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Robert L. Paretta

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Sometimes very high data processing speed can actually be a handicap to the company employing it. Obviously, very fast flow is important in an airlines reservation system, but that's not equally true of production scheduling—

THE FREQUENCY OF INFORMATION FLOWS: A MISUNDERSTOOD MANAGEMENT VARIABLE

by Robert L. Paretta

University of Delaware

THE ADVENT of electronic data processing machinery and its constant increase in speed of processing ever since have posed a problem to many businesses. Is all this speed necessary in every instance or has the capacity of the machines outstripped in many cases the ability of management to absorb and use the information generated?

Cost-benefit ratio

Accountants and systems analysts have been working together in recent years trying to provide managers with information relevant to their planning, operating, and control decisions in a form the users can understand. To service these

decision needs they have developed management information systems to provide data in many forms geared to forecasting, measuring, and evaluating economic events. Assuming the content of the information transmitted to a decision maker at a given periodic rate is both relevant and comprehensible, a question they must often face is whether management performance can be significantly improved by increasing the frequency of reporting. Can the firm benefit, for instance, from information that flows through its decision centers weekly or monthly rather than quarterly or annually? Will these benefits exceed their costs? The exploration of these issues is the primary concern of this article.

Intuitively it might appear that more frequent information should always be preferred by the firm to less frequent. If for the moment it is assumed that increasing the frequency of information flows has a zero marginal cost, a plausible response to the questions posed above might be to increase reporting frequency in all decision centers to the maximum technically possible.

Unfortunately, however, this will not improve a decision maker's performance in every instance. An examination of three specific examples will make this point clearer.

1. *Decisions Improved*—There are some decisions where management performance can be improved by increasing the frequency of report-

ing to the maximum. The kinds of critical control processes found in the generation and transmission of electric power, the refining of oil, and the production of chemicals—where remedial action must be immediate, or nearly so, to prevent unpleasant consequences or avert a disaster—are good examples of how the firm can benefit from very rapid information flows. In addition, the installation of on-line-real-time systems for handling passenger reservations has often been cited as the major factor in allowing airlines to improve service to the public at lower cost with smaller fleets by permitting more efficient allocation of available aircraft space.

Using the approach suggested by Bedford and Onsi for measuring the value of information by comparing the outcome of the actions of the decision maker before and after the receipt of a message,¹ the effects of information frequency on the profitability of the firm can be depicted graphically as in Exhibit 1, page 48. In Frame A of Exhibit 1, the curve shows the result to be expected in the case of the critical control processes outlined above; the value of information is highest when the reporting cycle (the time between an event taking place and the receipt of a report) is zero, and drops off sharply becoming valueless when the unpleasant consequences the system is designed to guard against occur.

2. *Decisions Unaffected*—Other kinds of decisions can be noted where increasing the frequency of reports will have *no effect* on the manager's performance and hence will produce no benefits to the firm. This is common when the decision maker is unable to act on more frequent data because of queuing, scheduling, or capacity constraints. For example, providing daily sales and inventory information to someone responsible for

production scheduling would be meaningless if it were neither technically nor economically feasible to reschedule production runs daily.² Furthermore, with regard to variance analysis, problems of non-linearity can make shortening the reporting cycle of little value. Dearden demonstrates this quite well:

"In the area of performance evaluation, real-time management information systems are particularly ridiculous. When a division manager agrees to earn, say, \$360,000 in 1966, he does not agree to earn \$1,000 a day or \$1,000/24 per hour."³

In this situation the messages transmitted to the decision maker, at least at the high frequency discussed, have no rational basis for being supplied. In Frame B of Exhibit 1 it can then be seen that where reporting cycle is a shorter time period than that necessary to take action, the value of information (and therefore the effect on profitability) is zero. As the reporting cycle increases to a point consistent with the ability to act on information received, the value increases sharply to a maximum, then falls as the information gradually loses its usefulness to the decision maker.

3. *Decisions Hindered*—Finally, two conditions can be identified under which management performance and profitability can actually *suffer* when information frequency is too high. First, when dealing with data that is very unstable, increasing the frequency of information flows substantially enlarges the

probability of introducing random variations in the reports received by a decision maker. A message containing data that is the result of a random fluctuation not representative of the events being observed, may transmit a false signal to the manager causing him to take action when none is appropriate. This can prove harmful to the firm when the cost of taking the wrong action is high, compared with the cost of not acting and waiting for more information.

