

**AN ADAPTIVE PROCESS FOR SETTING  
RESEARCH PRIORITIES IN CSIRO**

CSIRO CORPORATE PLANNING OFFICE

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## ORIGINS OF THE PROCESS

Priority setting is probably the central issue in research management - working out which activities should grow and which should be wound back. It is an issue given much consideration by CSIRO in the past.

Over recent years, there has been increasing recognition that scientific excellence is a necessary but not a sufficient condition for success. CSIRO's ministerial guidelines, issued in 1988, note that:

*CSIRO's main task will be the conduct of strategic and applied research in support of national economic, social and environmental objectives.*

In October 1987, the new CSIRO Board noted the need to consider mechanisms to establish national research priorities, reflecting its concern that:

- It was poorly placed to undertake its key task of determining future strategic directions for CSIRO without a prior view of what Australia's research priorities are.
- CSIRO should take a stronger role in determining national research priorities.

In March 1988, the Board established a sub-committee on National Research Priorities to examine this question in detail. The sub-committee recognised at an early stage that the task was of a complexity that demanded a systematic framework to support robust decision-making. It devoted considerable effort to the development of a methodology to allow the systematic, qualitative evaluation of the likely economic, environmental and social benefits to Australia of research for a wide range of purposes, giving explicit consideration to all factors relevant to the actual delivery of those benefits.

The Board's interest in broad research priority determination was complemented by the Executive Committee, comprising the chief executive, the six institute directors, and the directors responsible for business development and corporate services. This corporate executive group reaffirmed at its March 1990 meeting the need to link corporate planning and the assessment of national research priorities. Following this meeting, the corporate executive group initiated a major effort towards priority evaluation at, first, the national and then the Organisational level. As a result the Board agreed in May 1990 that:

*There is a continuing need for CSIRO to have a systematic and open approach to the assessment of national research priorities. The Chief Executive's current emphasis on this task is strongly supported. To progress this matter, the Chief Executive would draw on the work of the Board's sub-committee and propose revised definitions of research purposes and assessment criteria to establish a strategic framework to enable the determination of CSIRO's research priorities within the national agenda.*

This agreement served as a blueprint for the corporate executive group.

## **Why Assess National and Set Organisational Research Priorities?**

From the outset, explicit benefits to CSIRO were envisaged by the Board and corporate executive group from the effort to assess national research priorities and thereby provide a context for the determination of CSIRO's research priorities. It was realised that doing this in a way which could be clearly understood by all staff and external stakeholders would accentuate these benefits.

In addition to guiding the determination of CSIRO priorities, the activity of assessing national research priorities, with an eye firmly on increasing the international competitiveness of Australian industry, would allow CSIRO to contribute to key national debates and inquiries with increasing authority and persuasiveness. It would also enhance the capacity of CSIRO to perform as an 'honest broker' in natural resources and environmental management debates and inquiries of national significance.

Within the CSIRO the benefits of setting its research priorities in an increasingly inclusive manner would include:

- Provision of a systematic way of comparing all the things we do with the things we might do.
- Determination of CSIRO's strategic directions to maximise the expected benefits for Australia as one of its key contributions to the nation.
- Effective communication of the outcomes to all stakeholders.
- Effective participation of the whole organisation in the process.
- Implementation of a capacity to allocate resources in a timely manner to major cross-Division programs focussed on critical national needs and to breakthroughs in scientific understanding, particularly those with significant commercialisation potential.

These then were among the critical factors for evaluating the success of establishing a process for setting CSIRO's research priorities. An evaluation of how well CSIRO has performed is provided in the last chapter.

## **First Triennial Review of Research Priorities**

The corporate executive group conducted its priority assessment work in three distinct stages:

- Development and application of a methodology for reaching group consensus on national research priorities.
- Agreement on the most appropriate CSIRO response to the conclusions on national research priorities - in effect translating national priorities into an agreement as to CSIRO's appropriate role in relation to each of the research purposes considered.
- Determination of necessary resource allocation shifts to align CSIRO's distribution of research effort with conclusions as to its appropriate response in relation to each research purpose.

The challenge was to develop a methodology for priority determination which:

- Is rigorous and transparent.
- Facilitates group participation and ownership of its outcome.

The application of the methodology using an interactive group process is considered vital to its success. The group process is the means by which the rigour and objectivity of individual views are challenged and assessed. The methodology uses scoring as a means of comparing and ranking judgements but has no illusions to being either quantitative or "objective" in the sense that the repetition of the exercise by a different group would provide the same conclusions. It is simply an effective decision-making tool which enables the group to:

- Take all factors critical to the decision into account in an explicit and logical manner.
- Identify underlying reasons for differing judgements.
- Re-examine and test against the available objective evidence their pre-conceptions.
- Assemble its collective insight and values into a comprehensive output which makes the basis for its conclusions clear.

Following three special workshops and considerable time taken in its normal monthly meetings, the corporate executive group concluded this phase of its work in October 1990. Its conclusions were endorsed by the Board in November and were given effect through the CSIRO Strategic Plan for the period 1991-96.

### **Second Triennial Review of Research Priorities**

The follow up to the first review resulted in CSIRO's institutes and nearly all of the Divisions within these Institutes conducting similar priority setting exercises. These generally involved institute and division advisory committees, comprising external advisors representing industry and other key stakeholders.

The process of reviewing research priorities in the lead up to the second triennial review was adapted to benefit from:

- The findings and assessments from a recent workshop convened by the CSIRO Board to evaluate CSIRO's performance since establishment in 1987 following the ASTEC review of CSIRO in 1985 (ASTEC 1985). This evaluation was then used by Board Members to assist in identifying and assessing global and national challenges, focussing on those most relevant to CSIRO's capacities. The workshop was facilitated by Rob McLean, Managing Partner, McKinsey & Company who also played a key role in consulting advice provided to CSIRO by McKinsey & Company soon after the Board was established.
- The assessments and findings of sector-level priority exercises conducted by Institutes provided an integrated, 'bottom up' input to supplement the 'top down' data and information, which in large part was relied upon in the first review.
- A concerted effort to improve the coverage, quality and structure of the decision-supporting 'top down' data and information. This involved selection and condensation of data and information from official statistical sources, government inquiries, industry and community investigations, and international studies.
- The experience of conducting institute and division priority setting exercises and providing support to external organisations in adapting and adopting CSIRO's process led to improved procedures.

A few months prior to the workshop which initiated the determination of research priorities for the second triennium, the chief executive convened a preparatory workshop. This involved Members of the Board and the corporate executive group in

the opening day, designed to provide the strategic context for determining CSIRO's research priorities for the next five years and beyond. Three guest speakers were invited to stimulate debate on directions for Australian industry and the environment within the context of global challenges and the opportunities and threats these posed for Australia. They also led the discussion of how this might influence CSIRO's research opportunities. The guest speakers were: Mr Ralph Evans, Managing Director, Austrade, who led the discussion of the implications for Australian business of trends in the globalisation of technology; Mr Eriks Velins, General Manager, Corporate Planning and Economics, Shell Australia, who spoke about Shell International's global view; and Dr Gus Hooke, Managing Director, Corporate Economics Australia Limited who led a discussion of the scale of global and Asian market opportunities which Australia might most appropriately capture over the next 30 years.

The CSIRO process for setting research priorities comprises three stages: the preparatory stage, the determination stage, and the implementation stage. The lead up to the corporate executive group workshop held in March 1993 to determine research priorities for the second triennium (referred to as the priorities workshop) completed the preparation stage of the process. It involved the CSIRO institutes, divisions, key external shareholders, the corporate executive group and the Board supported by the Corporate Planning Office. The priorities workshop constituted the determination stage. Gaining agreement by the Board to the draft priority decisions from the priorities workshop commences the implementation stage of the process. Based on the agreed priority decisions, the institutes and divisions then specified and selected priority research programs in consultation with the chief executive. These were subsequently approved by the Board in late 1993 and initiated the preparation of the CSIRO Strategic Plan for the period 1994-99. An outline of the steps involved in each of the three stages is provided in the concluding section of the next chapter. Details of each individual stage are provided in a chapter of the same name.

### **External Adaptation and Adoption of the CSIRO Process**

CSIRO has responded to requests from many organisations in Australia and overseas seeking advice in establishing their own processes of setting research priorities. Details are provided in the case studies chapter. Three government inquiries into different aspects of the public research system included in their recommendations a case for research organisations in Australia to establish priority setting processes similar to that introduced by CSIRO. The inquiries were:

- The Task Force on the Commercialisation of Research in its report *Bringing the Market to Bear on Research* (Commonwealth of Australia 1991).
- The Parliamentary Joint Committee of Public Accounts in its report *Public Research and Development* (Commonwealth of Australia 1992).
- The Federal Government's White Paper on Science and Technology, *Developing Australian Ideas, A Blue print for the 1990s* (Commonwealth of Australia 1992).



## OVERVIEW OF THE PROCESS

### Strategic Management in CSIRO

To achieve its goal of giving Australians a better future, CSIRO conducts active programs of strategic management which it evaluates according to six key performance areas as follows:

- Research.
- Research Transfer & Commercialisation.
- Research Funding & Financial Management Support.
- Human Resource Management.
- Communication.
- Corporate Development.

Effective strategic management provides well conceived directions for action which will shape the organisation's future, preparing it to thrive by meeting the challenges of a rapidly changing environment. In reviewing and evaluating performance, the question arises as to whether we need more structured processes for thinking strategically about the changing environment.

The primary focus of CSIRO's strategic management effort has been on the management of research. This has led to an increased effort to ensure that the strategic objectives of the *research* key performance area drive the formulation of the objectives of the key performance areas for *research transfer & commercialisation* and *research funding & financial management support*. At the same time there is a need to adapt continuously the objectives of the research support functions of *human resource management, communication, and corporate development*.

As an expression of ethos, CSIRO believes:

- Improvement in Australia's economic performance and, at the same time, its care of the environment depends on its scientific and technological capability.
- The nation should derive the greatest benefit from its research.
- Its ability to carry out its role effectively depends on the creativity of its staff and the quality of its management.
- Service to the nation through scientific excellence will underpin its achievements.

The vision statement which flows from this set of beliefs is shown in Box 1. The underlying goal is to give Australians a better future. CSIRO is committed to achieving that goal by:

- Sharpening the focus of its research effort at all levels on the Return-on-R&D to Australia by
  - improving the means of assessing both the attractiveness and scientific feasibility of research directed towards meeting national socio-economic objectives.
- Cross-fertilising corporate best practice in delivering the results of its research.
- Improving the effectiveness of interaction with users
  - particularly in maximising user benefits subject to striking a balance between public and private sector funding that is consistent with public policy directions and initiatives.

- Enhancing the attractiveness of careers in science by
  - practising performance-based advancement, fostering team commitment, and providing challenging and sustainable career opportunities.
- Empowering all staff to promote to the limit of their reach the value of CSIRO's contribution to the nation.
- Exploiting our primary competitive advantage by
  - marshalling, from the depth and diversity of resources, the essential range of skills required to contribute effectively to emerging challenges and opportunities facing Australia.

**Box 1: Vision**

An overview of specific initiatives in the six key performance areas is provided in a report prepared for the Task Force on Management Improvement of the Australian Public Service (MacRae et al 1992). This report focusses on a specific initiative within the *corporate development* key performance area.

*Corporate development* programs support the leadership of CSIRO by the chief executive and the Board, establish the broad environment in which staff work and provide support services best delivered centrally. Corporate planning is the program charged with the responsibility of supporting the establishment and adaption of the process for setting research priorities.

**Priority Setting as a Driver of Planning**

The adoption of a corporate planning system in the mid 1980's, following a review of CSIRO's strategic research planning activities (CSIRO 1984), and the introduction in 1991 of the priority setting process (CSIRO 1991a) have given impetus to a changing ethos and commitment to stakeholders which is more aligned to the changing external environment in which CSIRO operates. Important characteristics of this changing environment have been tightened budgets and increased pressures for accountability and demonstration of performance, reflected for example in the management improvement reforms introduced into the federal public sector during the 1980's by the Commonwealth Government.

If Australia is to gain the utmost benefit from CSIRO's research, CSIRO must ensure that it distributes its resources consistently with national priorities. And that calls for thorough and far-sighted planning.

CSIRO's corporate planning process, shown in Box 2, has at its core the organisation's assessment of the nation's research priorities in the areas in which CSIRO operates or might choose to operate. In this process the Board of CSIRO has responsibility for formulating the organisation's strategic plan and organisational policies as well as assessing the effectiveness of the implementation of both.

## Box 2: Corporate Planning Process

To do this it has played a role in articulating the CSIRO vision and ensuring that the organisation sets priorities which drive the formulation of the strategic plan. At this stage in the development of the corporate planning process there are three largely implicit activities which link the vision and mission of CSIRO to priority setting. These activities are shown in Box 2 as:

- Building a profile of CSIRO's stakeholders' expectations and perspectives as the basis of a situational analysis.
- Compiling the CSIRO Outlook: the global and national outlook from a CSIRO perspective, incorporating analysis of key trends and projections.
- Prospective assessments: ordering perceptions about alternative environments in which strategic decisions might be played out.

Conducted explicitly these activities would constitute a systematic approach to strategic thinking which would drive the strategic management effort of CSIRO including the activity of priority setting at all levels of the organisation.

### *Stakeholder Profiles and Situational Analyses*

In addition to its Board, all of CSIRO's six institutes and its thirty three divisions have advisory committees comprising leading representatives of industry, government bodies, the scientific community and the community in general. Advisory groups also exist for many of the organisation's 200 or so research programs, including the 32 (as of 1994) which require an integrated effort from more than one division. Similar but more formal arrangements exist for the 51 cooperative research centres established as of 1995 by the federal government in partnership with industry and the research effort of the universities and the state and territory governments. CSIRO is a core participant in 43 of these centres.

Taken together with its dynamic interaction with R&D corporations in the agriculture, natural resources and the environment, and energy fields, it is clear that CSIRO operates relative to a particularly influential network which can be brought to bear on the determination of its strategic directions.

Building cogent profiles of its stakeholders' expectations and perspectives could be a by-product of the increasing involvement of effectively utilising this network in the process of setting research priorities at all levels of CSIRO. Many assessments of the 'strengths-weaknesses-opportunities-threats' variety have been conducted jointly with stakeholder organisations. These have provided valuable inputs to the priority setting process.

### *CSIRO Outlook*

In early efforts to prepare an outlook for CSIRO attempts were made to throw light on the complex set of relationships among social, economic, political, technological,

resource and environmental factors underlying the priority setting decisions facing CSIRO. This involved, among other things, the compilation of information on long-term trends and projections in relation to these factors, at global and national scales. This has now been formalised into the preparation of the *CSIRO Research Priorities Data Compendium* which is closely aligned to the needs of the priority setting process. Details are provided in the section on inputs to priorities process in the methodology chapter.

### ***Prospective Assessment Process***

At this stage CSIRO has not developed a formal process for building prospective assessments into its process for setting research priorities. One form of prospective assessment referred to as 'scenario building' is conducted in a way which is highly compatible with the process of setting priorities in CSIRO. Like most approaches to prospective assessment it facilitates the processes of synthesis often building detailed assessments and analyses. As such scenario building can provide a means of ordering perceptions about alternative environments in which strategic decisions might be played out.

The involvement of Shell Australia in the final preparatory workshop for the second triennial review of research priorities provided the opportunity for collaboration in scenario building between Shell and CSIRO. Shell International is probably the leading exponent of this approach in the business world. They also have an R&D effort of more than \$US1 billion per annum which could benefit from this collaborative effort. An outline of this initiative is provided in the case studies chapter.

Some of the issues involved in integrating scenario building and priority setting in CSIRO are considered in the next chapter in the section on the integration of prospective assessment and priority setting.

### **Elements of Priority Setting Process**

CSIRO conducts a triennial review of its research priorities to guide the redistribution of limited resources among competing research opportunities. It does this with the objective of maximising the returns to Australia from its research effort.

The review process has the following salient features:

- Classification of CSIRO's research purposes by the socio-economic objectives (SEOs) for research identified in the Australian Standard Research Classification produced by the Australian Bureau of Statistics. This classification changes to reflect changes in the direction and emphasis of federal government policy. It currently comprises:
  - Five divisions: *Defence, Economic Development, Society, Environment, and Advancement of Knowledge*,
  - Twenty SEO sub-divisions, of which 17 are relevant to CSIRO, as shown in Box 3 in a slightly modified form to align with the structure of the research effort in CSIRO.
  - Seventy-two SEO groups and 372 SEO classes relevant to CSIRO.
- Application of a framework to assess the *return-on-R&D to Australia* for each research purpose. As shown in Box 4, the framework comprises two general and independent components:

*Attractiveness* defined by the product of 'scores' for two 'priorities criteria', namely

- *Potential benefits of successful research.*
- *Ability to capture the benefits.*

*Feasibility* given by the product of 'scores' for two 'priorities criteria', namely

- *R&D potential.*
- *R&D capacity.*

- Preparation of a *data sheet* and an *evaluation sheet* for each research purpose (SEO sub-division at the corporate level) to assist scoring judgements. The former covers industry and R&D information in the form of a generalised strengths-weaknesses-opportunities-threats analysis. The latter focusses on appraisals of the key factors perceived as characterising the four priorities criteria. These are considered in the methodology chapter.
- Preparation of scores for the four priorities criteria for each research purpose by the participants in the priority setting process.
- Agreement by lead participants on the *return-on-R&D to Australia* by averaging their scores and combining them into overall judgements and displaying them on a screen of the type shown in Box 5.
- Interpretation of the screen in terms of the strength of emphasis and degree of selectivity that are appropriate at a national level for each research purpose.
- Determination of CSIRO's *role statements* for each research purpose, comprising a priority rating, a priority decision statement, statements of strategies, potential outcomes, and key priority activities, recognising the roles of other research performers.
- Allocation of a priorities fund to new research programs guided by the *role statements*.
- Incorporation of the *role statements* into a *strategic plan* with an annual review of performance towards planned outcomes in an *operational plan*.

**Box 3: Research Purposes**

**Box 4: Priorities Assessment Framework**

**Box 5: Return-on-R&D to Australia Screen**

## Operation of the CSIRO Process

Box 6 shows the main stages and steps in the process of setting research priorities in CSIRO.

### Box 6: Stages and Steps in the Process of Setting Research Priorities

The *Preparation Stage* comprises the following steps:

- *Scoping Workshops* - orientation of possible participants, agreement on the objectives and planned outcomes from applying the methodology, adaptation of methodology as appropriate, agreement on the appropriate internal and external participants in the process of determining research priorities, and agreement on a suitable classification of research purposes.
- *Compilation and Synthesis of Inputs* - assembly of data, information, and business and other intelligence for each research purpose according to the specifications of scoping investigations and agreements.
- *Preparatory Workshops* - identification of broad challenges and opportunities facing the organisation's main stakeholders, appraisal of the capacity of the organisation to respond, and evaluation of these and the foregoing inputs to identify additional needs, improvements, and refinements.
- *Preliminary Assessments of Priorities by Individual Participants* - determination of preliminary priority scores for each research purpose by each individual participant and preparation of background 'role statements' for each research purpose.

The *Determination Stage* (the priority determining workshop) comprises the following steps:

- *Review of Preliminary Assessments of Priorities* - structured consideration of participants' outlier scores for each research purpose leading to re-scoring of outliers by participants persuaded so to do.
- *Agreed Assessment of Priorities by Participants* - agreement by all participants to the average scores of the group using various screens showing the rating of each research purpose from different criteria-based perspectives.
- *Agreed Draft Priority Decisions* - formulation of first draft wording of the priority decision for each research purpose in syndicate groups followed by agreement on draft priority decisions by the group as a whole.
- *Agreed Draft Role Statements* - formulation of first draft wording of the role statements, incorporating the priority decisions, for each research purpose in syndicate groups followed by agreement on draft role statements by the group as a whole.

