Technology Innovation Centers:

A University-based Program to Promote University-Industry Collaboration in Research and Education

VOLUME I

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A Collaborative Effort of

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I. BACKGROUND

KACST was directed by a 1986 Royal Decree to "propose a national policy for the development of science and technology and to devise the strategy and plans necessary to implement them."[1] In July 2002, the Council of Ministers approved the 20 year National Plan for Science and Technology, which drew up the broad lines and future direction of science, technology, and innovation in the Kingdom, considering the role of KACST as well as that of that of universities, government, industry, and society at large. The plan, which was developed in consultation with hundreds of people, encompasses:

- STI regulations
- Developing and diversifying financial support
- Human resources
- Strategic technologies
- Transfer and localization
- R&D capabilities
- Administrative structures of STI institutions
- STI and society.

The national orientation of the 20-year Plan was incorporated in two development plans, the fifth plan (1410-1415) and the sixth plan (1415-1420), which called for accelerating the national long-term plan for science and technology in the Kingdom. Implementation of the long-term plan, including direct administrative and technical supervision, is entrusted to a committee chaired by the Deputy Chairman of KACST for Scientific Research Support and the Deputy Minister for Planning of the Planning Ministry. This committee is also responsible for follow-up of the tasks and requirements of the plan and the proposals of the subcommittees and various national work teams required.[2] Further, the plan states that KACST and the Ministry of Planning will jointly "provide the planning expertise in completing the various elements of the [implementation] phase, in a way that ensures . . . that the sound strategic options will be selected and that the national priorities will be set, within the framework of the plan's orientations and goals."[3]

The *Eighth Five-Year Development Plan* (2006-2010) calls for the implementation of an integrated set of programs that fall into three categories: Sectoral Programs, National Programs, and National Initiatives. Within National Programs, the Plan notes that KACST, higher education institutions, and scientific and technological agencies in public and private sectors will be responsible for programs "concerned with the development of the tasks and functions of the science and technology system at the national level."[4] The programs include education and

[1] *National Long-Term Comprehensive Plan for Science and Technology*, 2001-2020, p. 7.
[2] *Ibid.*, p. 7
[3] *Ibid.* pp. 51-52.
[4] Ministry of Economy and Planning, *Eighth Development Plan*, 2005-2009, Chapter 19.

training, R&D, technology transfer, indigenization and development of technology, spread of technology, and optimizing its use and social benefits.

In the "Strategic Technologies" area, KACST is responsible for 5-year strategic and implementation plan for 11 technologies:

- Aerospace and Aeronautics
- Advanced Materials
- Biotechnology
- Electronics, Communication & Photonics
- Energy
- Environment
- Information Technology
- Nanotechnology
- Petrol & Gas
- Petrochemicals
- Water

KACST is also responsible for "building the infrastructure needed for supporting scientific research in the kingdom, including management of research grants, setup of communication networks and science and technology databases and conducting applied research." KACST thus has major responsibility for S&T policy planning, coordination, and implementation in the Kingdom. The Technology Development Center within KACST was established within KACST to strengthen and promote technology development and commercialization activities within the Kingdom. TDC is a key part of KACST's responsibilities assigned under the National Science and Technology Plan to promote the national scientific and technological base, thereby helping to realize the objectives of economic diversification, enhancement of growth, and promotion of human development.

II. TIC OBJECTIVES AND CONTEXT

In both mature and newly industrializing, technology-based economies, strong collaborative relationships between research universities and private industries are found to be an important feature of the national innovation system. This has led to the creation of a variety of government-supported industry-university collaborative research centers in countries such as the U.S., Germany, Korea, China, India, Ireland, and Australia. These programs are yet another example of the importance of strong linkages among the various elements of national innovation systems, notably between research-performing units in government and universities and private firms interested in tapping the expertise and knowledge of university-based researchers and students. Yet these programs face major barriers, the most significant of which are differences in the organizational cultures of universities and industry, issues related to conflicts of interest for university faculty, and the costs of negotiating intellectual property rights.

