POLICIES AND CONCEPTS

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A specific standard for quality in fundamental research

Abstract The specific standard described here constitutes the heart of the quality system set up by the Commissariat à l'Energie Atomique – French Atomic Energy Commission – for its main "Fundamental Research" entity, the Directorate for the Sciences of Matter. It is a coherent standard (set of shared rules and provisions laid out in a clear fashion) designed, in the first instance, to provide those taking part in research, including the hierarchy, with the means to satisfy their requirements in the field of quality. And, secondly, to create the conditions for recognition of this action by third parties, which all research entities must nowadays convince of their trustworthiness (supervisory ministries, research partners, industrial companies, etc.). This standard places particular emphasis on the preponderant roles of initiative and freedom in fundamental research, which are a prerequisite for creativity, innovation and, last but not least, the motivation of personnel.

Key words Fundamental research · Specific standard · Quality

Introduction

In a scientific, socio-economic and legal environment subject to incessant change, the responsibility of research entities, with regard to the knowledge that they produce, is increasing in line with the rising awareness of the growing impact of science on society. Those involved in research have a major responsibility regarding the production of "certified" knowledge, the uncertainty and scope of validity of which must be explicitly identified. Society must be able to have full confidence in scientific results, and to use them without constantly worrying about their reliability. Furthermore, the notion of a research entity's eligibility has also tended to become commonplace, owing to the increasing need to decide on the allocation of resources between research entities that are sometimes in competition with each other. At the same time, those commissioning research (supervisory ministries, possible "clients") are becoming more and more demanding. The recognition accorded to research bodies, of primary importance in the operation of the scientific community, could in the future be based on broader criteria than the opinion of peers alone. The need for a system to increase confidence and provide assurance has therefore gradually emerged. In the complex balance between, on the one hand, the fight for autonomy and, on the other, the ever closer links between science and society, this notion of confidence now appears as one of the keystones characterizing a situation that is fragile and in need of rebuilding. The quality approach is one of the answers to this major challenge facing research [1–2].

In response to this, the "Fundamental Research" entity of the French Atomic Energy Commission in the field of the sciences of matter (CEA/DSM) has initiated a wide-ranging investigation with the aim of designing and implementing a quality system suited to its specific activities. Considering current quality standards [3–6] not to be adapted to fundamental research, the CEA/DSM has opted to take a different path, with the same basic aims (improve the control of processes and transparency), but different in form. In fact, the scientific community, international by its very nature, long ago put in place its own rules, which evolve over time and are validated by peers, to ensure the production of reliable knowledge ("scientific method"). Although not known explicitly as such, this constituted a veritable quality system before the notion became current, and these rules form the basis of the CEA/DSM standard [7]. Creating an internal standard does not signify abandoning the quest for constant improvement. The basic principle of this standard is that, in order to be acceptable and meaningful for all those involved in research (first and foremost the scientists themselves) and finally applicable, the very people involved must be the driving force behind the introduction of this quality approach. Moreover, the standard must be sufficiently flexible and free of constraints as to be able to encompass a constant striving for improvement of practices or "ways of doing".

This quality standard distinguishes two categories of activities: on the one hand, functions providing logistical support for research (administration, security, secretariat, technical maintenance, various user services, etc.) and, on the other hand, the research activity itself and the development of instruments and carrying out of experimental setups associated with it. The latter is defined on the basis of three tools which may be combined or include each other: management of a research project, a realization project, and a thematic action. The decision to use one or several of these tools, depending on what is at stake in the research, is determined by the reorientation implied by the objective to be achieved, and the resources allocated compared to the other activities of the research body. In other words, the higher the stakes, particularly socio-economic, of the research, the more rigorous the quality system that must be put in place. Conversely, activities with purely cognitive ends (a prerequisite in fundamental research) require no specific, restrictive formalization, as the basis of the reliability of results obtained is the rigorous application of the "scientific method".

