Parachute Manual: DRS-General

Version 2.3-EN

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Contents

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Warranty will be terminated if parachute is re-packed by yourself.

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2 Introduction

The DRS is an autonomous parachute solution for unmanned air vehicles (UAVs), providing the following advantages:

- **UAV-independent sensors**
- **Very light-weighted**
- **Easy to reuse** within minutes
- **Visual and acoustical indication signals**
- **No use of pyrotechnics/explosive components** to deploy the parachute
- **No use of compressed gas cartridges** to deploy the parachute
- **Bayonet mechanism** to simply attach and detach the whole system

This document will guide you through the system components, installation, configuration and pre-flight checks as well as possible firmware updates, storage and maintenance recommendations.

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3 Components

Table 1 lists all system components. Within the document, parts are linked by their short ID, e.g. container for the carbon container.

Short ID	Picture[1]	Quantity	Description
Container		1	Carbon container of the DRS system
Container Lid		1	Lid of the container
Parachute		1	Parachute (wrapped in a plastic cover secured by some rubber bands)
Parachute cord		3	Cords mounted to the UAV
Hook and loop fastener		3	Hook and loop fastener
Hook		1	Brummel hook
Hook protection sleeve		1	Protection sleeve for the brummel hook

[1] Depending on the actual DRS configuration, the component pictures in Table 1 may slightly differ from your system.

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Short ID	Picture[1]	Quantity	Description
Logic/PWM Breakout cable[2]		1[2]	Cable to fan the DRS connection out for logic and PWM motor enable signal
MAVLink Breakout cable and board[3]		1[3]	Cable and breakout board to fan the DRS connection out for MAVLink interface
UART cable[3]		1[3]	Cable to connect the flight controller (e.g., Pixhawk) with the breakout board; used for MAVLink communication
	Optional components		
Emergency Trigger[4]		1[4]	Handheld radio controlled (RC) transmitter and antenna to deploy parachute in case of emergency.
RC Receiver[4]		1[4]	Radio controlled (RC) receiver for the emergency trigger.

Table 1 System components

[2] For Logic- and PWM-Interface only
[3] For MAVLink Interface only
[4] For RC variant only

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4 Installation

Unmount all propellors and detach all batteries and other power supplies before starting the installation!

Caution:
Mounted propellors may cause injuries or damages.

Caution:
It is mandatory to verify the correct operation with an assembly test right after the installation! See chapter 4.5 Assembly test for details.

4.1 Install the DRS

4.1.1 Container Placement

The positioning of the container is very important for a successful rescue in case of a parachute deployment. The system must be mounted to the frame of the UAV in a way that the parachute can deploy without getting tangled into the propellers or collide with any other parts (e.g., GNSS or RC antennas). Figure 1 shows an example of possible positions on basis of a quadcopter. The top surface of the DRS container should be located higher than the propellers. Otherwise the parachute might get tangled into the propellers if deployed. Keep in mind that turbulences, wind, airstream, etc. have influence on the deployment of the canopy and the cords. It is recommended to place the container close to the center of mass in order to reduce inertia and other unwanted influence on the flying behavior.

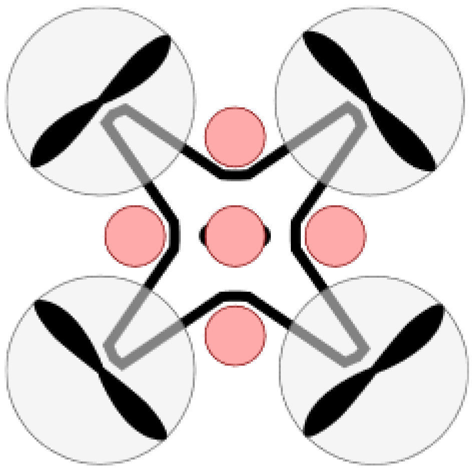

Figure 1: Conceivable positions for the container (red circle) on a quadcopter

Caution:
If the container placement is chosen wrong, the parachute cords or the parachute might get tangled or collide with parts. This might cause a crash in case of a deployment!

4.1.2 Mount the container

There is no general instruction for mounting the container because it strongly depends on your application. The container is equipped with a rail (see red marking in Figure 2), which provides a firm installation. Several drill holes enable you to screw the container to your UAV. Take care not to harm or clamp the elastic rubber springs.

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Figure 2: DRS container with installation rail (marked red)

4.1.3 Connect the DRS

You need to supply the DRS with power, establish a connection to the flight controller, and optionally attach an RC cable for the manual trigger PWM signal. Use the 5-pin female connector at the bottom of the container (see Figure 3) and the appropriate fanout cable to do so. The pinout of the connector and cable depends on the type of interface you use.

Figure 3: Interface connector on the DRS container

Logic Motor Enable Signal

Connect your application to the DRS system with the logic/PWM breakout cable shown in Figure 4. Table 2 shows the pinout of the cable. A detailed description of the interface can be found in chapter 6.3 and chapter 6.4.1.

Figure 4: Logic/PWM breakout cable

Pin	**Color**	**Signal**	**Description**
1	Brown	MOTOR_OFF	3.3V-CMOS or TTL logic signal, output
2	White	MANUAL_DEPLOY	3.3V-CMOS or TTL PWM signal, input "PWM2"
3	Blue	VCC	Power supply 12V – 25V (3S – 6S Lipo cells)
4	Black	GND	Ground signal level (0V)
5	Grey	RESERVED	currently not used

Table 2: Pinout for logic interface

PWM Motor Enable Signal

Connect your application to the DRS system with the logic/PWM breakout cable shown in Figure 4. Table 3 shows the pinout of the cable. A detailed description of the interface can be found in chapter 6.3 and chapter 6.4.2.

Pin	Color	Signal	Description
1	Brown	MOTOR_OFF	3.3V-CMOS or TTL PWM signal, output
2	White	MANUAL_DEPLOY	3.3V-CMOS or TTL PWM signal, input "PWM2"
3	Blue	VCC	Power supply 12 V – 25 V (3 S – 6 S Lipo cells)
4	Black	GND	Ground signal level (0 V)
5	Grey	RESERVED	currently not used

Table 3: Pinout for PWM interface

MAVLink Interface

Use the MAVLink breakout cable and board to fan the signals out. Figure 5 shows the breakout board. The numbered dots are described in detail below.

