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Objekttyp: **Article**

Zeitschrift: **Technische Mitteilungen / Schweizerische Post-, Telefon- und Telegrafenbetriebe = Bulletin technique / Entreprise des postes, téléphones et télégraphes suisses = Bollettino tecnico / Azienda delle poste, dei telefoni e dei telegrafi svizzeri**

Band (Jahr): **59 (1981)**

Heft 4

PDF erstellt am: **06.08.2024**

Persistenter Link: https://doi.org/10.5169/seals-874183

Testing Activities in Computer Projects: A Customer's Point of View

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DK: 621.376.56:621.394.49:621.395.491:681.327.8

1 Computers and Telecommunications

One of the most important aspects of the technological and technical advances in the domains of telecommunications and data processing is the fact that the future of each domain relies more and more on the possibilities offered by the other. On the one hand computers and microprocessors have become central parts of switching and transmission system control in telecommunications networks; on the other hand the future of many new computing applications — such as distributed processing — is conditioned by the availibility of efficient telecommunication facilities.

11 Examples at Swiss PTT

Computers have been used by Swiss PTT for more than 20 years now to *rationalize the business applications* of the Telecommunications Services. A typical example in this category is the processing of telephone bills.

The first use of computers *for pure telecommunications tasks* was the introduction of the Ateco system, a message switching system for the telegram service. Ateco was operational at the beginning of 1972 [3].

Several other applications have followed this first step. They can be divided into two categories:

- computers for telecommunications systems
- computers for teleprocessing systems

111 Computers for telecommunication systems

The applications of computers in telecommunication systems can be divided into four groups:

- Telephone switching equipments [1], [2]
  - SPC (Stored Program Control) systems
    The most important joint effort by Swiss PTT and Swiss industry is the IFS project, the development of a new telecommunication system for telephone with digital transmission and switching. In its final stage IFS will integrate voice and data communications.
  - Modernization of electromechanical exchanges
    The IFS system will be introduced from the mid-1980s. Studies have shown that the use of minicomputers and microprocessors would allow to add new facilities to old electromechanical exchanges, which have to remain in service until replacement by IFS equipment. This solution will give to the old hardware a new lease of life during the transition period, permitting to offer a better service to the customers without too substantial short-term investments by the PTT.
  - PABX
    New types of private exchanges also make extensive use of electronic switching controlled by processors or microprocessors.
- Telex and data switching equipment
  - The old electromechanical telex exchanges are being replaced by computer-controlled switches (project EDWA). The first exchanges were operational at the beginning of 1980. The EDWA systems will offer a 300-baud data switching service in addition to the telex service.
  - Swiss PTT is also setting up a data switching service based on packet-switching techniques. The first step was the installation of a EURONET node in Zürich in 1980. In addition, and in connexion with the EDWP project, a general public data network is being planned. This network should be available at the beginning of 1982.
- Message switching systems
  - The Ateco telegram switching system has already been mentioned in this paper. Its concept is based on a high degree of availability (hardware is triplicated) and a user-optimized approach (routing is by direct interpretation of alphabetic geographic destination names without use of computer-oriented codes).
  - A message switching system for telex customers (project SAM) has been operational since the beginning of 1979 [4].
- Auxiliary Systems
  Computer based systems to implement auxiliary functions in the telecommunication networks have already been installed or are at the planning or development stage.
  We may mention as examples:
  - a system to supervise and control radio stations
  - a system to control remote measurements and to collect and analyse alarms on the telephone network
  - a system to collect billing and statistical information from international telephone exchanges
  - a system to improve telephone network availability by automatic connexion of alternate paths in case of carrier system failures

112 Computers for teleprocessing systems

- The Terco system [5], [10]
  Terco is a long-range project to rationalize the admin-

istrative work of the telecommunications services of Swiss PTT. The project makes extensive use of teleprocessing. In a first phase two applications were implemented: the production (editing and preparation) of the telephone directories, and the inquiry service (directory assistance). The system has been fully operational since the beginning of 1978 with a total of some 800 display terminals.
Terco offers a 24h/day, 7days/week service. High availability was a very important requirement for the system. According to the present concept, Terco will ultimately have three computing centres. Each centre will process an applications group. The three centres will be interconnected as a computer network. In case of failure of one computing centre, its applications will be automatically switched over to another centre, with no or only minimal degradation for the user.