Basic principles of the standard

As the research standard must be acceptable, recognized by all the researchers (especially by the scientists themselves) and, as a result of this, applied, the personnel must be the driving force behind the introduction of the quality approach. To this end, the quality actions that may be initiated within the framework set out must be guided, first and foremost, by the expression of needs by those directly involved (including, naturally, the "hierarchy", which plays an essential role in such a process). The CEA/DSM standard is therefore based squarely on a model of co-production of quality together with associated knowledge and know-how, by all those taking part in research, on the basis of a gradual and continual learning process. It resolutely refuses any arbitrary conformity to a model external to the research community (i.e. incompatible with the current "paradigm" according to Kuhn's word [8]), the consequences of which would, in the longer term, be counter-productive.

In effect, quality in fundamental research cannot simply be defined as conformity to a standard, which is the role of any true innovation to transgress. Quality must rather be based on a procedural process (like the "scientific method" itself) having as its objective the facilitation of learning by those involved with a view to achieving excellence and a guaranteed place among international competition. Consequently, those involved in research have a major responsibility to identify criteria enabling evaluation of their learning over the course of the re-

search process, and to put in place the corresponding monitoring and evaluation indicators.

A quality standard in fundamental research can therefore be constructed on the basis of the following three points:

1. It is necessary to highlight and circulate all the approaches and procedures used by the scientific community itself in order to guarantee, insofar as this is possible, the reliability of its results. These approaches and procedures do not on the whole exist in written form. Though not universal in the strict sense of the word, they are widely shared in a given scientific community and therefore correspond very precisely to the notion of a paradigm. They are often implicit in nature, are for the most part transmitted tacitly and by word of mouth, and therefore are a part of the culture of the scientific community. The primary function of training through research is the transmission of this knowledge and know-how. Certain procedures are nevertheless formalized, such as submitting an article to an international journal with its referees (which is, incidentally, a well-codified form of quality control in research). In the same way, the mission (or "terms of reference") assigned by the CEA/DSM to the members of the scientific advisory committees who regularly evaluate the activities of the various bodies are a part of this formalization process.
2. It is necessary to provide scientists with a highly flexible but coherent framework and method (i.e. the least formal and most adaptable) enabling them to put forward and implement by themselves a realistic and useful process of improvement, i.e. one corresponding to specific real needs. It should be borne in mind in particular that any initiative must, in principle, be capable of being validated by peers (insofar as this is necessary). There would be absolutely no point in putting in place methods of producing knowledge that satisfy the quality expert but do not receive the approval of the scientists themselves, who alone, in the end, can vouch for their pertinence. Such an undertaking might even have lasting negative consequences for the credibility of the quality approach.
3. Each entity can define the set of day-to-day and repetitive tasks that do not interfere with the creative process, for the purpose of listing them, standardizing them and even, where the need is felt, formalizing them, for example in the form of "standardized operating procedures". Each CEA unit (Laboratory/Group, Service, Department, etc.) can in fact be separated into an entity carrying out research as such (made up of scientists, engineers and technical staff) and an entity that might be referred to as logistical support for research (administrative staff, managers, secretaries, etc.). The latter does not carry out research itself but does contribute to the research effort. Quality must apply to these two components: there would be no point in having high demands from laboratories if the logistical support hindered rather than facilitated this improvement process. Consequently, this standard does not concern only the scientists; it applies to all personnel at CEA/DSM.

