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NOAA Technical Memorandum ERL WPL-126

PROFILER STANDARD FORMAT FOR DATA EXCHANGE: PROFILER SITE TO HUB COMPUTER

John Forberg
Michael Barth

Wave Propagation Laboratory
Boulder, Colorado
September 1985

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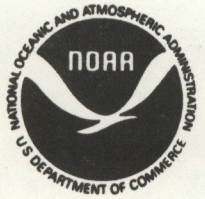

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Profiler Standard Format for Data Exchange: Profiler Site to Hub Computer

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ABSTRACT

The National Oceanic and Atmospheric Administration (NOAA) has established a Wind Profiler Demonstration Project. Its goal is to show that a network of wind Profilers can routinely support agencies such as the National Weather Service under operational conditions. Through the Wave Propagation Laboratory's Profiler Technology Transfer Group, NOAA will deploy a network of wind Profilers in the Colorado-Kansas-Oklahoma area in support of the project. This document describes the formats and content of the data transmitted by this network of Profilers to the central computer located in Boulder, Colorado. This flexible set of formats will make possible automated exchange of Profiler data generated by this network or any other computer system.

1. INTRODUCTION

1.1 Purpose

The flexible, common set of formats described is for the transfer of Profiler and Profiler-related data. Use of these formats will permit automated collection and processing of Profiler data generated by any computer system, using any set of radar parameters. The device and application independence resulting from use of these formats will simplify and thus promote the dissemination of Profiler data sets among both government and nongovernment agencies.

1.2 Background

Since 1982, the Wave Propagation Laboratory (WPL) has field-tested several Profilers at various locations in Colorado (see Strauch et al., 1984). These tests have demonstrated the

feasibility of measuring wind profiles from near the Earth's surface into the stratosphere by means of a Doppler radar called the wind Profiler. The tests have further suggested that the Profiler can measure vertical profiles of the horizontal wind component with the accuracy and time resolution required for an operational synoptic- and meso-alpha-scale scale network (Gage and Schlatter, 1984; Schlatter, 1985).

Consequently, the National Oceanic and Atmospheric Administration (NOAA) has established a Wind Profiler Demonstration Project. Its goal is to show that a network of wind Profilers can support routine operations of the National Weather Service (NWS) and large field experiments such as those of the National STORM (STormscale Operational and Research Meteorology) Program. Through WPL's Profiler Technology Transfer Group, NOAA will deploy a network of 30 wind Profilers in the Colorado-Kansas-Oklahoma area by 1988 and operate it through 1992. Wind profile data will be collected, processed, archived, and distributed by a central (Hub) computer located in Boulder, Colorado. During that time, NWS and the Environmental Research Laboratories (ERL) will jointly assess the network's performance. Other government agencies such as the Federal Aviation Administration and the Department of Defense, universities, and private industry will also take part in the assessment.

This document describes the format and content of the data transmitted by this network of Profilers to the central (Hub) computer located in Boulder, Colorado.

1.3 Reference Standard

The formats described in this document are compatible with the reference standard established by the U.S. Department of Commerce (1982). The Federal Aviation Administration, the Navy, and several other agencies have automated systems using the reference standard, and it is planned for use in several new

systems under development by the National Weather Service.

1.4 Extensions to Reference

Certain amendments to the reference standard were requested, to make possible its application to Profiler systems. In May 1985, the Federal Coordinator for Meteorological Services and Supporting Research gave tentative approval of those amendments for inclusion in the 1985 version. The figures, tables, and appendices include information relating to the amendments (U.S. Department of Commerce, 1985).

1.5 Document Overview

For a complete understanding of the formats and their applications, it is desirable to be familiar with the reference document, particularly the opening chapters. It is suggested that those chapters be read prior to study of this document, to avoid possible confusion. To eliminate redundancy, we have not included definitions for every element and field used, but refer the reader to the reference for that information.

This document serves two roles. The first is to present formats for support of any Profiler-related data set, facilitating the exchange of data between agencies. The second role is to describe the specific content of the data stream sent from Profilers in the Wind Demonstration Network to the Profiler Hub.

Section 2 describes the general format of a Profiler product data set. This lists the portions of the reference standard that are used for product data sets containing Profiler data. Note that not all portions of the reference standard are supported. This section is of particular interest to anyone who wishes to create a Profiler product data set.

Section 3 details the exact data stream from Profilers in the Wind Demonstration Project. This section has two purposes. First, it can be used as an example of how the format defined in Section 2 can be implemented, further clarifying the general case. Second, it serves as a reference for anyone who uses Profiler product data generated by the Wind Demonstration Network.

