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# **bebop\_autonomy Documentation**

*Release indigo-devel*

**Mani Monajjemi**

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*bebop\_autonomy* is a ROS (Robot Operating System) driver for [Parrot Bebop drone](#) (quadrocopter), based on Parrot's official [ARDroneSDK3](#). This driver has been developed in [Autonomy Lab](#) of [Simon Fraser University](#) by [Mani Monajjemi](#).

[\[Source Code\]](#) [\[ROS wiki page\]](#) [\[Support\]](#) [\[Bug Tracker\]](#) [\[Developer Forum\]](#)



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## Features and Roadmap

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| Feature  | Status       | Notes                        |
|--|--------------|------------------------------|
| Core piloting  | Yes          |                              |
| H264 video decoding                                  | Yes          | Enhancement: #1              |
| ROS Camera Interface                                 | Yes          |                              |
| Nodelet implementation                               | Yes          |                              |
| Publish Bebop states as ROS topics                   | Yes          |                              |
| Dynamically reconfigurable Bebop settings            | Yes          | <i>Configuring the Drone</i> |
| Inline build of ARDroneSDK3                          | Yes          | Enhancement: #2              |
| Bebop In The Loop tests                              | Yes          | <i>Tests</i>                 |
| Joystick teleop demo                                 | Yes          |                              |
| TF Publisher   | No (Planned) | #3                           |
| Odometry Publisher                                   | No (Planned) | #4                           |
| Provide ROS API for on-board picture/video recording | No (Planned) | #5                           |
| GPS Support  | Partial      | Not fully tested             |
| Mavlink Support                                      | No           |                              |
| Binary Release                                       | No           |                              |
| Support for Parrot Sky Controller                    | No           |                              |





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## Table of Contents

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## 2.1 Changelog and Release History

### 2.1.1 Changelog for package `bebop_driver`

#### 0.4.0 (2016-01-17)

- Update Parrot SDK to 3.7.5 (from 3.6) - Remove upstream XML hash from .msg files to minimize msg type changes from now on - New Topic and Message type for *DefaultCameraOrientation*
- Add `cmd_vel` timeout for safety - The driver now sends stop command if no new `cmd_vel` is received within a pre-defined timeout period. This timeout is set to 0.1s by default and can be changed via `cmd_vel_timeout` parameter.
- Fix right-jand rule bug of angular.z @jacobperron (fixes #26)
- Patch ARSDK to fix Sanselan's old URL - This is temporary and must be reverted when this is fixed upstream. Issue reported here: [Parrot-Developers/ARSDKBuildUtils#61](#)
- Add bebop ip address as ROS parameter (fixes #19) - (Param name: *bebop\_ip*, default value: 192.168.42.1)
- Fix CameraInfo issues (closes #10) - Fix bugs in loading camera calibration data and update the tests - Add a sample calibration file for bebop camera: `bebop_camera_calib.yaml` - Load camera calibration file by default in both node/nodelet launch files
- Remove redundant `bebop.launch` file (closes #11)
- Fix coordinate system inconsistencies (fixes #13) - Fix `cmd_vel.linear.y` sign error - Use attitude values in tests instead of velocities
- Contributors: Anup, Mani Monajjemi, Jacob Perron

#### 0.3.0 (2015-09-17)

- Renamed package to `bebop_driver`
- Built against ARSDK3\_version\_3\_6
- `bebop_autonomy` is now a metapackage - `bebop_autonomy` is the ROS metapackage name - Rename `bebop_autonomy` package to `bebop_driver` - Rename `bebop_autonomy_msgs` to `bebop_msgs`
- Contributors: Mani Monajjemi

## **0.2.0 (2015-09-10)**

- Finalized documentation
- Remove bebop\_autonomy's dependency to image\_view
- Improvements to code autogeneration scripts.
- CLAMP values for cmd\_vels and anim\_id
- Added contents to almost all doc pages
- Bebop In The Loop tests (first revision)
- Fixed more style (lint) issues
- Finalized the first revision of tests
- Add autogenerated docs for Settings, Topics and Params
- Contributors: Mani Monajjemi

## **0.1.2 (2015-09-05)**

- Move 'state' params to their own param namespace
- Add missing unzip dep to package.xml
- Contributors: Mani Monajjemi