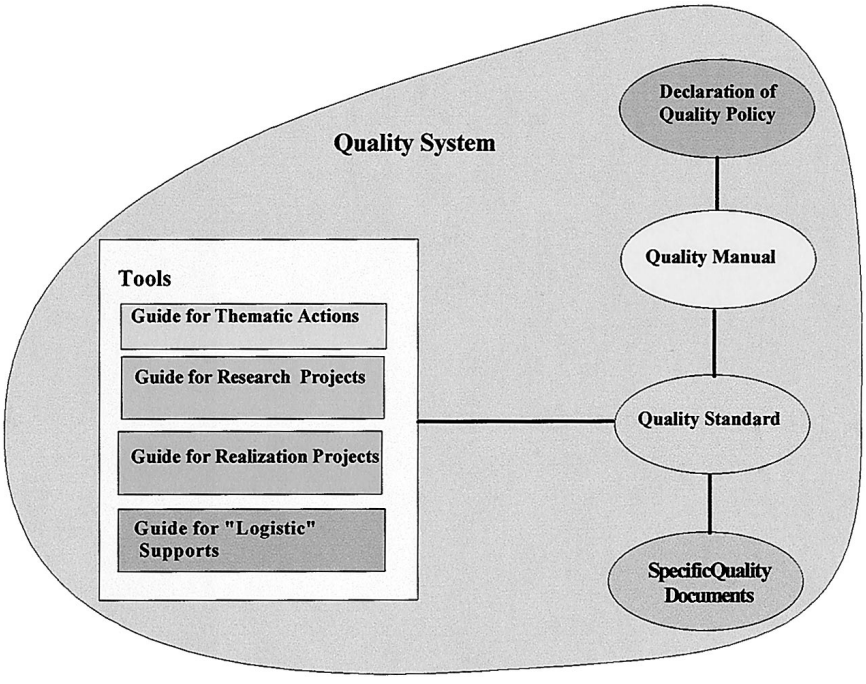

Fig. 1 Directorate for the Sciences of Matter (DSM) quality system

In order for the standard to be usable, it must be part of a global system for quality within the DSM (Fig. 1) and find expression in a limited number of documents as short and simple as reasonably possible to avoid the "mountain of paper" effect for which quality is often held to blame.

These documents are to be supplemented at the appropriate levels in all DSM entities (Departments and Services).

Categories of research actions

The CEA/DSM standard identifies the various categories of actions in order to pair them with the appropriate quality requirements, i.e. those that are necessary and sufficient to achieve the objective, taking into account the nature of these actions. For each of these categories, there should be as little formalism as possible, and existing systems should be promoted where they benefit from a broad consensus amongst those involved in research (taking particular note of largely accepted practices). The standard includes two main categories of action: the project (with two specific components described below) and the thematic action. At an organizational level, all these actions take place at CEA within the framework of programme segments which are horizontal structures running through the various entities of CEA setting long-term, but annually revisable, general objectives to a given direction of research in a strategic perspective. The positioning of the actions conducted in each segment, with regard to the general missions of CEA and the status of the field of knowledge, is the result of an asset/benefit analysis taking into account the strategic guidelines produced by the General Management.

A project, corresponding to both quality and management procedures, is only meaningful when it is an answer to a sufficiently major issue – be it scientific, financial, social, environmental, or determined for instance by partnerships imposing certain constraints (as is the case for European projects). In all other cases, the quality standard considers that research corresponds to the conduct of normal

thematic actions requiring the minimum amount of formalization possible (see the Section "Thematic action"). The setting up of a project therefore supposes that during the conduct of "normal business" a research unit (Laboratory/Group, Service, Department, Directorate) identifies a need of sufficient scale to require a particular mode of management, budget control and quality procedures. The more serious the issues at stake, (particularly socio-economic issues), the greater the demands placed on the quality system in terms of criteria and specific measures to satisfy these criteria (formalized in as clear and simple a way as possible). Actions where the issues at stake are purely cognitive, on the other hand, do not require a specific and restrictive formalization other than the rigorous application of the "scientific method" (including laboratory best practices) on which the reliability of the results is founded.

In practice, the standard distinguishes between two categories of projects which can be identified as traditional tools of management and budget control and which, in the context of the CEA/DSM, may in some cases be combined (see below).

Research projects

Research projects involve a co-ordinated attempt to acquire new knowledge through the application of the "scientific method" relevant to the field of research in question (in the context of a programme segment). Those playing a role in this project category have primarily an obligation of "best effort" undertaking, i.e. they must do all to carry out their research according to the highest standards of the discipline by mobilizing the resources required (knowledge, technical and human resources). Although the principal demand is to attain the objective, failure to do so does not necessarily signify that the project itself has failed, provided that all within reason has been done to achieve success.

The very nature of fundamental research sometimes creates insuperable uncertainties with regard to the conditions that must normally be met in a project (objective, cost, deadline and risk): the quality standard must take this into account. Although the best possible control over the process is always desirable – generally determined by the professional experience of the scientists themselves – there are no "infallible" management techniques in this respect.

