Diagramming tools are available for creating functional diagrams. The use of Microsoft Visio for diagramming is described in the Visio Lab Manual, which the reader can download from the Web site supporting this book. Professional IDEF software is available from several companies and can be downloaded in trial version, which may be useful in completing the end-of-chapter exercises. We refer the reader to selected Web sites listed at the end of the bibliography section at the end of this book. The IDEF0 standard, as published by the National Institute of Standards and Technology (NIST) can be obtained from http://www.itl.nist.gov/fipspubs/idefo2.doc.

Although these structured analysis methods provide a standard set of graphic primitives and a set of rules to guide their use, different analysts often come up with different diagrams when employing these techniques (there is some latitude for interpretation, which causes this variation). However, their ease of use and their value as a communication tool among analysts and experts involved in the design process overcomes this shortcoming. The importance of the functional architecture becomes evident as analysts begin to define the specific information (data) needed to support these functions. In the next chapter, we focus on the information (data) model required to complete the conceptual modeling development process.

**REVIEW EXERCISES**

4.1 Describe the difference between an IDEF0 input and a control. For example, why is the production schedule and recipe a control instead of an input?

4.2 In Figures 4.11 and 4.12, the activity “Control Incoming Materials” was documented using the IDEF0 methodology. Using this example, document this process using the equivalent data flow diagram methodology.

4.3 In Figures 4.15 and 4.17, the activity “Control Stored Materials” was documented using the DFA methodology. Using this example, document this process using the equivalent IDEF0 diagram methodology. You will have to use the description of this case in the chapter to uncover the material flows involved, which are not explicit in Figures 4.15 and 4.17.

4.4 Review Exercise 3.5 provided a description of how a customer is processed by USF Rent-a-Car when she arrives at a branch location to pick up a car. From that description, create a set of data flow diagrams that describe the functional architecture for the process of picking up a car. The context diagram should be titled “Service Customer during Rental Pick Up.”

**CASE STUDIES**

4.5 ACME Machine Shop Case (B)

*Introduction*

The ACME Machining Company is a small job shop that provides machining services. The company owns ten general-purpose computer numerical control machine tools and employs 15 people, 8 of whom are tool designers and machine tool operators. The company provides machining services to other manufacturers in the area who require machining services done that they are not interested in doing in-house. Therefore, ACME’s orders from customers are usually for high-precision or special-purpose machined parts in small lots.
The most important assets of the business are the highly trained tool designers and machinists, and the very expensive precision tools owned by the company. The owner of the company has a simple view of his business: whenever a machinist or a machine is idle and there are jobs waiting to be processed, the company is losing money. Therefore, the owner has always put a high priority on machine maintenance, especially preventive maintenance, to avoid unnecessary downtime.

Maintenance is the responsibility of the plant supervisor, Mr. Bill Wrench. Bill has set up the entire preventive maintenance program for the plant, which consists of regularly performing certain preventive maintenance tasks based on the number of hours of operation on a machine. The manufacturers of each of the 10 machine tools have provided Bill with a list of preventive maintenance tasks and the frequency with which they are to be done.

The company owner has suggested to Bill that he maintain records of the preventive maintenance functions in a computer database. The owner has heard that there are inexpensive database systems that can be purchased and used for this purpose. Also, a nearby college has students that are knowledgeable about the use of databases, and they can be hired as interns to help to design the application. Bill decides to follow-up on his boss's suggestion, and he hires you to advise him on the design.

**The Preventive Maintenance Function**

Your first step is to meet with Bill to discuss the preventive maintenance function as it is now performed. The description that Bill provides you is given in the following paragraphs:

**Bill:** “First, let me show you my database; it’s over here in the filing cabinet.” [He opens a drawer.]

“This documents are the most important information that I have. The machine tool vendors have given me the exact maintenance that I should follow on each machine. For example, look at this schedule [Exhibit CS4.1]. It’s for the Mazak 2120 CNC Mill. See, every 100 hours of operation I have to check the slides for lubrication, and every 500 hours of operation I have to do a tear down of the milling head to check the condition of gears and belts. The other vendors have provided me with similar kinds of instructions for their machines.”

**Student:** “So how do you know when the machine has been operated for 100 hours or 500 hours since the last maintenance?”

---

**Mazak Corporation**

322 Mill Street

Lexington, KY

**PREVENTIVE MAINTENANCE SCHEDULE FOR: 2120 CNC MILL**

<table>
<thead>
<tr>
<th>TASK NO</th>
<th>FREQUENCY</th>
<th>DESCRIPTION</th>
<th>REFERENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Every 100 hours</td>
<td>Lubricate slides as needed</td>
<td>Manual M5.1, p. 4</td>
</tr>
<tr>
<td>2</td>
<td>Every 500 hours</td>
<td>Milling head: check gears and belt</td>
<td>Manual M5.1, p. 6</td>
</tr>
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</table>

*EXHIBIT CS4.1 Example Preventive Maintenance Schedule*
Bill: “Oh, I keep records. Each machine has a meter on it that keeps track of operating hours. In the morning, the manufacturing department collects the meter readings and sends them to me. The machinists then reset the meters for the start of a new day. This way, I have a record of the hours of operation for each day. I also keep a sum column so that I know the total number of hours on the machine. See.” [He holds up Exhibit CS4.2.]