The goal of the TIC program element is to create a series of Technology Innovation Centers in carefully selected locations in the Kingdom. Collectively, the individual Centers, supported and coordinated by the agency managing the program, should:

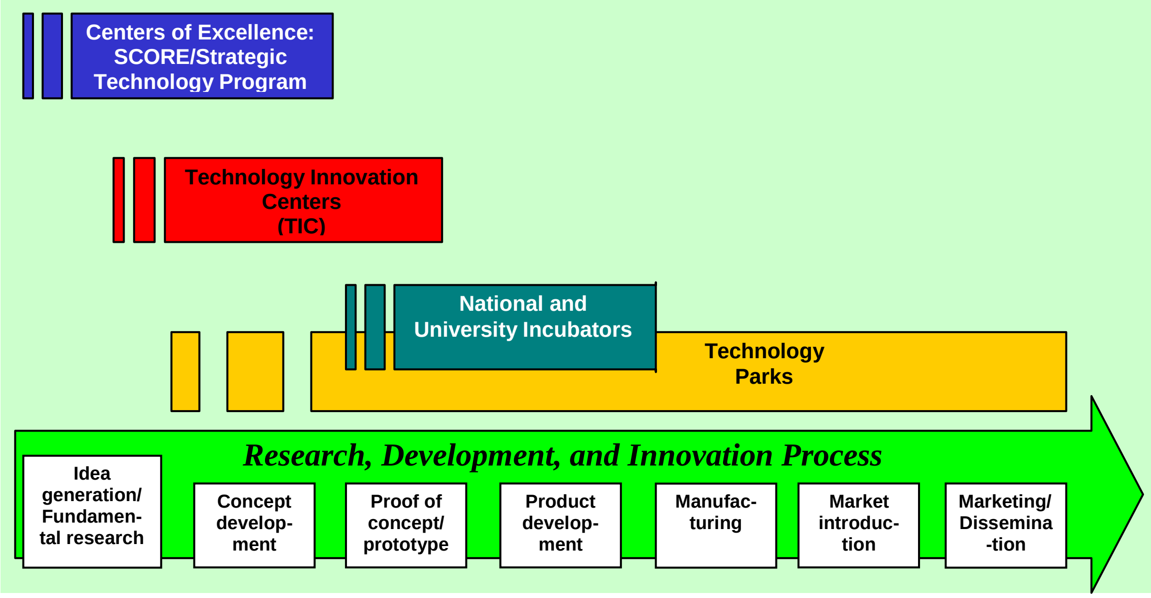
- Promote university-industry research collaboration and technology transfer;
- Strengthen university research and engineering education;
- Address economic and social goals of the Kingdom; and
- Implement appropriate features of the structure, incentives, and requirements of successful programs in countries similar to KSA.

TIC cannot achieve these goals unless its design and operations recognize the importance of the proposed program's relationship to complementary programs also intended to strengthen the Kingdom's national innovation system. Many of these programs were conceived as key elements of the National Science and Technology Plan and are now being implemented, coordinated by the Strategic Technologies Committee.

The National S&T Plan assigned key roles for KACST and TDC in national strategic technologies effort to strengthen the Kingdom's research and technology transfer infrastructure. This three-tiered strategic concept, coordinated by the Strategic Technologies Committee, consists of a fundamental research tier to support university-based basic and applied research aligned with the 11 strategic technologies identified in the National S&T Plan; a Technology Innovation Centers (TIC) tier that will focus on university-industry collaborative applied research; and a third tier consisting of a system of incubators that support product development and business start-ups. One element of the fundamental research tier, aimed at strengthening university research capacity, is being funded directly by the Ministry of Education: the Saudi Centers of Excellence in Research Program (SCORE). The second element of this tier, funded through KACST, supports university basic and applied research in the 11 technology priority areas. The second and third tiers, which are partially industry-driven, focus on technology development and commercialization and are being coordinated by TDC. Managerially, the SCORE program reports to the Ministry of Education through the universities, while the strategic technologies program, the TIC program, and selected activities in the incubator tier (e.g., national incubators) report to KACST.