The guide to conducting research projects associated with the CEA/DSM standard, presented in detail [7], proposes a series of provisions designed to ensure the quality of the management of a research project during its three key phases:

1. The initial objective must be validated. The corresponding evaluation, which in fundamental research must rely to a large extent on independent appraisal by peers, is based on a "project document" describing in particular the objective aimed for and its relevance in the research field, the associated resources (human, technical and financial), the envisaged path of the project and the results expected.
2. The research process must be controlled and, in particular, should be sufficiently traceable using adaptable indicators. Scientists should keep the initiative in this field, as the best quality assurance in research is the rigorous application of the "scientific method" itself. However, these demands must be satisfied in an adequate manner.
3. The results must be exploited in the appropriate manner. Given the diversity of the actors involved in society, that research must now be able to convince of the interest of its work, the results of a research project must be distributed widely, not forgetting transmission to non-specialist audiences using all suitable means. The publication of the results in the best international journals remains, however, the principal requirement of the standard. Patents should be applied for where appropriate.

In a general sense, the research project team must be capable of supplying proof of its "public" pronouncements, whether these are contained in publications, statements, conferences, or even internal memos when these make commitments. It is not the purpose of the standard to set rigid rules with regard to a question which is not only a matter of the professional abilities of scientists and engineers, but perhaps essentially a matter of ethics. The responsible behaviour of scientists, in a society which expects a great deal of scientific research, is essential when the latter express themselves in a professional context, for when scientists make commitments they do so not only on a personal level, but also as representatives of their employers.

To help scientists implement their quality approach, the guide to conducting research projects proposes a list of common quality criteria which is, however, neither obligatory nor exhaustive. Once more, the CEA/DSM standard stresses the fact that it is those involved in research who must themselves define the criteria to be taken into account, in line with best practices in every discipline as accepted by the international scientific community. This community must, in the last analysis, be able to recognize the value of these criteria as a guarantee of the reliability and credibility of the results produced.

The quality structure of the project may be organized in the following manner in the initial project document:

– *Quality management system*

For each of the three key phases of the project, the project leader and his team define the quality criteria most relevant to their action, through discussion with all those involved in the project. The choice of these criteria should be governed by the principle of universality as befits the very notion of scientific community, and by a spirit of openness so that they can be accepted or shared by possible partners. The quality standard does not require that the research process be described in detail.

– *Quality assurance system*

The project leader and his team then make appropriate provisions to best comply with the quality criteria chosen in the quality management system and implement corresponding solutions. The weight of these provisions and solutions should be determined by the importance of the criterion, what is at stake in the research, and the type and scale of this research. The identification and control of critical points in the research, when possible, is a useful step.

– *Quality control system*

The standard therefore systematically recommends quality control procedures carried out by peers (i.e. people who are competent on the scientific and technical level). Two quality control systems are already in place, namely the publication of research works in journals with a board of referees and evaluation by scientific advisory committees. Other systems may be implemented within this framework at the initiative of scientists or the hierarchy. For example, an audit relating to a major research investment, after a sufficient time of operation (generally 3 or 5 years maximum) has elapsed, carried out by a recognized expert or group of experts independent from the team that led the project.

An example, based on a common quality criterion, can serve to illustrate this process: "to be capable of proving". This criterion is particularly relevant to research in the event of controversy (anteriority of a discovery, contesting an article on scientific grounds, responsibility with regard to regulatory or legislative

Table 1 Example of implementation of quality criterion

Quality criterion	Example of quality assurance provisions	Examples of quality solutions proposed
"Supply proof"	Traceability	• Laboratory notebooks • Reference dossier for each publication

provisions, etc.). The instrument generally proposed, not to supply proof in the strict sense of the word but to track the history of the elements making up the proof, is a traceability system. A common way in which this traceability is ensured in the research field is the use of laboratory "notebooks". To keep to a minimum any non-productive formality, the standard leaves to the appreciation of the scientists the level of traceability necessary as well as the tools to be used (paper, photographs, etc.). The corresponding quality control could be provided by peer audits (Table 1).