2. GENERAL FORMAT OF A PROFILER PRODUCT DATA SET

2.1 Overview

Portions of the reference standard will be used in the Profiler Standard Format for Data Exchange. Each site will send a product message at the end of each data acquisition period. Each product message consists of control blocks and data blocks, generally ordered as follows:

Product Identification Block
Product Definition Block
Data Description Block
Data Blocks
Data Description Block
Data Blocks
.
.
.
End-of-Product Block

2.2 Product Identification Block

This block shall be formatted as shown in Figure 1 (Section 5). The purpose of this block is to identify the origin of the product, the classification, retention time, product identifier, and file time.

2.3 Product Definition Block

This shall be an 18-byte block, including LENGTH and CHECKSUM. The purpose of this block is to define the product being transferred. The specific format shall be as shown in Figure 2.

2.4 Data Description Block

The Formatted Binary Data Description Block, Option Number 2 (Fig. 3), acts as an interpretation table for the data in the

following Binary Data Block(s). It describes the data in the Formatted Binary Data Block(s) in sufficient detail to allow the recipient to use the data. The length of the Formatted Binary Data Description Block shall depend on the number of repeating data sections required to define the product. (See Note 13 for Figure 3.) Note that this block is an amendment to the 1982 version of the reference standard.

2.5 Data Block

The Formatted Binary Data Block shall be formatted as shown in Figure 4. The block(s) will contain the data in format, units, etc., as specified by the Formatted Binary Data Description Block, Option Number 2, that was last encountered in the message stream.

2.6 End-of-Product Block

The End-of-Product Block shall be formatted as shown in Figure 5. It shall be the last block sent within each message, signifying the end of a transmission for each site for a given time period.

3. SPECIFIC CONTENT OF ONE PROFILER PRODUCT DATA SET

3.1 Overview

Two control blocks are used: the Product Identification Block and the End-of-Product Block. All other blocks are of the Formatted Binary type. Following is a list of the blocks in their order of transmission. These constitute a Product Data Set and will be transmitted to the Profiler Hub every 6 minutes.

Order	Block Type, (Mode, Submode(Octal)) [Data Type]	Size
1	Product Identification Block, (1,1)	28 bytes
2	Formatted Binary Product Definition Block (3,20)	18 bytes
3	Formatted Binary Data Description Block (3,22)	220 bytes
4	Formatted Binary Data Block (3,1) [Site info]	34 bytes
5	Formatted Binary Data Description Block (3,22)	220 bytes
6	Formatted Binary Data Block (3,1) [Radar data]	276 bytes
7	Formatted Binary Data Block (3,1) [Radar data]	276 bytes
8	Formatted Binary Data Block (3,1) [Radar data]	276 bytes
9	Formatted Binary Data Block (3,1) [Radar data]	276 bytes
10	Formatted Binary Data Block (3,1) [Radar data]	276 bytes
11	Formatted Binary Data Block (3,1) [Radar data]	276 bytes
12	Formatted Binary Data Description Block (3,22)	204 bytes
13	Formatted Binary Data Block (3,1) [Spectral data]	284 bytes
14	End-of-Product Block (1,2)	6 bytes
		2670 bytes

The wind Profiler systems support an auxiliary RS-232 port for the ingest of other data sources, such as radiometer and surface meteorological data. When data of these sorts are sent to the Profiler system through the auxiliary port, they will be integrated as blocks within this Product Data Set transmission, subject to all the constraints imposed on the message content and format.

Additionally, the wind Profiler systems will include status information within the message transmitted for each time period to allow remote diagnosis of system failures. The status information sent will include the appropriate control, data definition, and binary data blocks to send the information in a manner consistent with the specified format standard. The special symbols (QQ1-9) or special parameters (ZZ1-9) will be used for the status mnemonic. The exact content of status information is vendor specific, so full definition and representation within the standard are not appropriate.

3.2 Product Identification Block

The fields within the Product Identification Block to be used by the wind Profiler for data transmission are as specified in the notes for Figure 1.

3.3 Formatted Binary Blocks

Following are descriptions of the Formatted Binary Blocks and their use to form a message for transmission from the wind Profiler to the Hub.

3.3.1 Formatted Binary Product Definition Block

This is depicted in Figure 2.

