Consortium of Organizations for Strong-Motion Observation Systems

COSMOS

Strong Motion Data Format

COSMOS Strong Motion
Programs Board

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COSMOS Strong Motion Data Format

Introduction

The COSMOS Strong Motion Data File Format[1] is designed to be a common format that meets current needs by combining:

- similarity with traditional strong motion formats,
- current needs for higher resolution in data and parameters,
- needs for flexibility by networks, and
- user convenience, with a single format structure.

Format flexibility is a key element of the COSMOS approach, allowing strong motion networks to produce data with wide choices. Even with this flexibility, a user can read the full range of variations with a single program as long as the format framework has been maintained.

This format specification builds on earlier formats used by Caltech, USC, USGS, CDMG and others. References for the documentation of the earlier formats are listed below. This format itself is meant to be a growing standard, and the tables with reference codes will be expanded as more networks are established and new instruments and sensors come into use.

Purpose

One of the first goals of the COSMOS consortium was the development of a common strong motion data format. Several factors contributed to the importance of this issue:

1) The increasing number of networks collecting and releasing strong motion data led to an increased number and variability of data formats. The lack of commonality impeded application of recovered data by users in studies to increase seismic safety.

2) Technological advances, as high-resolution accelerographs introduced in the last decade continue to supplant film record digitization, mean that even existing data formats needed to increase resolution capability. In another advance, increased station location precision, available with GPS, mean more resolution is also required to specify station location.

3) The increased number of networks make unique station identification an issue for users, since two networks might each have a station number 1552, for example. COSMOS borrows from the Internet IP protocol model, adding a network number as part of an expanded station number. Thus the full number of the two stations might be 02-1552 and 07-1552, and the uniqueness of the stations is preserved for the user. (The network number is cross-referenced to the IRIS seismic network codes where applicable.)

4) The increasing interface with classical seismic networks, associated with increased common goals and the in-common use of seismic instruments, makes the interchange of data for dual use in both earthquake engineering and seismology research an important goal.

[1] The COSMOS format was developed by a Working Group of the COSMOS Strong Motion Programs Board with participation by N. Abrahamson and W. Savage (PG&E); R. Borcherdt, D. Boore, W. Joyner, G. Glassmoyer, C. Stephens and K. Fogelman (USGS); R. Archuleta, A. Tumarkin and M. Squibb (UCSB); R. Ballard and M. Savage (USCOE); C.B. Crouse and R. Graves (URS); M. Huang, V. Graizer, C. Scrivner, and H. Haddadi (CDMG); A. Viksne and C. Wood (USBurRec); W. Lee and D. Dodge; A. Shakal. (Chair).

Date File Structure

Each data file consists of a header followed by data. More specifically, a file contains a header and data for a single component of motion and for a single type of data (acceleration, velocity, displacement, etc.) (The component files can be easily concatenated to form traditional multi-component files, and some networks may take this step for convenience in distribution.) The data header itself has three sections (text, integer and real), each of which contains information of the corresponding type.

Header Section:

1. Text Header:
   - Provides alphanumeric information, such as the name of the earthquake and station, the location of the sensor (in the case of a structural, geotechnical or other array), and a short description of the site geology.
   - Provides convenient, quickly readable information that does not require reference tables to understand. Its purpose is human readability; precise values of parameters should be obtained from the numeric headers.
   - The basic text header has 13 lines, but can be longer if a network chooses, provided the first 13 lines follow the format described here.

2. Integer Header:
   - The basic integer header includes the specification of a minimum set of parameters.
   - A larger number of parameters may be included beyond that set, defined as desired.
   - The numeric format that the integer parameters are written in can be chosen by the agency, and is specified in the header itself.

3. Real Header:
   - Like the integer header, the basic real header includes the specification of a minimum set of parameters, and a larger number may be included, defined as desired.
   - The numeric format for the real parameters is specified in the header itself (either a floating point or exponential format can be used).

Data Section:

- The first line of the data section includes the type of data (accel., velocity, displ., etc.) and its units, the number of data points, and the format to be used in reading the data. The format will type be for integer or real values, as appropriate; the format for real values can be floating point (e.g., 8f10.5) or exponential (e.g., 5e16.7). Although not required, 80-character line lengths are most convenient for many engineering strong motion data users.
- The first line is followed by as many lines of data as are needed to accommodate the number of points, given the format in which the data values are written.

Revision Process

This format uses a set of tables (Tables 1 through 12) that contain codes for the variety of necessary metadata information parameters about the data. Some tables, especially those containing information about networks, instruments and sensors, are expected to change and grow with time, and gaps have been left to accommodate this need. COSMOS will introduce new values in these tables as the need develops, and upon input from users (please email cosmos@eerc.berkeley.edu with suggestions when a need becomes apparent).

Changes in the 3-digit format version number (e.g., 1.20) will reflect the introduction of changes. Major version changes will be reflected in the first two digits; changes in the minor number (third digit) will indicate that only additional table code values have been defined. This document and the latest versions of the supplemental tables will be available at the COSMOS web site and at the web sites of several of the core members (e.g., http://nsmp.wr.usgs.gov/ and ftp://ftp.consrv.ca.gov/pub/dmg/csmip/formats/. It is planned that machine-readable versions of the tables will be available at these sites so that user programs can automatically look up unknown/new Table entries.