Figure 1, below, is a graphical representation of this three-tiered concept, with each tier placed roughly along a simplified model of the process of technological innovation. (It is important to note that actual processes of innovation are often *not* linear, but can originate with ideas rather than research, involve numerous feedback loops, and may consist of putting existing technologies together in new ways.) Nonetheless, the diagram does suggest that the TIC program performs a critical role by linking the knowledge outputs generated by university-based research to incubators and technology parks designed to identify commercially promising ideas, develop them, and introduce them into the marketplace.

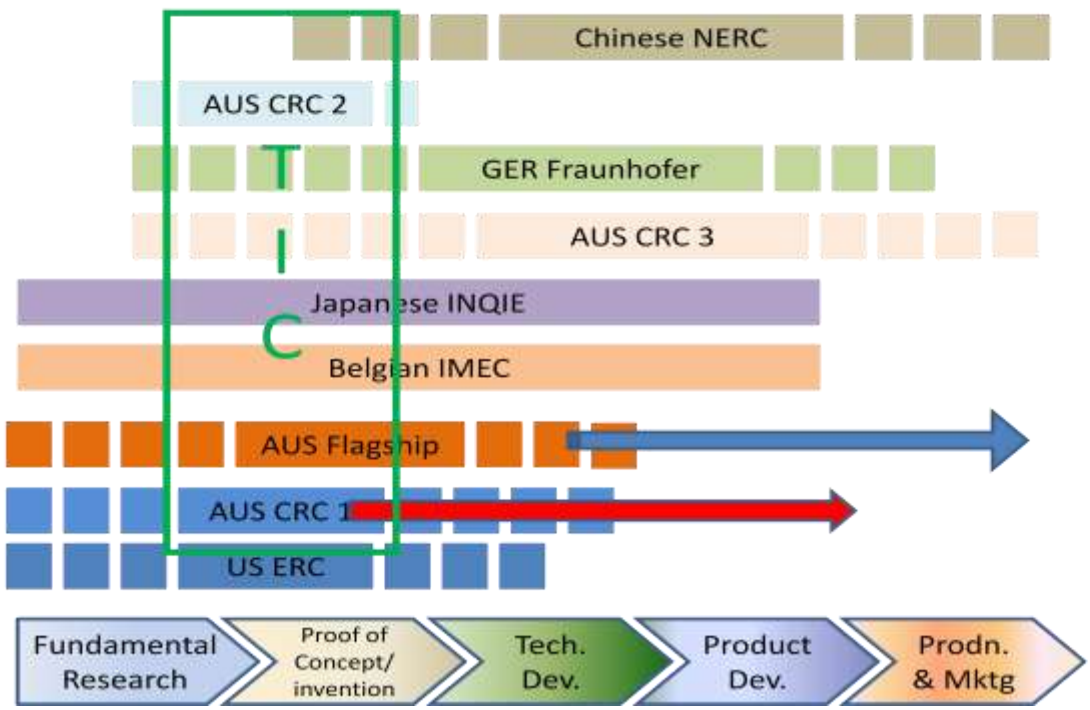
Figure 1: Strategic Technologies Committee Concept Promoting Research-based Economic and Social Development in the KSA



III. INSIGHTS FROM WORLDWIDE PRACTICE IN PUBLIC-PRIVATE PARTNERSHIPS

Two years ago, the US National Science Foundation (NSF) commissioned a study of international adaptations of the highly successful NSF program of university-industry collaborative research, the Engineering Research Centers (ERC). One of the members of the present SRI TIC project team was a member of this NSF panel, and so brings lessons learned and other insights to bear on the design of the TIC program. The NSF panel studied various centers by visiting them first-hand and meeting with their management and personnel. (Appendix A to this report provides selected results from the report.) As the following diagram shows, the centers studied (the diagram includes only a partial set) differ in the range of research conducted as well as in their primary focus, as measured by their location on a linear model of the processes of technological innovation. The diagram is based on the NSF study as well as on an evaluation of Australia's Cooperative Research Centers (CRC) program.

