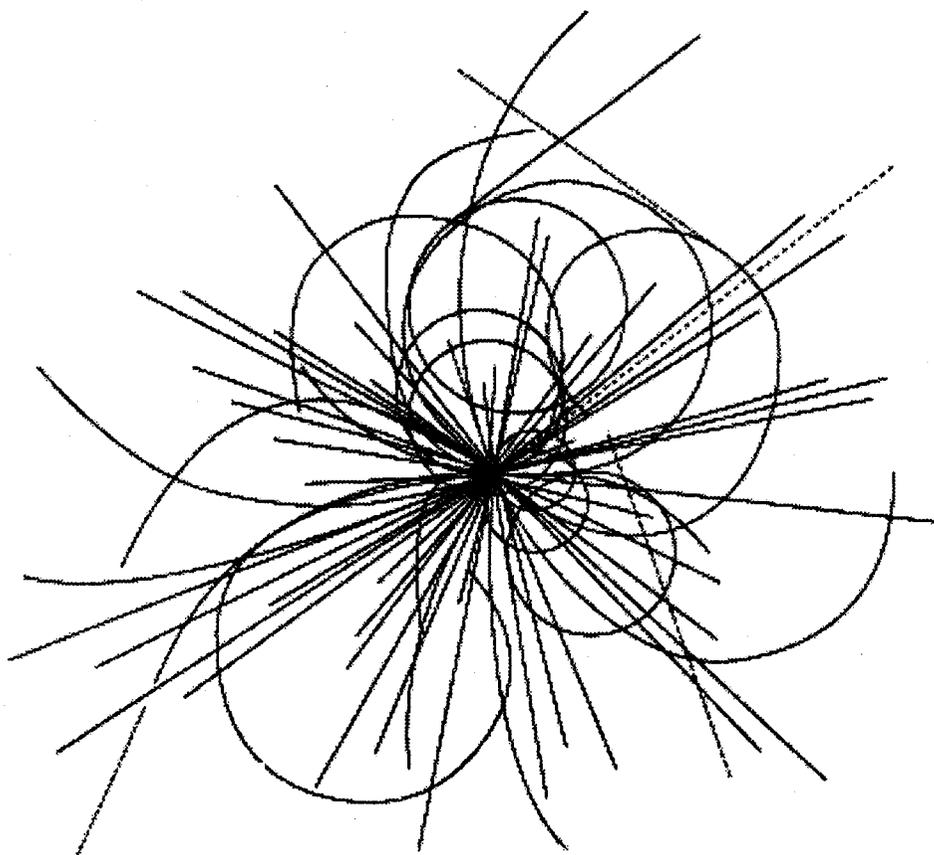


Databases for Analysis of Superconducting Cable Manufacturing

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Superconducting Super Collider
Laboratory

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Cable Manufacturing***

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DATABASES FOR ANALYSIS OF SUPERCONDUCTING CABLE MANUFACTURING

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INTRODUCTION

Starting in September 1991, eight cable vendors began fabricating approximately 10,000 kg each of Inner or Outer superconducting cable for the Superconducting Super Collider's (SSC) cable Vendor Qualification Program (VQP). This program, designed to identify vendor's for competition for the supplying of superconducting cable for the manufacture of SSC magnet systems, will conclude in June, 1993.

The conductor database was developed as an integral part of the VQP in order to analyze the origins of variation within the conductor fabrication processes, and develop and implement control procedures to minimize such variations. In addition, the database development effort will provide a direct link to the MAGCOM database system being implemented by the Test and Data Management Department of the Magnet Systems Division of the SSCL.

DATA ANALYSIS

At no time in the past has such extensive access to superconducting wire/cable processes been available to a superconductor development program. The database development effort is designed to contain every critical process variable for the production process of each of the vendors in the VQP. These parameters are presently stored and analyzed using FoxBASE+/Mac, a Macintosh based database management program which is dBase compatible.

