Chapter 2
Expert Technologies and Principles

This chapter pretends to be a navigator over *expert technologies*. It describes the basic stages and methods of expertise, methods of expert grouping, typical errors, as well as the general technology of expertise organization and its principles. Finally, we discuss some prediction problems. The exposition *par excellence* proceeds from generalization of well-known classical statements (see *the theory of expert appraisals*) with emphasizing the specifics of e-expertise.

2.1 Stages and Methods of Expertise

Expertise [52] comprises the following *stages*:

(1) Deciding on the necessity of expertise and defining its goals by a Principal;
(2) Selecting and appointing the staff of a working group (WG) by the Principal. Generally, a WG consists of a scientific supervisor and a secretary; in the case of e-expertise, it also includes a subject supervisor, moderators (facilitators) and specialists in expert technologies);
(3) Elaborating requirements specification for expertise and approving this document by the Principal;
(4) Working out a detailed scenario (i.e., a procedure) of acquiring and analyzing expert opinions (comments, assessments), possibly, with modeling;
(5) Selecting experts;
(6) Forming of an expert commission (group);
(7) Acquiring expert information;
(8) Performing computer analysis of expert information (in several rounds according to an expert procedure scenario—repeating this stage and the previous stage);
(9) Performing final analysis of expert opinions, with interpretation of the results obtained and preparation of an expert report for the Principal;
(10) Official closure of the WG including expert report approval by the Principal.

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The specifics of e-expertise must be accounted at Stages 4–7. Common problems of expert finding and grouping are explored in Chap. 4. Next, the peculiarities of networked acquisition of expert information are considered in Chap. 1. For the rest stages (1–3 and 8–10), one may and should adapt well-known results from the theory of expert appraisals.

We also suggest the following typical scheme of expertise, see Fig. 2.1. Within the framework of this approach, the specifics of e-expertise must be considered at Stages 1, 4, 5, 6, 7 and 8.

As a rule, e-expertise represents collective expertise. Researchers separate out the following *features of collective expertise*:

- guaranteeing the maximum possible apprehension of a situation;
- revealing sure uncompetitive decisions;
- revealing true "theoretical" judgments and hypotheses;
- obtaining objectified assessments with weighty evidence;
- obtaining experts appraisals of higher reliability.

When collective expertise has electronic (networked) implementation, the listed features are supplemented by methodological and technological tricks described in Chaps. 1 and 3 of the book.

One can propose the following *quality assurance conditions for expert information*:

(1) the presence of subject supervisors enjoying the trust and understanding of their Principals;
(2) the presence of methodologists mastering the theory and practice of decision-making support in uncertain conditions;
(3) the presence of an expert commission (group) with professional knowledge of the subject (topic) of expertise and extensive practice of expert work;
(4) the presence of an analytical group with high-level skills of expertise organization and conduct, cognitive modeling and quality management methods, acquisition and processing methods for expert information;
(5) reliable expert information extraction;
(6) correct treatment and analysis of expert information using conceptual computer simulation.

Perhaps, we should append an important condition (*the principle of integrity*):

(7) complete and holistic coverage for the properties of the topic of expertise (assessed object) by professional competencies of experts (with feasibility of involving experts from allied fields) [90].

Consider e-expertise performed by a fixed collective of professional experts (we refer to the classification of e-expertise procedures in Sect. 1.2). A distinguishing characteristic of such expertise (against "conventional" expertise) lies in wide usage of information and communication technologies for expertise. Imagine that an expert audience is not a priori fixed. In this case, ensuring the desired professional level of experts, reliability of expert information and complete coverage