Positioning of various centers on the innovation continuum



Here again, we have placed the TIC program in an appropriate position on a simplified diagram of the innovation process. TIC centers may conduct some fundamental research, but only if necessary to address industry needs, and are expected to generate prototypes and/or proof-of-concept results appropriate for moving promising ideas into technology and product development.

A number of important general insights were gained from the NSF-sponsored study (one member of the SRI team served on the study panel), and the SRI team's intimate knowledge of the US ERC program, the Australian Cooperative Research Centers, and the Australian Flagship program. These insights are summarized briefly below.

- Programs pick research areas using "top down" approaches; industry plays a role in selection
- Not all centers are university-based; there are advantages to being stand-alone
- Core government funding is seed funding/"stamp of approval" for industry and other funding
- Industry-funded does not automatically imply short-term research
- Flexible Intellectual Property (IP) arrangements are important
- "Bridging" institutions exist and appear to accelerate knowledge transfer
- Most centers have international partners
- There are efforts to overcome cultural barriers to innovation

In addition to these broad insights, the SRI team's past research and experience with these programs yielded a wealth of more specific information about their features, especially those features that have contributed to the programs' effectiveness and continuation. Of course, the contexts of these programs differ widely, and none of them exist (or were initiated) in settings that closely resemble the Saudi situation. However, a careful analysis of these specific features results in a number of "findings" that, when combined with the knowledge of the Saudi context gained from the workshops and interviews held with stakeholders during the first half of 2008, yielded the basis for our recommended plan for the TIC program. The analysis of international program experience and features is based on the matrix that appears in Appendix A to this report; the results follow.

- ***Eight of the nine international programs analyzed work on research in fields that are linked to national priorities.*** The exception is the U.S. Engineering Research Centers program.

- Programs vary in the relative emphasis each places on research, education, and industrial relevance/technology transfer. ***Nearly all programs place a strong emphasis on research*** (the one exception is the Chinese National Engineering Research Centers, which are strongly oriented to regional economic development through company start-ups). ***All programs place either strong or moderate stress on technology transfer and industrial or user relevance***. And, ***six of the nine programs emphasize education as well***; the exceptions are the German Fraunhofer Institutes, the Chinese NERCs, and the Belgian Inter-university Micro Electronics Center (IMEC). Thus the pattern is, for the most part, strong or moderate emphasis on all three goals; indeed, they are usually mutually reinforcing.

- ***Strategic planning is practiced and is an important ingredient in nearly all programs, required in many****.* This would appear to be essential in programs with relatively long award periods), which nearly all of these are. Award periods range from seven years up to essentially indefinite, with termination depending on declining relevance, funding availability, or absence of the key principal investigator/center director.

- Not surprisingly, ***strong center leadership is evidenced in every one of the programs analyzed***, and is considered to be essential to the success of both individual centers and the programs themselves.

- ***Centers in early all programs engage in interdisciplinary, team-based research***, mirroring the organization of research in industry.

- ***All but one center program enjoy financial support from industry (or research users).*** Center reliance on industry support varies widely, ranging from about 1/3 of the total center budget (U.S. Engineering Research Centers) to as much as 80-85% (Belgian IMEC and Australian Flagship). The range among most programs is 40-60% industry or user support. The amount of support seems less important than its existence, signifying commitment. ***Correspondingly, industry or user involvement in planning and/or center research is strong or moderate in nearly all centers.***

- ***Co-investment by state or local government units is common to most programs***, although the amount of support varies quite widely, from none as much as 20% of total center budgets.