In a general manner, the project leader will attach importance to the following points which are important for quality and ought to be present in the initial project document:

– Regular ("progress") meetings for the discussion and internal evaluation of progress on the project, in which all those involved take part. In research, these meetings do not necessarily have to be programmed in a rigid manner, but should take place at appropriate times over the course of the project (key phases of the research) to ensure that information circulates well, to enable consensus to be reached or, on the contrary, to make constructive use of possible differences of opinion. In all cases, these meetings give participants a sense of responsibility for what has been achieved and present the possible future course of the research project.
– The organization of feedback, as a project is also a collective learning exercise. This notion of learning is both fundamental in research and one of the key ideas of this quality standard. Learning is specific to each situation and the standard cannot define in the place of those involved either what it consists of, or the nature of the indicators appropriate for measuring it qualitatively or quantitatively. For example, measuring the impact of publications connected with the project and their position in the literature as a whole (research fronts, networks, etc.) using suitable scientometric indicators may be highly useful, on condition that the results are interpreted carefully and discerningly.

This "philosophy" has been developed in the pilot guide for quality in research by a working group of 42 representatives of public research organizations and private firms under the aegis of the French ministry in charge of research. It is coherent with the approach adopted in the EURACHEM/CITAC Guide 2 on "Quality Assurance in Research and Development for Non-routine Analysis" (see http://www.vtt.fi/ket/citac/rdguide.htm).

Realization projects

Realization projects involve the design and/or construction of a "technical object" – of greater or lesser sophistication – meeting a requirement expressed for the conduction of a scientific programme. In this category of project, the principal obligation of those involved is that of a "firm commitment" undertaking. The engineers' mastery of the often very complex technical aspects of the project is essential in order to be able to comply with the specifications drawn up at the outset (this corresponds to the traditional notion of "product guarantee"). In this case, the usual conditions of a project (objective, deadline, cost and risk) are met in theory, even if they have a degree of modularity.

The guide to conducting realization projects associated with the CEA/DSM standard, which is presented in a detailed fashion elsewhere [9], proposes a series of provisions designed to ensure the quality of the management of a realization project over its different phases:

1. The phase of proposition or emergence, through a "maturing" process that may be long and complex, serves to identify the central requirement of a programme or research project. At CEA/DSM, this proposal is made by the scientists. It generally involves overcoming a technological block so that research can continue with the benefit of adequate resources. It is necessary to set up a realization project when these resources (various technical devices, instrumentation, etc.) are not available on the market on account of their novelty or the need for exceptional performance levels. This phase implies close collaboration between scientists and engineers, the latter being in most cases responsible for the continuation of the realization project. In fundamental research, this phase includes the evaluation of "opportuneness", i.e. validation of the need, which may imply selecting the projects to be realized if there are a number of proposals. This enables the transition from the initial idea of scientists and engineers, or the request of the project commissioner, to the effective realization of the project. It is the responsibility of the hierarchy in particular to analyse the demand and to identify the opportunities and risks that realization of the project may generate. One of the models applied is that the proposal is examined and evaluated by the Scientific and Technical Committee of the Service (STCS) concerned, which then decides on the response to the proposal.
2. The preparation phase (which may have one of various names) initializes the process through the precise definition of the objectives, constraints, risks and resources allocated to the project (expression of the technical response to the need). The person responsible for this phase, designated by an official assignment letter, may naturally be the same person as the future "head of the realization project" (see point 3); however, in certain cases it can be worthwhile separating the two roles. The preparation phase, which is concluded by a "project document" (known as the "white book" in some units) includes a phase of technico-economic feasibility and a phase of working out and negotiating the offer of a solution presented to the requestor. This last phase includes in particular the drawing up of detailed specifications. In some units, this preparation phase is divided up explicitly into a pre-project (or feasibility) phase and a specification phase.
3. The realization phase, which begins with the nomination of the "head of the realization project", constitutes the actual implementation of the technical response to the need expressed and validated in the previous phases. It contains two phases, consisting first of updating the project document resulting from the previous phase, putting in place the planned organization (operating rules, procedures, etc.) and initializing the action. The realization phase, in the strict sense of the word, begins at this point enabling the development of the system that is the objective of the project. Its progress is controlled by the hierarchy by means of project reviews.
4. The operation and maintenance phase most commonly involves the implementation of technical devices (instrumentation, specific experiment, etc.) with a view to conducting a research project or a thematic action. The CEA/DSM scientists, engineers and technicians themselves operate and

maintain these devices, with the occasional help of external competencies. The devices produced are not generally intended to be distributed on the market – a particular characteristic of fundamental research.