User Convenience

The COSMOS format strives to achieve flexibility for the data-generating agencies while preserving user convenience by including, in the format prescription, the number of parameters and number of lines to be read. Though reading this format is slightly more complex than reading one of the legacy formats, with this approach a single user program can easily read data files that are quite different in detail.

As an example, to read an Integer header which has been written with a specific numeric format (e.g., I10, as in the illustration), the following general coding (in Fortran) can be used:

```
character  textstring*80, IhdrFormat*12
integer  Ihdr(100)
    :
read (iunit, '(a)') textstring
read (textstring,'(i4, t57, a12)')  nIhdrValues, IhdrFormat
read (iunit, IhdrFormat)  (Ihdr(i), i=1,nIhdrValues)
```

(good practice would monitor read errors, and check that the value of nIhdrValues is in range, of course.) Source code templates in Fortran and other languages will be available from COSMOS.

Converters for Compatibility with Legacy Formats

Many programs and software packages require input data in a specific format (for example, the Caltech Bluebook format, the CDMG format, one of the USGS formats, etc.). It is the expressed intent of COSMOS that these application programs not be rendered unusable by the new format. Therefore, conversion routines will be available at the COSMOS website that will convert files in this format into one of the traditional formats. The user need only download the executable program, run it on a data file in the COSMOS format, and obtain a file in the legacy format that is readable by the existing application program.

Some users who have used one of the legacy formats for years may feel that this new common format is unnecessarily complex, and involves too many parameters. The complexity and number of parameters is an aspect of bringing together disparate formats, and is necessary for future growth. However, at this time a user need only deal with the subset of parameters they actually use in their work, and the above converters can be used to convert the new format to a file they are accustomed to. Other users may wish to strip off the top header section of the file and save it in a "--.hdr" file in the same folder, and work directly with the data section, referring to the .hdr file as needed for reference.

Additional converters are planned to provide conversion to and from common spreadsheet and application program formats, and seismological network formats such as SEED, thus making "dual use" of the data in earthquake engineering and seismological research very convenient.

Data File Types

The data file types commonly used in strong motion have their roots in the Caltech Bluebook project and are named Volume 1, 2, etc. (or Phase 1, 2..). They range from very raw files to processed and user-ready product files. They are all ASCII files and so do not have the machine dependency problems of binary files. The Volume 2 product file is used most often in earthquake engineering analysis.

- Volume 0 files have raw data values in digital counts, obtained directly from the native binary files of the recording instrument. (Records obtained by digitizing analog film generally do not have a V0 file.) V0 files may have almost no quality control or checking, and so they may be treated as internal files by networks. V0 files have adequate information in the headers to be converted to files with physical values. There is one component per file, so one record obtained by a triaxial recorder will result in three files.

- Volume 1 files contain raw data, but converted to physical units. V1 files are traditionally referred to as “Uncorrected” acceleration files, primarily because the instrument correction has not been performed. In the V1 file, digital counts (which are dependent on a recorder’s word length and the span and offset of its analog-to-digital converter) have been converted to physical units (e.g., "g") with normal range. No correction for instrument response and no filtering to remove noise is performed. V1 files are often zero-mean; if so the average value that was removed is stored in the real header. V1 files often have the same sampling rate as their V0 files. Again, there will be three files for one record from a triaxial recorder.

- Volume 2 files are time-series product files obtained through signal processing operations on V1 files. The operations generally include correction for the instrument response and digital bandpass filtering and/or base-line correction procedures. The V2 acceleration is obtained from the V1 acceleration through these calculations. The velocity is obtained from the V2 acceleration via numerical integration, and the velocity is integrated to obtain the displacement, each integration possibly accompanied by long-period filtering. Each component yields three files (acceleration, velocity and displacement), so a triaxial record produces 9 files.

- Volume 3 files are spectral product files. Each file includes response spectra (relative displacement, SD, relative velocity, SV, and absolute acceleration, SA) at a fixed set of periods and damping values, which are given in the file. The file will also contain an approximation of the Fourier amplitude spectrum (FS) of the acceleration. (Note that the pseudo relative velocity (PSV) and pseudo absolute acceleration (PSA) spectra are not included since PSV can be obtained as ω x SD, and PSA as ω^2 x SD.) One file is produced per component, so one triaxial record will result in three V3 files.

Format References

Background:

Shakal, A.F. and R. D. Borcherdt (1999). Toward a common format for strong motion data, in Proceedings, SMIP99 Seminar on Utilization on Strong-Motion Data, Sacramento, CA, p. 121-133.

Caltech (Bluebook) Format:

Hudson, D.E., A.G. Brady and M.D. Trifunac (1969). Strong-motion earthquake accelerograms, digitized and plotted data, Vol. I, Parts A-Y, Calif. Inst. Technology, EERL Reports.

Hudson, D.E., A.G. Brady, M.D. Trifunac and A. Vijayaraghavan (1971). Strong-motion earthquake accelerograms, Corrected accelerograms and integrated velocity and displacement curves, Vol. II, Parts A-Y, Calif. Inst. Technology, EERL Reports.

Hudson, D.E., M. Trifunac and A.G. Brady (1972). Response spectra, Vol. III, Parts A-Y, Calif. Inst. Technology, EERL Reports.

USC Format:

Lee, V.W and M.D. Trifunac (1973) Automatic digitization and processing of strong motion accelerograms, Part II: Computer processing of accelerograms, Univ. of Southern Calif., Report 79-15.

