# TELEMETRY MEASUREMENT ATTRIBUTES PROCESSING AT THE WESTERN TEST RANGE

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## ABSTRACT

The processing of telemetry data received at the Western Test Range (WTR) requires the use of user supplied measurement attributes information. The telemetry streams currently being presented for support are from technologically advanced test vehicles which often involve complex measurement definition schemes. This document describes some of the current definition schemes and the processing required to obtain and utilize the data. The chaotic state of this environment is in no small part due to the lack of standardization of the measurement definition scheme and its media. The trend has been, and will continue to be, a condition of ever increasing complexity and variety unless some standardization is applied.

## INTRODUCTION

The design of telemetry transmission systems have evolved to highly sophisticated computer-based environments where measurement descriptive attributes require large amounts of text information. This data must be supplied to multiple agencies for use in telemetry support operations. Typically, a developer of a system requiring telemetry support accumulates the attributes information in a computer data base. It is natural that the data definition scheme is one which is compatible with existing (in-house) data base services. As a general rule, these data bases are not compatible with outside agencies that must receive and utilize the information. In a processing environment such as exists at WTR, the variety of user defined schemes creates a large overhead in software and manpower to assimilate and utilize the user supplied data.

In addition, the utilization of computers in the design of airborne systems has progressed so rapidly that procurement authorities are overwhelmed with technological specifications. The concentration of effort on the design of the weapon system itself results in insufficient attention being given to ground station interfaces. Since a measurement attributes format standard does not exist, a reference document is not available to a procuring agency. The data delivery scheme and media become options deferred to the data supplier which cause software development by the recipient in order to utilize the data.

## MEASUREMENT ATTRIBUTE PROCESSING

The processing of telemetry data at WTR serves a multitude of users and operational functions. Processing provides both real-time user displays for health and status of test vehicles and real-time inertial guidance for range safety purposes. Since most testing at WTR involves moving objects, at least one telemetry data stream is received and processed in order to assure that the article being tested flies in the prescribed flight corridor. To properly configure a telemetry processing system, given the current airborne systems capacities, the users generally provide the telemetry streams measurement description information on digital magnetic tape. These tapes are provided in various formats and recording modes. Table I provides a list of (most) tapes currently received at WTR and the general description of each tape. The following paragraphs describe the processing required for some of these tapes.

## PEACEKEEPER TAPE PROCESSING

Tapes “a” through “d” of Table I are used by WTR to develop a composite (merged) measurement attributes data base tape “h”. This data base is used by WTR for operational setup of telemetry systems, post flight data processing and is provided back to the Peacekeeper associated contractors. WTR is the single point of convergence for these four tapes. The range technical services contractor performs cross-tape comparisons to assure measurement definition consistency. The processing overview is shown in Figure I. The CSAR tape is processed initially to establish the master list. The telemetry format location data is then added by processing the MULOAD tape. If a measurement name was omitted from the CSAR but is found on the MULOAD tape, it will be inserted into the data base. The next tape (GCSC) is then processed to complete the basic telemetry format allocation for all data except the embedded MECA area. The MECA tape processing generates a separate data base set due to the complicated sampling scheme involved. There are four different MECA data sampling categories, one of which requires 15 specific entries in the data base for format locations. The embedded data area for guidance computer data is used to relay a combination of data rates. Continuous fixed rate (10 ms) and variable data rates of 30 ms, 150 ms, and 450 ms are multiplexed into the reserved buffer area of the telemetry format. In many cases, the data from one frame must be held and concatenated with data from the next telemetry frame. The full details of the entire set of processing accomplished on these tapes is too extensive to describe in this document; however, it is apparent that the programming and processing workload is significant. The four input tapes are converted into 15 work files, six control files, and eight data files. This processing occurs multiple times for each flight test due to preflight changes in user tape inputs. Test programs involved in R&D such as Peacekeeper generally require many changes during the prelaunch periods.

## SPACE TRANSPORTATION SYSTEM TAPE PROCESSING

The NASA multifile shuttle data tape (STS-MFSDT) provided to WTR describes up to 100 data formats that are possible for use on an STS mission. Typically a mix of high data rate, low data rate, and payload formats are found on the tape. Since the WTR role for telemetry processing consists primarily of providing range safety support, only a limited number of formats are currently extracted from the many described on the tape. The formats required are involved with the ascent mode of flight and various abort mode formats.