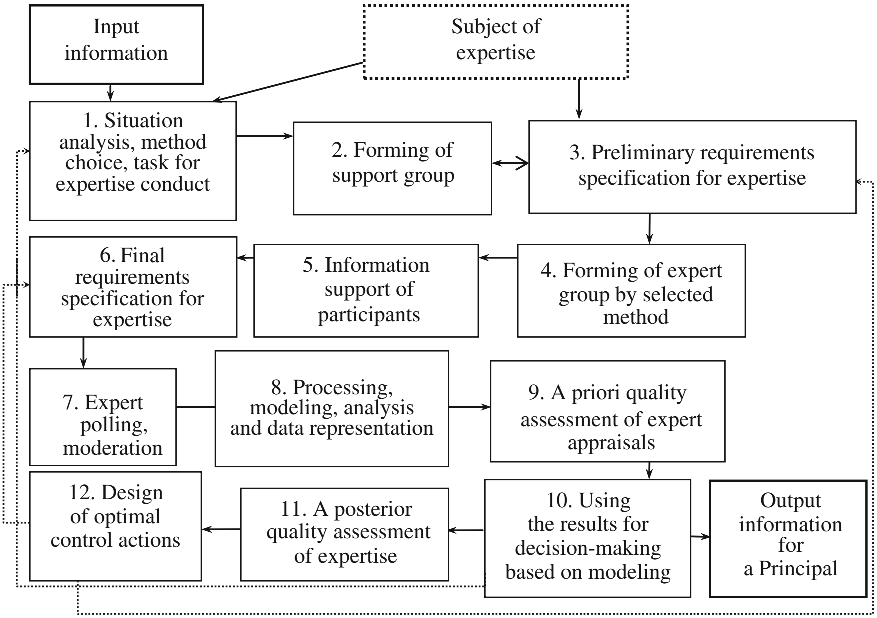

Fig. 2.1 A typical scheme of expertise

of the topic of expertise require additional analysis and efforts from coordinators of e-expertise.

Organizational *methods of expert selection and forming of expert groups*, namely,

- assignment methods;
- mutual recommendation methods (“snowball” methods);
- sequential recommendation methods;
- nomination methods for professional units and organizations by collectives;
- documentation methods;
- testing methods, etc.

have been intensively studied in scientific literature. E-expertise can employ traditional methods or other methods dictated by its specifics. For instance, we mention the “*self-nomination*” *method* when expertise engages volunteers or all persons concerned (particularly, in public expertise). Another example is the “imperative assignment” method, i.e., inviting experts from allied fields with high incentives and motivation.

Certain methods of expert selection get predetermined by the goals of expertise and its subject with proper consideration of intended methods of expert information processing, and so on. Furthermore, one should not ignore the established structure of professional communications among experts (trust networks and competence networks, see Chap. 4).

Conventional expertise possesses a wide range of approved *methods of expertise organization and conduct*. Here we note the Delphi method (and its modifications), brainstorming, scenario technologies, situational analysis methods, trees of goals and criteria, decision-making matrices, and prediction graphs. Many of them can be adapted to e-expertise taking into account the capabilities and constraints imposed by information and communication technologies. Some methods become difficult to use for a large number of participants of networked expertise [58]. For others, electronic support facilitates appreciably.

Select traditional *methods of expertise* such as polling, interviewing, panel discussion or mixed questioning. Following the advances in information technology, they are subjected to computerization and, in addition, are supplemented by Internet polls, content analysis and data mining, analysis of electronic media and social networks, teleconferencing, etc.

Acquisition and processing methods for expert information include expert rankings, classifications, paired and multiple comparison, the Terstone method, the Churchman–Ackoff technique, and preference vectors. Methods of expertise result definition (embrace averaging, row-wise summation, Kemeny's medians, to name a few) are discussed in detail in many publications, both in theoretical and practical aspects. Of course, their choice is restricted by specific methods of expert information acquisition and processing. All common methods can serve for processing of e-expertise results (depending on its form). A quite another pair of shoes is that e-expertise may yield results in an arbitrary form (e.g., texts, see Sect. 1.3). Extraction of well-structured "quantitative" information requires analytical work with certain methods of intelligent data analysis [39, 40], semantic analysis of knowledge mining from natural language texts.

There exist four basic types of *procedures intended for expert information acquisition*:

(1) one-shot procedures with direct getting of experts' comments and appraisals;
(2) repeated procedures without direct interaction among experts (e.g., repeated acquisition of comments and assessments from experts, mass polling of experts, current expert monitoring);
(3) iterative procedures with direct interaction of experts (e.g., strategic expert conversations [88] or panel discussions in conventional expertise, electronic brainstorming [58], discussion forums or blog posts in the case of e-expertise);
(4) iterative procedures without direct interaction among experts (Delphi procedures).

Application of such procedures in e-expertise proceeds from modern information and communication technologies, as well as information analysis and collective intelligence technologies, see Chap. 3.