5. The decommissioning phase is often mandatory, in particular for technical devices installed at major national or international facilities when the experiment requiring the installation has been completed or terminated. This phase does not however exist for all CEA/DSM realization projects. The operation and maintenance (see point 4) of certain devices may in fact continue over very long periods, significantly exceeding the duration of the project itself.
6. The purpose of the conclusions phase is to analyse the project that has taken place and facilitate the capitalization of feedback for the benefit of future projects.

Reviews are necessary during the course of the project and map out the changes of phase. They are moments at which project participants and the hierarchy sit down together. The autonomy accorded to the project for the purposes of efficiency should not be taken for independence with regard to the research unit authorities. Moreover, regulatory and legislative guidelines (and standards in general) must naturally be adhered to over the length of the project, in particular as far as safety is concerned.

Thematic action

The CEA/DSM standard defines a thematic action as a research activity that is neither a realization project nor a research project in the senses indicated above. Depending on the unit, thematic actions may be relatively rare or, on the contrary, may correspond to the largest part of research underway. In "light" or theoretical physics, for example, most of the laboratories' usual research activities are thematic actions. In these cases, the criteria generally used to define projects (objectives, deadlines, costs and risks) are not necessarily defined in terms of management and budget control tools belonging to a formalized approach. The characteristic of this type of action is rather the continuous renegotiation of these criteria by the scientists themselves. There is therefore nothing to be gained by requiring formalization that would be both ineffective and costly in terms of time (and for these reasons rejected by those involved in research).

Moreover, thematic research actions often concern the medium and long term and are as little formalized as possible. This does not mean that the researchers involved do not strive for the excellence, which is the common aim of all CEA/DSM research activities (as it is for fundamental research in general) and, at the same time, demonstrate the same mastery of the "scientific method", according to the criteria applied in the scientific community concerned, which serves as a guarantee of the quality of the research carried out. Finally, the purpose of research in this case is primarily to produce excellence on a given, validated theme and not to achieve a pre-defined objective, although it is always essential to define the objective in order to maintain the dynamic of the action. The standard also recognizes that the results achieved in the context of a thematic action may be infinitely more interesting and important, from the point of view of society, than objectives that might have been given at the outset: this is indeed the characteristic of any innovation (or "discovery") of particular importance. The question of achieving the aim of a thematic action is therefore different from that of a research project. The best source of validation is essentially that provided by peers working in the same discipline. It is therefore the research process that must be subject to regular critical appraisal, principally by means of publications and other communications validated by peers, so that it is accepted and recognized as being of quality.

The guide to conducting thematic actions associated with the CEA/DSM standard, details of which are presented elsewhere [7], proposes a series of concrete provisions capable of ensuring the quality of the management of this type of action. This quality may be built around certain simple requirements or principles that would be found on any list of good practices in the world of research:

1. Identify the person responsible (for the theme) and the purpose of the thematic action, as well as the complete group of people involved, obtaining assurance of their competence with regard to the action to be carried out; identify the principal resources associated when necessary at the outset.
2. Ensure that the resources employed (instrumentation, software, etc.) are mastered according to best practices recognized by the scientific community. This requirement, which is normally a matter of the professionalism of those involved in the research, is intended in particular to enable "public" pronouncements (publications, conferences, internal memos making commitments, etc.) to be backed up with the appropriate evidence.
3. Use appropriate means to exploit the work performed, with a view to gaining the recognition of peers, as well as potential partners, for the excellence of the research. The publication of results in the best international journals naturally remains the principal requirement of the standard, although broader exposure is strongly encouraged, particularly with regard to the general public. Patents should be applied for where appropriate.

