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# **bebop\_autonomy Documentation**

*Release indigo-devel*

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*bebop\_autonomy* is a ROS (Robot Operating System) driver for [Parrot Bebop 1.0](#) and [2.0](#) drones (quadrocopters), based on Parrot's official [ARDroneSDK3](#). This driver has been developed in [Autonomy Lab](#) of [Simon Fraser University](#) by [Mani Monajjemi](#) and other contributors ([List of Contributors](#)).

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



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## Features and Roadmap

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| Feature                                                            | Status | Notes                                                   |
|--------------------------------------------------------------------|--------|---------------------------------------------------------|
| SDK Version                                                        | 3.10.1 | Since v0.6                                              |
| Support for Parrot Bebop 1                                         | Yes    | Tested up to Firmware 3.3                               |
| Support for Parrot Bebop 2                                         | Yes    | Tested up to Firmware 3.9                               |
| Support for Parrot Disco FPV                                       | No     | Not tested (help wanted)                                |
| Core piloting                                                      | Yes    |                                                         |
| H264 video decoding                                                | Yes    | Enhancement: <a href="#">#1</a>                         |
| ROS Camera Interface                                               | Yes    |                                                         |
| Nodelet implementation                                             | Yes    |                                                         |
| Publish Bebop states as ROS topics                                 | Yes    |                                                         |
| Dynamically reconfigurable Bebop settings                          | Yes    | <a href="#">Configuring the Drone</a>                   |
| Use <a href="#">parrot_arsdk</a> instead of building ARSDK3 inline | Yes    | Since v0.6: <a href="#">#75</a>                         |
| Bebop In The Loop tests                                            | Yes    | <a href="#">Tests</a>                                   |
| Joystick teleop demo                                               | Yes    | sec-pilot-teleop                                        |
| TF Publisher                                                       | Yes    | Since v0.5 ( <a href="#">TF</a> )                       |
| Odometry Publisher                                                 | Yes    | Since v0.5 ( <a href="#">Odometry</a> )                 |
| Provide ROS API for on-board picture/video recording               | Yes    | Since v0.4.1 ( <a href="#">Take on-board Snapshot</a> ) |
| GPS Support                                                        | Yes    | Since v0.6 ( <a href="#">GPS</a> )                      |
| Support for 720p streaming                                         | Yes    | Since v0.6                                              |
| 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

#### 0.6.0 (2016-11-02)

- Use Parrot ARSDK as a thirdparty dependency - Instead of building the SDK inline, bebop\_driver now utilizes the catkin version of Parrot ARSDK available at [https://github.com/AutonomyLab/parrot\\_arsdk](https://github.com/AutonomyLab/parrot_arsdk) and in a binary form via the ROS buildfarm: `ros-<DISTRO>-parrot-arsdk`
- Rename liblibbebop to libbebop
- Full SDK 3.10.x support - ROS API change: `states/ARDrone3/..` topics renamed to `states/ardrone3/..`
- Disabling video stabilization works with Firmware 3.9 (tested on Bebop

2.

- Camera control API fix for SDK 3.10.x
- Refactor H264 decode class to support dynamic picture size - Add support for determining picture size from the stream - Add dynamic buffer re-allocation on picture size change
- Use `av_frame_alloc()` instead of the depr. `avcodec_alloc_frame()`
- Fix inconsistent SDK 3.10.1 key values
- Update autogenerated msgs/headers/docs to SDK 3.10.1
- CMake: fix dynamic reconfigure dependency bug
- Rename topic 'navigate\_home' to 'autoflight/navigate\_home'
- Add autonomous flight plans
- Contributors: Jacob Perron, Mani Monajjemi

#### 0.5.1 (2016-05-04)

- Add bebop\_description as a build dep to bebop\_driver (fixes #45)
- Fix inline build of arsdk to use the frozen manifest (fixes #46) - Prior to this release, the build script would always compile the development branch of ARSDK. This fix ensures that instead of *default.xml* manifest file -

which represents the dev version of ARSDK package - *release.xml* is used by *repo*. This manifest file includes a certain hash for each ARSDK package that enforces a consistent build for ARSDK.

