Knocking my neighbor’s kid’s cruddy drone offline.

michael robinson
First, a shout out...

Alan Mitchell
Ron McGuire
Chris Taylor
Katie Herritage
My neighbor.

Sigh.

My neighbor’s kid.

Double sigh.
My neighbor.

Sigh.

My neighbor’s kid.

Double sigh.

Way too much discretionary spending.
My initial response:
But that got me thinking...
What if this showed up?
Or if this showed up?
Now there are LOTS of regulations governing the flying of Unmanned Aircraft Systems.
Most laws restrict:

1. Government/law enforcement’s use
2. Commercial use (FAA needs to authorize.)
Non-commercial, private (hobbyist) use largely not regulated YET.
Some current regulations on UAS:

1. **No fly zones:**
   1. Around Washington, DC (15 mi radius)
   2. Around airports (5 mi radius)
   3. On military bases
2. Cannot launch, land, or crash in a national park. Technically, air space is not National Park Service’s (NPS) to regulate; however, NPS can get you for safety (reckless endangerment) and noise issues.
3. Temporary Flight Restrictions within the area of a disaster, wildfire, stadium/sporting event, or Presidential visit.
4. Cannot mount a gun on a UAS – it becomes a weapon system.
5. 400 foot ceiling
6. Line of site
7. Sixteen states have enacted their own laws.
Requirements to Qualify as a Model Aircraft under the FAA Modernization and Reform Act of 2012 (P.L. 112-95, section 336)

Section 336 also prohibits the FAA from promulgating “any rule or regulation regarding a model aircraft, or an aircraft being developed as a model aircraft” if the following statutory requirements are met:

• the aircraft is flown strictly for hobby or recreational use;
• the aircraft is operated in accordance with a community-based set of safety guidelines and within the programming of a nationwide community-based organization;
• the aircraft is limited to not more than 55 pounds unless otherwise certified through a design, construction, inspection, flight test, and operational safety program administered by a community-based organization;
• the aircraft is operated in a manner that does not interfere with and gives way to any manned aircraft; and
• when flown within 5 miles of an airport, the operator of the aircraft provides the airport operator and the airport air traffic control tower ... with prior notice of the operation....
No Fly Zones in the Eastern U.S.
Recordings automatically uploaded via Bebop controller apps.*

* It wasn’t until app version 3.5.9 that it was possible to set the Academy flights to private by default.
A quick comparison

2,000 in DC

2,000 in NYC
That’s nice and all, but...
My neighbor’s kid is **STILL** annoying, and I want to know...
Is there a way to force a drone/quadcopter to land?
Maybe something more subtle?
Let’s take a look.
Parrot Bebop Drone Specifications

- Parrot P7 dual-core CPU; Quad-core GPU
- 8 GB of Flash Memory
- Top horizontal speed: ~45mph
- OS: Runs on Linux with SDK
- 2 dual-band Wi-Fi antennas
- Integrated GNSS type GPS chip/Glonass
- Operates on both 2.4 GHz and 5 GHz MIMO frequencies.
- Generates its own Wi-Fi 802.11 network
- Optional Skycontroller (2 km range)
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- Optional Skycontroller (2 km range)
Parrot Bebop Drone Updates

Updates to the FreeFlight 3 app, the optional Skycontroller, and to the Bebop Drone are not processed via the app store.

The app does a lookup on Parrot’s website and notifies the user of an update.

The user can ignore the update and still fly the Bebop Drone.
Parrot Bebop Drone Specifications

Return Home Feature

Altitude: >10 meters
Bebop Drone returns directly to its starting position.

Altitude: <= 10 meters
It will rise and stabilize itself at 10 meters before returning to its take-off position in a straight line.

Once it has reached its take-off position, it will stop and hover 2 meters above the ground.
Parrot Bebop Drone Specifications

Lost Connectivity:

If the connection between the smartphone/controller and the Parrot Bebop Drone is lost, the Parrot Bebop Drone will return to its starting point automatically after 30 seconds of disconnection.*

* Based on firmware update 2.0.28
Parrot Bebop Drone Specifications

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* Based on firmware update 2.0.28
Hmmm....
What happens, if we:
1. “Disrupt” Wi-Fi signal from controller?
2. “Disrupt” GPS signal?
3. Introduce a magnetic field?
Disrupting the Wi-Fi signal
Paired connections:
1. iPad to drone (Wi-Fi)
2. App to app

As seen by a Pineapple router
Introduce a little mischief
Paired connections:
1. iPad to drone (Wi-Fi)
2. App to app

Continuous deauth for 30 seconds invokes landing sequence!