These requirements presuppose that those involved in research themselves design and put in place adequate procedures for managing quality, quality assurance and quality control (see the Section "Research projects"). The form this takes is left to their discretion but must be validated or capable of validation by their peers (and naturally by the hierarchy).

In a general manner, in the same way as for research projects, the person responsible for the thematic action must organize regular meetings (without the need for fixed times, but at opportune moments during the research) to promote the circulation of information within the team as well as discussion and internal evaluation, and to encourage the responsibility of all persons concerned. The organization of feedback, making it possible to capitalize on collective learning, is also one of his major missions. The person responsible for the theme must set up appropriate indicators for the qualitative and/or quantitative measurement of what the team has learned.

Logistical support for research

Logistical support for research includes all functions that allow projects and thematic actions to proceed properly, whether these be administrative and management functions (secretariats, budget, personnel, etc.) or technical support functions (mechanics, glazing, electronics workshops, maintenance of apparatus and heavy equipment, various user services, etc.). These types of activity are in theory governed by a more traditional quality approach, but their interaction with research as such means that quality needs to be introduced carefully, even in this field. It should be remembered that the main justification for these support activities is to help research (in certain cases they also monitor and control it, for example on the budget level); they should not therefore limit or constrain its progress. Each department should appreciate the value of putting in place a general set of standard procedures (e.g. of the ISO 9002 type) for these activities (and these activities alone).

Whatever the particular decisions taken, this guide (still under elaboration) will use as a minimum the following criteria for the quality of logistical support for research:

1. Identify the person responsible for each dossier examined or action undertaken, whatever its nature (administrative, management, technical).
2. Assure control of the dossier examination process and of actions undertaken according to best existing practices (including other sectors of activity or professional environments when such practices are compatible) for each type of activity. This should in particular take the form of suitable traceability. The person responsible should be able to report to the hierarchy on the manner in which the objectives of improving the quality of support services are attained by identifying, along with all those concerned, suitable evaluation criteria.
3. Improve the efficiency of the service rendered (in particular, its rapidity) by encouraging respect of the terms of reference (latest processing date, etc.), which may, where necessary, be clarified at the appropriate level (Service or Department).
4. Improve the simplicity of procedures, within the general framework of the provisions in place at the CEA. In particular, any new procedure must as a priority address the objective of simplification in order to stem any tendency towards generating "mountains" of paperwork.
5. Promote the spirit of a client/supplier relationship between the support teams and those actually involved in research, the former being at the service of the latter. There must be a constant desire to provide the best service possible and this should be the basis on which staffs are evaluated, respecting the general management rules set out by the CEA.

Associated quality documents

The circulation of information within most research entities, and to their usual partners (financing bodies, journal editors, etc.) takes place by means of various documents, certain of which may clearly be considered "quality" documents (in the sense that they implicitly fulfil a quality function) without initially having been designed to be tools in an explicit quality approach. These documents have been developed in response to the requirements of scientific rigour and/or administrative demands, taking account of the general operating procedures of the body on which they depend. Consequently, by identifying these documents and associating them with common quality terminology, it can easily be shown that fundamental research is already endowed with an "invisible" quality system, even if it is not as complete as would be desirable. It is therefore this fund of procedures and documentation that should be exploited and enriched in the quality standard put in place. By way of illustration, and despite some particularities linked to the way the CEA functions, we have set out below the existing documentation system and that to be developed (Table 2).

Most quality documents demanded by the standard actually exist already, even if when necessary and where possible their presentation should be improved. The standard was designed precisely to fit in as much as possible with the daily life of the teams, avoiding the tendency to generate mountains of paperwork. There are deliberately few new documents.