Second, increasing the frequency of reporting can cause problems where the time necessary to evaluate information received is longer than the reporting cycle. A situation could develop where the manager is supplied new information before he has had the opportunity to fully evaluate information received in the prior period. Receiving the new information would make his analysis-in-process obsolete and he would very likely postpone a decision until the most recent information was evaluated. If the decision maker reacted in this way to every new piece of relevant information he received, a condition could develop in the extreme case where a decision would never be made. Evaluating, updating, and re-evaluating problems would be a continuous closed-loop process with no exit for positive action, unless the frequency was reduced to a rate in phase with the analytical time frame demanded by the decision. Though somewhat exaggerated, this example demonstrates that there is an opportunity cost associated with a manager being exposed to information too fre-

2—This is not to imply that this data is intrinsically valueless, for it may have value at high frequency for some other kind of decision, or have value for this decision if it is gathered in the system and stored for later review. The point being made is that the value of information is a function of many variables including frequency.

3—Dearden, John, "Myth of Real-Time Management Information," *Harvard Business Review*, May-June, 1966, p. 126.

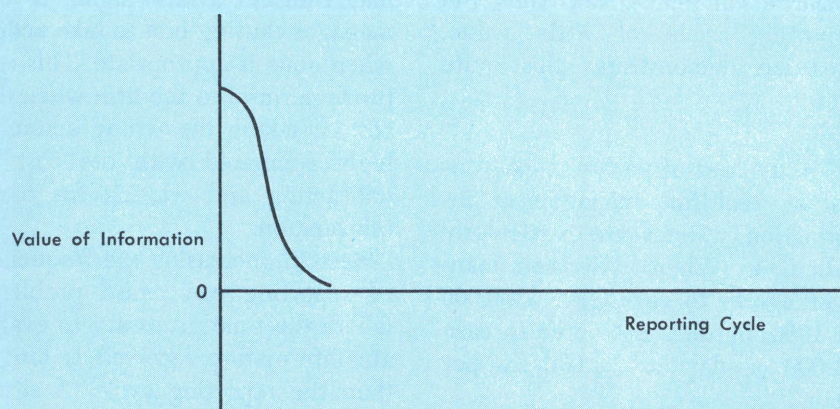
1—Bedford, Norton M. and Mohamed Onsi, "Measuring the Value of Information—An Information Theory Approach," *Management Services*, January-February, 1966.



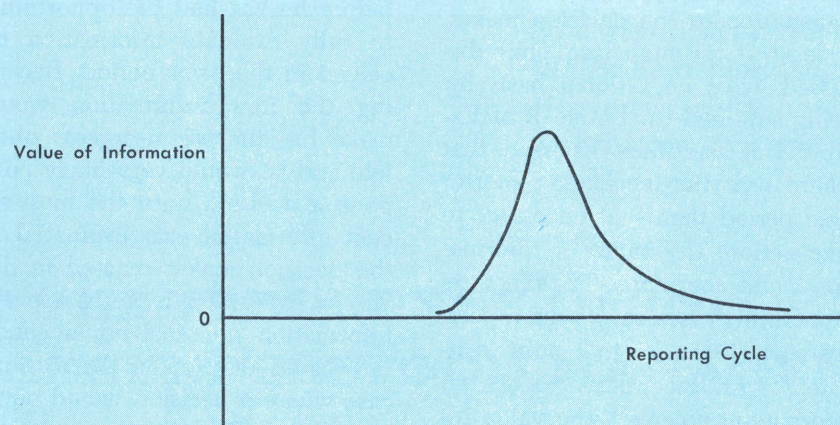
ROBERT L. PARETTA is assistant professor of accounting at the College of Business and Economics, University of Delaware. Previously he taught at the State University of New York, Binghamton. He has undertaken consulting assignments for E. I. DuPont DeNemours & Co., Mayan Towers Development Corp., and Syracuse University. Dr. Paretta received his B.B.A. from Iona College, his M.B.A. from Long Island University, and his M.S. and Ph.D. from Syracuse University.

EXHIBIT I

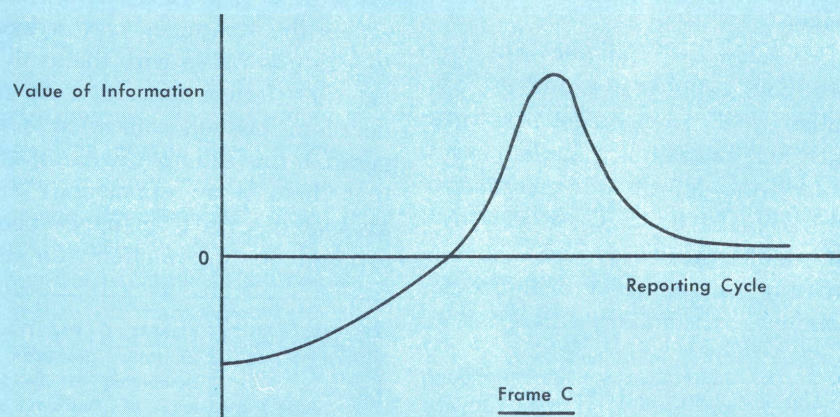
The Value of Information Expressed as a Function of Frequency



Frame A



Frame B



Frame C

quently. Reinforced is the fact that a decision maker's time is a scarce resource that must be efficiently allocated by the firm.

