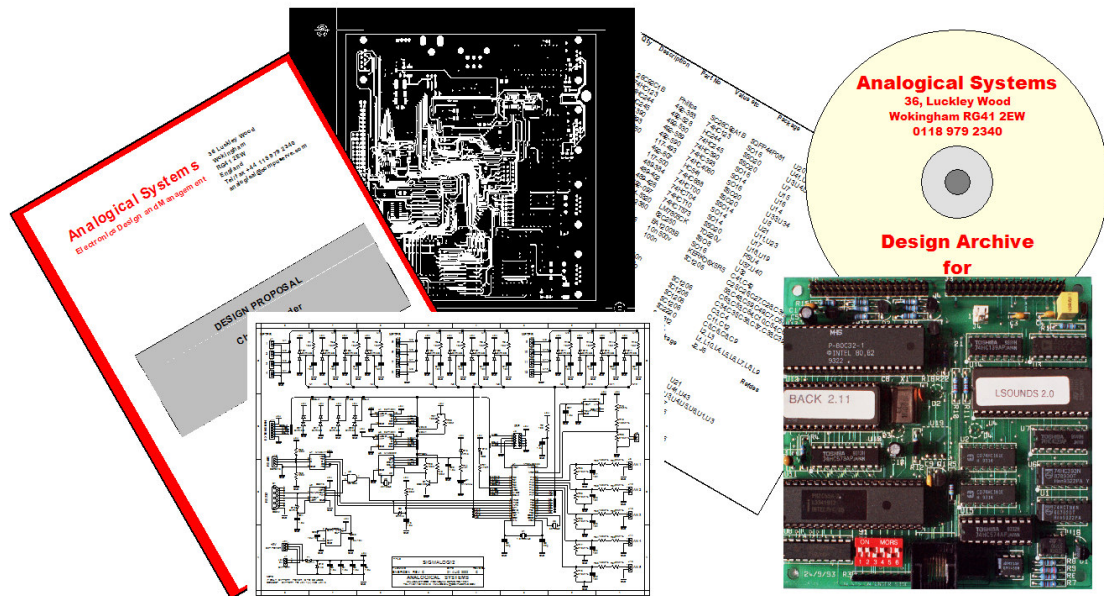


Successful Product Development

A handbook



Analogical Systems

Electronics Design & Management

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Introduction

Nowadays, electronics is a part of daily life. Many companies without technical expertise are considering new products or services which require the development of electronics devices to bring their ideas to commercial success.

This booklet is provided to help those organisations in the unfamiliar process of managing such work through the use of an external design agency. The agency can provide research, development and production start-up skills that would not be economical for a less technically-oriented company to sustain. This booklet primarily addresses the definition and electronic design aspects of converting a bright idea into a real product. However, there are important issues to be considered in market determination, production, sales and finance. These factors are highlighted at each phase in the development process.

Small projects can often merge several phases, or at least move through them very quickly. In cases where the final product volume is small, the manufacturing phases can be deleted and the entire production output handled as a large example batch. When such acceleration techniques are used, remember that each succeeding phase greatly increases the total investment and the cost of making changes rises rapidly in the later stages. Some authorities consider that any given change becomes ten times more expensive in each successive stage!

Incomplete product definition is particularly damaging to project success and it is the most common planning deficiency. Be careful with your dreams, for they will come true.

Follow the steps outlines in this booklet and your idea will rapidly become reality.

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The Design Process

Every development program moves from brainwave to production reality through a series of clearly identifiable phases. These phases have been found to be remarkably consistent across many different products and company organisations. The nature of the work in each of these phases is very different and can be brought to an explicit and checkable conclusion before major commitments to the next phase are made. In this way progress can be closely monitored and costs can be anticipated and controlled.

Each chapter of this booklet deals with one phase in the development process and provides a checklist to ensure that all the problems and issues are properly considered and resolved before commitments are made to the next phase.

These checklists have been developed over many years and used within many different company product development regimes. They encourage a wide perspective of the product design process, incorporating the need for financial, marketing and production involvement throughout the program. The checklists are not exhaustive or rigid and should be regarded as a guide and prompt rather than a crutch. Do not be afraid to answer "not applicable" or "don't know" to some of the questions. Such answers, properly considered, are valid and valuable responses.

Very few projects consist of only electronics hardware development. Often the electronics are realised as a microprocessor and associated parts, which then require a program to be written for the microprocessor to do its job. Or the product requires a computer to operate it, and a new computer program. Almost every product has some mechanical design element even if it is only enclosed in a simple plastic box. The product design processes described here are equally applicable to developments that include firmware, software and mechanical design. Only the documentation changes.