The *Implementation Stage* comprises the following steps:

- *Synthesis of Feedback on Draft Priority Role Statements* - incorporation of 'top-down', and 'bottom-up' feedback on priority decisions and the various assessments

provided in the role statements using the activity of specifying and selecting research programs for priorities funding as a driver.

- *Final Role Statements* - preparation of final role statements incorporating priority decisions, planned outcomes, strategies, and performance indicators.
- *Preparation of Strategic Plan* - preparation of strategic plan based on role statements for each research purpose.
- *Annual Evaluation of Performance* - preparation of an operational plan which provides an annual review of performance against the indicators of performance provided in the strategic plan.

## **METHODOLOGY**

This chapter explains the various components of the CSIRO methodology for setting research priorities under the following headings:

- Vision Focus
- Determination of Research Purposes.
- Specification of Priorities Criteria.
- Combining Criteria in Overall Judgement of the Return-on-R&D.
- Inputs to Priorities Process: Information, Indicators and Intelligence.
- Scoring the Criteria.
- Building Group Consensus.
- Participation in the Priority Setting Process: Toward a Multi-Level, Interactive Process
- Integration of Prospective Assessment and Priority Setting.
- Contribution of Scenario Building and Benefit-Cost Analysis to Research Priority Setting

The following three chapters provide details of the preparatory, determination, and implementation phases of the process in which this methodology is applied.

### **Vision Focus**

Setting research priorities is generally focused on particular needs. For example, priorities could be set in the context of the specific directions or the vision of an organisation such as the vision for CSIRO shown earlier in Box 1. Ignoring this aspect may create a risk of the outcomes being an extension of the past with only marginal differences in planned activities from current activities. Key elements of the organisation's vision may be factored into the criteria used to determine research priorities, ensuring that the priority outcomes are consistent with these directions of the organisation. Setting priorities in the absence of a long-term vision or goal can result in losing sight of long-term research opportunities and of not reconciling the researchers' objectives with the organisation's (Contant and Bottomley 1988, p.7, cited in Blyth and Upstill 1994).

### **Determination of Research Purposes**

#### *Overview*

The determination of the basis for classifying research purposes is a critical factor in research priority setting. It is the first key step on the path to successful priority setting and implementation (Blyth and Upstill 1994). CSIRO bases its classification of research purposes on the socio-economic objectives (SEOs) of the Australian Standard Research Classification, adjusted to better represent CSIRO's research focus. Within CSIRO, some divisions, programs and projects have adopted the CSIRO SEO research classification for their priority setting, while others have chosen alternative structures. When selecting research purposes it is essential that the final set be:

- Mutually exclusive.
- Exhaustive.



- Consistently based.
- Outcomes oriented.

Research purposes should be totally independent of each other if they are to be effectively assessed and compared. The set of research purposes should be comprehensive, including current research areas and areas in which the organisation could be involved in the future. The priorities process should be relevant to the future and therefore it must include assessment of areas and activities beyond the current set.

Consistency of definition of research purposes is also critical to meaningful comparison. CSIRO's use of socio-economic objectives is an example of the application of definitional consistency. Socio-economic objectives allow the organisation to focus on the outcomes of the research, rather than the means or process by which the research is conducted or how the objective is achieved. For CSIRO, this has been a significant factor in generating the commitment of management and staff to the priorities process and the outcomes.

Those responsible for managing and implementing the outcomes of the research priorities exercise should be involved in the selection or determination of the set of research purposes which meet these and other relevant criteria. This may be achieved with the aid of a workshop involving these individuals and with reference to relevant existing research classification structures and the like. To keep the process manageable the group should aim to contain the number of research purposes to around 12 to 15. This workshop is also an opportunity to introduce the group to the overall priorities process and to discuss subsequent steps.

### *The CSIRO Experience*

In the early stages of trialling various approaches to priority setting, the Board and Corporate executive group considered several ways of classifying CSIRO's research effort into what it referred to as *research purposes*. Trials were conducted using classifications based on national challenges and opportunities, industry sectors and community concerns, technology-based outcomes, type of technology, and combinations of the foregoing.

For several years prior to this CSIRO had been reporting the distribution of its research effort by sectors and emerging technologies. This had led to CSIRO participating in a project coordinated by the Australian Bureau of Statistics (ABS) to design an Australian Standard Research Classification (ASRC). The ASRC is based on a hierarchy of socio-economic objectives (SEOs), specifying a category of expected national benefit rather than the immediate objectives of the researcher. Since the ASRC subsumed the sector-based Australian Standard Industrial Classification, incorporating its division, sub-division, group, and class levels, alignment with major collections of official collections was possible. As these collections included a wealth of high quality data on aggregates such as gross value of production, exports, imports, R&D intensity, industry structure, etc, the corporate executive group agreed that the Interim ASRC, available at that time, would ensure that CSIRO's classification of *research purposes* were not only focussed on its principal ministerial guideline, "*CSIRO's main task will be the conduct of strategic and applied research in support of national economic, social and*

*environmental objectives*”, but also provided an informed basis for setting research priorities.

The ASRC classifies research activity according to the purpose for doing the research or the most direct Australian beneficiary. The classification is a hierarchy with divisions at the broadest level, disaggregating through sub-divisions and groups to classes. It was modified slightly by CSIRO, resulting in 17 research purposes, equivalent to the sub-division level of the classification as shown in Box 7. The 72 groups within these sub-divisions are also indicated in Box 7. The full classification, currently comprising and 372 classes, is provided in the appendix on the Research Classification. The resulting set is both meaningful to CSIRO and representative of economic, social and environmental activity in Australia.

**Box 7: Research Purposes - Socio-Economic Objectives at Sub-Division Level**

The in-house variations by CSIRO do not affect the capacity to compare data as only a slightly different aggregation of lower (group) level SEOs has been made. These reflect minor departures in the way CSIRO views industry structure from that used in the ASRC. This complementarity enables assembly of a large body of general economic, research and other data necessary to support decision-making. Given the wide-spread consultation required by the ABS to reach agreement on the ASRC, it was envisaged that its use by CSIRO would encourage similar adoption by other research performing and funding bodies. This in turn could lead to a consistent basis for prioritising the entire research effort of the Federal Government.

The research purpose referred to as "Advancement of Knowledge", which relates only to pure basic research, has been interpreted by the corporate executive group as including only astronomy in the case of CSIRO. It has been concluded that work of a generic and precompetitive nature carried out in the Organisation can be identified as being for the potential benefit of a particular research purpose (although in reality more than one research purpose may potentially benefit, eg 'gene shcars' work is likely to benefit more than the Plant Production and Primary Products). This conclusion is consistent with CSIRO's role as a performer of strategic and applied, rather than pure basic, research (for relevant ABS definitions see the Research Classification appendix).

A research purpose corresponding to an SEO sub-division does not correspond directly with CSIRO's institute and divisional structure. In most cases an SEO sub-division covers research conducted by more than one institute.

### **Specification of Priorities Criteria**

The starting point for assessing research purpose priorities was that the highest priority research should be that which has the potential to return the highest economic,

environmental and other social benefits to the nation. This is equally true of both national priorities and CSIRO priorities.

The corporate executive group has developed an assessment framework based on an analytic framework for understanding how R&D contributes to the profitability of corporations brought to the attention of CSIRO by McKinsey & Company in a consultancy commissioned by the newly constituted Board of CSIRO in 1987. The analytic framework is based on work by the R&D Productivity Sub-Committee of the USA-based Industrial Research Institute, chaired by a director of McKinsey & Company. Results of this work were published in the journal *Research Management* (Foster et al 1985).

CSIRO has adapted this framework into the relatively simple assessment framework linking four priorities appraisal criteria shown earlier in Box 4 in outline form and in expanded form in Box 8. The definitions of the criteria used to appraise research purpose priorities are shown under the headings: *Potential benefits* of successful research; *Ability to capture the benefits*; *R&D potential*; and *R&D capacity*. Also shown are several general and independent factors characterising each criterion.

#### **Box 8: Priorities Assessment Framework - Expanded**

The framework allows the successful marriage in an interactive environment of judgements about both the socioeconomic (external) environment and the scientific (internal) environment. It is used to generate a rating of the overall return to Australia of research for a particular purpose. This is achieved by comparing individual or group judgements on the likely benefit or *attractiveness* of the research with that for the *feasibility* of achieving the necessary technical progress. *Attractiveness* is determined by combining the two potential benefits and ability to capture the benefits criteria and *feasibility* by combining the R&D potential and the R&D capacity criteria. This is described later in this chapter in the section on combining the four criteria into an overall judgement of the return-on-R&D to Australia.

It is important that all participants in group exercises have the same understanding of the criteria. Some discussion and iteration is usually necessary to ensure that this is the case. In other priorities exercises external to CSIRO the discussion of the criteria has been led by experienced practitioners in the sectors targeted by the research purposes and in relation to the issues pertaining to a particular criterion. A workshop appraisal of the criteria led by four such practitioners (one for each criterion) can result in the formulation of a well-conceived and group-owned set of independent factors, often expressed in the form of *key discriminant questions*, for each of the criteria and a sophisticated, common understanding of how to apply the criteria. Successful applications of this approach are outlined in the case studies chapter in the section on customising the criteria.

The criteria are independent, as they should be in any approach to multiple criteria decision-making, and it is important for accurate assessments that they be treated as

such. It is necessary to be on guard against 'double-counting' when applying the criteria as described below.

### ***Potential Benefits***

In this the potential benefits of R&D are defined as the maximum economic, environmental and other social returns possible (for Australia) from technological improvement in the sector(s) covered by a research purpose. A more detailed version of the factors comprising potential benefits are shown in Box 9 in the form of ***key discriminant questions***. Data and assessments germane to these questions were taken into account by the participants in Corporate executive group exercises.

#### **Box 9: Priorities Criteria: - Key Discriminant Questions**

The corporate executive group found that their first use of the criteria made apparent some uncertainty as to whether the potential benefit was a measure of the marginal or absolute benefit resulting from technological advances in the sector. It was resolved that the absolute benefit was what should be considered for the reason given in Box 10.

#### **Box 10: Assessing Potential Benefits**

Care also had to be taken in guarding against marking down the potential benefits of technological advances in a particular sector because of knowledge of poor technology transfer capacity in the sector. Consideration of the potential benefits must assume perfect capture. Technology transfer concerns are dealt with as part of the second criterion - Australia's ability to capture the potential benefits.

### ***Ability to Capture the Benefits***

The ability to capture the benefits of R&D is defined as the ability of Australia's companies, organisations and utilities to convert technical progress into commercial and other returns for Australia. It depends on a wide range of factors, both internal and external to these enterprises such as shown in Box 8 and expressed in the form of key discriminant questions in Box 9.

The fruits of R&D can be broadly described as the creation of new technologies, improved standards of service, more efficient use of internal resources, a broader range of products and services delivered to the market and better performance in meeting external standards and community expectations. There is considerable scope for R&D that recognises the role of behavioural adaptation by customers (for example in response to changes in pricing regimes) as well as new possibilities for technological solutions. In

an increasingly competitive world flexible strategic approaches are needed to capture the full benefits of R&D.

Innovation is marked by the first real use in a market - it is the result of invention and commercialisation. R&D is thus a means to an end, not an end in itself, but the thrust of Australian innovation is biased towards technology push rather than market pull. The appropriate balance between science push and demand pull is likely to vary from problem to problem and technology to technology.

### ***R&D Potential***

The potential of R&D in this context is a measure of the technical potential of relevant fields of research and development, indicated by the maturity of the fields, the closeness of technical and physical limits and the prospects for scientific breakthroughs. It is more difficult to assess in a systematic way than the other three criteria. The concept of the technology S-curve identified in the key discriminant questions in Box 9 rests on the premise that no technology can be advanced without limit.

Technology progresses along the curve illustrated in Box 11(a), with performance increasing slowly at first, then more rapidly, and finally more slowly as the limits are reached. The slope of this curve represents the amount of technological progress provided by a given input of effort. This slope varies markedly depending on where a technology is on its S-curve at any point in time. Areas of high R&D potential have one or more relevant technologies that are on the steep slope of the curve.

#### **Box 11: The S-Curve**

- (a) The S-curve of technological performance versus effort
- (b) Technical capability trends in lighting
- (c) Efficiency of external combustion energy conversion systems

The S-curve can be determined with some precision for individual technologies; for example, the incandescent and mercury vapour fluorescent lamps illustrated in Box 11(b). Such individual technologies inevitably approach an intrinsic constraint. The objectives of technological advancement for all but the narrowest research objectives are not limited to a single technology. Progress is made by the progressive substitution of new technologies as old ones reach their intrinsic limits. However, the larger technological objective may in turn reach an intrinsic limitation. This is shown in Box 11(c) for the energy conversion efficiency obtained in thermal power plants. The curve, which was compiled in the late 1960s, is probably optimistic in its expectations of progress. Nevertheless, in his analysis, Ayres (1968) notes that the curve already 'feels the looming presence of an intrinsic and absolute upper limit' of 100% conversion efficiency.

In an exercise of the scope under taken by the CSIRO corporate executive group, considerations of R&D potential become very complex, given the breadth of research purposes under potential consideration (eg. those to benefit commercial services).

The range of technologies considered for each research purpose is also relevant to other criteria in the CSIRO framework for assessment of the overall return-on-R&D to Australia. R&D potential may be low for a dominant and mature technology (eg. generation of electricity using fossil fuels) but the traditional research programs and industry structure may be such that the efficiency of making small incremental technological improvements is high (high R&D capacity) and the rate and extent of uptake is likely to be high also (high ability to capture rating). On the other hand, the R&D potential of other forms of electricity generation might be high but the R&D capacity and the ability to capture low. In areas like this, the concept of selectivity is important, as is the need to link research priorities with broader policies of relevance to the area under consideration. This concept is considered later in this chapter in the section on combining the four criteria into an overall judgement of the return-on-R&D to Australia.

In applying this criterion to the prioritisation of the R&D effort of the Sydney Water Board, a differentiation was made between the maturity of technology(ies) for a specific research purpose (ie position on the S-curve) and the current prospects for achieving a significant development in technology (ie., the dimension of uncertainty). Details are given in the case study chapter.

### *R&D Capacity*

R&D capacity is a measure of research capability, in terms of the quality and quantity of resources available to achieve the R&D potential in a timely way. The expression of key discriminant questions in Box 9 notes that this criterion can be applied for a nation *or* an R&D performing enterprise. As such it is different to the other criteria which are equally valid at national *and* enterprise levels.

The corporate executive group of CSIRO in applying this criterion had to consider Australia's R&D capacity (as opposed to CSIRO's) for each research purpose as an input to the procedure it had devised to combine the four criteria into an overall judgement of the return-on-R&D to Australia.

In considering Australia's R&D capacity in its second priorities exercise the corporate executive group took the following into account:

- The extent to which research for a particular research purpose, however desirable it may be nationally, should be publicly supported having regard to the extent to which the potential benefits are appropriable by individual beneficiaries as opposed to the public at large.
- Improved coordination between the various industry or sector-based government R&D corporations and their introduction of strategic approaches to priority identification.
- Increasing efforts by research providers in the government and university sectors to develop stronger links with the business sector through a range of initiatives.

- Increased emphasis on assembling teams of scientists from different disciplines and organisations to tackle priority research issues.

In translating its view of national research priorities to internal resource allocation decisions, the corporate executive group focussed on the following:

- The relative R&D capacity of CSIRO and other research performers covered by each research purpose.
- The twin themes of developing R&D capacity and building stronger, more productive links with research receptors and users; ie, enhancing the ability to capture.
- CSIRO's active involvement in
  - establishing new research programs which drew on CSIRO's major comparative strategic advantage - the capacity to deploy rapidly its wide ranging skills across the organisation in response to urgent and emerging national needs
  - the cooperative research centres established by the federal government as outlined in Box 12.

**Box 12: Critical Determinants of CSIRO's R&D Capacity**

**Combining Criteria in Overall Judgement of the Return-on-R&D**

The CSIRO framework is structured to allow rating of the likely return on R&D for a particular research purpose. Given that both ability to capture and R&D capacity refer to the relative effectiveness of achieving the full potential benefits and R&D potential respectively, they can simply be multiplied by their companion criteria to provide estimates of the actual benefits likely to be realised (the R&D attractiveness) and the technological progress likely to be made (the R&D feasibility). That is:

R&D attractiveness ( $\Delta\text{benefits}/\Delta\text{technical progress}$ ) = potential benefits x ability to capture.

R&D feasibility ( $\Delta\text{technical progress}/\Delta\text{R\&D investment}$ ) = R&D potential x R&D capacity.

Equally, the return on R&D is the product of R&D attractiveness and R&D feasibility. That is:

$$\frac{\Delta\text{benefits}}{\Delta\text{R\&D investment}} = \frac{\Delta\text{benefits}}{\Delta\text{technical progress}} \times \frac{\Delta\text{technical progress}}{\Delta\text{R\&D investment}}$$

All composite scores are plotted on a Return-on-R&D (Attractiveness-Feasibility) screen, which shares some similarities with common business screens such as that of the Boston Consulting Group. As is shown in Box 13, the position on the screen guided the corporate executive group as to the emphasis that should be given to each research purpose at the national level.

**Box 13: Priorities Return-on-R&D Screen to Australia - Expanded**  
(Differentiate from Box 5 in the chapter on Overview of the Process)

The corporate executive group is of the view that Australia should place strong emphasis on research to support those sectors where

- The research is highly attractive; i.e., the likely benefits of successful research are high.
- The research is highly feasible; i.e., there is a high likelihood of achieving a high level of technical progress in Australia.

There should be selective emphasis in those areas of either high attractiveness and low feasibility, low attractiveness and high feasibility or medium attractiveness and medium feasibility. Those areas for which both attractiveness and feasibility are relatively low should receive only limited support.

This model should not be interpreted as implying the desirability of an automatic redistribution of funds from those research purposes in the bottom left corner to those in the top right. Later steps in the methodology demand consideration of the actual distribution of total research effort with an ideal based on the screen positioning.

The notion of increased selectivity, as indicated in Box 13, is an important part of the corporate executive group conclusions in regard to national research priorities. It is recognised that, although returns on R&D for the purposes positioned in the bottom left of the screen will be lower on average, specific areas will still give high R&D returns. This is to be expected, given that the research purposes at the sub-division level are very broad and lumpy with regard to their R&D attractiveness and feasibility.

While conceptually plausible, the attractiveness and feasibility scores have not been combined, as it is felt that the single resulting number has little meaning in itself and conveys considerably less information to guide further decision-making than can be obtained from interpretation of the return-on-R&D screen. It must also be kept in mind when making manipulations of this nature that the scores are not absolute quantities and that their scales cannot be assumed to be strictly linear. Indeed the corporate executive group found value in comparing the scores for the components of attractiveness and feasibility. The resulting screens are illustrated in Box 14. These provide a valuable guide as they indicate where there may be specific weaknesses and imbalances in relation to each research purpose.

**Box 14: Attractiveness Screen and Feasibility Screen**

Of particular significance is the fact that research performing and funding agencies can directly influence only one of the four criteria on which the overall judgements are based; i.e., research capacity. Therefore, a research purpose which is attractive and for which



R&D capacity is low in relation to R&D potential might reasonably be a candidate for additional funds as much on the basis of where it might be moved to on the return-on-R&D screen through additional R&D funding as where its present position is.