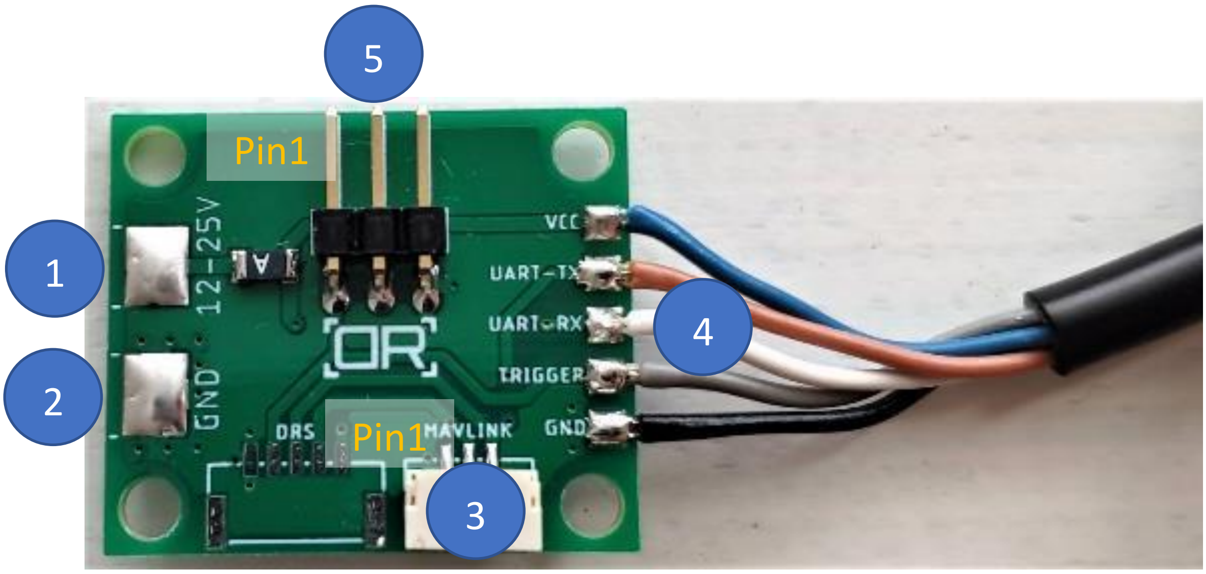

Figure 5: Breakout board

1. **Positive supply**
   12 VDC to 25 VDC (3 S – 6 S Lipo cells) input via solder connection
2. **Negative supply**
   Ground (0 V) input via solder connection
3. **MAVLink UART connection**
   Plug in the UART cable here. Plug the other end into a (3.3V-CMOS or TTL) UART socket of your flight controller (e.g., TELEM1, TELEM2, or SERIAL4/5 of a Pixhawk – whatever is appropriate for your application). Check if the cable pinout matches the UART socket of your flight controller.

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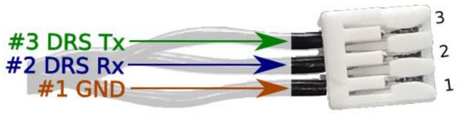
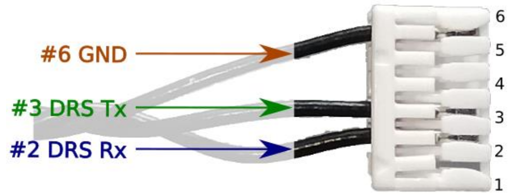


3-pole JST Connector (to breakout board)
Pin 1: GND Pin 2: DRS Rx (Pixhawk Tx) Pin 3: DRS Tx (Pixhawk Rx)



6-pole telemetry connector (to flight controller)
Pin 1: not connected Pin 2: DRS Rx (Pixhawk Tx) Pin 3: DRS Tx (Pixhawk Rx) Pin 4: not connected Pin 5: not connected Pin 6: GND

Caution:
Connecting the UART cable with mismatched pinouts can damage the DRS and/or the flight controller. Check the pinout before connecting!

4. **Cable to DRS**
   Connect this cable to the DRS.
5. **Manual trigger signal pinheader (optional)**
   Pin 1 is on the left side (as marked in Figure 5).

Pin 1: 3.3V-CMOS or TTL PWM signal, input "PWM2" Pin 2: not connected Pin 3: GND

A detailed description of the interface can be found in chapter 6.3 and chapter 6.4.3.

4.2 Mount the cords

You must attach the parachute to the UAV's frame appropriately by using the parachute cords. The best solution for this depends on the structure of your UAV and your application. For instance, you could use three mounting points on a hexa-shaped UAV or four mounting points on a quad- or octo-shaped UAV. The mounting points should be very solid parts of the frame e.g., the arms as shown in Figure 6.

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Figure 6: Mount points example

This way, the UAV will descend in a horizontal position and touch down on the landing gears. We recommend the following procedure to mount the cords to the UAV's arms:

Make sure the drone is in a stable upside position. Choose the positions where you want to mount the cords (e.g., the UAV’s arms) in a way that the cords will not interfere with mounted GPS antennas or other equipment. Note that all cords will rapidly be tautened when the parachute is deployed. No drone parts should be ripped off in this case.

To mount a cord to an arm, pull the cord around it, thread one end of the cord through the other end’s loop, and tighten the cord well. If you use other mounting positions or methods, ensure a reliable link.

Put the hook and loop fastener over each parachute cord.

Now fasten the hook and loop fastener.

Thread the open ends of the parachute cords through the hook's small hole without opening.

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Push the parachute cords far enough through the hole to wrap the loops over the hook. Pull the hook to firmly tighten the knot.

Stow all cords properly. They must be fixed tight enough to prevent unintentional loosening through vibrations or wind, though loose enough to be unfolded by the parachute when it deploys.

Caution:
If the container cords are not tightened well or if they build a loop, the cords might get tangled in the UAV propeller which would cause a crash!

4.3 Configure the Flight Controller

If you want the flight controller to generate the trigger signal for the manual deployment, be sure to meet the requirements (see chapter 6.3).

4.3.1 Logic and PWM Motor Enable Signal

Configure the flight controller to react properly to the logic or PWM motor enable signal. For a detailed description of these interfaces see chapter 6.4.1 and 6.4.2 respectively.