## DATA EXTRACTION

The processing required (see Figure 2) to obtain a specified telemetry format is accomplished by first extracting the requested format using program "STSEXT" from the fourth file on the tape. Then for each measurement name found in that file a scan is made in files 2 and 3 looking for a matching measurement name. The measurement name found in file 4 may not have entries in either files 2 or 3. The files are sorted prior to scanning to facilitate the scanning algorithm.

Upon completion of the extraction process, three files exist which contain the extracted data. Using a file of data base directive control language, the data is transformed into an on-line data base. Reports and lists are then available as required for all WTR agencies.

The data base generated on WTR systems from this processing are of various sizes dependent upon the telemetry function. For example, file 4 typically exceeds 115,000 data records with extracted formats sized as follows:

a. Format 21 - ≃ 4000 measurements each in file 4 and 2
≃ 1000 measurements each in file 3

b. Format 12 - ≃ 1300 measurements each in file 4 and 2
≃ 250 measurements each in file 3

c. Format 129 - ≃ 3600 measurements each in file 4 and 2
≃ 1100 measurements each in file 3

What these formats represent are the orbiter format (129), the primary flight computer format (21), and the backup flight computer format (12). All three must be supported in real time to obtain the selected data for range safety outputs. Typically, two multifile shuttle data tapes are received for each STS mission. The first represents a first-cut list for planning purposes and the second tape is a final (certified) version for operational support.

## ADDITIONAL ATTRIBUTES TAPE PROCESSING

There are several additional programs supported at WTR where the users provide measurement information on digital magnetic tape. These tapes, for programs such as Anti-Satellite and Cruise missile, have a variety of recording formats. One WTR user employs a card image (80 column) format with multiple card image types. The various card images are used to specify the attributes in user defined field lengths and annotation modes. Multiple sets of card images are often employed just to describe super-commutated measurements. In other cases, bit masks are sometimes used to specify this condition. Other user defined schemes may simply provide a bit map of a multiplexor memory which must be decoded to determine telemetry format assignments.

## TAPE HANDLING/LABELING

The condition of many tapes received at WTR provides a real challenge to WTR personnel trying to use them. The exterior markings are many times devoid of useful information and the tape must be serially listed to printer and studied prior to programming a tape processor. Once programmed, the tapes are often changed without prior notice. In other words, this environment is lacking stability and control.

## RECOMMENDATION

The trend within the telemetry community is toward more data sampling at higher rates using complex computer based techniques. The information required to receive and process these telemetry links is growing at a fast pace. In todays environment there is little attention being given to the interface between the airborne system and ground system in the area of measurement attributes. There is no standard for developing and delivering the often voluminous data necessary for ground station support. This entire industry would be greatly served if the Inter-Range Instrumentation Group (IRIG) would form a committee to assess and establish an appropriate standard for measurement attributes data and media.

Once established, the user community should be required to provide outputs from internal data bases or other sources in the standard format. The receiving agencies such as WTR and other support test ranges, would see a reduction in the proliferation of data reformatting programs. The weapon systems developers would have a standard for reference in the requirements specifications. And foremost, stability and order will be established in an area that is currently out of control.

## PROPOSED DATA FORMAT

Table II is a possible configuration of data definition that would serve the needs of WTR for variable telemetry measurement descriptive data. The format includes a header file that could be expanded to include telemetry link information if so desired. File 2 provides for required attributes, necessary for ground station setup, early in the data record. It is highly recommended that use of special characters such as “$”, etc., be disallowed due to the variety of data bases that use them for character string delimiters.

The table is to be considered as an example for use as a starting point for deriving a useful standard format acceptable to standard setting committee members. Items such as numbering sequence for frame counting and data word orientation are not addressed by the table.

## CONCLUSION

For every user of the Western Test Range, where computer based telemetry systems are employed, a significant amount of processing is accomplished to compensate for the users input data tape format. Each new test vehicle creates another set of software and operating steps that must be performed to obtain support information. Each program presented to the various National Test Range agencies must develop a similar set of software to acquire the needed telemetry attributes information. In general, these costs are not considered during the initial phase of systems procurement. This problem could be reduced and eventually eliminated if a data tape format standard is devised and followed by the range user community.

## ACKNOWLEDGEMENT

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## REFERENCES


a. Peacekeeper interface control documents:

1. Interface Control - Instrumentation and Flight Safety System Support Equipment Software to Western Test Range, Ballistic Missile Office (BMO) Document No. C-008-013-2018, Revision B, dated 29 October 1980.