USGS Formats:

- Brady, A., V. Perez, and P. Mork (1980) The Imperial Valley earthquake, October 15, 1979, Digitization and processing of accelerograph records, U.S. Geol. Survey, Seismic Engineering Data Report, Open File Report 80-703.
- SMC-format data files: http://nsmp.wr.usgs.gov/smcfmt.html
- CDROM data file format: http://nsmp.wr.usgs.gov/data2/cdrom_sm_1933-1986/docfiles/techinfo.txt, Appendix B
- BBF-format data files: http://nsmp.wr.usgs.gov/docs/bbffmt.txt
- GEOS VFBB format: http://nsmp.wr.usgs.gov/GEOS/HELP/header.doc

CDMG Format:

Shakal, A.F. and M.J. Huang (1985) Standard tape format for CSMIP strong-motion data tapes, CSMIP Report OSMS 85-03, 26p; ftp://ftp.consrv.ca.gov/pub/dmg/csmip/formats.

Contents of Following Format Description Sections

Figure 1. Illustration of COMOS Data File Format v. 01.20

```
       Columns 1111111111222222222233333333334444444444555555555566666666667777777778
Line 123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890
  1  Corrected acceleration    (Format v01.20 with 13 text lines) Src: 24236a13.evt
  2  Northridge Earthquake                   January 17, 1994 04:31 PST
  3  Hypocenter: 34.215   -118.531   H= 28km(SCSN) ML=6.6, Mw=6.7(CIT), Ms=6.7(NEIC)
  4  Origin: 01/17/1994, 12:30:55.4 UTC (SCSN)
  5  Statn No: 01- 24236 Code:CE-J236   CDMG Los Angeles - Hollywood Storage Bldg
  6  Coords: 24.0900 -118.3390  Site geology:Shallow alluvium over granite
  7  Recorder: SSA-2  s/n  908 ( 3 Chns of  12 at Sta) Sensor:FBA-11  s/n 123456
  8  Rcrd start time:01/17/1994, 12:30:52.900 UTC (Q=2) RcrdId: 24236-F0900-94017.04
  9  Sta Chan  4: 360 deg (Rcrdr Chan  1) Location:8th Floor: Center
 10  Raw record length = 110.000 sec, Uncor max =    -.057 g, at   19.635 sec.
 11  Processed:01/25/1994,09:14:18 PST, USGS. Max =   -55.639 cm/sec2  at   9.640 sec
 12  Record filtered below  0.05  Hz (periods over   16.5 secs), and above  23.1  Hz
 13  Values used when parameter or data value is unknown/unspecified:    -999, -999.0
 14    100 Integer-header values follow on  10 lines, Format= (10I8)
 15         2       1       3     110       1    -999    -999   24236    5431    -999 1
 16         5       5       2       5    -999       1    -999    -999      10    -999 2
 17       360       4      12    -999     103       3     908       3       3       3 3
 18        12      12    -999    -999       4       1    1994      17       1      17 4
 19        12      30      52     900       5       4    -999    -999    -999       4 5
 20         1       2   23456     360     360    -999    -999    -999    -999       5 6
 21      -999       5    -999       2       0    -999    -999    -999    -999      91 7
 22         5    -999    -999    -999       1       0       1    -999    -999    -999 8
 23      -999    -999    -999    -999    -999    -999    -999    -999    -999    -999 9
 24      -999    -999    -999    -999    -999    -999    -999    -999    -999    -999 10
 25    100 Real-header values follow on  17 lines, Format= (6F13.6)
 26      24.090000  -118.339000  -999.000000  -999.000000  -999.000000  -999.000000   1
 27    -999.000000  -999.000000  -999.000000    34.215000  -118.531000    18.000000   2
 28       6.700000     6.700000     6.600000  -999.000000  -999.000000  -999.000000   3
 29    -999.000000  -999.000000  -999.000000  -999.000000  -999.000000  -999.000000   4
 30    -999.000000  -999.000000  -999.000000  -999.000000  -999.000000   500.000000   5
 31    -999.000000  -999.000000  -999.000000  -999.000000   500.000000  -999.000000   6
 32      30.000000  -999.000000  -999.000000    46.300000      .670000     1.820000   7
 33    -999.000000  -999.000000  -999.000000  -999.000000     1.000000  -999.000000   8
 34    -999.000000  -999.000000  -999.000000  -999.000000  -999.000000  -999.000000   9
 35       0.067000  -999.000000  -999.000000  -999.000000    23.000000  -999.000000   10
 36    -999.000000  -999.000000  -999.000000  -999.000000    55.639000     9.640000   11
 37       1.230000     0.480000  -999.000000  -999.000000  -999.000000  -999.000000   12
 38    -999.000000  -999.000000  -999.000000   980.660000  -999.000000  -999.000000   13
 39    -999.000000  -999.000000  -999.000000  -999.000000  -999.000000  -999.000000   14
 40    -999.000000  -999.000000  -999.000000   980.660000  -999.000000  -999.000000   15
 41    -999.000000  -999.000000  -999.000000  -999.000000  -999.000000  -999.000000   16
 42    -999.000000  -999.000000  -999.000000  -999.000000                             17
 43       2 Comment line(s) follow, each starting with a "|":
 44  |   This is a sample header, not corresponding to an actual record,
 45  |   to illustrate what a Cosmos Vers 01.20 file would look like.
 46      8000 acceleration pts, approx  200 secs, units=cm/sec2(04),Format=(8F10.3)
 47        .000      .000      .000      .000     -.001      .001      .001     -.004
 48       -.004     -.006      .001      .005      .004      .008     -.009     -.016
 49       -.018      .002      .015      .011      .016      .013      .021      .005
     :
     :
     End-of-data for Chan  4 acceleration
       Columns 1111111111222222222233333333334444444444555555555566666666667777777778
     123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890
```

```
Alternate Examples of 1st line of header:                       (62-80 for agency use)
Corrected acceleration    (Format v01.20 with 13 text lines) FileCode am013.evt)
Uncorrected acceleration    "                         "                   "
Raw acceleration counts     "                         "                   "
Velocity data               "                         "                   "
Displacement data           "                         "                   "
Response spectra            "                         "                   "
```

```
Examples of Data-Section leader line (line 46 in this example):
   90000 velocity     pts, approx 1200 secs, units=cm/sec  (05),Format=(5E16.7)
      .. displacement pts,    "     10 secs,    "   cm      (06),Format=(8F10.3)
      .. raw accel.   pts,    "    200 secs,    "   counts  (50),Format=(10I8)
      .. pore press.  pts,    "   9000 secs,    "   psia    (60),Format=(8F10.6)
         rel. displ.  pts,    "    100 secs,    "   cm      (06),Format=(8F10.6)
    2500 time-accel pairs,    "     50 secs, units=sec&g   (03),Format=(8F10.6)
```