A high potential benefit rating coupled with low capture may signify structural problems in the research purpose (SEO sub-division) amenable to improvement by various non-technological measures. In these cases CSIRO would look to contributing as appropriate to the development of policy measures to overcome impediments to capture, rather than simply responding to this as an immutable circumstance.

In all cases a balanced consideration of all four criteria is essential when deciding an appropriate response to the national research priorities.

### **Inputs to Priorities Process: Information, Indicators and Intelligence**

The corporate executive group based its determination of scores for the four priorities criteria for each research purpose (SEO sub-division) on data and qualitative information assembled to assist in this regard. Various means of accessing and comprehending supporting information were established as follows:

- *CSIRO Executive Information System*
- A compendium referred to as the *SEO Sub-Division Data and Evaluation Sheets* (CSIRO 1993b).
- *CSIRO Research Priorities Data Compendium* (CSIRO 1993c).
- *Industry Data and Analysis.*
- *Environmental Data.*
- *Accounting for CSIRO's International Activities.*
- *A Glossary of Economic Terms.*

### ***CSIRO Executive Information System***

The *CSIRO Executive Information System* (EIS) provides a great wealth of 'hard' data from ABS sources at the sub-division, group and class level of the research purpose classification. Official economic and industry statistics linked to the Australia and New Zealand Standard Industrial Classification are supplemented by major collections of detailed statistics on the environment, demography, health, education, and other social concerns. It is also possible to obtain 20 year trends in many of the variables considered pertinent to the determination of research priorities. Spatial disaggregation according to the 56 Statistical Divisions of Australia is also possible.

As a hard copy of this mega source is not practical, access needs to be through a user friendly EIS. The ability to 'drill down' in a quick and ready way to group and even class level, when making judgements at the sub-division level, can often be invaluable. Consequently, priority was given to providing online access to the EIS by the corporate executive group during their second priorities determination workshop, even though it was held at a remote location.

### ***SEO Sub-Division Data and Evaluation Sheets***

The *data sheet* for each research purpose provides industry indicators in time series form, R&D information and an analysis of industry prospects. The challenge is to distill the considerable volume of available data, information, and indicators into a two page synopsis which provides the essentials to all participants required to judge priorities. An example of current best practice in CSIRO for the SEO sub-division level is shown in Box 15 for the research purpose of Animal Production & Primary Products.

#### **Box 15: Data Sheet - Animal Production & Primary Products**

The preparation of inputs for CSIRO's triennial review of research priorities leads to the accumulation of significant amounts of useful data and information of relevance to each of the SEO sub-divisions. However, limits on the scope and length of Data Sheets often means that much information is highly summarised and some is not used. To facilitate access to all relevant information and data compiled for the research priorities review, the *CSIRO Research Priorities Data Compendium* has been introduced as described below.

The *evaluation sheet* for each research purpose provides appraisals of the key factors perceived as characterising the four priorities criteria. A best practice example in CSIRO for the corporate research purpose level is shown in Box 16 for the Information and Communications Industry.

#### **Box 16: Evaluation Sheet - Information and Communications Industry**

### ***Priorities Data Compendium***

The *CSIRO Research Priorities Data Compendium* is a key source document for much of the data and information inputs to the priorities process. In many respects it is a companion tool to the computer based EIS. Where the EIS is a key source of hard data, the *Compendium* is a key source of soft data, including synopses of various industry studies, reports and inquiries, specific industry data and other disaggregated data and references to relevant material. It comprises background indicators mainly in the form of social, economic and environmental indicators and intelligence in the form of briefing papers on public and private sector inquiries in Australia and internationally.

As for the EIS economic and related data are principally sourced from the Australian Bureau of Statistics (ABS). In general data is from published sources, although where sub-divisions are unique to CSIRO (such as the minerals and energy classifications), recourse has to be made to unpublished data at a higher level of disaggregation in a number of instances. Other data sources include the publications and databases of the

Australian Bureau of Agricultural and Resource Economics, the Bureau of Transport and Communication Economics and the Department of Industry, Technology and Commerce.

Data on existing levels of CSIRO R&D effort are assembled according to the SEO classification adjusted slightly to align with CSIRO needs. Where available, national R&D expenditure was sourced from the ABS. Available data on international R&D comparisons were also assembled for OECD countries but comparisons at the sub-division level were hampered by classification differences.

The *Compendium* also has a direct link to the SEO sub-division data and evaluation sheets. Data and background information summarised in a data sheet can be expanded in the *Compendium*. Details behind broad assessments and assertions provided in an evaluation sheet can be included in the *Compendium*. Statements made, forecasts quoted and references cited may be substantiated through fuller details and descriptions in the *Compendium*.

As well as carrying supporting data, information and references for each of the SEO sub-divisions the *Compendium* includes data and information on the broad Australian economy, including various international comparisons of Australia's economic and social performance and status. There are summaries of recent short-term and medium-term forecasts for the Australian economy and for various Australian industries. It also includes briefs on key issues of relevance to CSIRO's strategic planning, covering important issues such as Australia's competitiveness, science and technology priorities and policies of other agencies and countries and the state of the natural environment. Broad indicators for research and development, including international comparisons are also presented. The full contents list for the *CSIRO Research Priorities Data Compendium* is shown in Box 17.

**Box 17: Contents of Research Priorities Data Compendium**  
(Double page spread)

Chapter 3 of the *Compendium* provides summaries of medium-term forecasts for the Australian economy and for various Australian industries. CSIRO subscribes to the BIS-Shrapnel and Syntec forecasting services. Other projections are available from 'outlook' conferences and major features in business journals. Of special interest in this list is the 'Centre of Policy Studies - Projections for 1989-90 to 2000-01'. Box 18 shows some of these projections for a range of key economic indicators corresponding to the CSIRO research purposes based on the slightly modified SEO sub-divisions. This goes well beyond the single year actual figures for these economic indicators which influenced judgements made by corporate executive group members who participated in the first review of research priorities. Also shown are projections of the effects on these indicators of a one percent change in technological improvement in activities covered by CSIRO's research purposes. These projections are estimates of a one percent change in one research purpose on the outputs of each of the other research purposes, based on linkages between industries and activities covered by the research purposes.

**Box 18: Projections of Key Economic Indicators by SEO Sub-Divisions,  
1990 to 2000**

(Graphs showing 1990 and 2000 levels with and without the 1 percent technological improvement.)

The last four sources chapter 3 of the *Compendium* refer to key outputs from a preparatory workshop referred to earlier in this report. They are considered in further detail in the chapter on the preparatory stage.

The *Compendium* holds considerable potential to be used as a high quality reference source for priorities workshop participants when scoring the research purposes. For example, a statement made in an evaluation sheet may be traced through the corresponding data sheet to the more detailed information and data in the *Compendium*.

For hard industry and research data the EIS provides the means to 'drill down' from the SEO sub-division level of the research purpose classification presented in the data sheet to the group and class levels. Together the EIS and the *Compendium* provide effective and comprehensive support and background to the priorities assessments. These two tools are useful during and after priorities workshops.

A 1993 edition of the *Compendium* was released for use throughout CSIRO as an adjunct to divisional and institute planning and priority setting exercises as well as to corporate exercises. By maintaining a loose leaf format, revisions and additions can be readily made, particularly in relation to the indicator tables and charts and the projections and forecasts. Briefs on emerging issues and trends shaping Australia's strategic directions can be readily incorporated.

***Extending the Basis of Industry Data and Analysis***

***AMC study by McKinsey and CSIRO-McKinsey follow-up industry level data sheets prepared by IIT - see Garrett Upstill.***

Finally increasing attention is now being given to markedly improving the data and analysis on Australian companies and industries which needs to be incorporated into CSIRO's prospective assessment and priority setting processes. Of relevance in this respect are the contributions of Porter's theories on competitive advantage and, eventually inputs from the application of extended multi-sectoral economic analysis. Thinking strategically about the influence of research and technology development on the prospects for Australian companies and industries will be a major guide to CSIRO's drive to achieve best Australian and international practice in strategic management and planning.

## ***Environmental Data***

The structure of environmental data and indicators is much less developed within the official collections of economic and social statistics. In recent years the ABS has worked to remedy this with efforts by government agencies to report on the state of the environment providing a guide to appropriate structures. This effort has drawn from and interacted with comparable activities by the United Nations Statistical Office and the OECD. At the same time CSIRO has played a major role in the development of the class, group, and sub-division structure of the Environment Division of the Australian Standard Research Classification (ASRC), both as a key user and significant provider of the basic data structured according to this classification.

As a result CSIRO supplemented existing data and indicators from the ASRC. An adaptation of the 'stress-response' framework originally developed by the OECD was used to guide the identification and formulation of indicators as shown in Boxes 19 and 20 for the Environmental Aspects of Economic Development and the Environmental Knowledge sub-divisions respectively. This framework then served as a guide to the preparation of a sub-compendium of environmental data to support research priority judgements of to be made by the Corporate executive group participants. An overview of the structure of this sub-compendium (identified as sections 5.12 and 5.13 in the contents of the *CSIRO Research Priorities Data Compendium* shown in Box 17) is provided in the next chapter.

**Box 19: Indicators of Economic Development Environmental Aspects  
Sub-Division by Group**

**Box 20: Indicators for Environmental Knowledge Sub-Division by Group**

## ***Towards a Prioritisation of CSIRO's International Activities***

Scientific research has a significant international dimension. With the increasing globalisation of information technology, environmental activities and greater emphasis being placed on international competitiveness, the significance of this dimension is also growing. Collaboration with overseas agencies provides a means of achieving critical mass in high priority areas as well as obtaining leading edge information on new technology developments. In addition, collaborative R&D with overseas agencies may contribute to Australia's economic and trade development, as may R&D in the form of overseas aid.

The range of options and the demand for resources for such activities typically outstrips the available supply of resources, and choices have to be made. A complicating factor is that the conduct of such activities does not always lie solely in the domain of CSIRO, but will also involve other government departments and agencies. Accordingly it seems

logical that the priorities process should embrace international activities undertaken by CSIRO. But the determination of these priorities must be made in concert with our stakeholder partners who interact with us in the conduct of these activities.

In the lead up to the second review CSIRO collaborated with the Department of Industry, Technology & Commerce in hosting a workshop to consider the development of a framework and process and for determining and implementing Australia's international research priorities. Representatives of AUSTRADE, the Department of Foreign Affairs & Trade, the Department of Primary Industries & Energy, and the Department of Arts, Sport, Environment & Territories. At this workshop CSIRO reported its objectives in prioritising its own international research effort to include the following:

- To incorporate the international dimension in determining priorities for research addressed to the range of SEO-based research purposes.
- To improve the transfer and commercialisation of CSIRO's research effort through collaborative R&D with Australian based multi-national corporations and multi-national corporations operating in Australia.
- To collaborate with major scientific programs (international and country-based) in building critical mass for CSIRO's research effort in high priority areas.
- To determine the optimum level of CSIRO's research effort which should be funded through multilateral, bilateral and Australian-based aid sources.

Reflecting these objectives, Box 21 provides a preliminary attempt to formulate key discriminant questions corresponding to CSIRO's four priority assessment criteria.

**Box 21: Criteria for Prioritising CSIRO's International Research Effort**

Various exploratory attempts have been made to formulate an appropriate international data sheet. Box 22 provides an example of a data sheet for China. Similar sheets were prepared for ..... and made available to Institutes to support the preparation of the research purpose data sheets.

**Box 22: International Data Sheet for China**

***A Glossary of Economic Terms***

The CSIRO research priorities process has introduced participants to many new terms, concepts, indicators and measures, especially from the 'dismal' discipline - economics. To aid workshop participants and others using the *Compendium* and the EIS a start has been made to define some of the most frequently used terms which may not be fully understood or which may be incorrectly interpreted. In time the list of terms, concepts, indicators and measures will be extended to form a comprehensive list. It also can be

updated and extended. The glossary compiled for the second review of research priorities is provided in Box 23.

**Box 23: Glossary of Economic Terms**

**Scoring the Criteria**

At the micro, or company, level it may be possible to make rough quantitative estimates of the four priorities criteria adopted by CSIRO in relation to a particular research purpose. The approach is complementary with benefit-cost methodology for retrospective and prospective evaluation of research projects employed by CSIRO and outlined in the last section of this chapter.

However, at present quantitative estimates cannot realistically be made at the broad macro level inherent in the consideration of research purposes at the SEO sub-division level. Rather than attempting this, participants in exercises assign a score of 1 to 10 to each criterion for each research purpose in turn. The judgements underlying these scores are strengthened by reference to the key data and information outlined in the last section. The projections of the effects of 'technology improvement' on selected macro-economic variables and industry outputs from 1990 to 2000 are a step in the direction of providing key indicators of the scale of the potential benefits of research for a SEO sub-division.

A number of scoring variants have also been employed in different exercises throughout CSIRO. These include assignment of a fixed number of points in relation to a particular criterion, those points then being distributed amongst the research purposes. The precise method is not critical as long as it is conceptually logical and capable of achieving useful discrimination. Descriptions of some of these exercises within and external to CSIRO are provided in the case studies chapter.

It is important that adequate discrimination is achieved in scoring, since the whole point of the exercise is to identify priorities. This can be difficult, particularly at the national level, where all research purposes being considered are important in their own right. One means of ensuring discrimination and relativity is for individuals, when commencing scoring, to scan all purposes in relation to each criterion and to assign a score of 10 or thereabouts to their most highly ranked and 1 or thereabouts to their least highly ranked. The remaining purposes can then be scored between these.

The Board sub-committee, in early trials, explored the use of a pairwise comparison approach (Saaty 1980). This involves, as the name suggests, comparing each research purpose with each other and establishing a relative preference on a nine point scale. Although the approach is a powerful means of testing qualitative discrimination, it was not favoured because of its complexity and time demands. It is also not as well suited to the group interaction which is at the heart of the CSIRO method.

The scores have no absolute significance - the whole exercise is one of comparative, rather than absolute, judgements. This is consistent with the aim of the exercise, which is to comparatively assess a diverse set of research purposes.

The judgements involved cannot pretend to be value free. For example, the potential benefits of research coming within the Environmental Knowledge sub-division cannot effectively be quantified - the majority of research which can readily have a dollar value assigned to it is likely to come within the Environmental Aspects of Economic Development sub-division; eg, degradation of agricultural land. Therefore, the assignment of a score for the potential benefits of environmental research involves a subjective comparative judgement (in relation to the economic benefits of things like a competitive minerals industry) of the potential benefits of improved capacity to adapt to climate change, preservation of endangered species, etc. Both personal and community values must come into play under these circumstances.

### **Building Group Consensus**

The CSIRO priority setting approach is a method for achieving group consensus on priorities. After a number of trials and based on experience gained in many exercises by institutes and divisions, the procedure detailed in Box 24 has evolved as the most generally suitable. It uses aspects of both Delphi and Nominal Group techniques.

#### **Box 24: Procedure for Group Scoring Exercises**

It is important to keep in mind that the scores are a means of identifying and exploring differing judgements. Key process factors are:

- Adequate preparation - so that participants understand what is going on and can use their group time on the important thing - exploring the views underlying the scores, rather than wasting it on the mechanics.
- 'Champions' for each research purpose, who can lead the discussion and address issues as they arise.
- The full commitment of all participants (including a willingness to step outside of day-to-day concerns and take a fresh look at the total area under consideration).

The scoring approach is a means of exploring views outside the norm, which might otherwise be lost in the weight of group opinion. These views are highlighted and, if convincing, may sway the group as a whole. In this sense, a similar group scoring approach has been characterised as an "automatic chairman".

Although the approach makes reference to a "champion" for each research purpose, this should not imply any partisanship; rather, every research purpose should be supported by a person fully familiar with it, able to make the best possible case for it and capable of dealing with questions which arise during the discussion.

Another essential ingredient for success is the willingness to accept that exercises may need a number of iterations to build confidence in the approach and outcomes. This was



particularly so for the corporate executive group, which was making modifications to the approach as it proceeded, but would appear to be generally true for all groups adopting this approach for the first time.

### **From National Priorities to Resource Allocation Decisions**

The national research priority assessment process provides a two dimensional ordering of the research priorities for Australia as a whole. It does not provide any automatic decision tool for determining how much should be invested in research for each purpose, either in absolute or relative terms. Although it gives a good "feel" to what the balance should be, a high priority rating on the screen does not automatically imply the need for or expectation of additional funding at either the national or CSIRO level. However, consistent with the central role of the notion of selectivity, additional funding does imply a high priority, at the corporate research purpose level, i.e., the SEO sub-division level, or within a sub-division, i.e., the group level, or at the full class level of the classification.

Subsequent reference to what the balance actually is at the national level points, in a qualitative fashion at least, to where funding levels might be adjusted. It says nothing about the following (although some of these matters may have come into play in the decision-making process):

- Where the research should best be undertaken.
- The nature of the balance between strategic and applied research.
- Who should pay for the research.

The corporate executive group adopted a qualitative approach to this part of the decision-making process, looking at its conclusions on national research priorities in the light of the following additional factors:

- The relative R&D capacity of CSIRO and other research performers in the research purpose.
- The extent to which research for a particular purpose, however desirable it might be nationally, should be publicly supported having regard to the extent to which the potential benefits are appropriable by individual beneficiaries.

In doing this, reference was made to CSIRO role statements for each research purpose prepared by members of the corporate executive group. Preliminary draft versions of the role statements prepared prior to the priorities workshop contained key background information to assist in translating conclusions about national research priorities into agreements about CSIRO's effort in each research purpose over the next 5 years. The structure of the role statements is shown in Box 25.

#### **Box 25: Structure of Role Statements**

These statements were revised following the completion of the exercise and now form the key record of the process and guidance to strategic effort over the next 5 years. The

final role statements, which are provided in full in a companion document, address *inter alia*:

- Whether the research purpose's share of CSIRO appropriation funds should be earmarked for increase or decrease over the next 5 years
- Specific areas (at lower levels of the research classification) within the research purpose which should receive selective support.
- The extent to which appropriation funds would focus on strategic research.
- The extent to which maintenance of an agreed desirable level of CSIRO effort in the research purpose would be contingent upon additional external support from the client group.

### **Participation in the Priority Setting Process: Toward a Multi-Level, Interactive Process**

By conducting priorities exercises at all levels of CSIRO, which have involved internal management and external stakeholders, CSIRO is moving toward an internally and externally responsive process for priority setting.

#### ***Selection of Participants in the Process***

CSIRO experience indicates that representation from the following groups should be considered when determining participation in the priority process:

- Internal management, especially those responsible for implementing priority decisions and those accountable for the achievement of planned outcomes.
- External stakeholders, including representatives from industry, government and the community.
- Current and future customers and users of the research outputs of the organisation.
- Staff.

In addition to these factors consideration needs to be given to:

- The level of representation for each research purpose.
- The numbers involved (Blyth and Upstill 1994).

CSIRO has conducted workshops ranging from those involving representatives from all key groups noted above, to those involving internal managers only. Experience has shown that external participation is highly rewarding. It adds credibility to the outcomes of the exercise, it builds good relations with customers and stakeholders who value their role in assisting the organisation set its priorities and directions, and it allows a mixing of minds, broadening the scope of the exercise beyond a purely scientist's perspective. Experience has also taught us that pairing each internal expert with an external representative allows them to work together in the workshop, which reinforces the benefits noted above. Ideally, there should be one internal (expert), and therefore one external representative, for each research purpose.