## **0.1.1 (2015-09-04)**

- Add support for downloading and building ARDroneSDK3 during the build process
- Add flattrim, flip and navigatehome interfaces
- Add forward declaration to classes where it is possible
- Major bug fixes and improvements - Dynamic Reconfigure: Convert all two state int\_t values to enum - Fix the private nodehandle bugs in State and Settings handlers - Fix the data flow of Settings between rosparam and dynamic reconfigure and bebop - Fix SDK enum types in C (I32 instead of U8) - Add Start/Stop streaming to Bebop interface class
- Add bebop\_nodelet launch with image\_view
- Organized DynR configs into groups + Moved the autogeneration report to a seperated file + build speed improvements
- Dynamically reconfigurable Bebop settings
- Add support to enable publishing of a specific State
- Add support to propogate states from bebop to ROS
- Auto-generated .msg and .h files based on libARCommands XML files
- New threading model for data retrieval and publishing - Nodelet now manages its own thread to receive frames from Bebop - GetFrame() function abstracts all sync to access the rgb frame - All subscribers send commands to the Bebop in their callbacks
- Integreate ARSAL logs into ROS\_LOG - Fix sync issues between frame grabber and publisher
- Improve video decode/publish pipeline - Adopt frame decoding from official examples - Thread safe access to raw frame ptr - Synchronised frame decoding and publishing

- Proof of concept ROS driver for bebop drone
- Contributors: Mani Monajjemi

## 2.1.2 Changelog for package bebop\_tools

### 0.4.0 (2016-01-17)

- Fix cmd\_vel.linear.y sign issue in joystick config file
- Contributors: Mani Monajjemi

### 0.3.0 (2015-09-17)

- Renamed package to bebop\_tools
- Contributors: Mani Monajjemi

### 0.2.0 (2015-09-10)

- Move image\_view nodelet demo to bebop\_tools package
- Contributors: Mani Monajjemi

### 0.1.2 (2015-09-05)

- Initial release of joystick teleop for bebop\_autonomy
- Contributors: Mani Monajjemi

### 0.1.1 (2015-09-04)

## 2.1.3 Changelog for package bebop\_msgs

### 0.4.0 (2016-01-17)

- Update Parrot SDK to 3.7.5 (from 3.6)
- New Topic and Message type for *DefaultCameraOrientation*
- Contributors: Mani Monajjemi

### 0.3.0 (2015-09-17)

- Renamed to bebop\_msgs
- Contributors: Mani Monajjemi

### 0.2.0 (2015-09-10)

- Contributors: Mani Monajjemi

### 0.1.2 (2015-09-05)

- Contributors: Mani Monajjemi

### 0.1.1 (2015-09-04)

- Auto-generated .msg and .h files based on libARCommands XML files
- Contributors: Mani Monajjemi

## 2.2 Installation

### 2.2.1 Compiling From Source

Pre-requirements:

- ROS *Indigo* or *Jade* (Only tested on *Ubuntu*)
- Internet connection
- Ubuntu packages: `build-essential`, `python-rosdep`, `python-catkin-tools`
- Basic familiarity with building ROS packages

```
$ sudo apt-get install build-essential python-rosdep python-catkin-tools
```

To compile from source, you need to clone the source code in a new or existing `catkin` workspace, use `rosdep` to install dependencies and finally compile the workspace using *catkin*. The following commands demonstrate this procedure in a newly created `catkin` workspace.

```
# Create and initialize the workspace
$ mkdir -p ~/bebop_ws/src && cd ~/bebop_ws
$ catkin init
$ git clone https://github.com/AutonomyLab/bebop_autonomy.git src/bebop_autonomy
# Update rosdep database and install dependencies
$ rosdep update
$ rosdep install --from-paths src -i
# Build the workspace
$ catkin build -DCMAKE_BUILD_TYPE=RelWithDebInfo
```

The first time build may take up to 15 minutes, since ARDroneSDK3's build script downloads and compiles ~20 packages from Internet.

```
$ cd ~/bebop_ws/src
$ git clone https://github.com/ros-teleop/teleop_tools.git
# Do rosdep steps again
```

## 2.3 Running the Driver

You can run Bebop's ROS driver either as a ROS [Nodelet](#) or as a standalone ROS Node. The former is recommended if you intend to perform any kind of processing on Bebop's video stream.

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**Note:** If you compile the driver from source, do not forget to source your `catkin` workspace prior to running the driver. (i.e. `source ~/bebop_ws/devel/setup.[bash|zsh]`)

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**Note:** Ensure that your Bebop's firmware is at least **2.0.29** and your computer is connected to Bebop's wireless network.