(Note: Color/shading used to indicate variable fields.)

Figure 2. Modification for Response Spectrum Files

```
Line Columns  111111111122222222223333333333444444444455555555556666666666777777777778
     123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890
     Line 1 becomes:
   1 Response spectra         (Format v01.20 with 13 text lines) Src: 24236a13.evt
     Line 11 becomes:
  11 Processed:01/25/1994,09:14:18 PST,CDMG. SaMax= 1.53g at  2.64 sec prd,  5%damping
     And lines 46 and beyond (in this example) become:
  46     5 damping values for which spectra are computed: .00, .02, .05, .10, .20
  47    91 periods at which spectra computed,      units=sec     (01),Format=(8F10.3)
   :      .040      .042      .044      .046      .048      .050      .055      .060
   :      .065      .070      .075      .080      .085      .090      .095      .100
          .110      .120      .130      .140      .150      .160      .170      .180
          .190      .200      .220      .240      .260      .280      .300      .320
          .340      .360      .380      .400      .420      .440      .460      .480
          .500      .550      .600      .650      .700      .750      .800      .850
          .900      .950     1.000     1.100     1.200     1.300     1.400     1.500
         1.600     1.700     1.800     1.900     2.000     2.200     2.400     2.600
         2.800     3.000     3.200     3.400     3.600     3.800     4.000     4.200
         4.400     4.600     4.800     5.000     5.500     6.000     6.500     7.000
         7.500     8.000     8.500     9.000     9.500    10.000    11.000    12.000
        13.000    14.000    15.000
        91 values of approx Fourier spectrum,      units=in/sec  (08),Format=(8E10.3)
      .201E-01  .397E+00  .130E+01  .285E+00  .724E+00  .141E+01  .908E+00  .836E+00
      .189E+01  .169E+01  .318E+01  .250E+01  .206E+01  .105E+02  .688E+01  .865E+01
         :
         :
        91 values of Sd for Damping = .00,         units=inches  (09) ,Format =(8E10.3)
      .559E-02  .667E-02  .123E-01  .106E-01  .153E-01  .174E-01  .153E-01  .170E-01
      .301E-01  .344E-01  .482E-01  .521E-01  .947E-01  .152E+00  .158E+00  .187E+00
         :
         :
        91 values of Sv for Damping = .00,         units=in/sec  (08),Format=(8E10.3)
      .287E+00  .588E+00  .130E+01  .685E+00  .113E+01  .172E+01  .124E+01  .146E+01
      .238E+01  .274E+01  .340E+01  .323E+01  .645E+01  .105E+02  .993E+01  .109E+02
         :
         :
        91 values of Sa for Damping = .00,         units=g       (02),Format =(8E10.3)
      .357E+00  .387E+00  .650E+00  .512E+00  .677E+00  .713E+00  .518E+00  .483E+00
      .729E+00  .717E+00  .876E+00  .833E+00  .134E+01  .192E+01  .179E+01  .191E+01
     :
        91 values of Sd for Damping = .02,         units=inches  (09) ,Format =(8E10.3)
         :
         :  (Sv and Sa included here)
         :
      [repeat pattern for other dampings, as needed]
         :
         :
     End-of-data for Chan  4 response spectra
     Columns  111111111122222222223333333333444444444455555555556666666666777777777778
     123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890
```

HEADER SECTIONS

I. Text Header

The Text Header provides intrinsically textual information (names, descriptions, etc.) and allows a human-readable quick introduction to the file. Numeric values appearing in the text header are for quick reference and convenience; the actual value of parameters should be obtained from the numeric headers.

The following description assumes nominal header sizes (13 text header lines, 100 integer and real header values, and 3 comment lines); these correspond to the attached illustration (Figure 1).

Line	Cols	
1	1-25	Type of physical parameter of the data that follows. Examples: "Corrected acceleration", "Velocity data", "Uncorrected acceleration", "Displacement data", "Raw acceleration counts", "Rel. Displacement data", "Response spectra", "Pore pressure data"
	36-40	COSMOS format version number (major.minor).
	47-48	Number of lines in text header (including this one).
	62-80	Field reserved for use by preparing agency.

