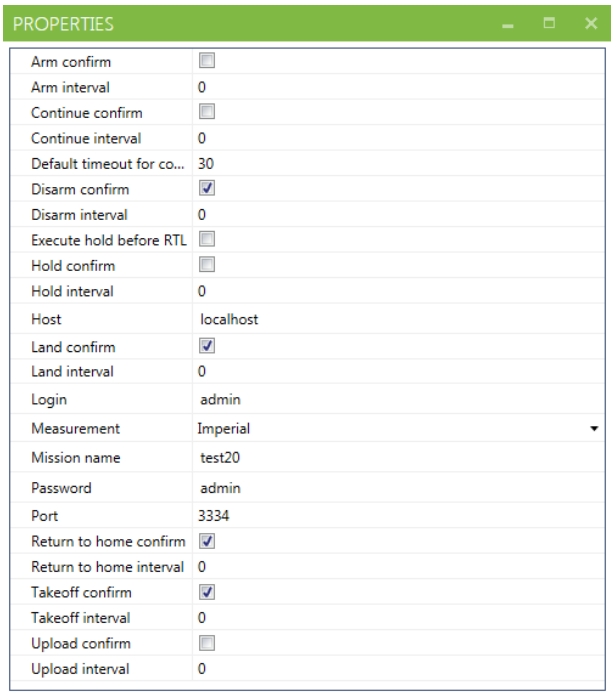


Image 16. *General options window showing the available controls*

In “Options” tab the “General options” button opens up a window with following controls:

- **Command confirm** – enables or disables confirmation message before executing each of the commands (“ARM”, “Continue”, etc.)
- **Command interval** – adds time in s (seconds) after which the command will actually be sent to the vehicles (“ARM”, “Continue”, etc.)
- **Default timeout for command** – timeout after which command will be regarded as not executed or failed
- **Execute hold before RTL** – enables or disables **DDC** executing “hold” command before executing Return to Home command
- **Host** – sets the host IP which to connect to (UCS Server)
- **Login** – sets the login username
- **Measurement** - Sets between Imperial or Metric measurement units
- **Mission name** – displays current mission name, one may change to different mission by entering different mission name and after restarting **DDC** the new mission will be used
- **Password** – allows to change Users password
- **Port** - allows to change connection port

In “Help” tab buttons “Support” and “Contacts” are located, that lead to according pages on **UgCS** website.

4.2. Vehicle selection tab

The vehicle selection tab (Nr. 2 in the Image 14) consists of the following commands:

- **Select All** - selects all vehicles
- **Clear All** – clears the selection of all selected vehicles
- **Select Failed CMD** – selects only the vehicles which last command had failed
- **Select by Mode** – selects vehicles which state conform to the state set. There are three states available to select:
    - Disconnected
    - Disarmed
    - Armed

4.3. Filter by Operator or status tab

The filter by Operator or status tab (Nr. 3 in the Image 14) allows operator to instantly show only the vehicles which conform to the status chosen in this tab. The following options are available:

- **All** – displays all vehicles
- **Armed** – displays only the vehicles which are armed
- **Disarmed** – displays only the disarmed vehicles

Group – By default there are three Groups available which different operators may use for displaying only the vehicles needed. It is also possible to add new groups.

4.4. Vehicle status column

For essential information about vehicle status in **DDC** a column displays current vehicle state. There are four different statuses:

- **Standby** – Vehicle is ready for take-off
- **Airborne** – Vehicle is currently airborne
- **Not ready** – Vehicle is not yet ready for take-off
- **Critical** – Vehicle battery is low or flight controller reports sensor problems

4.5. Commands to start Route

The following commands are available in Route starting tab (Nr. 4 in the Image 14):

- **Calculate** – Calculates the route for selected vehicles
- **Upload & Fence** – Uploads the route, sets Geo-Fence and sets altitude offset*
- **Calibration** - Recalibrates the barometer
- **Takeoff** – Starts mission execution
- **ARM** – arms the motors

*- Altitude offset parameter is used to correct vehicle altitude when disarmed and placed on ground

4.6. Route's Continue command and Stopwatch tab

The Continue and stopwatch tab (Nr. 5 in the picture Image 14) holds two functions:

- **Stopwatch** – Can be used by operators to sync precise execution of routes
- **Continue command** – One of the most important commands in **DDC**, is used to continue route execution after a vehicle has reached a waypoint with “Hold” action

4.7. Commands to end Route

The commands in this tab (Nr. 6 in the Image 14) controls the actions needed to end route execution.

- **Return to Home** – Makes the vehicle reach pre-set return to home altitude and return to home location
- **Land** - Executes landing algorithm – vehicle will land in current position
- **Hold** - Pauses mission execution and makes vehicle hover in current position
- **Disarm** – Disarms the motors

5. Typical workflow

This section contains information on how a typical drone dance event is planned and executed. It is meant to introduce users to main functions and steps required to run a drone show with **DDC**.

5.1. Connecting vehicles and creating routes

First step to start off is to confirm that all the vehicles can be connected and are displayed both in **UgCS** client and **DDC** Client. To do that, please refer to sections Configuring Vehicle Specific Module (VSM) and Configuring **UgCS Drone Dance Controller (DDC)**.