When inviting people from outside the organisation the field should not be limited to those individuals, companies and organisations with whom the organisation presently deals. In addition to known customers and stakeholders, invitations could be extended to individuals who may not be directly linked to the organisation at present, but who

could be of significance in the future and who could make a valuable contribution. The aim is to cover those elements of the priorities framework where the organisation is weakest. Typically, for a public sector research organisation these would be on the attractiveness side and would include individuals with specific industry and market knowledge, knowledge of the role of government and policy instruments, and/or awareness and understanding of social and community attitudes and issues (Blyth and Upstill 1994).

### ***Multi-Level, Interactive Process***

Although the priority evaluation carried out by the corporate executive group was originally a top down exercise intended to agree broad strategic directions, it was recognised that early and coordinated action to extend consideration down one level in both organisational and research purpose terms would have the following advantages:

- It would provide the corporate executive group with a better appreciation of the areas of particular opportunity contained in each research purpose (SEO sub-division) - which is of particular relevance to the previously discussed concept of high selectivity in lower priority areas.
- It would stimulate discussion of possible oversights or weaknesses in the corporate executive group analysis by pointing to any areas of difference between their and the view of division chiefs, and likewise different views by institutes sharing an interest in the same research purpose at the group level.
- It would be a start in developing wider familiarity with an approach to priority evaluation having potential application at almost all organisational levels.

The steps in a prioritising research purposes at the SEO group level are listed in Box 26. The results of the approach were necessarily treated with a considerable degree of caution because the SEO sub-division screens (the collations of group level judgements for each sub-division) bring together scores which have been made relative to different sets of research purposes. Therefore, strict comparability is not possible.

### **Box 26: National Research Priorities at the SEO Group Level**

Nevertheless, the screens provide a useful 'drill down' picture of priorities at the group level. Comparability of judgements by the one Institute is valid and in other cases comparability between Institute judgements may be attempted with caution - the latter reflecting that the scoring scales do have a degree of absolute significance to the majority of participants in exercises, which results in greater internal consistency than might be expected from a purely theoretical view of the process.

In CSIRO these exercises have become part of an on-going process, consistent with the responsibility of institutes (and divisions) to identify selective opportunities at the group and class level and to redirect resources to these consistent with agreed processes considered later in the chapter on the implementation stage.

However, the challenge is to go beyond substantial bottom-up input into the process of setting corporate research priorities during the implementation stage to corporate

appraisals of future prospects which utilise bottom-up inputs. In CSIRO this is achieved by conducting priorities exercises at Institute and cross-Institute level in the preparatory stage of a corporate review of priorities. In the same way Division level exercises can influence the outcomes of those conducted at the Institute level. Beyond this, prospective inputs from the research program and project level can be achieved through priorities exercises at that level and from prospective benefit-cost analysis of individual programs and projects. As a consequence assessments at any level will benefit from an increasing quality of input from the level below. Examples of prospective priorities exercises at the institute, division, program and project levels are given in the case studies chapter.

To improve the quality of inputs from the research program and project level, CSIRO is making increasingly effective use of benefit-cost analysis methods (Blyth, MacRae and Young, 1991). Interaction between the various levels in CSIRO in the determination of research priorities is depicted in Box 27.

**Box 27: A Multi-Level Interactive Process**

**Integration of Prospective Assessment and Priority Setting**

Based on a creative interplay between wide ranging situational analyses pertaining to CSIRO's global, national, regional and sectoral contexts and systematic syntheses of scenarios, prospective assessment can provide a way of appraising risks, anticipating key moments of change and identifying trade-offs between competing CSIRO priorities. The results can guide the resolve "to create our future" set by Professor Adrienne Clarke, Chairman, CSIRO (CSIRO 1992b).

The broad outcomes of a proposed process for prospective assessment are as follows:

- Anticipation of global, national, regional, and sectoral challenges from CSIRO perspectives.
- Appraisal of relevant manifestos and policy assessments.
- Application of existing public sector tools for generating long-term techno-economic and environmental projections.
- Application of commercially available means of generating long-term projections.
- Preparation of outlooks for CSIRO as a whole and according to the sectors and community concerns it services.
- Creation of corporate and sectoral scenarios guiding CSIRO's research effort and its process of setting research priorities through systematic syntheses of the foregoing.
- Determination and implementation of CSIRO's research priorities.
- Involvement of CSIRO's external stakeholders.
- Evaluation of the impacts of CSIRO's research effort, the influence of the process of setting research priorities, and the influence of involving external stakeholders in the process.

A schematic representation of these broad outcomes and the interplay between them is shown in Box 28.

### **Box 28: Proposed Process for Prospective Assessment**

#### ***Anticipation of Challenges***

CSIRO needs to be involved with the ongoing and increasingly dynamic processes of anticipating challenges at global, national and regional levels which are likely to impact significantly on Australia's future. These challenges also shape the sphere of opportunities and constraints within which CSIRO maps its own spheres of global, national, and regional influence. For CSIRO as a whole this might be viewed as follows:

- ***At the global scale*** (ie, Australia's international context, or Australia's Asian context, or Australia's European context, etc.) challenges could be anticipated and monitored by CSIRO, relative to its own sphere of influence, at various levels of sophistication.
- ***At the national scale***, contributing to the creation of conditions fostering the international competitiveness and preparedness of Australian enterprises could provide a driving force for CSIRO's attempts to map its own national sphere of influence and chart a course within that sphere.
- ***At the regional scale***, CSIRO is very well placed to respond to the needs of a society seeking sustainable living outcomes, including sustainable settlements and lifestyles, in 21st century Australia.

Anticipation of the global, national, and regional scales is also relevant to appraisals of CSIRO's research effort directed to the needs of specific sectors and community concerns. Indeed, the process described in this section is applicable at all levels of research management in CSIRO. By way of an example the CSIRO Board conducted an exercise in the preparatory phase of the second corporate review of priorities which demonstrates an approach to anticipating challenges.

Members of the Board used an iterative approach, through a series of preparatory meetings, to identify then begin to focus on specific global and national challenges by focussing on the question 'what are the potential world challenges over the next 5-20 years, and how will these challenges affect Australia?' Board members eventually agreed on the challenges listed in Box 29.

### **Box 29: Potential World Challenges and Impacts on Australia, 1995-2015**

The selection of key challenges by individual Board members involved the simultaneous rating of the significance of each challenge and the ability of CSIRO to assist Australia to handle the challenge. This involved implicitly rating each challenge by assigning it to one of four 'significance-ability' quadrants as follows:

- Challenges which are not significant, but CSIRO is well equipped to handle, posing the question 'should CSIRO shift its resources to assist in handling more significant challenges?'
- Challenges which are not significant and CSIRO is not well equipped to handle. Challenges which are significant and CSIRO is not well equipped to handle, leading to the question 'should CSIRO develop capabilities?'
- Challenges which are significant and CSIRO is well (and uniquely?) equipped to handle.

The selective screening of challenges by this approach is depicted in Box 30. The approach is based on judgements which are made more intuitively than by any systematic assessment procedures.

**Box 30: Prioritisation Framework for Key Challenges**

A grouping of Board members' ratings led to the selection of challenges marked by an asterisk in Box 29. "Decision-support" information was compiled for the key opportunities characterising each of the selected challenges. The Chairman then convened a workshop for Board members to assess how these opportunities might benefit Australia through possible new or re-affirmed directions for CSIRO's research effort. These deliberations also drew on a Board led evaluation of CSIRO's performance since the establishment of the Board in 1987 following the ASTEC review in 1985. As noted in the first chapter, this workshop was facilitated by Rob McLean, managing partner, McKinsey & Company who also played a key role in providing consulting advice to CSIRO soon after the Board was established.

The anticipation and preliminary appraisal of challenges corresponds to the 'anticipation' cell in the schemma shown in Box 28. The evaluation of past performance, such as conducted by the Board, is related to the 'impacts' cell which provides a key feedback to the 'anticipation' cell.

The role this workshop and its outcomes played in the second review of research priorities is considered later in the chapter on the preparatory stage of the priorities process.

The results of the Board workshop provided a key input to a further workshop called by the chief executive to complete the preparations for the main priorities workshop. Involving members of the Board and the corporate executive group, this workshop provided the strategic context for determining CSIRO's research priorities for the next five years and beyond. Three guest speakers stimulated debate on global challenges and related opportunities for Australian industry and attendant implications for management of the environment. Discussion focussed on how the Australian research community might respond to these challenges and opportunities. The first guest speaker, Mr Ralph Evans, managing director, Austrade, spoke on the subject of the implications for Australian business of trends in the globalisation of technology. Highlights from his presentation are set out in Box 31.

**Box 31: "Globalisation of Technology: Implications for Australian Business"**

The second speaker, Mr Eriks Velins, general manager, Corporate Planning and Economics, Shell Australia, spoke about Shell International's global view, highlights of which are shown in Box 32. Mr Velins involvement in this workshop led to subsequent collaboration between Shell and CSIRO in exploring the application of scenario building approaches to anticipating changes in the means of meeting the research needs of major multi-national enterprises. An outline of this follow up activity is provided in the case studies chapter.

**Box 32 "Shell International's Global View"**

The third speaker, Dr Gus Hooke, managing director, Corporate Economics Australia, led a discussion of the scale of global and Asian market opportunities which Australia might most appropriately capture over the next 30 years. Box 33 provides some notes on this presentation. An outline of the underlying methodology used by Dr Hooke is provided later in this section.

**Box 33: "Australia's Global and Asian Context to 2020"**

Synopses and the full text of these papers are provided in the *CSIRO Research Priorities Data Compendium* and the *Proceedings of the Chief Executive's Retreat* (CSIRO 1993e). The influence of this preparatory workshop on the inputs to and structure of the priorities workshop is considered in the section on the Identification and Assessment of Challenges in the next chapter.

***Appraisal of Manifestos and Policy Inquiries***

The appraisal of major initiatives and accompanying manifestos and the reports of policy inquiries can support the anticipation of challenges. This is shown as one of three 'policy & projections' activities in Box 28. At the global scale major manifestos and reports include:

- The blueprint for a green planet, *Agenda 21*, a major outcome of the 1992 United Nations Conference on Environment and Development.
- Agreement on the Uruguay Round of GATT.
- The *World Competitiveness Report*, compiled annually by the Geneva-based World Economic Forum to cover 23 developed countries and 14 rapidly developing economies.
- The formation of the Asia Pacific Economic Cooperation.

At the national scale we have:

- Political manifestos such as *One Nation* and the White Paper on Employment, *Working Nation*.
- 'Blueprints' designed to shape national policies which include:
  - ⇒ *Australia and the Northeast Asian Ascendancy* (Garnaut 1989).
  - ⇒ *The Global Challenge : Australian Manufacturing in the 1990s* (Australian Manufacturing Council 1990).
  - ⇒ Final Reports of the *Ecologically Sustainable Development Working Groups* (Commonwealth of Australia 1991).
  - ⇒ Report of the Task Force on the Commercialisation of Research, *Bringing the Market to Bear on Research* (Commonwealth of Australia 1991).
  - Report of the Parliamentary Joint Committee of Public Accounts, *Public Research and Development* (Commonwealth of Australia 1992).
  - Federal Government's White Paper on Science and Technology *Developing Australian Ideas, A Blueprint for the 1990s* (Commonwealth of Australia 1992).
  - ⇒ The Senate Economic Reference Committee's report on CSIRO, *The Case for Revitalisation*.
  - ⇒ The Industry Commission's draft report, *Research and Development*.

At the regional scale there is a realisation that slowly but increasingly Australians are accepting the need to live sustainably and to create the types of productive communities which will revitalise Australia. Initiatives such as the Federal Government's *Better Cities Program* and the report to the Federal Government by the *Taskforce on Regional Development* (Commonwealth of Australia 1993) are part of this push.

### ***Application of Long Term Techno-Economic and Environmental Projections***

Existing tools of multi-sectoral economic analysis are inadequate for exploration of the long-term impact of policy options. The Industry Commission, the Australian Bureau of Agriculture and Resource Economics (ABARE), and the Bureau of Industry Economics (BIE) are among the principal users of existing multi-sectoral economic models, such as ORANI, generally for short to medium term assessments.

In addition to vigorous efforts to increase awareness of the influence of innovation, technology change and environmental protection on long-term economic growth, CSIRO and the Ecologically Sustainable Development Working Groups have fostered a research program to produce major improvements in ORANI by the Centre of Policy Studies at Monash University. The latest version of the ORANI Model, now referred to as the MONASH Model, can provide projections for all 56 statistical divisions of Australia and be used to conduct the 'technology improvement' projections undertaken by CSIRO as part of the preparations for its last review of research priorities and provided in the *CSIRO Research Priorities Data Compendium*.

### ***Application of Commercially-Available Long-Term Projections***

Business intelligence services are provided by many companies, some operating internationally. Services emphasising technology-based opportunities are provided by



SRI International, Battelle Memorial Institute, Arthur D Little and others. BIS Shrapnel and Syntec are among the commercial services in Australia which supply long-term economic projections of value to CSIRO at both corporate and sectoral levels. These services also make use of economic models sponsored by the public sector, such as the MONASH Model, and interpret projections from these models commissioned by the Industry Commission, ABARE, BIE, and other agencies of government.

In his presentation to the preparatory workshop for the second review of priorities involving members of the Board and corporate executive group, Dr Gus Hooke made use of various global models to assess Australia's long-term prospects in exporting various goods and services. Since then he has extended this capacity to assess prospects at the regional level. This is done by identifying those local strengths - and what is required to build local strengths - which correspond to strong prospects for capturing shares of growing national and international markets for goods and services. Use is made of the Regional Economic Advantage Model (REAM), developed by Dr Hooke for the federal governments' Office of Regional Development. REAM comprises:

- **A products identification model** to project world demand for major products by sector and industry, based on world models for the level and geographic distribution of income, the size and age composition of population, and the level and sectoral direction of technical knowledge.
- **A world competitiveness model** to separate out the high value products that could be produced commercially in Australia.
- **A regional matching model**, using projected characteristics for a target region, to allocate the identified products across the 56 statistical divisions of Australia.
- **A set of enterprise models**, to allow pre-feasibility studies to be made for the top 10 products or services identified for the region under study.

Work is progressing on integrating this capacity with the capacity of the MONASH Model to evaluate industry and employment opportunities and threats for a region within the context of scenarios for long-term development of the Australian economy. A preliminary application of the MONASH model has been used to estimate, in broad terms, the national economic benefits of two major regional development projects in Australia (James and Dixon 1991) and (James et al 1994).

### *Preparation of CSIRO Outlooks*

Box 28 shows the flow of information from the 'anticipation' and 'policy & projections' cells to the 'outlooks & scenarios' cell. The results of the CSIRO Board's workshop to anticipate challenges provided a key input to the preparation of the outlook for CSIRO as expressed in the *CSIRO Research Priorities Data Compendium*. In addition to the various sources of policy assessments and long-term projections, Australia has annual outlook conferences for agriculture and energy facilitated by ABARE and industry facilitated by the BIE.

These sources are drawn on by CSIRO in preparing its priorities data compendia at various levels of aggregation. The activities involved in preparing an outlook can range from the straightforward compilation of social, economic, political and technological perspectives such as used by CSIRO in preparing its *Compendium* to multi-sector scenario building exercises. The latter are used by organisations to appraise risks,

anticipate key moments of change and identify trade-offs between competing priorities. The output from single or multi-sector outlook exercises could provide key inputs to scenario building exercises. Conducting scenario exercises could assist CSIRO to overcome the problems of overspecifying its priorities databases (at single or multi-sector levels) and failing to reach a collective comprehension between participants of the substance of databases compiled for priority setting exercises.

### *Creation of CSIRO Scenarios*

Also shown in Box 28, creating or building scenarios can provide a systematic means of appraising anticipated challenges for planning and decisionmaking relative to possible future environments. In this context, a scenario is an internally consistent narrative of how the business environment or the external environment in which an organisation operates might develop over time.

An organisation assessing long-term prospects, through the building or synthesis of scenarios, would typically build up multiple scenarios to make sense of the myriad diverse, but inter-connected factors in the external environment, and to identify the critical uncertainties that could affect the organisation's future direction.

CSIRO has begun assessing the applicability of scenario building methods to strengthening its research planning and priority setting process (Blyth and Young 1994). The focus has been on approaches evolved over time by the Shell International Petroleum Company and the Battelle Memorial Institute (Millet 1988, 1992). Shell has found that the 'scenario technique' is 'more conducive to forcing people to think about the future than the forecasting techniques' it had used earlier (Benard 1980 - quoted in Wack 1984). One of the great strengths of scenario building is that it is a learning process. Decisionmakers are involved. Scenarios do lead to better decisionmaking because they improve the decisionmakers' understanding of the world (Kahane 1991). As such, scenarios could enhance the processes of strategic management, planning and research priority setting in CSIRO. These processes are adaptive in character and well placed to capture possible enhancements.

CSIRO has collaborated with Shell Group Planning in conducting an exercise to apply the scenario method to research organisations (Blyth 1993). This is outlined in the case studies chapter.

### *Determination and Implementation of CSIRO Priority Setting*

The linkage between assessing the future, through the preparation of outlooks and the creation of scenarios, and the process of setting research priorities is also depicted in Box 28. This is a two way linkage as the changing needs of the priorities process will influence the activity of assessing future prospects.

The interplay between the prospective assessment and priority setting activities and external stakeholders are also shown as two way interactions.

By maximising its research effort for national benefit, CSIRO will expand its sphere of influence and, as such, increase the contribution it makes to assisting Australia handle the challenges of the 1990s and beyond.

### ***Involvement of CSIRO's External Stakeholders***

The CSIRO priority setting process is also applied at group, class and even finer levels of disaggregation. Scenario building conducted at any particular level would benefit from scenarios created at higher levels of aggregation. Re-creating scenarios at any particular level would also benefit from the existence of scenarios at lower levels of aggregation.

Effective integration of top-down and bottom-up scenario building efforts could play a major role in maximising the contributions to CSIRO of the advisory committees which support all levels of management in CSIRO. This in turn could enhance the influence of advisory committee members on Australia's science and technology system. Conceivably this 'second order' effect could be as powerful as CSIRO's direct impact on its goal of giving Australian's a better future.

### ***Evaluation of the Impacts***

The main feedback loop in Box 28 indicates that systematic appraisal of CSIRO's future prospects would need to draw on evaluations of its performance. This might range from the broad brush evaluation by the Board referred to above or to a synthesis of performance against the detailed planned outcomes set out each year in the *CSIRO Operational Plan*. This is elaborated on in the chapter dealing with the implementation stage of the priorities process.

Even more detailed levels of evaluation could result from syntheses of the outcomes of project level priority setting or the results of retrospective benefit-cost analysis of all CSIRO projects. The case for project level priority setting is made in the chapter on case studies. Since the establishment of the CSIRO Board increasing efforts have been made by many Divisions to conduct analyses of the benefits and costs of their research programs and projects. Reports on significant efforts to do this include *Rural Research - The Pay-Off* (Johnston et al 1992) and *Environmental Research - The Pay-Off* (Carter and Young 1993).

Perhaps the most comprehensive form of prospective assessment would be achieved from synthesising the results of prospective benefit-cost analyses of all of CSIRO's programs and projects. This would be the ultimate 'bottom-up' approach to prospective assessment. However, this process of synthesis would benefit from the simultaneous conduct of an essentially top-down approach to prospective assessment by approaches such as scenario building.