Earthquake information (note that the location and magnitude reflect information available when the file was generated and may be preliminary and subject to revision; the source seismic network should be referred to for the current best estimates of the parameters):

Line	Cols	
2	1-40	Earthquake name (before a name has been assigned, may appear as "Record of"; test records may use "Test Record of", etc.).
	41-80	Earthquake date and time (including time zone).
3	12-46	Hypocenter: 12-20 Latitude (positive North); 22-31 Longitude (positive East); and 35-37 Depth (km); 40-46 Source agency for hypocenter information.
	47-80	Magnitude(s), including source agency for values (may be entered manually, so spacing may be variable).*
4	9-42	Earthquake origin date and time, in UTC (i.e., GMT), with source agency; 43-80, For use by preparing agency; may include note, e.g., "Preliminary Processing", etc.

Station information:

Line	Cols	
5	10-80	Station identification: 10-12 Network number (see Table 4); 14-19 Station number; 26-27 Network code, IRIS (if assigned; see Table 4); 29-34 Station alphanumeric code (left justified); 36-40 Network abbreviation; 41-80 Station name.
6	8 -16	Station latitude (positive North); 17-26 longitude (positive East); 41-80 Site geology description.

Recorder and sensor information:

Line	Cols	
7	11-26	Recorder type and serial number.*
	28-29	Number of channels in recorder; 39-41 Number of channels at station.
	58-80	Sensor type and serial number.*

Record information:

Line	Cols	
8	17-50	Record start time (date and time of first sample; may be approximate - precise value should be obtained from real header) and time quality (0 through 5 correspond to lowest through highest quality).
	59-80	Record identification, assigned by preparing agency.
9	9 -20	Station channel number for this sensor, and sensing direction (azimuth or word; refer to code in Ihdr(54) and Table 11).
	33-35	Recorder channel number, if different.
	47-80	Location of sensor (for structural or other arrays).

10 20-27 Length of raw record, as recorded (seconds); 45-54 Maximum of raw (uncorrected) record in g (or other units);* 60-67 Time max occurs in raw record (secs after start).*
11 11-40 Processing/release date, time and agency.
48-80 Maximum of data series in file, units, and time of maximum (seconds after start).*
12 22-27 Filter band used in processing: Low frequency 3 dB corner frequency, in Hz; in 45-50, expressed as period, in seconds; 68-72 High frequency 3 dB corner frequency, in Hz.
13 65-80 Value used in file to indicate a parameter or data value is unknown or not specified: 65-71, value for integers; 73-80, value for reals.

* Note: Because of the variability of the information, these fields may not be parsable strictly by column position. The most reliable way to access the information is through the parameters in the Integer or Real headers.

II. Integer Header

14 1 - 4 Number of values in Integer Header.
38-40 Number of lines of Integer Header values that follow.
57-80 Format by which the Integer Header values are written.
15 - 24: Lines with Integer header values (actual number of lines, and line numbers in rest of header, depend on number of elements in the header and the format).

III. Real Header

25 1 - 4 Number of values in Real Header.
35-37 Number of lines of Real Header values that follow.
54-80 Format by which the Real Header values are written.
26 - 42: Lines with Real header values (actual line numbers will vary).

IV. Comments

43 1 - 4 Number of comment lines that follow, each starting with "|"; may be zero. Comment lines contain special information about the record (e.g., problem with timing, gain, orientation, or processing issues such as filtering, noise, etc.)

DATA VALUES SECTION

<u>Line</u> <u>Cols</u>
1st 1 - 8 Number of data points following; 10-21 Physical parameter of the data.
35-38 Approximate length of record (rounded to nearest sec; see Rhdr(66) for precise value).
52-58 Units of the data values (e.g., cm/sec2); 60-61 Index code for units (see Table 2).
71-80 Format of the data values written on the following lines.
N lines: Data values.

End-of-Data Flag Line:

N+1 1 -11 End of data flag string, "End-of-data for..".
21-36 Station channel number and physical parameter of data (a checksum may optionally be included on the remainder of this line).

RESPONSE SPECTRUM FILES

Response spectrum files follow the pattern of the time-history files. Differences include:
11 48 -80 Maximum of Sa and period of max.
Lines 46 and beyond follow the header-line-plus-data pattern of the Data Values section for each of the spectra (see Figure 2).