- Videotex service
An experimental Videotex service was introduced at the end of 1979. Videotex can be considered a mixture of data communication and teleprocessing services. It will provide access to public and private data bases. A potential large-scale application of Videotex with a public data base could be the direct access to telephone directory information in the Terco system, allowing Videotex customers to obtain telephone numbers directly.

2 The Development Cycle of a Computer Project

The life of a project may be divided into six distinct phases [8]:

- definition Phase
- design Phase
- development Phase
- system Test Phase
- acceptance Phase
- installation and operation Phase

Definition Phase
During this phase, a plan for the project in terms of basic functional requirements is written and the technical problem is defined.

Design Phase
During this phase, the feasible solutions are discussed. An acceptable solution is chosen and then fixed in a design document.

Development Phase (Programming Phase)
A system is developed in accordance with the defined problem and the blueprint solution. The necessary hardware and software is built and tested.
If the system is based on standard processing hardware, this reduces development effort to the production of the software and the phase may be called the Programming Phase.

System Test Phase
The testing of individual parts of the system during the development phase has to be complemented with tests of the whole system.

Acceptance Phase
The finished system including its documentation is demonstrated to the customer in order to gain his formal agreement that the system meets his requirements.

Installation and Operation Phase
The accepted system is introduced into its real operating environment and put into operation. Before the beginning of operation, the system is often submitted to a final test in the real environment.
The main subject of this paper is the problem of acceptance tests. We shall therefore specially point out the problems encountered during the acceptance phase of a project. Some aspects of the other testing activities will also be covered.

3 Type of Involvement of the Customer in the Development of a System

Our considerations are based on systems produced under a formal contract between a customer (such as the PTT) and a supplier.
Even if there is no formal contract, or if the system is built with standard hardware and the software developed by the data processing department of the customer, it will be sound policy to act as if the user and the developer are under contract.
The different possibilities of involvement of the customer in a project are described in the table of *Figure 1.*
The two extreme cases are the following:

Minimal involvement
- preparation of a Request for Proposal
- choice of a contractor
- approval of the acceptance demonstrations
- operation of the system

Maximal involvement
- the customer is active in all phases of the project and because of his responsibility he is also engaged and accepted as a full partner for the whole project

The normal case lies in between the following
- often, the customer becomes involved during the definition phase, when the contractor may need clarification or further specification of the requirements listed in the request for proposal
- the customer collaborates to the System Test Phase
- the customer is directly involved in the planning and execution of the Acceptance Test Phase
- the customer is involved in the installation of the system

As a rule the customer is not responsible for the design and development of the system. These activities are fully under the responsibility of the contractor. In some cases the customer wants selected staff of his organisation to participate in the development of the software as training for eventually taking over the maintenance of the system.
Figure 1 gives as an example the type of involvement of Swiss PTT in different projects.
Generally speaking, the PTT is always strongly engaged in the definition and testing of a system. In some instances the testing activities may be the principal ones. This is the case for new systems which industry developes without a request for proposal from the PTT