- ***Co-investment by universities is also present in most of the programs analyzed***. Support ranges from 5% to 20% of total center budgets, with provision of facilities often the mechanism of support.

- Although university faculty, researchers, and students are strongly involved in research in most of these centers, ***in most cases the centers themselves are not a regular part of the university organizational structure***. Instead, with just two exceptions, they exist as separate organizations. And, although separate organizationally, ***most centers are co-located with a university*** so that faculty and student participation in center research is facilitated. ***Student involvement is strong in most center programs***.

- These ***center programs also include substantial numbers of permanent research sta***ff, although the sources vary—some centers rely on secondment of university staff, others depend on support from industry for staff salaries.

- Finally, these ***programs all show a strong role by the funding program or agency in the initial program design and/or in subsequent program design changes based on feedback generated by systematic studies, reviews, and evaluation***.

IV. INSIGHTS FROM TIC STAKEHOLDER WORKSHOPS AND INTERVIEWS

The SRI team visited KACST twice in the first half of 2008 and met with a variety of TIC stakeholders. (See Appendix B for a list of people involved in the workshops and interviews conducted during these two visits.) These workshops and interviews, planned and managed by the KACST Technology Development Center, drew extensive and candid assessments concerning the contexts in which the planned TIC program would exist, other programs and activities that would relate to the TIC program, the challenges that the program would face. At the same time, stakeholders offered many useful suggestions about how these challenges might be overcome (or at least their negative effects on the TIC program minimized). Given that the primary focus of the TIC program is the interaction between research universities and industry, most of the stakeholder comments and suggestions dealt with the characteristics of these two institutions that must be taken into account in planning and implementing the TIC program. The following two sections summarize stakeholder comments and suggestions regarding, first, the Saudi university system and, second, Saudi industry.

University System

The Saudi university system faces a number of major cultural challenges that must be addressed if universities are to overcome productive partners with Saudi industry. Foremost is the deep mistrust that exists in industry of the capabilities of academic researchers. Few academicians consult for industry, which is the normal basis for initial industrial contacts with universities in the developed nations. Partly this mistrust is a product of the bureaucratic system at the universities, where in the past consultants referred to industry were not always adequate or even ones with appropriate expertise or experience. As a result, nearly all consultancies now happen privately through individual contacts between the faculty and industry. The institutional memory and database of consulting specialties do not exist.

A second critical problem is a large salary differential between the university and industry. Those faculty members who consult successfully often find it more lucrative to permanently move to industry. The low salary levels in academia also make it difficult to recruit new faculty. This problem is compounded by the fact that typically 80% of the faculty members at universities are in non-science and engineering disciplines, while the student demand for science and engineering courses is increasing. The salary differential and burdensome administrative requirements at universities essentially prevent recruitment of adjunct teaching faculty from industry. Thus the few capable faculty members are burdened with high teaching loads, making it difficult to conduct research activities. They are also often burdened considerable administrative work. Finally, there exist few, if any, incentives for faculty to engage in industry-oriented research. Aside from the teaching burden, there are no financial rewards from participating in such research, nor do university promotion criteria recognize and reward attracting or working on sponsored research.

Unlike some western universities, most of the bachelors and masters students do not do any research. Therefore, the only segment of students that can conduct research are Ph.D. students. Unfortunately, the number of PhD students in Saudi universities is quite limited. According to data presented in the National S&T Plan, 23% of all students enrolled in higher education are in scientific and technical fields, while the comparable figure worldwide is 39%. Very few of these postgraduate students are working on Ph.D. degrees. Data from the Ministry of Higher Education for 2006-7 show just 228 Ph.D.s were awarded in *all* fields for that year, and a total of 2410 Ph.D. students enrolled, again in all fields. There is also concern that those who continue with post-graduate education often do not possess the high levels of knowledge and skills needed for research-oriented projects. Thus, human capital needs are quite acute.

