AUTOMATIC POSITION REPORTING SYSTEM

The APRS Working Group

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Prelude

FOREWORD

This APRS Protocol Reference document represents the coming-of-age of WB4APR's baby. Starting with a simple concept — a way to track the location of moving objects via packet radio — programs using the APRS protocol have grown into perhaps the most popular packet radio application in use today. It's also become one of the most complex; from the simple idea grew, and still grows, a tactical communications system of tremendous capability. Like many ham projects, the APRS protocol was designed as it was being implemented, and many of its intricacies have never been documented.

Until now. This specification defines the APRS on-air protocol with a precision and clarity that make it a model for future efforts. The work done by members of the APRS Working Group, as well as Technical Editor Ian Wade, G3NRW, should be recognized as a tremendous contribution to the packet radio art. With this document available, there is now no excuse for any developer to improperly implement the APRS protocol.

As an APRS Working Group member whose role was mainly that of observer, I was fascinated with the interplay among the APRS authors and the Technical Editor as the specification took form. Putting onto paper details that previously existed only in the minds of the authors exposed ambiguities, unconsidered consequences, and even errors in what the authors thought they knew. The discussion that followed each draft, and the questions Ian posed as he tried to wring out the uncertainties, gave everyone a better understanding of the protocol. I am sure that this process has already contributed to better interoperability among existing APRS applications. Everyone who has watched the specification develop, from the initial mention in April 1999 until release of this Version 1.0 document in August 2000, knows that the process took much longer than was hoped. At the same time, they saw the draft transformed from a skeleton into a hefty book of over 110 pages. With the specification now in hand, I think we can all say the wait was worth it. Congratulations to the APRS Working Group and, in particular, to G3NRW, for a major contribution to the literature of packet radio.

John Ackermann, N8UR
TAPR Vice President and APRS Working Group Administrative Chair
August 2000

Preamble

APRS Working Group

The APRS Working Group is an unincorporated association whose members undertake to further the use and enhance the value of the APRS protocols by (a) publishing and maintaining a formal APRS Protocol Specification; (b) publishing validation tests and other tools to enable compliance with the Specification; (c) supporting an APRS Certification program; and (d) generally working to improve the capabilities of APRS within the amateur radio community.

Although the Working Group may receive support from TAPR and other organizations, it is an independent body and is not affiliated with any organization. The Group has no budget, collects no dues, and owns no assets. The current members of the APRS Working Group are:

- John Ackermann, N8UR Administrative Chair & TAPR Representative
- Bob Bruninga, WB4APR Technical Chair, founder of APRS
- Brent Hildebrand, KH2Z Author of APRS+SA
- Stan Horzepa, WA1LOU Secretary
- Mike Musick, N0QBF Author of pocketAPRS
- Keith Sproul, WU2Z Co-Author of WinAPRS/MacAPRS/X-APRS
- Mark Sproul, KB2ICI Co-Author of WinAPRS/MacAPRS/X-APRS

Acknowledgements

This document is the result of contributions from many people. It includes much of the material produced by individual members of the Working Group.

In addition, the paper on the Mic-E data format by Alan Crosswell, N2YGK, and Ron Parsons, W5RKN was a useful starting point for explaining the complications of this format.

Document Version Number

Except for the very first public draft release of the APRS Protocol Reference, the document version number is a 3-part number "P.p.D" (for an approved document release) or a 4-part number "P.p.Dd" (for a draft release):

Thus, for example:

- Document version number "1.2.3" refers to document release 3 covering APRS Protocol Version 1.2.
- Document version number "1.2.3c" is draft "c" of that document.

Release History

The release history for this document is listed in Appendix 7.

Document Conventions

This document uses the following conventions:

- `Courier font` ASCII characters in APRS data.
- ␣ ASCII space character.
- ... (ellipsis) zero or more characters.
- /$ Symbol from Primary Symbol Table.
- \$ Symbol from Alternate Symbol Table.
- 0x hexadecimal (e.g. 0x1d).
- All callsigns are assumed to have SSID –0 unless otherwise specified.
- Yellow marker (appears as light gray background in hard copy). Marks text of interest — especially useful for highlighting single literal ASCII characters (e.g. ") where they appear in APRS data.

- Shaded areas in packet format diagrams are optional fields.

Feedback

Please address your feedback or other comments regarding this document to the TAPR aprsspec mail list.

To join the list, start at http://www.tapr.org and then follow the path Special Interest Groups ⇒ APRS Specification ⇒ Join APRS Spec Discussion List.