2. Interface Control - Missile Electronics Computer Assembly Software Telemetry Map Tape to WSMC. Ballistic Missile Office Document No. C-013-079-2143, Revision B, dated 24 January 1985.

3. MX Measurement Data Compression Document for System Flight Analysis. Martin Marietta Corporation Document No. ST-0129, latest revision.

b. NASA space transportation system documents.

1. Space Shuttle Telemetry and Command Data Characteristics Handbook, Telemetry Downlink, Volume I., Document No. JSC-08118, Revision C.

2. Shuttle Data Integration Plan - Tape Formats, Document No. JSC-18206, Volume III, Revision C, dated September 1984.

3. Space Shuttle Telemetered and Recorded Data Format Requirements, Document No. JSC-10784, Revision F, dated March 1984.

c. Air-launched anti-satellite document.

Data Handling Plan (Volume III), ASAT Support Data File, Boeing Document No. D349-20182-3, 14 September 1982.

| | TAPE NAME | TRACKS | DENS. | CPU TYPE | LABEL | # FILES | MODE | BLOCK SIZE | TERM. METHOD | # RECORDS | FUNCTION |
|---|---|---|---|---|---|---|---|---|---|---|---|
| a. | CSAR | 9 | 1600 | IBM | YES | 2 | EBCDIC | | "END" | >800 | PEACEKEEPER Master Measurement List |
| b. | MULOAD | 9 | 800 | SEL | NO | 8 | ASCII | 80 | S-EOF | 3,276 | PEACEKEEPER Decom Format List |
| c. | GCSC | 9 | 800 | XEROX | NO | 1 | ASCII | 80 | D-EOF | 7,232 | PEACEKEEPER Embedded Data Map List |
| d. | MECA | 9 | 1600 | SEL | NO | 4 | ASCII | 132 | S-EOF | 4,910 | PEACEKEEPER Embedded Computer MAP LIST |
| e. | STS-MFSDT | 9 | 6250 | IBM | YES | 7 | EBCDIC | 6 SIZES | S-EOF | >7,600 | STS Multiple Formats Strapping and Description |
| f. | GDCSDF | 9 | 1600 | CDC | NO | 3 | ASCII | 80 | S-EOF | ≈ 10,575 | Telemetry Format Assignments |
| g. | ASATSDF | 9 | 1600 | CDC | YES | 8 | ASCII | 5120 | "*WEOR" | ≈ 4,000 | Telemetry Formats and Word Structures |
| h. | DI206.15 | 9 | 1600 | CDC | NO | 7 | BINARY | 5300 | S-EOF | ≈ 1,200 | WSMC Merged PEACEKEEPER Attributes |
| i. | MUVERIFY | 9 | 800 | SEL | NO | 2 | ASCII AND BINARY | 768 | S-EOF | ≈ 2,496 | PEACEKEEPER Multiplexer Memory Load Data |
| j. | TITAN II & III | 9 | 800 | IBM | NO | 1 | EBCDIC | 160 | S-EOF | ≈ 109 | Link 7 TITAN II Time Slot Tape. Calibration data is on separate tape. |

**TABLE 1. MEASUREMENT ATTRIBUTES TAPE CHARACTERISTICS.**

## TABLE II. PROPOSED DATA FORMAT

| FILE 1 (HEADER) | # CHARACTERS | REMARKS |
|---|---|---|
| Vehicle name | 24 | |
| Creation date | 10 | |
| Revision | 4 | Should include all variable administrative data needed to accomplish test mission. Use multiple records if needed. |
| Security class | 2 | |
| No. of files to follow | 2 | |
| Test no. | 8 | |
| Comments | 30 | |
| EOF | | |