- Contributors: Mani Monajjemi

### 0.5.0 (2016-04-01)

- Based on Parrot ARSDK 3.8.3. Tested with Bebop 1.0 (2.0.57) and Bebop 2.0 (3.1.0)
- Update to SDK 3.8.3 - SDK 3.8.3 from [https://github.com/Parrot-Developers/arsdk\\_manifests.git](https://github.com/Parrot-Developers/arsdk_manifests.git) - SDK 3.8.3 git hash: 2930cc7f7a79173d51c1fc167475fa9fa6650def
- Add support for VideoStream v2.0
- Publish TF
- Experimental implementation of odometry (pose, velocity)
- Publish the GPS fix as a ROS standard message (closes #39) - Message type: sensor\_msgs/NavSatFix - Topic: fix
- Add joint state publisher for camera's pan/tilt - Add a new param to enable/disable the TF publisher for odom - Add a new param to set the odom frame id
- Include bebop\_description and robot\_state\_publisher in driver's launch files
- Add proper limitations for camera's pan/tilt joints
- Add explicit linkage to libav (fixes #32)
- Fix libav API inconsistency issues #30 #35 #36
- Improve H264 parameter update method - Implement a better way to pass SPS/PPS params to H264 decoder (SDK 3.8.x)
- Add a new CMake option "RUN\_HARDWARE\_TESTS" to explicitly enable hardware in the loop testing (disabled by default)
- Contributors: Mani Monajjemi, chartoin, Jake Bruce

### 0.4.1 (2016-02-17)

- Add ROS API for recording on-board picture/video (closes #5)
- Add a new ROS topic for taking on-board snapshot: *snapshot*
- Add a new ROS topic for toggling on-board video recording: *record*
- Update the docs
- Add curl as a rosdep build dep (fixes #33)
- Fix a bug in bebop\_driver's nodelet destructor
- Fix a bug in ASyncSub class
- Contributors: Mani Monajjemi

### 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 rosparm 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 propagate 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
- Integrate 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**

### **0.6.0 (2016-11-02)**

- Added Xbox 360 config file
- Make flattrim joystick command match comment
- Contributors: Jacob Perron, Thomas Bamford

#### 0.5.1 (2016-05-04)

#### 0.5.0 (2016-04-01)

- Improve the organization of launch and param files
- Contributors: Mani Monajjemi

#### 0.4.1 (2016-02-17)

- Update the joystick configuration file for taking snapshots
- Make bebop's namespace in joy\_teleop launch file a parameter
- Contributors: Mani Monajjemi

#### 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

#### 0.6.0 (2016-11-02)

- Update autogenerated msgs/headers/docs to SDK 3.10.1
- Contributors: Mani Monajjemi

### 0.5.1 (2016-05-04)

### 0.5.0 (2016-04-01)

- Update to SDK 3.8.3 - SDK 3.8.3 from [https://github.com/Parrot-Developers/arsdk\\_manifests.git](https://github.com/Parrot-Developers/arsdk_manifests.git) - SDK 3.8.3 git hash: 2930cc7f7a79173d51c1fc167475fa9fa6650def
- Contributors: Mani Monajjemi

### 0.4.1 (2016-02-17)

- Fix dynamic\_reconfigure's inconsistency - The inconsistency was between the filename and the target name
- Contributors: Mani Monajjemi

### 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

## 2.1.4 Changelog for package bebop\_description

0.6.0 (2016-11-02)

0.5.1 (2016-05-04)

0.5.0 (2016-04-01)

- The initial version of bebop\_description package - Add a simple kinematic model of Bebop as URDF/Xacro (base\_link, camera joints and the optical frame)
- Contributors: Mani Monajjemi

0.4.1 (2016-02-17)

0.4.0 (2016-01-17)

0.3.0 (2015-09-17)

0.2.0 (2015-09-10)

0.1.2 (2015-09-05)

0.1.1 (2015-09-04)

## 2.2 Installation

### 2.2.1 Compiling From Source

Pre-requirements:

- ROS *Indigo*, *Jade* or *Kinetic* (Only tested on *Ubuntu*)
- 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.