---

### 2.3.1 Running the driver as a Node

The executable node is called `bebop_driver_node` and exists in `bebop_driver` package. It's recommended to run the Node in its own namespace and with default configuration. The driver package comes with a sample launch file `bebop_driver/launch/bebop_node.launch` which demonstrates the procedure.

```
$ roslaunch bebop_driver bebop_node.launch
```

Listing 2.1: `bebop_node.launch`

```
<?xml version="1.0"?>
<launch>
  <group ns="bebop">
    <node pkg="bebop_driver" name="bebop_driver" type="bebop_driver_node" output="screen">
      <param name="camera_info_url" value="package://bebop_driver/data/bebop_camera_calib.yaml"/>
      <param name="bebop_ip" value="192.168.42.1" />
      <roscparam command="load" file="$(find bebop_driver)/config/defaults.yaml" />
    </node>
  </group>
</launch>
```

### 2.3.2 Running the driver as a Nodelet

To run the driver as a ROS Nodelet, you need to first run a Nodelet manager, then load the driver's Nodelet (`bebop_driver/BebopDriverNodelet`) in it, along with other Nodelets that need to communicate with the driver. `bebop_tools/launch/bebop_nodelet_iv.launch` is a sample launch file that demonstrates these steps by visualizing Bebop's video stream using an instance of `image_view/image` Nodelet. Similar to `bebop_node.launch`, it also runs everything in its own namespace and loads the default configuration.

```
$ roslaunch bebop_tools bebop_nodelet_iv.launch
```

Listing 2.2: `bebop_tools/launch/bebop_nodelet_iv.launch`

```
<?xml version="1.0"?>
<launch>
  <!-- include the nodelet launch file from bebop_driver -->
  <include file="$(find bebop_driver)/launch/bebop_nodelet.launch" />
  <!-- use the same nodelet manager and namespace, then load image_view nodelet -->
  <group ns="bebop">
    <node pkg="nodelet" type="nodelet" name="bebop_image_view_nodelet"
      args="load image_view/image bebop_nodelet_manager">
      <remap from="image" to="image_raw" />
    </node>
  </group>
</launch>
```

## 2.4 Sending Commands to Bebop

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Listing 2.3: bebop\_driver/launch/bebop\_nodelet.launch

```
<?xml version="1.0"?>
<launch>
  <group ns="bebop">
    <!-- nodelet manager -->
    <node pkg="nodelet" type="nodelet" name="bebop_nodelet_manager" args="manager" output="screen" />
    <!-- bebop_nodelet -->
    <node pkg="nodelet" type="nodelet" name="bebop_nodelet"
      args="load bebop_driver/BebopDriverNodelet bebop_nodelet_manager">
      <param name="camera_info_url" value="package://bebop_driver/data/bebop_camera_calib.yaml" />
      <param name="bebop_ip" value="192.168.42.1" />
      <rosparam command="load" file="$(find bebop_driver)/config/defaults.yaml" />
    </node>
  </group>
</launch>
```

**Note:** bebop\_tools package comes with a launch file for tele-operating Bebop with a joystick using ROS joy\_teleop package. The configuration file (key-action map) is written for Logitech F710 controller and is located in bebop\_tools/config folder. Adapting the file to your own controller is straightforward. To teleop Bebop while the driver is running execute `roslaunch bebop_tools joy_teleop.launch`.

---

### 2.4.1 Takeoff

Publish a message of type `std_msgs/Empty` to takeoff topic.

```
$ rostopic pub --once std_msgs/Empty [namespace]/takeoff
```

### 2.4.2 Land

Publish a message of type `std_msgs/Empty` to land topic.

```
$ rostopic pub --once std_msgs/Empty [namespace]/land
```

### 2.4.3 Emergency

Publish a message of type `std_msgs/Empty` to reset topic.

```
$ rostopic pub --once std_msgs/Empty [namespace]/reset
```

### 2.4.4 Piloting

To move Bebop around, publish messages of type `geometry_msgs/Twist` to `cmd_vel` topic while Bebop is flying. The effect of each field of the message on Bebop's movement is listed below:

|          |     |                    |
|----------|-----|--------------------|
| linear.x | (+) | Translate forward  |
|          | (-) | Translate backward |
| linear.y | (+) | Translate to left  |
|          | (-) | Translate to right |
| linear.z | (+) | Ascend             |
|          | (-) | Descend            |

|               |                          |
|---------------|--------------------------|
| angular.z (+) | Rotate counter clockwise |
| (-)           | Rotate clockwise         |

Acceptable range for all fields are  $[-1 . . 1]$ . The drone executes the last received command as long as the driver is running. This command is reset to when *Takeoff*, *Land* or *Emergency* command is received. To make Bebop hover and maintain its current position, you need to publish a message with all fields set to zero to `cmd_vel`.

**Note:** Since version 0.4, sign of `angular.z` has been negated to conform with *ROS Standard Message Types (i.e Twisl) - REP 103* and `ardrone_autonomy`.