4.3.2 MAVLink Interface

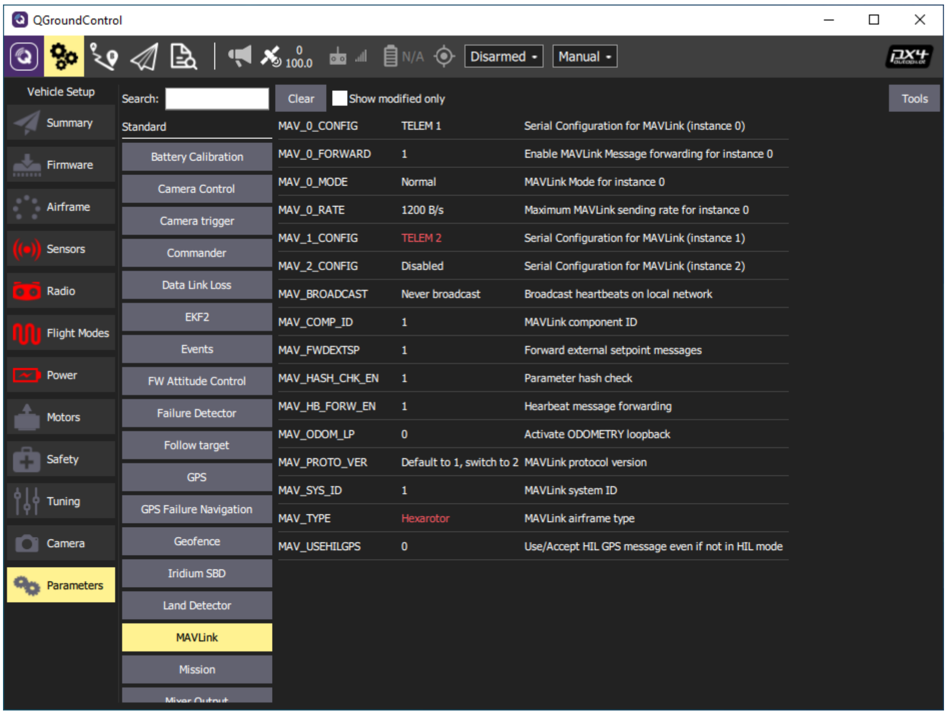
The following instruction applies to Pixhawk / QGroundControl and should show the principle of the setup. Your setup procedure may differ depending on the used flight controller and configuration software (e.g., you may use different settings, ports, etc.).

MAVLink setup with QGroundControl
Perform these steps to set up your Pixhawk/PX4 for MAVLink communication with DRS:

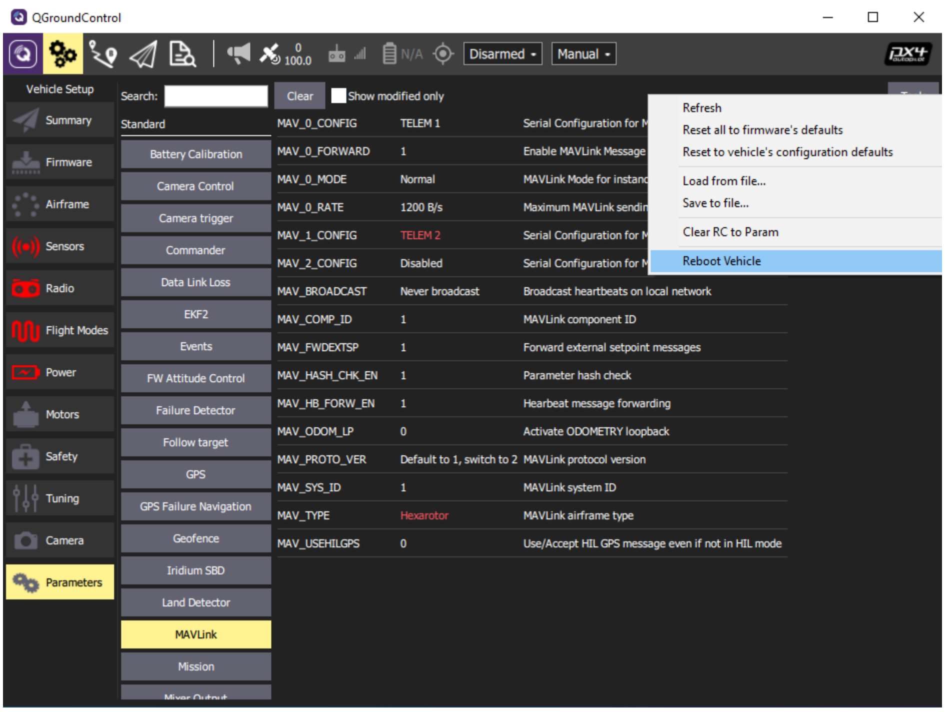
1. connect Pixhawk to a PC with a USB cable

2. start QGroundControl

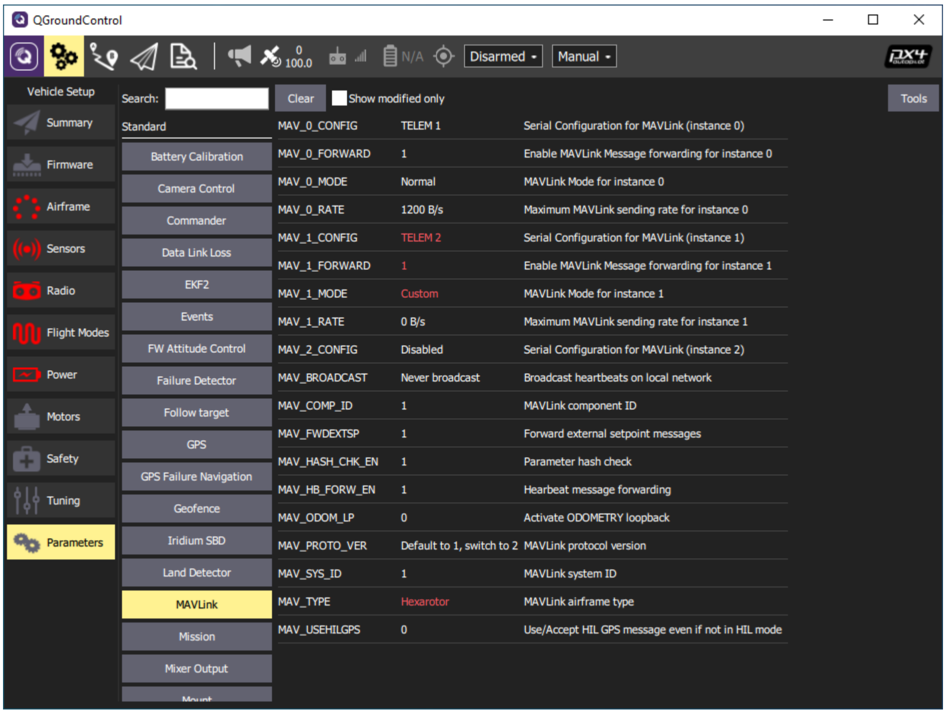
3. navigate to `Parameters > MAVLink` and set `MAV_1_CONFIG` to the port that is connected to the DRS (e.g., `TELEM2`)