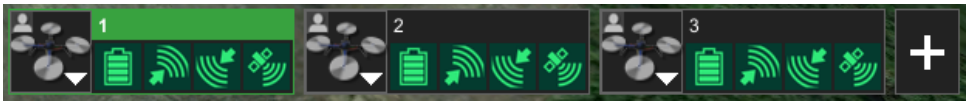


Image 17. *Displaying three properly connected vehicles in* ***UgCS*** *with good telemetry status of all sensors*

After all the involved vehicles have been confirmed to connect and display correct status both in **UgCS** and **DDC**, one may begin to create routes for those vehicles. If some vehicles do not appear on the list, make sure to check if they can be seen in ‘Uplink connected’ list under *Menu/Vehicles/ Uplink* connected or look for the vehicles by clicking on “+” button next to connected vehicles in Image 16.

Next step is to either create a new mission (mission contains routes, routes are the waypoints for each vehicle) or modify an existing one. If creating a new mission, make sure to set the appropriate mission name in **DDC** Client Properties - Image 15.

While creating a route, please pay attention to the following factors:

- Place the first waypoint in the place where the vehicle will be located when taking off
- Pay attention that each route (flight path) is no closer than 5m from each other at any point
- Make sure, that if a symmetric execution of routes is needed, to place the same number of waypoints with “Hold” action in each of the routes (Read more: Creating a route with “Hold” actions)
- Where necessary add Set Servo or Repeat Servo waypoint actions for show elements

- Choose either to finish the route with “Landing” waypoints or to land the vehicles with command “Land” from **DDC**

5.2. Taking off and running the show

When the routes are finished, it is time to work with **DDC**. First, check that the vehicles are connected and correctly displayed in **DDC**. For ease of use, it is possible to filter the vehicles and display only the ones necessary – see section Filter by Operator or status tab.

Next step is to assign correct routes to the specific vehicles – make sure that the intended route is assigned to correct vehicle. In case it is necessary to assign already assigned route to another vehicle, one must first clear the existing assignment as shown in Image 17.

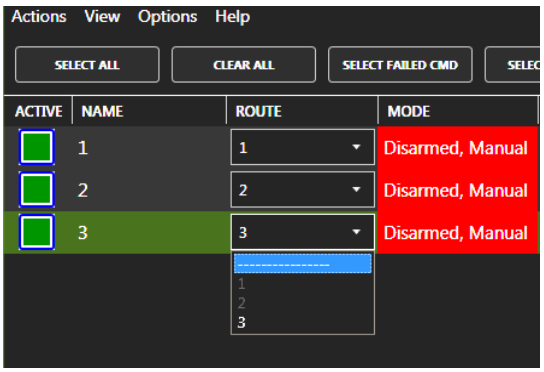


Image 18. *Clearing existing route assignment to vehicle*

When correct routes are assigned, the actual flying may begin. A convenient feature is the ability to change location of the last waypoint according to location of the drone, the feature is described in section 4.1 Actions and Options tab. It is strongly recommended to use this action to ensure that vehicle returns exactly to the start location.

Next step would be to set the take-off point altitude, which makes sure, that route is calculated according to the altitude of the drone (assuming that the vehicles are on ground). Then the routes must be calculated and afterwards routes upload follows by clicking the “Upload & Fence” button.

After all routes have been successfully uploaded, it is time to Arm motors and take off, using commands “ARM” and “TAKEOFF”. As soon as the vehicles will reach any waypoint with “Hold” action, the status will appear displaying “Waiting at # ..” then using the “Continue” command vehicles will continue to next waypoint.

If a unpredicted situation occurs, vehicle can be held in place using “HOLD” action, afterwards using Click & Go function in **UgCS** or “Return to home” command in **DDC** vehicle can be landed safely.

6. Troubleshooting

This section consists of various non-standard situations which might occur during mission execution.

The vehicle can not be armed

- Make sure, that communications link is good, check if GPS/Compass and other sensor status is sufficient. If that does not explain, try power cycling the vehicle. If everything fails, contact support@ugcs.com

The vehicle can not be armed and in DDC error "The path cannot be found. Please try to change the location of the basic point(s) or values or parameters." Is shown.

- Make sure that the current location of vehicle is within Geo Fence radius. The radius is calculated from Home Location.

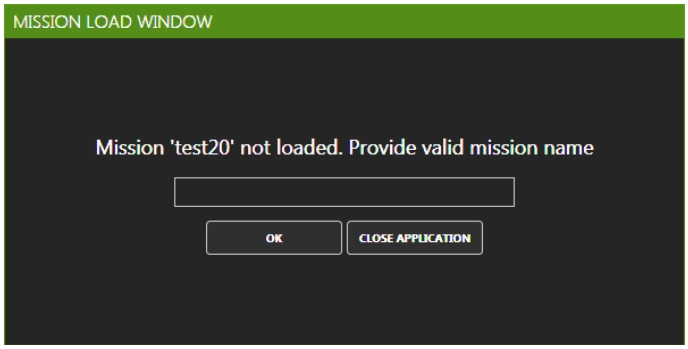
Route can not be uploaded to a vehicle

- There is a high possibility that the communications link is weak and therefore **UgCS** is having trouble sending route data to the vehicle. Try placing the vehicle closer to ground end of communications module.

During flight vehicle suddenly returns home

- Check Geo-fence radius and altitude, there is a high possibility that vehicle has reached fence limits

When starting DDC client the following message appears:



- This message is caused because the mission that is configured to work with **DDC** is either removed or renamed. Either enter the new mission name in the input field or change the mission name to previous one in **UgCS** Client. Note: **DDC** needs to be restarted if the name of mission was changed.