Experienced-Based Printer Product Development Process

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Abstract

This paper is intended to provide an experience-based, real world guideline for anyone intending to define and develop digital printer products. Digital printers are complex systems, and it is well known that the development of these products requires a complete range of skills encompassing the technical disciplines of hardware design, software, process physics, materials engineering etc. These skills and disciplines are formally taught to engineers and technologists. However, the process used to develop the printer product, which can significantly affect the time to market and the market acceptance of the product, is less well known, and cannot be legislated or prescribed with certainty. Many of the key elements of a good development process have been learned by experience and trial and error. There is no single process that is right for all products, companies or situations, but all effective product development processes share some common principles. This presentation defines the significant key principles that are necessary to successfully implement a complex digital printer product development process. Success is defined as meeting or exceeding the priorities of product cost, schedule and performance (quality).

Introduction

This paper is based on 30 years of "in-the-the-trenches" observations and accounts from individuals representing the disciplines required to accomplish successful development of a digital printer. The variables in the product development process are both subjective and objective. Among them are specifications derived from market demands and the state of the technology, development environment, the integration of a multi-disciplined team into a cohesive unit and the quality of the development tools.

The content is based on empirical observations made by scientists, technicians and business management personnel.

An attempt has been made to assemble product development principles by treating these observations as empirical data. Some of these principles may appear to be obvious or trite. The frequency with which developers ignore these principles and the results of ignoring them

surely indicate that anyone proposing to develop a digital printer ought to at least take a look at them before embarking on the development of the project.

A simple exercise before beginning a project would be to take a look at the last project or projects. Examine the project schedule and resource plan, such as that developed in Microsoft Project® assess the variables involved and see how accurate were the predictions. The actual schedule and cost of completing that task should be a window to development of the roadmap for the new project.

There is no universally applicable or accepted methodology for developing a digital printer. What works in one situation may not work in another. The selected methodology needs to take into account such details as the scope of the project, the goals, the available resources, the marketplace and many other factors.

There is a very wide range of products incorporated in the concept, "digital printers." These can include simple personal desktop devices to very large production printing systems aimed at 24-hour a day operation. The process for developing such products usually includes creating a team of managers, engineers, scientists and technicians into a smoothly working unit with clearly defined directions and goals.

The experience base used to develop this paper indicates that there are many methods and processes that have been described and used successfully and unsuccessfully. In spite of this we contend that there are a number of common principles that can be applied to any digital printer development project.

For the purposes of this paper we have grouped these principles into the following four categories: Preparation; Good People; Commitment; and Good Tools. In addition to following these principles, we need to recognize that there are equally significant enemies of success. These enemies may be characterized as: poor planning; failure to manage change; innovation; lack of unity. These enemies will be described as we go through the principles for good development.

Preparation

As noted before, it appears obvious that a great deal of preparation is necessary when developing a printer product. Unfortunately, this does not mean that all printer products

are well-planned projects. It also does not mean that the principles of good preparation are well understood.

Documents

The most basic part of preparation consists of documents. These documents may go under different names and for the purposes of this paper we have identified them as, Purpose Statement, Priority Statement and an Elevator Speech.

The Purpose Statement

The Purpose Statement should answer the question, Why are we doing this? In many cases, companies have a written or unwritten Purpose Statement for a product that focuses on answering the question in terms of the benefits for the company. Unless the Purpose Statement also answers the question in terms of benefits for the user of the product, it is unlikely to be a complete Purpose Statement. For example, the Purpose Statement may list the key advantages and benefits for the user as being that this product is cheaper, faster, smaller, etc., than currently available or competing products. At the same time, the purpose for the company may be written in terms of profitability, market share, prestige, etc. The Purpose Statement would ideally take up one side of one sheet of paper (letter size please!), or at the most both sides of that sheet of paper.

The Priority Statement

The Priority Statement will often imply the priority of the product. A number of factors can be the highest priority for a printer product during its development. They include schedule, development cost, capital cost, unit cost, feature superiority, etc. The old saw that states, "Pick any one," is unfortunately true. Most companies are reasonably good at picking the highest priority item from the list. They are not so accomplished at prioritizing the rest of the items on the list or at accepting the trade-off that prioritization implies. The Priority Statement should not only list the highest priority, it should also explain in one sentence why this item *is* the highest priority. The remaining items should be appended in priority order. The Priority Statement should also take up one side of one sheet of paper.