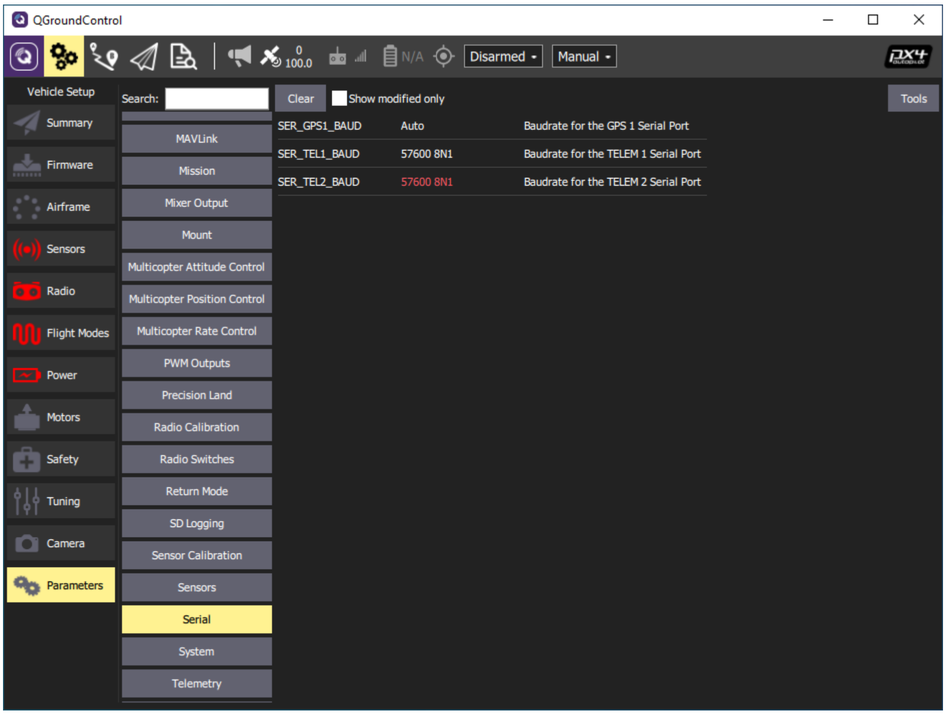
4. reboot Pixhawk (click on `Tools` and select `Reboot Vehicle`)



5. navigate to `Parameters > MAVLink` again and set `MAV_1_FORWARD` to 1 and `MAV_1_MODE` to `Custom`



6. navigate to `Parameters > Serial` and set `SER_TEL2_BAUD` to `57600 8N1`



7. close QGroundControl and disconnect Pixhawk from the PC

4.4 DRS Configuration

The DRS system is pre-configured for a standard use case application. You must fit the configuration to your specific usage. Configuration is described in chapter 6.2.

4.5 Assembly test

Perform this assembly test right after the installation (before the first flight) and after every 50th flight to verify the proper operation of the parachute system. The intention is to test the engine shutdown and the deployment mechanism without a parachute actually being loaded in the container. It is necessary to switch on the motors but keep the UAV on the ground during this test.

Follow this checklist:

- Unmount the propellors

> **Caution:**
> **Mounted propellors may cause injuries or damages**

- Verify that all cables are connected tightly and are fixated.
- Verify that the container is still fixed tight.
- Put the container under tension as described in chapter 5.2.1. The system should be strained but not loaded with a parachute after this step.
- Insert a dummy load into the container (e.g., an appropriate bottle filled with water).

> **Caution:**
> **Triggering (deploying) an empty container will cause damage to the device!**

- Turn on the UAV and perform the usual takeoff procedure until the motors are spinning but without taking off.
- Verify the correct status of the DRS by observing the LED and the buzzer signals. The DRS should be in the MANUAL state if you intend to trigger the test-deployment via a PWM signal, or in the TIMED DEPLOYMENT state if you want to use the deployment timer for the test.
- Prepare to catch (or at least dodge) the dummy.

> **Caution:**
> **The dummy load will be shot out heavily. Take precautions to prevent it from causing any harm or damage!**

- Trigger the manual deployment via PWM or use the timed deployment function as described in chapter 6.6 "Timed Deployment via File".

Verify that

- **the motors have been turned off,**
- **the dummy load has been deployed,**
- **the DRS's buzzer and LED indicate the DEPLOYED state.**

All these conditions must be met for a positive test result.

Turn off the UAV afterwards.

5 Flight

5.1 Pre-Flight Inspection

To ensure a safe and reliable operation visually check the following conditions before each flight. Verify that

- there is no visual damage to the elastic rubber springs of the container or any other component
- all cables are connected tightly and fixated
- the container is fully under tension and the deployment base is at the bottom
- the parachute is packed in the plastic cover
- the parachute is fully loaded inside of the container and no parachute fabric is protruding
- the parachute is properly linked to the UAV with the cords, the hook, and the hook protection sleeve
- the container lid is tightly clipped on the top of the container

5.2 Loading and unloading the parachute

5.2.1 Put the Container under tension

First open the release mechanism of the container, which is the small shutter at the bottom. The easiest way to do so is to get underneath the shutter using your fingernail and lift it to the stop. When lifted, place the container on a flat surface and keep the shutter in this position.

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Use a solid object which fits the inner diameter of the container and is longer than the whole unit. A plastic pipe is very convenient, but a small bottle of water works as well. Use it to gently push down the deployment mechanism until it reaches the bottom position. While holding this position, release the shutter. Now slightly decrease the pressure on the deployment mechanism until the shutter snaps into place.

Gently push the shutter back in place until it does not stick out of the container tube.

Caution:
In case the shutter is not fully back in place or is manually pulled out, the Parachute will get deployed and might cause injuries or damages!

5.2.2 Load the parachute

Remove the rubber band from the parachute but keep the plastic cover shut or the parachute will unfurl.

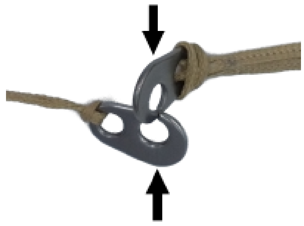
Completely insert the parachute into the container with the jagged edge first.

Check if the parachute fabric is fully covered by the plastic cover. Pay special attention to the bottom side.