The “Return to Home” function is not invoked!
It looks like this...
What else?
Flying Wireless Access Point

Default Name: BebopDrone-#####

IP Address: 192.168.42.1
Subnet Mask: 255.255.255.0
DHCP Enabled

Security: Open
MAC address: a0:14:3d:##:##:##

Wi-Fi Channel: 9

As seen by NMAP

<table>
<thead>
<tr>
<th>Port</th>
<th>State</th>
<th>Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>21/tcp</td>
<td>open</td>
<td>ftp</td>
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<td>23/tcp</td>
<td>open</td>
<td>telnet</td>
</tr>
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It’s a flying FTP server!
Bebop Drone
Running BusyBox v 1.20.2 (rel. July 2, 2012)
FTP server

/\internal_000/
   Bebop_Drone
      academy
      media
      thumb
   Debug
      archive
      crash_reports
      current
      cksm
   flightplans
   gps_data
   log
   lost+found
   scripts

Bebop_Drone_2015-07-22T111815+0000_3B205A.mp4
Bebop_Drone_2015-07-22T111815+0000_3B205A.mp4.jpg
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Bebop_Drone_2015-07-22T111815+0000_3B205A.mp4
Bebop_Drone_2015-07-22T111815+0000_3B205A.mp4.jpg

I replaced his pictures of naked girls with...
U
JUST
GOT
RICK
ROLLED
Maybe something more...
...and then there is telnet.

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Subnet Mask: 255.255.255.0
DHCP Enabled

Security: Open
MAC address: a0:14:3d:##:##:##

Wi-Fi Channel: 9
Here is a shortened list of directories and files available via telnet:

bin
  ardone3_fvt6.sh
  ardone3_shell.sh
  ardone3_shutdown.sh
  ardrone3_stop.sh
  asix_setup.sh
  colibrySend.sh
  common_check_update.sh
  gps_connect.sh
  data
  dragon.conf
  fvt6.txt
  magneto_calibration.conf
  system.conf
  data_us
  debugfs
  dev
  etc
  factory
  home
  lib
  proc
  sbin
  sys
  tmp
  core
  emmc_status
  gps_debug
  gps_easy_cmd
  gps_nmea_in
  gps_nmea_out
  log
  mac_address.txt
  run
  temp_gyro
  udev
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```
bin
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    magneto_calibration.conf
    system.conf
  data_us
  debugfs
  dev
  etc
factory
home
lib
proc
sbin
sys
tmp
core
eMMC_status
gps_debug
gps_easy_cmd
gps_nmea_in
gps_nmea_out
log
mac_address.txt
run
temp_gyro
udev
update
usr
var
version.txt
www
```

Really?
The following was entered while the Bebop drone was in flight!

telnet 192.168.42.1
The following was entered while the Bebop drone was in flight!

telnet 192.168.42.1
#

The following was entered while the Bebop drone was in flight!

telnet 192.168.42.1
# ardrone3_shutdown.sh
The following was entered while the Bebop drone was in flight!

telnet 192.168.42.1
# ardrone3_shutdown.sh
shutdown: Shutdown Dragon
shutdown: Asking Dragon to stop...
shutdown: Stopping users of eMMC
eMMC_release: Releasing eMMC...
MTP: stopping service
shutdown: Synchronise filesystems
eMMC_umount: Umounting eMMC...
Connection closed by foreign host.
In case you missed it.
Let’s just take the damned thing!
Paired connections:
1. iPad to drone (Wi-Fi)
2. App to app

Paired connections:
1. iPhone to drone
2. App cannot connect

Multiple devices can connect to the Bebop drone at the same time!
Bebop Drone hovering as seen by an iPad.
Bebop Drone hovering as seen by the iPhone at the same time.
A little more mischief
Paired connections:
1. iPad to drone (Wi-Fi)
2. App to app

Paired connections:
1. iPhone to drone
2. App cannot connect
Paired connections:
1. iPad to drone (Wi-Fi)
2. App to app

Deauth

Paired connections:
1. iPhone to drone
2. App cannot connect
At this point he’s having a bad day.
Establish a race condition. Who will reconnect faster?

A. The pilot
B. You, who has your finger on the connect button
Bebop Drone hovering as seen by an iPad.

Frozen screen!
Bebop Drone hovering as seen by the iPhone!

Note the altitude.
Paired connections:
1. iPad to drone (Wi-Fi)
2. App cannot connect

Paired connections:
1. iPhone to drone
2. App to App
Bebop Drone hovering as seen by an iPhone!

A very bad day!
When the device running FreeFlight 3 was disconnected, the device did not always re-connect to the Bebop drone by default.
Parrot Bebop can come with a Skycontroller.
Paired connections:
1. iPad to Skycontroller
2. Skycontroller to drone
3. App to drone
Paired connections:
1. iPad to Skycontroller
2. Skycontroller to drone
3. App to drone

Paired connection:
1. iPhone to drone, or
2. iPhone to Skycontroller
Bebop Drone after hijack and crash as seen by an iPhone.

This button would transfer control from the iPhone to the Skycontroller.
Disrupting the GPS signal.
# Frequencies used by GPS

<table>
<thead>
<tr>
<th>Band</th>
<th>Frequency (MHz)</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>1,575.42</td>
<td>Course/Acquisition L1 Civilian (L1C) Military (M) code</td>
</tr>
<tr>
<td>L2</td>
<td>1,227.60</td>
<td>L2 Civilian (L2C) Military (M) code</td>
</tr>
<tr>
<td>L3</td>
<td>1,381.05</td>
<td>Nuclear/research</td>
</tr>
<tr>
<td>L4</td>
<td>1,379.913</td>
<td>Research</td>
</tr>
<tr>
<td>L5</td>
<td>1,176.45</td>
<td>Safety-of-Life (SoL) Data and Pilot</td>
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<td>L1OF, L1SF</td>
<td>1,602</td>
<td>FDMA signals</td>
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<td>LSOF, L2SF</td>
<td>1,246</td>
<td>CDMA signals</td>
</tr>
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<td>L1OC, L1SC</td>
<td>1,600.995</td>
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</tr>
<tr>
<td>L2OC, L2SC</td>
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<tr>
<td>L3OC, L3SC</td>
<td>1,202.025</td>
<td></td>
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One teeny, tiny little problem:
47 U.S.C. 333 – Willful or Malicious Interference

No person shall willfully or maliciously interfere with or cause interference to any radio communications of any station licensed or authorized by or under this Act or operated by the United States Government.

Communications Act of 1934

For radio communications, it is illegal to operate, manufacture, import, or offer for sale, including advertising.

Blocking radio communications in public can carry fines of up to $11,000 or imprisonment of up to one year.

Penalties

The FCC may impose monetary forfeitures of up to $16,000 for each day of such continuing violation up to a maximum forfeiture of $112,500 for any single act or failure to act.
Federal law prohibits the operation, marketing, or sale of any type of jamming equipment, including devices that interfere with cellular and Personal Communication Services (PCS), police radar, Global Positioning Systems (GPS), and wireless networking services (Wi-Fi).

*Jamming devices create serious safety risks. In the coming weeks and months, we’ll be intensifying our efforts through partnerships with law enforcement agencies to crack down on those who continue to violate the law. Through education, outreach, and aggressive enforcement, we’re tackling this problem head on.*
--- P. Michele Ellison, Chief, Enforcement Bureau
What to do?
## Frequencies used by GPS

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</table>
