FLIGHTZOOMER
1.5

INSTALLATION

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2 Disclaimer

While FlightZoomer offers fantastic features, the following operation rules are strictly to be followed:

- The system is intended for hobby usage.
- Be familiar with the operation of RC aircraft having 1kg flying weight or more.
- Use FlightZoomer only aboard a proved combination of RC equipment, airframe, flight controller, motors, propeller, battery and ESCs.
- Operate FlightZoomer strictly within the safety boundaries of any other used components.
- Operate FlightZoomer strictly within the boundaries of any local regulatory requirement.
- Fully respect any disclaimer and safety note which is associated with any other used component.

3 Installation

3.1 What hardware do you need?

Related to FlightZoomer operations:

Component	Required equipment	Specifications	Mandatory	Recommended
FlightZoomer Sensorics	Windows Phone 8 or higher device	- Mobile plan with decent data support	X	
		- Supports Bluetooth		X (highly)
		- Compass sensor		X
FlightZoomer Groundstation	Windows Phone 8 or higher device	- Mobile plan with decent data support	X	
		- Support Bluetooth		X
		- 6” display		X
FlightZoomer Relay Server	PC or Server with Windows 7 or higher, located at home or alternatively in the cloud	- Internet connection	X	
		- High availability/ unattended operation	X	
Stabilizing unit	Flight controller; FlightZoomer has been tested with the APM/Pixhawk derivative AUAV X2.	- Support stabilized flight	X	
		- Ardupilot based		X
		- Support fully redundant failback (e.g. RETURN-TO-LAUNCH -mode)	X	
		- Offer MAVLink connectivity using the APM flavor		X (highly)
MAVLink bridge	Bluetooth transceiver HC-06 or compatible (e.g. from 3DR or Ebay)	- The UART side must be compatible with the flight controller		X (highly)
		-		

Not related to FlightZoomer itself you need the following equipment minimally:

Component	Required equipment	Specifications	Mandatory	Recommended
Aircraft	RC airplane or multicopter	- Fully equipped in flyable condition also without FlightZoomer	X	
		- Unproblematic handling		X
		- Electric propulsion		X
Radio system	Radio transmitter and receiver	- Possibility to command constant yaw		X
		- Possibility to command constant pitch		X

3.2 Prepare the FlightZoomer Relay Server

3.2.1 Shall it run in the cloud or at home?

The relay server principally can be operated unattended. For the normal operation scenario the relay server needs to be started and that´s it.

There are two possibilities to run the FlightZoomer Relay Server application.

1. **On a cloud-based virtual machine** 

2. **On your own PC (at home).** 

It is recommended, to us the cloud option because of these advantages:

- You do get a DNS service out of the box. If the relay server runs at home, an extra DNS service needs to be provided.
- The UDP port forwarding requirement can be implemented in a common and easy way.
- Access on the virtual machine is easily possible from the phone. This means that the relay server can be accessed from any place (e.g. from the outdoor location where you are flying). This is normally not needed, but in some cases it could turn out to be advantageous (e.g. if you forgot to launch the application at home).

Disadvantages of a cloud based relay server would be:

- There is a fee for a cloud based virtual machine (VM). There are price models however, which charge per operating hour, which means that per flight the price would only be some cents.
- Cloud dependency.

The following lists shows the steps needed to prepare the relay server:

One-time installation steps:

Step		
Select a virtual machine provider	X	
Create a virtual machine instance	X	
Provide DNS capabilities		X
Configure port forwarding		X
Install the FlightZoomer Relay Server application	X	X
Open the firewall for the required ports	X	X

Recurrent preparation steps:

Step		
Start the virtual machine	X	
Access the virtual machine (from a PC and from a smartphone)	X	
Shutdown the virtual machine after usage	X	

More details about any of these steps in the following chapters.

3.2.2 Select a virtual machine provider

This step is needed for:

While there are tons of VPS providers in the Internet, it is recommended to run the FlightZoomer Relay Server application on Microsoft Azure. Other providers often focus on virtual Linux boxes while FlightZoomer requires a virtual Windows machine. It is paid per usage hours so the fees for FlightZoomer purposes are really very moderate. The following guidelines describe the usage of an Azure virtual machine.

3.2.3 Create a virtual machine instance on Microsoft Azure

This step is needed for:

For this step first a Microsoft Azure account needs to be opened. Login into Azure from this page. If you don't have a Microsoft account yet, click on ***signup up now*** first (but you should already have one if you have set up your Windows Phone devices properly):

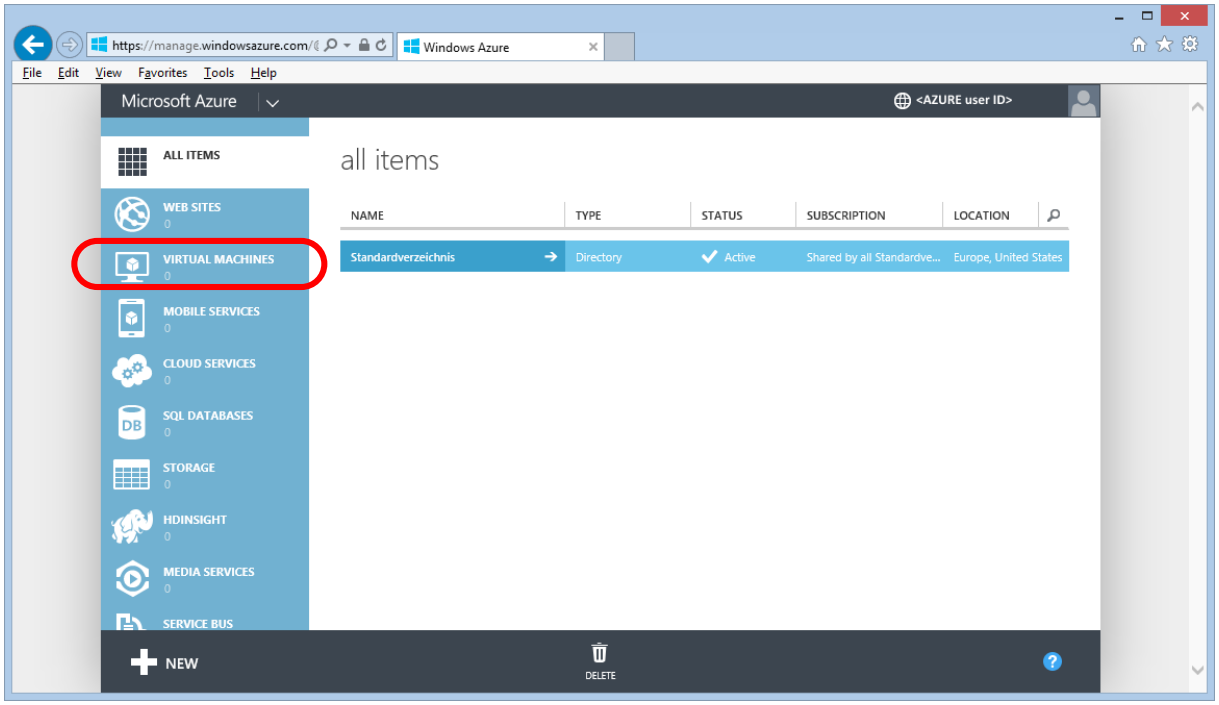
Azure login

After that the following steps are needed:

Step 1: Go to the Management Portal

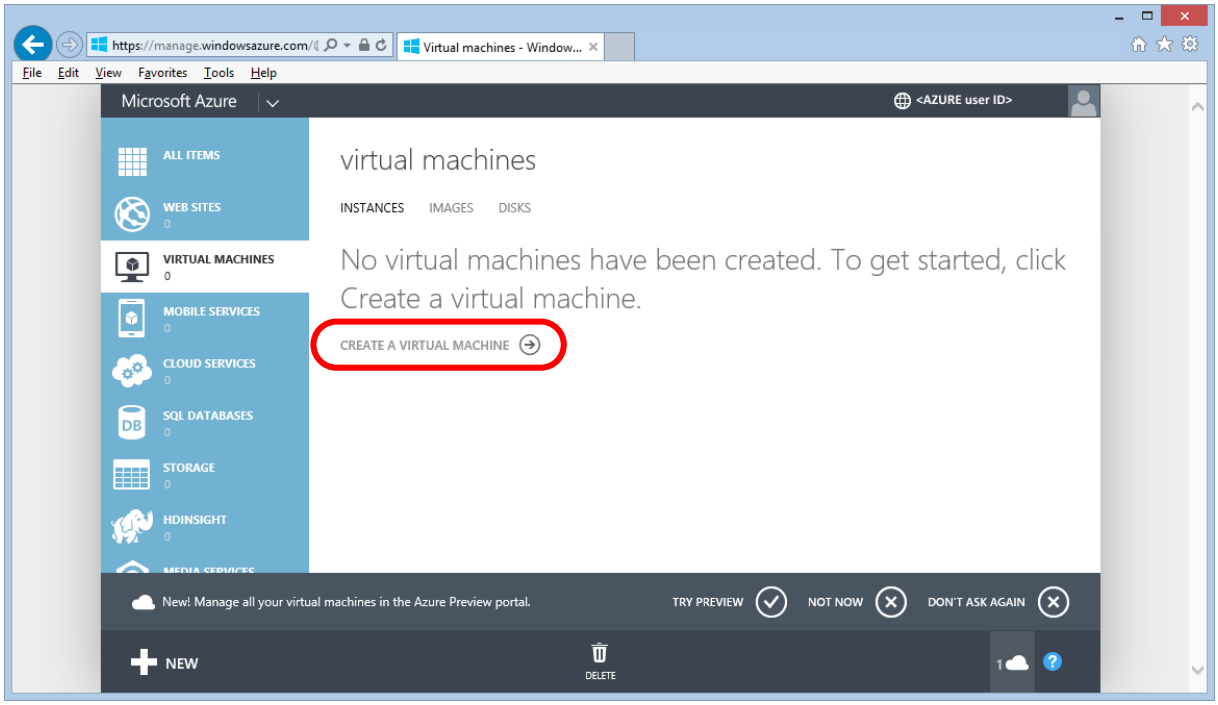
Here you can see all items that you have created so far…

Now click on VIRTUAL MACHINES on the left hand menu bar



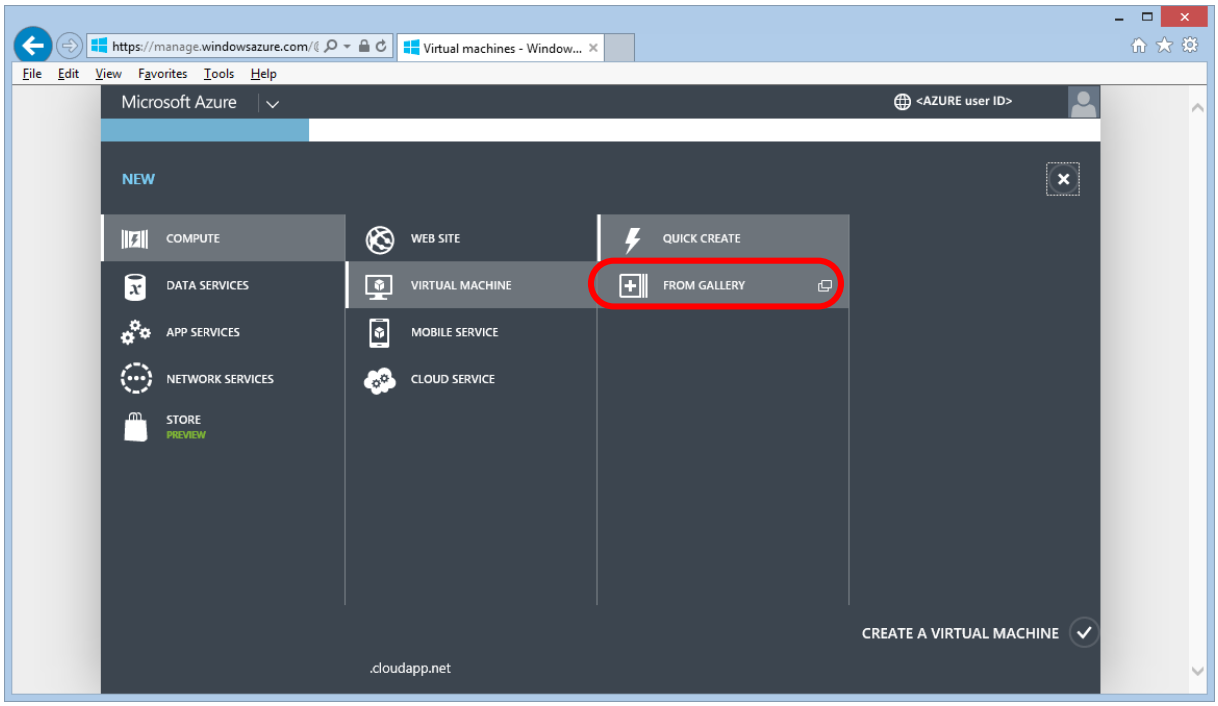
Step 2: Virtual machines screen

Here you can create a new virtual machine. Click on the red-marked link to do that:



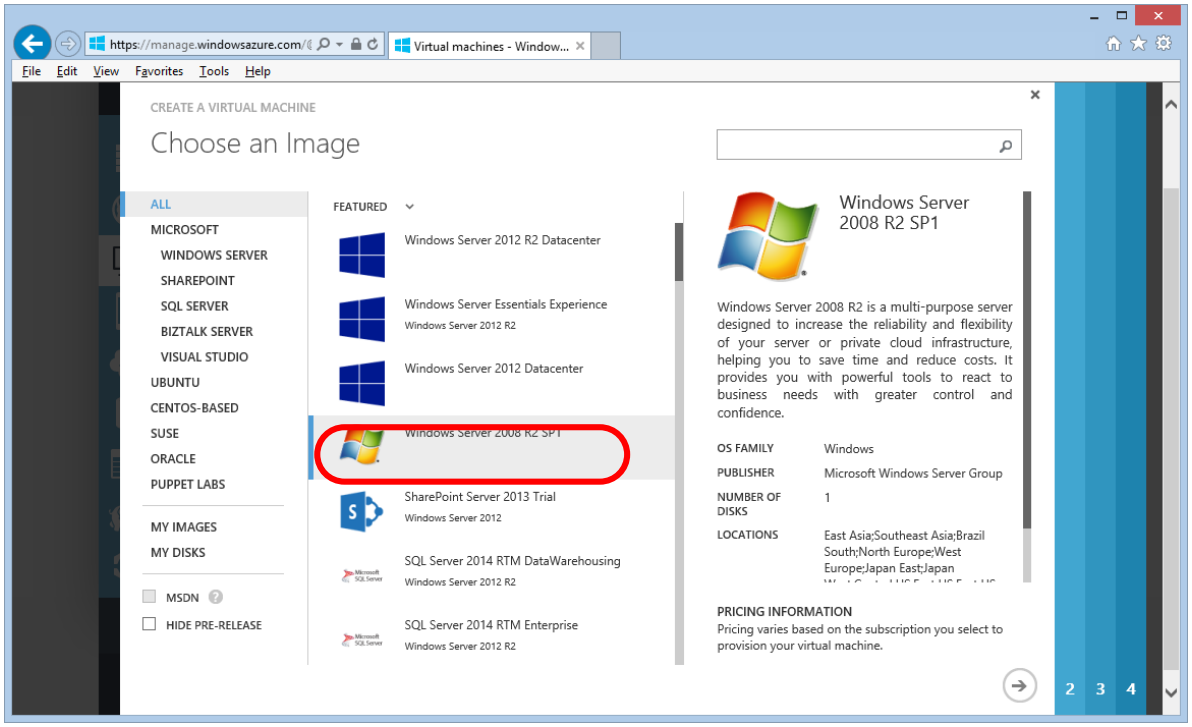
Step 3: Create new virtual machine screen

Here select *COMPUTE* > *VIRTUAL MACHINE* > *FROM GALLERY*



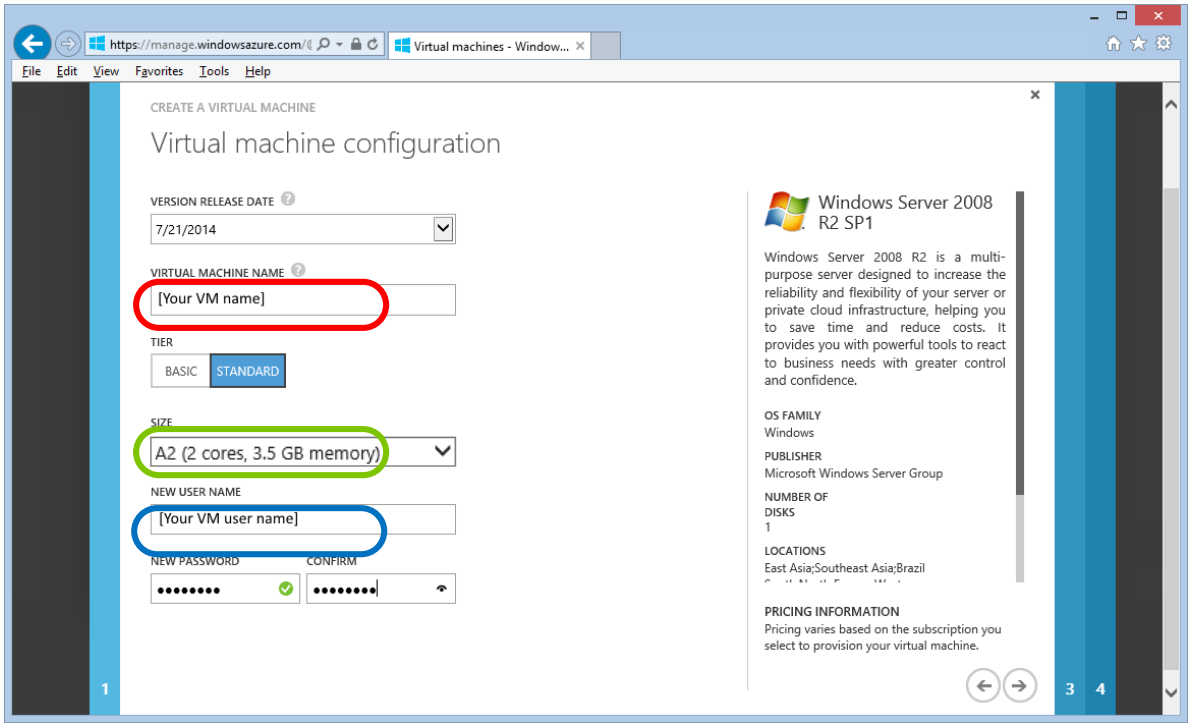
Step 4: Image selection screen

From the various options choose Windows Server 2008 R2 SP1. It is good enough by far for our purposes:



Step 5: Configuration screen I

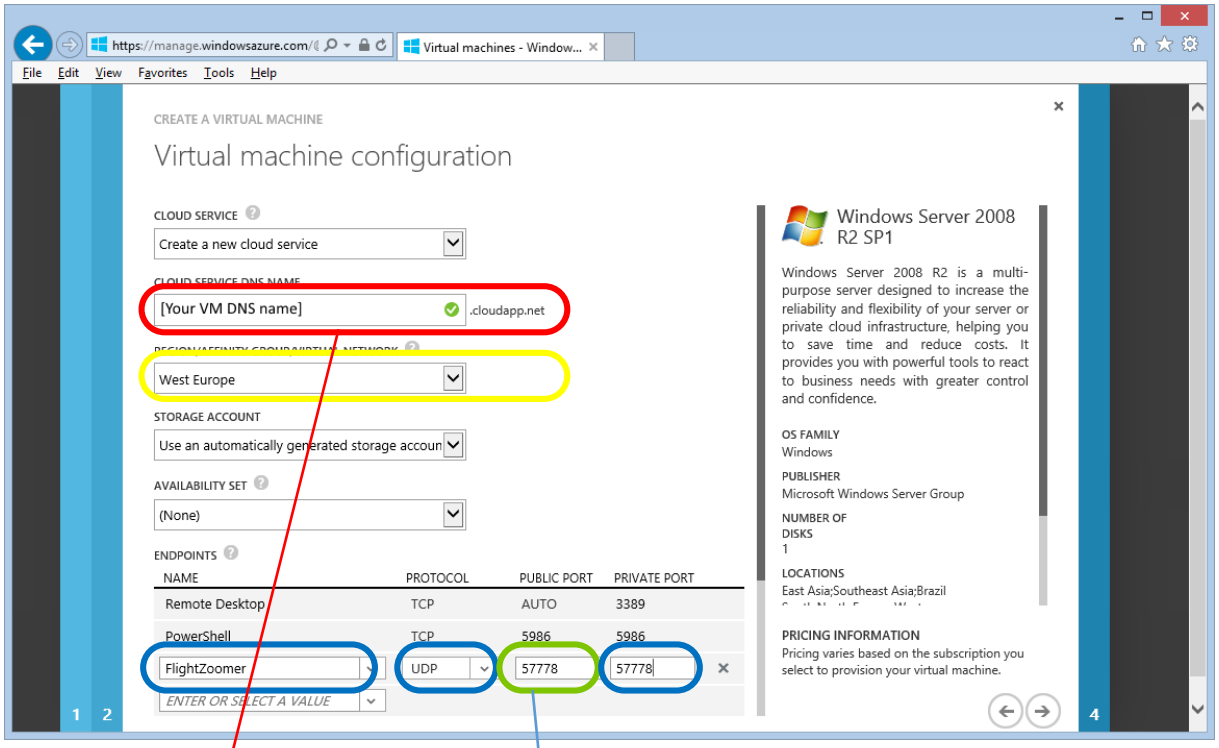
Provide a name for the virtual machine (red box), the machine size (green box) and a user name, for later login purposes (blue box). Note the specified names for later usage. Also provide a password for the user, which will be used to login from now on. This user is only created on the new virtual machine:



A remark regarding the machine size: it is recommended to choose A2 or higher

Step 6: Configuration screen II

On this page the public name of the virtual machine (red box) and the UDP port forwarding shall be specified. Here the DNS name shall be kept ready for later usage. Also select the region which is located the closest to places you usually fly (yellow box). Also add an endpoint as shown in the blue/green boxes:

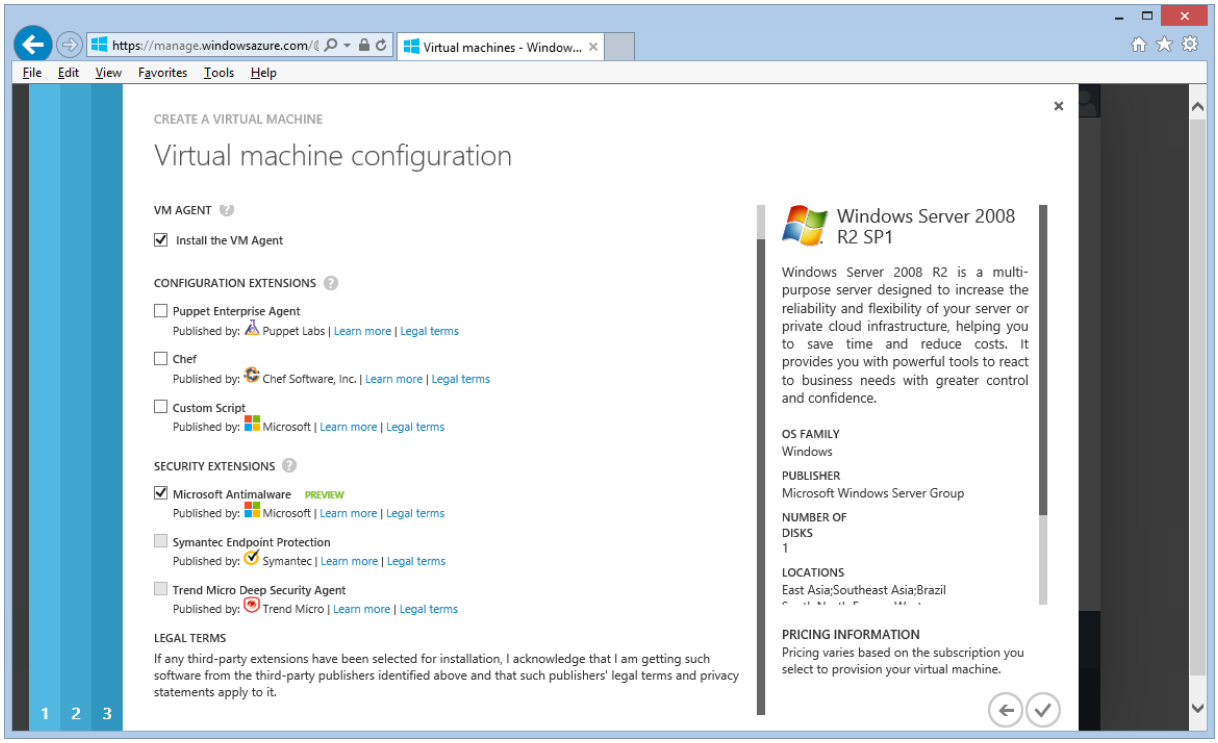


The information on this page is all that you need for connecting both the Sensorics- and the Groundstation-app to the relay server. In both apps you would enter the Network Address on the add relay server screen according to this pattern:

[Your VM DNS name].cloudapp.net : [Public Port]

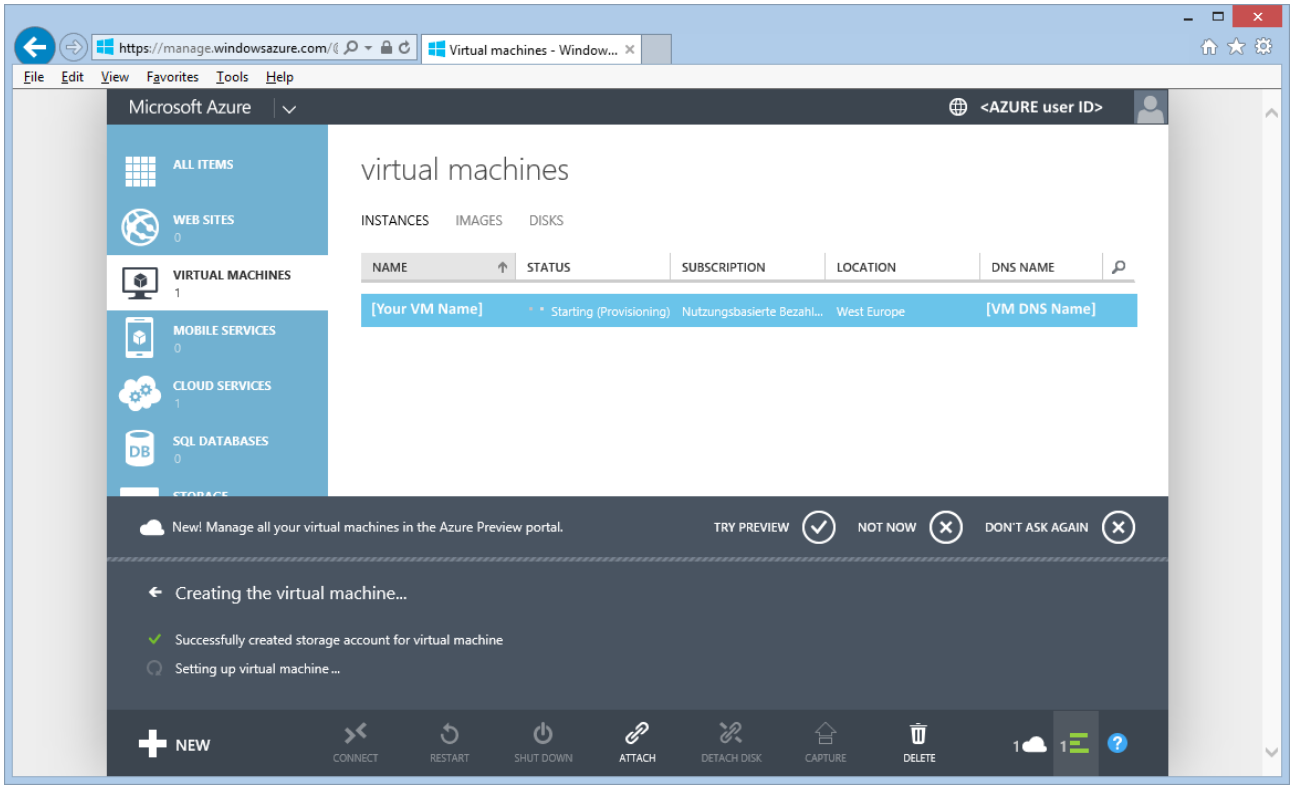
Step 7: Configuration screen III

Here just pick the suggested options and finalize the order with the button on the right hand bottom:



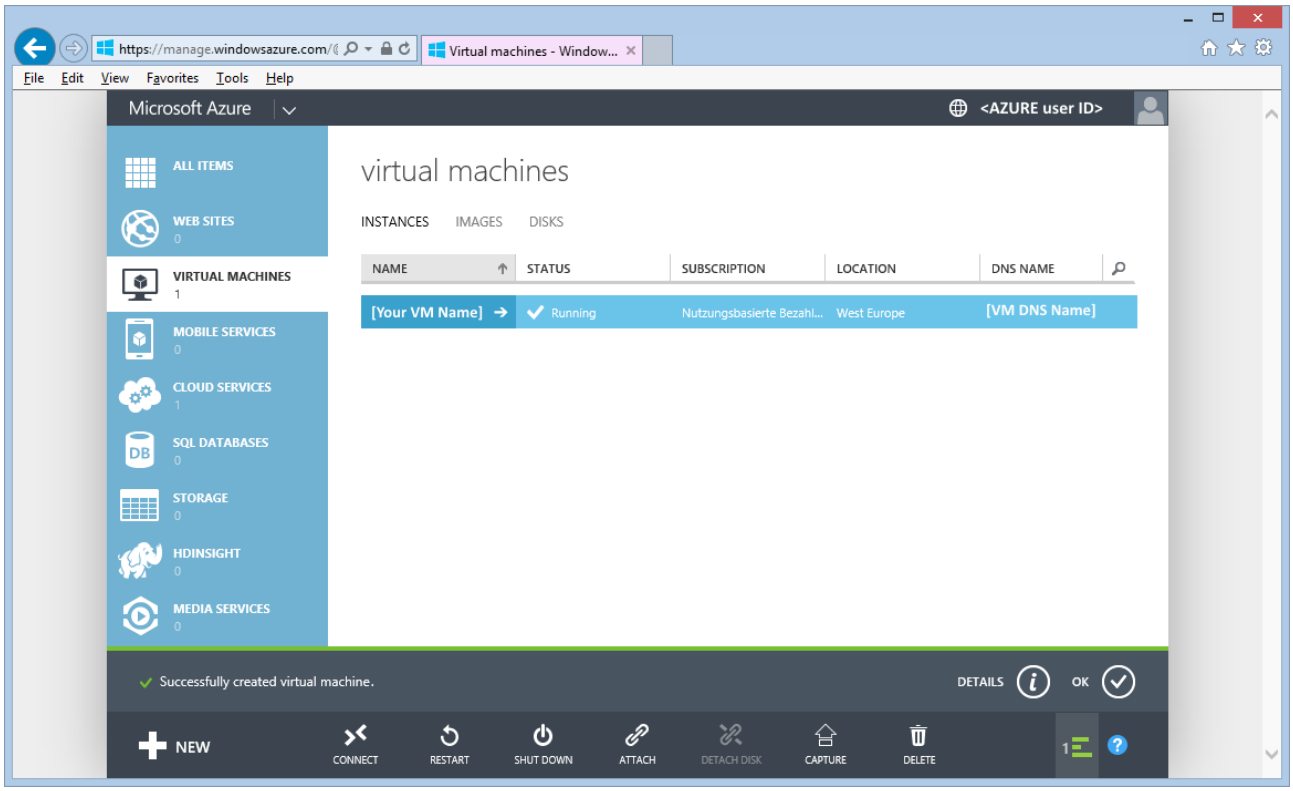
Step 8: Virtual machine screen, creation status

On bottom of this screen you can see the virtual machine creation progress. After creation, the VM will be running:



Here the virtual machine has been created successfully and is running. At this point there are two options:

- Connect to the instance using a Remote Desktop Client (RDP Client) -> go to chapter 3.2.9
- If you are not using the VM at the moment, switch it off avoiding charges -> go to chapter 3.2.10



After creating the virtual machine for the first time, it is already running. In case you do not continue, don't forget to shut down the virtual machine as described in chapter 3.2.10.

3.2.4 Provide DNS capabilities

This step is only needed for:

While using the Azure based virtual machine, the DNS service is already available out of the box.

If you are using a PC at home, you need to configure a DNS service accordingly.

The DNS serves the purpose, that the relay server can be reached from any point in the Internet via a public name (like google.com is a name that can be reached from anywhere in the internet). Actually the public

name will resolve to the public IP address of your internet router or modem. Reaching the relay server from the router is explained in the next chapter.

The public name of your relay server needs to be entered as relay-server network address in both the Sensorics- as well as the Groundstation-app.

DNS services require a DNS provider and some configuration in your router that the actual public IP address of your home endpoint gets reported to the provider.

There is a large variety of DNS providers. Some of them have been free, but no longer are (dyndns), some are pseudo-free (noip) and some are really free (FreeDNS).

Setting up DNS services requires these steps:

1. Pick a suitable DNS provider
2. Get an account
3. Set up everything as explained by the DNS provider in your modem/router.

3.2.5 Configure port forwarding

This step is only needed for:

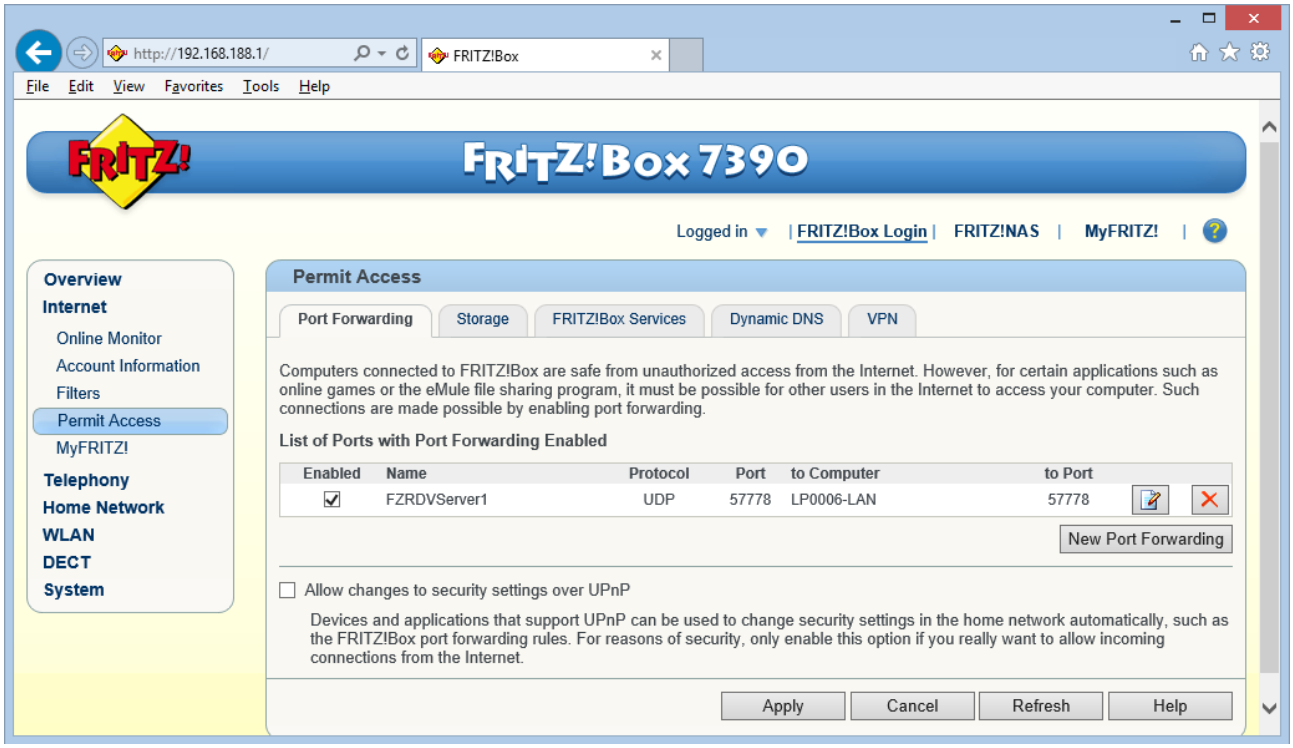
While using the Azure based virtual machine, the port forwarding is already available out of the box.