Authors' Foreword

This reference document describes what is known as APRS Protocol Version 1.0, and is essentially a description of how APRS operates today. It is intended primarily for the programmer who wishes to develop APRS compliant applications, but will also be of interest to the ordinary user who wants to know more about what goes on "under the hood". It is not intended, however, to be a dry-as-dust, pedantic, RFC-style programming specification, to be read and understood only by the Mr Spocks of this world. We have included many items of general information which, although strictly not part of the formal protocol description, provide a useful background on how APRS is actually used on the air, and how it is implemented in APRS software. We hope this will put APRS into perspective, will make the document more readable, and will not offend the purists too much.

It is important to realize how APRS originated, and to understand the design philosophy behind it. In particular, we feel strongly that APRS is, and should remain, a light-weight tactical system — almost anyone should be able to use it in temporary situations (such as emergencies or mobile work or weather watching) with the minimum of training and equipment.

This document is the result of inputs from many people, and collated and massaged by the APRS Working Group. Our sincere thanks go to everyone who has contributed in putting it together and getting it onto the street. If you discover any errors or omissions or misleading statements, please let us know — the best way to do this is via the TAPR aprsspec mailing list at www.tapr.org.

Finally, users throughout the world are continually coming up with new ideas and suggestions for extending and improving APRS. We welcome them. Again, the best way to discuss these is via the aprsspec list.

–The APRS Working Group, August 2000

Disclaimer

Like any navigation system, APRS is not infallible. No one should rely blindly on APRS for navigation, or in life-and-death situations. Similarly, this specification is not infallible.

The members of the APRS Working Group have done their best to define the APRS protocol, but this protocol description may contain errors, or there may be omissions. It is very likely that not all APRS implementations will fully or correctly implement this specification, either today or in the future.

We urge anyone using or writing a program that implements this specification to exercise caution and good judgement. The APRS Working Group and the specification's Editor disclaim all liability for injury to persons or property that may result from the use of this specification or software implementing it.

The Structure of this Specification

This specification describes the overall requirements for developing software that complies with APRS Protocol Version 1.0. The information flow starts with the standard AX.25 UI-frame, and progresses downwards into more and more detail as the use of each field in the frame is explored. A key feature of the specification is the inclusion of dozens of detailed examples of typical APRS packets and related math computations. Here is an outline of the chapters:

Introduction to APRS – A brief background to APRS and a summary of its main features.

The APRS Design Philosophy – The fundamentals of APRS, highlighting its use as a real-time tactical communications tool, the timing of APRS transmissions and the use of generic digipeating.

APRS and AX.25 – A brief refresher on the structure of the AX.25 UI-frame, with particular reference to the special ways in which APRS uses the Destination and Source Address fields and the Information field.

APRS Data in the AX.25 Destination and Source Address Fields – Details of generic APRS callsigns and callsigns that specify display symbols and APRS software version numbers. Also a summary of how Mic-E encoded data is stored in the Destination Address field, and how the Source Address SSID can specify a display icon.

APRS Data in the AX.25 Information Field – Details of the principal constituents of APRS data that are stored in the Information field. Contains the APRS Data Type Identifiers table, and a summary of all the different types of data that the Information field can hold.

Time and Position Formats – Information on formats for timestamps, latitude, longitude, position ambiguity, Maidenhead locators, NMEA data and altitude.

APRS Data Extensions – Details of optional data extensions for station course/speed, wind speed/direction, power/height/gain, pre-calculated radio range, DF signal strength and Area Object descriptor.

Position and DF Report Data Formats – Full details of these report formats.

Compressed Position Report Data Formats – Full details of how station position and APRS data extensions are compressed into very short packets.

Mic-E Data Format – Mic-E encoding of station lat/long position, altitude, course, speed, Mic-E message code, telemetry data and APRS digipeater path into the AX.25 Destination Address and Information fields.

Object and Item Reports – Full information on how to set up APRS Objects and Items, and details of the encoding of Area Objects (circles, lines, ellipses etc).

Weather Reports – Full format details for weather reports from standalone (position-less) weather stations and for reports containing position information. Also details of storm data format.

Telemetry Data – A description of the MIM/KPC-3+ telemetry data format, with supporting information on how to tailor the interpretation of the raw data to individual circumstances.

Messages, Bulletins and Announcements – Full format information.

Station Capabilities, Queries and Responses – Details of the ten different types of query and expected responses.

Status Reports – The format of general status messages, plus the special cases of using a status report to contain meteor scatter beam heading/power and Maidenhead locator.

Network Tunneling – The use of the Source Path Header to allow tunneling of APRS packets through third-party networks that do not understand AX.25 addresses, and the use of the third-party Data Type Identifier.

User-Defined Data Format – APRS allows users to define their own data formats for special purposes. This chapter describes how to do this.

Other Packets – A general statement on how APRS is to handle any other packet types that are not covered by this specification.