3.3.2 Formatted Binary Data Description Block

This is depicted in Figure 3. There are currently three description blocks in the data stream. The first one is the third block of a message sent; it describes the data going into the "site info" blocks. The second one is the fifth block of the message sent; it describes the data contained within the succeeding six radar data blocks. The third description block describes the radar spectral data block. Additional data

description blocks may be included to describe subsequent blocks of status data or data from other meteorological instruments at the radar site.

In general, a data producer can send header information, data elements, and data arrays; use any defined data representation; and send its data in any order. The NUMBER OF BYTES/ELEMENT SET and the NUMBER OF BYTES/ELEMENT determine array length in bytes. The NUMBER OF BYTES/ELEMENT and the DATA REPRESENTATION CODE tell the receiver how to decode the data to a machine's required formats. The ELEMENT SET MNEMONIC and the UNITS CODE tell the receiver what the data are in terms of a Profiler. If all necessary information (beam azimuth, pulse repetition frequency, etc.) is sent along with the radar data, a receiver will be able to archive and process all the information sent, regardless of radar-dependent variables such as number of beams, operating frequency, etc.

The fields for MULTIPLIER MANTISSA, MULTIPLIER CHARACTERISTIC, and ADDITIVE CONSTANT are established by the data producer to scale the data into the data types, units codes, and precision requirements specified for each mnemonic in the data description blocks.

3.3.2.1 Formatted Binary Data Description Block for Site Info.

Number of Element Sets: 13 (Number of elements in site info block)
Number of Bytes/Section: 28 (Length of site info block)
Number of Sections: 1 (Number of site info blocks)

Following are the contents of the 13 sets of repeating descriptor bytes for the element sets in the site info block.

	Element Set Mnemonic	Start Byte	Number of Bytes/ Element Set	Number of Bytes/ Element	Data Represent. Code	Units Code
1.	RAM	0	4	4	2	23
2.	SRN	4	2	2	0	23
3.	RSN	6	6	6	2	23
4.	YR	12	2	2	0	65
5.	MO	14	1	1	0	64
6.	DAY	15	1	1	0	63
7.	HR	16	1	1	0	62
8.	MN	17	1	1	0	61
9.	ELV	18	2	2	0	3
10.	SRP	20	2	2	0	61
11.	OPF	22	2	2	0	22
12.	NRG	24	2	2	0	23
13.	TSP	26	2	2	0	23

It is assumed that the values for each element set are in effect until the same mnemonic is encountered in a subsequent Data Description Block.

See Appendix A for translations of the mnemonics and contents of each element set of Profiler data.

3.3.2.2 Formatted Binary Data Description Block for Radar Data

Number of Element Sets: 13 (Number of elements in radar block)
Number of Bytes/Section: 270 (Length of one radar data block)
Number of Sections: 6 (Number of radar data blocks)

Following are the contents of the 13 sets of repeating descriptor bytes for the element sets in the radar data block.

	Element Set Mnemonic	Start Byte	Number of Bytes/ Element Set	Number of Bytes/ Element	Data Represent. Code	Units Code
1.	FGH	0	2	2	0	3
2.	ABA	2	2	2	0	37
3.	ABE	4	2	2	0	37
4.	VGW	6	2	2	0	3
5.	VGS	8	2	2	0	3
6.	PRP	10	2	2	0	102
7.	TDA	12	2	2	0	23
8.	NSA	14	2	2	0	23
9.	DFG	16	36	1	0	23
10.	RSP	52	72	2	0	23
11.	RMV	124	72	2	0	104
12.	RVV	196	72	2	0	103
13.	RNL	268	2	2	0	23

See Appendix A for translations of the mnemonics and contents of each element set of Profiler data.

3.3.2.3 Formatted Binary Data Description Block for Spectral Data

Number of Element Sets: 12 (Number of elements in spectral block)
Number of Bytes/Section: 278 (Length of one spectral data block)
Number of Sections: 1 (Number of separate spectral blocks)

Following are the contents of the 12 sets of repeating descriptor bytes for the element sets in the spectral data block.

	Element Set Mnemonic	Start Byte	Number of Bytes/ Element Set	Number of Bytes/ Element	Data Represent. Code	Units Code
1.	FGH	0	2	2	0	3
2.	ABA	2	2	2	0	37
3.	ABE	4	2	2	0	37
4.	VGW	6	2	2	0	3
5.	VGS	8	2	2	0	3
6.	PRP	10	2	2	0	102
7.	TDA	12	2	2	0	23
8.	NSA	14	2	2	0	23
9.	NRG	16	2	2	0	23
10.	RSD	18	256	2	0	23
11.	SVL	274	2	2	0	23
12.	SVH	276	2	2	0	23

In this case, the number of range gates is 1, so the NRG mnemonic shall supersede the current value of 36 established within the data for the SITE INFO block. This value of 1 remains in effect until set to another value or until the End-of-Product Block is encountered.