---

**Note:** Since version 0.6, [Parrot ARSDK](#), the main underlying dependency of *bebop\_autonomy* is not build inline anymore. Instead, the slightly patched and catkinized version of it, called [parrot\\_arsdk](#), is fetched as a dependency during the `rosdep install` step below. This dramatically decreases the compile time of the package compared to previous versions (e.g. from ~15 minutes to less than a minute on a modern computer). If you are re-compiling from source, you need to clean your workspace first: `$ catkin clean [-y]`.

---

```
# 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 (including parrot_arsdk)
$ rosdep update
$ rosdep install --from-paths src -i
# Build the workspace
$ catkin build -DCMAKE_BUILD_TYPE=RelWithDebInfo
```

## 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.

---

**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]`)

---

---

**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>
  <arg name="namespace" default="bebop" />
  <arg name="ip" default="192.168.42.1" />
  <arg name="config_file" default="$(find bebop_driver)/config/defaults.yaml" />
  <arg name="camera_info_url" default="package://bebop_driver/data/bebop_camera_calib.yaml" />
  <group ns="$(arg namespace)">
    <node pkg="bebop_driver" name="bebop_driver" type="bebop_driver_node" output="screen">
      <param name="camera_info_url" value="$(arg camera_info_url)" />
      <param name="bebop_ip" value="$(arg ip)" />
      <rosparam command="load" file="$(arg config_file)" />
    </node>
    <include file="$(find bebop_description)/launch/description.launch" />
  </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 -->
  <arg name="namespace" default="bebop" />
  <include file="$(find bebop_driver)/launch/bebop_nodelet.launch">
    <arg name="namespace" value="$(arg namespace)" />
  </include>
  <!-- use the same nodelet manager and namespace, then load image_view nodelet -->
  <group ns="$(arg namespace)">
    <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>
```

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

```
<?xml version="1.0"?>
<launch>
  <arg name="namespace" default="bebop" />
  <arg name="ip" default="192.168.42.1" />
  <arg name="config_file" default="$(find bebop_driver)/config/defaults.yaml" />
  <arg name="camera_info_url" default="package://bebop_driver/data/bebop_camera_calibration.yaml" />
  <group ns="$(arg namespace)">
    <!-- 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="$(arg camera_info_url)" />
      <param name="bebop_ip" value="$(arg ip)" />
      <rosparam command="load" file="$(arg config_file)" />
    </node>
    <include file="$(find bebop_description)/launch/description.launch" />
  </group>
</launch>
```

## 2.4 Sending Commands to Bebop

**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 zero 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`.

The `linear.x` and `linear.y` parts of this message set the **pitch** and **roll** angles of the Bebop, respectively, hence control its forward and lateral accelerations. The resulting pitch/roll angles depend on the value of `~PilotingSettingsMaxTiltCurrent` parameter, which is specified in degrees and is dynamically reconfigurable (*Dynamically Reconfigurable Parameters for Bebop*).

The `linear.z` part of this message controls the **vertical velocity** of the Bebop. The resulting velocity in m/s depends on the value of `~SpeedSettingsMaxVerticalSpeedCurrent` parameter, which is specified in meters per second and is also dynamically reconfigurable (*Dynamically Reconfigurable Parameters for Bebop*). Similarly, the `angular.z` component of this message controls the rotational velocity of the Bebop (around the z-axis). The corresponding scaling parameter is `SpeedSettingsMaxRotationSpeedCurrent` (in degrees per sec).

|                                |                                          |
|--------------------------------|------------------------------------------|
| <code>roll_degree</code>       | <code>= linear.y * max_tilt_angle</code> |
| <code>pitch_degree</code>      | <code>= linear.x * max_tilt_angle</code> |
| <code>ver_vel_m_per_s</code>   | <code>= linear.z * max_vert_speed</code> |
| <code>rot_vel_deg_per_s</code> | <code>= angular.z * max_rot_speed</code> |

## 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.

|                        |     |           |
|------------------------|-----|-----------|
| <code>angular.y</code> | (+) | tilt down |
|                        | (-) | tilt up   |
| <code>angular.z</code> | (+) | pan left  |
|                        | (-) | pan right |

## 2.4.6 GPS Navigation

### Start Flight Plan

An autonomous flight plan consists of a series of GPS waypoints along with Bebop velocities and camera angles encoded in an XML file.

Requirements that must be met before an autonomous flight can start:

- Bebop is calibrated
- Bebop is in outdoor mode
- Bebop has fixed its GPS

To start an autonomous flight plan, publish a message of type `std_msgs/String` to `autoflight/start` topic. The `data` field should contain the name of the flight plan to execute, which is already stored on-board Bebop.

---

**Note:** If an empty string is published, then the default 'flightplan.mavlink' is used.

---

**Warning:** If not already flying, Bebop will attempt to take off upon starting a flight plan.

The [Flight Plan App](#) allows easy construction of flight plans and saves them on-board Bebop.

An FTP client can also be used to view and copy flight plans on-board Bebop. *FileZilla* is recommended:

```
$ sudo apt-get install filezilla
$ filezilla
```

Then open *Site Manager* (top left), click *New Site*:

- *Host*: 192.168.42.1
- *Protocol*: FTP
- *Encryption*: Use plain FTP
- *Logon Type*: Anonymous
- Connect.

## Pause Flight Plan

To pause the execution of an autonomous flight plan, publish a message of type `std_msgs/Empty` to `autoflight/pause` topic. Bebop will then hover and await further commands. To resume a paused flight plan, publish the same message that was used to start the autonomous flight (ie. to the topic `autoflight/start`). Bebop will fly to the lastest waypoint reached before continuing the flight plan.

---

**Note:** Any velocity commands sent to Bebop during an autonomous flight plan will pause the plan.

---

## Stop Flight Plan

To stop the execution of an autonomous flight plan, publish a message of type `std_msgs/Empty` to `autoflight/stop` topic. Bebop will hover and await further commands.

## Navigate Home

To ask Bebop to autonomously fly to it's home position, publish a message of type `std_msgs/Bool` to `autoflight/navigate_home` topic with the `data` field set to `true`. To stop Bebop from navigating home, publish another message with `data` set to `false`.

**Warning:** The topic has changed from `navigate_home` to `autoflight/navigate_home` after version 0.5.1.

## 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     |

## 2.4.9 Take on-board Snapshot

New in version 0.4.1.

To take a high resolution on-board snapshot, publish a `std_msgs/Empty` message on `snapshot` topic. The resulting snapshot is stored on the internal storage of the Bebop. The quality and type of this image is not configurable using the ROS driver. You can use the official FreeFlight3 app to configure your Bebop prior to flying. To access the on-board media, either connect your Bebop over USB to a computer, or use a FTP client to connect to your Bebop using the following settings:

- Default IP: 192.168.42.11
- Port: 21
- Path: `internal_000/Bebop_Drone/media`
- Username: `anonymous`
- Password: *<no password>*

## 2.4.10 Toggle on-board Video Recording

New in version 0.4.1.

To start or stop on-board high-resolution video recording, publish a `std_msgs/Bool` message on the `record` topic. The value of `true` starts the recording while the value of `false` stops it. Please refer to the previous section for information on how to access the on-board recorded media.

# 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 Standard ROS messages

### Odometry

New in version 0.5.

- ROS Topic: `odom`
- ROS Message Type: `nav_msgs/Odometry`