Product Development Phases

Definition

Identify the purpose, features, potential problems.
Set cost and timescale targets

Investigation

Assessment of technical feasibility
Estimates of project and product costs, timescales and required resources

Design

Conversion of ideas and goals into hardware and achievements
Create prototypes, test against requirements, improve, repeat

Production start-up

Set up production processes and procedures
Create test procedures and QA standards
Train production personnel

Homework

Before a design agency is approached the client company (the company with the idea for a new product) should evaluate some basic issues concerned with the need for a new product development and how best to use an external design agency.

Any new product development will take longer, cost more and be less certain of success than using an existing product. Test the need for a new product by asking "What aspects of the idea require a new product to be designed?" and "Why?". Don't attempt to specify in detail what is required, that comes later. Only identify items that are key to the success of the new idea. Only if an appropriate product is not available should the new product development be undertaken.

Even if a new product is needed it may be possible to adapt an existing device to suit the new requirement. Once again costs, timescales and risks are reduced. If an existing product can be modified, identify the aspects which have to change.

Remember that the ubiquitous personal computer (PC) or its junior cousin the personal data accessory (PDA) can be used as the basis for many products. Products that once consisted of unique electronics hardware with a microprocessor running custom firmware have now been superseded by standard PCs or PDAs running custom software.

Even if the PC cannot do the entire job it can still be a very effective data entry, manipulation and display device. With the addition of a new internal or external peripheral the PC can provide a very flexible new product. The time and cost of developing such a product will be much less than a complete product development and have lower risk.

It is very easy to get carried away with all the wonderful features that can be loaded onto the basic product idea particularly if it is PC-based. Try to keep the product concept as lean as possible. A simple product will get to market faster making your product the innovation that can be sold at a premium price. The market feedback from early sales will dramatically improve the definition of the next product and the early cash flow will fund its development.

Finally prepare a brief for the design agency. The brief should state the purpose of the new product and the key features and performance parameters.

All these efforts to clarify and refine the original idea will make the first meeting with design agencies much more fruitful. The next step is to meet the agency and discuss the project.

Homework Checklist

Adapting an existing product

by internal change

software

firmware

hardware

by external change

by add-on devices

Reason for a new Product

Cost

Features

Performance

Size, power, other problems of "fit"

Cosmetic changes

Marketing

Product volume

Sales timing

seasonal

keyed to specific events

Follow-on products

Phase exit reviews

method of new product creation

timing

degree of sophistication and refinement

later enhancements and expansion

Choosing a Design Agency

Design agencies can be single people working from a home office or quite large organisations with a wide range of skill and facilities. Size is not as important as expertise and flair in the techniques necessary for the successful design of your product. Many small companies have affiliations with others offering complementary services and so are able to provide the client with a single point of contact and responsibility for the entire design process.

The client company should consider what is required from the design agency. If new product design is not a normal activity then the design agency should be competent to offer a turn-key service of consultancy, design, project management and production start-up. If design or other skills exist in the client company then a less comprehensive service may be adequate.

The relationship between client and design agency is a close one. During the development problems will arise which were not foreseen (and there will be some otherwise there would be no need to go through the process of product development). The resolution of these problems will require the client to reconsider the route to his objectives and the design agency to propose alternative design solutions. This is a stressful situation and will be survived only if client and agency have a good working relationship. Empathy and rapport are ideal, mutual respect is a minimum second best. Formality at this stage is detrimental to innovation and progress.

The best design agencies provide innovative solutions to difficult problems and often have ideas that enhance the original concept. This flair should be evident at the first meeting and the quality of such ideas should be one of the criteria for selection of a design agency.

Be prepared to answer some questions from the design agency regarding the client's abilities to direct and finance the proposed development.

Once the agency has been selected the client and the agency work together through the next two phases to completely specify and understand the new product. The agency may quote separately for this stage if the product requires significant experimental or analytical work to reach a full understanding of the design content.

Design Agency Selection Checklist

Service Expected

- Advice
- Consultancy
- Product Design
- Project Management
- Production Start up
- Continuing production supervision

Design agency information

- Client company stature and status
- Source of funds
 - client
 - external investment
 - client's client
- Clients expertise
- Clients facilities

Rating of Design Agency

- competence and expertise
- facilities
- affiliations
- understanding
- advice offered
- ideas offered

Defining the product

This is the most important phase, although it is quite short. In smaller programs it can be merged with the following Investigation phase. During this phase the spirit of the idea is captured and expanded into a complete and unambiguous statement of what should emerge from the production line.

Making mistakes and correcting them in this phase is cheap, much cheaper than making mistakes and leaving them to be corrected later. Spend 20% or 30% more time here than you really think is necessary, the extra is cheap insurance against errors and oversights that will delay and compromise the new product.