The Elevator Speech

The *elevator speech* concept is based on the ability to fully communicate a concept that the listener understands while in an elevator going from the first floor to the fifth floor. The speech itself is the response to someone asking you, So what are you doing? You have only a short time in which to answer the question, and no time to think about the answer. Everyone involved in a printer product development team needs to be able to answer that question without thinking. Thus the elevator speech should be a short paragraph that probably should not exceed two sentences. It should describe what is being done and why it is being done.

Use the Documents

The management of the organization developing the printer must develop these documents. This will go along way to ensuring buy-in and commitment on behalf of the management and subsequently the development team. Each person making a contribution to the project should be provided with a copy of each of these documents. In addition, the documents should be prominently displayed in the areas where the product is being developed. The project leaders and managers need to know and understand these documents completely, even by rote. The documents are not the Ten Commandments. They can and should be amended if necessary. The documents should be used at the beginning of every major management presentation or meeting in which the printer product development or status is to be discussed. Management is then presented with the opportunity to make changes to these documents to reflect current conditions. If the documents are changed in any way, copies should be immediately distributed to all team members and, if advisable, explanations made as to the reason for the modifications and how they reflect on the project.

Minimize Innovation

In today's world, time to market is one of the most important aspects in printer product development. There are no projects that are not time sensitive. When preparing to develop a printer product, the single most effective way to reduce time to market is to make use of existing resources. Hard questions must be asked and answered. Can we make use of current assets, by re-packaging something that we already have? Can we modify something that we already have? Can we buy a company that has a product that will meet the need? Can we buy the product from someone else? Can we license a product from someone else? Can we pay someone else to develop the product, or a portion of it? Is there someone else who can do a better job of managing the task? Can we do a joint venture to get the product to market ahead of the competition? Can we put together a consortium of companies that will develop the product? Can we get someone else to help pay the development cost? Can we buy a part of the product? Can someone else develop a part of the product under contract? Can we get vendors to develop part of the product? Can we legitimately copy someone else's product? Can we improve someone else's product? Can we use existing parts or tooling?

To a group of scientists or engineers many of these questions look like heresy. This reaction is dependent upon the desire to develop better and new technology. Answering these questions could lessen the most interesting aspect of the product development process. However, the correct answers are also likely to reduce development cost and shorten schedule and thus time to market. These factors are usually of primary importance to the organization's strategic managers with ROI responsibility.

Expect Change

All printer product development programs undergo change during the project. Failure to understand this, accept it and manage it well can cause major problems in the development program. Project goals, schedule, and funding will be the most likely areas subject to change during the development phase. All the people associated with the project from senior management to machine operators need to know that change will happen. One of the best ways to minimize the impact of change on the development team is to frequently ask the question, What has changed? When change occurs it must be identified, its impact assessed, and then incorporated into the project plan. The impact of change must be communicated widely both upward and downward within the project team.

Identify The Impact

Change may be a key team member leaving, failure to meet a key milestone, recognition that a performance or cost goal cannot be achieved, or some other problem. In any event, the most likely impact of change is on schedule, resources, or cost. The Priority statement may imply that there is no possibility of changing the key goal that is affected. This does not necessarily mean that the project comes to an end. There are two possible outcomes. The first is negotiation, in which the Priority statement or the Purpose statement is renegotiated in the form of changes to schedule, cost, or some other major goal. The other possible outcome is perhaps more creative. A different way must be found to achieve or restore the priority that is in jeopardy. It is not possible to give hard and fast rules for the solution path, but most of us can remember anecdotal events where creative solutions to difficult circumstances have been invented or found.

Plan Realistically

Realistic planning also seems to be an obvious step. However, under pressure, even in the initial planning stages of a new project, many people create schedules that are not based in reality. There needs to be a general acceptance that it cannot be done right the first time. This is counter-intuitive. At the beginning of the project many planners can visualize the end result and are therefore tempted to believe that it will be easier to achieve it *this time*. It is *never* easier to achieve *this time*. We need to look back at the resources required, the schedule and the expense of earlier projects and recognize that the best we are likely to do is to improve slightly over what we did last time. The smart money says that we will do about the same as we did last time. Inability to recognize this principal will inevitably result in the fostering of distrust and frustration throughout the project.

People

The team consists of people in several categories: general manager, project leaders, team members and third parties.

The more dedicated the team can be, the more likely it is to succeed.