Frame C of Exhibit 1 shows that in this case, where the reporting cycle is too short, the value of the information is negative until a point is reached beyond which randomness and the decision's analytical lead-time are no longer factors. As the reporting cycle increases, the value rises to a maximum level, then declines as the usefulness of the information to the manager fades with time.

Analysis of costs and benefits

By looking at the three classes of decisions above, it was quite easy to show that increasing the frequency of information flow can have a variety of effects on profitability—even when it was assumed to have been achieved free of additional cost. Relaxing this assumption introduces a new set of problems for *all* classes of decisions.

If the firm is to maximize the utilization of its scarce resources, the expected cost of providing information at a given frequency must be matched against the expected benefit of receiving more frequent reports. In a world of certainty, given a specific decision, the process of matching costs against benefits can be readily accomplished. In the real world, however, costs and benefits can be difficult to determine for several reasons.

First, not all costs and benefits readily lend themselves to measurement in monetary terms. Some may be of a behavioral nature. The organizational structure of the firm, the intensity of budgetary pressure within the firm, the degree of stability in the demand for the firm's products, and the trend of that demand, are just a few of the things that can influence the way some managers perceive their "needs" for information at given frequencies. A large part of these perceived needs may be emotional, and, in fact, may far exceed the frequency rates that are warranted

by the decisions involved. Nevertheless, to deny information at the frequencies managers feel they "need" may result in poor performance because of the resultant loss of confidence they surely will suffer.

Second, since decisions within the firm are interrelated, benefits and costs, even if measurable, may be difficult to isolate. In the examples cited above three classes of decisions were examined in a kind of vacuum, and it was easy to identify the consequences brought about by changes in the frequency of information flows. But in the real world this is neither possible nor appropriate because it ignores the fact that the firm is composed of a system of interrelated decisions where the decision output of one decision center often becomes the input for another decision center. The direction of the links between and among decisions can be vertical, horizontal, or even circular, all with numerous points of intersection. Separating the costs and benefits under these circumstances is not quite as simple as it might first appear.

Conclusions

There is a popular belief that increasing the frequency of information flows will improve a manager's performance. In this article, it has been explained why this is not always the case. Careful analysis must be made of (1) the frequency needs of given classes of decisions, and (2) the interaction effect of decisions made in one decision center on other decision centers. In order to achieve this, several factors must be kept in mind:

1. *The sensitivity of the decision process*—As an example, it was shown that where a process has the potential to produce serious consequences when permitted to go out of control, very frequent information (perhaps to the point of continuous monitoring) might be needed to avert disaster.

2. *The flexibility of the decision process*—It was shown that certain

kinds of processes (like production-run scheduling) which allow managers to take action only at specific intervals (after which the firm is committed to a course of events that does not readily lend itself to modification until a discrete point in the future), make it necessary for information to be supplied at frequencies in phase with the given interval. To supply it more often would result in a misallocation of the firm's scarce resources.

3. *The variability of decision input data*—It was shown that in cases where the decision input data is unstable, raising the rate of information flow tends to increase the probability that a message sent to a manager will contain data that is not representative of the events being observed. This could transmit a false signal to the manager causing him to take action where none is called for.

4. *The analytical lead-time required by the decision process*—Every decision process has associated with it what might be called "analytical lead-time"—that is a period of time before a decision can be made when information is evaluated and analyzed. If the information flow is more rapid than the analytical lead time, it was shown that the manager's performance could suffer as a result of being saturated with more information than that with which he can effectively deal.

5. *The cost of information vs. the benefits received*—If the firm is to efficiently allocate its scarce resources, the cost of providing information at a given frequency must be matched against the expected benefit of receiving it. It was shown how this matching is often very difficult in the real world.

Though the above list of factors does not purport to be exhaustive, it represents those which should be of immediate interest to individuals responsible for designing the firm's information system. If the frequency of information flows is to be a meaningful management variable, these factors must be considered.

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