Academics participating in our workshops voiced their own distrust of the university administrative structure. The most common recommendation regarding the TIC program was to set up TICs outside the normal university structure, as a separate legal entity. This would allow a measure of autonomy for TIC staff and permit creation of incentives that could attract faculty researchers and students to centers. There are several examples of these types of arrangements: the Chinese National ERCs are collocated on university campuses but are separate legal entities with their own governance structure. Similarly, the Australian CRCs are managed by a CEO who reports to an independently constituted board of directors. The Belgian Inter-university Micro Electronics Center is collocated at the Katholik University of Louvain campus, but is a separate legal entity.

Industry

The greatest challenge for Saudi industry is to identify and recruit technical and managerial talent. The inadequate Saudi elementary and secondary education seems to be blamed for this, but since the world is moving rapidly, stakeholders agreed that KSA cannot wait for the Saudi education system to improve. Corrective action needs to be implemented as soon as possible. The solution proposed by participants in our industry workshop was to provide incentives for more capable students to go into research-oriented careers.

The second challenge for Saudi industry is its low level of investment in R&D. With the exception of three major organizations (Saudi Aramco, SABIC, and SAGIA), there is little demonstrated record of significant investment in indigenous R&D. Indeed, some participants in our industry workshop disputed whether even these three giants have a track record of investment in R&D that generates original products and processes, as they have often purchased IP from abroad and adapted it to Saudi conditions. They suggested that much industrial "R&D" done in the KSA is not high risk, but is instead incremental, low risk, and short term, consisting of little beyond testing and adaptation of existing technology rather than product/process development. .An additional area of weakness of Saudi industry is lack of industry or trade associations or professional societies that give collective voice to industry concerns.

Reflecting the general industry distrust of academic expertise, a major theme to emerge from the workshops was the recommendation to hire capable industry professionals to plan and manage some aspects of the future TICs. Another disadvantage of working with academia is the slow pace at which decisions are made in university bureaucracies.

It was also pointed out strongly that Profit/Loss thinking and financial incentives would be the prime movers for nascent Saudi industry to participate in TICs. However, a dissenting opinion was also expressed--while financial incentives are indeed important, they cannot and should not be the prime driver. This perspective regarded the education and training of both students and faculty in the processes of technology development and commercialization to be the unique and most valuable contribution that academia can make to industry.

Among the several solutions proposed in our meetings:

1. Companies can identify some of their smartest employees, and ask them to focus on a few problems that can contribute to their P/L; then deploy these employees to TICs for 6 months to work and come up with a solution; and

2. Bring in high school students who often have creative, forward-looking ideas; they would need some training in business, marketing, and product design, but then could come up with fresh ideas.

It was suggested that KACST can play the role of a catalyst – bringing together researchers and managers from industry and academia on selected topics in alignment with the 11 national priority areas by conducting 1 or 2-day workshops. The outcome of these workshops would be a better understanding of the problems facing the relevant industry, the capabilities of academia to help with these problems, and potentially a basis for a future TIC.

V. RECOMMENDATIONS FOR TIC CENTER AND PROGRAM FEATURES

Integrating the results of our workshops and interviews with TIC stakeholders and the features of successful university-industry collaborative research programs worldwide, we have developed a set of recommendations for the overall design and management of the KACST TIC Program. These are listed below, separated into two categories: recommendations for the structure and governance of the centers, and recommendations for the structure and staffing of the (initially) KACST-based TIC Program unit. More specific recommendations, including examples of key documents and procedures, cost models, and staffing plans for the centers and funding agency will be presented in subsequent sections of this report.