Matrix organization structures tend to require a great deal more communication and management than less bureaucratic structures to work efficiently. For efficiency purposes, the flatter the organization the better. Standard principles of organization apply to printer product development. For example, it has been consistently demonstrated that one person can manage at least 10 people. This level of management must also allow for the 'manager' to be a key technical contributor.

One of the most important requirements for everyone on the team is that they "sign up" for the duration of the project. One of the reasons that this is a critical principle is that it ensures that team members recognize that this project is the highest priority for their career. Likewise management must structure their organization and compensation plan to reflect this principle. This demonstrates and measures the commitment by everyone involved. Large multi-year projects in large corporations often have difficulty in achieving this principal.

The General

The General is a key person in the development process. This person will be solely responsible to management for the printer project deliverables. Different organizations have different titles for this function. We have seen the titles Chief Engineer, Systems Engineer, Commercialization Manager, Program Manager, and so on, used for this individual. Management needs to select a person who is first and foremost a leader. This person must be credible and trusted by the management and by the team members. The General should have a good working knowledge of the dominant technology used in the printer. He or she must be involved in the details of the project, and not aloof from the team members. Ideally the General will be capable of conducting a long, friendly and detailed conversation with any team member or manager about their specialized area and its current status. The General will have a personal involvement in the printer to the extent that his or her ownership is clear and evident to everyone. This will become one of the strongest factors in motivating the other team members.

Project Managers

After the General the project managers are the most important individuals on the printer development project. They will be people with proven capabilities and specialized knowledge of their own technology area. They need to be people whom team members recognize and accept as at least their technical peer, if not their superior. They also need demonstrated people skills and communication skills. They need to know that they have the confidence of the organization's management as well as that of their own people. This means that they need to be empowered and accountable.

Team Members

The usual requirements for team members are well understood. Because of this we will merely list a couple of principles that may not be quite as well known. A deliberate blend of mature experienced technologists and younger (or newer) engineers can contribute to the creation of an excellent team. Newness to a process often brings with it enthusiasm. Secondly, people should only be added to the team when there is an undisputed, proven need.

Commitment

The single most important quality of any of the people involved in the development of the printer product is the commitment to achieving the goals of the product as set out in the Purpose Statement. Management commitment is generally demonstrated by subscription to the documents described above and by the commitment to other necessary resources to achieve the task. This commitment needs to be continually reinforced with interest and support. Team members' commitment is demonstrated by their willingness to subscribe to the goals as set out in the Purpose Statement, and in their willingness to sign on for the duration of the project.

Good Tools

We now turn to the implementation of the task at hand. The most common misconception about product development is that implementation *is* product development. When, in fact, good product development, using good tools, will never be successful without careful preparation, management commitment, and good people. Assuming that adequate preparation has been made, management is committed, and good people are available, it is also critical that good tools be used to develop the product. In this section, we address the use of tools in several categories: simple measurement systems, elegant product architecture, proven designs, robust design principles, testing, motivational tools, change management systems, and the follow on plan.

Simple Measurement Systems

These systems are typically not referred to as measurement systems, they may be called program management systems, or product development systems, but in fact their sole purpose is to enable management and the team to measure progress against planned goals. They are usually focused around a simple Gantt chart, a resource plan, and a set of progressive performance features that culminate in the performance features established in the product specification.

Measurement systems generally include periodic reviews of all facets of the progress of the project. It is crucial that every member of the development team and everyone in management responsible for the printer product should know exactly where their piece of the product fits within the measurement system. If the measurement system does not provide this facility then it is a poor tool. It is also extremely important that all aspects of the measurement system be incorporated into a change management system. What is needed is not a documentation change management system, but a program change management system. Frequent examination of the Purpose and Priority documents with respect to the changing corporate and market environment must be made, any changes must be communicated quickly, and agreement reached as to the implication of the changes. This is primarily a task for the General or Program Manager.

Elegant Product Architecture

The essence of good design is simplicity. It is worth spending a great deal of effort in the early stages of the product development to assess all of the possible architectures for the product in order to establish the simplest and most effective approach. This applies equally to hardware and software architectures, and to the integration of the technology within those architectures. Complex architectures will invariably take longer to implement and give rise to more problems than simple architectures. Architecture problems will never go away.