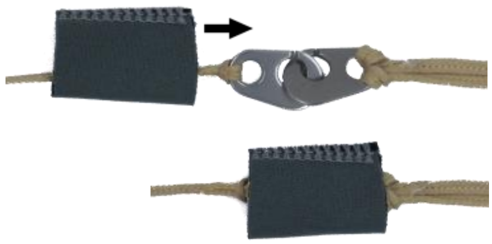
Caution:
Protruding parachute fabric at any side might impede a proper parachute deployment!

Clip on the container lid to protect the parachute from sunlight and other environmental influences. The cord of the parachute should lead out underneath the container lid at its designated position pointing to the center of the UAV.

Pull the hook protection sleeve over the hook of the parachute.



Fit the two hooks into each other (i.e. link the parachute to the UAV).



Afterwards, slide the protection sleeve over both hooks.

Caution:
The protection sleeve prevents an unintentional detachment of the hooks, thus always has to be in place!

5.3 Takeoff

The system runs through the INITIALIZATION states where it initializes all necessary HW components for the operation and features as configured by the parameters (see chapter 6.2). As soon as the MANUAL state is shown, the DRS is ready for takeoff. Do not take off if a warning or an error is shown.

Right after the takeoff you must observe the LED and buzzer to check if the DRS has correctly detected the takeoff. Hover the UAV above the configured TAKEOFF_HEIGHT over the ground for a few seconds and wait until the DRS switches its state to AUTOMATIC. The automatic failure detection is only active if the DRS is in this mode and shows no warning or error.

Caution:
If the DRS does not detect the takeoff, you must land the UAV because the automatic deployment function is inactive. Switch the power off, wait 10 seconds and repeat the start procedure.

If the failure persists, inform Drone Rescue Systems GmbH or it's reseller and provide the logfile for failure analysis.

5.4 After flight

After each flight it is recommended to do a short visual overall inspection to see if any part or component looks abnormal, worn out or broken. Replace damaged parts before using the DRS the next time.

If you don't use the parachute rescue system for a longer period of time we recommend to take out the parachute and remove the tension from the container as described in chapter 9.

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6 Device

The DRS is equipped with a micro SD memory card slot. The SD card is FAT32 formatted and used to store logfiles, perform firmware updates, and load configuration parameters.

6.1 Device States and Signals

An indication light (LED) and a buzzer are used to inform the pilot about the DRS's internal system states as described in Table 4. States with two color entries let the LED blink alternately in the two specified colors, e.g. the LED continuously changes between blue and purple while booting, and when the parachute has been DEPLOYED, the LED cycles through all shown colors rapidly.

State / Blink Colors		Acoustic signal	Description	User action
INITIALIZATION				
blue	purple	-	booting	wait until done (a few seconds)
blue	off	-	waiting for man.dep.	apply PWM signal for manual deployment
blue	cyan	-	waiting for interface	check connection to the interface
blue	white	-	waiting for GNSS	check GNSS reception
blue	yellow	three short beeps	warning	do not take off; check logfile
blue	red	continuous on/off	error	do not take off; check logfile
MANUAL				
green	off	two long beeps (only at landing)	ready for takeoff	take off when you are ready
green	yellow	three short beeps	warning	do not take off; check logfile
green	red	continuous on/off	error	do not take off; check logfile
AUTOMATIC				
green		one long beep	normal flight	-
yellow		three short beeps	warning	land; check logfile before next flight
red		continuous on/off	error	land ASAP; check logfile before next flight
DEPLOYED				
		continuous high/low	parachute deployed	-

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UPDATE				
purple	off	-	updating FW	wait until done (a few seconds)
TIMED DEPLOYMENT				
cyan		short beep every 1000/500/100ms	timed deployment	wait for deployment
INCOMPATIBLE HW				
red	yellow	-	incompatible HW	switch power off, contact Drone Rescue Systems GmbH

Table 4: System states

6.2 Device Configuration

The DRS parachute system's behavior can be configured with multiple parameters. A configuration-file (ASCII text) named "config.txt" contains mandatory parameters, optional parameters, and comments. It is processed when the system is turned on and must be placed in the root directory of the micro SD card.

All mandatory parameters must be set exactly once in the configuration-file. Optional parameters may be omitted. If an optional parameter occurs repeatedly, its previous value is overwritten. A hash symbol (#) marks the rest of the line as a comment. To set a parameter to a specific value just write the parameter's name and the value separated with a space (see example file below).

If the configuration-file cannot be processed for any reason, the system enters the INITIALIZATION-error state which is indicated by the LED and buzzer, and it also writes an example file named "config_example_v2.0.txt" to the root of the SD card. You can use this file as a template for your own configuration.

```
# DRS CONFIGURATION FILE FOR FW v2.1

# A hash symbol marks the rest of the line as a comment.
# All mandatory parameters must appear exactly once. Optional
# parameters may be omitted.
# A complete list and a description of the parameters can be
# found in the parachute manual.

#----------------------#
# Sensor configuration #
#----------------------#

TAKEOFF_HEIGHT 3.0       # [m]
MAX_BANK_ANGLE 55        # [deg]
MAX_SINKRATE 7.00        # [m/s]
MAX_YAWRATE 300          # [deg/s]
MIN_ACCELERATION 3.00    # [m/s/s]
POWER_MONITOR 1
```

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```
#-------------------------#
# Interface configuration #
#-------------------------#