### **Contribution of Scenario Building and Benefit-Cost Analysis to Research Priority Setting**

CSIRO has actively explored the potential of scenario building as an aid to improving the quality of the top-down performance of its priority setting process. At the same time extensive application throughout the organisation of benefit-cost analysis to the

prospective appraisal of research programs and projects is enhancing the quality of the bottom-up performance.

***A Comparison of Scenario Building Approaches Assessed by CSIRO and their Contribution to Research Priority Setting***

Two types of approaches to building scenarios have been explored by CSIRO: intuitive logics developed by Royal Dutch/Shell and cross-impact analysis applied by Battelle. These and other approaches are compared in detail by Huss and Honton (1987).

The approaches have some common elements and some distinct differences. Interaction with the critical decision makers through workshop participation and interviews is common to both, although there is more of this in the intuitive logics approach. The role of specialist analysts is also common probably with a greater contribution in the cross-impact approach. Differences largely relate to the framework for developing the scenarios. Intuitive logics is highly interactive and allows construction of scenarios which are consistent with the needs and culture of the organisation and which show the pathway from the present to the future. Cross-impact analysis on the other hand, is a more quantitative approach based on the probabilities of outcomes, and is focused on the state of the environment at the end of the scenario horizon.

The intuitive logics approach was developed by Royal Dutch/Shell (see Wack 1985a, 1985b) and is also practiced by SRI International and the Global Business Network (GBN). The main steps in the approach are set out in Box 34.

**Box 34: Scenario Building by Intuitive Logics**

The desire to give greater realism to qualitative forecasts by taking account of the interrelationships between key events lead to the development of cross-impact analysis. One of the most popular of these is the approach developed and practiced by the laboratories of the Battelle Memorial Institute, known as BASICS (Battelle Scenario Inputs to Corporate Strategies). There are seven steps which make up the BASICS approach as set out in Box 35.

**Box 35: Scenario Building by Cross-Impact Analysis**

A comparative overview of these approaches and the ways in which they complement CSIRO's priority setting approach is outlined in Box 36.

**Box 36: Scenario Building and Priority Setting**

Advantages of the cross impact approach noted by Huss and Honton (1987, p. 28) include the generation of a distribution of scenarios based on consistency and relative likelihood of occurrence. Furthermore, they claim that by using ranges of key variables and uncertain events, greater flexibility as well as a broader set of outcomes is achieved. The availability of software such as Battelle's BASICS, is also considered to be a further advantage to the approach.

Selection of the most appropriate scenario approach should be made in light of the culture of the organisation, including such aspects as existing strategic planning processes, resources available for strategic analysis and planning, management style, and the structure of the organisation. The nature of the particular focus of the scenario analysis may also be relevant to the choice of method.

Regardless of the particular scenario building method used, there are a number of common steps in the process. These are:

- Agree the scenario issue or topic and the scenario time horizon and other relevant aspects of focus.
- Identify and describe the key drivers or variables in the business environment.
- Rank/analyse the variables and select the key drivers - the critical uncertainties.

These stages are usually completed within workshops and/or with the aid of interviews with key managers and relevant experts, supplemented by analysis and review by the scenario analysts. Once the key variables or descriptors have been identified, the methods differ in how the scenarios are created. The Shell approach to building focused scenarios for example, proceeds to the scenario logics, beginning with the creation of story lines from the key variables. From the story lines, themes are discerned which form the basis of the scenarios. Before the scenarios are accepted they are subject to extensive testing and analysis. They are not finalised until the logic of each scenario is water tight. The Battelle approach, on the other hand, proceeds to assign probabilities to the states of each key variable and then to the determination of the cross impacts. These data are fed into Battelle's BASICS program and the scenarios are generated. Examples of the intuitive logics approach used by Shell and the cross impacts approach used by Battelle are provided in Blyth and Young (1994).

Blyth and Young (1994) also articulated the pointers set out in Box 37 for introducing scenarios into organisations.

**Box 37: Some Pointers for Introducing Scenario Building**

***A Comparison of Priority Setting and Benefit-Cost Analysis Approaches Used by CSIRO***

There is substantial bottom-up input into CSIRO's corporate research priorities process, particularly in the implementation phase. Furthermore, priorities exercises have been conducted at many levels beyond the corporate level, ranging from Institute, through

Divisions, down to individual programs and projects. As a consequence assessments at any level will benefit from an increasing quality of input from the level below. To improve the quality of inputs from the research program and project level, CSIRO is making increasingly effective use of benefit-cost analysis methods (Blyth, MacRae and Young 1991).

In the preparatory stage for the second review of CSIRO's research priorities, the Bureau of Industry Economics was commissioned to conduct benefit-cost analyses of four research projects of the CSIRO Institute of Industrial Technologies and the CSIRO Institute of Information Science and Engineering (BIE 1992). The resulting report also explored the relationship of benefit-cost analysis to CSIRO's priority setting framework.

The BIE concluded that "formal quantitative cost-benefit analysis is best applied when its informational requirements can be met - that is at a late stage of research when more detailed analysis is needed to support investment. It would be least suited for identification of broad areas of research opportunity or initial screening of early research proposals, (BIE 1992, p24) which is the proper role of the CSIRO priorities assessment framework. The BIE further concluded that cost-benefit analysis and the CSIRO priorities assessment framework have the potential to complement each other, first in setting broad strategic directions for R&D and secondly in ranking and evaluating specific R&D projects BIE (1992, p30). A summary comparison of the two approaches based on the BIE assessment is shown in Box 38.

**Box 38: Comparison of Benefit-Cost Analysis and the CSIRO's Research Priority Setting Process**

## **PREPARATORY STAGE**

### **Appraisal of Process Suitability**

Appraising the suitability of CSIRO's framework for setting research priorities, generally takes the form of an 'interactive-briefing' for the most senior decision makers of the research organisation considering the adoption and adaptation of the framework. The briefing is generally provided by one or two planners with experience in overseeing adaptation for other clients. This is done with a view to stimulating decision makers to discuss in a preliminary way which the elements of the framework are appropriate and which need to be adapted. Charts and graphic displays are used to facilitate this dialogue. Examples are provided in the Appendix: View Graphs Illustrating Research Priority Setting Process.

The significance of reaching agreement among the decision makers on the focus for the priorities exercise is emphasised. Often research priorities will be determined within the context of an organisational vision or agreed strategic directions.

The linkage between the agreed focus and the purposes for conducting research is discussed. Reaching agreement on the classification of the research purposes to be prioritised is a non trivial task. The issues involved need to be brought out for early discussion and decision, generally at the first workshop to decide on the design of the process which is likely to best suit the organisation.

Stress is always placed on the critical need for the chief executive of the organisation to take the leading role in the process of adoption and adaptation. Also discussed is the issue of who should participate in the process. What are the pro and con of involving external stakeholders?

The interactive-briefing session would usually reach agreement on the stages and steps to follow and on an indicative timetable for establishing the process.

### **Agreement on Design of Process**

This step might be conducted as a series of meetings among the likely core participants convened by the chief executive and/or a priorities scoping workshop chaired by the chief executive. The issues to be resolved, as identified in the interactive-briefing, are as follows:

- Determination of the focus for setting research priorities, with reference to how this should be linked to the context of an organisation's vision or strategic directions.
- Agreement on the classification of the research purposes to be prioritised, with reference to how this should be linked to the focus for priority setting.
- Agreement on the elements of the framework for prioritising the research purposes.
- Agreement on who should participate in the process and whether external stakeholders should be involved.

The first these issues is considered in the 'Vision Focus' section in the last chapter. The following section provides a comprehensive account of the issue to be resolve in reaching agreement on a classification of resarch purposes.

Several subsequent sections consider various aspects of each element of the framework for determining priorities. The main task is generally one of adapting the *attractiveness* and *feasibility* criteria to the organisation and its agreed focus for priority setting. A good deal of thought also needs to go into formulating the *key discriminant questions* characterising each of the criteria. One approach is to invite speakers to lead the discussion on appropriate questions. This was used to good effect in scoping workshops conducted by the Sydney Water Board and CSIR India as described in the case studies chapter. This then leads to reaching agreement on:

- The data (generally in the form of key statistics or indicators and or relevant assessments) required in relation each *key discriminant question*.
- The components of the *data sheet* and *evaluation sheet* to be prepared for each research purpose.
- The components of the *role statement* for each research purpose.
- The procedures for scoring each criterion for each research purpose.
- The spokesperson or 'champion' for each research purpose, generally from among the core participants.

By this stage the core participants are in a position to determine the composition of internal and external stakeholders who should participate in the determination of the organisation's research priorities. establishment and application of priority setting and then draw up a list of invitees.

Finally agreement would be reached on tasks to be allocated to the chief executive, the research purpose 'champions', and staff supporting the establishment of the priority setting process. A timetable for the completion of these tasks would also be agreed.

This step would conclude by inviting and briefing internal and external participants. In CSIRO's case, the advisory committees to the Institutes and Divisions often complement the core participants in the team effort required to successfully establish the process. The CSIRO Board plays an active role in guiding the application of the process for CSIRO as a whole.

### **Compilation and Synthesis of Inputs**

The compilation and synthesis of inputs is the most time consuming task in the process of setting priorities. For CSIRO the focus is on preparing the data sheets (see Box 15) and evaluation sheets (see Box 16) for each research purpose and the *CSIRO Research Priorities Data Compendium* (Box 17 provides the contents list).

Planning staff supporting the participants meet frequently to assess progress in the preparation of the data and evaluation sheets. During this period many cross-sectoral and sectoral priorities exercises are conducted. The inputs to and results from these exercises influence the preparation of the data and evaluation sheets. Some of these exercises are outlined in the case studies chapter.

The planning staff supporting the chief executive prepare the *Compendium*. In addition to the wealth of external data and information, this compendium provides past and current profiles of the level of the research effort for each research purpose. Also highlighted is the influence on these profiles of past decisions on research priorities.



## Identification and Assessment of Challenges

The identification and assessment of challenges facing the research organisation is the most challenging but potentially most rewarding task in strategic planning and priority setting. Approaches to prospective assessment, such as scenario building by Shell, can be used to facilitate the collective involvement of the participants in the priorities process in the conduct of this task. However, this is a major undertaking which judging by the Shell experience may take several years to establish in an organisation.

As steps in this direction, CSIRO conducted two preparatory workshops in the lead up to its second priorities workshop.

The first, involving the members of the CSIRO Board, supported by McKinsey and Company, was a three day workshop conducted some nine months prior to the priorities workshop. The focus was on evaluating progress towards the challenges identified some five years earlier and identifying a new set of challenges for the next five years and beyond. The results obtained and methodology used are outlined in Box 29 and Box 30 respectively.

The second, involving members of the CSIRO Board, the corporate executive group and three guest speakers, was a one day workshop conducted six weeks prior to the priorities workshop. Three guest speakers participated in the first half of this workshop. Highlights of their presentations on Australia's global and Asia context and implications for CSIRO are provided in Boxes 31, 32, and 33. At the outset of the subsequent discussion, the chairman likened the task of the workshop to the challenge articulated by Abraham Lincoln in his annual message to the United States Congress exhorting its members to join him in a united venture to be conducted by the executive and legislative branches of government December 1, 1862:

*Still the question recurs "can we do better?". The dogmas of the quiet past are inadequate to the stormy present. The occasion is piled high with difficulty, and we must rise with the occasion. As our case is new, so we must think anew, and act anew.*

She then interpreted the findings of the Board's workshop in the light of the insights generated by the guest speakers. Corporate executive group members who served as research purpose 'champions' then led the discussion by presenting the broad case for the research purpose, also relative to the insights stimulated by the guest speakers. The chief executive summed up the main outcomes of the workshop as follows:

- A shared perspective on key issues and challenges facing Australia and related strategic opportunities for research over the next decade and beyond.
- An increased focus on linkages with the receptors and users of CSIRO's research.
- An increased focus on the strategies for building the skills base to better establish and harness these linkages.

The first outcome influenced the final set of key issues briefs provided in the *Compendium* and the content of the data sheets and evaluation sheets for the research purposes. The linkages between the second and third outcomes and the existing priorities process as it had developed to that stage are depicted in Box 39. The left side

of this graphic display indicates the extent of process development at that stage. The central and right hand sides correspond to the second and third outcomes. While the linkages with receptors and users and the corresponding skills required to build these linkages had been to the fore of strategic management in CSIRO, it was now to become the primary focus of the strategic planning and priority setting effort. It provided the driving logic for the final preparations and conduct of the priorities workshop.

**Box 39: Extending the Scope of the Priority Setting Process**

### **Assessment of Inputs**

The challenge in this step is not only to source high quality inputs but to ensure the participants are collectively involved in the evaluation of this quality and as a group absorb the trends and insights embodied in the total 'data set' underlying the process of reviewing priorities.

Immediately following the workshop for members of the Board and the corporate executive group the latter continued on into a two day workshop designed to evaluate the quality of and progress made in the preparation of the data and evaluation sheets and to report on the contributions to this from sectoral priorities workshops led by corporate executive group members. Consideration was also given to the contents of the *Compendium*. This was the final corporate assessment of the compilation and synthesis of inputs to this review of priorities.

A workshop, conducted by the CSIRO Agricultural Sector Advisory Committee, culminated the process of a multi-sector review of CSIRO's agriculture and environment research priorities. Held about half way between the final preparatory workshop and the corporate priorities workshop, it covered the research of both of CSIRO's rural research, the Institute for Animal Production & Processing and the Institute for Plant Production & Processing, and the inputs to rural research from other institutes, particularly the CSIRO Institute of Natural Resources and Environment. It involved many external stakeholders and a member of the CSIRO Board. This workshop and other sectoral workshops conducted earlier had a strong bearing on the final content of the data and evaluation sheets.

### **Completion of Inputs**

All inputs are finalised about two weeks prior to the priorities workshop to provide the basis for the next step of assessing priorities 'out-of-session'.

For CSIRO this involves completing the inputs to and finalising the compilation of the *SEO Sub-Division Data and Evaluation Sheets* and the *CSIRO Research Priorities Data Compendium*.

## Preparation of Preliminary Priority Assessments

This step involves the preliminary assessment of priorities by the participants in the process. Participants are assisted in this task by receiving an account of the current research profile - showing the distribution of the organisation's research effort by research purpose - data sheets, evaluation sheets, scoring sheets, and instructions to all participants about two weeks prior to the final priorities workshop.

In CSIRO's case, corporate executive group members were provided a guide to out-of-session scoring in a booklet referred to as *Individual SEO Sub-division Score Sheets and Scoring Procedures* (1993d) two weeks before the Priorities Workshop. This document together with the *Compendium* and *SEO Sub-division Data and Evaluation Sheets*, which had been circulated two weeks earlier, assisted corporate executive group members to determine their priorities scores out-of-session. The booklet consisted of a proforma for each research purpose (SEO sub-division) which provided a means of recording a score between 1 and 10 for each of the four priorities criteria and alongside these scores setting out the accompanying **reasons** for the estimates made as shown in Box 40.

### Box 40: Example of a Research Purpose Scoring Sheet

This booklet also provided detailed guidelines on scoring procedures, the key discriminant questions, the final CSIRO classification of research purposes down to SEO class level, the group average scores for each criterion for each research purpose for the priorities review three years earlier, the return-on-R&D to Australia screen display of these scores, and instructions on how these scores would be processed and circulated to corporate executive group members prior to the priorities workshop. These instructions also explained how the processed scores would be used at the outset of the priorities workshop.

After recording their score for each criterion for each research purpose each participant then transcribed all of their scores onto the summary score sheet shown in Box 41.

### Box 41: Summary Score Sheet of the Priority Setting Process

These sheets were processed by planning support staff. The group average scores were used to identify outlier scores and to produce the returns-on-R&D to Australia screen and other subsidiary screens. Comparisons with the final screens generated by the previous priorities review were also prepared. One week before the priorities workshop all participants were provided with an account of the scores of all other participants with outliers identified. They were also given the various screens and requested to use the scoring proforma to record further **reasons** and note **questions** pertaining to their own and the other participants' outlier scores as shown in Box 40.

## Preparation of Preliminary Draft Role Statements

The final step before the priorities workshop is to prepare preliminary draft versions of the role statement for each research purpose according to SEO-subdivisions in CSIRO's case.

The role statements are a major product of the research priority setting process. Each statement provides a **national perspective** covering:

- Definition and description of the research purpose.
- Rationale for the national priority rating assigned.
- National R&D context, including the identification of areas for national R&D emphasis.

The subject matter of the first and third items is contained in the data and evaluation sheets for the research purpose and can be provided in first draft form as briefing for participants in the priorities workshop. The third item is formulated during the priorities workshop in the form of a draft statement of the organisation's rationale for the national priority rating assigned to the research purpose. The final reasoning for the group average scores for each of the four priorities criteria are agreed by all participants as a major outcome of the workshop.

The role statement also provides the **organisation's response** relative to the national perspective covering:

- The organisation's contribution to national R&D.
- The organisation's decision on the priority rating.
- The organisation's strategy for the research purpose.
- Priority areas of research.
- Potential outcomes from the research effort covered by the research purpose.

The subject matter of the first and to a limited extent the third, fourth and fifth items is also contained in the data and evaluation sheets for the research purpose. The second item is formulated during the priorities workshop as a draft statement of the decision on the direction of shift in resources towards the research effort covered by the research purpose.

All eight items in the role statement undergo assessment and revision during the implementation stage of the process. An example of a completed role statement is provided in the chapter on the implementation stage.

## Input Documents to the Priorities Process

To recap, substantial documentation supports the participants in the priorities workshop. In CSIRO's case its second review involved the preparation of the following inputs:

- *Science & Innovation*, Discussion Notes from the CSIRO Board Workshop.
- *CSIRO Research Classification*.
- *Proceedings of the Chief Executive's Retreat*.
- *SEO Sub-division Data and Evaluation Sheets*.
- *CSIRO Research Priorities Data Compendium 1993*.

- *Individual SEO Sub-division Score Sheets and Scoring Procedures.*

The title pages of these documents are shown in Box 42.

**Box 42: Key Documents Prepared as Inputs to the Priorities Process**

## **DETERMINATION STAGE: CONDUCT OF PRIORITIES WORKSHOP**

Priorities workshops are generally conducted over a period of one to three days. In CSIRO's case three days are required.

### **Preview of Workshop Agenda and Outcomes**

The workshop opens by previewing the agenda and the following expected outcomes:

- Discussion of results of pre-workshop scores, focusing on outliers.
- Amendment of pre-workshop scores.
- Generation and discussion of revised attractiveness and feasibility charts for national R&D priorities.
- Agreement on reasons supporting average scores for the four priorities criteria underlying the determination of national R&D priorities.
- Assessment of receptor/user linkages and skills/discipline base.
- Agreement on draft statement of decisions on the direction of broad shifts in the organisation's resources between research purposes.
- Agreement on indicative magnitude of shifts.
- Agreement on extended draft role statement for each research purpose.
- Agreement on schedule for implementation stage.

### **Review and Amendment of Pre-Workshop Scores**

The next step in the workshop is to appraise the pre-workshop scores for each of the four criteria for each research purpose in turn. To assist in this, the research purpose 'champions' provide an overview of 'their' research purposes at the outset of considering the scores corresponding to a particular criterion.

Following these brief presentations the workshop chairman works systematically through the pre-workshop scores of participants focusing on scores which are two or more above or below the group average. The resulting discussion of outlier scores draws on the reasons and questions noted by participants in their own copy of the score sheets for each research purpose. Reasons would generally focus on a participant's case for their outlier scores, brought to their attention prior to the workshop. Questions would generally be noted in relation to the other participant's outlier scores, also brought to their attention prior to the workshop. This procedure generally precipitates lively discussions, often leading to new ways of looking at the prospects for research purposes in relation to one or more of the priorities criteria. As another means of stimulating these outcomes, CSIRO also provides participants on-line access to the Executive Information System. The capacity to drill down to SEO group and class level data for any particular research purpose at any time can often add substance to a line of inquiry a participant may wish to pursue during these discussions.