## 2.4.5 Moving the Virtual Camera

To move Bebop's virtual camera, publish a message of type `geometry_msgs/Twist` to `camera_control` topic. `angular.y` and `angular.z` fields of this message set **absolute** tilt and pan of the camera in **degrees** respectively. The field of view of this virtual camera (based on our measurements) is ~80 (horizontal) and ~50 (vertical) degrees.

**Warning:** The API for this command is not stable. We plan to use `JointState` message in future versions.

|               |           |
|---------------|-----------|
| angular.y (+) | tilt down |
| (-)           | tilt up   |
| angular.z (+) | pan left  |
| (-)           | pan right |

## 2.4.6 GPS Navigation

**Warning:** Not fully integrated/tested yet.

## 2.4.7 Flat Trim

**Error:** Test fails, probably not working.

Publish a message of type `std_msgs/Empty` to `flattrim` topic.

```
$ rostopic pub --once std_msgs/Empty [namespace]/flattrim
```

## 2.4.8 Flight Animations

**Warning:** Be extra cautious when performing any flight animations, specially in indoor environments.

Bebop can perform four different types of flight animation (flipping). To perform an animation, publish a message of type `std_msgs/UInt8` to `flip` topic while drone is flying. The `data` field determines the requested animation type.

|   |               |
|---|---------------|
| 0 | Flip Forward  |
| 1 | Flip Backward |
| 2 | Flip Right    |
| 3 | Flip Left     |

## 2.5 Reading from Bebop

### 2.5.1 Camera

The video stream from Bebop's front camera is published on `image_raw` topic as `sensor_msgs/Image` messages. *bebop\_driver* complies with ROS camera interface specifications and publishes camera information and calibration data to `camera_info` topic. Due to limitations in Parrot's ARDroneSDK3, the quality of video stream is limited to **640 x 368 @ 30 Hz**. The field of view of this virtual camera (based on our measurements) is ~80 (horizontal) and ~50 (vertical) degrees.

To set the location of camera calibration data, please check this page: [Configuring Bebop and the Driver](#). Since v0.4, the package ships with a default camera calibration file located at `bebop_driver/data/bebop_front_calib.yaml`. Both default `node`/`nodelet` launch files, load this file when executing the driver.

### 2.5.2 States (aka Navdata)

Unlike Parrot ARDrone, Bebop does not constantly transmit all on-board data back to the host device with high frequency. Each state variable is sent only when its value is changed. In addition, the publication rate is currently limited to **5 Hz**. The driver publishes these states **selectively** and when **explicitly** enabled through a ROS parameter. For example setting `~states/enable_pilotingstate_flyingstatechanged` parameter to `true` will enable the publication of flying state changes to topic `states/ARDrone3/PilotingState/FlyingStateChanged`. List of all such parameters and their corresponding topics and message types are indexed in the following pages:

**Common States** `autogenerated/common_states_param_topic`

**Bebop-specific States** `autogenerated/ardrone3_states_param_topic`

## 2.6 Configuring Bebop and the Driver

### 2.6.1 Driver Parameters

Following parameters are set during driver's startup:

#### `~bebop_ip`

Sets the IP address of the Bebop. The default value is `192.168.42.1`.

#### `~reset_settings`

Setting this parameter to `true` will reset all Bebop configurations to factory defaults. Default value is `false`.



### ~camera\_info\_url

Sets the location of the camera calibration data. Default is empty string. For more information check [this documentation](#).

---

**Note:** Since v0.4, the package comes with a default camera calibration file located at `bebop_driver/data/bebop_front_calib.yaml`.

---

### ~camera\_frame\_id

Sets the `frame_id` of camera and image messages. Default value is `camera`.

### ~cmd\_vel\_timeout

New in version 0.4.

Sets the safety timeout for piloting `cmd_vel` commands in seconds. Default is set to **0.1** seconds (100 milliseconds). If no piloting command is received by the driver within this timeout period, the driver issues a stop command which causes the drone to hover.

## 2.6.2 Dynamically Reconfigurable Parameters for Bebop

Following ROS parameters change Bebop's settings. They can be tweaked during runtime using [dynamic reconfigure GUI](#). Setting `~reset_settings` parameter to `true` will reset all these settings to factory defaults.