The new documents required by the standard are as follows:

1. Thematic action documents, which sometimes already exist under other names (their content is, however, very varied and their presentation takes various forms), that appear useful to respond to a need.
2. Quality assurance plans that specify the quality criteria used and the measures taken to satisfy them. These plans may serve as a basis for carrying out quality audits adapted to fundamental research.
3. The quality audit reports (other than the report of the scientific advisory committee, unless the mission of the latter changes to occupy this function more explicitly) that appear useful to respond to a need. The duality between quality specific to research in the strict sense of the word and quality adapted to logistical support services for research can only be managed by the hierarchy at a suitable level. In particular, the audit system, which is a corollary of the quality approach, must provide for two markedly different types of evaluation:

– Audits specific to research, the purpose of which is to examine practices that are best adapted to meet the real needs of the unit, with the aim of working constructively with research partners. In no event should this take the form of an inspection or control of "proper conduct". This type of audit, for which the work of scientific advisory committees acts as a preliminary, must be performed by competent peers who are made aware of the quality approach. This point is essential as it is not always possible (nor desirable) in fundamental research to distinguish between form (procedures, working methods,

Table 2 Existing documentation system and new elements from the quality standard

Nature of the research action	Existing "quality" documents	New quality documents	Nature of the quality assured
Programme (Segment)	Programme contract		Quality management
Thematic action	Objective contract Research proposal Minutes of meeting Publications Report by the scientific advisory committee	"Thematic action" document Audit report	Quality management Quality assurance Quality control
Research or realization projects	Objective contract "Project" document Thesis dossier Minutes of meetings Publications Report by the scientific advisory committee	Audit report Quality assurance plans	Quality management Quality assurance Quality control
Logistical support	Various notes on organization and procedures	Quality procedures	Quality management Quality assurance Quality control

etc.) and content (new knowledge produced). The most important innovations on the scientific level commonly lead, although this is not always the case, to a modification or even transgression of procedures and other types of formalized processes, at the same time as new knowledge is being produced. (This essential point is not an isolated opinion, but the well-known result of the history and sociology of science [10], which the quality approach cannot fail to recognize). The CEA/DSM could in particular rely on voluntary research directors and senior experts (after suitable quality training) to carry out useful quality audits, as well as external experts that have the necessary scientific competencies and who could be chosen from a list of names put forward by the units themselves.
– Audits of logistical supports that could in theory be conducted by conventional quality auditors with an awareness of research activities, without it being necessary for these auditors to have in-depth scientific training. These audits are in particular based on quality assurance plans and/or quality procedure sheets specific to these activities, insofar as they appear useful to respond to a need.

The quality standard insists on the essential role of the hierarchy in the setting up, development and, finally, the success of a quality approach. The strong and consistent involvement of the hierarchy, based on the organization put in place by the CEA/DSM (Quality Club, quality correspondents in the units, etc.) and described in the Quality Manual, is in fact essential.

Conclusion

This standard is different from usual standards on account of the large degree of freedom and initiative left to those taking part in research. The standard grants them, in particular, a large margin of appreciation of what is important for the quality and/or excellence of research, and what is not. It is specifically adapted to the requirements of fundamental research. It is an internal standard proposed by and for those involved in research (scientists, engineers, technical staff and administrative personnel). The coherent framework thus put in place enables the progressive, systematic classification of actions undertaken to respond to "needs" of the research process and of its logistical support structures. Everyone taking part in new research actions can therefore immediately find out on what level of the coherent framework the action is situated and consequently, what requirement(s) may legitimately be imposed with regard to the quality of the results.

The goal of the CEA/DSM standard is therefore to offer research staff (i.e. all those taking part, including the hierarchy) a standard to which each can comply, all the more easily in that it respects the specific requirements of fundamental research and will prove useful in the day-to-day business of the teams. The aim of the standard is to take its place in the procedures that currently exist, in conformity with the general organizational principles of the CEA, without creating a needless revolution, or an excessive degree of disturbance, but by keeping to the legitimate objective of a gradual improvement approach. The standard must also take into account the aspirations of scientists (and of all research staff) who, more perhaps than in other organizations, know what they want, say what they want, and expect the structure, at least to some extent, to adapt to their demands. This is a requirement of team motivation and efficiency. Any arbitrarily standardizing system would obviously be counterproductive.

Although specific to CEA/DSM and its particular activities, this standard is compatible with the general principles of international standards of the ISO type (and notably with the evolution it is felt these will undergo by the year 2000), so as to enable its value to be recognized easily by the competent quality authorities (with a view to later certification and/or accreditation). It is also sufficiently broad in scope and flexible to be extended, as necessary, to other research entities.

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