If you are using a PC at home, you need to configure your internet router accordingly.

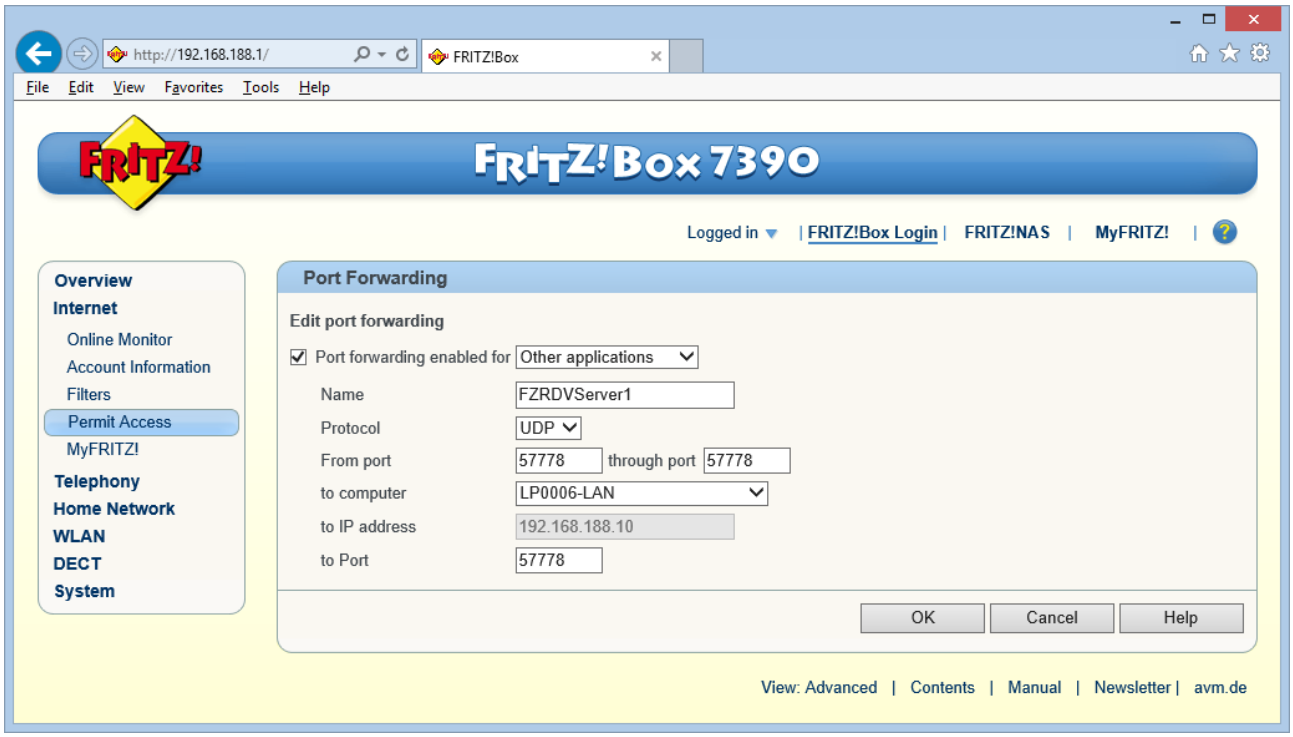
What basically is needed, is that UDP messages reaching your public home IP address are forwarded to the PC, where the relay server application runs.

The method, how to do that differs from router to router. Therefore the required settings are only shown here exemplarily for the Fritzbox 7390 Router:

Step 1: Overview page for the port forwarding feature:

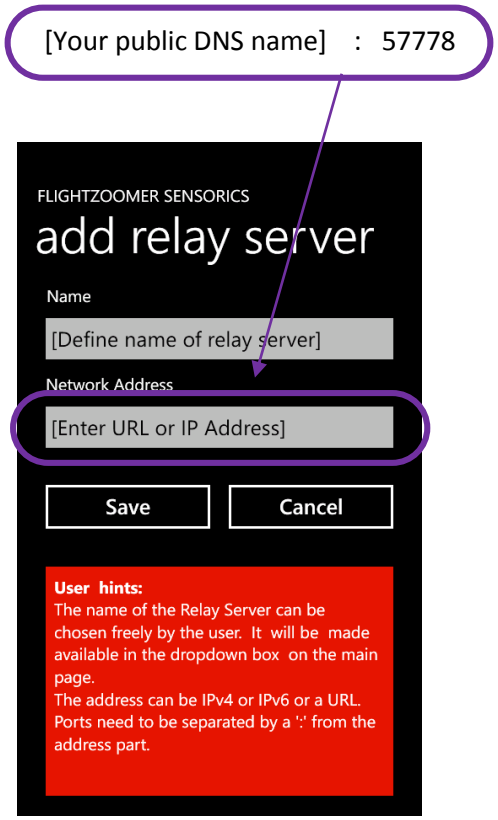


Step 2: Detail page for the relay server port forwarding:



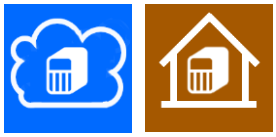
Whatsoever this screen looks for your router, you need to configure an UDP port forwarding from the listening port 57778 to the IP address and port 57778 of the PC, where the relay server runs upon.

At this point there is a public URL pointing to your house (see the chapter before) and a port forwarding to connect the public network endpoint with the relay server. The related parameter can be used to connect both the Sensorics- and the Groundstation-app to the relay server. In both apps you would fill in the *Network Address* according to this pattern (on the *add relay server*-screen):

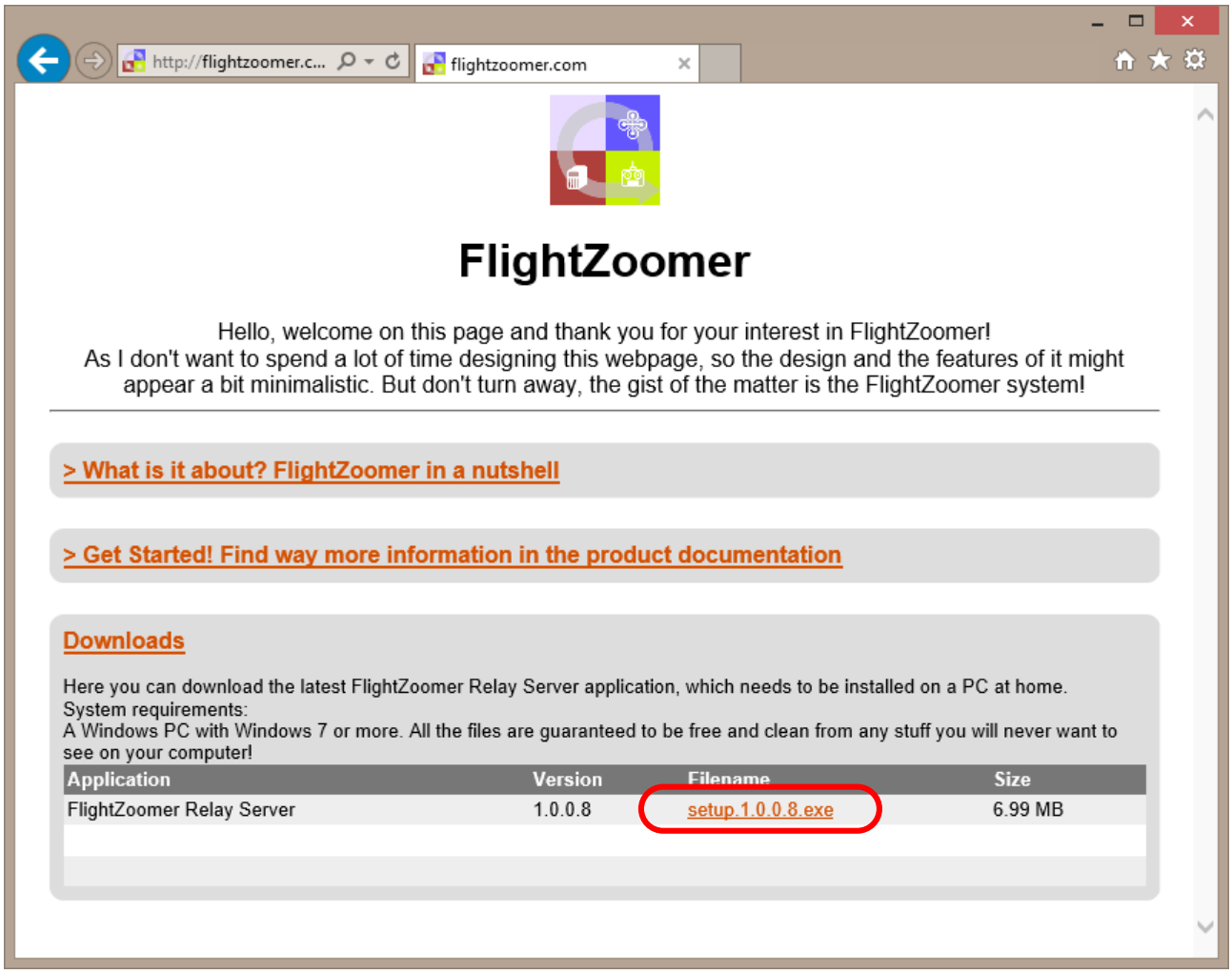


3.2.6 Install the FlightZoomer relay server application

This step is needed for:

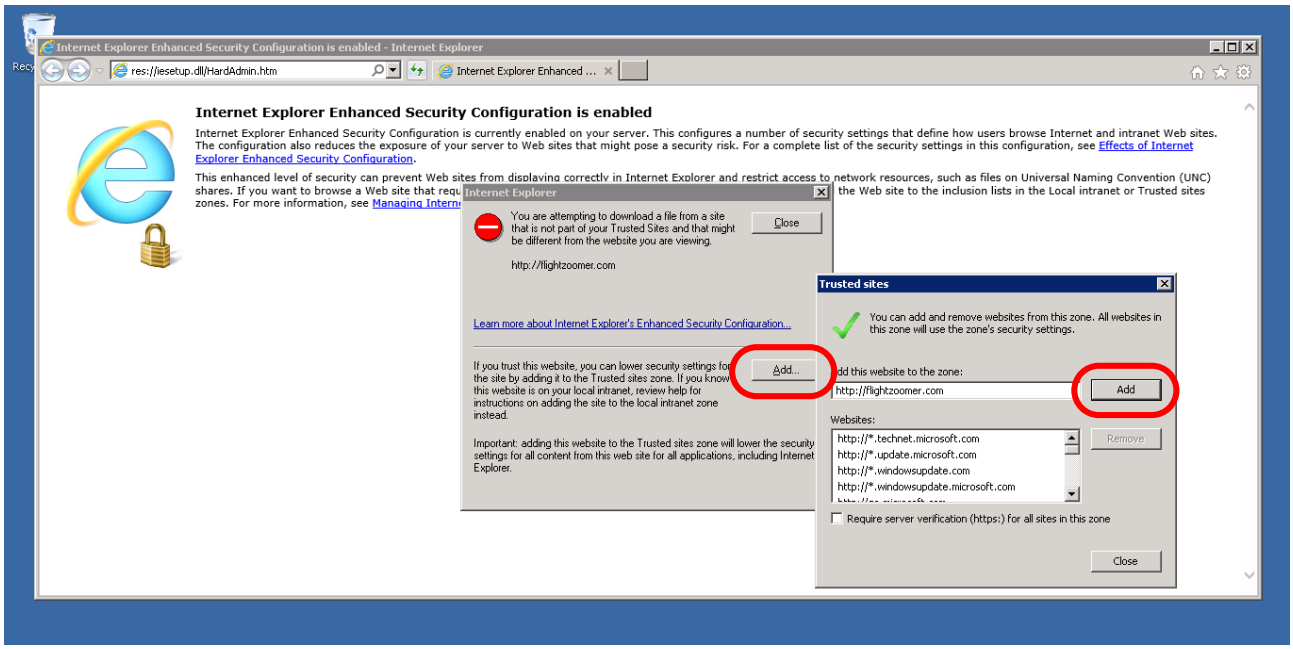


Step 1: Go to http://flightzoomer.com/downloads.html and download the latest version of the FlightZoomer Relay Server application:

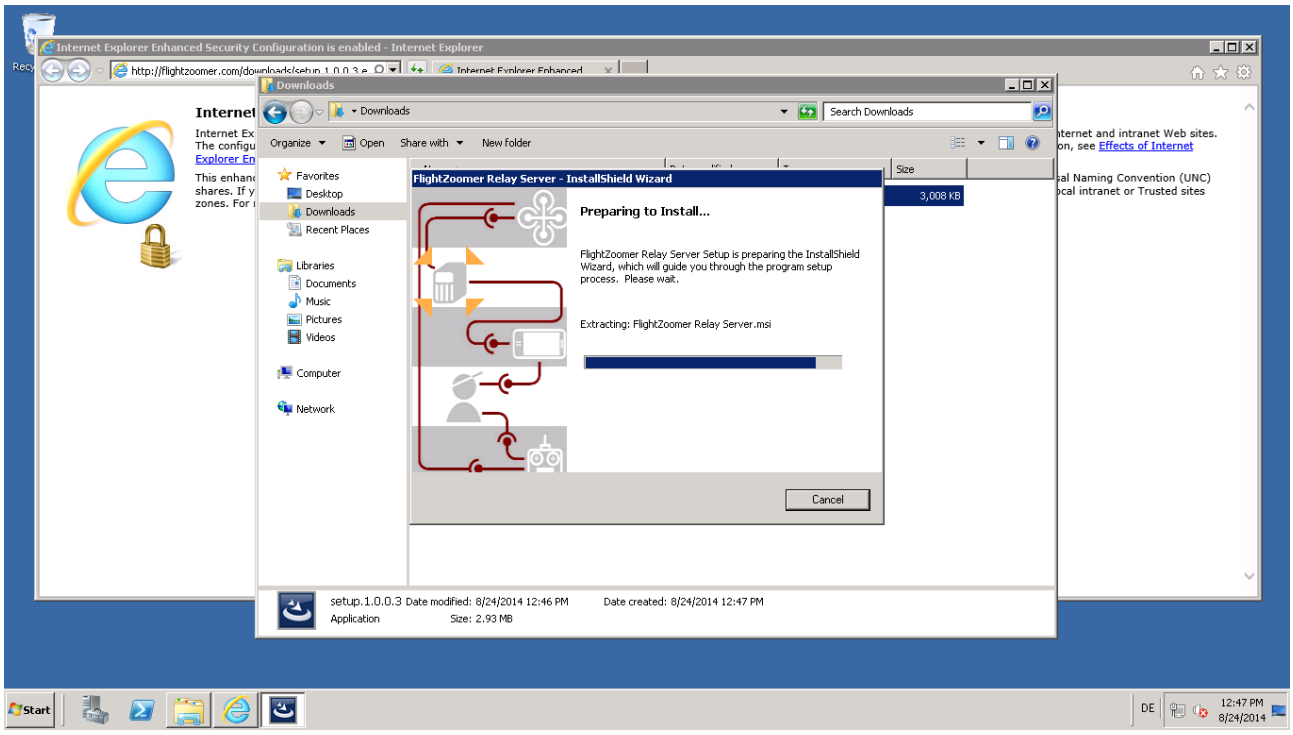


Step 2: Add flightzoomer.com to the list of trusted websites (only on )

When the download link from flightzoomer.com is clicked, a warning pops up. Add flightzoomer.com to the trusted websites as shown. The reason for this is that the operating system on the virtual machine is not plain vanilla Windows but the Server version which has higher security standards.

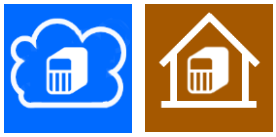


Step 3: Download the setup file and run it:



3.2.7 Open the firewall for the required ports

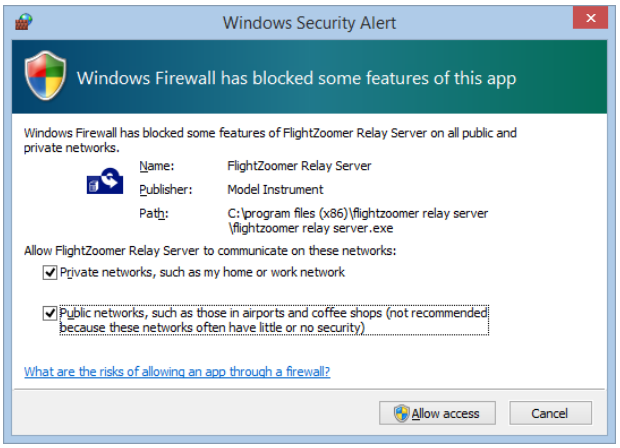
This step is needed for:



In this chapter there are two sections. The first describes opening the firewall on your PC at home and the second shows how it is done on the virtual machine.