`autogenerated/ardrone3_settings_param`

## 2.7 Coordinate System Conventions

### 2.7.1 ROS Standard Message Types (i.e Twisl) - REP 103

|             |         |
|-------------|---------|
| <b>+x</b>   | forward |
| <b>+y</b>   | left    |
| <b>+z</b>   | up      |
| <b>+yaw</b> | CCW     |

### 2.7.2 Bebop Velocities

|           |       |
|-----------|-------|
| <b>+x</b> | East  |
| <b>+y</b> | South |
| <b>+z</b> | Down  |

### 2.7.3 Bebop Attitude

|             |         |
|-------------|---------|
| <b>+x</b>   | forward |
| <b>+y</b>   | right   |
| <b>+z</b>   | down    |
| <b>+yaw</b> | CW      |

### 2.7.4 SDK's setPilotingPCMD

|               |         |
|---------------|---------|
| <b>+roll</b>  | right   |
| <b>+pitch</b> | forward |
| <b>+gaz</b>   | up      |
| <b>+yaw</b>   | CW      |

## 2.8 Contribute

### 2.8.1 Contribute to bebop\_autonomy

You can contribute to *bebop\_autonomy* by:

- Reporting bugs using driver's [Issue Tracker](#) on Github.
- Submitting patches, new features, sample codes, documentation and supplementary materials (i.e. launch and configuration files) as Github [Pull Requests](#).
  - Please check current [open issues](#) and [Features and Roadmap](#) section for a list of known bugs and feature request.
- Joining driver's [developers forum](#) and participate in technical discussions on new features, bugs and roadmap.

### 2.8.2 List of Developers

- [Mani Monajjemi](#)

### 2.8.3 List of Contributors

- [Anup Parikh](#)
  - #19 Add bebop ip address as ROS parameter
- [Jacob Perron](#)
  - #26 Bebop now follows right-hand rule

### 2.8.4 Acknowledgments

- [Mike Purvis](#) for his help with designing the initial architecture of the driver.

## 2.9 Frequently Asked Questions

### 2.9.1 Is *bebop\_autonomy* based on *ardrone\_autonomy*?

No. *ardrone\_autonomy* is based on Parrot's [legacy SDK](#) for AR-Drone 1.0 and 2.0, while *bebop\_autonomy* uses Parrot's new SDK for its third generation drones. Since these two SDKs and their underlying protocols are totally different and incompatible, we had to develop *bebop\_autonomy* from scratch.

### 2.9.2 Is *bebop\_autonomy* compatible with *ardrone\_autonomy*?

Not completely.

- Topic names, types and coordinate frame conventions for core piloting tasks are identical, however there is no explicit namespacing (i.e. `takeoff` instead of `ardrone/takeoff`)
- *bebop\_autonomy* does not expose services for *Flight Animations* or *Flat Trim*; topics are used instead.
- Front camera video stream is published on `image_raw` topic only.
- Parameter names, types and effects are different.
- AR-Drone *Navdata* is replaced by *Bebop States* (see [States \(aka Navdata\)](#))

## 2.10 Under The Hood

This page contains information about the architecture of the driver and different techniques used for its development.

### 2.10.1 Automatic Code Generation

TBA

### 2.10.2 Threading Model

TBA

### 2.10.3 Publishing States

TBA

### 2.10.4 Configuring the Drone

TBA

## 2.10.5 Tests

### 2.10.6 Upgrading Bebop SDK

1. Update `GIT_TAG` of `ARDroneSDK3` in `bebop_driver/CMakeLists.txt::ExternalProject_Add` to your desired commit hash, branch or tag (release). The official upstream repository is hosted [here](#).
2. Checkout (or browse) the upstream repository at the same hash used in step (1) and open `repos.xml` file. From this file, extract the commit hash of `libARCommands` from `rev` property of this XML tag: `<repo name="libARCommands" rev="" />`.
3. Open `bebop_driver/scripts/meta/generate.py` and update `LIBARCOMMANDS_GIT_HASH` variable to the hash obtained in step (2).
4. Change the working directory to `bebop_driver/scripts/meta`, then execute `generate.py` from command line. This will regenerate all automatically generated message definitions, header files and documents.
5. Copy the generated files to their target locations by calling `install.sh`.
6. In `bebop_driver/include/bebop_driver/autogenerated/ardrone3_setting_callbacks.h` change `ARCONTROLLER_DICTIONARY_KEY_ARDRONE3_PILOTINGSETTINGSSTATE_MAXDISTANCECHANGED_VAL` to `ARCONTROLLER_DICTIONARY_KEY_ARDRONE3_PILOTINGSETTINGSSTATE_MAXDISTANCECHANGED_CURRENT`. This is due to a bug in upstream XML definitions.
7. Remove `build` and `devel` space of your `catkin` workspace, then re-build it.

## 2.11 License

### 2.11.1 Parrot ARDrone3 SDK

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### **2.11.2 bebop\_autonomy (driver and tools)**

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## Indices and tables

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