The existing theory of expert appraisals provides fruitful results in many fields, namely,

- analysis of expertise results including consentience study of expert appraisals or estimation of the consistency index of experts;
- assessment methods for experts (rating systems, a priori and a posteriori assessment);
- solution of different problems such as inaccuracy and inconsistency, reliability and fuzziness of expert appraisals, missed consentience of expert appraisals during collective expertise.

All of them can be applied in e-expertise.

Expert activity is accompanied by the following typical *errors*:

- incorrect choice of a method for conducting expertise and further processing of expertise results in a specific situation;
- depreciated role of the normative, moderative and motivational provision of expertise;
- overstated capabilities of expert methods including the potential of network technologies;
- superfluous attention on "common sense" (far from always, such approach generates sensible ideas);
- usage of incompetent experts or incorrectly selected experts;
- ambiguous statement of the problem for experts;
- rejection of multi-alternative expertise, closeness of expertise;
- superfluous attention on quantitative estimates and formal models, to the prejudice of qualitative estimates and conceptual models;
- violated principles of measurement theory (incorrect operations with expert appraisals), incorrect analytic treatment of expertise results;
- insufficient or superfluous informational interaction of experts, deficient usage of methods and tools of virtual collaboration [115];
- disregarded strategic behavior of experts (including conformism—see Chap. 5 of the book);
- incorrect interpretation of expertise results (sometimes, with substitution of expertise for decision-making process, etc.).

2.2 General Technology

Clearly, the system character of expertise is realized via complex choice of different elements in the technology, motivation and moderation of expert opinions with proper consideration of a specific problem situation. In what follows, we describe nine sets of elements; expertise organization requires selecting certain elements from these sets, which possess required properties [101].

1. Formation methods of expert groups. There exist numerous techniques to compose expert groups including assignment, mutual recommendations or the so-called snowball. At the same time, e-expertise calls for tighter regulations and a wider range of expert finding methods (for a detailed discussion, we refer to Chaps. 3 and 4).
2. Candidates' selection criteria for expert groups. It is possible to use various criteria such as creativeness and activity of an expert, the number of publications, the h-index, the number of approved expert forecasts, the level of competence in a corresponding field, practical experience, ability to perform decomposition and synthesis, stability of opinions. The specifics of e-expertise are reflected in Chap. 4.
3. Means and methods of expertise (e.g., commenting, strategic conversation, divergent brainstorming, polling with linguistic scales, interviewing, depth interview, and so on).
4. Elementary types of expert appraisals including verbal judgments, numerical score, interval score, (single or multiple) point estimates, grouping, paired comparison, multiple comparison, ranking, preference vectors, functional estimates, etc.
5. The basic principles of expertise conduct. In the first place, expertise publicity or the independence of experts from other subjects during their expert activity, multiple-alternative expertise (see Sect. 2.3).
6. Algorithmic operations and procedures for indirect generation of a selected type of expert appraisals. For instance, the procedure of paired comparison and hierarchy analysis [99], cognitive models and SWOT-analysis, matrix comparison, the Churchman–Ackoff technique, the von Neumann–Morgenstern method, classification and multiple comparison, and others.
7. Elementary organizational procedures and methods for the activity of expert groups to accumulate new knowledge from experts (e.g., brainstorming, focus-group, problem-related group, the Delphi method).
8. Choice and analysis methods for error indices to perform a posterior quality assessment of an expert report.

While choosing certain elements of the general technology of expertise in a specific case, one should have in mind the following:

(1) the specifics of an object, event, a material or process under consideration;
(2) the level of problem comprehension by an ultimate user (a subject supervisor, an analyst and/or a Principal) and an expert;
(3) the goals and tasks of expert activity participants, as well as a series of constraints:

    (3.1) financial constraints (payment for all expertise work, individual honoraria of independent experts);
    (3.2) temporal constraints (forecast period, elaboration period of an expert report);

(3.3) personnel-related constraints (the capabilities of expert selection and expertise coordinator finding);
(3.4) normative and legal constraints (the status of an expert report: mandatory or recommendatory);
(3.5) motivational constraints (first of all, nonfinancial incentives).