FILE 2

| | | |
|---|---|---|
| Sensor name | 10 | Alphanumeric |
| Sensor type (A, DS, C, Db) | 2 | (Analog, Discrete syllable, computer, Discrete bit) |
| Formats assigned | 10 | Integer or mask |
| Frame first location | 8 | Integer word relative to frame sync |
| Frame increment | 8 | Symetrical strapping increment |
| Extended word flag/ non-symetrical flag | 1 | Number to indicate condition |
| Second part location | 8 | Integer |
| Subframe location | 8 | Integer |
| Subframe increment | 8 | Integer |
| Sub subframe location | 8 | Integer |
| SSF increment | 8 | Integer |
| Sensor description | 30 | Alphanumeric |
| Data units | 10 | Degrees, KPSIA, etc. |
| Minimum value | 10 | Minimum valid data value |
| Maximum value | 10 | Maximum valid data value |
| Data word size | 2 | Bits per word (1-64) |
| Data word alignment | 3 | MSB, LSB |
| EUC type | 8 | Table, polynomial, character string |
| Scale factor | 2 | Integer |
| Multiplier | 14 | Floating point |

| | | |
|---|---|---|
| No. of coefficients | 2 | Integer |
| Coefficient 1 | 14 | (EUC type dependent) |
| Coefficient N | 14 | (EUC type dependent) |
| Character string | 20 | Alphanumeric |
| User unique data | | As required |

EOR

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Additional sensor attributes