Contents of Integer and Real Headers

Param.No. I	R	Parameter Description	First Used
		Data/File Parameters	
1		Processing stage index of data in this file (0,1,2,3 for v0 through v3)	0
2		Physical parameter of data in this file (1,2,3..=acceleration, velocity, displ., etc; see Table 1	0
3		Units of data following this header (1,2,etc; see Table 2)	0
4		COSMOS format version number (major.minor x 100)	0
5		Type of record (1 for seismically triggered; other values for other record types in Table 3	0
		Station parameters	
8		Station number (as assigned by operating network)	0
9		Secondary station number (assigned by secondary network, if any)	0
		Network number for station (see Table 4)	
11		Network number of operating network	0
12		Network number of network/agency owning this station	0
13		Network number of secondary network with previous or secondary responsibility for this station (if any	0
14		Network number of network/agency that processed this record	0
	1	Latitude of station (decimal degrees, North positive)	0
	2	Longitude of station (decimal degrees, East positive)	0
	3	Elevation of station above sea level (m)	0
16		Reference datum for station coordinates (see Table 5)	0
	4	Site geology parameter V30 (km/s)	
18		Code for site geology at station (assigned by agency)	0
19		Station type (freefield, small bldg; instrumented bldg, bridge, or dam, etc; see Table 6)	0
		Instrumentation orientation direction at station	
20		- For freefield/triaxial stations: Connector Reference Orientation (azimuth of accelerograph connector, accelerometer connector in the case of an external biaxial or triaxial pkg); 1-360 deg, CW from N	0
21		- For structural stations or arrays: Structure/Array Reference Orientation (azimuth of Structure/Array "Reference North" relative to True North); 1-360, CW from North	0
22		Number of recorders in system at station	0
23		Total number of channels in recording system at station	0
		Earthquake Parameters (location and magnitudes may be preliminary, and subject to revision	
	10	Earthquake latitude (decimal degrees, North positive)	0
	11	Earthquake longitude (decimal degrees, East positive)	0
	12	Earthquake depth (km).	0
25		Reference for location and depth determination (see Table 7)	
	13	Moment magnitude, M.	0
	14	Surface-wave magnitude, MS.	0
	15	Local magnitude, ML.	0
26		Reference for Moment magnitude (see Table 7)	
27		Reference for Surface-wave magnitude (see Table 7)	
28		Reference for Local magnitude (see Table 7)	
	16	Other magnitude (see comments, if used)	0
	17	Epicentral distance to station (km).	0
	18	Epicenter-to-station azimuth (CW from north)	0
		Recorder/Datalogger parameters	
30		Recorder type code (see Table 9)	0
31		Recording medium (1=film, 2=tape, 3=solid state).	0
32		Recorder serial number (if non-numeric, given by text string in Text Header, line 7	0
33		Number of channels in recorder	0
34		Number of channels in recorder that were recorded (may be same as above)	0
	22	Recorder least significant bit (LSB) in micro-volts (i.e., uv/count)	0
	23	Recorder full-scale input (volts)	0
35		Sample word length as originally recorded (i.e., number of bits; so full scale counts = ±2**(nbits-1))	0
36		Effective number of bits (may be the same as above)	0
	24	Pre-trigger memory recording time (secs)	0
	25	Post-detrigger recording time (secs)	0

Contents of Integer and Real Headers

Param.No. I	Param.No. R	Parameter Description	First Used
	26	Corner frequency of anti-alias filter (Hz)	0
	27	Decay of anti-alias filter (dB/octave)	0
	28	If film record, size of digitizer y-step (acceleration) of digitizer used, in microns (i.e., cm/10000	0
		Record parameters	
38		Trigger number of this record in the recorder (if applicable)	0
39		Shock number in this trigger; normally 1	0
		Start time of record (time of first sample, UTC (i.e., GMT))	
40		Year (4 digit)	0
41		Julian day	0
42		Month	0
43		Day of month	0
44		Hour	0
45		Minute	0
	30	Seconds (with fractional part)	0
46		Time quality indicator (0-5 = poorest to best	0
47		Time source (see Table 8).	0
	31	Correction applied to recorder clock time (if applicable, e.g., for Time source=1 or 2) to obtain abov	0
		start time (secs); i.e., Tstart = Trecorder + Tcorrection	0
	32	Offset of local time zone from UTC (i.e.,GMT); i.e., Offset (hrs) = UTC - local time	0
	34	Data sample interval (sec) in original (v0) record	0
	35	Length of raw (v0) record (secs)	0
	36	Mean value removed to make V1 time series zero-mean (if any); in units of V1 data	1
		Sensor/channel parameters	
50		Station channel number.	0
51		Recorder channel number (if analog, counted downward from top of film)	0
52		Sensor type code (FBA, etc; see Table 10; -1 if no sensor attached)	0
53		Sensor serial number (if non-numeric, given by text string in text header, line 7)	0
	40	Sensor natural frequency (Hz)	0
	41	Sensor damping (fraction of critical)	0
	42	Sensor sensitivity (for accelerometer, in volts/g (cm/g if film record); for other sensors, in volts pe motion unit given in Ihdr(3)).	0
	43	Full scale output of sensor (volts)	0
	44	Full scale sensing capability of sensor (in g for accelerometer; in units given by Ihdr(3) for other sensors	0
	45	Sensor low-frequency corner (Hz; 0 for traditional FBA)	0
	46	Sensor low-frequency decay (dB/octave; n/a for traditional FBA	0
	47	Gain applied to sensor output prior to recording (1.0 if no amplification; 2.0 for doubling, etc.	0
		Azimuth of sensor (i.e., direction of motion corresponding to positive-going data values	
54		- Azimuth of sensor relative to True North (1-360 deg; see Table 11 for other values	0
55		- Azimuth of sensor relative to Reference Orientation, if any (1-360 deg; see Table 11 for other values	0
56		Location Index of sensor site at station, in the cose of a multi-site array	0
	50	North offset of sensor site from station location reference, if array (m	0
	51	East offset of sensor site (m)	0
	52	Vertical offset of sensor site (m; up positive)	0
		Filtering/Processing parameters	
60		Processing stage (1-3 = preliminary, intermediate, final)	1
61		Low-frequency filter type used in vol2 processing (see Table 12	2
	54	Corner frequency of low-frequency filter (Hz	2
	55	Decay of low-frequency filter (dB/octave)	2
	56	Roll-off width of low-frequency filter (Hz), if applicable (e.g., Ormsby	2
62		High-frequency filter type used in vol2 processing (see Table 12)	2
	57	Corner frequency of high-frequency filter (Hz	2
	58	Decay of high-frequency filter (dB/octave)	2
	59	Roll-off width of high-frequency filter (Hz), if applicable (e.g., Ormsby	2