MANUAL_DEPLOY_INPUT 2
INTERFACE 0


#-------------#
# Peripherals #
#-------------#

GNSS_MODE 0
GNSS_TIMEOUT_DEPLOY 0


#---------------#
# Miscellaneous #
#---------------#

DEPLOY_DELAY 0.000   # [s]
LOG_MODE 1
#DRONE_NAME John_Doe          # optional
```

Contents of "config_example_v2.0.txt"

Table 5 shows a list of all mandatory parameters.

TAKEOFF_HEIGHT

Specifies the height in meters where the DRS switches to AUTOMATIC state. You can set it to zero if you want to "fake" a takeoff, i.e. to switch to automatic immediately at start, but take special care when doing so because the parachute can be deployed immediately when any other deployment criteria is met (e.g. bank angle).

Recommended: 3	Range: 0 – 1000	Resolution: 0.1	Unit: m

MAX_BANK_ANGLE

Maximum allowed bank angle in degrees. Deploy when bank angle exceeds set value in automatic state. Set to zero to disable this feature.

Recommended: 55 (DJI M600) 55 (DJI M210) 60 (DJI M300)	Range: 0, 20 – 90	Resolution: 1	Unit: deg

MAX_SINKRATE

Maximum allowed sink rate in m/s. Deploy when vertical velocity exceeds set value in automatic state. Set to zero to disable this feature.

Recommended: 7	Range: 0, 5 - 100	Resolution: 0.01	Unit: $\frac{m}{s}$

MAX_YAWRATE

Maximum allowed yaw rate in deg/s. Deploy when yaw rate exceeds set value in automatic state. Set to zero to disable this feature.

Recommended: 300	Range: 0, 100 - 500	Resolution: 1	Unit: $\frac{deg}{s}$

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MIN_ACCELERATION The parachute is deployed when the DRS is in automatic state and the norm of the acceleration vector drops below this value given in m/s/s. Set to zero to disable this feature. Recommended: 3 Range: 0, 0.05 - 5 Resolution: 0.01 Unit: $\frac{m}{s^2}$
POWER_MONITOR 0: no deployment on power loss 1: deploy on power loss in automatic state (Caution: opening the bayonet mount of the DRS container disconnects the power supply which is interpreted as a power loss, thus causes a deployment if the DRS is in automatic state!) Recommended: 1 Range: 0, 1 Resolution: - Unit: -
MANUAL_DEPLOY_INPUT 0: PWM signals are not used 1: PWM channel 1 is used to trigger deployment 2: PWM channel 2 is used to trigger deployment 3: a trigger signal must be sent on both PWM channels to deploy the parachute 4: a trigger signal can be sent on either PWM channel to deploy the parachute Recommended: - Range: 0 - 4 Resolution: - Unit: -
INTERFACE The interfaces are explained in chapter 6.4. 0: logic motor enable signal 1: PWM motor enable signal 2: *reserved for future use* 3: DJI-API (Onboard SDK) 4: MAVLink (UART) Recommended: - Range: 0 - 4 Resolution: - Unit: -
GNSS_MODE The GNSS feature is only available on DRS variants with GNSS support. GNSS_MODE must be set to 0 on standard variants. 0: GNSS disabled 1: GNSS enabled, data recording only 2: GNSS enabled, geofence enabled (geofence file has to be provided) Recommended: - Range: 0 - 2 Resolution: - Unit: -
GNSS_TIMEOUT_DEPLOY If GNSS is enabled and geofence is used, parachute deploys when GNSS signal is lost for this period given in seconds. Set to zero to disable this feature. Recommended: 0 Range: 0 - 600 Resolution: 1 Unit: s
DEPLOY_DELAY Delay between motor-off signal and deployment of parachute given in seconds. This applies to manual as well as automatic deployment. Recommended: 0 Range: 0 - 10 Resolution: 0.001 Unit: s

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LOG_MODE				
	0: do not log sensor readings (such as IMU-data) 1: start logging sensor readings at power-on 2: start logging sensor readings at first takeoff, then keep logging until power-off 3: log sensor readings only during flight (start at takeoff, stop at landing, continue at next takeoff, etc.)			
	Recommended: 1	Range: 0 - 3	Resolution: -	Unit: -

Table 5: Mandatory parameters

Table 6 shows a list of all optional parameters. Currently, there is only one.

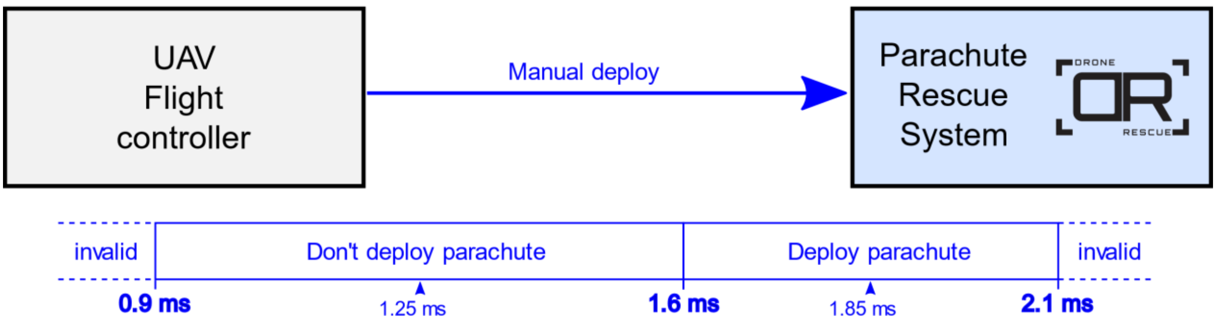
Parameter	Type	Range	Description
DRONE_NAME	text	max. 30 chars	You can specify a custom name which will appear in the logfile.

Table 6: Optional parameters

Caution:
Be careful when choosing the values. Use proper values for your UAV and application. Using improper parameter values may cause the parachute to fail from deploying as well as unwanted deployments.

6.3 Manual Deployment