3.2.7.1 Opening the firewall on your PC at home

This task is very easy: when the FlightZoomer Relay Server application is started for the first time, the following pop up window will appear. Allow communication with the suggested networks and click on "Allow access":



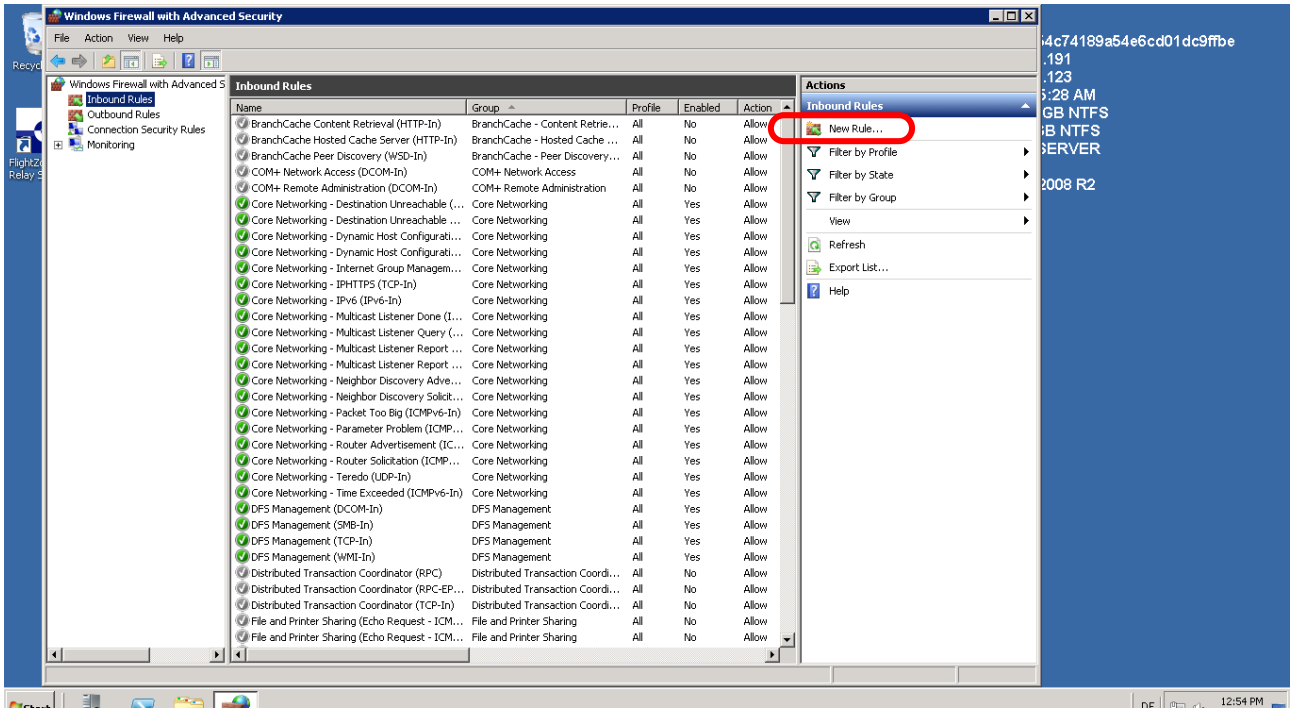
3.2.7.2 Opening the firewall on the virtual machine

As the virtual machine operates a Windows Server operating system, the default security settings are higher. Therefore the following steps are needed:

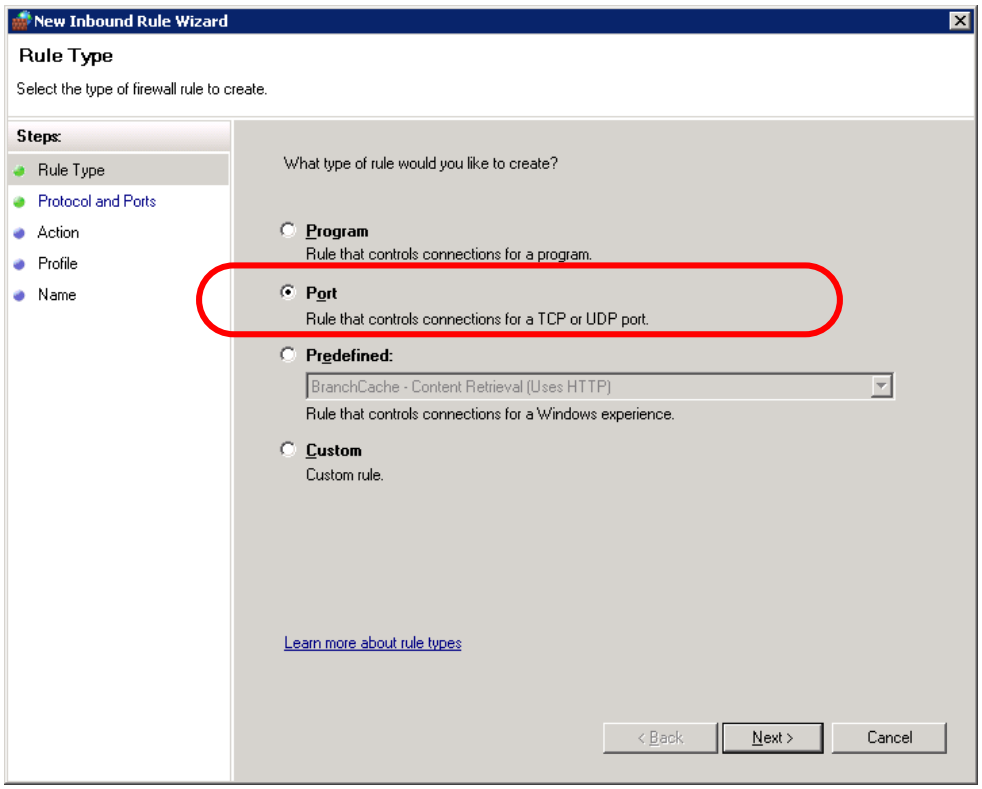
Step 1: Click on the *Windows Start*-button and write "*firewall*"

Step 2: Open *Windows Firewall with Advanced Security*

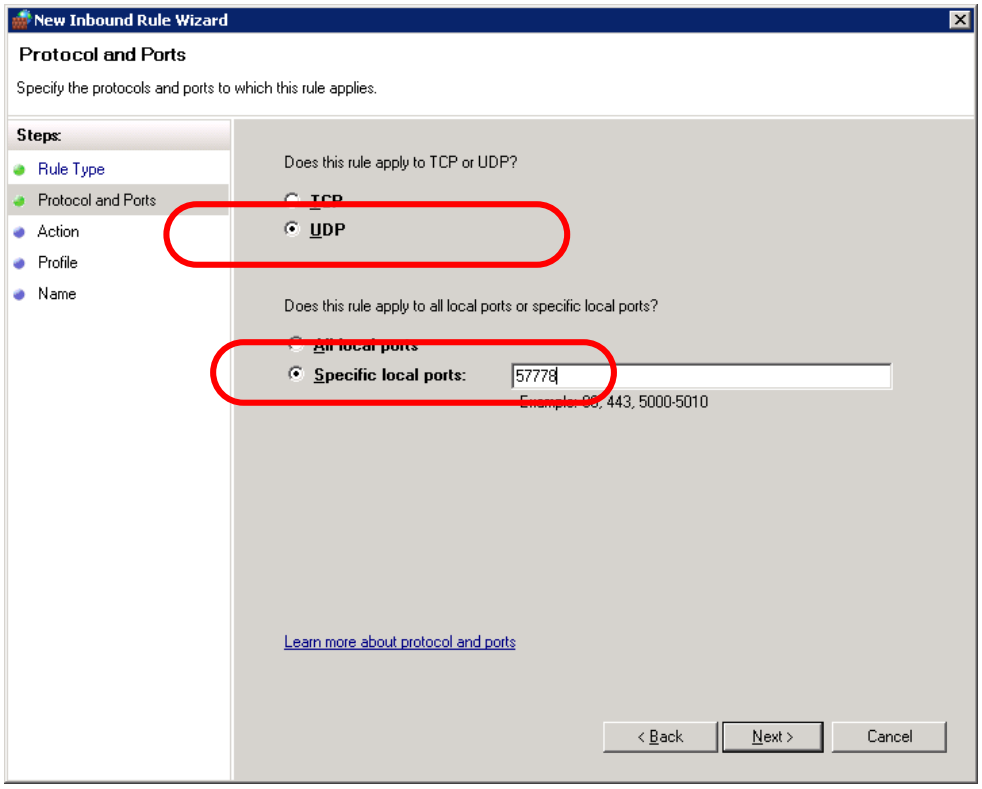
Step 3: Create a new rule



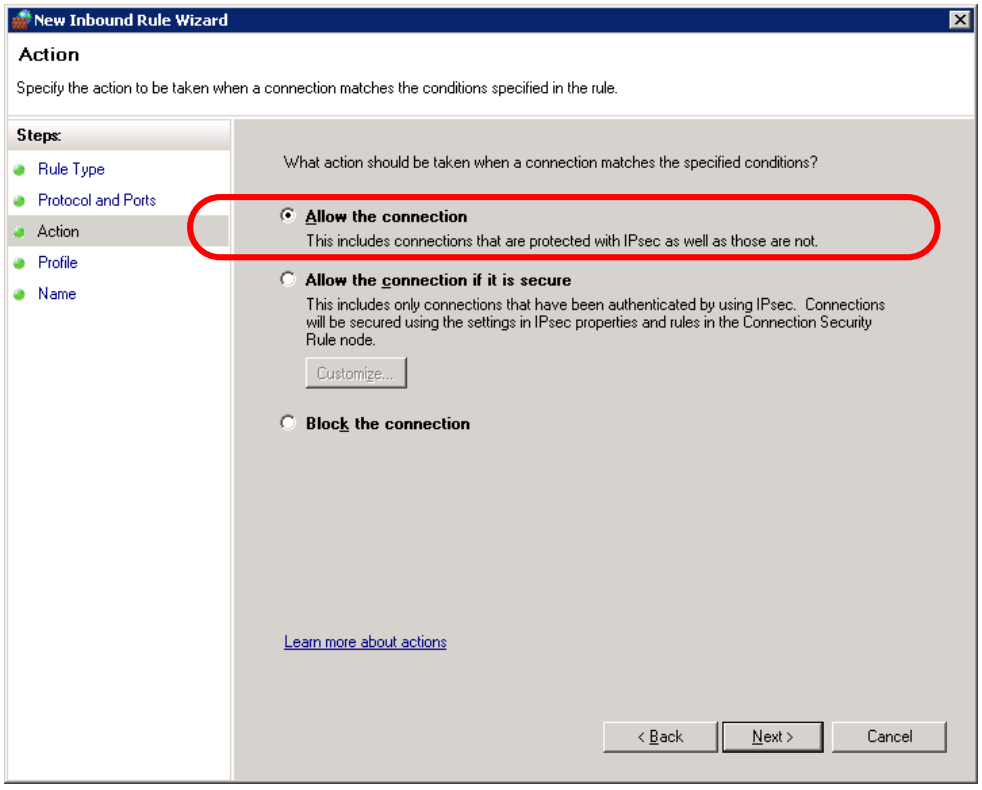
Step 4: Select Port as firewall rule type



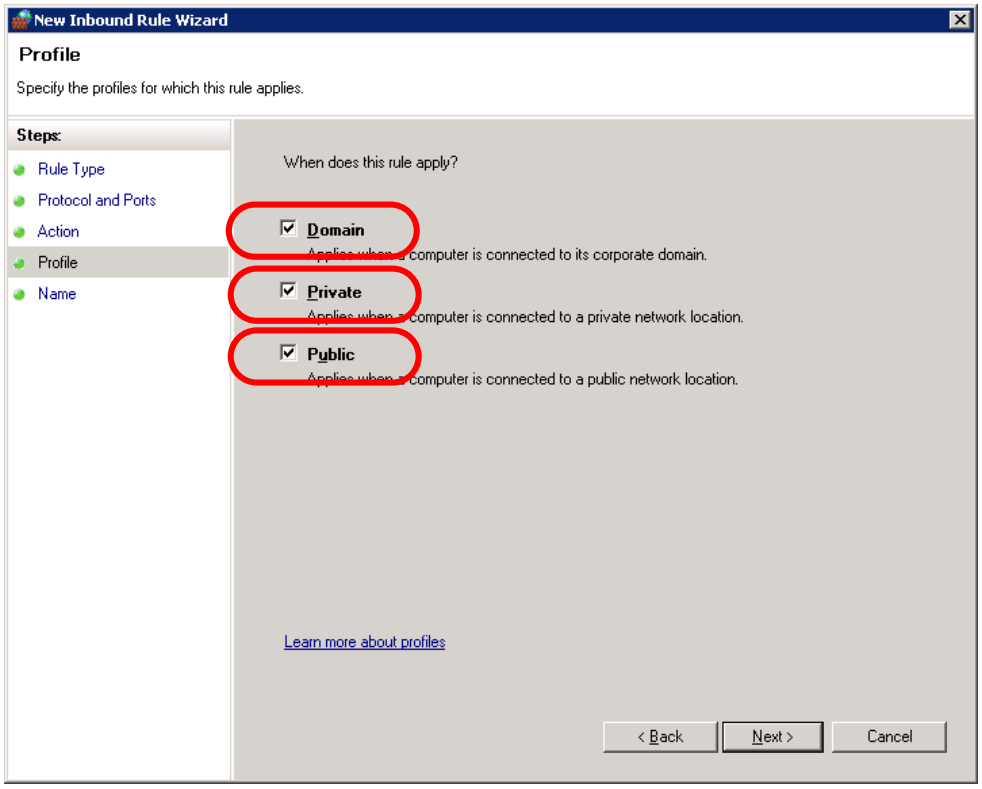
Step 5: Enter the options for the firewall



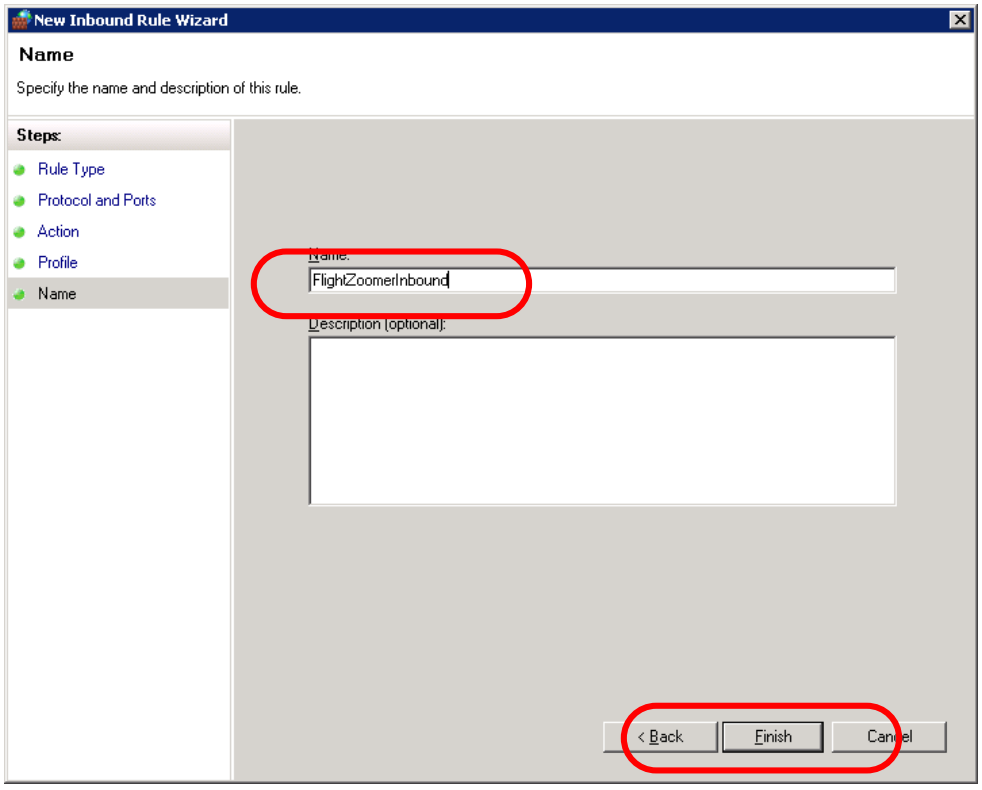
Step 6: Allow the connection



Step 7: Let this rule apply always



Step 8: Define the name of the rule (only for displaying purpose). Click on Finish afterwards.



3.2.8 Start the virtual machine

This step is needed for:

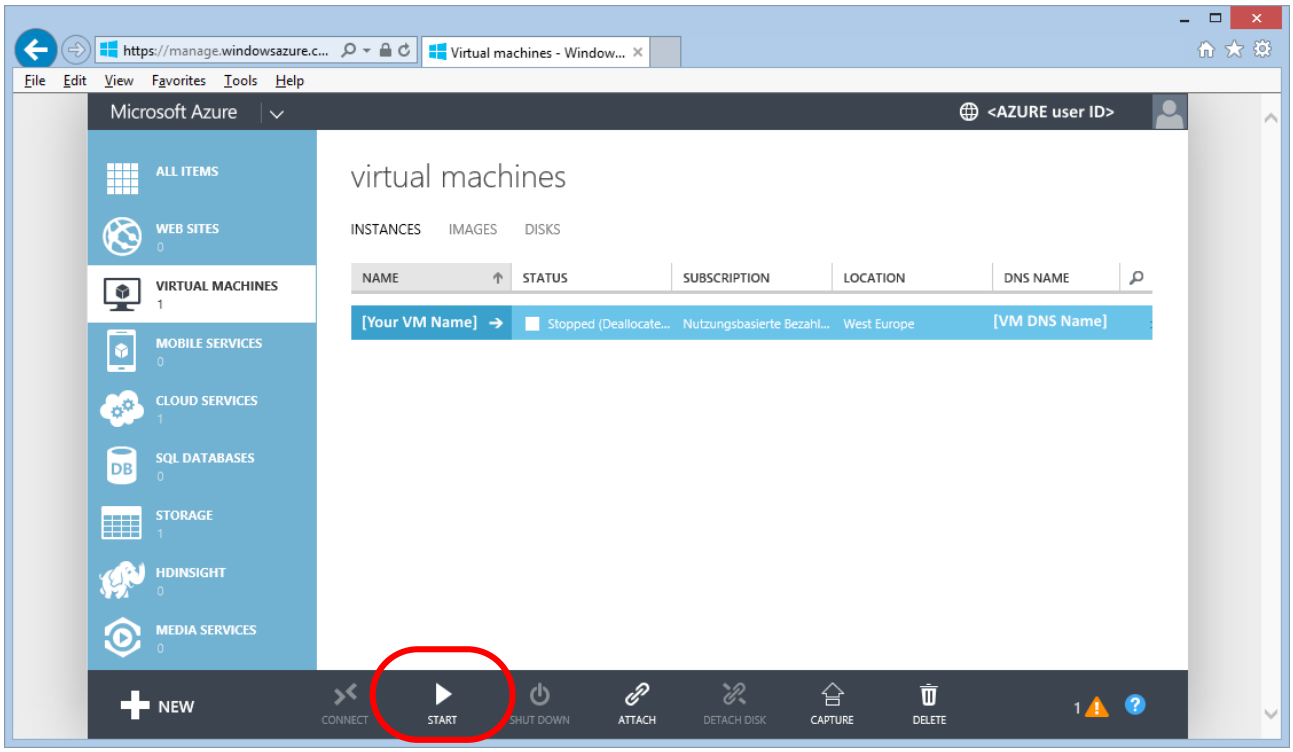
After creating the virtual machine for the first time, it is already running. If that is the case, skip this chapter and continue with the next chapter. Otherwise follow these steps, to start the virtual machine:

Step 1: Log first into your Azure Management site under https://manage.windowsazure.com

Step 2: Then enter the Portal at the top right.