But this phase demands more than time. It is important to give full attention to the definition process. Tired, distracted minds do not find the innovations that make the difference between yet another ordinary product and the star that transforms the company. The brainwave that began the whole product development cycle may indeed have been the work of a moment but working out how to create an entire product that does it justice requires hard intellectual effort. Again, the brainwave will have been the creation of a single mind but the complete definition will benefit enormously if several creative minds can contribute to the final result.

The key issues may not all be technical, there may be objectives and requirements for quality, appearance, relationships to other products etc. Write them down, they will influence the design at a later stage.

The design agency can do some, perhaps most, of this work if the original concept is clearly stated, and go on to propose a specification and a quotation for the work to completion.

Once the product has been completely defined the technical investigations and problem solving can begin.

Product Definition Checklist

Features

- Mandatory
- Desirable
- Non-features

Performance

- minimum
- desirable

Size, Weight, Power

Regulations & Type Approvals

- mandatory before production
- others

Interfaces

Marketing

- Cost & Price
- Introduction date
- Product linkages
 - other client products
 - products from other companies

Other Goals

- Quality
- Corporate image

Agency prepares plans for Investigation Phase

Client meeting to discuss Investigation phase.

Investigation Phase

This phase completes the details of design definition, demonstrates that all problems are solvable and that all product requirements and specifications can be achieved.

Feasibility can usually be established by reference to existing products or component literature. Where this search reveals a problem, analysis or experimentation will be needed. This effort must not be skimmed or left until a later phase since the failure to provide a feature or reach a performance goal may radically reduce sales of the product.

An explicit statement of non-features is important. It is too easy for contentious product issues to be left unresolved with the danger that the designer omits a feature that the client expected. Every feature that has been discussed should appear in either the final specification or the non-feature list.

Design margins are important to provide a design that will be easy to make and reliable in operation. There will normally be three sets of specifications. The published specs are those which the product is guaranteed to meet under any operational condition within the declared limits for the product. The first level of internal specification is used by production test and QA departments to ensure that every product will perform to the published specifications. There will be a margin imposed to allow for measurement errors and uncertainties, degradation in service and drift with time and environmental variations. Finally the design goals will be tighter still to ensure that products built with component variations covering the full spectrum of tolerances cannot compromise the intended performance. The internal specifications may include unpublished parameters if this is necessary for product integrity. Internal testing will include sample audit testing to a more searching standard, again to ensure on-going product integrity.

The end of the Investigation phase is a major turning point. All the evaluations are done, and from now on the project is expected to proceed to completion without major change.

A review must be held to ensure that the investigation has been thorough and the results are acceptable to the client. This review is often termed "Detailed Design Review". The design agency will also present a plan and budget to continue the work through the design and production start-up phases.

The product idea is now ready for realisation.

Investigation phase checklist

Product specification

- features
- options
- extensions
- interfaces

Compatibilities

Mandatory Regulations

Non-features

Design margins set

Demonstration of Feasibility

- Literature search
- Math analyses
- Breadboards
- Measurements

Product cost analysis

- material
- labour
- expenses
- margins

Critical Manufacturing Issues

- processes
- equipment
- skills

Development Schedule

Project Cost & Resource Plan

Agency prepares investigation report for client

Agency offers proposal & quotation for remaining program phases

Client meeting to agree further work program

Design Phase

This phase is the meat of the project. It is certain to be the most expensive since it is here that ideas are turned into reality. By now it should be apparent that a successful design requires considerable imagination, analysis and decision-making before the detail design starts. Reworking a design because of an incomplete definition or faulty investigations may well be fatal to the product and possibly to the companies involved.

Entry to this phase marks the end of intended change and the beginnings of the disciplines of production control. From now on project complexity grows rapidly with major purchases of materials and equipment, extensive documentation and the involvement of production, finance, sales and marketing departments. In larger programs dedicated management of the project becomes imperative.

Activities within this phase will always be different but the exit criteria will always be the same. Is the product ready for production? Is the company ready for sales? Readiness can be checked under several headings in the following checklist.

By the end of this phase all design and manufacturing problems are solved and example products supplied to the client. Complete design documentation and first draft production documents are available.

Many industries are required to submit example products to independent testing for compliance with statutory regulations. The testing may take several weeks and require two or more valuable prototypes. Either additional examples must be built for this purpose or the test period included in the development schedule.

The final part of this phase may overlap with production start-up activities such as the purchase of components or equipment with long delivery schedules.