APRS Symbols – How to specify APRS symbols and symbol overlays, in position reports and in generic GPS destination callsigns.

APRS Data Formats – An appendix containing all the APRS data formats collected together for easy reference.

The APRS Symbol Tables – A complete listing of all the symbols in the Primary and Alternate Symbol Tables.

ASCII Code Table – The full ASCII code, including decimal and hex codes for each character (the decimal code is needed for compressed lat/long and altitude computations), together with the hex codes for bit-shifted ASCII characters in AX.25 addresses (useful for Mic-E decoding and general on-air packet monitoring).

Glossary – A handy one-stop reference for the many APRS-specific terms used in this specification.

References – Pointers to other documents that are relevant to this specification.

1. Chapter 1: Introduction to APRS

1.1. What is APRS?

APRS is short for Automatic Position Reporting System, which was designed by Bob Bruninga, WB4APR, and introduced by him at the 1992 TAPR/ ARRL Digital Communications Conference.

Fundamentally, APRS is a packet communications protocol for disseminating live data to everyone on a network in real time. Its most visual feature is the combination of packet radio with the Global Positioning System (GPS) satellite network, enabling radio amateurs to automatically display the positions of radio stations and other objects on maps on a PC. Other features not directly related to position reporting are supported, such as weather station reporting, direction finding and messaging.

APRS is different from regular packet in several ways:

- It provides maps and other data displays, for vehicle/personnel location and weather reporting in real time.
- It performs all communications using a one-to-many protocol, so that everyone is updated immediately.
- It uses generic digipeating, with well-known callsign aliases, so that prior knowledge of network topology is not required.
- It supports intelligent digipeating, with callsign substitution to reduce network flooding.
- Using AX.25 UI-frames, it supports two-way messaging and distribution of bulletins and announcements, leading to fast dissemination of text information.
- It supports communications with the Kenwood TH-D7 and TM-D700 radios, which have built-in TNC and APRS firmware.

Conventional packet radio is really only useful for passing bulk message traffic from point to point, and has traditionally been difficult to apply to real-time events where information has a very short lifetime. APRS turns packet radio into a real-time tactical communications and display system for emergencies and public service applications.

APRS provides universal connectivity to all stations, but avoids the complexity, time delays and limitations of a connected network. It permits any number of stations to exchange data just like voice users would on a voice net. Any station that has information to contribute simply sends it, and all stations receive it and log it.

APRS recognizes that one of the greatest real-time needs at any special event or emergency is the tracking of key assets. Where is the marathon leader? Where are the emergency vehicles? What's the weather at various points in the county? Where are the power lines down? Where is the head of the parade? Where is the mobile ATV camera? Where is the storm? To address these questions, APRS provides a fully featured automatic vehicle location and status reporting system. It can be used over any two-way radio system including amateur radio, marine band, and cellular phone. There is even an international live APRS tracking network on the Internet.

1.2. APRS Features

APRS runs on most platforms, including DOS, Windows 3.x, Windows 95/98, MacOS, Linux and Palm. Most implementations on these platforms support the main features of APRS:

- **Maps** –APRS station positions can be plotted in real-time on maps, with coverage from a few hundred yards to worldwide. Stations reporting a course and speed are dead-reckoned to their present position. Overlay databases of the locations of APRS digipeaters, US National Weather Service sites and even amateur radio stores are available. It is possible to zoom in to any point on the globe.

- **Weather Station Reporting** – APRS supports the automatic display of remote weather station information on the screen.

- **DX Cluster Reporting** – APRS an ideal tool for the DX cluster user. Small numbers of APRS stations connected to DX clusters can relay DX station information to many other stations in the local area, reducing overall packet load on the clusters.

- **Internet Access** – The Internet can be used transparently to cross-link local radio nets anywhere on the globe. It is possible to telnet into Internet APRS servers and

see hundreds of stations from all over the world live. Everyone connected can feed their locally heard packets into the APRS server system and everyone everywhere can see them.

- **Messages** – Messages are two-way messages with acknowledgement. All incoming messages alert the user on arrival and are held on the message screen until killed.

- **Bulletins and Announcements** – Bulletins and announcements are addressed to everyone. Bulletins are sent a few times an hour for a few hours, and announcements less frequently but possibly over a few days.

- **Fixed Station Tracking** – In addition to automatically tracking mobile GPS/LORAN-equipped stations, APRS also tracks from manual reports or grid squares.

- **Objects** – Any user can place an APRS Object on his own map, and within seconds that object appears on all other station displays. This is particularly useful for tracking assets or people that are not equipped with trackers. Only one packet operator needs to know where things are (e.g. by monitoring voice traffic), and as he maintains the positions and movements of assets on his screen, all other stations running APRS will display the same information.