Step 3: Click on *VIRTUAL MACHINES* in the menu on the left.

Step 4: The virtual machine can be started as shown on the following screen. Wait until *STATUS* shows *RUNNING* (this can take several minutes):



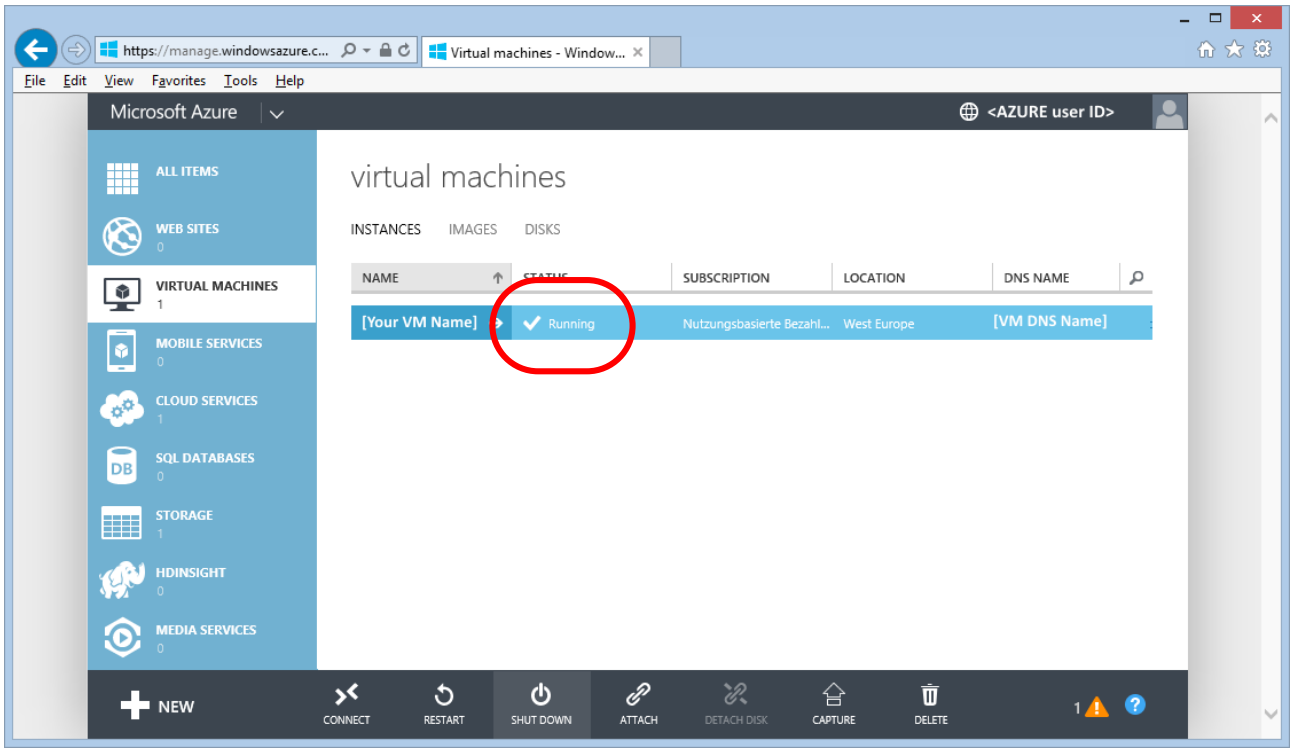
3.2.9 Connect to the running virtual machine

This step is needed for:

Like a real PC is accessed by taking a chair and sitting in front of it, a virtual machine needs to be accessed. For that purpose there is a program which is available on any Windows PC. This program is called Remote Desktop and allows to see the desktop of the virtual machine, as if you would sit in front of it.

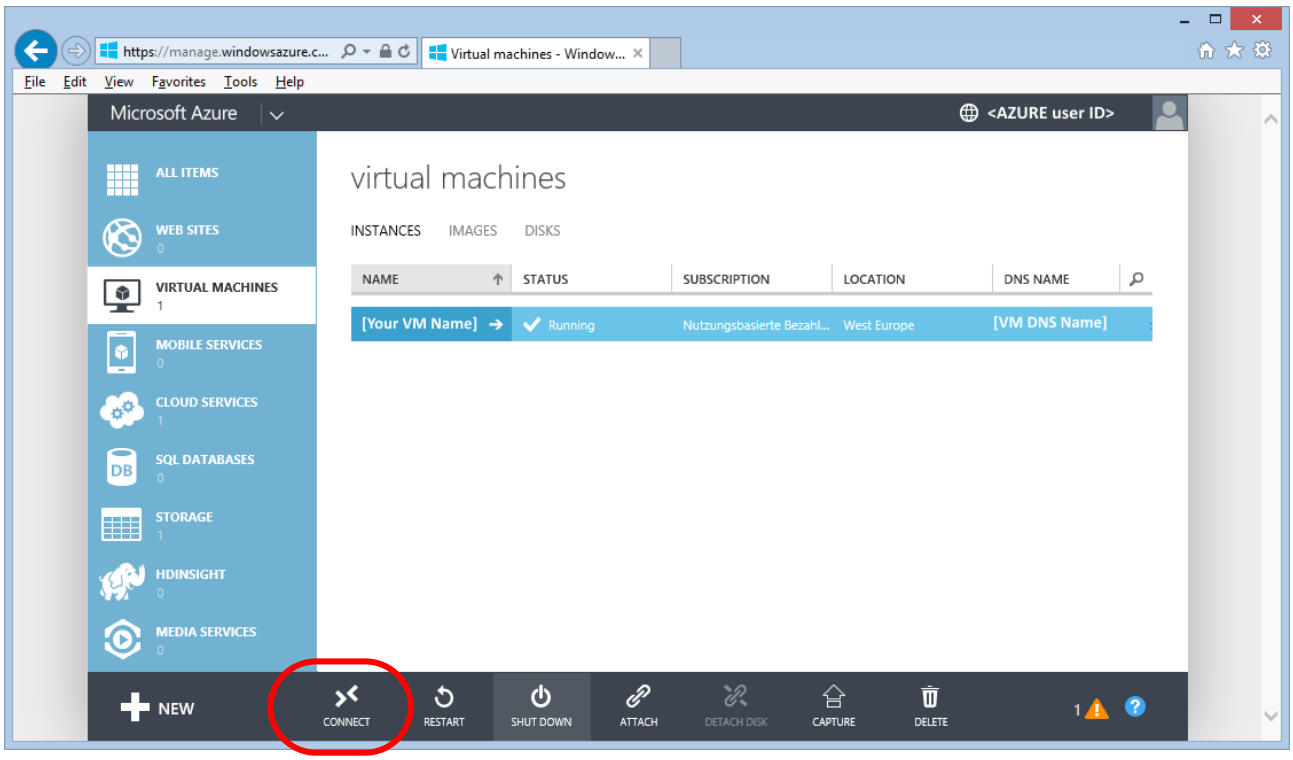
In this chapter there are two sections. The first describes accessing the virtual machine from a desktop PC and the second shows how it is done via the phone.

Precondition is that your virtual machine shows the status RUNNING in the Azure Management site console (https://manage.windowsazure.com):

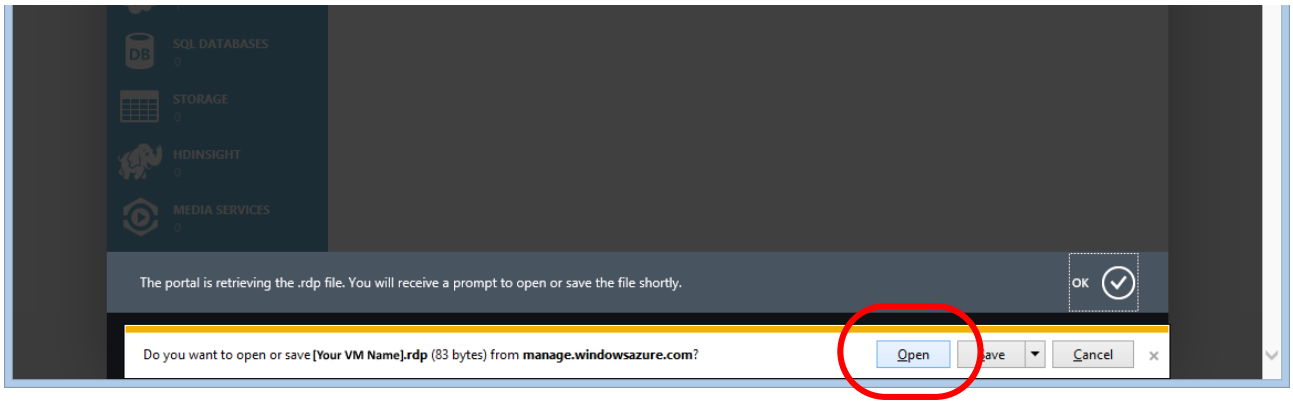


3.2.9.1 Accessing the remote machine from your PC

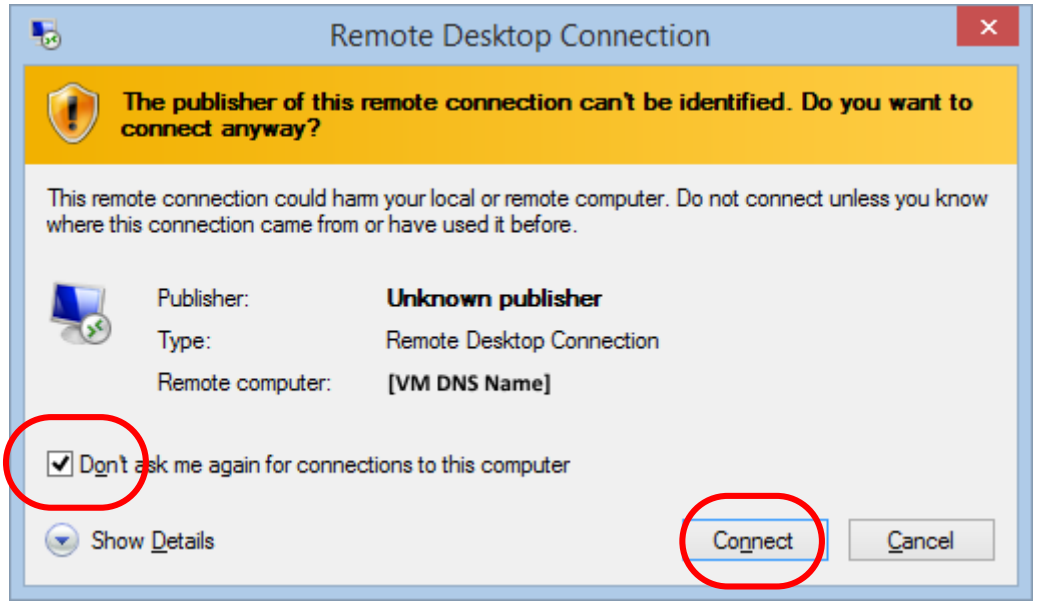
Step 1: Connect to the running virtual machine by clicking on the *CONNECT*-button



Step 2: Click on Open to launch the downloaded *.rdp file

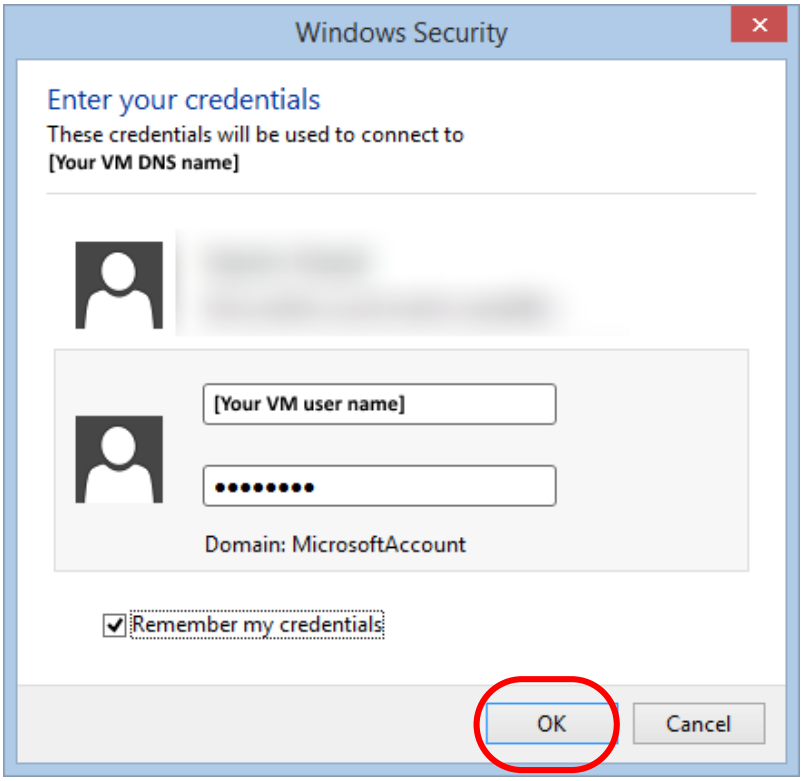


Step 3: Select the checkbox "Don't ask me again for connections to this computer" and press Connect

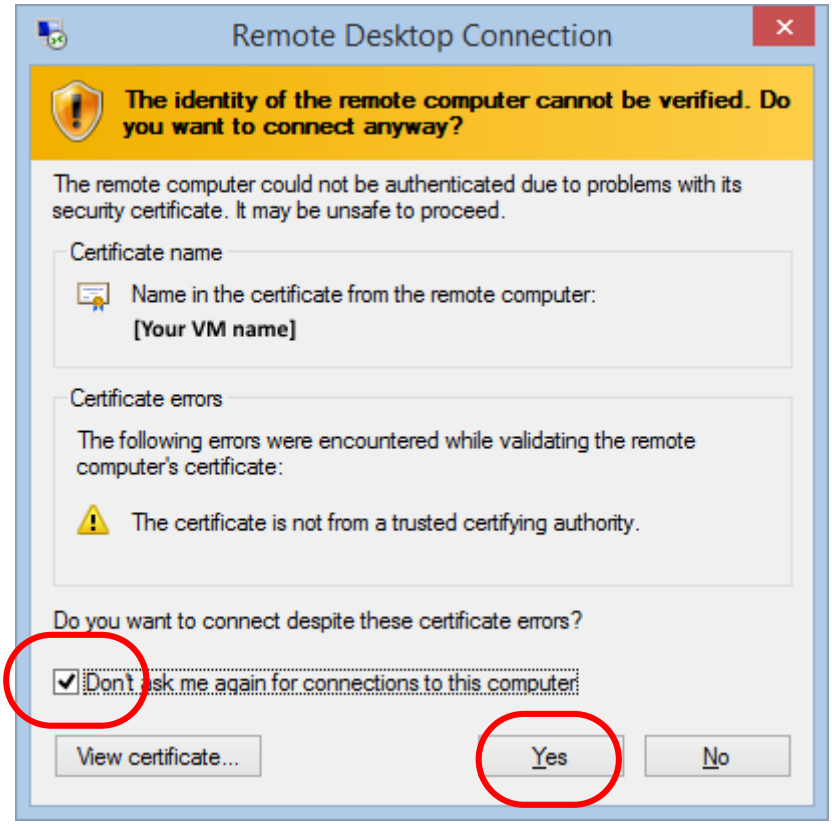


Step 4: Enter the user credentials of the virtual machine as defined, when the VM was created

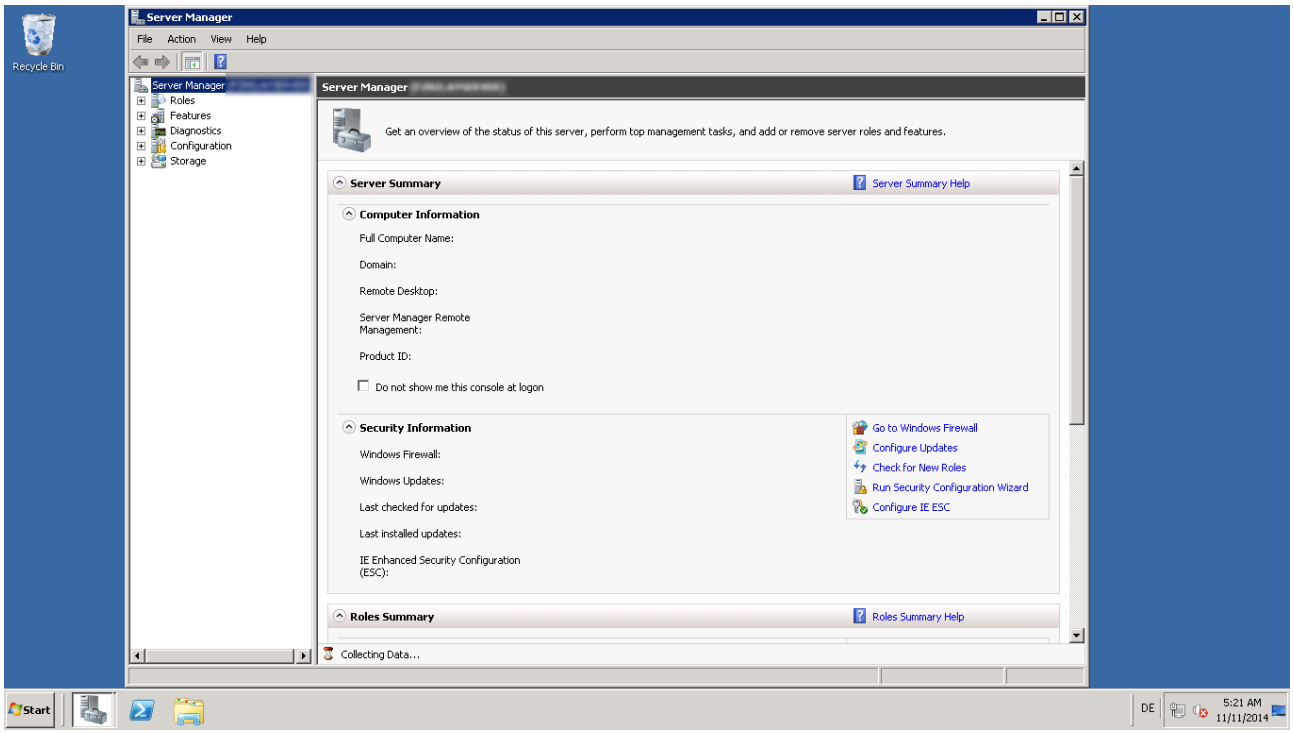
Here the user credentials need to be used that you have entered during Step 5 in chapter 3.2.3.