See Appendix A for translations of the mnemonics and contents of each element set of Profiler data.

3.3.3 Formatted Binary Data Blocks

These are shown in Figure 4. They have been described by the preceding Formatted Binary Data Description Block. It should be noted that, because the maximum block size is 4096 bytes, the radar data have been divided into 6 blocks, each one corresponding to a different set of radar parameters. The division provides a logical structure that facilitates understanding and ease of use of the data.

3.4 End-of-Product Block

The End-of-Product Block (Fig. 5) follows all the Formatted Binary Blocks, and represents the end of a transmission. Its content does not vary.

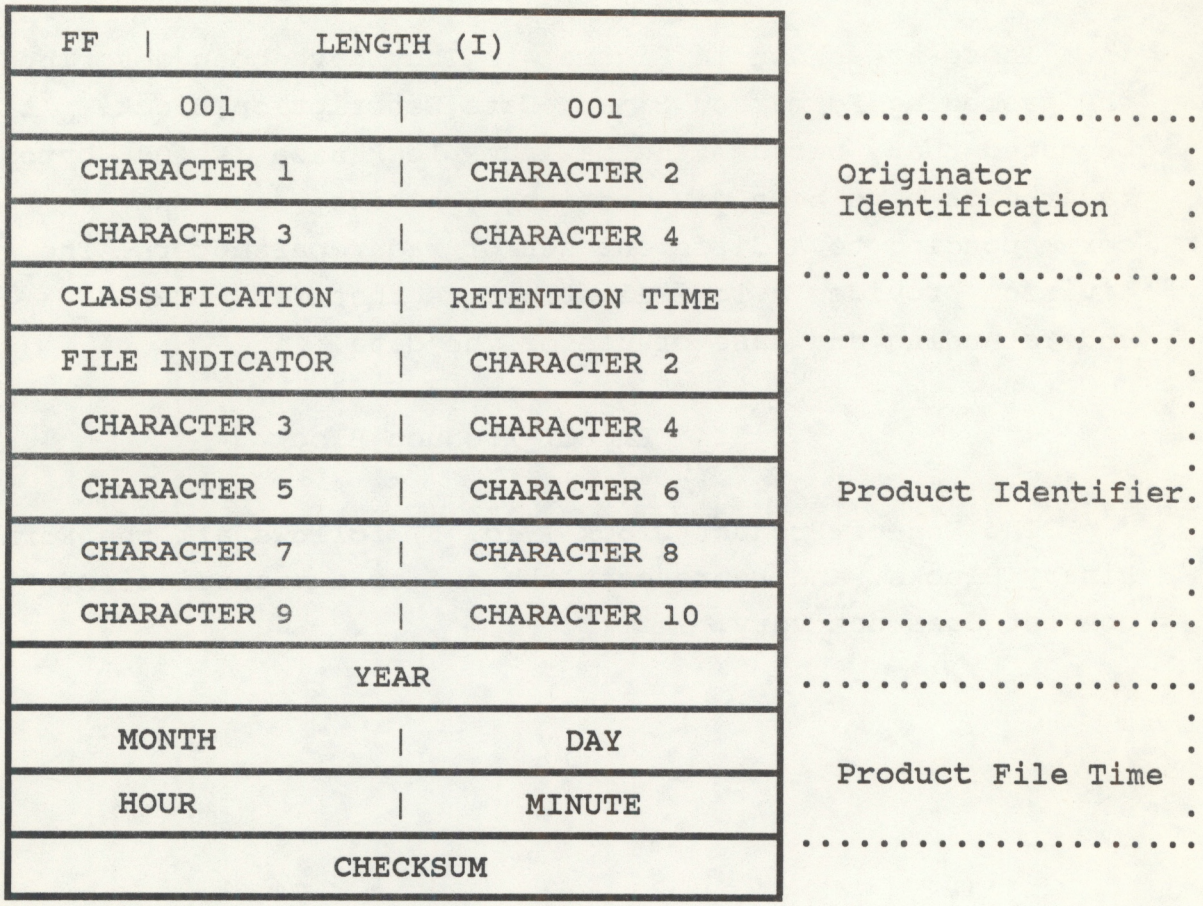

Figure 1
Product Identification Block
Mode 1, Submode 1

NOTES:

1. **CHARACTER 1-4: 'WIPS'**
2. **CLASSIFICATION: 'U'**
3. **RETENTION TIME: 377 (Unused)**
4. **FILE INDICATOR: 177 (Unused)**
5. **CHARACTER 2-10 of FILE INDICATOR: (Unused)**
6. **YEAR, MONTH, DAY, HOUR, MINUTE: Time of beginning of data acquisition period**

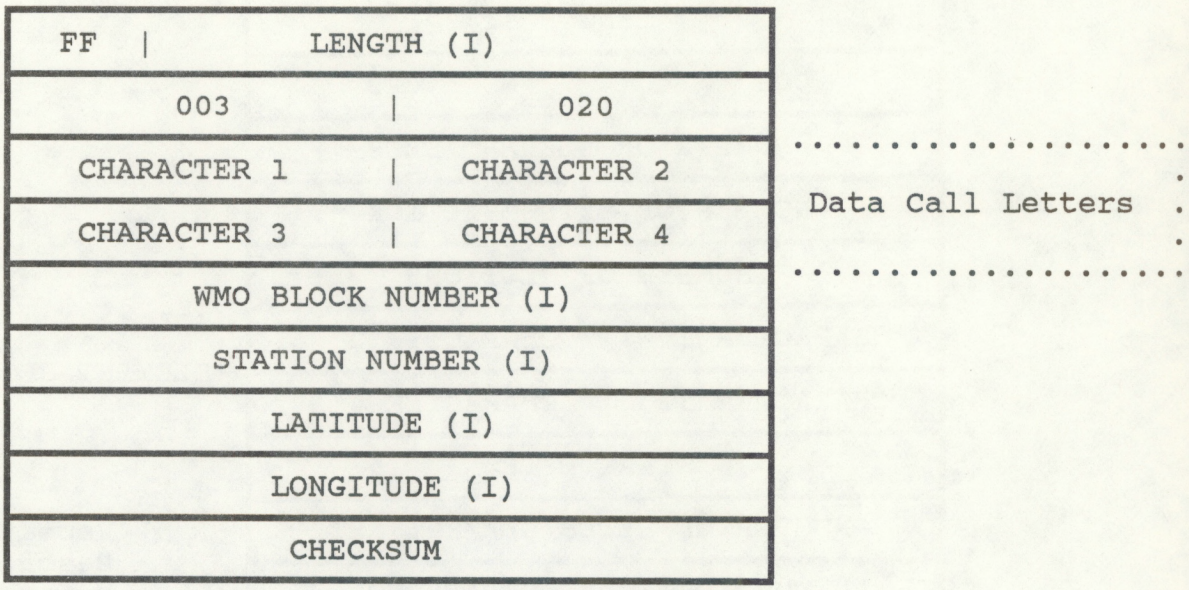

Figure 2
Formatted Binary Product Definition Block
Mode 3, Submode 20

NOTES:

1. Data Call Letters: The International Civil Aviation Organization (ICAO) identification of the originator station.*

2. WMO BLOCK NUMBER: A two-digit identifier of a section of the Earth based on a system developed by the World Meteorological Organization (WMO).*

3. STATION NUMBER: A three-digit station identification within the region identified by the WMO BLOCK NUMBER.*

4. LATITUDE, LONGITUDE (I): Latitude and longitude must be multiplied by .01 to get the actual value. Negative latitude indicates South, negative longitude indicates East.

---

*Specific codes and values will be provided after site location is assigned.