Center Features

Center research must demonstrate alignment with KSA national priorities. This is an essential feature of TICs, not only because it is required by the National S&T Plan, but also because it is a feature of virtually every major, successful program of university-industry collaborative research programs worldwide. Successful proposals for TICs must demonstrate alignment of the proposed work with one or more of the eleven strategic technology areas identified in the Plan, and must show how the outputs from the proposed center are expected to contribute specifically to the problems faced by industry and the Kingdom in the relevant field or fields.

Successful centers must meet standards of research excellence, human and social capital development, and industry relevance. TICs must address all three areas shown by international experience and by our workshop results to be critical to the ability of TICs to achieve the ambitious goals set for them. Excellence in research and related activities is the *sine que non* (without which, nothing) of industry-university collaborative programs. Excellence in industrially-relevant research will build confidence in industry that faculty and students possess the skills to address selected industry problems in creative and effective ways. The combination of research excellence and orientation to addressing industry-relevant problems builds trust, but it also builds the human and social capital so highly valued by companies that have worked successfully with universities. This goes beyond faculty and student research skills and industry orientation; it also includes knowledge of the processes of technological innovation and, for some center staff, skills in planning and managing applied R&D, identifying and fostering potentially commercializable ideas, and managing intellectual property. These skills are in critically short supply in the Kingdom and are highly valued in all sectors of the economy. Based on worldwide experience with TIC-like centers, human and social capital with these skills are typically these centers' most highly-valued outputs.

Centers must plan strategically to achieve integration of research, education, and technology transfer. Successful university-industry collaborative research centers must plan and manage not just large, long-term programs of industrially-relevant research, but also must balance this activity against substantial investment in education (i.e., human capital development) and in transfer of new knowledge and technology to industry. This complex mix of related activities must be planned strategically and implemented in ways that engage faculty, students, and industry researchers and managers both initially and continually over the years as centers produce research results, graduate students, and generate payoffs to participating companies. Even in advanced industrial economies, this is quite difficult. Strategic planning has been shown to be an essential element in successful centers and must be practiced in the proposed TICs.

Center activities must reflect central roles for interdisciplinarity, collaboration, and industry orientation. Research and development in successful, technologically-intensive companies is conducted in interdisciplinary teams with a focus on problems. In the most successful innovative companies, teams frequently include not only researchers from many backgrounds, but also representatives of business units, manufacturing, and marketing. Faculty and students in successful TICs must learn to work together in teams on problems identified by industrial collaborators, not by colleagues in the same academic discipline. Composition of teams is based on the nature of the problem, not on the organizational location of university participants. This is difficult to achieve in traditional university organizational settings and incentive systems. Typically, achieving these kinds of characteristics requires that collaborative industry-university research centers operate outside traditional university rules and regulations.

Collaborating parties must demonstrate commitment to the TIC via co-investment/cost sharing. Numerous studies of collaborative research centers, as well as the experience of successful centers worldwide, shows that collaborators demonstrate commitment to the collective enterprise by co-investing in it via cash or in-kind contributions. It is probably less important what the exact level of commitment is, than that the commitment is more than a token amount and represents a real risk to the investor. For TICs, then, minimum levels of co-investment should be required of participating organizations: the university, the companies, government agencies, other users or stakeholders. Appropriate levels of commitment should be flexible to accommodate the wide range of situations likely to prevail in TICs that focus on different problems, industries, and technologies.