Step 5: Confirm that you trust the remote computer

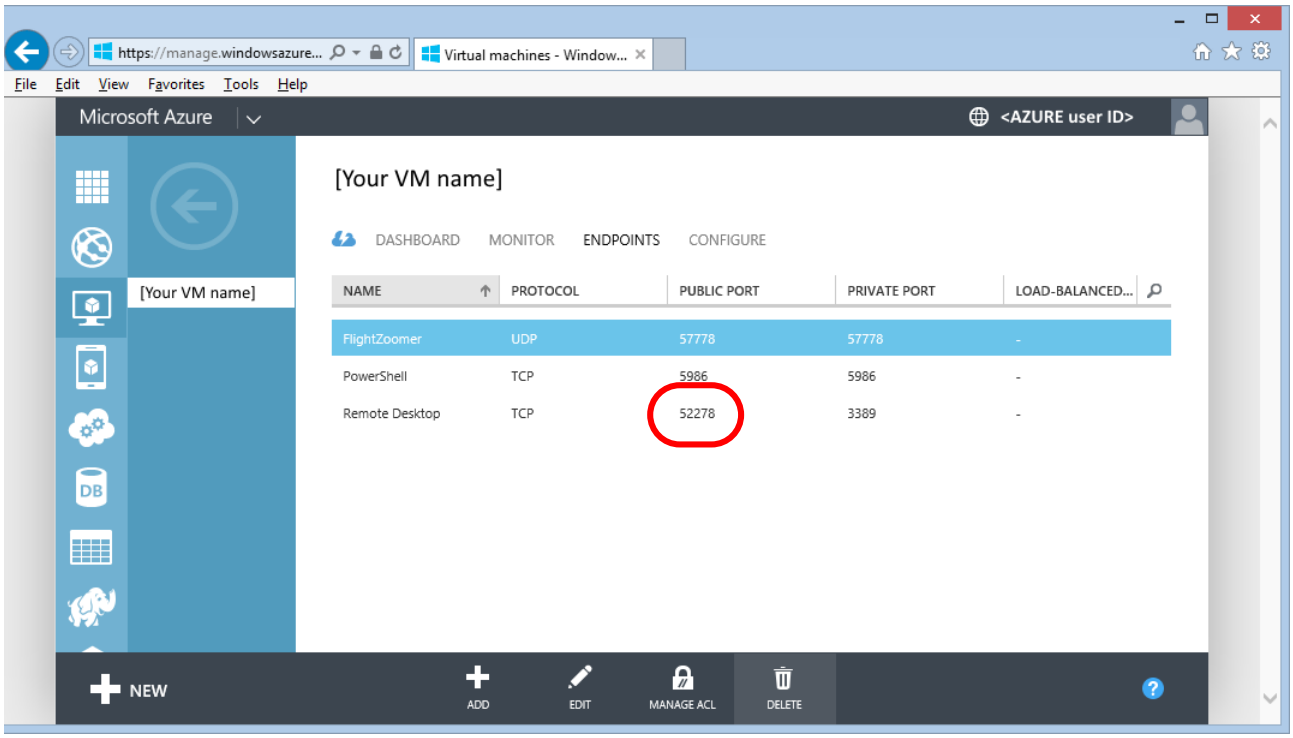


Step 6: At the end you see the Azure desktop of the virtual machine:



3.2.9.2 Accessing the remote machine from your phone

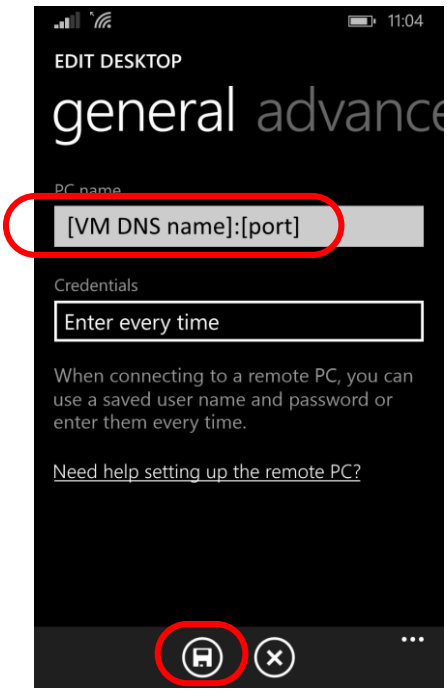
Step 1: Figure out and note the port needed for the remote desktop connection
Navigate to the following page on the Azure Management site by clicking on *VIRTUAL MACHINES* -> [your VM] -> *ENDPOINTS*. Note the *PUBLIC PORT* for Remote Desktop connectivity:



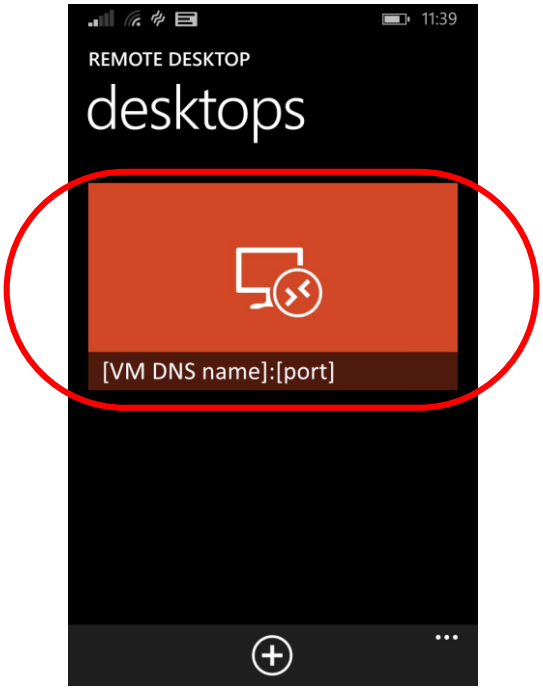
Step 2: Install the free app REMOTE DESKTOP from the Store and start it

Step 3: Press on the + button to create a new connection as follows

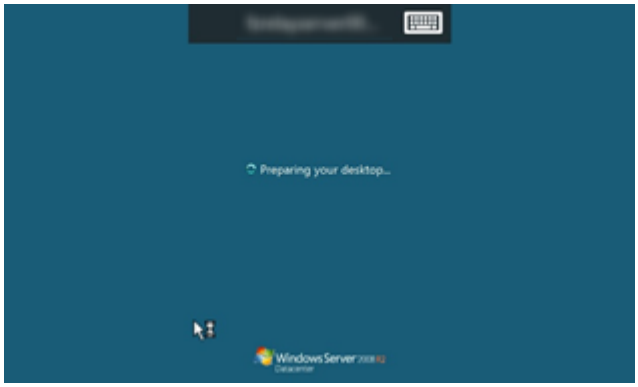
Enter the VM DNS name and the noted port from step 1 into the PC name textbox, separated by a colon. Save the connection afterwards.

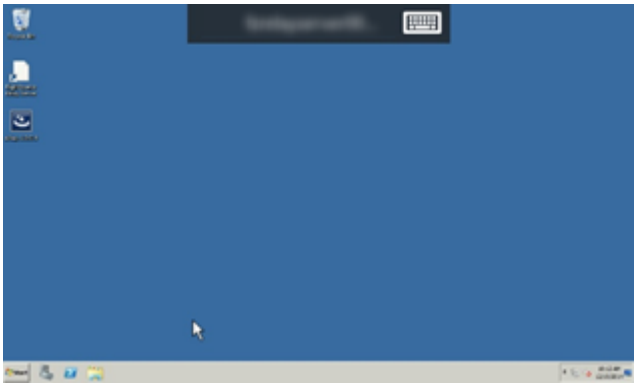


Step 4: After that connect to the server



Step 5: Et voila, there is your relay server, accessed from the phone

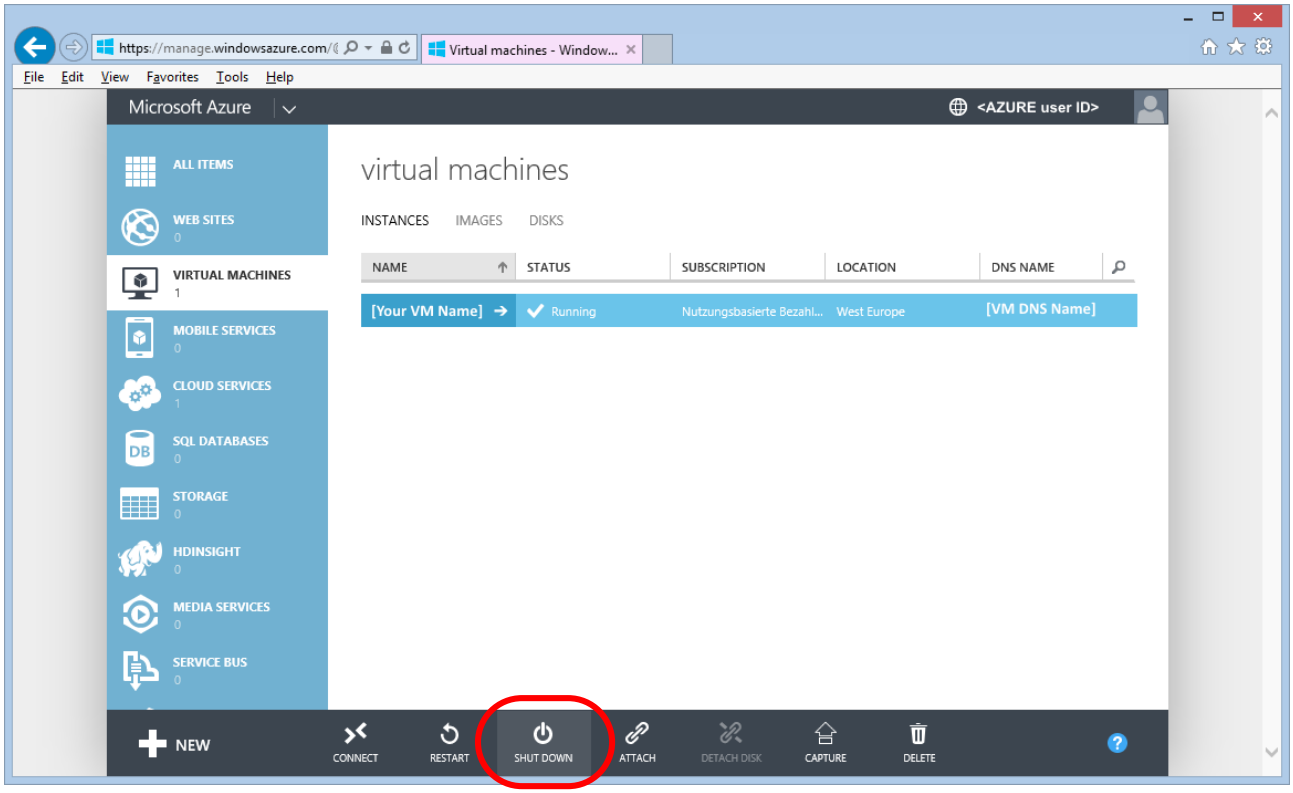




3.2.10 Shutdown the VM after usage to minimize charges

This step is only needed for:

In order to avoid charges don't forget to shut down the virtual machine after the work is done:



3.3 Prepare the FlightZoomer Sensorics-app

3.3.1 Attach the sensor smartphone

This chapter explains how the sensor smartphone needs to be mounted on an RC aircraft or copter. There are some things that need to be considered, some things that don't need to be considered and some things that depend on user preferences.

To be considered:

- The smartphone needs to be mounted detachable (in order to remove the device for compass calibration).
- Provide lightweight, yet sturdy installation.
- Provide as much clearance as possible to other electrical components.
- The smartphone needs to stay in a fix relative attitude vs. the aircraft/copter.

Not to be considered:

- The actual attitude of the smartphone relative to the aircraft/copter.
- It is not necessarily required that the touchscreen of the smartphone is accessible while the device is attached.

Dependent factors:

- If you intent to use the camera of the smartphone to create inflight footage or images stick to these guidelines:
    - The smartphone needs to be fitted with unobstructed camera vision.
    - Keep vibrations away from the smartphone. Google "copter" and "vibrations".

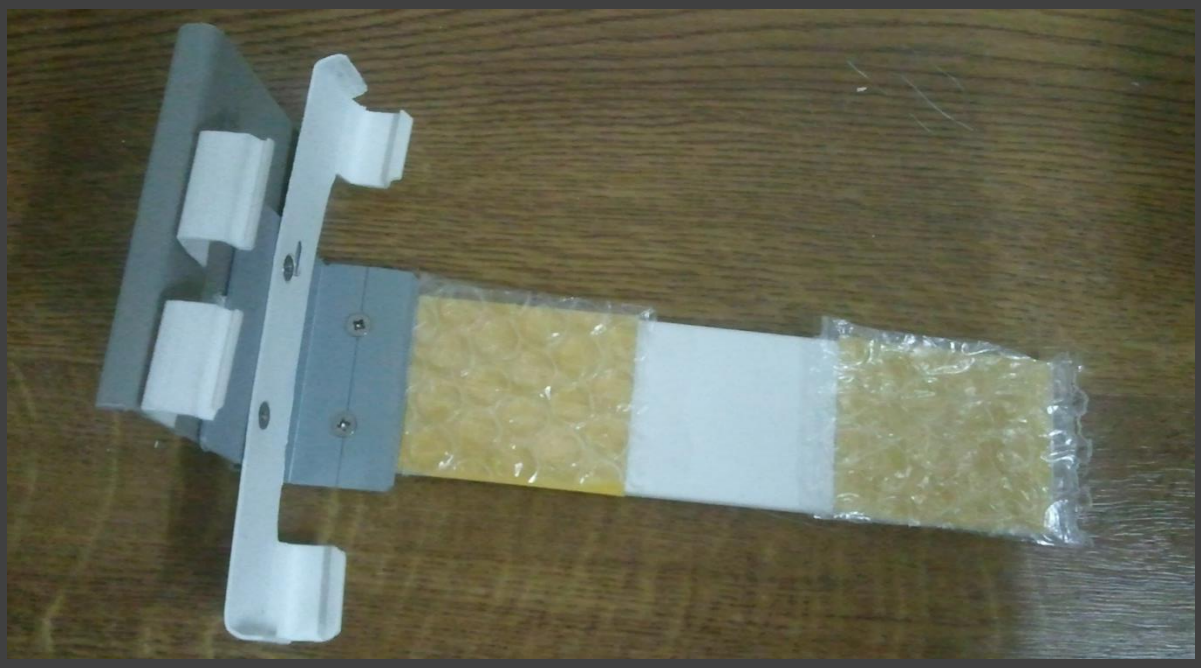
3.3.1.1 Best practices

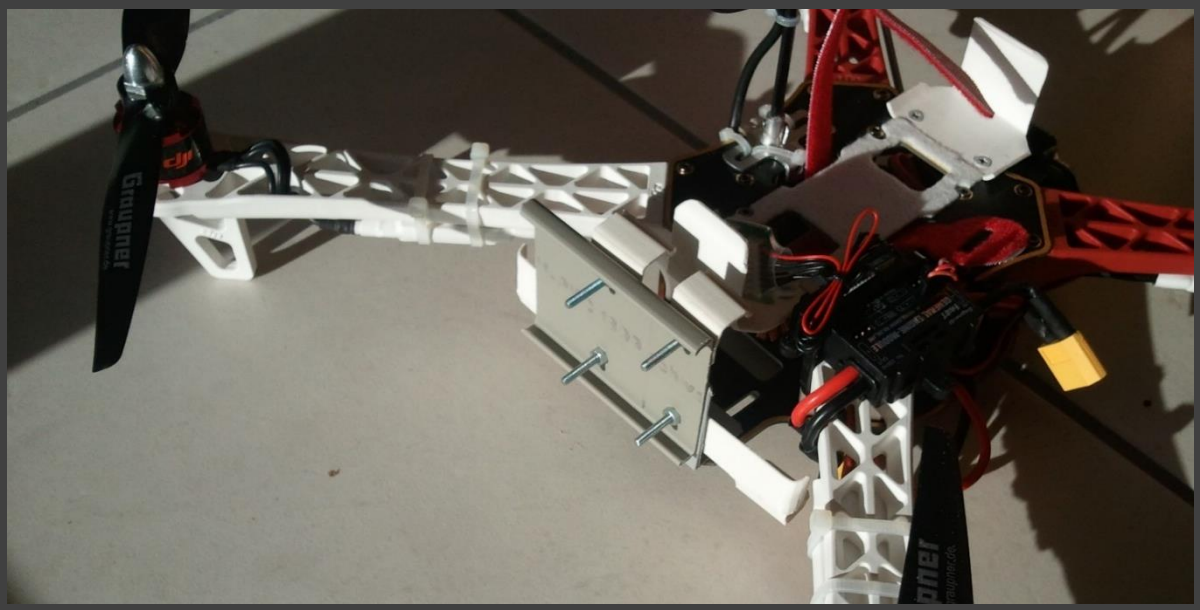
The following images show some solutions how smartphones have been successfully attached to multicopters.