9. Methods of accelerated reaching a consensus among the participants of an expert procedure regarding their goals and ways of actions, forecasts, opinions, conclusions, as well as most efficient managerial decisions. Different structuring techniques of expert information, which base on some methods of thermodynamics, solution procedures for inverse problems on nonmetric spaces or even methods of quantum mechanics [62, 88, 90], may provide appreciable assistance here.

2.3 Principles of Expertise

Following [67, 81, 101], consider fundamental principles for any modern type of expertise including e-expertise (specific difficulties of e-expertise arise immediately as one endeavors to meet the requirements below).

1. **Requisite variety**. All subjects participating in elaboration of an expert report must have the opportunity of choosing any elements of expertise technology (including selection of expertise methods, types of expert appraisals, ways of expert finding and polling, as well as accuracy indices). Furthermore, this principle guarantees the freedom of actions for all participants of expert activity based on an appropriate legal base). On the other hand, for the sake of expert procedure convergence and accelerated reaching a consensus, all experts must follow a uniform methodology or a system of interconnected methodologies of multistage expert processes and recommendations of moderators.
2. **Publicity of expertise** (the stages of elaborating requirements specification for expertise, discussion of final results and decision-making) implies publishing of different materials (except confidential or overhead information stipulated by legislation and normative acts). They include

   - the register of experts, members of expert commissions and local or federal authorities;
   - documents regulating organization and operation of basic participants of expert activity;
   - the conditions of tournaments and auctions, as well as the rules of query submission;
   - the list of conducted expertise procedures;
   - the results and materials of expertise (in the case of socially-oriented expertise).

3. **The system character of expertise and its technology** lies in that, as a type of activity, expertise represents an element of general decision-making. This principle manifests itself in definition of boundaries for the subject (topic) of expertise, in precise substantiation of the tasks and goals of expertise, as well as in specification and consideration of external links in an assessed object. It is necessary to balance the order and chaos in informational processes accompanying decision-making [112].
4. **Quality control for expert appraisals** (the need for feedback in expertise). The coordinators of any expertise must contrast the appraisals of different experts with each other and with the reality. Quality control plays a crucial role in experts' rating and their selection for further expertise procedures.
5. **The system character and continuity in expertise conduct**:
   - the systematic consideration of expert messages and selection of experts from potential candidates for expertise conduct based on the principle of quality control (feedback in expertise);
   - continuous improvement of the methodological, informational and organizational support of expertise (update and perfection of databases, background and normative materialsù as well as information on the staff and qualification levels of expert communities);
   - acquisition and analysis of information on the consequences of decisions made on the basis of conducted expertise;
   - spot checks of expertise quality, implementability assessment for previous forecasts of experts.
6. **Independence of experts from other participants of expert activity** is achieved via
   - appropriate normative and legal provision (adoption of rights, duties and responsibilities for participants of an expert activity);
   - professionalism and high mental and ethical qualities of experts;
   - involvement of experts without individual interests in certain results of expertise;
   - formulation of definite rules of expert selection and exclusion from expert commissions;
   - formation of certain mechanisms neutralizing and/or compensating external factors with one-way effect on experts' opinions;
   - strategy-proofness of expert procedures (see Chap. 5 of the book).

The independence within established authorities must be maintained by current civil legislation and other normative acts which provide for punishment for any pressure on an expert or interference in the activity of an expert or expert commissions.

7. **Legal balance** concerns the parity of rights, duties and responsibilities of each expert activity participant within legal boundaries.

8. **Objectivity or eliminating "the conflict of interests"** among participants of expert activity. The following rules fix contraindications to involvement of specific subjects in independent expertise:

   - experts do not assess objects whose representatives have well-established relations with them treated as community/conflict of interests;
   - representatives of an assessed object do not participate in its expertise as experts or coordinators;
   - representatives of expertise customer do not participate in settlement of issues, where they have individual interests;
   - the number of staffers in an expert commission (here a staffer means a representative of an organization maintaining operation of such expert commission or a representative of a subordinate organization) does not predetermine decisions for the benefit of this organization.

9. **Personification of experts**. During expertise, the status of an expert as a high-level specialist in an appropriate field comes before his belonging to a certain organization or subordination to a Principal. In the case of e-expertise, this principle often holds true.
10. **Single-shot expertise**. Actually, repeated expertise of a same object is allowed in the following situations:

    - by a decision of superior authorities (for expertise customer);
    - by a legal decision;
    - if decision-making is impossible due to uncertain results of previous expertise.

