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# Part 1 – General Information

## Chapter 1 Necessary Overhead

numeric information, domain specific definitions, preface, section summaries so you know where to go quickly,

### Origin of this Document

This document originated as a fork of the Phase 4 Ground Air Interface working document. Flying ARAP is a Phase 4 Ground project.



### Motivation

The Flying ARAP Project was proposed by Howie DeFelice as a way to test the Symposium Demonstration GNU Radio flow graph in low earth orbit. The Symposium Demo flow graph has four FDMA NBFM channels received, digitized, and multiplexed into a single digital downlink and is the basis for the Phase 4 Ground ARAP.

Anticipated receivers for Flying ARAP are off-the-shelf VHF-capable SDRs and receiver dongles. The Flying ARAP is a lightweight version of the Phase 4 Ground ARAP. Flying ARAP provides testing of core concepts in an inexpensive easy-to-construct experiment. Flying ARAP is a 1U spacecraft that (if approved) will be launched from ISS in 2017.

It will be active for only a few months. Therefore the user interface and functionality needs to be simple, powerful, and intuitive.

Reuse of this design is possible on other missions. Reuse of this design is possible in terrestrial applications.

## Chapter 2 Link Budget

detailed description of our environment and link budget.

## Chapter 3 System Time

define system time and how it’s derived and used in the system.

## Chapter 4 Tolerances

what parts of the system have a lot of margin and what do not have a lot of margin. In SDR-based systems, some parts of the system are high performance so that other parts don’t have to be. This chapter defines what those are and how much slop we have.

## Chapter 5 Forward Compatibility Rules

if there is extra room for future expansion in the message formats (and there better be) then extra bits are defined and marked as “0”.

# Part 2 – Requirements for Operation

## Chapter 6 Transmitters

### Frequencies

|  |  |  |  |
| --- | --- | --- | --- |
| **Mission** | **Uplink Frequency Band** | **Bandwidth** | **Access Type** |
| Flying ARAP | 70cm | 20kHz | NBFM channelized |

Channel spacing and channel bandwidth vary with respect to local band plan and are therefore configurable within the ARAP.

The number of uplink channels is limited by hardware capability, hardware configuration, and the regulations that apply to the particular downlink band used.

Having more uplink channels than the downlink can legally accommodate is not optimal. Therefore, the capacity of the downlink provides an upper limit on the number of uplink channels.

For the Flying ARAP Project, the four NBFM uplink channels shall be on 70cm.

Four voice channels shall be supported.

These channels follow the Phase 4 Ground Air Interface sub channel specification, where transmissions are identified by call\_sign:SSID:subchannel.   
  
This allows the traffic to be successfully routed to or from any Phase 4 radio.



Finding, filtering, and sorting sub channel traffic depends upon using the right application layer tool.

### Voice Signal Quality

There is unhappiness with the lack of attention paid to voice quality in most CODECs borrowed from industry. Voice codecs literally are the voice of the system. A radio design can be exemplary, but if the codec sounds harsh, the entire system will be harshly judged.

There are many factors in quality voice coding and decoding. Things like compression, pre-emphasis, deviation limitation, limit filters, and transmit level adjustments all affect voice signal quality.

Phase 4 Ground recommends and implements the following.

CODEC2

OPUS

Flying ARAP implements CODEC2.

### 

### Emission Type

### Emission Type Designation

emission designation, conducted and radiated spurious emissions.

## Chapter 7 Receivers

### Frequencies

|  |  |  |  |
| --- | --- | --- | --- |
| **Mission** | **Downlink Frequency Band** | **Bandwidth** | **Access Type** |
| Flying ARAP | 2m | TBD | TDM |

For the Flying ARAP Project, the single digital downlink channel shall be on 2m. 9600 baud was assumed to be a practical limit.

Bill Werner suggested using the same signal that NOAA’s EMWIN uses. This satellite transmits an OQPSK 20kHz wide downlink at 1692.7MHz from GOES East and West (75 and 137 degrees GEO stationary). Bill reports that “After all the FEC is done, it delivers a very respectable 17,500 bps of data.” There is software in the public domain to receive it, which provides significant advantages.

EMWIN stands for Emergency Managers Weather Information Network. Information about the satellite and the receiver documentation and software can be found here: http://www.nws.noaa.gov/emwin/index.htm

### Emission Type

The emission type is a single-channel digital time-division multiplex downlink. The possible modulations are (TBD). Frames are encoded using (TBD).

### Emission Type Designation

limitations on emissions, conducted spurious emissions, radiated spurious emissions, security and identification, authentication, station ID, registration, registration memory, access overload (proposed quality of service scheme from 2008), storing and forwarding, MESH networking requirements.

## Chapter 8 Supervision

control operation, failure detection. It may be best to have this controlled by a small team in order to protect access to the space segment.

## Chapter 9 QSO Processing (System Access!)

System access is achieved by transmitting a narrow-band FM signal on the correct frequency, with enough power to be received by the satellite.

All successfully received signals are multiplexed into the downlink. The uplink channel that the transmitted station used is the subchannel designation. Phase 4 Ground subchannel designations are letters in English alphabetical order.

If there are four subchannels, then they are designated A, B, C, and D.

The subchannel designation is how different uplinks are sorted, filtered, and distinguished by the application layer.

## Chapter 10 Reconfiguration

Flying ARAP space deployment is not reconfigurable.

Reconfigurations of the terrestrial deployments of the Flying ARAP are achieved by editing the GNU Radio flow graph installed on board the processor.

## Chapter 11 Idle State

When there is capacity, then onboard telemetry is transmitted. Excess capacity occurs when channel utilization is less than 100%.

Onboard telemetry for the spacecraft is traditional spacecraft telemetry. Data streams from terrestrial projects can include weather, APRS, images, or any other digital data that the ARAP can collect or generate.

The term for swapping in data when there is excess capacity is called “stat-muxing”.

## Chapter 12 Emergency Communications

Declared communications emergencies do not change the status or configuration of this mission. It can be used in an emergency just like any other amateur radio communications resource. Due to the nature of this project, as it is in LEO, emergency communications usability may be limited.

## Chapter 13 mesh operation

Mesh operation is not required for this mission. Mesh operation can be implemented as an option for terrestrial deployments.

## Chapter 14 Gateways to Other Services

Gateways to other services are not specified for Flying ARAP.

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Comment and critique welcomed and encouraged. This document will be developed in collaboration with the space segment team.

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