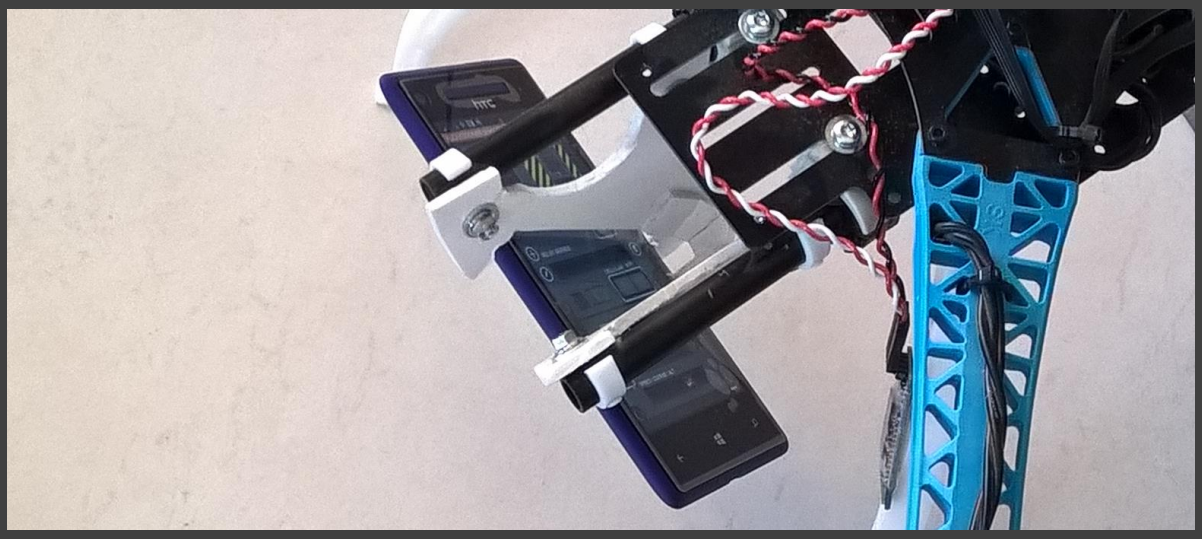
A very successful approach was to fix only the back cover of the phone, so the phone itself could easily be detached from the copter:

Another example where the back cover is fixed on the copter and the phone itself is just clipped onto the back cover:

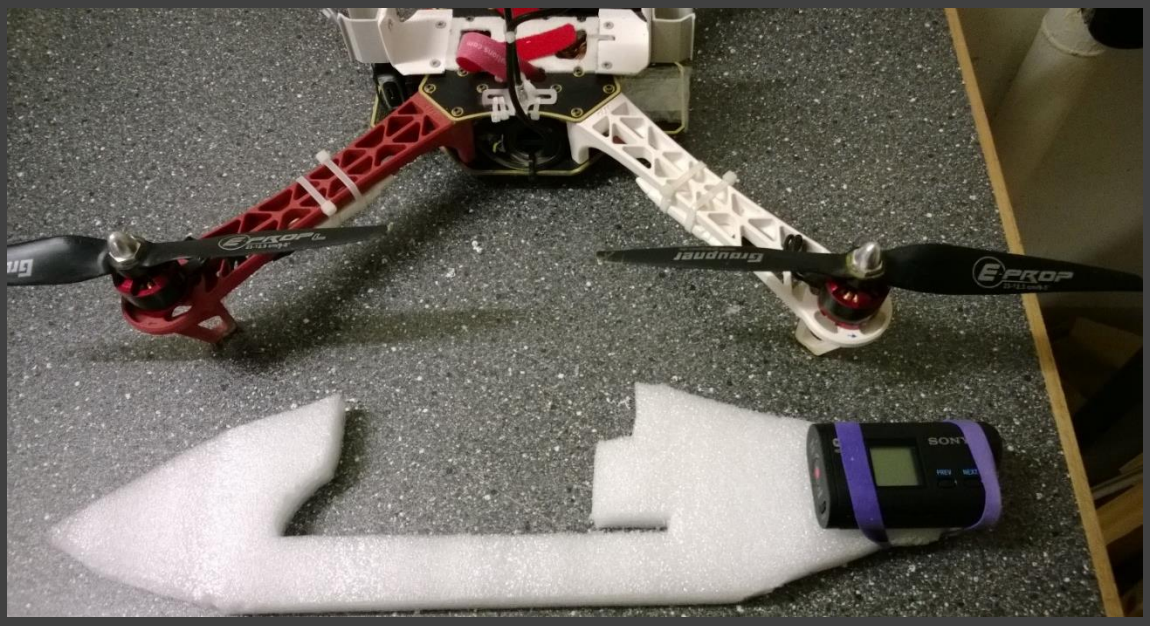
The first two designs are not suitable to use the camera of the phone. The next two design have a front-mounted phone which allows using the camera:

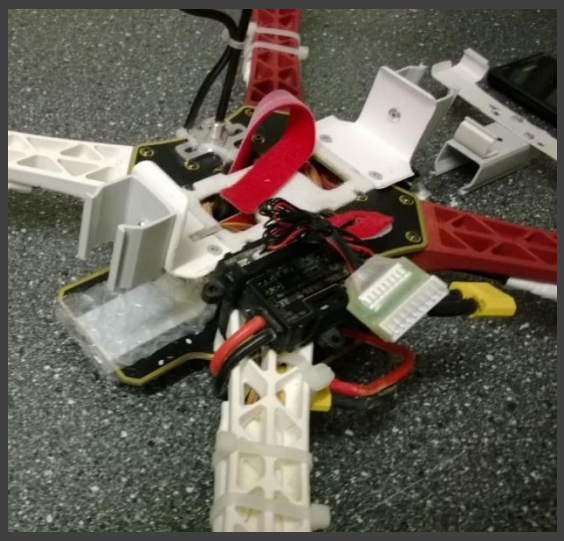


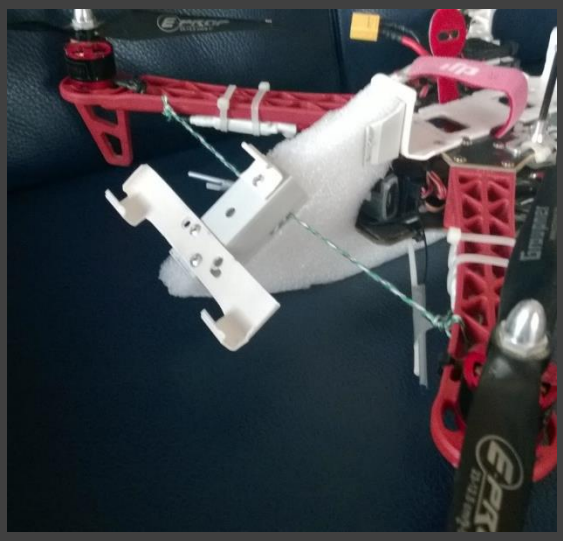



htc

Another design:







3.3.2 Install the app

The FlightZoomer Sensorics app can easily be loaded on any device from the store. Just enter “flightzoomer sensorics” in the search textbox.

3.3.3 Install and configure MAVLink connectivity

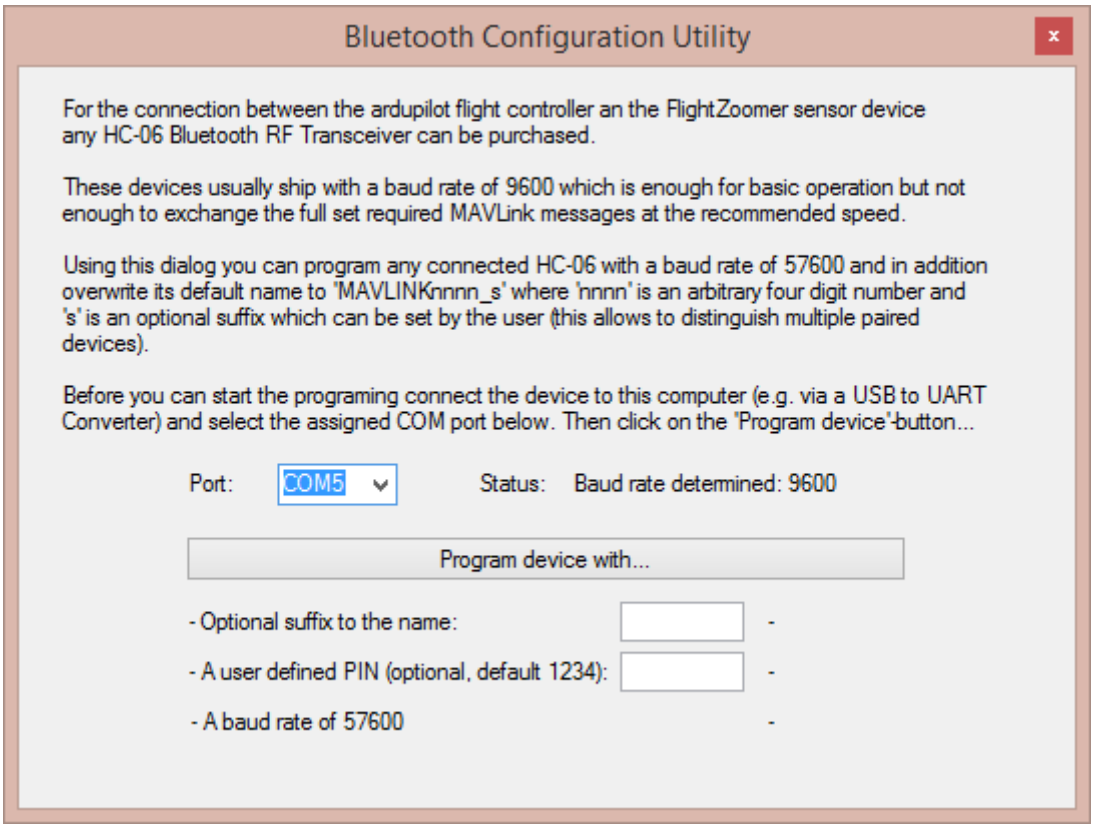
In order to mate sensor smartphone to the Ardupilot based flight controller a HC-06 Bluetooth transceiver needs to be used. This device can be purchased from 3DR or in many other online shops (e.g. on Ebay).

The following steps are needed to accomplish MAVLink connectivity between the flight controller and the onboard smartphone:

Step 1: Configure the Bluetooth transceiver to the recommended baud rate of 57600

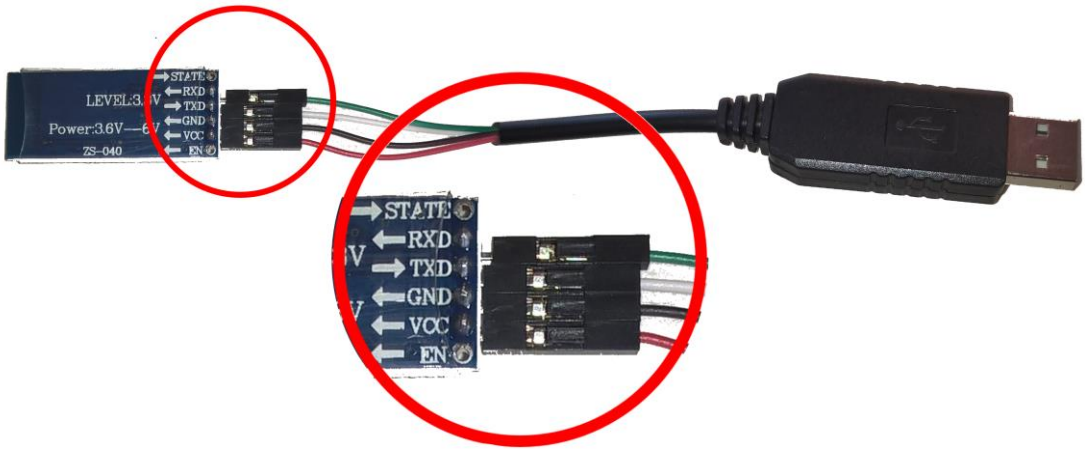
While the 3DR device comes already configured at 57600 baud, other HC-06 devices typically have the default baud rate of 9600. As 9600 is not enough for the recommended MAVLink packet update rates, it is recommended to change the configuration of the transceiver accordingly.

For this purpose the Relay Server application has a special utility to automatically overwrite the configuration parameters of a HC-06 Bluetooth transceiver with the correct values:

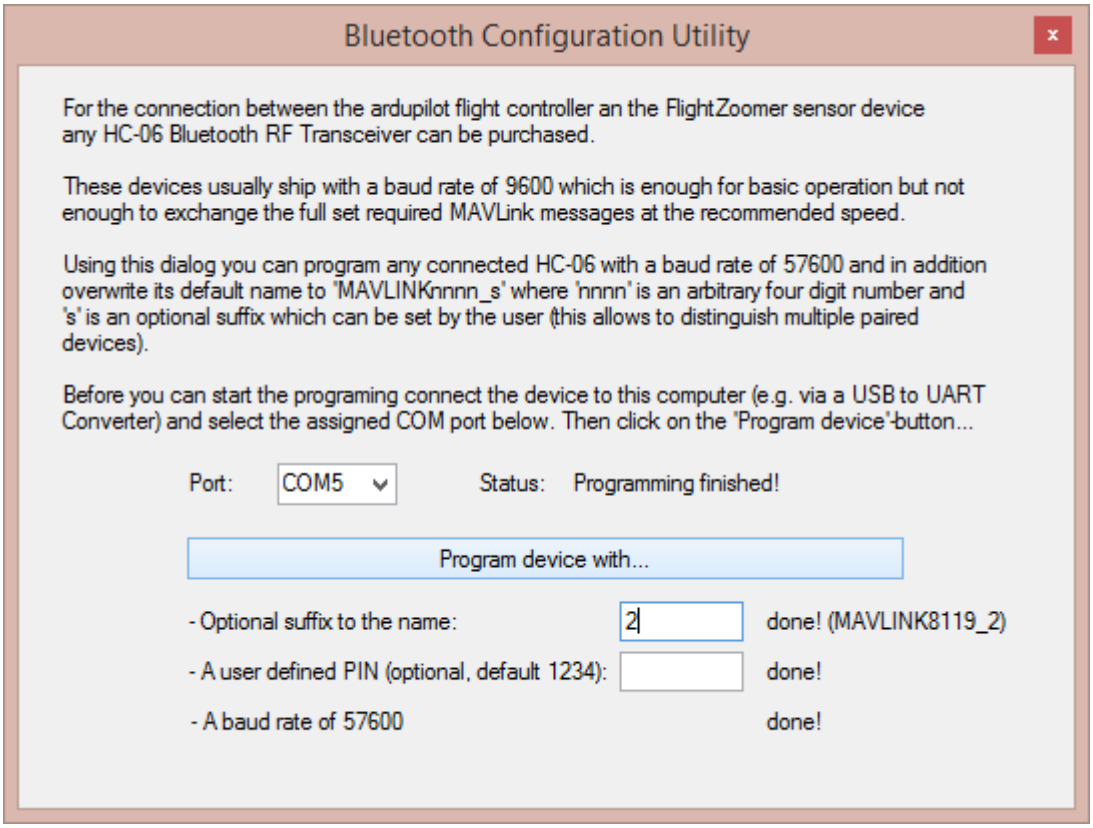


Perform the following actions to re-program the HC-06 device:

- Connect the HC-06 with the computer using a typical USB to RS 232/UART Adapter (as offered for Arduino) like shown on this image:



- Open the Bluetooth programming utility from the Relay Server main window by clicking the button *Bluetooth Configuration Utility…*.
- Confirm that the correct COM port is shown in the *Port* dropdown box (or select it otherwise).
- The current baud rate will automatically be determined!
- Choose whether you want to add a one-character-suffix to the name and choose a PIN code (or leave it at 1234).
- Click on the button *Program device with…*
- Once all steps are completed the utility looks like this:

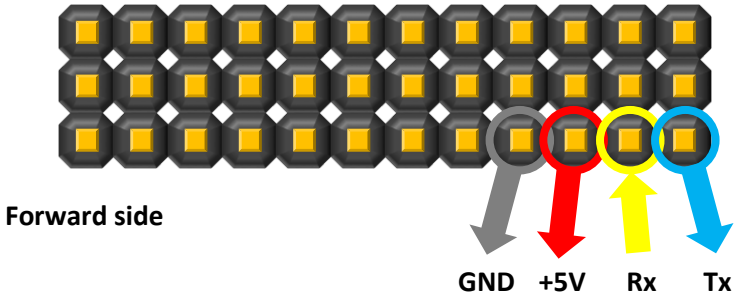


Step 2: Connect the Bluetooth transceiver to the flight controller

For this step the documentation of the flight controller needs to be consulted. The following wiki page shows the connection for the APM and the PIXHAWK:

http://copter.ardupilot.com/wiki/common-optional-hardware/common-telemetry-landingpage/common-mission-planner-bluetooth-connectivity/