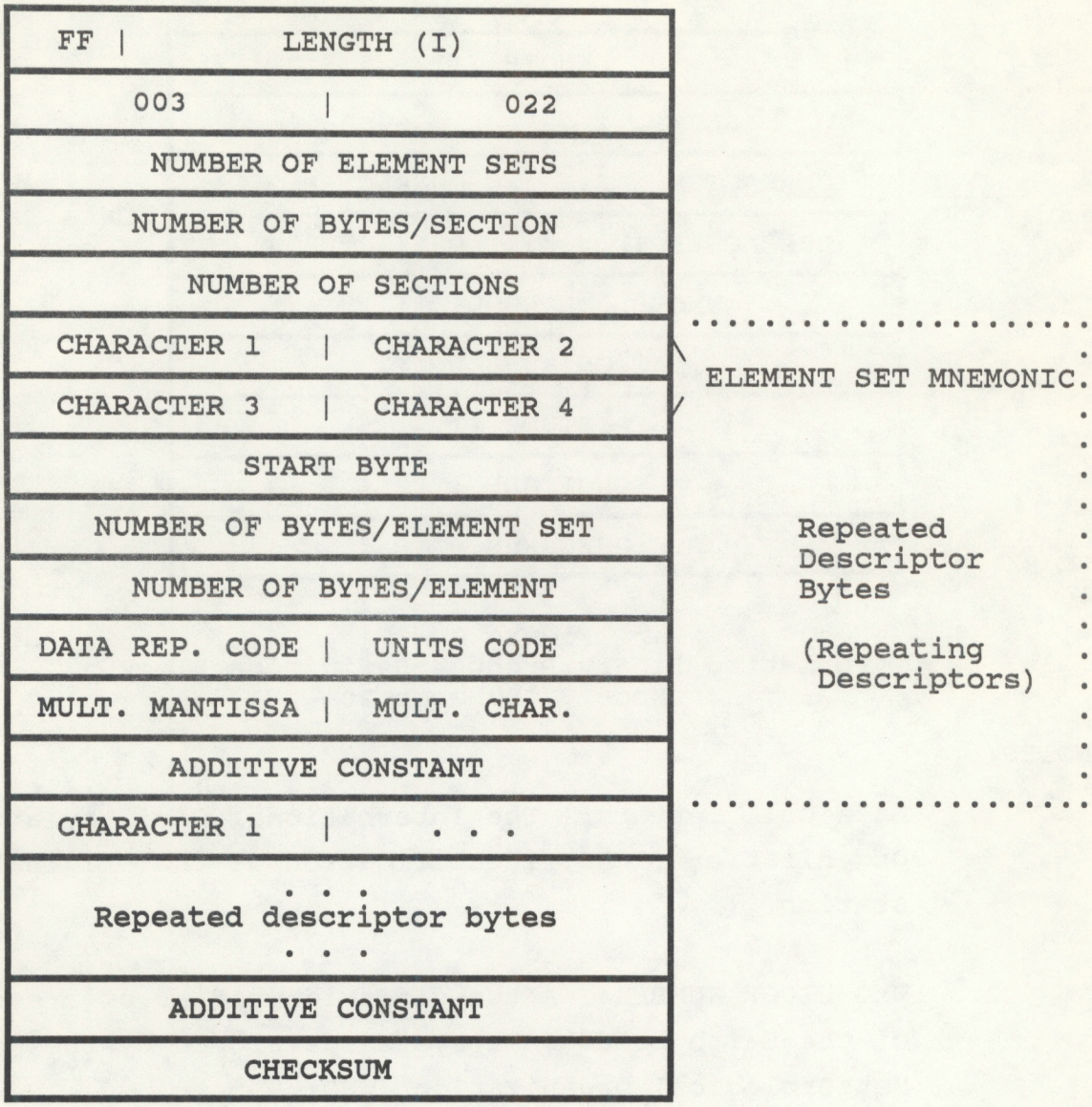

Figure 3
Formatted Binary Data Description Block
Option Number 2
Mode 3, Submode 22

NOTES:

1. NUMBER OF ELEMENT SETS: The number of element sets (an element set is either one element or an array of elements) contained in each repeating section of the data block(s). This field indicates the number of 16-byte repeating descriptors in the data description block.

2. NUMBER OF BYTES/SECTION: Total number of bytes contained in a repeating section. This is the number of bytes that must be skipped to read the first element of a given element set from each repeating section.

3. NUMBER OF SECTIONS: The total number of repeating sections in the data block(s).

The remaining parts of the Data Description Block are the repeating descriptors described in Note 1.

4. ELEMENT SET MNEMONIC: A four-character set that identifies the element set being described. The mnemonics to be used for Profiler data are listed in Appendix A.

5. START BYTE: The byte number in the data block where the element set first occurs. Succeeding occurrences of the element set can be found by successively adding numbers of bytes per section to the start byte number.

6. NUMBER OF BYTES/ELEMENT SET: The number of bytes in the data block occupied by the element set.

7. NUMBER OF BYTES/ELEMENT: The number of bytes in the data block occupied by each element of the element set. (If this is equal to the NUMBER OF BYTES/ELEMENT SET, then this element is not an array.)

8. DATA REPRESENTATION CODE: A code specifying the representation type of the element. Table 1 lists the codes. Data representation codes are two's complement integer, floating point, or ASCII.

9. UNITS CODE: A code specifying the units of the data elements. The codes to be used for Profiler data are listed in Table 2.

