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SOME EFFECTS OF TIME USAGE PATTERNS
ON THE PRODUCTIVITY OF ENGINEERS

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INTRODUCTION The performance of the 1500+ engineers at MSFC is critical to the Center's mission. Worker's performance, however, is a variable affected by ability, motivation, role understanding, and other factors. Managing subordinates' performance is a great challenges to managers. Special challenges confront the managers of engineers because engineers often work with general goals, long deadlines, and considerable autonomy (1).

Budget challenges should make all managers concerned about their workgroup's efficiency as well as its effectiveness(2). One measure of efficiency is productivity -- the amount of useful output which is obtained per unit input. Productivity is easy to measure when the output is easy to count, the time required to produce each unit is relatively short, and the standards for acceptable quality are apparent and routine. For example, a manufacturing plant might produce 200 cars per day, or a license bureau might process 20 applications per hour. Productivity of the typical S&E branch at MSFC is not as easy to measure. However, some examples of productivity improvements include completing more critical tests per month, finishing analyses more quickly, or serving the branch's customers well with fewer engineers.

The productivity of a team or branch is a function of the productivity of each of its members. While many managers have personal theories about how to run their work group, surprisingly little systematic scientific knowledge exists about the effects of various factors on engineers' productivity. This study is intended to help lay the foundation for such a program of research.

METHOD The primary goals of the present study have been to familiarize the principal investigator (PI) with the work environment and the nature of the tasks faced by MSFC engineers, to gain insights into how productivity might be measured for engineering tasks, and to formulate models and hypotheses which suggest relationships among these issues. The PI thus spent fifty days at MSFC observing numerous engineers from three S&E labs and two Chief Engineers' offices as they went about their daily work, and interviewing them regarding their work. These observations included attending numerous meetings and teleconferences with engineers. Several managers from various levels of the S&E organization were also interviewed. Particularly valuable insights were gained from in depth interviews of 40 MSFC engineers using a structured set of open-ended questions (summary of questions below).

Interview Questions For Engineers' Time And Work Study

1. Job title, brief job description, projects you work on
2. Education history and career path; why you became an engineer, why you joined NASA

3. Present top priority tasks and deadlines
4. Activities in a typical week; time in meetings, on phone, on computer
5. How your work tasks/projects are initiated; by whom
6. Extent to which you like your job
7. How you feel about your work performance; indicators of success in your work
8. How one might judge productivity in a job like yours
9. Things that block you from being more productive
10. How many hours you work each week, day
11. Percent of your time you typically feel to be productive
12. How you would describe yourself as a worker; self discipline, perfectionist, time manager, confidence
13. What the most productive engineers you have observed do differently from average engineers
14. What you need from NASA/your boss to be more effective
15. Advice for a new employee to be successful in your job
16. How you feel about NASA's current mission and direction

OBSERVATIONS AND DISCUSSION **Measuring Productivity** In order to manage an outcome one generally must be able to measure it(2). Most interviewees initially expressed uncertainty about how to measure productivity, but then went on to speculate usefully on possible methods or criteria for such measurement. Many expressed a belief that supervisors who stay in touch daily with what their engineers are working on can make a reasonably accurate subjective estimate of engineers' productivity. Factors which should be integrated into this judgement include the difficulty of the task (including the development stage of the required tools or methodology), comparison of progress rates among engineers doing similar types of tasks (or past experiences with people doing similar types of tasks), and comparison of progress against a mutually-agreed-upon time line (when posing a design or analysis question to an engineer, it helps to specify whether one wants a one-day answer, a one-week answer, a one-month answer, etc.)

Work output measurements for estimating productivity could include specific observations of work methods or outcomes. For example, track the number of analyses an engineer produces in a period of time, the number of papers they publish or present, the number of phone calls made or received, the number of action items completed, or even the number of action items not completed by the requested date. Or poll customers for feedback on an engineer's work, including their general satisfaction with work quality or pace, estimates of work impact on a program or at least the thinking of others, the degree to which an engineer is consulted by others for an opinion, or the general accuracy of one's models, tests, and designs. Finally, productivity might

be reflected in system-level indications such as whether one's work has held up a flight or test schedule, a new motor flew tested without problems, or a meeting was productive.