    There must be a clear provision for other cases of repeated expertise in the normative document of expertise. Moreover, repeated expertise is allowed only with another group of experts; the materials of the previous expertise are considered only at the stage of decision-making.
11. **Confidentiality of expertise**. Without permission of interested subjects,[1] the customer and coordinator of expertise must not announce (a) an expert making a certain appraisal (to representatives of the object of expertise) and (b) the authors or source organization of specific materials submitted to expertise (to experts). These representatives must have no influence on the motivation or financial stimulation of experts.
12. **Democracy of expertise**. Formation of temporal or permanent expert commissions requires

    - conducting an open tournament of candidate experts (any exceptions must be mentioned);
    - updating the staff of permanent expert commissions based on expert ratings.

[1] In the case of e-expertise, such permission can be "implemented" by default. For instance, when an expert shares his opinion during open online debates, he provides public access to such opinion.

13. **Responsibility of expert activity participants and their legal safety**. It is necessary to make a clear provision for:

    - the responsibility of an expert for his messages and usage of confidential information accessed during expertise;
    - the responsibility of customer for ignoring expertise results in decision-making (in the case of material damage, financial losses, etc.).

Such responsibility is maintained as follows. A decision of an expert or expert commission causing material or moral damage, financial losses can be the subject of a legal action and further reimbursement of damages.

Legal safety of all expert activity participants is guaranteed by legislation and corresponding realization mechanisms, i.e., local normative acts.

2.4 Expert Forecasting

At all times, people strive for reducing the impact of uncontrolled factors on the results of their activity (by acquiring additional information on the unknown or incompletely known). Perhaps, this aspect explains the popularity of various forecasts (weather forecasts, marketing forecasts, economic forecasts, scientific and technical forecast, etc.). According to Merriam Webster Dictionary, a forecast is a prophecy, estimate, or prediction of a future happening or condition.

There exist several groups of *forecasting methods* for practical application [101]. For example, these are extrapolation methods, strategic planning methods, expert appraisal methods, logical simulation methods.

Extrapolation methods concern analyzing major tendencies in certain developmental aspects of a society, science and technology, forms of labor organization, industrial engineering, etc. Various information on the history and further development of phenomena and processes is studied, compared and transformed in numerical form. Subsequently, certain regularities and laws are extended to future periods (extrapolated). The corresponding conclusions serve as the foundation of a resulting forecast (generally, the evolution of considered objects).

Strategic planning methods. A directive sets a required future state of an object. For instance, during a strategic discussion, participants are asked about the future level of a company, industry, department, etc. Using their "forecast," a strategic plan of directions and measures is compiled then.

Expert appraisal methods. Essential information for forecasting bases on the opinions of highly-skilled experts in dedicated fields. Such opinions are formulated independently and accumulated by specialists. Next stage lies in their statistical treatment and strategic analysis. As a result, one obtains a snapshot of the future state, as well as possible scenarios.

In other words, *expert forecasting* can be treated as a forecasting method and as a type of expertise. Therefore, e-expertise may serve for forecasting. Unfortunately, networked technologies are still not intensively adopted in forecasting problems, although a series of research works demonstrate the efficiency of collective intelligence, mob or group wisdom, etc.

Logical simulation methods imply designing logical models that draw analogies between heterogeneous phenomena or processes, as well as generalize data on scientific, technological, economic or social development.

Researchers distinguish between the descriptive approach and the normative approach to forecasting [77]. The *descriptive* approach defines possible future states of a forecasted object. An example is a forecast of energy development (the appearance of new energy sources, the usage of existing energy sources after several years).

A problem of *normative forecasts* consists in choosing the ways and periods of reaching desired states of an explored object in future. A normative forecast represents prophecies attracting interest and stimulating some actions. For instance, imagine that we have a normative forecast of energy development. Then it is possible to pose the forecasting problem for the energy sector of a country. Here the ultimate aim consists in guaranteeing a required level of per capita energy consumption under certain constraints on available nonrenewable resources.