In some cases it may be appropriate for the workshop chairman to keep his or her own pre-workshop scores to themselves and provide their final score only following the workshop discussion of each outlier score or scores (where more than one participant has an outlier score) and once participants have settled on their own final score. This is the case in CSIRO where the chairman is the chief executive.

Once discussion of a particular outlier is completed the chairman invites all participants to change their pre-workshop score if they wish. Also after each such discussion participants and planning staff supporting the workshop would finalise their notes on issues and insights raised for possible use in the drafting tasks to be undertaken in the subsequent steps of the workshop.

### **Generation and Review of Revised Attractiveness-Feasibility Screens**

Once all outlier scores have been review and revised by participants it is possible to move quickly to plots of the group average score for each research purpose on screens for attractiveness using the axis for 'potential benefits' and the 'ability to capture these benefits', feasibility with axis for 'R&D potential' and 'R&D capacity', and the composite axis of attractiveness-feasibility representing the 'Return-on-R&D to Australia' and depicting a view of the nation's R&D priorities.

These screens are then examined carefully by the group of participants and conclusions drawn along the lines depicted in Boxes 13 and 14 and explained in the section 'combining criteria in overall judgement of the return-on-R&D' of the methodology chapter.

This discussion can also be supported by providing computer-based, on-line comparisons of the new priority screens with the priority screens from the last review of research priorities. In CSIRO's case this comparison was facilitated by showing both sets of scores on the same screen. As shown in Box 43 this allowed a quick check on the direction and magnitude of the shift in CSIRO's view of national research priorities between 1990 and 1993.

#### **Box 43: Return-on-R&D to Australia, 1990 and 1993**

### **Agreement on Rationale for National R&D Priorities Scores**

At this point of the workshop participants formed syndicates of two, assisted by planning support staff, to formulate in the reasoning underlying the whole group's agreement on the national R&D priorities. This involved providing reasons for the group score for each of the four priorities criteria for each research purpose.

The formulation of reasons also draws on the pre-prepared draft role statements, other briefing materials participants brought to the workshop and the various input documents prepared in the lead up to the workshop.

Agreement on a set of draft reasons is then reached in a plenary session of the group of participants. This in turn provides the basis for completing the national perspective section of the draft role statements.

## **Assessment of Receptor/User Linkages and Skills/Discipline Base**

The next two sessions of the CSIRO's priorities workshop sought to assess, firstly, the linkages between CSIRO and its receptors and users and, secondly, the critical shifts in the mix of skills and disciplines required to maximise the benefits of these linkages. This focus was prescribed as a major outcome of the preparatory workshop convened by the chief executive, described in the previous chapter and illustrated in Box 39. As a result the planning staff supporting the chief executive compiled data and drew on existing national and sectoral assessments relevant to these topics. This was used by two of the participants as a basis for presentations to the group as a whole. These presenters had corporate responsibility for R&D commercialisation and human resource management.

The main findings of these two sessions are summarised in Boxes 44 and 45.

### **Box 44: Receptor/User Linkages**

### **Box 45: R&D Capacity - Meeting Human Resource Needs**

## **Agreement on Scale of Resource Shifts**

As noted in the methodology chapter, the process of assessing national research priorities generates a two dimensional ordering of the research priorities for Australia as a whole. However, it does not provide any automatic decision tool for determining how much should be invested in each research purpose, either in absolute or relative terms. While it provides a measure of what the balance should be, a high priority rating on the screen does not automatically imply the need for or expectation of additional funding at either the national or CSIRO level. Subsequent reference to what the balance actually is at the national level points, in a qualitative fashion at least, to where funding levels might be adjusted.

This step of the workshop involves participants in what is essentially a qualitative approach to considering the direction and extent of the shifts in resources between research purposes. The agreement on national research priorities is considered in the light of the following additional factors:

- The relative R&D capacity of CSIRO and other research performers in the research purpose.
- The extent to which research for a particular purpose, however desirable it might be nationally, should be publicly supported having regard to the extent to which the potential benefits are appropriable by individual beneficiaries.

Acting on the basis that the national ratings for 'potential benefits', 'ability to capture' and 'R&D potential' would be equally valid for CSIRO, the group focussed on



differentiating between the national 'R&D capacity' and CSIRO's 'R&D capacity' for each research purpose.

The result of these deliberations allowed the chief executive to express his initial views on the broad direction of shifts in CSIRO's resources for each research purpose. This was then discussed before he finalised his view on the broad shifts he would subsequently recommend to the CSIRO Board.

#### **Agreement on Draft Priorities Decisions**

Once again participants formed syndicates of two to prepare the first draft text supporting the decisions on the broad shift in resources between the research purposes that had emerged in the previous session. These carefully crafted statements on the group's decisions draw on the results of earlier deliberations and the various inputs to the workshop.

Agreement on the wording of draft decisions for the research purposes is then reached in a plenary session of the group of participants. This the main outcome from the workshop. In CSIRO's case, it becomes the key piece in the subsequent interactive briefing and decision-making meeting with the Board held soon after the workshop. The draft decisions reached by CSIRO in its 1993 review are shown in Box 46.

#### **Box 46: Priorities Decisions, 1994-95 to 1996-97**

#### **Agreement on First Draft Role Statements**

Given agreement on the priorities decisions participants are then in a position to work on the completion of the first draft role statements. By this stage the focus is on extending preliminary drafts of the sections dealing with strategy, priority areas, and potential outcomes for each research purpose. This involves a fair bit of effort and once again syndicates of two participants are formed. Each syndicate covers a number of research purposes with participants generally working on the research purposes for which they have management responsibility or a close familiarity.

An example of a role statement for the CSIRO research purpose on the Information and Communication Industries is shown in Box 47. As it happens this statement benefited to some degree from the post-workshop feedback which occurred during the implementation stage considered in the next chapter.

#### **Box 47: Example of a Draft CSIRO Role Statement**

### **Agreement on Schedule for Implementation Stage**

In CSIRO's case the priorities workshop concludes by considering the schedule for the appraisal of the workshop outcomes by the Board and management teams in all CSIRO divisions, and in many cases by multi-divisional teams, as described in the next chapter on the implementation stage. The CSIRO schedule as agreed at its 1993 priorities workshop is shown in Box 48.

**Box 48: Example of a Schedule for Implementation of Research Priorities**

## IMPLEMENTATION STAGE

This chapter provides details of that part of the priorities process concerned with the activities involved in implementing the preliminary determination of priorities for the organisation. It begins with an overview of those activities before focusing on the objective and principles governing implementation. A full account is then provided of the activities involved each step. As indicated in Box 48, the schedule for the implementation of the Boards decisions on research priorities involves undertaking the following steps:

- Board Agreement on First Draft Role Statements and Priorities Fund.
- Board Agreement on Shifts in Appropriation Funds and Draft Role Statements.
- Bottom-up Feedback on Role Statements.
- Determination of Priority Research Programs.
- Board Agreement on Role Statements and Portfolio of Research Programs.
- Preparation of Strategic Plan.
- Annual Evaluation of Performance.

The following overview provides the context for these steps.

### Overview

The implementation of funding decisions presents a challenge equal to that involved in their formulation. To meet its particular circumstances, CSIRO has chosen to develop a funding process which will improve its capacity to transfer resources from lower to higher priority areas at all levels, consistent with the role statements agreed by the corporate executive group for each research purpose.

A target research profile for the organisation's research purposes is developed by the corporate executive group for decision by the Board. After comparing the target research profile with the existing distribution of effort, the Board decided on a level of change under the mechanism necessary to meet the target. This level was set at about 3% of CSIRO's appropriation funds for the 1990 and 1993 reviews of research priorities.

The actual change is effected through the specification of proposals by management teams in all divisions of the organisation of new and strengthened programs in the priority areas of the research purposes. These proposals, which generally involve a number of divisions and institutes, are presented to the corporate executive group by the priorities workshop participant responsible for the research purpose in question. The corporate executive group will determine which initiatives should be recommended to the Board for consideration and subsequent decision, having particular regard to their contribution to achieving the target research profile.

The implementation process for the first triennium was based on an across-the-board levy (*with limited exemptions*) and redistribution of appropriation funds to selected priority areas. The process facilitated collaboration across the organisation through brokering and advocacy of research proposals. Multi-Divisional Programs, where they clearly add value, are an effective means of optimising the research attack on major problems and opportunities.

The process is self-financing in part through the creation of a central fund for priorities operating at a level of change agreed by the Board on a recommendation of the chief executive for allocation to successful research proposals. For CSIRO the level of change was set at about 1.5% of appropriation in the first and second triennial reviews. In addition, institutes are requested to identify matching funds (i.e., equivalent to the level priorities funding attracted) to be redirected from lower priority areas to the new initiatives. This device ensures that attention is paid to selectivity even in those areas receiving net funding increases through the operation of the priorities funding process.

The process for implementing research priorities has helped facilitate collaboration across the organisation through brokering and advocacy of research proposals.

The proposed operation of the process is described in the following.

### **Objective and Principles of the Implementation Process**

It is essential that national research organisations change the balance of their appropriation resources between research purposes in accordance with changing national needs in a planned and measured way. Formal consideration of *attractiveness* and *feasibility* criteria has become the standard methodology used by CSIRO for assessing the relative priority of research purposes.

However, CSIRO's experience with implementing the priorities determined in the review corresponding to the organisations move from annual to triennial funding led to the identification of substantial improvements. The process of implementation needs to be administratively straight-forward, efficient and consistent to gain commitment and ownership of its results throughout the organisation. To meet these requirements, the process should be based on a clear objective. In CSIRO's case this is

*To allocate funds and resources from a research purpose (based on socio-economic objectives) priorities profile to a line management structure such that the process is owned by managers and that accountability is maintained.*

This objective needs to be applied in relation to an equally clear set of principles. The principles which have evolved as appropriate to CSIRO's administrative systems are set out in Box 49.

#### **Box 49: Principles of the Implementation Process**

### **Board Agreement on First Draft Role Statements and Priorities Fund**

To recap, in CSIRO the Board's involvement in the priorities process is provided in various ways including the following:

- Involvement in examining and suggesting modifications to the analytical framework and conduct of the priorities process, drawing on the Board's leading role in the establishment of the framework and process.
- Provision of comments on the *attractiveness* and *feasibility* of research areas within the expertise of individual Board members in the lead up to the priorities workshop, such as the Board's workshop on challenges described in the preparation stage chapter.
- Assessment of and provision of feedback on the corporate executive group's recommendations from the priorities workshop, including the national research priorities and draft priority decisions and first draft role statements for each research purpose and, as a consequence, changes to the research purpose profile which would result from implementing the decisions.
- Adoption of the final role statements, the potential outcomes from areas of research priority set out in these statements, and the chief executive's recommendations (developed in active collaboration with the organisation's research managers) on the suite of research programs to receive priority funding.

The responsibilities covered in the last two points govern the priorities implementation activities. This step refers to the second last point.

In bringing the priorities recommendations to the Board for initial consideration the chief executive also proposes a proportion of CSIRO's appropriation funds - the 'priorities fund' - which should be held back for central reallocation to high priority areas. Among other things, this approach allows CSIRO to stress to the government that additional recurrent or non-recurrent funding for the second triennium would be committed to the priorities fund for allocation according to the Board's priority decisions.

In CSIRO's case, the amount of funds centrally reallocated between research purposes at the SEO sub-division level is set conservatively by the Board. The organisation's strategic planning, and performance agreements set for members of the corporate executive group are relied upon to achieve the bulk of the change within the institutes and divisions using the Board's decisions and agreed approach to reaching these decisions as a guide. As would be expected, priority setting at the SEO group and class level would inevitably lead to much greater change than at the sub-division level of research purposes.

As well as giving in principle agreement to the priorities fund level the Board also agrees on whether exemptions of particular types of activities will be allowed and whether to apply the requirement for priority funds to be matched. These are described in the following.

#### **Board Agreement on Shifts in Appropriation Funds and Draft Role Statements**

Given the Board's in principle approval of the draft priority decisions and role statements and the priorities fund level, the corporate executive group works on determining the research purpose profile, referred to as the target profile, and the attendant financial implications of the Board's decisions on the priorities fund level, approved exemptions, if any, and matching.

### ***Target Profile***

Acting on the Board's in principle agreement to the priorities decisions and an estimate of the likely level of appropriation funding, changes to the profile of appropriation funds for each research purpose can be projected subject to

- The rules for the classification of research by beneficiaries.
- Exemptions, if any, for national facilities.
- The requirement to match priority allocations to research purposes.

In CSIRO the decision was made by the corporate executive group that all research should be classified by beneficiaries but that it should be restricted as far as practicable to the *main beneficiary* or at least no more than three beneficiaries. This is supported by the use of detailed guidelines on how to classify research in a consistent manner throughout the organisation. This in turn provides a basis for monitoring progress towards meeting the target profile for each research purpose at SEO sub-division level.

In relation to *exemptions*, CSIRO moved from a position in its first triennial review of priorities of allowing exemptions for national facilities maintained and used by the organisation to one of no automatic exemptions in the second review. The previous effect of an exemption was only achieved by an explicit decision of the chief executive to provision such facilities at a level which compensates by the same amount the central allocation of funds to the priorities fund. As a result of this ruling national facilities were free to compete for priority research funds.

*Matching* operates by requiring that the priority funds allocated to a research purpose are matched by all institutes obtaining a share of these funds. This encourages commitment to the process and the outcomes.

In CSIRO it was determined that matching must be at least 50% of the priority funds allocated with 100% being the preferred norm. Departures from this norm are considered by the chief executive based on supporting argument from the member of the corporate executive group designated to play a lead role in relation to the overall allocation of priority funds to a particular research purpose. A further requirement is that at least 50% of matching is to come from outside the research purpose receiving the increased priority funding. Up to 50% may be matched from within the research purpose.

Thus when matching is included the absolute shift to each priority research purpose is between 1.5 and 2 times the absolute amount centrally reallocated to each research purpose less the impact of the central reallocation.

### ***Board Decisions***

In addition to working through the broad allocation of funds to research purposes the corporate executive group is required to obtain feedback within the organisation's institutes on the priorities decisions and the draft role statements.

The Board is then in a position to reach an agreement on the recommended priority decisions. The set of decisions recommended as a result of the second triennium review

is shown in the previous chapter in Box 46. At that point the Board is also able to agree on the current draft role statements for the research purposes with their agreement on the final draft being dependent on:

- Members of the corporate executive group, designated to play a lead role in relation to the allocation of priority funds to any particular research purpose, incorporating inputs from other members of the group with a management interest in the conduct of research for that research purpose.
- The development by 'lead members' of recommendations on the allocation of the priority funds to specific research programs. This is done in active consultation with other interested members and the chief executive if there is a requirement to reach an agreement in any particular instance.

Applying the priorities decisions, as set out in Box 46 (see also the return-on-R&D to Australia screen shown in Box 43), and using an indicative level of change of 1.5% of appropriation funding, with no exemptions, led the corporate executive group to recommend (through the chief executive) an increase in funding of \$1.5 million per annum to the priority research purposes of Mineral Resources, Manufacturing, and Information & Communication. They also recommended an allocation of \$0.5 million per annum for Environmental Knowledge, and Environmental Aspects of Economic Development, approximately the amount required in each case to maintain their current share of appropriation. This resulted in \$5.5 million per annum being held centrally in reserve for the priorities fund.

The Board agreed to these recommendations and made the decision to continue the requirement to match a dollar of priority funding with a further dollar reduction in funding elsewhere. Thus the total research priorities funding for research purposes at the SEO sub-division level could reach a maximum of \$11.0 million per annum. Since change at the SEO sub-division level is likely to be much less than change at the group and class level of the classification of research purposes, the determination of research priorities at these levels will lead to an overall shift in resources from lower to higher priorities many times the \$11.0 million per annum stimulus applied by the Board.

### **Bottom-up Feedback on Role Statements**

To recap the development of role statements by members of the corporate executive group are accomplished in the following stages:

- In the lead up to the priorities workshop first draft versions are prepared covering among other things
  - a description of the research purpose at the SEO sub-division level in terms of the component SEO groups
  - definition of the research purpose as a Socio-Economic Objective
  - draft ideas on CSIRO responses, strategy, and broad directions of strategic research opportunity.
- During the priorities workshop the national priority rating and its rationale is determined for each research purpose and the CSIRO response, strategy and broad directions of strategic research opportunity are drafted.
- Following the priorities workshop the draft role statements are considered by the Board then appraised interactively by the the coporate executive group and chiefs of Divisions before final approval by the Board.

Members of the corporate executive group with line management responsibility for research obtain and incorporate organisation-wide feedback on role statements, including the priority areas of research to be pursued within each research purpose. This includes consultations with other group members as appropriate and with chiefs of divisions to decide on indicative allocations of funds to the priority areas and which divisions will take part in the next step of preparing proposed new research programs for priorities funding.

### **Determination of Priority Research Programs**

Annual, centrally-allocated funds for those research purposes which are to grow or remain constant are allocated in the first instance to the members of the corporate executive group taking the lead for these research purposes. In addition to taking responsibility for reaching an agreement on the priority areas of research to be stressed in the role statement for the research purpose, the lead member has the responsibility for deciding the divisions to take part and an indicative level of funds to be allocated to each priority area.

Lead members are accountable to the chief executive in exercising this responsibility. In doing so they are expected to establish consultative mechanisms with fellow members of the corporate executive group, who in turn will involve division chiefs in advising on the level of funds to be allocated to each priority area. One such mechanism is to convene workshops led by brokers (generally division chiefs) who are given the task of developing the case for each new research program within the priority areas of research. They are also asked to indicate the amount of priority funding required for each program within the indicative level set for the priority area. Brokers will consequently recommend, amongst other things, an allocation of recurrent priority funds to institutes and divisions and matching funds identified at the institute level.

The research program need not be completely new work but the emphasis in activities to be supported with new appropriation funds should be firmly on the need to strengthen long term strategic research capability because of expectations of future pay-off.

Competition among programs and participants at this level will culminate in a research program, often a multi-division program, which is well documented with appropriate arguments supporting the quality of ideas, the practicability of research approaches, the realism and expected value of outcomes, as well as its general attractiveness and feasibility.

Each broker will present a single refined research program plan to the appropriate lead member. The latter, after consultation with his fellow members of the corporate executive group, will in turn recommend the portfolio of programs for the research purpose to the chief executive.

This process is synchronised with the institute/divisional planning cycle. Once the overall portfolio of priority research programs are approved by the Board, individual programs are then managed in the same way as all other research programs in the organisation.



## **Board Agreement on Role Statements and Portfolio of Research Programs**

By the time the chief executive has decided on the final composition of the portfolio of priority research programs to be recommended to the Board, the role statements have undergone considerable further scrutiny and refinement to reach the form shown in the previous chapter in Box 47. One particular challenge in relation to each role statement is to identify and formulate a set of potential outcomes which are visionary, challenging and cover the scope of the research purpose. The potential outcomes are generally 'firmed up' during the formulation of priority research programs corresponding to the priority areas. The chief executive is then in the position to seek the Board's agreement to

- The resulting set of role statements, focussing mainly on the potential outcomes.
- The portfolio of priority research programs.

