Wireless Communication Technologies For Drones
〜Application to Safety Operations of Drones Beyond Line-Of-Sight〜

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Beyond LOS (Line-of-Sight) Operations in Mountain or Urban Areas

- **Good radio condition at high altitude**
- **Beyond LOS**
- **Poor radio condition at low altitude**
  - No control!
  - No telemetry!
- **Descend for missions**
- **Aerial photo**
- **Logistics**
- **Infra-structure maintenance**
  - Descend for missions
(1) Multi-hop Remote Control Communication “Command Hopper”

Research target

To remotely control beyond-LOS drones or robots by cooperation with nearby robots with continuity even with disasters(*).

Obstacles to attenuate or block radios

Buildings, walls, trees, or mountains

Operator (GCS)

Specifications

<table>
<thead>
<tr>
<th></th>
<th>Normal Mode</th>
<th>Backup Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freq. band</td>
<td>920MHz</td>
<td>169MHz</td>
</tr>
<tr>
<td>Transmitting Power</td>
<td>&lt; 20mW</td>
<td>Air.&lt;10mW Ground&lt;1W</td>
</tr>
<tr>
<td>Data rate</td>
<td>~50 kbps</td>
<td>~20kbps</td>
</tr>
<tr>
<td>Latency</td>
<td>~60msec</td>
<td>~2.6 sec</td>
</tr>
<tr>
<td>Size</td>
<td>96 x 93 x 31.7 mm (w/o antenna, battery)</td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td>~340g (w/o antenna, battery)</td>
<td></td>
</tr>
</tbody>
</table>

(*) Cell phone networks would be disabled due to the power outage or physical damages

※ This research is supported by the project “Tough Robotics Challenge” in the ImPACT Program of the Cabinet Office.
Field Test 1  
(Nov. 2016)

Ultra-high speed relay route switching from 1 hop to 3 hops  
(switching latency ~ 50-60 msec)

GCS (fixed on pole)  
Relay stn. 1  
(fixed on pole)  
Relay stn. 2  
(onboard UGV)  
Terminal stn.  
(onboard drone)

1 hop (Direct)  
2 hop  
3 hop
Field Test 2 (Jun. 2017)

Successfully achieved take-off and ascending from the ground beyond line-of-sight

Relay drone

Target drone

GCS

BLOS

Take-off from low ground behind the thick trees

Telemetry information received via multi-hop transmission

Command

Telemetry

Command

Telemetry
Field Test of Multi-hop Drone Control
(Nov. 2016@Aobayama Campus, Tohoku Univ.)

A drone flying away via 3-hop C2 link
(2) Location Information Distribution Network for Aerial Vehicles “Drone Mapper”

Research target

To share the location and ID information among nearby drones and manned helicopters within the area of 1〜2km.

Features

- Base on Infra-less decentralized D2D network
- Simplified broadcast access control protocol
- Covering beyond LOS by 2-hop relay
- Using 920MHz band and no license needed (RF device complies with ARIB STD T108)
- Included in international standard IEEE802.15.8

※ Basic technology of this research is supported by the project “Tough Robotics Challenge” in the ImPACT Program of the Cabinet Office.
Drone Mapper: Field Test

Monitor Display on the Android Tablet PC
(Location, altitude, heading, etc. for near drones)

<table>
<thead>
<tr>
<th>Single-hop/Multi-hop mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
</tr>
<tr>
<td>TX power</td>
</tr>
<tr>
<td>Data rate</td>
</tr>
<tr>
<td>Size</td>
</tr>
<tr>
<td>Weight</td>
</tr>
</tbody>
</table>

Data of each of the drones
V2V Communication Field Test for Location Info. Sharing Between Drones and Manned Helicopters

Manned helicopter
(receives data of near drone locations and their IDs)

Drone

Ground monitor station
(receives data of near manned helicopter location and its ID)

Monitoring on a tablet PC
Data logging

Drone mapper units

920MHz帯

Date: March 2, 2018
Venue: Kiso river, Aich pref.
Promotor: NEDO, Sky Perfect JSAT, NICT
Support: Aisai City, Terra Drone, Nakanihon Air Service

* This experiment was supported by “Drones and Robots for Ecologically Sustainable Societies (DRESS) Project”
Implementation

On a drone

Dronemapper unit (920MHz-20mW, LoRa)

Carried into the helicopter as a hand baggage
### Tablet PC Display of the Ground Monitor Station
(showing the location of a helicopter around 9 km away)

<table>
<thead>
<tr>
<th>Helicopter ID</th>
<th>Range</th>
<th>Altitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drone (own)</td>
<td>~9km</td>
<td></td>
</tr>
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</table>
Summary

● Wireless technology is one of the key issues for safety operations of drones, particularly for Beyond LOS operations.
● Our research works focus on the improvement of reliability and availability of wireless technologies for drone operation including over urban areas.