There are two "extremes" in the impact of a forecast on the pace of developments. A *self-implementing forecast* is a forecast which becomes reliable only by having been made. If we predict a rise in inflation due to uncontrolled growth of money supply, this rise occurs *per se*. A self-canceling forecast is a forecast which becomes unreliable (or avoidable) only by having been made. In the middle of the 1980s, Academician N. N. Moiseev formulated the forecast of possible consequences of a nuclear conflict between the Soviet Union and the United States (the so-called "nuclear winter" model). To a large degree, this forecast facilitated *START* (Strategic Arms Reduction Treaty), a bilateral agreement between the United States and the Soviet Union on the Reduction and Limitation of Strategic Offensive Arms. The treaty was signed on July 31, 1991 and entered into force on December 5, 1994.

It is possible to differentiate between *active* and *passive forecasts*. A passive forecast is a forecast whose result does not affect (and cannot affect) a forecasted object. For instance, we mention weather forecasts. If the impact of a forecast on a forecasted object might not be neglected (an active forecast [78]), a forecast must then consider the effect of forecasting results. Hence, any normative forecast is active; similarly, descriptive forecasts used in decision-making are active.

2.5 Expertise in Quality Management

The well-known Quality Function Deployment (QFD) method bases on step-by-step multi-aspect expertise. The latter requires accurate work organization for a set of experts, i.e., e-expertise mechanisms. Construction of the customer requirements matrix, transformation of customer requirements into target values for technical descriptors of a final product may include several steps (see Fig. 2.2, where some steps are omitted).

Step 1. Making a list of Customer Requirements for a product. Primary external requirements expressing the needs of customers are specified in the form of second- and third-level requirements. Thus, they form a list of concrete requirements. Wherein not all requirements are known to a customer, expert groups must document requirements dictated by management or regulatory standards. For a market segment, such list may comprise about 50–100 requirements (e.g., maximum speed, body color, comfort level, etc.). Experts have to compile this list of requirements.

Step 2 consists in paired comparison of the importance of different customer requirements by an expert group. This stage ranks customer requirements, i.e., each requirement is assigned some customer importance rating.

Step 3 serves for selecting technical descriptors of new products by experts. Correctly defined target values of these descriptors would meet customer needs stated at Step 1. Technical descriptors are design attributes of a product or service that can be measured against the competition. Later on, technical descriptors must be deployed in specific requirements at different stages of product design, manufacturing, assembly and service in order to appear in the functional performance of new products and customer satisfaction. The list of technical descriptors can be 5 times larger than the list of customer needs (e.g., wearing capacity, robustness, rated power, melting temperature).

In the next step, expert groups have to determinate the direction of improvement for each technical descriptor (this step is omitted in Fig. 2.2).

Step 4 lies in verification of the correspondence between technical descriptors and customer requirements. Here experts analyze the existing relationships between the latter and the former. E-expertise assists in compiling the relationship matrix, where rows stand for customer requirements and columns answer for technical descriptors. This stage may consume much time and involves many expert groups. Actually, experts have to coordinate their actions and generate consentient expert appraisals.

Step 5 promotes innovations. Experts identify inconsistent requirements to new products or equipment (see Fig. 2.3). For instance, "engine power must be improved," whereas "engine weight must be decreased." Such a conflict calls for an additional research work and, accordingly, product redesign and/or production reengineering. At Step 5, it may happen that the list of technical descriptors should be modified or supplemented for adequate reflection of all customer needs.

Step 6. For a new product entering a market, it is necessary to conduct expert appraisal of market characteristics. Such appraisal implies assessing the relative importance of product requirements according to customers (Step 2) and comparing the competitive ability of existing products (customer rating of the competition). Benchmarking takes place. The relative importance ratings of product requirements allow defining the domains of most interest or maximum expectations (on the one hand) and identifying "bottlenecks" to-be-improved. Estimation of the competitive ability of products shows how ultimate users interpret the products against competitors in the sense of their needs satisfaction.