Given approval by the Board the role statements are compiled into a compendium and made available to stakeholders and individuals and organisations requesting copies. The roles of the organisation's strategic plan and annual operational plan in assessing progress towards the potential outcomes comprise the final two steps of the implementation stage.

### **Preparation of Strategic Plan**

The role statements produced as a result of the first triennial review of research priorities formed the basis for the organisation's strategic plan for the period from 1991-92 to 1995-96.

Following a message from the chairman of the Board and an overview of the plan, the strategic plan provided a distillation of the priorities data and information on challenges and the CSIRO environment into a two page statement comprising a number of graphs of significant trends in global markets, national sectors, and R&D expenditure. This was followed by a two page account of the priorities process and its role in 'driving' the strategic plan.

The core of the plan then followed. This comprised a two page statement for each research purpose. In each case the text covered the context, the corporate goal and strategies grouped according to three of the organisations key performance areas; namely, *research*, *transfer*, and *funding* as shown in Box 50 for the Manufacturing Industries research purpose. A set of planned outcomes over the period of the plan were also provided. These became the potential outcomes referred to above during the process of conducting the second triennial review of research priorities.

The plan concluded with a section on research support. This comprised two page statements for *human resources management*, *communication*, and *corporate development*. These in fact correspond to the other three key performance areas against which CSIRO judges its performance at various levels of the organisation. Each statement comprise a context note, a corporate goal and strategies.

A major organisation-wide effort was made to obtain photographs of the people and technologies of CSIRO in action. These complemented key graphs in bringing to life the message on each two-page opening of the plan.

Since this strategic plan was still current at the time of the second triennial review of research priorities in 1993, the role statements from the latter were used to prepare a report on CSIRO's research priorities and strategies for the period 1994-95 to 1996-97. An extract from this report for the research purpose dealing with Information and Communications Industries shown in Box 51 can be compared with the role statement for the same research purpose provide as an example in Box 47.

### **Annual Evaluation of Performance**

The decisions on centrally reallocated recurrent funds to the research purpose SEO sub-divisions are intended to apply for the whole of the budget triennium. However, given sufficient change in the external environment the priority shifts at this level may be revised at annual intervals by the Board on the recommendation of the corporate executive group.

The research purpose lead members of the group may propose a mixture of recurrent and non-recurrent funding of individual research programs within the recurrent funding envelope. This may involve such arrangements as boosting some programs over time; short term funding of others, deferred commencement etc.

Progress towards meeting the research purpose *planned outcomes* expressed in the *CSIRO Strategic Plan 1994-95 to 1998-99* and the potential outcomes in the report *Research Priorities Strategies 1994-95 to 1996-97* are assessed each year in the *CSIRO Operational Plan*. Details of how this is achieved are contained in the *CSIRO Operational Plan 1994-95* (CSIRO 1994a) and *CSIRO Operational Plan Guidelines 1994-95* (CSIRO 1994b). An outline is provided in the next chapter on evaluation of the process.

## EVALUATION OF THE PROCESS

This chapter will be structured according to the foregoing layout of this report: namely, a general section providing the context of evaluation in CSIRO as a whole; methodology; preparation stage; determination stage; implementation; and a section on the need for the process to adapt. Various existing reports and short papers are relevant as listed below. The text of those marked with an asterisk is set out in the following.

### General

- Strategic Management in CSIRO paper prepared for Australian Public Service's Management Improvement Advisory Committee.
- Towards an Evaluation Strategy for CSIRO.\*
- CSIRO Evaluation Strategy.\*

### Methodology

- Priorities, Priorities, Wherefore art thou .....\*
- The Priorities Process - Some Shortcomings.\*

### Preparation Stage - Determination Stage - Implementation Stage

- Effective Priority Setting for Public Sector Research: CSIRO's Experience.\*

### The Need to Adapt

- Effective Priority Setting for Public Sector Research: CSIRO's Experience.\*
- Three Government inquiries on R&D in Australia that commented on and made recommendations concerning CSIRO's priority setting process.
- Also of relevance is the report of the *Strategic Planning in Australia* project which compared strategic planning in several large Australian companies and public service agencies.

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## Towards an Evaluation Strategy for CSIRO

### What is Evaluation and Why do we Need it?

CSIRO is (or is striving to become) an "outcomes-oriented" organisation. Evaluation is a process in which an organisation focuses on its performance; that is on its achievement of outcomes in the light of its objectives. The purpose of evaluation is to provide information which helps the organisation:

- Set appropriate objectives
- Assess the effectiveness and efficiency of performance
- Identify ways in which future performance can be improved.

CSIRO is also a complex organisation with many objectives at many different levels. An evaluation strategy is needed to provide a coherent framework for the total evaluation effort, to make explicit the need for different types of evaluation and to provide broad guidelines for the conduct of evaluation in CSIRO. (It is not intended that the strategy become a detailed "how to do it" manual).

## **Who are the Customers/Users of Evaluation Information?**

Evaluation is first and foremost an essential management tool, so the primary customers of any evaluation are the managers of the program, process or entity subject to evaluation.

External customers and stakeholders also have an obvious interest in the effectiveness, efficiency and appropriateness of CSIRO's activities (from their own perspectives). Such information is relevant to their decisions to increase or decrease their level of support/funding/commitment/collaboration.

Adoption and implementation of a rigorous evaluation strategy is both a sign of commitment to continual improvement in performance and a means of demonstrating high levels of achievement in an authoritative manner. For these reasons an evaluation strategy is a potentially powerful tool in "marketing" the Organisation to its customers and stakeholders.

## **The Focus of Evaluation**

As noted above the focus of the evaluation process is on the objectives or planned outcomes of the program, process or entity subject to evaluation. There are three key issues:

- **Effectiveness:** the extent to which a program's outcomes achieve its stated objectives. Key elements include identifying internal and external factors affecting achievement of outcomes and identifying unanticipated outcomes.
- **Efficiency:** concerned with the cost of achieving objectives. Key elements include establishing whether benefits exceed costs and whether the same benefits could be achieved at less cost.
- **Appropriateness:** Appropriateness has to do with the "worthiness" of the program's objectives, even in the event that it may be both effective and efficient. Key elements include whether the program addresses the needs of clients and the alignment of its objectives with government goals and organisational priorities.
- **Types of Evaluation (Components of an overall evaluation strategy).**
- **'Macro level':** main focus on "appropriateness" and potential (net) benefit; priority setting; SEO sub-division, regional or business area analysis.
- **Program/Project level:** ex-ante (prospective); ex-post (retrospective); focus on effectiveness and efficiency as well as appropriateness; research and non-research coverage (eg human resources or intellectual property management).
- **Monitoring:** continual process of evaluation; measurement analysis of performance indicators and benchmarking studies
- **Audit:** integration of CSIRO Strategic and Tactical Audit plans into overall evaluation strategy.

## **Other Issues**

- **Evaluation Cycle/Synchronisation of Effort:** Evaluation is an important component of the proposed annual business performance review. Effort needs to be timed accordingly. Documentation and process for the review both need to strike a balance between assessment of past performance and evaluation of future opportunities.

- CSIRO strategy also needs to meet requirements and timing imposed by DIST/Department of Finance (Portfolio Evaluation Plan)
- Potential contribution to Budget process is also a consideration.
- External Involvement: The question of who performs an evaluation is an important one. The need for an independent view (eg an external consultant) should be considered in appropriate cases. Existing advisory committees may often be an appropriate source of input.
- Quantative versus Qualitative Evaluation: In almost all cases, evaluation will should include a significant qualitative component. It must also be remembered that even the hardest of hard data is not "value free".
- Methodology: There are many evaluation tools of which formal cost-benefit analysis is one of the better known (and most abused). The Department of Finance publication "Doing Evaluations: A Practical Guide" is recommended as an overview on good evaluation practice. Advice and technical assistance should be sought as necessary in the design and conduct of evaluations. The Strategic Planning and Evaluation Group, private consultants and the Department of Finance are all potential sources.

### **CSIRO Evaluation Practices**

It may be helpful to include a section which highlights (perhaps by example) the range of evaluation activity undertaken in CStRO. For example, from the priorities process at Corporate, Institute and Divisional levels, through II~s project and program reviews, formal MDP procedures and the Audit program to leer review of projects and individual publications. This could also serve to highlight any particular gaps or inconsistencies, with suggestions for integration into a coherent but flexible strategy.

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## **CSIRO Evaluation Strategy**

CSIRO's research priorities are established on the basis of anticipated "returns to Australia", derived from comprehensive assessments of the attractiveness and feasibility of conducting research directed to identified socio-economic objectives. These assessments form the basis for CSIRO's strategic and operational planning. Evaluation activity is consequently focused on CSIRO's performance in achieving planned outcomes in relation to these socio-economic objectives. A complementary perspective is provided by additional assessments of performance conducted and reported by management unit.

Evaluation activity spans each of the six key areas in which CSIRO gauges its performance - research, commercialisation and transfer, flinding, human resource management, cotutnunication and corporate development.

The key elements of CSIRO's current evaluation strategy are described below. Following observations on CSIRO's program evaluation activity by the Australian National Audit Office in Audit Rcpont No 35, 1992-93 *Program evaluation: strategies. practices and impacts*. CSIRO is endeavoring to establish a more coherent evaluation strategy and more consistent reporting of evaluation activities in key planning documents.

## **Evaluation Plans**

The most comprehensive record of CSIRO's program evaluation activity is found in the CSIRO Evaluation Plan. It describes evaluations completed by each Institute in the current year and those planned for the next two to three years. Major evaluations - those of portfolio significance or potential interest to the Minister - are also reported in the annual Portfolio Evaluation Plan compiled by the Department of Industry, Technology and Regional Development.

## **Program Performance Statement**

An overview of the performance of CSIRO's research effort is provided in the contribution CSIRO makes to the annual Portfolio Program Performance Statement (PPS) tabled in Parliament as a budget related paper. The PPS focuses on the outcomes (and planned outcomes) of research targeted to particular socio-economic objectives.

## **Operational Plans and Performance Reports**

The annual CSIRO Operational Plan, and Institute and Divisional Operational Plans, are not strictly evaluation documents. Nevertheless, planned outcomes which are focused on program evaluation are included and identified as such in the CSIRO Operational Plan. In many cases performance reports are prepared using operational plans as the documentary basis for evaluation of progress toward planned outcomes. Practice varies between Institute and Division but all are subject to some form of regular performance evaluation encompassing at least the six key performance areas noted above.

## **Corporate Audit Group**

The Corporate Audit Group conducts a program of management reviews in CSIRO's administrative units and risk-based reviews of administrative functions. Details of the review cycle are set out in a three-yearly Strategic Audit Plan and updated annually to reflect current concerns in the Tactical Audit Plan.

## **Individual Performance**

CSIRO's Performance, Planning and Evaluation (PPE) Scheme involves all staff in evaluating their work performance against agreed objectives and milestones.

## **Methods of Evaluation**

*Attractiveness-Feasibility Assessment:* This method is covered in detail in the priority setting module of this course.

*Goals-Achievement Matrix:* The goals-achievement matrix is a qualitative evaluation technique. It is useful for contrasting alternative projects at the selection stage as well as for monitoring and ex-post evaluation of individual projects.

*Planning Balance Sheet:* This is a semi-quantitative approach to project evaluation. The technique is drawn from town planning but may be adapted to the R&D context.

Essentially, the balance sheet consists of a list of potential gains/advantages/benefits on one side and a list of losses/disadvantages/costs on the other. Where possible the size of an effect is indicated (for example,+++ or --) as is the sector or group on which the impact falls.

*Cost-Benefit Analysis:* Cost benefit analysis (CBA) is a quantitative technique of weighing the costs and benefits of a project in commensurate terms (dollars or other currency units). CBA is treated in more detail in a following section. It may be self standing or it may contribute to other assessment methodologies such as attractiveness, feasibility assessment or portfolio analysis.

*Portfolio Analysis:* R&D covers a broad spectrum of activities from basic to applied, from strategic to tactical, from long term to short term. It addresses objectives which are deemed to be "for the public good" but also includes commercially oriented objectives. The research portfolio of an organisation may span these various dimensions each carrying its own degree of risk. Portfolio analysis asks whether the balance of risks is OK. The appropriate balance depends of course on the nature of the organisation, its stakeholders and sources of finance.

*Macro-economic modelling:* As mentioned above, the role of R&D in driving economic growth is currently a fertile field of economic research. Economists seek to enhance their theories of economic growth and build macro-economic models to provide robust empirical estimates of the contribution of R&D to economic growth.

### **Cost-Benefit Analysis**

Cost Benefit Analysis (CBA) is an attempt to evaluate all (the) impacts of a project in commensurate terms. This is a \_\_\_\_\_ goal but frequently unreachable for reasons which will become apparent - including valuation problems and uncertainty about impacts.

Nevertheless the technique is extremely valuable because of the discipline it requires in identifying impacts. In many cases, it is not necessary to measure a particular impact precisely. It can be sufficient to show whether an impact is above or below a particular threshold level.

While there are some differences in application between ex-ante and ex-post CBA, the general procedure is the same, and can be described in eight stages.

- Define the boundaries of the analysis.
  - Identify the costs and benefits.
  - Identify the gainers and losers.
  - Quantify costs and benefits.
  - Compute present values.
  - Compute decision criteria.
  - Conduct sensitivity analyses.
  - Interpret policy/program implications.
-

## **Priorities, Priorities, Wherefore art thou .....**

The CSIRO framework for assessing research and development priorities follows a two step approach:

- Assess National Research Priorities across broad areas of research opportunities (ARO's) relevant to CSIRO, mission/charter
- Determine CSIRO's response/resource allocation

The first step consists of identifying the broad areas of research opportunity in which CSIRO might appropriately be involved in some degree, and then applying the following four criteria to each ARO.

- Potential Benefits of successful R&D directed to this ARO.
- Ability to Capture (for Australia) the Benefit of R&D directed to this ARO.
- Technical Potential for successful R&D directed to this ARO.
- Capacity to undertake the R&D directed to this ARO.

There is a problem in CSIRO's application of the R&D capacity criteria at Corporate level. To be consistent with the objective of assessing "Returns to Australia" (ie finding *national* research priorities). R&D capacity should refer to Australian capacity - not CSIRO's capacity. This clearly has not been the case in the two exercises so far conducted - see the rating of Education and Training for example.

The second step consists of making a strategic decision as to the relative weight to be given each ARO - particularly in relation to its share of appropriation funding, given consideration of CSIRO's role vis a vis other providers/funding sources.

The priority assessment framework can be adapted to a finer level of detail - for example applied to a particular industry segment or research discipline.

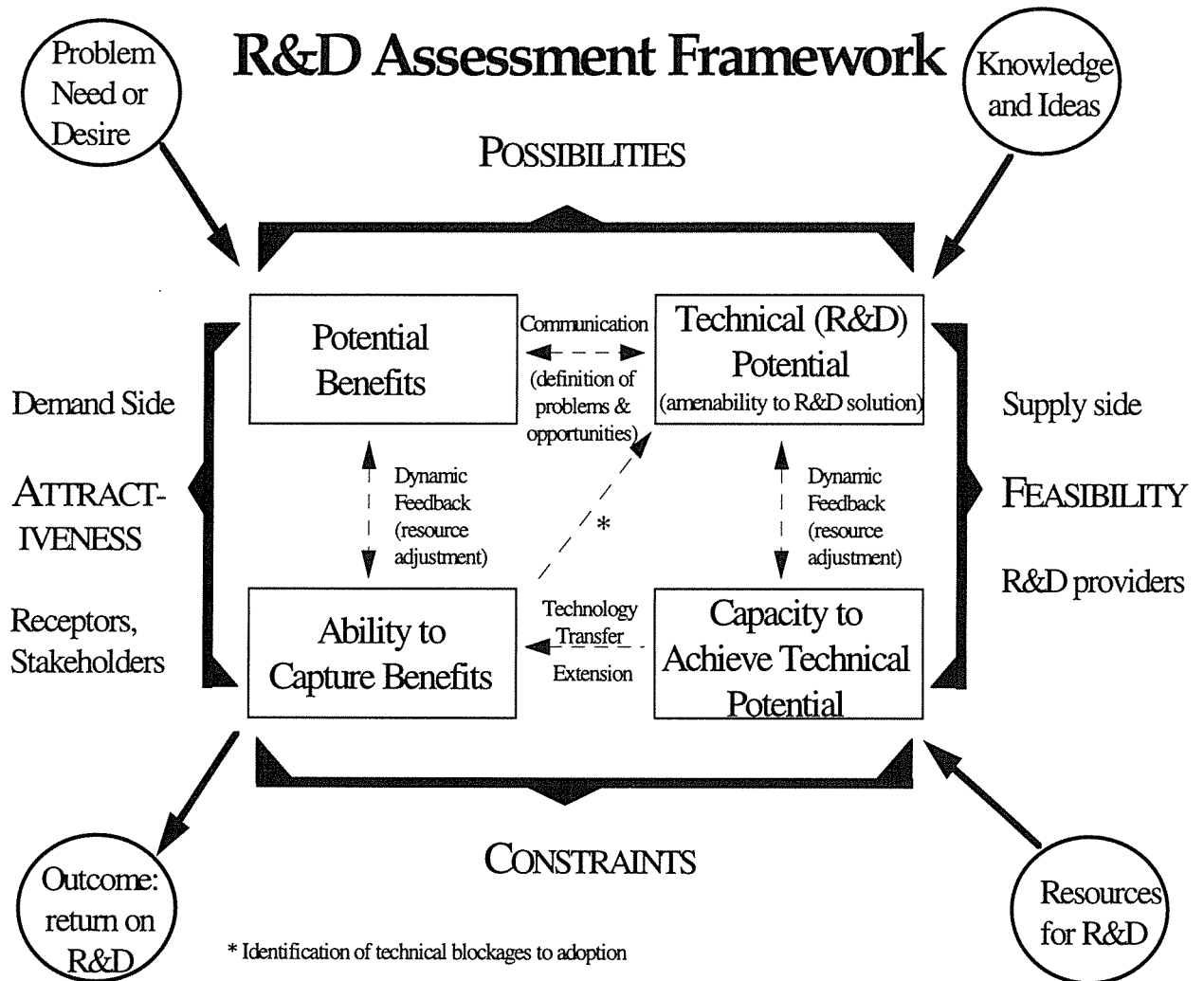
The methodology can also be adapted to non-research applications - that is, for assessing the relative priorities of a number of non-research activities. Rather than "areas of research opportunity" a set of key result areas (KRA's) or areas of business opportunity may be identified. With this modification the potential benefits, ability to capture and capacity criteria remain relevant as before. However the technical potential criterion is less directly relevant and so maybe replaced by explicit consideration of the appropriateness of directing effort to each of the identified result areas. In summary the four (modified) criteria are:

- Potential Benefits from effort directed to this KRA.
- Ability (of our stakeholders) to Capture these benefits.
- Appropriateness/Justification for effort.
- Capacity to deliver.