Ideally, engineers and their supervisors should collaborate to find the best method for monitoring their productivity. Where colleagues or customers are in the best position to judge an engineer's productivity, a formal or informal system could be set up to gather their feedback. While some engineers may be sufficiently defensive about their work to make them uncomfortable with such a feedback program, most appear to be justly proud of their work and of the world-renown accomplishments of the Center, and many expressed great interest in learning from any available feedback.

Being Busy Versus Being Productive One's work effort can be viewed as a vector. The length of the Effort Vector might indicate the degree to which one is busy during the work day. However, that work effort can be factored into a Productive Work component (i.e., work which is directed toward accomplishment of the specified job goal) and a perpendicular "Wasted Motion" component (e.g., work effort which is directed toward simply satisfying one's curiosity, looking busy, or fulfilling a perfunctory obligation). Thus, one engineer might be seen as putting forth less work effort than another (e.g., attending fewer meetings, writing shorter memos, taking a longer lunch break), yet might actually accomplish more than the latter with respect to job goals. Both continuous clarification of organizational and departmental goals and honest feedback to engineers by supervisors or co-workers can affect powerfully the direction of work effort toward productive ends. Many engineers feel that they need more goal clarification or feedback than their supervisors now give.

Some engineers seem to find it difficult to prioritize their work activities. For example, some are inclined to study a problem forever in search of an optimal answer, though the organization needs a sufficient answer quickly to meet a project deadline. Indeed, some engineers in the labs see "getting smart" on an issue being as important in their job as is applying their knowledge to a specific project. However, an overly compulsive or extremely cautious personality in such a person might result in a great deal of wasted motion. Others believe that learning directed toward specific project questions is most efficient in the long run. In any event, it is natural for workers to spend as much time as possible on the activities they find intrinsically interesting. Thus, to optimize productivity, engineers must be placed in jobs which require the work they intrinsically enjoy.

Career Issues Five career types were observed in interviews. 1) The Center has a lot of "New Kids" who are in the early phases of their NASA careers. Most do not yet know for what job they are best suited, and their work habits and

standards are still extremely malleable. They need a good view of the types of work available at MSFC, and close supervision to ensure task success until their competence and confidence grows. Young engineers typically aspire to high levels of technical competence. Highly experienced engineers from project offices who would spend a year or two back in the labs before retirement might make excellent mentors and role models for New Kids. 2) Some engineers mature into "Techo-Wizards", carving out an area of great technical expertise from which they greatly influence design, analysis, or test methodology decisions. They work with maximum autonomy. 3) A few engineers find that they enjoy questioning and helping define departmental/ organizational priorities and strategic direction even more than developing greater technical expertise. Those with good interpersonal skills may become "Movers and Shakers", seeking management track careers. 4) Many engineers, perhaps due to differing interests, have not developed the technical proficiency of Techno-Wizards nor the leadership qualities of Movers and Shakers, but instead specialize in attending to details of information and data management, tasks often critical to project success. These "Worker Bees" seem satisfied with a modest level of technical challenge in their jobs. 5) However, a few engineers never found appealing career tracks, or somehow run out of steam. These "Lost Souls" often eventually were relegated to tasks which are least critical to the organizational mission. They seem to have low expectations of the prospects for whatever years remain in their career. Perhaps a "PIP Program" for veteran engineers could help place these Lost Souls into more productive work.

Future Research Clearly research on engineers' productivity is in a preliminary stage. A questionnaire survey of 300 randomly-selected MSFC engineers, sponsored by Dr. George McDonough, Head of S&E, is now gathering information from a wider sample about many issues related to engineers' effectiveness and use of time. It builds on previous research by the PI(3) plus insights from the present study.

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