The driver integrates visual-inertial velocity estimates reported by Bebop's firmware to calculate the odometry. This message contains both the position and velocity of the Bebop in an ENU aligned odometry frame also named as `odom`. This frame name is configurable (see *Driver Parameters*) The coordinate frame convention complies with ROS REP 103 (*ROS Standard Message Types (i.e Twist, Odometry) - REP 103*). Please note that since odometry is calculated from Bebop States (see *States (aka Navdata)*), the update rate is limited to **5 Hz**.

## GPS

New in version 0.5.

- ROS Topic: `fix`
- ROS Message Type: `sensor_msgs/NavSatFix`

## Joint States (Pan/Tilt of The Virtual Camera)

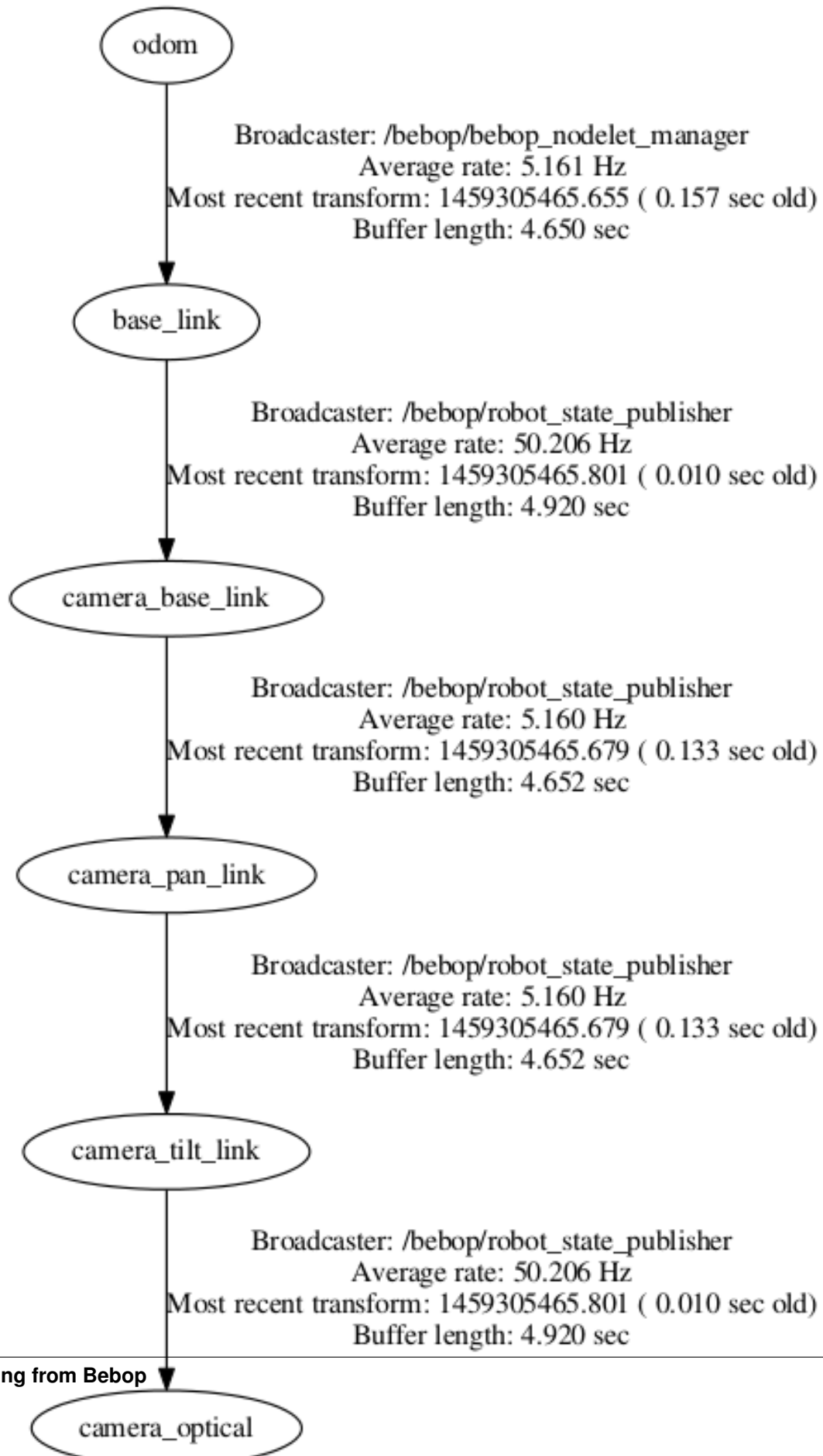
New in version 0.5.

- ROS Topic: `joint_states`
- ROS Message Type: `sensor_msgs/JointState`

## 2.5.3 TF

New in version 0.5.

The driver updates the following **TF** tree based on a simple kinematic model of the Bebop (provided by `bebop_description`) package, the current state of the virtual camera joints and the calculated odometry (if `publish_odom_tf` is set, see *Driver Parameters*).



## 2.5.4 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`.

---

#### `~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.

#### `~odom_frame_id`

New in version 0.5.

Sets the `frame_id` of the odometry message (see [Standard ROS messages](#)) and the odometry frame used in the TF tree (see [TF](#)). The default value is `odom`.



### `~publish_odom_tf`

New in version 0.5.

Enables the publishing of `odom` to `base_link` TF transform (see [TF](#)). The default value is `true`.

### `~camera_frame_id`

Deprecated since version 0.5.

Sets the `frame_id` of camera and image messages. The default value is `camera_optical`.

## 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 Twist, Odometry) - REP 103

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

- More information: <http://www.ros.org/reps/rep-0103.html>

### 2.7.2 Bebop Velocities

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

### 2.7.3 Bebop Attitude

|                   |         |
|-------------------|---------|
| <code>+x</code>   | forward |
| <code>+y</code>   | right   |
| <code>+z</code>   | down    |
| <code>+yaw</code> | 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
  - #57 Add autonomous flight plan capabilities to driver
- [Jake Bruce](#)
- [Charuvahan Adhivarahan](#)
  - #30 Fixed breaking build due to legac macro usage
- [Thomas Bamford](#)
  - Added Xbox 360 config file
- [Sepehr Mohaimenianpour](#)

### 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 the States

TBA

### 2.10.4 Configuring the Drone

TBA

## 2.10.5 Tests

### Enabling Bebop In The Loop Tests