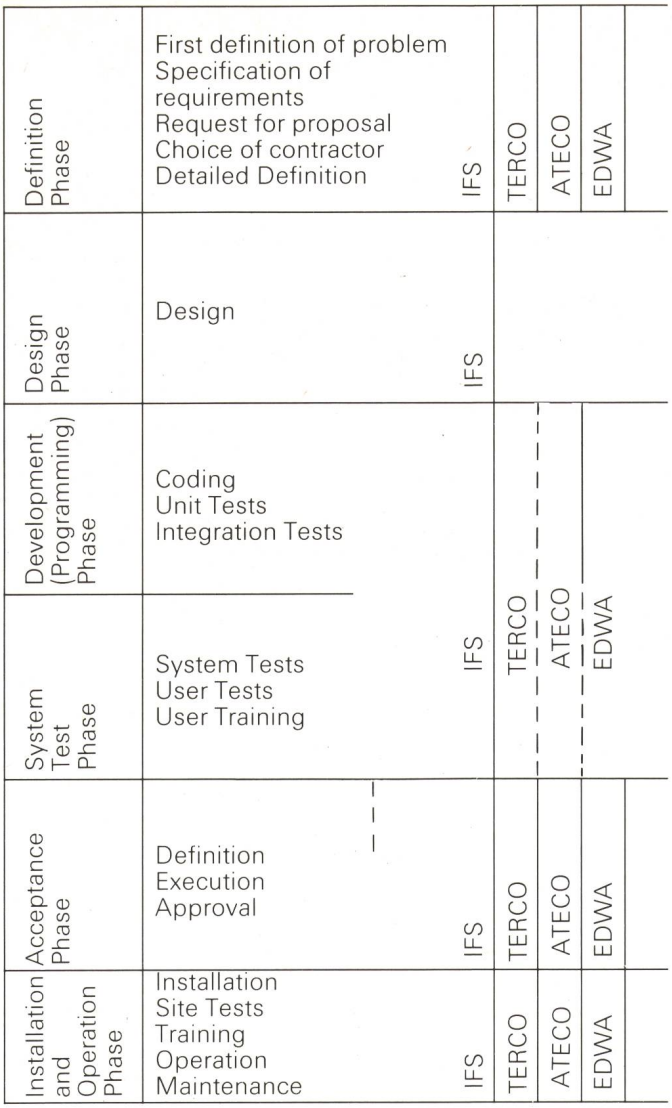

Fig. 1
Possibilities of involvement of customer in a project. Examples of Swiss PTT projects

Involvement in order
to train maintenance staff

and which are presented to the PTT for evaluation. A similar situation exists for privately owned systems which are connected to the PTT's telecommunication networks and which have to be submitted for approval.

In this paper, we will limit our presentation mainly to experience gathered during two particular projects, the Telegram Switching System Ateco and the teleprocessing system Terco. Testing of systems built with standard hardware will above all be examined. In this case the testing effort is aimed essentially at the software.

The items presented here do not reflect the situations encountered in these projects in an absolute way. Instead, we will try to treat the problems in a more generalised manner, hoping to make some suggestions useful to organisations engaged in future projects.

4 The Different Test Phases During a Project

We find test activities during most of the life of a project. They begin with the development phase and practically never end, because tests will also be necessary during the operating period of the system as a component of the maintenance activities [7].

The tests planned and carried out from the very beginning of development up to the commissioning of a system generally fall into the following categories:

- unit tests (also called module tests)
- integration tests (also called package tests)
- system tests
- acceptance tests
- site (or installation) tests

These test categories will be briefly described in order to emphasize the differences between the acceptance tests and the others.

41 The Unit Tests

The objective of a unit test is to test an individual low-level program in an isolated environment before combining it with other tested units. The unit test has to demonstrate that the unit, when finally inserted into the system, will do its job as a black box. Unit testing is the programmer's job. There is normally no rigid, formal test scheme for the programmer, only general guidelines.

The customer is not usually involved at all in the unit tests. This activity is completly under the responsibility of the contractor.

42 The Integration Tests

The integration tests may begin as soon as groups of unit-tested modules become available. Units are combined and tested to form components: these components are grouped to form packages and so on, up to the structure sketched in *Figure 2* until the system has been put together and progressively, exhaustively tested.

The integration tests are usually carried out with the help of an Integration Test group, which is independent of the Programming groups. The level at which the programs are handed over to the Integration group may vary and depends on the project organisation. The units (modules) already may be handed over to the integration group for further testing. On the other hand, the programmer's motivation may be stronger if he is fully responsible for larger pieces of programs. For instance, the programming groups can test up to program pack-