For the Arsov AUAV X2 the Bluetooth transceiver needs to be connected with the USART3 (SERIAL2) on the front side. The following diagram shows the respective pins. Always connect the Rx pin on one side of the connection with the Tx pin on the other side (and vice versa):

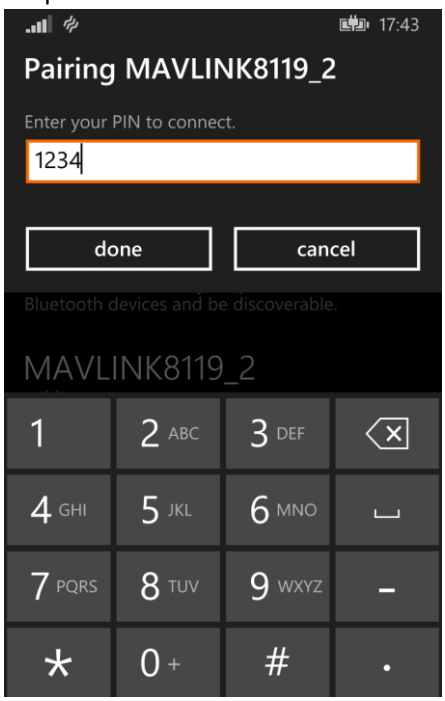


Step 3: Pair a new Bluetooth transceiver with the phone

This steps needs only to be done once for each particular HC-06 Bluetooth transceiver:

1. Power up the new transceiver until the red LED blinks.
2. On the phone open the *Settings* > *Bluetooth* screen.
3. Turn Bluetooth on if not yet done.
4. Select the new device in the list (identify the device with the name as generated in step 1 above) and press *tap to pair*:

5. Enter the PIN as also defined in Step 1 above:



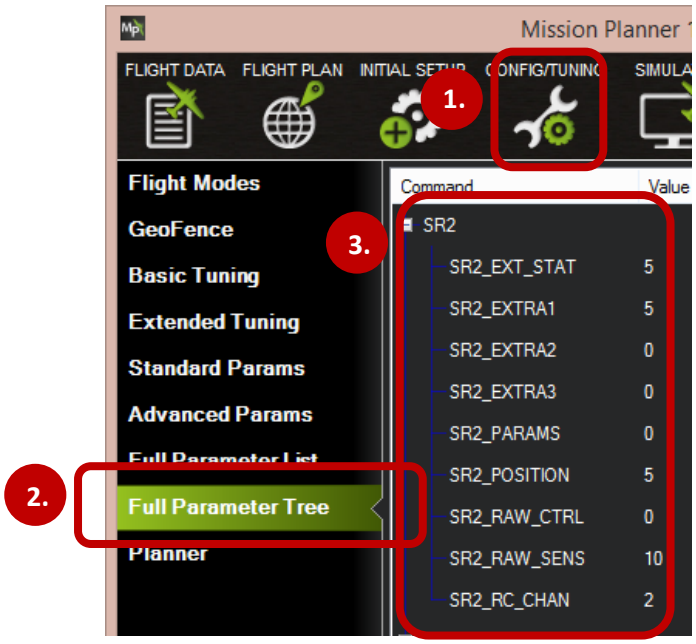
6. Finished! From now everything can be done in the app.

Step 4: Configure the flight controller to feed the required MAVLink packets

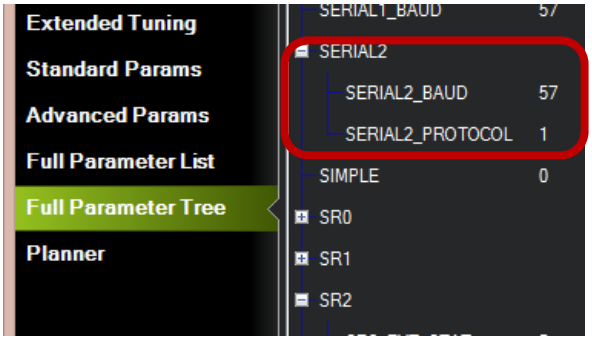
As the last step the flight controller needs to configured to stream the required packets at the recommended rate.

Consult the functional aspects document to understand the exact set of packets which are needed.

Use the Ardupilot Mission Planner to set the SRx-parameters rates as follows (x stands for the chosen serial port):



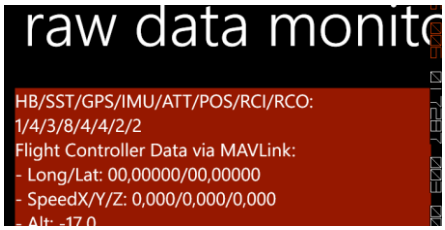
Also set the baud rate of the serial port which feeds the Bluetooth transceiver to 57600 and the protocol to '1' (GCS MAVLink):



Step 5: Test the configuration

Run the FlightZoomer Sensorics-app and the flight controller. Mate the app with flight controller and check whether the MAVLink Status LED turns solid green after some time.

Also consult the raw data screen, to check the rate of the received MAVLink packets:



The first two lines show how many relevant packets have been received in the last second. The legend shows the order of listed packets and needs to be decoded as follows:

HB = HEARTBEAT/SST = SYS_STATUS/GPS = GPS_RAW_INT/IMU = RAW_IMU/ATT = ATTITUDE/
POS = GLOBAL_POSITION_INT/RCI = RC_CHANNELS_RAW/RCO = SERVO_OUTPUT_RAW

3.3.4 Prepare the app

Once the device is fitted to the aircraft/copter and the app is loaded on the device, the initial setup can take place. The initial setup is very easy and consists of these three steps:

1. Configure the relay server.
2. Configure the MAVLink connection to the flight controller (see the chapter before)
3. Geometry capturing. With this step the actual attitude of the device relative to the aircraft is measured.
4. Optionally choose options for the inflight camera (default = off).

3.4 Prepare the FlightZoomer Groundstation-app

3.4.1 Attach the device to the RC transmitter (optional)

While it is possible to keep the groundstation device loosely it is much more convenient, if the device is attached to the RC transmitter, so you have enough “hands” to hold everything properly.

A good and proved solution would be to buy a cheap case for the device and attach the case to the handle of the RC transmitter. Be inspired by the following images!

3.4.2 Install the app

The FlightZoomer Sensorics app can easily be loaded on any device from the store. Just enter “flightzoomer groundstation” in the search textbox.

3.4.3 Prepare the app

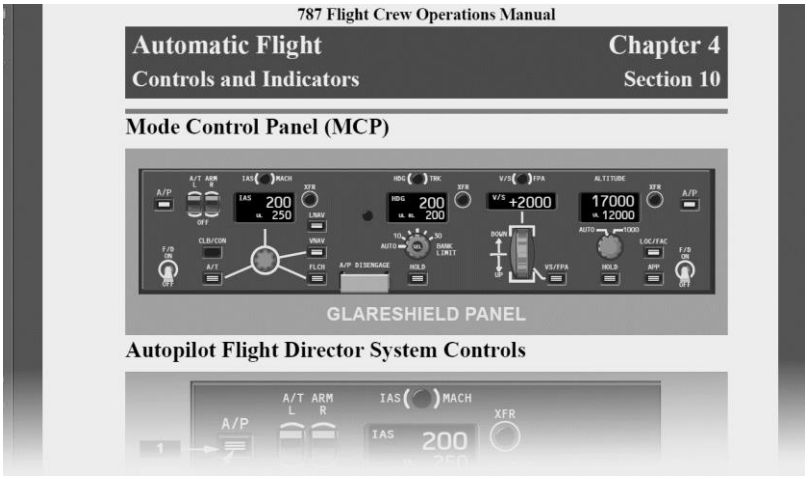
The preparation for the groundstation is even simpler than for the sensor device and has only one step:

1. Configure the relay. This is done exactly the same way as for the Sensorics-app.
2. Additionally the standard turn rates can be configured. Alternatively these they can be gained by the flight test feature (the system measures the turn rate automatically while steady turns are flown by the (test-)pilot…

3.5 Prepare the RC system

While it is possible to use with FlightZoomer with a regular RC system without modification, the flying experience and the realism can be greatly enhanced if the RC transmitter is configured adequately to simulate the behavior and autoflight systems of real aircraft.

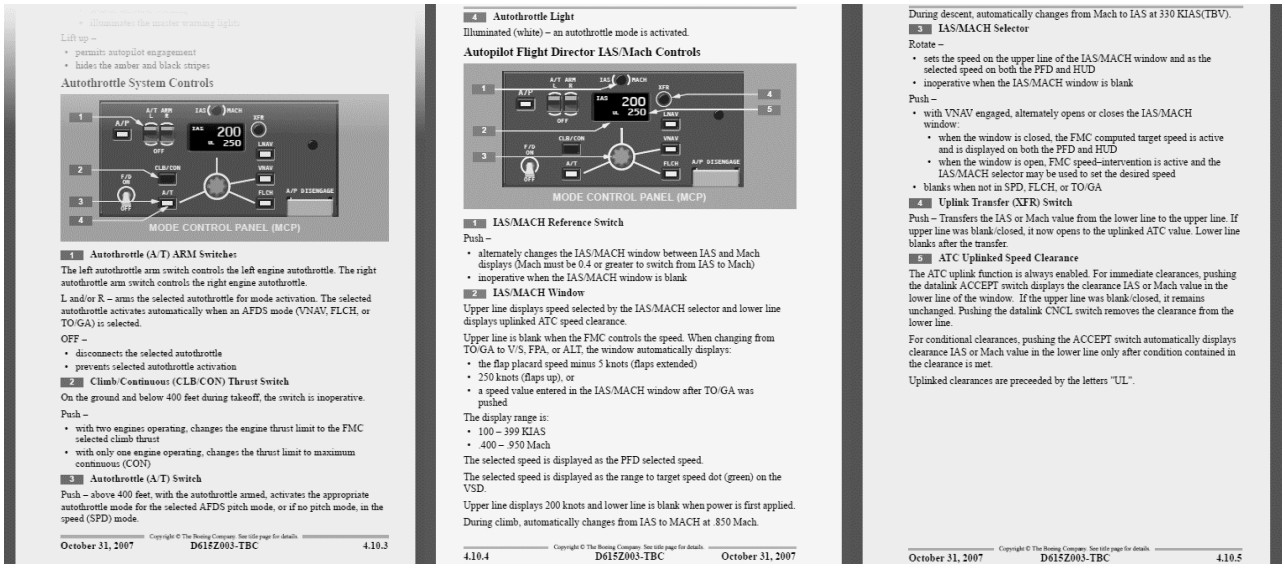
As FlightZoomer is modeled after the Boeing 787 Dreamliner, let's first have a look at the original Boeing documentation, which explains the autopilot of the mighty 787. The following extract shows the glareshield panel of the autopilot:



The panel looks rather complicated but the meaning of each control is quite understandable if we dig a bit deeper in the next chapters.

3.5.1 Speed hold/autothrottle mode

The following extract from the original manual explains in detail the controls of the autothrottle and speed controls (IAS/MACH = the two speed modes):



• illuminates the master warning lights

Lift up –
- permits autopilot engagement
- hides the amber and black stripes

Autothrottle System Controls

MODE CONTROL PANEL (MCP)

1 Autothrottle (A/T) ARM Switches

The left autothrottle arm switch controls the left engine autothrottle. The right autothrottle arm switch controls the right engine autothrottle.

L and/or R – arms the selected autothrottle for mode activation. The selected autothrottle activates automatically when an AFDS mode (VNAV, FLCH, or TO/GA) is selected.

OFF –
- disconnects the selected autothrottle
- prevents selected autothrottle activation

2 Climb/Continuous (CLB/CON) Thrust Switch

On the ground and below 400 feet during takeoff, the switch is inoperative.

Push –
- with two engines operating, changes the engine thrust limit to the FMC selected climb thrust
- with only one engine operating, changes the thrust limit to maximum continuous (CON)

3 Autothrottle (A/T) Switch

Push – above 400 feet, with the autothrottle armed, activates the appropriate autothrottle mode for the selected AFDS pitch mode, or if no pitch mode, in the speed (SPD) mode.

4 Autothrottle Light

Illuminated (white) – an autothrottle mode is activated.

Autopilot Flight Director IAS/Mach Controls

MODE CONTROL PANEL (MCP)

1 IAS/MACH Reference Switch

Push –
- alternately changes the IAS/MACH window between IAS and Mach displays (Mach must be 0.4 or greater to switch from IAS to Mach)
- inoperative when the IAS/MACH window is blank

2 IAS/MACH Window

Upper line displays speed selected by the IAS/MACH selector and lower line displays uplinked ATC speed clearance.

Upper line is blank when the FMC controls the speed. When changing from TO/GA to V/S, FPA, or ALT, the window automatically displays:
- the flap placard speed minus 5 knots (flaps extended)
- 250 knots (flaps up), or
- a speed value entered in the IAS/MACH window after TO/GA was pushed

The display range is:
- 100 – 399 KIAS
- .400 – .950 Mach

The selected speed is displayed as the PFD selected speed.

The selected speed is displayed as the range to target speed dot (green) on the VSD.

Upper line displays 200 knots and lower line is blank when power is first applied.

During climb, automatically changes from IAS to MACH at .850 Mach.

During descent, automatically changes from Mach to IAS at 330 KIAS(TBV).

3 IAS/MACH Selector

Rotate –
- sets the speed on the upper line of the IAS/MACH window and as the selected speed on both the PFD and HUD
- inoperative when the IAS/MACH window is blank

Push –
- with VNAV engaged, alternately opens or closes the IAS/MACH window:
  - when the window is closed, the FMC computed target speed is active and is displayed on both the PFD and HUD
  - when the window is open, FMC speed–intervention is active and the IAS/MACH selector may be used to set the desired speed
- blanks when not in SPD, FLCH, or TO/GA

4 Uplink Transfer (XFR) Switch

Push – Transfers the IAS or Mach value from the lower line to the upper line. If upper line was blank/closed, it now opens to the uplinked ATC value. Lower line blanks after the transfer.

5 ATC Uplinked Speed Clearance

The ATC uplink function is always enabled. For immediate clearances, pushing the datalink ACCEPT switch displays the clearance IAS or Mach value in the lower line of the window. If the upper line was blank/closed, it remains unchanged. Pushing the datalink CNCL switch removes the clearance from the lower line.

For conditional clearances, pushing the ACCEPT switch automatically displays clearance IAS or Mach value in the lower line only after condition contained in the clearance is met.

Uplinked clearances are preceded by the letters "UL".

The autothrottle can work in several ways but the simplest mode is the speed (SPD) mode. In this mode the desired target speed is dialed in using the IAS/MACH Selector (Nr. 3 in the middle image, the value is shown in display Nr. 2). Pressing the A/T switch (Nr. 3 in the left image) the autothrottle starts controlling precisely the thrust to maintain the target speed.

This procedure currently can't be simulated with FlightZoomer but a similar behavior can be achieved by configuring the RC transmitter as follows (using a multicopter):

By mixing a configurable proportional control to the pitch channel, constant pitch-angles can be applied (while the channel's stick stays untouched). At a constant tilt angle, a multicopter will establish a constant speed (wind effects aside). So a certain target speed can be set by turning that control until the reported speed matches the desired target speed.

3.5.2 Constant turn mode

Another possibility which greatly improves the usability and the precision of FlightZoomer operations is the provision of constant turn rates by configuring the RC system accordingly. FlightZoomer uses a constant value as the expected turn rate for the calculation of turn radiuses, route length & duration and the turn countdown timer. The expected turn rate can either be set manually or measured automatically with the flight test feature. This behavior again matches real aircraft like the Boeing 787 Dreamliner which also have a standard 3°/second turn rate.

As a constant and consistent turn rate is hard to achieve manually (with the yaw/rudder channel) it is recommended to implement this capability also with the RC transmitter (this again makes only sense using a multicopter).

There are two recommended ways to achieve that:

1. By mixing two configurable switches (ideally spring loaded) to the rudder channel, constant turn rates can be commanded (while the channel's stick stays untouched). For a typical multicopter this might require to mix +10% to the yaw channel if the turn-right-switch is actuated and -10% if the turn-left-switch is actuated. A turn rate of about 6°/second proved to be quite good for RC modeling purposes.

Or alternatively:

2. Use the dual rate feature to have either the full travel or only +/- 10%. The second, reduced control travel will be used for constant, gentle turns and shall be made available by an external switch. This way the normal rudder stick can be used.

3.5.3 Example

The following image shows a solution how a RC transmitter has successfully been configured to support constant speed and constant turn rates operations with multicopters:

3.6 Prepare the navigation database

One important step for preparing FlightZoomer is the creation of a suitable navigation database. This task is done with the Relay Server application as described between in the functional aspects document.

Some tips how to setup the navigation database:

- Creating the navigation database means that you already have a clear vision what kind of flights you want to do.
- Wherever you wish to have waypoints for your routes place a VOR or a GPS FIX. You can cover the whole landscape with as many navigation aids as you want.
- Place airports that real (rural) roads are aligned with the runway. You don't need real landing strips, especially with multicopters. This means that you can defined touchdown points virtually everywhere (the reason is that the accuracy realistically anyway does not permit, to land actually solely based on the FlightZoomer ILS).
- One airport typically is enough because RC aircrafts usually land where they took off!

4 Appendix

4.1 Glossary

	Abbreviation/term	Description	Real aviation term
	FMS	Flight Management System	X
	ILS	Instrument Landing System	X
	IM	Inner Marker	X
	LNAV	Lateral Navigation Auto flight mode where the loaded flightplan is being followed.	X
	MM	Middle Marker	X
	ND	Navigation Display	X
	OM	Outer Marker	X
	PFD	Primary Flight Display	X
	VOR	VHF omnidirectional range	X