Effective range

20m
If the GPS signal were to be lost, the “return to home” feature immediately fails.
If the “return to home” sequence has been started, the Bebop drone will stop the sequence and hover.

The starting point is not overwritten.
Introducing a magnetic field.
No observable effect
Taking over a Bebop will leave artifacts on your phone, e.g., serial number of drone.

com.parrot.freeflight3\Library\Preferences\com.parrot.freeflight3.plist
What about something bigger?
Not that big.
DJI Phantom 3 Specifications

The signal transmission distance will vary depending on environmental conditions, but the Phantom 3 series can reach distances of up to 1.2 miles (2 kilometers) away from the pilot.

When operating in P-mode, height limits, distance limits, and No-Fly Zones function concurrently to manage flight safety.

In A-mode, only height limits are in effect, which by default prevent the aircraft altitude from exceeding 1,640 feet (500 m).

Top horizontal speed: ~35mph
DJI Phantom 3 Specifications

If the aircraft enters the restricted area in A-mode, but is switched to P-mode, the aircraft will automatically descend, land, and stop its motors.

GPS augmented with GLONASS, a Russian equivalent of GPS.

DJI App Pilot Prompt:
Warning: You are in a no-fly zone.

Action:
Automatic landing has begun.
DJl Phantom 3 Specifications

The compass is very sensitive to electromagnetic interference, which can produce abnormal compass data and lead to poor flight performance or flight failure.

Regular calibration is required for optimal performance.
The compass is very sensitive to electromagnetic interference, which can produce abnormal compass data and lead to poor flight performance or flight failure.

Regular calibration is required for optimal performance.
DJI Phantom 3 Updates

Updates to the DJI Pilot app and to the Phantom III are not processed via the app store.

The app does a lookup on DJI’s website and notifies the user of an update.

The user cannot ignore the update.
Disrupting the Wi-Fi signal.
Unlike the Bebop, the Phantom III does not use Wi-Fi for communication.
Disrupt GPS signal
The DJI app (DJI Pilot) maintains a database of no fly zones.

On iOS devices it is a database called .flysafeplaces.db

As of July 24, 2015, it contained 10,914 entries with:

- Latitude and longitude
- Country ID
- City
- Name of location, e.g., White House
- The radius around the location
- Shape (typically a circle)
- Warning - bit
- Disable - bit
- Update timestamp
Normal signal from DJI Phantom III regarding GPS signal
GPS signal lost nearly instantly. Device starts to drift!
Normal video channels from DJI Phantom III
Videos channels are listed as “unstable.” Video still comes through but there is jitter.
If GPS signals were “disrupted”,
when the Phantom III was flying outdoors
or when the “Return to Home” feature was in use,
flying became problematic...
especially in wind!
Introduce a magnetic field.
A magnetic field near the Phantom III prior to take off always required re-calibration to be performed.
## Results

<table>
<thead>
<tr>
<th></th>
<th>Parrot Bebop</th>
<th>Parrot Bebop with Skycontroller</th>
<th>DJI Phantom III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wi-Fi Deauth</td>
<td>Hi-jack possible</td>
<td>Hi-jack possible</td>
<td>N/A</td>
</tr>
<tr>
<td>GPS interference</td>
<td>RTH stopped functioning</td>
<td>RTH stopped functioning</td>
<td>Difficult to control once moving; Drifting; RTH problems; video interference</td>
</tr>
<tr>
<td>Magnetic Field</td>
<td>N/A</td>
<td>N/A</td>
<td>No take off; recalibration</td>
</tr>
<tr>
<td>Shotgun</td>
<td>Flight problems</td>
<td>Flight problems</td>
<td>Flight problems</td>
</tr>
</tbody>
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References

Association for Unmanned Vehicle Systems International
http://www.auvsi.org

DJI
http://www.dji.com

Drone Law
http://dronelaw.net

Drone Law Journal
http://dronelawjournal.com

FAA
http://www.faa.gov/uas/media/model_aircraft_spec_rule.pdf

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http://knowbeforeyoufly.org

Mapbox – Don’t Fly Drones Here Map
https://www.mapbox.com/blog/dont-fly-here/

Parrot – Wi-Fi channels

Unmanned Aviation News
http://www.suasnews.com
<table>
<thead>
<tr>
<th>Channels</th>
<th>Indoor use</th>
<th></th>
<th></th>
<th></th>
<th>Outdoor use</th>
<th></th>
<th></th>
<th></th>
</tr>
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<tbody>
<tr>
<td></td>
<td>2.4GHz</td>
<td>5.1GHz</td>
<td>5.8GHz</td>
<td>5.5GHz</td>
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<td>5.5GHz</td>
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<tr>
<td>Frequency (MHz)</td>
<td>2432</td>
<td>5150-5250</td>
<td>5725-5825</td>
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<td>5150-5250</td>
<td>5725-5825</td>
<td>5725-5825</td>
</tr>
<tr>
<td>US</td>
<td>4W</td>
<td>1W</td>
<td>4W</td>
<td>4W</td>
<td>4W</td>
<td>1W</td>
<td>4W</td>
<td></td>
</tr>
<tr>
<td>Europe</td>
<td>100mW</td>
<td>200mW</td>
<td>Forbidden</td>
<td>100mW</td>
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<tr>
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<td>200mW</td>
<td>2W</td>
<td>100mW</td>
<td>Forbidden</td>
<td>2W</td>
<td></td>
<td></td>
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<tr>
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<td>4W</td>
<td>200mW</td>
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Knocking my neighbor’s kid’s cruddy drone offline.

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^

michael robinson
gimmethepresentation@gmail.com