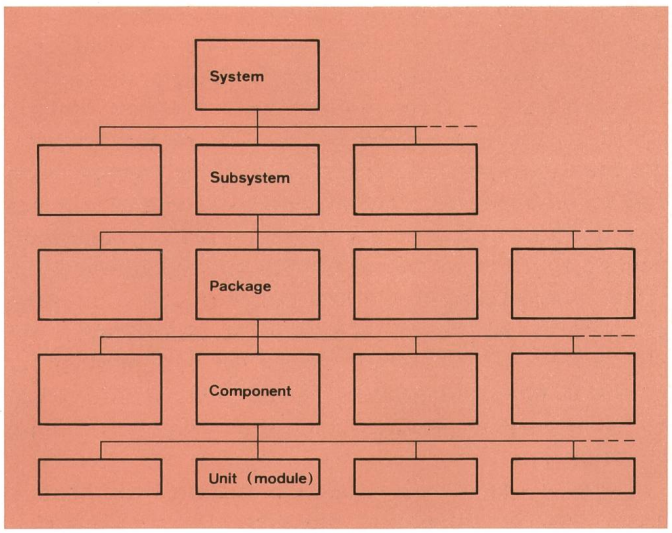

Fig. 2
System hierarchical structure

age level. The tested packages are handed over to the Integration group for final merging and testing of packages into subsystems and the subsystems into the system.

Integration Tests are not planned and executed by the person who coded the program. A special group is charged with this task.

The Integration Tests have to be much more structured and formalised than the Unit Tests. It is necessary to prepare an Integration Test Specification, which describes the test objectives, the general procedures and the test tools.

The success criteria are defined. A coverage matrix should show which specific tests cover which system functions. The tests are subdivided into test cases. The execution of every test is defined in a script (or scenario).

The same as the Unit Tests, the Integration Tests are usually planned and executed without customer participation.

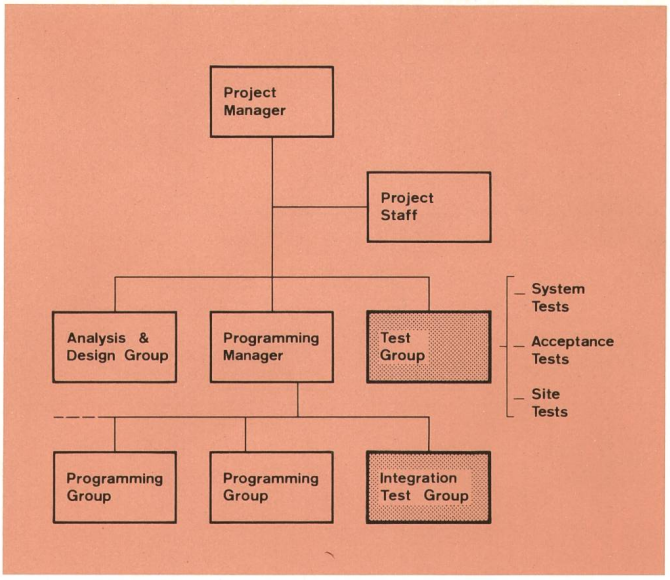

Fig. 3
Integration and System Test Groups in the project organisation

43 The System Tests

The execution of the system tests constitutes a project phase in itself in the project life cycle. It means that the system tests should first begin after completion of the programming activities: all programs should be developed and integrated in order to allow system testing on the whole system. This objective is often difficult to attain in practice. It is unlikely that all programming groups are synchronous in timing. Some subsystems will be ready earlier than others. In many cases the contractor will decide to overlap the end of the programming phase with the beginning of the system test phase to speed up things and to save time. Such an approach, however has to be very cautious. System testing can begin on completed subsystems before the full system is available. This is possible if the interfaces between the subsystems are simple. Otherwise, programming and system testing in parallel can bring more confusion and difficulties than gain of time.

We consider the System Test Phase essential for a project. The objective is to fulfil the requirements (functions and performance) in such a way that the system is ready for operation.

The managements of both the customer and the contractor are sometimes hard to convince of the need for a System Test Phase. They consider it an unnecessary delay on the way to acceptance and delivery of the system and would prefer to move direct from the programming phase to the acceptance phase. Contractors may be tempted to persuade the customer to mix system tests and acceptance tests. We strongly recommend to reject this. System testing and acceptance testing have their own objectives and therefore both are necessary.

The main objective of system testing is to submit the programmer's products as a whole to an extensive and thorough set of tests which are neither designed nor executed by the programmers. These tests have to run in as nearly a live environment as possible with a minimum of simulation.

A second objective is to use the System Test Phase to begin with the training of the system users. The customer should be ready to take over his new system at the end of the System Test period.