Design Phase Checklist

Develop product prototypes working to complete design specification

- all variants
- full environmental testing

Design Documentation Assembled

- Schematics
- Bills of Material
- Test results

Regulatory approval applications submitted

Product design under formal change control

Long delivery items identified

Production documentation complete

- assembly procedures
- test specifications and procedures
- test records database

QA specifications set

Manufacturing start-up planned

Product variants & quantities

- test equipment made or purchase
- production staff training
- component purchasing

Phase exit reviews held

- design integrity
- safety
- regulatory approvals
- documentation

Starting Production

This phase covers preparation for and production of the first saleable batch of the product. By this time the product should be near-perfect and the production run should be seen as a proving exercise for the documentation and earlier staff training. It should not be used for continued product development.

Nevertheless, it is prudent to expect to have to modify the product or the manufacturing process, and wise to set up a fast-reaction change procedure to make sure that early products are not compromised in performance or quality. The design team should be available to the production team for rapid resolution of problems. This is often a growth experience for design staff who have not seen their ideas turned into products before! The design team should not be directly involved in the manufacturing process.

This first production batch should be carefully examined to ensure that the product has been built correctly and that the test results are consistent with earlier measurements. This examination should cover all aspects of the design including customer documentation, consumables and packaging. It is likely that this batch will have been made from components bought at a different time and perhaps from different suppliers than those used for prototypes. There may be subtle undocumented variations in specification which affect the product.

A review of the results of the production start-up should be held to ensure that the products are of saleable quality, that any necessary remedial action is in hand and that mandatory regulatory approvals are obtained before the products are sold.

Production Start-up Checklist

Rework actions planned

Initial Regulatory Approvals received

Customer documentation complete

operating manual
service manual

Advertising literature

brochures
ad campaign
web site update

Accessories and consumables available

Phase Exit reviews held

design changes
safety
quality
manufacturing costs and difficulties
manufacturing documentation revisions

About Analogical Systems

Analogical Systems is an electronics design bureau with the expertise and facilities to execute most forms of electronic and microprocessor design. We specialise in systems and products that incorporate some form of communications, be it radio, induction loop, RFID, optical or wired.

Fixed price, fixed time proposals are offered to execute design briefs ranging from one-day consultancy to complete product design programs extending over several months. A project management service is also available for companies unfamiliar with this type of work, or as a way of coping with staff overload.

Analogical Systems was founded in 1990 and enjoys a close working relationship with companies having facilities for printed circuit manufacture and prototype assembly, so we can offer a complete service for innovation, design, prototype and batch production.

Analogical Systems is well equipped with tools for research and design. Computer facilities include Electronic Workbench MultiCap and UltiBoard for schematic capture and printed circuit board layout respectively; Simetrix SPICE for system and circuit simulation; several microprocessor firmware development tools; Visual Basic, Delphi and other languages for PC software development; and of course a full office suite for documentation. Electronic test equipment includes several signal sources covering audio and radio frequencies to 1 GHz, noise generators, oscilloscopes, microprocessor development systems and programmers, and a spectrum analyser.

Analogical Systems offer the following services:

Technical Consultancy

- feasibility studies
- design appraisals
- application advice

Project Management

- technical market research
- product definition
- electronics design
- regulatory approvals
- installation and commissioning
- production start-up

Electronics Design

- product research
- system analysis and design
- simulation and performance analysis
- analogue system and circuit design
- microprocessor hardware and firmware
- control programs using PCs

Previous work by Analogical Systems

Microprocessor-based systems

- Data capture and data logging using UHF communications
- Infra-red and visible laser guns, microprocessor controlled
- Optical amplifier controller
- Commercial dishwasher controller
- Large-scale public display systems
- Breathing monitor

Analog Designs

- Low noise, low power transducer signal processing
- Motor control
- Humidity and temperature measurements
- Complex filters
- RFID base station
- Telephone voice recorder

RF Designs

- L and C band to 70 MHz frequency translator
- 350 MHz to 915 MHz ISM band up- and down-converters
- 70 MHz satellite communications modem
- MSF standard time receiver
- Low frequency selective level measuring set
- Radio alarm system

PC-based systems

- Multi-channel telephone voice recording
- Multi I-O communications card

Satellite communication systems

- Earth station installation project management
- Product type approval assessment
- Ground test equipment design supervision
- Technical and managerial consultancies
- SSPA test program
- European Technical Regulation drafting

Previous Clients

Acurite Ltd
Basics Ltd
Danfoss
Energen Scientific
Energy Control Consultants Limited
ETSI (European Telecommunications Standards Institute)
Gibson Chemicals
Hewlett-Packard
Hughes Network Systems
ICO Global Communications
iD Systems
Inmarsat
Intersurgical
Lasertag Inc
Motorola
Pedalite
PE International
Rebel Racing
RF Waves
Searcher
Techspan Systems
Telegesis (Europe) Ltd
TwoWay Television
Voicelog (Europe) Ltd