The parachute deployment can be triggered manually. In the majority of applications this is initiated by the pilot. For this purpose a conventional servo signal (50 Hz PWM signal with a pulse width between 1 ms and 2 ms) is used. It is usually sent from the flight controller or an external RC receiver to the DRS. The DRS will deploy the parachute upon receipt of the trigger event, even if the DRS sensors show no problem.



The valid range for the servo signal is extended to 0.9 ms to 2.1 ms in order to compensate clock frequency errors of RC sender modules. A pulse width below 1.6 ms means normal operation, while a pulse width above 1.6 ms triggers the deployment of the parachute.

To gain some safety and to prevent deployments by mistake during the initialization process and before takeoff, the system waits for a pulse width in the range of the "don't deploy"-state before it completes the INITIALIZATION state.

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It is strongly recommended to generate the PWM signal with the nominal pulse widths set to the middle of the particular ranges (i.e., 1.25 ms and 1.85 ms) to avoid unwanted triggering due to clock frequency errors of the sender as well as the receiver of the PWM signal.

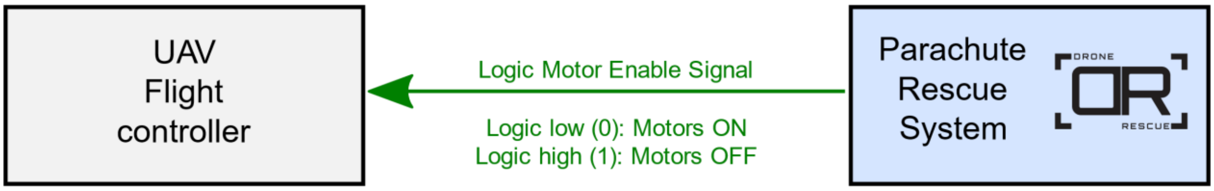
6.4 Interface description

The interface allows a communication between the DRS and the flight controller or any other computer which controls the UAV. Diverse data and events can be propagated depending on the interface type. The type of interface is selected with the configuration parameter INTERFACE.

6.4.1 Logic Motor Enable Signal

This is a very simple interface with only one piece of information to be transferred – the motor enable signal. Whenever the DRS decides to deploy the parachute (also in the case of a manual deployment), it informs the flight controller about it so it can stop the motors.

A 3.3V-CMOS voltage level is used for signaling the need to stop the motors. A logic low level indicates normal operation (i.e., motors on) while a logic high indicates to stop the motors.



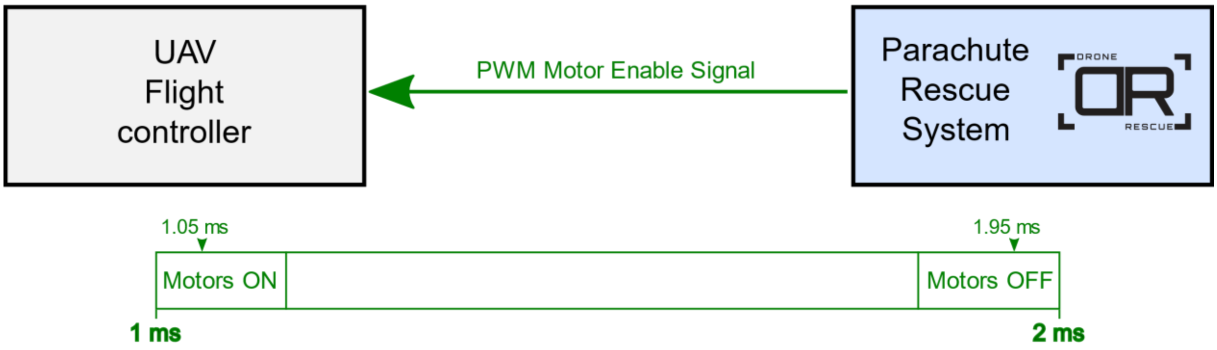
6.4.2 PWM Motor Enable Signal

This is a very simple interface with only one piece of information to be transferred – the motor enable signal. Whenever the DRS decides to deploy the parachute (also in the case of a manual deployment), it informs the flight controller about it so it can stop the motors.

A PWM signal is used to tell the flight controller to stop the motors. The general specifications are taken from a conventional servo signal (50 Hz PWM signal with a pulse width between 1 ms and 2 ms, 3.3V-CMOS voltage levels). The following pulse widths are generated by the DRS:

- 1.05 ms: Motors ON (normal operation)
- 1.95 ms: Motors OFF (request to stop the motors)

These pulse widths should be appropriate for most RC receivers, but keep in mind that they will deviate somewhat due to clock frequency errors of the sender as well as the receiver of the PWM signal.



6.4.3 MAVLink Interface

The DRS can easily be integrated in a Pixhawk ecosystem (PX4 flight stack, Ardupilot) with a UART connection. It works with MAVLink protocol version 1 as well as version 2. When the DRS wants to stop the motors, it sends the MAV_CMD_DO_FLIGHTTERMINATION (#185) command.

A watchdog timer is used to observe the connection health. It uses a timeout of 3.5 seconds and is reset on reception of a HEARTBEAT (#0) message. Therefore, the flight controller must be configured in such a way that it sends a HEARTBEAT message periodically, e.g., every second (see chapter 4.3.2). Note, that though the DRS shows an error with LED and buzzer signals in case of a watchdog timeout, it still tries to send the MAV_CMD_DO_FLIGHTTERMINATION command if the motors need to be stopped.

6.5 System Time

The DRS is capable of naming the log-files based on the current date and timestamp. Therefore, the system's time has to be set in advance. This is usually done before shipment but you are free to set it anytime, e.g. to adapt it to your local time zone.

To set the system time, place a file (ASCII text) named "set_time.txt" in the root directory of the micro SD memory card and specify the new date and time formatted like YYYY-MM-DD, HH:MM:SS. Lines beginning with a hash symbol (#) are ignored and can be used as comments.

The following example sets the date to June 21st in 2020 and the time to 3pm.