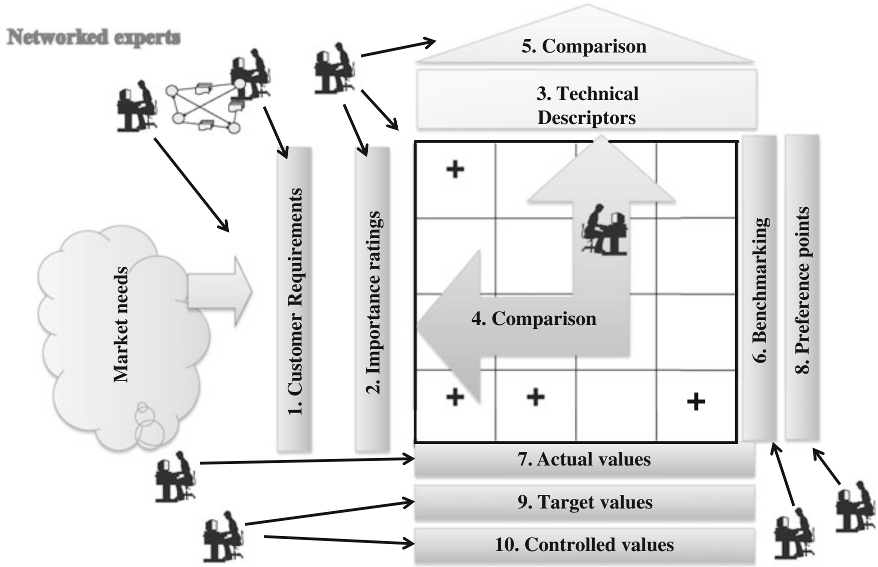

Fig. 2.2 Quality function deployment

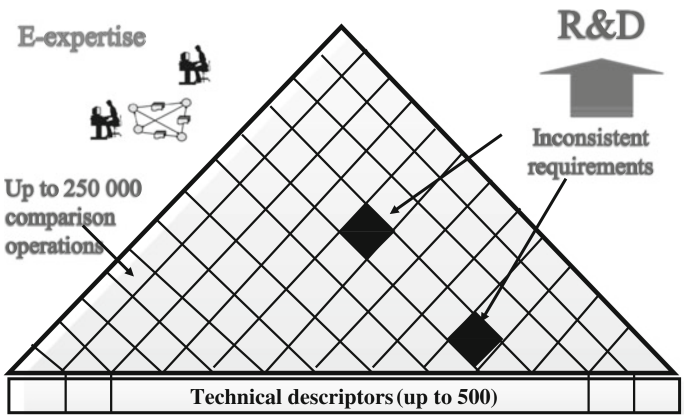

Fig. 2.3 Identification of inconsistent requirements to new products

Step 7 is connected with expert appraisal of the actual values of technical descriptors. Necessary data often follow from measurements and tests. Note that such information covers both the products of a company and its competitors. Experts also rate of the design attributes in terms of organizational difficulty.

Step 8. Using the ranking data in the right-hand columns of the comparison matrix, experts determine the "preference points" of new products. In fact, "a preference point" indicates which aspects in new products (e.g., best-in-class characteristics of speed) may attract customers. And so, such aspects should be emphasized during market entry. This information also serves for price quotation and product promotion.

Step 9. At this stage, it is necessary to establish target values for each technical descriptor of new products. This process takes into account the expert choice of "preference points," the importance ratings according to ultimate users, as well as current weak and strong properties of products. Networked expert appraisals are widely used here. The target values of technical descriptors must be measured at all steps of a project. For instance, consider electromotor design. One should assess the mechanical and functional properties of prototypes; corresponding technical descriptors must be studied during analysis of potential defects and prevention methods; these descriptors are measured on separate units manufactured on industrial equipment priori to serial production, as well as on first serially produced units.

Step 10 comprises the choice of controlled technical descriptors to-be-considered during product design, technology engineering and inspection methods. Such choice bases on the comparative assessment of the importance of product characteristics separated by customers, on "preference points" selection, on the feasibility of reaching the competitive advantage in these characteristics, as well as on the difficulties (opportunities) of target values achievement. Any technical descriptors having a strong impact on customer needs satisfaction and creating competitive disadvantages or advantages must be transformed into appropriate requirements, actions and inspection methods at all steps of a project.

Therefore, owing to e-expertise procedures, each participant of product design and technology engineering receives maximum reliable knowledge on the connection between his job and the level of ultimate user satisfaction. The result of any production process leads to quality improvement, thus enhancing the competitive ability of a business company and promoting the permanent growth of its socioeconomic efficiency.

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