Data has been analyzed to compare the chemical composition of NbTi and Nb sheet, the metallurgical parameters of both the raw materials and completed monofilament, the extrusion parameters of monofilament and multifilament billets, yield vs. aspect ratio (of the mono and multifilament billets), heat treatment studies, electrical and metallurgical properties of final size wire, electrical and metallurgical properties of finished cable, and

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cable degradation. In Phase II of this program, planned to test variability in each vendor's optimized process, all cable vendors happen to use the same alloy source. As a result, the program provides a uniquely broad perspective of the processing effects on the electrical, mechanical, and superconducting properties of NbTi. The VQP database will be a vital tool in the analysis of this effort.

Database Structure

At the start of the VQP, each vendor was given a disk containing the 16 database files listed in Table 1. Each database is created of fields which contain the pieces of information needed to examine a particular component, such as the billet number or the I_c of wire. FoxBASE+ allows for six field types: **character** which includes all keyboard characters; **numeric** includes numbers, decimal point and a leading plus or minus sign, and will accommodate limited mathematical analysis; **date** in a MM/DD/YY format; **logical** for true or false conditions; **memo** for explanatory text having no size limitations, and **picture** for information such as radiographs which would have to be scanned into the database.

Table 1. VQP Database Files

<u>Database Name</u>	<u>Description</u>	<u>Number of Fields</u>
CU_PROD	Raw Material Copper Data	11
NbTi_ig	NbTi Ingot Chemical Analysis	55
NbTi_LT	NbTi Lot Analysis	31
NbSHEET	Nb Sheet Analysis	47
MonoProd	Monofilament Billet Assembly Data	18
MonoWC	Monofilament Billet Weld and Compaction Data	17
MonoExt	Monofilament Billet Extrusion Data	32
MultiProd	Multifilament Billet Assembly Data	22
MultiWC	Multifilament Billet Weld and Compaction Data	17
MultiExt	Multifilament Billet Extrusion Data	32
HEATHIST	Wire Heat Treatment Data	21
STNDPROD	Strand Production Data	11
STNDTEST	Strand Test Data	27
STNDMAP	Strand Map Data	10
CblProd	Cable Production Data	16
ExtStnd	Extracted Strand Data	27

The SSCL is primarily a Macintosh environment but several of the vendors participating in the VQP are collecting data on DOS equipment. FoxBASE+/Mac is a Macintosh based data management system chosen for its compatibility to PC/MS-DOS versions of FoxBase+ and dBase III.¹ This facilitates the transfer of data without the need for reentry, therefore reducing the possibility of human error.

In addition to analyzing data entered in Numeric Fields, FoxBASE+ can generate reports that allow the operator to filter fields which contain information not suitable for wide distribution, such as proprietary process data.