10. MULTIPLIER MANTISSA: Integer constant to be multiplied by the element value to obtain the actual value of the element. Used in conjunction with the multiplier characteristic.

11. MULTIPLIER CHARACTERISTIC: Exponent of 10 to be used with the multiplier mantissa to obtain the true value of the element.

12. ADDITIVE CONSTANT: Integer constant to be added to the element value to obtain the true value of the element.

13. The 11th through 26th bytes are repeated for each element set in the data type being transmitted. These 16 bytes are referred to as a repeating descriptor, and may be repeated for up to 255 element sets. The actual number of 16-byte descriptors required depends on the data being transmitted.

14. The actual value of an element is calculated as shown below:

```
Element Value = Element Value * Mult.Mantissa*10**(Mult.Char.)
                + Additive Constant
```

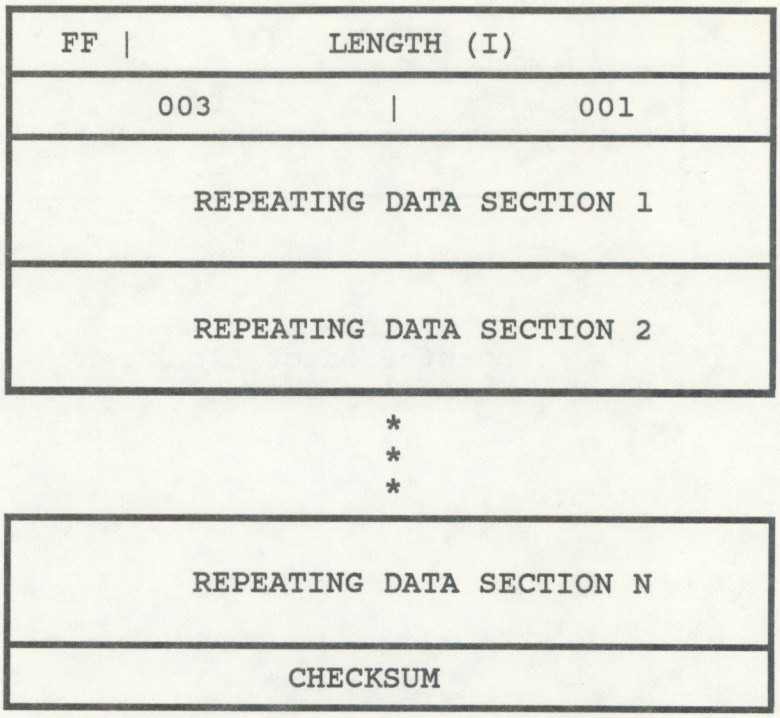

Figure 4
Formatted Binary Data Block
Mode 3, Submode 1

NOTES:

1. Maximum block length, including LENGTH and CHECKSUM, has been defined to be 4096 bytes. Thus, multiple data blocks may be described by one data description block. The user should consider the set of data blocks to be one logical block. That is, when calculating offsets, data lengths, etc., using the values in the data description block, one should assume that the LENGTH, MODE, and CHECKSUM words have been stripped off.

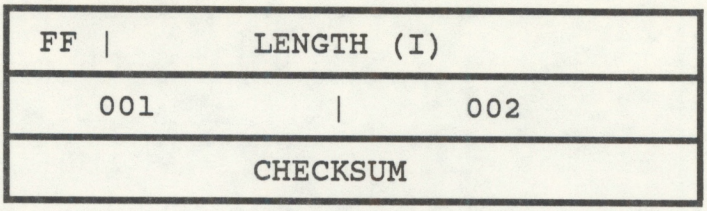

Figure 5
End-of-Product Block
Mode 1, Submode 2

5. TABLES

Table 1

Data Representation Codes (Octal)

Code	Definition
0	Two's Complement Integer
1	Floating Point
2	ASCII

Table 2

Units Codes (Octal)

Code		Unit	Symbol
3	=	Meters	m
14	=	Seconds	s
22	=	Per Second	1/s
23	=	Dimensionless	
37	=	Degrees (Compass Direction)	o
61	=	Mean Solar Minutes	min
62	=	Mean Solar Hours	h
63	=	Mean Solar Days	d
64	=	Months	mo
65	=	Years	yr
102	=	Number of Microseconds	s/(10**6)
103	=	Velocity Variance	(cm/s)**2
104	=	Velocity	cm/s

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APPENDIX A: TRANSLATIONS OF MNEMONICS, AND CONTENTS OF EACH ELEMENT SET