```
#YYYY-MM-DD, HH:MM:SS
2020-06-21, 15:00:00
```

The firmware will find and parse this file at startup, and if a valid entry is found, it sets the system time accordingly. The file will then be renamed to "set_time_ok.txt" on success or "set_time_fail.txt" if the entry cannot be parsed. This way, the user does not need to manually remove the file after setting the time.

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6.6 Timed Deployment via File

If your application setup does not offer a possibility to use the manual deployment trigger, then you can use the "timed deployment" feature to test the deployment on the ground. It deploys the parachute after a certain time has elapsed since the DRS was turned on. Activate it by placing a file named "deployment_timer.txt" in the root directory of the micro SD memory card. Specify the time in seconds after the keyword "deploy". Here is an example of the file:

deployment_timer.txt:
specify time of deployment in seconds # in the range of 10 to 60 seconds **deploy 20**

Lines starting with a hash symbol (#) are ignored and can be used as comments. The file is renamed when it is read in order to avoid repeated timed deployments. On success, it is renamed to "deployment_timer_ok.txt". If the deploy time could not be read, it is renamed to "deployment_timer_fail.txt". The LED and buzzer indicate the TIMED DEPLOYMENT state while the timer is running.

Caution:
Do not take off when the timed deployment feature is active because the parachute will be deployed and the motors will be stopped (if configured so) when the timer runs out. If the UAV is in the air in this moment, it will fall down.

6.7 Firmware Update

The newest firmware is already installed on the DRS when it is shipped to the customer. If you want to update it, you need the new FW which is a file with the extension ".bin" provided by Drone Rescue Systems GmbH. Simply store this file in the root directory of the micro SD card to perform a firmware update. When the DRS powers up, the file will be found and the update process starts automatically. The status LED indicates the UPDATE state during the update process which takes about 5 to 10 seconds. After a successful update the LED blinks green for a few seconds, the ".bin"-file is deleted, and the new firmware is started. In case of any error the LED blinks red for a few seconds and the old firmware is started. Observe the LED carefully to see if the update was successful. A file named "bootloader.txt" is written to the SD card in any case. It contains information about the update process, especially about the success. Also check this file to see if the update was successful. You can delete it afterwards.

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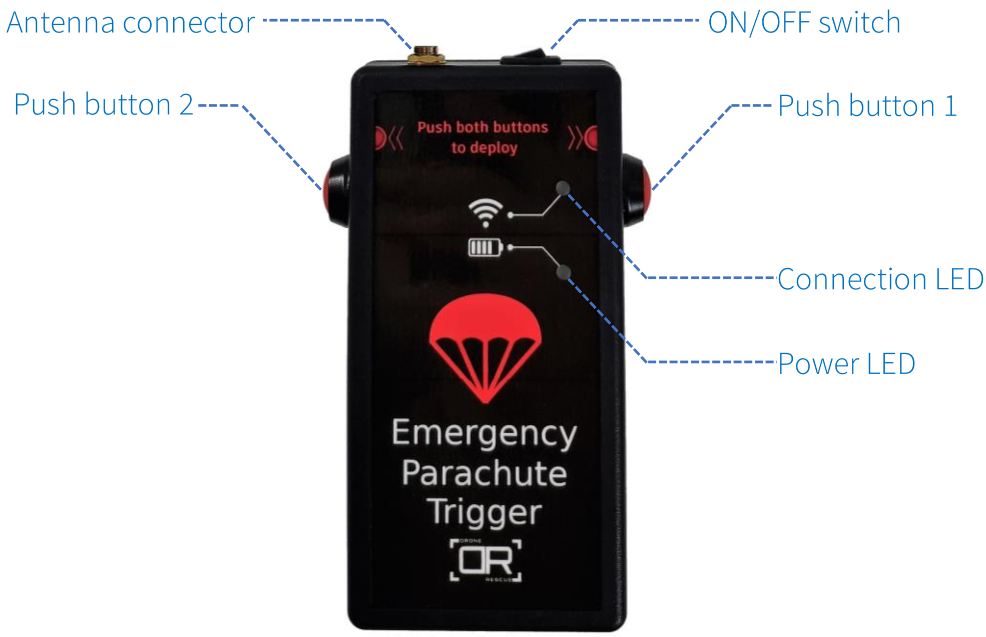
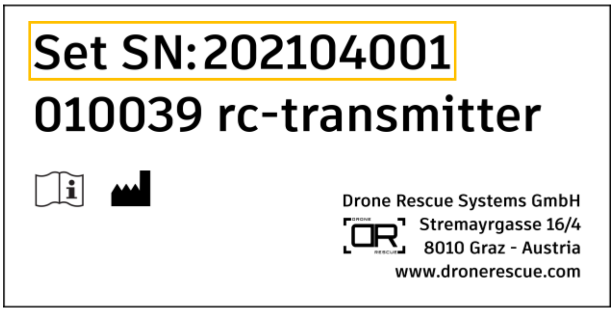
7 Emergency Trigger Device

The handheld radio controlled (RC) Emergency Trigger allows the user to deploy the parachute in case of an emergency by pressing both push buttons simultaneously.



Each Emergency Trigger device is paired with a single RC-receiver. The paired devices have the same set serial number (see pictures below).



Prior use the RC-receiver has to be installed on the UAV as described in chapter 7.5.

7.1 Function

As soon as a connection between emergency trigger and matching receiver is established a PWM signal, hopping between 1100µs and 1150µs every second, is transmitted to the DRS system. When a deployment is triggered, the PWM signal will change to 1800µs and release the parachute if the system is configured correctly.

7.2 Usage

Screw the antenna on the connector on the top of the device. Insert a 9V battery in the rear side battery box. Change the power switch position to “ON”.

Caution:
Using the device without antenna may destroy the Emergency Trigger or cause permanent connectivity problems!

Check if the power LED indicates good battery state (Table 7) and the connection LED indicates RC-GOOD (Table 8).

Press both push buttons to deploy the parachute.

Caution:
Pressing both push buttons will immediately initiate a parachute deployment! Take precautions to prevent accidental usage.

7.3 Specifications

	EU variant	NON-EU variant
Operating frequency	868MHz	915MHz
Max. current consumption (@9V)	190mA	150mA
Tested range	400m	400m
Power supply	9V battery (PP3 size)	
Dimensions	133x80x33mm (without antenna)	

7.4 LED states

7.4.1 Connection LED

RSSI value	Connection State	CONNECTION LED color
-	RC-PENDING	blinking purple
RSSI > 50	RC-GOOD	green
35 < RSSI ≤ 50	RC-LOW	orange
RSSI ≤ 35	RC-BAD	blinking red
DEPLOYMENT INITIATED	DEPLOYED	blinking blue

Table 7 CONNECTION LED - Connection state

7.4.2 Power LED

The Power LED indicates the battery state according to Table 8. Recommended batteries are rechargeable Li-Ion, but standard 9V batteries will work as well.

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Supply voltage (VCC) range	Battery State	POWER LED color
VCC > 7.0V	good	green
6.5V < VCC ≤ 7.0V	medium	cyan
6.0V < VCC ≤ 6.5V	low	orange
VCC ≤ 6.0V	empty	blinking red
DEPLOYMENT INITIATED	DEPLOYED	blinking blue

Table 8 POWER LED - Battery state

7.5 RC-Receiver Installation

Connect the cable of the RC-receiver to the corresponding lines of the logic/PWM breakout cable or the MAVLink breakout cable and board – whichever interface you use in your application.

The RC-receiver has an adhesive tape on its rear which you can use to fix it to the UAV. Clean a proper area of the UAV with alcohol. Remove the protection film from the adhesive tape on the backside tape of the RC-receiver and press the device on the center of the cleaned area.

8 Specifications

8.1 Operational and environmental conditions

Service life (before repack required)	1 year
Maximum altitude above sea level	3000 m (9842 ft)
Temperature range	-10 C° to +40 C°
Overall weight DRS-5	300 g (0.66 lbs)
Overall weight DRS-10	375 g (0.83 lbs)
Overall weight DRS-15	390 g (0.86 lbs)
Overall weight DRS-25	600 g (1.32 lbs)
Maximum number of deployments*	10

*not including manual deployment within chapter 4.5 Assembly test

9 Storage

If you don't use the parachute rescue system for a longer period of time, we recommend to take out the parachute and remove the tension from the container. Be careful not to unfold the parachute when you remove it from the container. Use the rubber bands to fix it. Use a solid object (e.g., pipe or water bottle), like the one you used within chapter 5.2 "Loading and unloading the parachute" to smoothly release the tension from the deployment mechanism.

Always store the system in a dry environment to prevent moisture accumulating inside of the parachute canopy, because it could increase the inflation time in case of a deployment.

10 Maintenance

The DRS parachute rescue system needs to be maintained once a year. The maintenance includes the following steps:

- Repacking of the parachute
- Replacement of the plastic cover
- Replacement of the elastic rubber springs
- Replacement of the parachute cords

The maintenance needs to be done by Drone Rescue Systems GmbH or a certified partner of Drone Rescue Systems GmbH.

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