Contents of Integer and Real Headers

Param.No. I	Param.No. R	Parameter Description	First Used
64		Filtering domain flag (1 if filter applied in time domain, 2 if applied in frequency domain)	2
	60	Length of filter operator (secs), if time domain filtering	2
65		Special-processing flag (0=normal; 1=special, described in comment lines)	2
		Time History Parameters	
	62	Sample interval of time series in file (dt, in msec)	
	63	Length of time series in file (i.e., npts*dt)	
	64	Maximum value of time series in file	0
	65	Time at which maximum value occurs (secs after start)	0
	66	Average value of time series	
		Initial values associated with numerical integration (if applicable)	
	68	Initial velocity value (cm/sec)	2
	69	Initial displacement value (cm).	2
		Response Spectrum Parameters	
70		Number of periods for which response spectra are computed	3
71		Number of damping values for which response spectra are computed (typically 5)	3
		Sa spectrum values for 5% damping:	
	70	Value of Sa at 0.2 seconds period (g).	3
	71	Value of Sa at 0.3 seconds period (g).	3
	72	Value of Sa at 1.0 second period (g)	3
	73	Value of Sa at 3.0 seconds period (g).	3
	74	Maximum value of Sa spectrum (g).	3
	75	Period at which maximum Sa occurs (secs)	3
	76	Time in record at which above maximum occurs (secs)	3
		Computed Parameters	
	80	Duration, bracketed (secs over 5% g)	2
	81	Duration, interval (5-75%, in secs).	2
	82	RMS of channel.	2
	83	Cumulative absolute velocity (m/s)	2
	84	Housner Intensity (SI).	2
	85	Arias Intensity.	2
		Miscellaneous	
	88	Scaling factor used to convert Vol1 units (g) to cm/s2 (e.g., 980.665)	2
75		Nominal-constants indicator (1 if nominal sensor constants used in processing)	1
76		Record problem indicator (0 = No problem; 1=fixed, 2=unfixed problem; see comments)	0
77		Instance code/processing index number	
		Auxiliary internal parameters used by networks	
80-100	90-100	Parameters assigned and used in internal processing and quality-control procedures by individual networks	

Notes:

1) For a V3 (response spectrum) file, parameters such as Ihdr(2), etc. are not applicable and may be set to zero.
2) If the frequency response of a sensor is given in terms of poles and zero rather than simply by natural frequency an damping (i.e., Rhdr(40) and Rhdr(41)), those parameters can be set to the null/unspecified value (given on line 13 in the Text header) and the poles and zeroes be stored in the supplemental parameters, with a note to that effect stored in the

Reference Tables

Table 1. Data Physical Parameter Codes

Code	Parameter
01	Acceleration
02	Velocity
03	Displacment (absolute)
04	Displacment (relative)
:	
10	Angular acceleration
11	Angular velocity
12	Angular displacment
:	
20	Pressure, absolute
21	Pressure, relative (gage)
:	
30	Volumetric strain
31	Linear strain
:	

Table 2. Data Units Codes

Code	Units	Code	Units
01	sec	50	counts
02	g	51	volts
03	secs & g	52	mvolts
04	cm/sec/sec	:	
05	cm/sec	60	psi
06	cm	61	
07	in/sec/sec	:	
08	in/sec	80	µstrain
09	in.	:	
10	gal		
11	mg		
12	µg		
:			
23	deg/sec/sec		
24	deg/sec		
25	deg		
:			

Table 3. Record Types

Code	Record type
1	Seismic trigger
2	Remote trigger
3	Preset trigger
4	Manual trigger
5	Function test
:	
10	Sensor calibration
11	Amplifier calibration
12	Recorder calibration
13	Other calibration
:	

Table 4. Strong Motion Network Codes

Code	Agency	Abbrev. (4-ltr)	IRIS Code
1	U.S. Coast and Geodetic Survey	C&GS	--
2	U.S. Geological Survey	USGS	NP
3	U.S. Bureau of Reclamation	USBR	RE
4	U.S. Army Corps of Engineers	ACOE	--
5	Calif. Div. of Mines and Geology	CDMG	CE
6	Calif. Institute of Technology	CIT	CI
7	UC Berkeley	UCB	BK
8	…	..	..
:			
100	CWB, Taiwan Central Weather Bureau	CWB	TW
:			

Table 5. Latitude/Longitude Datum Codes

Code	Datum
1	WGS84
2	NAD83
3	NAD27
4	WGS72
:	

Table 6. Station Type

Code	Freefield, Ground Response or Reference Stations
1	Small, fiberglass shelter (typically 1 m x 1 m x 1 m; e.g., T-hut).
2	Small, prefabricated metal building (typically 1-2 m x 1-2 m x 2 m high; e.g., Armco).
3	Sensors buried/set in ground (shallow, near surface).
4	Reference station (1-2 story, small, light building).
5	Base of building larger than above.
:	

