Potential Frequency Bands for RPAS Line-of-Sight Links

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OUTLINE

• Bandwidth Requirements for RPAS Command and Control (C2) Links

• Data Requirements and Structures for C2 Links

• Potential Frequency Bands for LOS
  – C-Band
  – L-Band

• Summary
Bandwidth Requirements for RPAS C2 Links

- Bandwidth Requirements for the RPAS C2 Links have been identified in ITU-R M.2171
  - 34 MHz required for radio line-of-sight (LOS) RPAS C2 communication
  - 56 MHz required for beyond radio line-of-sight (BLOS) RPAS C2 communication
Data Requirements and Structures for RPAS C2 Links

- Categories and rates of command and control data communication between the ground control station (GCS) and RPAS

### Uplink (GCS to RPAS)

<table>
<thead>
<tr>
<th>Activity</th>
<th>bps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telecommand</td>
<td>4593</td>
</tr>
<tr>
<td>Navigational Aid Setting</td>
<td>666</td>
</tr>
<tr>
<td>ATC Voice</td>
<td>4800</td>
</tr>
<tr>
<td>ATS Data</td>
<td>49</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>10108</strong></td>
</tr>
</tbody>
</table>

### Downlink (RPAS to GCS)

<table>
<thead>
<tr>
<th>Activity</th>
<th>bps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telemetry</td>
<td>7595</td>
</tr>
<tr>
<td>Navaid Display Data</td>
<td>1137</td>
</tr>
<tr>
<td>ATC Voice</td>
<td>4800</td>
</tr>
<tr>
<td>ATS Data</td>
<td>59</td>
</tr>
<tr>
<td>DAA</td>
<td>4800</td>
</tr>
<tr>
<td>Weather</td>
<td>27770</td>
</tr>
<tr>
<td>Video</td>
<td>270000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>316161</strong></td>
</tr>
</tbody>
</table>

Data Requirements and Structures for RPAS C2 Links

- Four RPAS service classes

<table>
<thead>
<tr>
<th>Service Class</th>
<th>Telemetry</th>
<th>Voice</th>
<th>Navigational Aids</th>
<th>Aircraft Targets</th>
<th>Weather Radar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 1</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class 2</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
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<tr>
<td>Class 3</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Class 4</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Small RPAS operating in a remote area at low altitude may only require uplink control and downlink telemetry (Service Class 1).

Large RPAS operating over a long range and high altitude would require all types of communications services (Service Class 4).
Potential Frequency Bands for RPAS LOS Links

Data Requirements and Structures for RPAS C2 Links

- Possible RPAS LOS C2 Waveform
- TDM uplink, FDM Downlink
Data Requirements and Structures for RPAS C2 Links

• Example for a 4 RPAS C2 system
Candidate Frequency Bands for LOS

• C-Band – 5030-5091 MHz
  – As of WRC-12, this band has both an AM(R)S and AMS(R)S allocation

• L-Band – 960-1164 MHz
  – ANRS allocation
  – AM(R)S allocation added by WRC-07

• Testing of prototype systems has been done in both bands, and RTCA MOPS for terrestrial LOS C2 are completed.
C-Band – 5030-5091 MHz

- The 5030-5091 MHz will be shared in some fashion by AM(R)S (terrestrial LOS RPAS C2) and AMS(R)S (satellite BLOS RPAS C2)

- Sharing of 5030-5091 MHz is under study
  - A partition between the AM(R)S and AMS(R)S is being considered, with AM(R)S occupying the middle portion between the AMS(R)S forward and return links

<table>
<thead>
<tr>
<th>SAT C2 Link RTN</th>
<th>LOS C2 Link</th>
<th>SAT C2 Link FWD</th>
</tr>
</thead>
<tbody>
<tr>
<td>5030 MHz</td>
<td>5091 MHz</td>
<td></td>
</tr>
</tbody>
</table>

FSMP WG/3 WP10 - On the sharing of the AMS(R)S allocation in the 5030-5091 MHz frequency band between a satellite and terrestrial system to provide UAS C2
C-Band – 5030-5091 MHz

- 5030-5091 MHz partition may be static or flexible
  - Flexible partition would allow different implementations in different regions depending on requirements for terrestrial vs. satellite
  - Static partition would enable common global equipment design
- The amount of 5030-5091 MHz available for LOS links is not yet known
L-Band – 960-1164 MHz

- Heavily used by navigation systems

SC203-CC021_Compatibility of Terrestrial L-Band CNPC with In-Band and Adjacent-Band Systems_vD_15March2013
Frank Box, Leo Globus, Warren Wilson, John Ashley, Michael Neale
L-Band – 960-1164 MHz

- Heavily used by navigation systems

Fixed U.S. and Canadian Assignments, March 2012
Potential Frequency Bands for RPAS LOS Links

L-Band – 960-1164 MHz

- 960-977 MHz band is considered promising for RPAS LOS C2, however there are some systems being used in this band (in the US at least) which constrain RPAS LOS
- 1020-1040 MHz and 1080-1100 MHz unavailable due to protection of SSR transponders
- Fitting RPAS LOS in between other navigation systems is very challenging
  - E.g. DME and TACAN interference threshold and receiver selectivity of the DME or TACAN receiver
  - More study is needed
L-Band – 960-1164 MHz

- Two AM(R)S systems are being studied for possible implementation in L-Band
- LDACS1 is an OFDM-based waveform
  - Bandwidth is approximately 500 kHz, centered on channels situated between the DME frequencies
  - An LDACS-1 channel may be sufficient to support LOS RPAS

- LDACS2 is a TDD system
  - Planned for 960–977 MHz sub band
  - A single channel may be insufficient for the highest RPAS LOS data rates required

- Actual implementation of either LDACS1 or LDACS2 is still unknown
Summary

- A requirement of 34 MHz has been identified to support RPAS LOS C2 communications
- Two bands have been identified as having potential to support RPAS LOS C2
  - L-Band – 960-1164 MHz has an AM(R)S allocation but is heavily used by navigation systems and thus is difficult to apply to RPAS LOS C2. Further study on possible L-Band implementations is needed.
  - C-Band – 5030-5091 MHz has AM(R)S and AMS(R)S allocations requiring a likely partition of the band between the two services. The amount of bandwidth to be available for RPAS LOS C2 is not yet determined.
- Prototype systems have been tested in both bands and Standards (MOPS) have been developed.