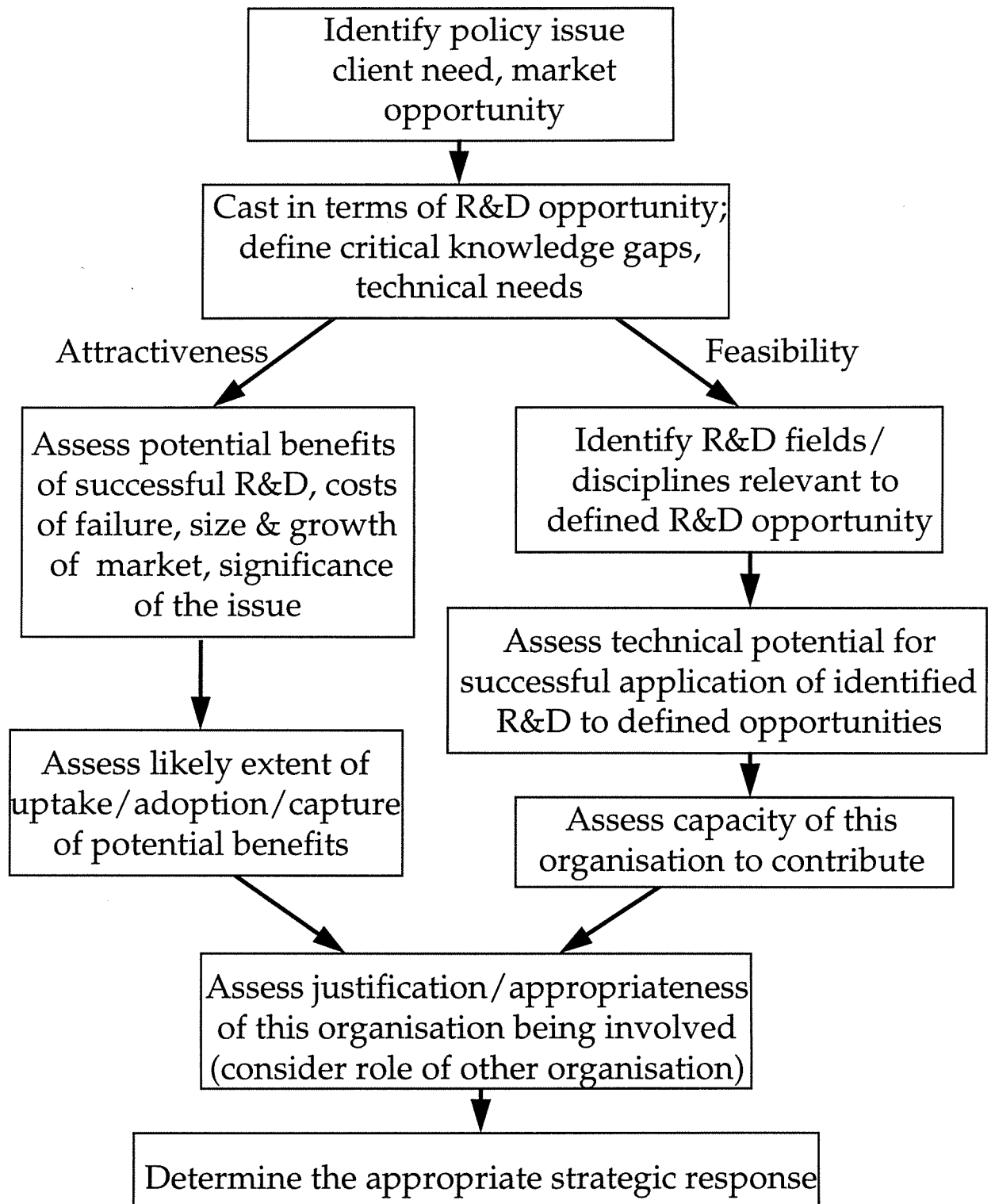
There is no sense here of assessing national priorities. The framework of reference for both the Appropriateness and Capacity criteria is the organisation itself. The key contrast with the basic CSIRO framework is that appropriateness has been made an explicit criterion and brought inside the formal rating process rather than considered in a less structured manner in the response stage. To the extent that consideration of "technical potential" is still relevant, this can be subsumed in the capacity to deliver



criterion (the logic being that technical infeasibility precludes the possibility of delivery).



# Logic of R&D Assessment Framework



## **The Priorities Process - Some Shortcomings**

It isn't hard to knock something if it's new and especially if it challenges the way we have gone about our business in the past. Furthermore, if perceptions are that the benefits of a new approach are unlikely to exceed the additional costs incurred, convincing managers that the proposed new approach can improve the quality of decision is very difficult. You must have the commitment of the managers. To gain this you must be able to demonstrate measurable benefits from the new approach.

Research priority setting in CSIRO met with a lot of resistance because it rocked the boat of traditional peer review. Judgments based on the collective experiences of research colleagues was considered to be sufficient to allocate the research resources. Scientific merit or feasibility of the proposed research is a necessary component of the assessment of research priorities, but it is not sufficient. Account of the likely economic and social benefits accruing to the nation from research is equally important. Together these two factors combine to provide a sufficient means of assessing research priorities.

Equal attention to the attractiveness of research opens a whole new ball game for most researchers. Many are offended, arguing that the only important criteria by which to assess research priorities is scientific merit and the pursuit of new knowledge. That may be fair enough but, not all new knowledge is transformed into useful information or technologies for industry and society to use and to improve as a result. Scientists through the products of their research make a significant contribution to the economic growth of the nation. If attention is given to economic and social pay-off as well as to scientific needs and challenges, then limited research resources can be allocated most efficiently for the nation, such that greater amounts of new knowledge are taken up by industry and society.

Shortcomings of the priorities process relate to its overall management, especially the adequate resourcing of the process, use of the criteria, interpretation of the outcomes, the scoring method and data and other supporting information.

### **Management and resourcing:**

Adequate time, staff, funds and ideas need to be available to the exercise. Allow sufficient time prior to the priorities workshop to assemble suitable information and data and provide it to workshop participants to assimilate (a difficult enough task in itself). The exercise and workshop should be open, and not closed to internal participants only. External participants enrich the flows of information and extend the breadth and depth of assessment for some areas. There are also positive spillovers for the host from involving external stakeholders, which go well beyond the priorities determination. A mindset which limits external involvement to indirect input, advisory committees and management boards is a difficulty which should be overcome. The potential benefits will be compromised if external participation is stifled.

The ideal priorities process should be a balance of top-down and bottom-up. The approach used by CSIRO may be criticised as being too top-down, despite the flow of inputs from Divisions and Institutes. The problem may be that the participants may not allow sufficient time to consider the bottom-up inputs. They survive the workshop on

what they know themselves. In other words they are not effective representatives of their staff, and make judgments almost exclusively based on their own knowledge, experience and mental map. Perhaps more formal or structured procedures need to be established for considering the inputs, especially those from Divisions, as they ultimately have to implement the outcomes.

Definition of research areas is not a trivial exercise. It is critical to the success of the workshop and to generating meaningful outcomes which are comprehensive and plausible. It is often the case that research areas are mixed - disciplines with industries with specific problems or issues. Ideally, they should relate to the broad, long-term purposes for doing the research. Adequate time needs to be allocated to this aspect of the exercise. Use of the ABS SEO classification should be encouraged, as it will avoid some of the above problems.

### **Use of the priorities criteria**

A common failing is understanding the criteria, interpreting them correctly and using them consistently.

Related to this is the consistent and correct use of supporting data relevant to the criteria.

The failure of the criteria to systematically handle uncertainty is another weakness, although it is not necessarily the criteria that are at fault but the users and those providing support to the users. For example, assessing ability to capture is highly judgmental in most cases because of the many influencing factors and the degree to which they might change in the future. The use of appropriate key discriminant questions and relevant supporting information and data may help. R&D Potential is subject to similar levels of uncertainty. Another approach to minimise risk is to identify an expert in the field and ask them to address the group or to prepare a suitable paper. That individual could be a member of the group. Similar presentations could be made for each criterion for each research purpose.

For the Potential Benefits criterion there is often confusion regarding the target if the benefits measure - ie, is it benefits to Australia only, global benefits, industry or sector benefits?

### **Interpretation of the outcomes**

There is no systematic approach to interpreting the priorities assessments as they are displayed on the Attractiveness - Feasibility screen. How do you partition the high from the medium and the low. What are the steps and stages for deriving strategies from the priorities.

Strategies require other inputs to be effective and cannot be expected to be based on research priorities alone.

## The scoring method

Each criterion is equally weighted. There may be arguments at particular levels of focus for having unequal weights on the criteria.

There are perennial difficulties in comparing research areas for which direct measures of benefits are available with those for which such measures do not exist. Benefits of R&D for the environment and social research areas tend to fall into this latter group.

Failure to adequately review the initial results of the scores - is this a reasonable result? Review the scores, think about criteria weights, is there consistent use of definitions, use of data etc.

## Data and other supporting information

While support and bottom-up input are important, the method may suffer from overkill, or from failure by the workshop participants to effectively utilise the available information. Too much data and information will deter its use and make it difficult by being too diffuse. Effective use requires, the bare minimum of data which is consistent between the research areas and is directly relevant to the assessment of the criteria.

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## Effective Priority Setting for Public Sector Research: CSIRO's Experience

The following are extracts from this paper by Blyth and Upstill.

### Critical factors in priority setting

Typically, priority setting involves three key stages: preparation, determination and implementation. It is the last of these, implementation, that is the proof of the pudding. If the priorities process is effectively implemented and resource shifts occur as intended, then the process could be considered as successful. However, successful implementation is the result of a number of critical factors, which extend back to the very beginnings the process, including the preparation and determination stages.

Mintzberg (1994) has shown that the factors most instrumental in successful planning, are the level of **commitment** in the organisation to the process and its outcomes, and the **congeniality** of the internal climate of the organisation to planning processes and change.

For research priority setting commitment and congeniality encompass four critical factors. These have been grouped as follows:

<b>Commitment</b>	<b>Congeniality</b>
- Ownership	- Convergence
- Simplicity	- Utility

### *Commitment*

The key factors in commitment are ownership and simplicity of the process.

While commitment of the top management team is necessary, it is not sufficient for success. An essential pre-requisite to commitment is **ownership**, by both top management and management and staff from lower levels. Participation by both management and staff in the priorities process will enhance ownership and result in greater commitment to the process and its outcomes. A common pitfall to avoid is that of the planners taking control and ownership of the process, with all other parties relegated to the role of mere implementors. Commitment is undermined in this situation.

**Simplicity** of the priorities process is also critical. A high degree of sophistication or complexity of the priorities process can detract from the level of commitment. This may arise where planners focus too much on the process itself and not enough on the needs of management and the organisation's external customers. The process should be jointly developed or adapted by management and staff with appropriate support and facilitation from planners. The simpler the priorities process or method, the easier it is to understand, the more amenable it is to a wide audience and therefore, the greater the participation of staff and management, which builds greater ownership and commitment. Simplicity also implies a robustness and a capacity to adapt to different applications.

### *Congeniality*

The key factors in congeniality are convergence and utility.

Mintzberg stresses the critical importance to successful planning (priority setting) of congeniality of the organisation's internal environment to priority setting and the changes that it hails. Change is generally not welcomed by nations, by organisations, or by individuals. **Convergence** is an important requirement in priority setting. The process should enable wide participation from across the organisation. Furthermore, it should engender sufficient leverage to cause changes which are more than incremental resource shifts within existing activity categories and simple extrapolations of the past. Priority setting should be challenging to existing mindsets and objectives, and should be firmly focussed on the long-term future. To this end, effective priority setting should be open and inclusive, involving participation from different disciplines and different areas from within the organisation, as well as being open to the experiences and perspectives of relevant external stakeholders. The process should allow consideration of different points of view. Within the organisation the process should encourage convergence of disciplines, ideas, experiences and perspectives.

The **utility** of the process is linked to its ability to enable the organisation to move towards its longer term goals and maintain flexibility for change. The priorities process should not lead to inflexibility in the organisation's activities and long-term directions. The process should identify the many influences on potential outcomes and the nature of change relevant to each influence. Priority outcomes should be largely consistent with the vision and broad goals of the organisation.

## Effectiveness of CSIRO Priorities Process

CSIRO's priorities process has performed reasonably well against the critical success factors cited in Section 2. However, while there has not been a rigorous evaluation of the process against those factors, it is possible to identify a number of significant instances which indicate favourable performance. The following table presents relevant instances selected from across the Organisation.

Critical success factor	CSIRO's performance
<b>COMMITMENT</b>	
<b>Ownership</b>	<ul style="list-style-type: none"><li>• The priorities method was developed iteratively with the active involvement of the CSIRO top management team.</li><li>• The process/method has been diffused within the Organisation, down to project level in some cases (eg, see Institute of Industrial Technologies project data sheet).</li><li>• Involvement of CSIRO Institutes and Divisions in priority setting exercises at lower levels prior to the CSIRO exercise; outcomes were fed into the corporate exercise (see CSIRO 1993).</li><li>• Championed by the Chief Executive from the very start.</li><li>• Broad recognition by Government stakeholders of the Organisation's use of the process and acceptance of the outcomes.</li><li>• Balanced consideration of factors relevant to the internal environment with factors from the external environment.</li></ul>
<b>Simplicity</b>	<ul style="list-style-type: none"><li>• The four criteria are simple, yet comprehensive; clear definitions aided by key discriminant questions.</li><li>• The process is systematic and staged, supported with standardised data and evaluation sheets which facilitate comparison.</li><li>• It is largely workshop based and participative.</li><li>• Allows consideration of quantitative and qualitative inputs</li><li>• Is able to generate useable results at the workshop, based on the judgments of participants.</li><li>• Is robust and adaptable to new situations, although its successful application is dependent on generic and specific aspects of the process discussed in section 2 of the paper.</li><li>• The process has been effectively transferred to many organisations outside CSIRO, through workshops and seminars. It does not require special computer software to implement.</li></ul>

**CONGENIALITY**

**Convergence**

- Wide consultation with staff in Institutes when preparing data and evaluation sheets, and involvement of external stakeholders in priorities exercises at the SEO level, such as through the use of Institute Advisory Committees.
- Common meeting ground for different disciplines and perspectives, including scientific, economic, commercial and social.
- Able to effectively accommodate internal and external representation - pairing by SEO or research purpose, especially at Divisional level.
- Process leads to reduction of conflict and shared views on outcomes.
- Able to effectively accommodate consideration of research purposes outside the current range of research activities.
- Method can be adapted to assess the current portfolio of research projects against the priorities outcomes - (see CSIRO Corporate Planning Office 1993a,b.)

**Utility**

- Change from a resource allocation process based on 'equal misery for all' to one based on favouring areas of highest return (ie, high attractiveness and feasibility).
- Flexibility of resource allocation enhanced through the expansion of multi-disciplinary programs in recent years from less than 10 to over 35 across CSIRO.
- Faced with a budget fall of around \$1.6 million over the next 3 years the Division of Tropical Crops and Pastures has departed from traditional resource allocation mechanisms where all areas get roughly equal treatment to one which bases the distribution of government appropriation funds to SEOs in accordance with the Division's assessments of the relative attractiveness and feasibility of the SEOs in which the Division works (see Clements 1994).

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**Future Challenges**

CSIRO's priority processes have fulfilled a useful role in the past few years and should have a continuing life in guiding the Organisations' activities. At the same time these processes will need to evolve to ensure their continuing effectiveness. An ongoing task will be to ensure the freshness of the approach, its adaptation to changing needs and its capacity to aid the flexibility of the Organisation.



Several challenges present themselves in considering the future usefulness of the priorities process.

**Ownership** is an ongoing task, and one that cannot be taken for granted. For CSIRO in the mid-1990s this will mean broadened use of the process and strengthening common ownership of the language and its concepts. In one of CSIRO's six Institutes, the Institute of Industrial Technologies, all projects now conform to a one-page project data sheet which summarises key information relevant to the project, *according to the four CSIRO priorities criteria*. At another level the participation and ownership by external stakeholders and customers is likely to become still more important in order to ensure alignment of CSIRO thinking with that of its key customer groups. This is likely to mean greater stakeholder involvement in preparation and decision processes.

**Adapting to Changing Needs:** The increasing globalisation of industry and R&D means that research priority setting has to have regard to the international competitiveness of research and the way research outputs are taken up and used by industry, government and community users. The priorities process will increasingly need to take this into account in its language and analysis - the international competitiveness of research groups and of prospective collaborating agents.

**Information and Analysis:** Flexibility will also be needed in respect of supporting analysis and data to assist decision making. Possible options include the use scenario analysis techniques and technology forecasting as supplements to current technical and economic information.

**Regional Research Priorities:** The growth of the Asia Pacific economies has been accompanied by a fast growing awareness of the importance of effective international collaboration for mutual benefit. Equally there are likely to be increasing opportunities in coming years for fruitful international research collaboration on areas of common or major regional concern. A shared priorities process based on some of the principles and practices set out in this paper could be an efficient way of establishing priorities for multi-national projects of mutual benefit.

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## CASE STUDIES

This chapter will provide short descriptions of exercises to adopt and adapt the priorities process within and external to CSIRO. The emphasis is on new insights obtained. The description will comprise one page of text alongside a Box which will provide the salient features of the case study or a key display such as shown in **Box A: An R&D Project Profile by Priorities Criteria** in the **The Research Project** case study. Case studies are being prepared for the following where sufficient documentation exists:

- Agriculture Sector
- Various Agriculture and Environment Sub-Sectors
- The Research Program
- The Research Project
- Overview of External Cooperation
- Customising the Criteria

- Contribution of Benefit-Cost Analysis
- National Research Facilities
- Collaboration with Shell Group Planning
- Adaption Beyond Setting R&D Priorities

### **Agriculture Sector**

Summary of CASAC exercise if it has been documented.

### **Various Agriculture and Environment Sub-Sectors**

Soils, Animal Health, and Wildlife and Ecology have been documented.

### **The Research Program**

An account of the Tropical Crops and Pastures approach featuring the Tropical Pasture Improvement Program case study which has been documented.

### **The Research Project**

A one page outline of the IIT Planning Schedule and including non commercial in confidence version of an IIT R&D Project Profile such as the following.

**Box A: An R&D Project Profile by Priorities Criteria**

### **Overview of External Cooperation**

Draw on exercises which have been documented by CSIRO: eg, ARRB, SWB, CSIR India, BPPT Indonesia and seek notes on exercises not documented by CSIRO.

### **Customising the Criteria**

The SWB and CSIR India experiences are worth outlining.

#### ***Sydney Water Board***

The fruits of R&D can be broadly described as the creation of new technologies, improved standards of service, more efficient use of internal resources, a broader range of products and services delivered to the market and better performance in meeting external standards and community expectations.

The ability to capture the benefits of R&D depends on a wide range of factors, both internal and external to the operating environment of the Board. Some key factors are identified in this presentation.

The general message is that more flexible strategic approaches are needed to capture the full benefits of R&D, in contrast to the more traditional approaches within the Board, which appear to have been dominated by supply-driven engineering design.

There is considerable scope for R&D that recognises the role of behavioural adaptation by customers (for example in response to changes in pricing regimes) as well as new possibilities for technological solutions.

### **Box B: Sydney Water Board - Ability to Capture Benefits**

#### **Contribution of Benefit-Cost Analysis**

Draw on the occasional papers *Rural Research - The Pay-Off* and *Environmental Research - The Pay-Off* and/or papers by Ralph Young and/or more recent BCA exercises in progress in CSIRO.

#### **National Research Facilities**

Support to ASTEC study. Provide expanded form of key discriminant questions for R&D potential and R&D Capacity.

### **Box C: Criteria and Questions to Assess the Contribution of National Research Facilities**

#### **Collaboration with Shell Group Planning**

Snapshot of Blyth exercise for Shell.

#### **Adaption Beyond Setting R&D Priorities**

Notes on use of approach for other than research priority setting

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**APPENDICES**

**Research Classification**

**Assessing Research Potential**

**Generic Stages and Steps in Research Priority Setting Process**

**View Graphs Illustrating Research Priority Setting Process**

**Scenario Building in a Research Environment**