Code	Instrumented Structures or Arrays	Code	
10	Building	50	Geotechnical array
11	Bridge	51	Other array
12	Dam	:	
20	Other structure		
:			

Table 7. Earthquake Parameter Information Sources

Code	Agency
1	USGS
2	NEIC, Golden, Colo.
3	UC Berkeley
4	Caltech, Pasadena
5	NCSN, Northern Calif.
6	SCSN, Pasadena, Calif.
7	UCSD, San Diego, Calif.
8	UNR, Reno, Nevada
9	USCGS
:	
100	CWB, Taiwan
:	
200	Other

Table 8. Recorder Timing Type

Code	Time source for record
0	None
1	Recorder clock
2	Auxiliary clock (e.g., TCG)
3	Radio time signal (e.g., WWVB, WWVH)
4	Clock that tracks radio signal (WWVB, etc.)
5	GPS signal
:	
20	Other
:	

Table 9. Recorder/Datalogger Codes

Code	Recorder/Datalogger
Analog Recorders	
1	C&GS Standard, USC&GS
2	AR-240, Teledyne
3	RFT-250, Teledyne
4	RFT-350, Teledyne
5	MO-2 (New Zealand)
6	RMT-280
7	SMA-1, Kinemetrics
8	SMA-2, Kinemetrics
9	SMA-3, Kinemetrics
10	CRA-1, Kinemetrics
:	
Digital Recorders	
100	DSA-1, Kinemetrics
101	DSA-3, Kinemetrics
102	PDR-1, Kinemetrics
103	PDR-2, Kinemetrics
104	SSA-1, Kinemetrics
105	SSA-2, Kinemetrics
106	SSA-16, Kinemetrics
107	SSR-1, Kinemetrics
108	K2, Kinemetrics
109	Etna, Kinemetrics
110	Mt Whitney, Kinemetrics
111	Everest, Kinemetrics
:	
200	DR-100, Sprengnether
201	DR-200, Sprengnether
202	DR-300, Sprengnether
202	DR-3016, Sprengnether
203	DR-3024, Sprengnether
:	
300	DCA-300, Terratech
301	DCA-310, Terratech
302	DCA-333, Terratech
310	IDS-3602, Terratech (IDS)
311	IDS-3602A, Terratech (IDSA)
:	
400	A700, Geotech
401	A800, Geotech
402	A900, Geotech
403	A900A, Geotech
:	
500	GEOS, US Geological Survey
:	
600	Q4120, Quanterra
601	Q4128a, Quanterra
602	Q730, Quanterra
603	Q736, Quanterra
604	Q980, Quanterra
:	
700	72A, RefTek
:	
1000	Other
:	

Table 10. Sensor Codes

Code	Sensor
Accelerometers	
1	Optical-mechanical (SMA,RFT,etc)
2	FBA-1, Kinemetrics
3	FBA-3, Kinemetrics
4	FBA-11, Kinemetrics
5	FBA-13, Kinemetrics
6	FBA-13DH, Kinemetrics
7	FBA-23, Kinemetrics
8	FBA-23DH, Kinemetrics
20	Episensor, Kinemetrics
21	Episensor ES-U, Kinemetrics
:	
50	FBX-23, Sprengnether
51	FBX-26, Sprengnether
:	
100	SSA 120, Terratech
101	SSA 220, Terratech
102	SSA 320, Terratech
:	
150	731A, Wilcoxon
:	
200	CMG-5, Guralp
:	
900	Other accelerometer
Velocity Sensors/Seismometers	
1001	SS-1 Ranger, Kinemetrics
:	
1050	S-3000, Sprengnether
:	
1201	CMG-1, Guralp
1202	CMG-3T, Guralp
1203	CMG-3ESP, Guralp
1204	CMG-40, Guralp
:	
1250	STS-1, Strecheisen
1251	STS-2, Strecheisen
:	
1300	L4, Mark Products
1301	L22D, Mark Products
:	
1900	Other seismometer
Other Sensors	
3000	Pressure series
3000	Pressure series
:	
3500	Dilatometer series
:	
4000	Relative displacement series
:	
4500	Rotational series
:	
9000	Other sensor

Table 11. Sensor Direction Codes*

Value	Orientation	Abbrev. (4-ltr)
1-360	Horizontal azimuth, clockwise (east) from North	n/a
400	Up	Up
401	Down	Down
402	Vertical, sense not indicated	Vert
:		
500	Radial, inward (-500 for outward)	Radl
501	Transverse, 90 deg CW from radial comp. (-501 for CCW from radial comp.)	Tran
:		
:		
600	Longitudinal (relative to structure)	Long
601	Tangential (relative to structure)	Tang
:		
700	H1 (horiz. sensor, azimuth unknown)	H1
701	H2 (horiz. sensor, azimuth unknown)	H2
:		
1001-1360	Horizontal azimuth relative to Chn 1, if absolute not known (e.g., Chn 2 is 1090 if it is 90 deg east of Chn 1)	n/a
:		
2000	Other (described in comments)	Othr

*Note: The direction specified is the direction of motion of the ground (or the structural element the sensor is attached to) that corresponds to upward motion of the trace.

Table 12. Codes for Filter Types used in Processing

Code	Filter type
0	None
1	Rectangular
2	Cosine bell
3	Ormsby
4	Butterworth, single direction (causal)
5	Butterworth, bi-directional (noncausal)
6	Bessel
:	