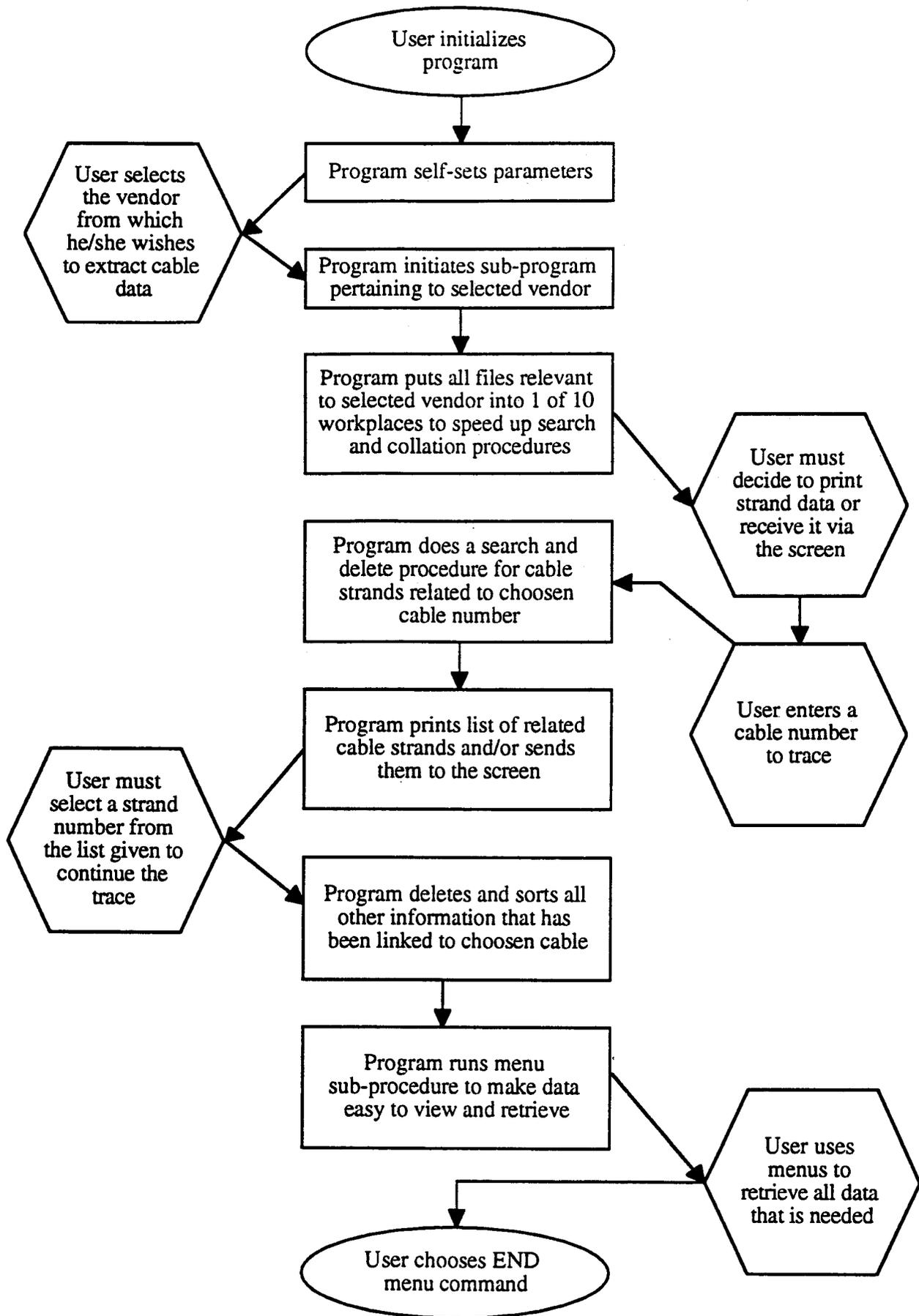


Figure 1. Flow chart of "Cable Info-Link"

Programming

FoxBASE+ uses the industry-standard dBase programming language. A program has been written to create a relational database system. The goal is to enter a cable number and trace process and raw materials data for the individual strands of superconductor (Inner CDM cable, 30 strands; Outer CDM cable, 36 strands; CQM cable, 30 strands). The system goes about this process by performing various search and delete sub-procedures which enable for quick and easy data retrieval. Figure 1 is a flow diagram of the program which has been titled "Cable Info-Link".

The major design setback for the program to work is it requires data from the later stages of cable development. Because of the differences in data entry each vendor file requires a customized program.

FUTURE PLANS

When the VQP started in September 1991, FoxBASE+ appeared to be the best database package available. Further investigation proved that 4th Dimension (4-D) might actually be more suitable. The importing of Phase I data into 4-D (which is also IBM compatible) is in process and there will soon be a running version of this program. At the time of completion, a comparison of the two database packages containing identical data will be conducted to determine the most appropriate package for data collection during full rate production.

The major difference between the two applications is that to obtain the desired end result, FoxBASE+/Mac has to do numerous search, sort, and delete routines. With 4-D the procedure is much simpler. By using a process known as singular relation², it allows users to relate, view, and filter the fields without actually tampering with the data. A runtime only version of 4-D is also available at a reduced cost which makes distribution to vendors easy and cost effective.

REFERENCES

1. "FoxBASE+/Mac Users Guide" Fox Software, Inc., Perrysburg, OH (1991).
2. "4th Dimension User Reference" ACI US, Inc., Cupertino, CA (1992.)