Detailed and accurate specifications must be developed for the system tests. A test schedule is necessary. The documentation and the execution methods of the system tests have many common points with those of the acceptance tests. We propose, therefore, to describe them later in this paper under the theme of acceptance tests.

The people who plan, execute and analyze the system tests are members of a Test Group. They must have technical skills and a liking for analytical work. They must understand very well the problems of the customer and the System Specification. Participation of some of the analysts who made the original problem analysis may be recommended.

The System Test Group should be different from the Integration Test Group *(Fig. 3)*. The latter has to execute the regression tests for the programs to be corrected during the System Test Phase, as soon as errors have been discovered by the Test Group. Indeed, it is advisable to separate programming and system test activities in order to eliminate interference between them.

The customer is not necessarily involved in the system tests themselves. But he should participate in the System Test Phase for training purposes. If he does not participate directly in the tests, he should at least have access to the system so that the users can become familiar with it.

It is advisable that the customer delegates some of his staff to the Test Group. Usually, the contractor will accept this because the experience of the customer's staff can help to minimize misunderstanding problems with the interpretation of the system specification and requirements.

44 Acceptance Tests

The Acceptance Tests are an independent phase in the life of the project, similar to the System Test Phase. The objective of the Acceptance Phase is to demonstrate to the customer that the system is ready to be delivered and that it satisfies the contract [6].

The Acceptance Tests are planned and carried out in

much the same way as System Tests. The difference is in the role of the customer. The customer is generally involved to a great extent in the planning, execution and analysis of the acceptance tests. Most important, he has to approve formally the results of the tests.

With the approval of the acceptance tests, the customer relieves the contractor of most of the commitments he accepted by signing the contract. For that reason this phase has a very important legal aspect.

Acceptance Tests will be described in detail in another paper, dealing with the specific problems and methods of the test category [9].

45 Site (or Installation) Tests

In many projects System and Acceptance Tests cannot be carried out in the real environment and with the final configuration of the system. They have to be performed in a test cell instead. This situation is encountered with practically all real-time and on-line systems.

For this reason, Site Testing is often necessary. It may be simply a repetition of earlier tests (acceptance tests). It may also require new tests, which have to be specially planned. This occurs, for instance, when Site Testing is the first opportunity for testing with live conditions (without simulation) or testing with real data.

In some cases site tests are part of the system approval procedure. The acceptance tests, executed before the definitive installation of the system, are made conditional. Full acceptance, however, is achieved only if site tests are sucessful.

Site Testing should be carried out as far as possible by the customer's staff and under his own responsability. From a certain point of view the site tests are the «dress rehearsal» before putting the system into operation.

The integration of some measure of Site Testing in the acceptance tests may be recommended. This is particularly useful if an important part of the acceptance tests relies on simulation, as is often the case with military, industrial and communications systems. Strange things sometimes happen when the system is connected for the first time to its real environment. If the approval procedure ist already fully completed at this time, the customer may be in an uncomfortable position.

The contractor may be reluctant to integrate Site Testing into the acceptance tests, because this phase presents too many unknown risks for him in terms of timing and responsability: the final installation of the system or of a part of it (for instance, geographically scattered user sites) is carried out by the customer, perhaps with an uncertain time scale; the system operation and the execution of the tests during Site Testing have also to be done by the customer (for instance, because hundreds of terminal operators are necessary). All this is not under the control of the contractor. The delimitation of responsibilities between contractor and customer may be difficult in case of system failures, problems or delays.

A possible alternative to the integration of Site Testing into the acceptance tests of the main contract is to negotiate two contracts: one for the development of the system, which ends with the approval of the acceptance test results, the other for Site Testing and assisting the customer in putting the system into operation. The contractor may be more willing to take responsibility in such a combination, because undefined difficulties, possibly imputable to the customer, do not carry the risk that the customer rejects the system completly in the end.

5 Conclusions

The test phases of a computer project have been described globally, taking account the grade and the type of involvement of the customer in the different testing activities. A next paper [9] will deal more precisely with the objectives and contents of the *Acceptance Tests,* which form the most important test phase from the point of view of the legal relationship between customer and contractor.

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