Proven Designs

This is probably the most useful, lowest cost, and best tool to use in the development of all new printer products, but it is also the most likely tool to be resisted or rejected outright. The most effective printer product development programs use proven designs for the system architecture and for individual subsystems. Proven designs can always be improved in cost and/or performance. Unfortunately, all engineers want to innovate. Innovation is the enemy of time to market. We can probably all accept and understand that invention cannot be scheduled. But this does not prevent experienced product development teams and project managers from proposing new printer development programs based on unproven designs. The General or Program Manager needs to insist on the use of this tool and needs to be vigilant in insuring that it is used effectively. Otherwise, it will be extremely difficult to meet the program goals.

Robust Design Principles

The available processes used by engineers to refine product designs have undergone significant change in the last twenty years. The best available process today is known as Robust Design. There are a number of papers specifically addressing Robust Design principles at this conference so it will not be necessary for this paper to go into any details. For the purposes of this paper, the most important aspect of Robust Design as a product development tool is that everyone on the product development team must be trained in the use of Robust Design techniques and must recognize the importance of this tool in the work that they do. The General or Program Manager has a particular responsibility with respect to the Robust Design techniques used on the project. That is, he

or she must know when to apply the rule(s) and when an exception proves the rule. In other words, know when the rule applies and when it doesn't. Robust Design is a tool, and like any other tool, there is a time to use it and a time not to use it.

Testing

Everyone who has ever been involved in the design and development of a printer product recognizes the importance of testing. When following Robust Design principles, this means that at every stage of the development the testing is aimed at establishing the performance of the system or subsystem with respect to the critical parameters already defined. What is less generally recognized is the importance of the direct link between the person responsible for the design and the person doing the testing. There is an unfortunate but growing tendency to separate these functions so that the design engineer may be responsible for defining the Critical Parameters, and even for defining the test plan, but not for actually conducting the test. There is no substitute for hands-on experience. It is vital that the design engineer be physically present to observe and monitor the testing, not necessarily during product life testing or qualification testing, but certainly when the Critical Parameters are being tested. Everyone involved in the project must fully recognize that there can never be enough testing. This is vital to the success of the project and product.

Motivational Tools

It is easy to understand that a highly motivated team will outperform the team that is poorly motivated. It is much harder to know *how* to properly motivate the team of engineers. Without a doubt the strongest motivation is belief in the company, the product and the team. Without this fundamental belief, all other motivational techniques are likely to be useless. Ultimately it is the responsibility of management to create a corporate environment of excellence that fosters a positive attitude among all employees. It is then the responsibility of the General or Program Manager to inspire the team members with enthusiasm. It is also important to ensure that all team members believe that this is the best product and the best product team that this, or any other company, is capable of developing. Only when management is satisfied that the team is properly motivated by belief in the company and the product, should consideration be given to other motivational tools. The next most effective tool is peer recognition. If carefully used this can add to the belief factor. Peer recognition should be used carefully, if

misused it can create internal competition which is highly undesirable. Finally, there are financial motivational tools. These should be used most sparingly. Most schemes are extremely hard to manage and are most likely to give rise to dissatisfaction and argument. Experience has shown that the most effective financial motivational tools are "Attaboys." An Attaboy is a financial reward for good or outstanding performance awarded after the fact and without prior expectation. Additionally, Attaboys should be private and not be used as part of a peer recognition program.

The Follow On Plan

Strange as it may seem, one of the inherent dangers in a printer product development program is the completion of the program. People will never finish their task if they think that it will mean they will lose their job. Management and the General Manager must develop a plan that shows where each person on the team goes next and communicate it to each team member individually. This needs to be done well before the scheduled completion of the project. In an ideal situation, as much of the team as possible should be kept together for the next project in order to maximize productivity, by minimizing the learning process.

Summary

The four empirical principles of good printer product development, Preparation, Commitment, Good People, And Good Tools, have been described and explained. In general, they are not controversial, but experience has shown that they are also not often practiced. So the only thing that remains to be said is: "just do it!"

Biography

Peter Mason is a Senior Vice President at Torrey Pines Research. Mr. Mason was a pioneer of laser printing, holding several basic patents in the field, and was directly responsible for the first commercial electrophotographic laser printer, the Telecopier 200. He has almost 30 years experience in the development of electrophotographic copiers and printers including more than 20 years at Xerox Corporation. While at Xerox he held positions in technical program management and materials development. He also worked for several years in the famed Xerox 'Skunk Works'.