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EOF

EOF

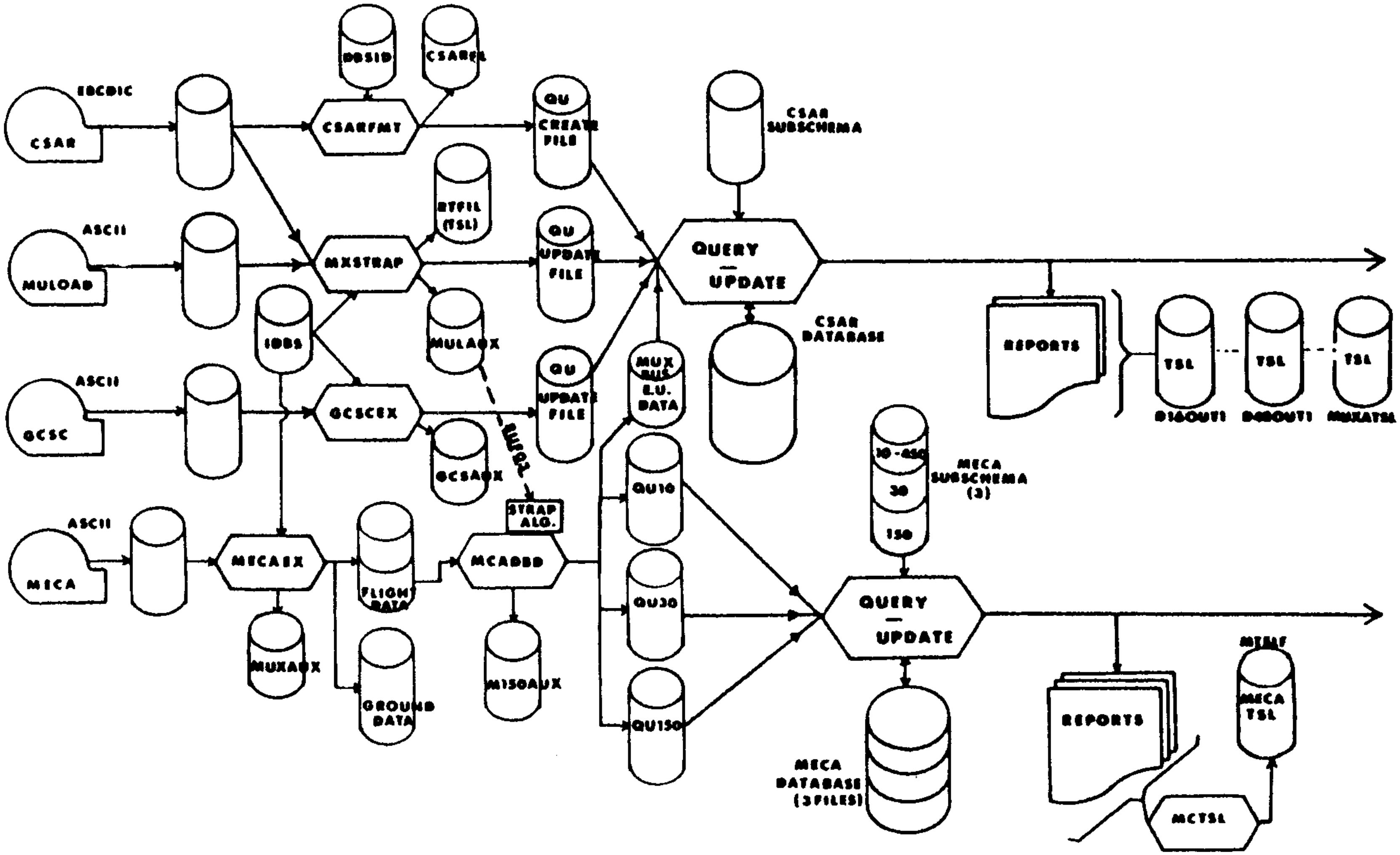


**Figure 1. Peacekeeper Tape Processing Overview.**

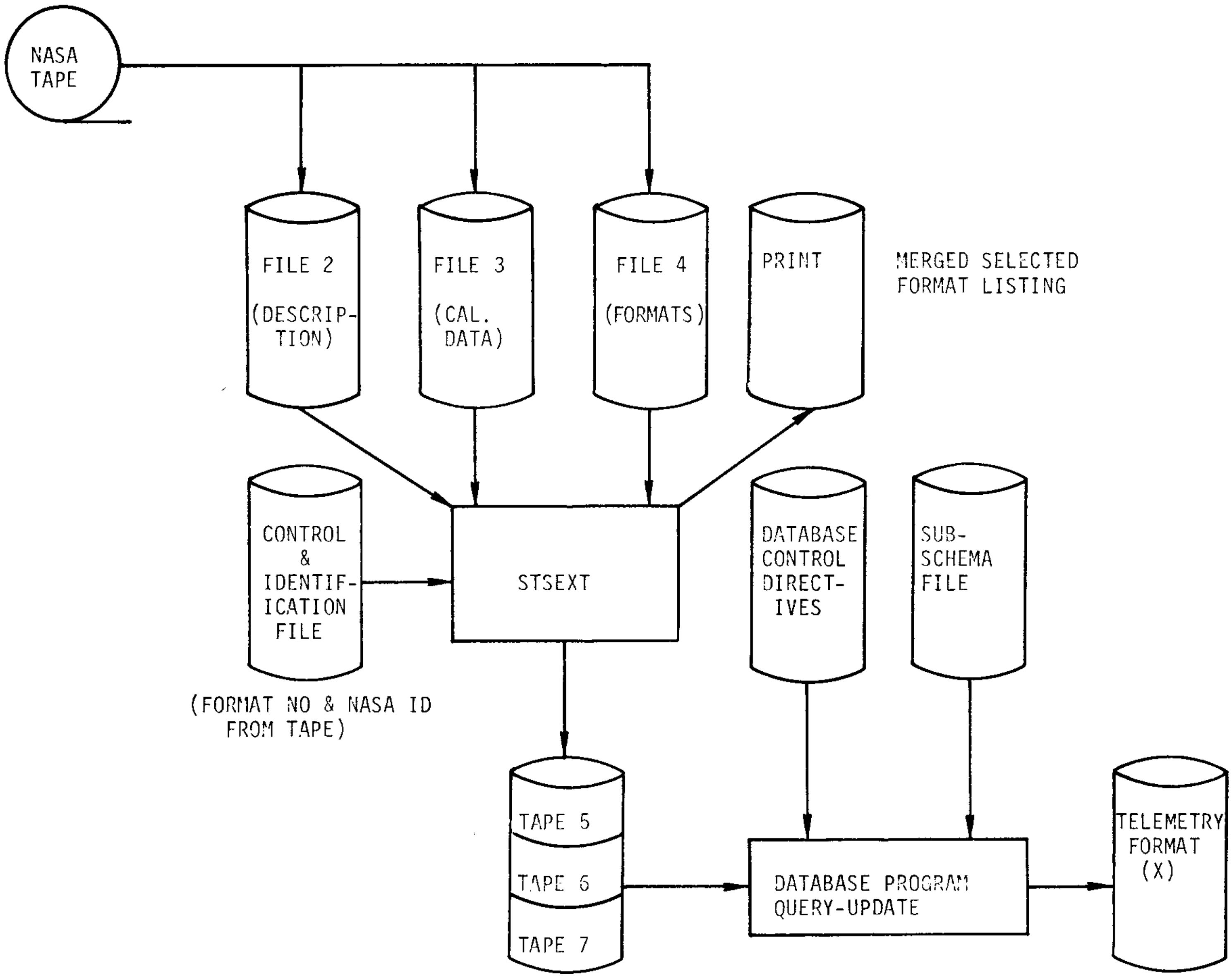


**Figure 2. STS Extractor Overview.**