Student: “Let me see if I understand. The first thing you do in the preventive maintenance function is that you receive the hours of operation data from manufacturing. Then you add those hours to your record. Then you look up the preventive maintenance schedule for each machine and compare it to the sum of the hours of operation in your record. If the prescribed number of hours of operation have elapsed since the last time a particular preventive maintenance task was done, you perform the task. One thing I don’t understand. How do you know that the prescribed number of hours have passed since the last time you performed the task?”

Bill: “Oh, that’s easy. I find that information in my file of completed maintenance records, which is this drawer containing completed maintenance work orders.” [He opens another file drawer.] “Each time I request preventive maintenance on a machine, I make out a work order. I put the work order into this tray [points to tray on desk], which is my open work order file. The maintenance technician works off this tray. He takes each order in sequence, performs the maintenance, and then returns the work order to me when the maintenance is completed. He puts the time worked on the work order and returns it to me for filing. Here, look at this [Exhibit CS4.3]. This is one of

<p>| MACHINE OPERATING HOURS RECORD |
|------------------|------------------|------------------|
| DATE | DAY | TOTAL | DATE | TOTAL |
| 2/1/99 | 4 | 90 | - | - |
| 2/2/99 | 8 | 98 | - | - |
| 2/3/99 | 6 | 104 | 5 | 5* |
| 2/4/99 | 0 | 104 | 6 | 11 |
| 2/5/99 | 5 | 109 | 8 | 19 |
| 2/6/99 | 6 | 115 | 6 | 25 |
| 2/7/99 | 8 | 123 | 5 | 30 |
| 2/8/99 | 8 | 131 | 8 | 38 |</p>
<table>
<thead>
<tr>
<th>2/9/99</th>
<th>4</th>
<th>135</th>
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<th>42</th>
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</tr>
</tbody>
</table>

* first day put into service.

EXHIBIT CS4.2  Record of Operating Hours by Machine

PREVENTIVE MAINTENANCE WORK ORDER

FM WORK ORDER NUMBER: 00512  DATE WORK REQUESTED: 2/4/99
MACHINE ID: E41320  MACHINE HOURS: 104
MACHINE NAME: Mazak 2120 CNC Mill  DATE WORK DONE: 2/4/99
FM TASK #1 - Lubricate slides as needed
MINUTES WORKED: 120

EXHIBIT CS4.3  Example Work Order
my records of preventive maintenance done in the past. The work order number is a unique number that I assign each time I request a specific task on a machine. Basically, it's just a rotating five-digit number. This one shows that this is the 512th preventive maintenance task I have performed on any of our machines. I put in the machine ID to identify the specific machine that is being worked on and the date work requested to show when the work was assigned. The machine ID is a number that comes off the manufacturer’s data plate. It’s basically his serial number, and it is unique for his machines. I also record the machine hours, which show how many total hours were on the machine when I did the maintenance. I get that number off this sheet [Exhibit CS4.2, again]. Finally, I record the preventive maintenance task that is to be performed, and the maintenance technician records how long it took to do the maintenance.”

**Student:** “When the maintenance technician returns the completed work order to you, does he hand it to you? What actually happens?”

**Bill:** “No, he doesn’t actually hand it to me. See this empty tray next to the one I use for open orders? He puts the completed work orders into this tray. I empty this tray at the end of the day. I add the last piece of information to each work order, the date work done, and then I put the completed work order into my completed maintenance record file. This is where I look to find out when a particular maintenance item was last done.”

**Student:** “Okay, Bill, I think I understand what you are doing. Please do me a favor and provide me with any other information you think might be relevant [provided later as Exhibit CS4.4]. Also, since we are going to have your records on a database, try to describe the kinds of summary reports that you think would be desirable to print out for your own purposes or for your boss. We might as well plan to accommodate all the desired information in our design at this time.” [Exhibit CS4.5 provided by Bill later.]

**Requirements**

1. Design a functional model using the IDEF0 methodology that shows how the preventive maintenance function is done.
2. Design a data flow diagram of the processes and information flows involved in the preventive maintenance process.
4.6 University Food Company Case (B)

The University Food Company wants to incorporate more information technology into its organization, particularly its shipping department. The sales department has already implemented a database for order entry functions, and the production planning department has an information system for tracking inventory, including finished goods. The shipping department currently uses information from these sources in the course of doing its daily tasks. The shipping supervisor has asked you to study the activities in the department and to recommend an information system design to support the operation. What follows is a description of the tasks performed by the shipping clerk and support personnel during a typical day.

At the beginning of each day, the sales department prints a report and sends it to the shipping department. This report, called the “Open Orders Report,” is a list of orders taken by sales that have not been closed out. Orders are not closed out until the final shipment has been made against the order. An example of a typical open orders report is shown in Exhibit CS4.6. Open orders are listed in the ascending order of their promised delivery date.

University Food plans its production in two ways: produce to order and produce to inventory. In the first case, production is scheduled for a specific order. In the second case, production is done in the absence of a specific order. The second case occurs because a specific order is small and it is desirable to have a longer production run before changing over to another product. Changeovers require that the machinery is thoroughly cleaned before the next product can be made, thus incur-