Mnemonic	Translation	Content for Profiler Data
ABA	Antenna beam azimuth	The radar antenna beam azimuth, in degrees, clockwise from north (range 0-359).
ABE	Antenna beam elevation	Radar antenna beam elevation, in degrees above horizon (range 0-90).
DAY	Day	Day in which data are acquired (range 1-31).
DFG	Digital-filtering gate	The digitally filtered ground clutter removal gates at which the ground clutter removal algorithm is applied. A value of 1 indicates a digital-filtering gate; a value of 0 indicates no filtering.
ELV	Elevation	Elevation of the site, in meters above mean sea level (range -100 -> +10,000).
FGH	First gate height	Height of center of first range gate (vertical distance, in meters).
HR	Hour	Hour in which data are acquired, in Greenwich Mean Time (range 0-23).
LAT	Latitude	Site's latitude, in degrees (+ = N; - = S).
LON	Longitude	Site's longitude in degrees (+ = W; - = E).
MN	Minute	Minute in which data are acquired (range 0-59).

MO	Month	Month in which data are acquired (range 1-12).
NRG	Number of range gates	The number of range gates ordered, starting from the gate closest to the ground. The number of gates is currently set at 36.
NSA	Number of spectral averages	The number of spectral averages as a function of mode, beam, and season.
OPF	Operating frequency	Center operating frequency of radar transmitter.
PRP	Pulse repetition period	Pulse repetition period of transmitter, in microseconds.
RAM	Radar acquisition mode	Four-character ASCII string identifying the radar acquisition mode as operational ('OPER') or test ('TEST').
RMV	Radial mean velocity	The first (1) spectral moments, in centimeters per second.
RNL	Radar noise level	The estimated mean noise level of the Doppler radar velocity power spectrum for the last (highest) gate only.
RSD	Radar spectral data	Values constituting the diagnostic spectrum.
RSN	Radar site name	A unique six-character ASCII string that identifies the Profiler site.
RSP	Radar signal power	The zeroth (0) spectral moments.
RVV	Radial velocity variance	The second (2) spectral moments, in centimeters per second, squared: (cm/s)**2.
SRN	Software revision number	Revision number of the software running at the site that generated the data packet.

SRP	Standard reporting period	The expected interval, in seconds, between measurements being transmitted by the Profiler site.
SVH	Spectral value, high	Maximum spectral value over all spectra.
SVL	Spectral value, low	Minimum spectral value over all spectra.
TDA	Time domain averages	The number of time domain averages performed, which is the number of points averaged to produce a single sample point.
TSP	Time series points	The number of time series points input to spectral analysis. This is also the number of FFT points.
VGS	Vertical gate spacing	The vertical spacing of the range gates, in meters, from the center of one gate to the center of the next gate.
VGW	Vertical gate width	The vertical range gate width. This is the vertical distance, in meters, over which the radar signal is averaged to produce a value for each gate.
YR	Year	Year in which data are acquired including century, decade and year (e.g., 1985).

APPENDIX B: DATA ITEM PRECISIONS

Precisions for data items output by the Profiler systems within the Demonstration Network shall be no less than those listed in the following table.

Data Item		Precision
1.	Date	Exact
2.	Time	± 0.1 min
3.	Number of wind data blocks	Exact
4.	CHECKSUM for error detection	Exact
5.	Site program revision number	Exact
6.	Site longitude	± 0.5 min
7.	Site latitude	± 0.5 min
8.	Site elevation	± 0.5 m
9.	Beam azimuth	± 2.0°
10.	Beam elevation	± 0.5°
11.	Vertical gate width	± 10 m
12.	Vertical gate spacing	± 10 m
13.	Pulse repetition period	± 0.1 microseconds
14.	Number of time domain averages	Exact
15.	Number of time domain periods	Exact
16.	Number of spectral averages	Exact
17.	Ground clutter removal gates	1 or 0
18.	Number of range gates	Exact
19.	Signal power (0th moment)	± 0.5 dB
20.	Mean velocity (1st moment)	± 0.01 m/s (vertical)
21.	Mean velocity (1st moment)	± 0.05 m/s (oblique)
22.	Velocity variance (2nd moment)	± 0.005 (m/s)**2
23.	Noise level estimates	To six significant digits
24.	Maximum spectral value	Exact
25.	Minimum spectral value	Exact
26.	Spectral data values	Exact
27.	Standard reporting period	± 0.5 min
28.	Operating frequency	To six significant digits
29.	First gate height	± 10 m