```
$ cd /path/to/bebop_ws
$ catkin clean --cmake-cache
$ catkin build bebop_driver --cmake-args -DRUN_HARDWARE_TESTS=ON
```

### Running Bebop In The Loop Tests

**Warning:** Bebop in the loop tests perform live unit tests with a real robot. Please proceed with caution and execute the tests in an area with at least 5 meters of clearance radius (empty space) around the Bebop.

```
$ cd /path/to/bebop_ws/build/bebop_driver
$ make tests
$ rostest --text bebop_driver bebop_itl_test.test
```

## 2.10.6 Upgrading the Bebop SDK

**Warning:** Since version 0.6, [Parrot ARSDK](#), the main underlying dependency of *bebop\_autonomy* is not build inline anymore. Instead, the slightly patched and catkinized version of it, called [parrot\\_arsdk](#), is fetched as a dependency. **The following documentation needs to be updated.**

1. Update the `GIT_TAG` of `ARDroneSDK3` in `bebop_driver/CMakeLists.txt::add_custom_target::./repo init ... -b GIT_TAG` 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 `release.xml` file. From this file, extract the commit hash of `arsdk-xml` from the revision property of this XML tag: `<project name="arsdk-xml" ... revision="" />`.
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 the 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 the following variables:
  - `ARCONTROLLER_DICTIONARY_KEY_ARDRONE3_PILOTINGSETTINGSSTATE_MAXDISTANCECHANGED_VALUE` to `ARCONTROLLER_DICTIONARY_KEY_ARDRONE3_PILOTINGSETTINGSSTATE_MAXDISTANCECHANGED_CURRENT`
  - `ARCONTROLLER_DICTIONARY_KEY_ARDRONE3_PILOTINGSETTINGSSTATE_BANKEDTURNCHANGED_VALUE` to `ARCONTROLLER_DICTIONARY_KEY_ARDRONE3_PILOTINGSETTINGSSTATE_BANKEDTURNCHANGED_STATE`
  - `ARCONTROLLER_DICTIONARY_KEY_ARDRONE3_PILOTINGSETTINGSSTATE_CIRCLINGRADIUSCHANGED_VALUE` to `ARCONTROLLER_DICTIONARY_KEY_ARDRONE3_PILOTINGSETTINGSSTATE_CIRCLINGRADIUSCHANGED_CURR`
  - `ARCONTROLLER_DICTIONARY_KEY_ARDRONE3_PILOTINGSETTINGSSTATE_CIRCLINGALTITUDECHANGED_VAL` to `ARCONTROLLER_DICTIONARY_KEY_ARDRONE3_PILOTINGSETTINGSSTATE_CIRCLINGALTITUDECHANGED_CU`

These changes are required because the upstream XML file is inconsistent for a couple of variable names.

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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