No single TIC "model" is likely to fit all situations. It is clear that the challenges facing Saudi universities and industry, outlined briefly earlier in this report, are pervasive. At the same time, it is also clear that there have been some successes in industry-university collaborations in research. Examples include some of the existing experience with faculty consultancies with industry, and a few examples of university-industry research centers, among which is the Schlumberger-Dhahran Center for Carbonate Research, located in the Dhahran techno-valley near King Fahd University of Petroleum and Minerals. We suspect, and our workshop discussions tend to support our tentative conclusion, that there exist in the Kingdom a number of "pockets of opportunity" that can be identified, supported, and built upon by the TIC program in planning and encouraging proposals for TICs. Each of these opportunities for building collaborations between universities and industry using resources made available through the TIC program is almost certain to vary widely in the nature of the industry problem, the experience and expertise of the potential faculty members and students, the research intensity of the industry, the size of potentially interest companies, the existence of relevant infrastructure to support collaborative work, the levels of trust between potentially interested parties, and the strength of the professional organizations that might be brought into or serve as catalysts for cooperation. As a consequence, we expect—especially in the formative years of the TIC program—that each TIC award will be unique, tailored to a very particular confluence of favorable characteristics. There will be no single "model" for a TIC, but instead a set of different TICs, each exhibiting the necessary general features described in this section of the report, but at the same time tailored strongly to meet the needs and expectations of the participating companies, industry, faculty, and students.

Centers should be affiliated with universities, but may be organized and managed outside the normal university structure. TICs should not be expected to tackle the challenges that face Saudi universities. They must, at least for the time being, accept these as conditions to be taken into account in making the centers work effectively. For this reason, TICs should be able to draw directly and easily on university faculty, students, and, where appropriate, other technical staff, but should be organized and managed independently of the university. Center working conditions, incentives, and procedures should more closely match those in industry than in academia.

Centers should promote engagement of women in all activities. As a program whose objectives include developing technical human capital in the Kingdom, TIC should play an active role is attracting women to work in TICs on industry problems. In some cases these women will be faculty members, in others graduate students or postdocs, and in still others technical professionals. TICs will offer an environment conducive to learning about both applied research on industry-related problems as well as learning about process of technology development and commercialization. Women trained in the TIC environment will be highly valued for their unique experience and skills and be highly sought by industry, government, and academia.

Centers should offer incentives for small and medium-sized companies as well as large firms. Most industry-university cooperative research centers worldwide find that large firms are much more willing and able to afford the center membership fee or necessary co-investment required for partnership status. However, there are many features of small and medium-sized firms that make it desirable to attract them as partners in such centers, especially centers with goals similar to those of the TIC program. Smaller firms are numerous, more flexible than large firms, and because their employment growth rates are generally higher than that of large firms, those located close to TICs can contribute to regional economic development. For these reasons, it is desirable for TICs to encourage participation of small businesses in center activities, perhaps through reduced or subsidized co-investment requirements or through forms of participation that require minimal financial contributions.

Program Features

The TIC funding agency staff must have a strong planning, monitoring, and evaluation capability. There are several reasons for this recommendation regarding the staffing and functions of the organization that will plan and manage the TIC program. These reasons are interrelated and have to do with the challenges that face the program in achieving successful outcomes, which are in turn related to the broader challenges, outlined earlier in this report, that fact universities and industry as both sectors seek changes leading toward greater research capabilities and innovative, risk-taking behavior.

First, participants in our stakeholder workshops and interviews were clear and consistent in their recommendation that the TIC program planned so that ***initial TIC awards should include several with strong potential for generating evidence of successful outcomes.*** It is very important that after just two or three years of operation, a significant proportion of the first cohort of centers achieve visible, significant signs of success. The reason is simple: the underlying lack of trust between academia and industry must be overcome if any substantial movement toward industry-university collaboration in research is to occur. And this, in turn, will not occur unless there are obvious examples of early success with the TIC effort. These early successes probably cannot exhibit the full range of impacts expected of the TIC program in the long term; there simply will not be sufficient time for centers to generate the desired flow of uniquely trained graduates, experienced faculty, and innovation-oriented managers that will be the most highly valued output of the centers program. Nor will there be time for a second important but long-term outcome, successful new products or processes introduced by participating companies but originating in collaborative center research. Instead, these successes will be "mid-term," showing a record of successful industry problem-solving that can be directly attributed to successful collaborations fostered by the centers. It will important that both faculty and students be engaged in these successful collaborations.

Second, and directly related to the first recommendation, ***the TIC program should be introduced on a phased, limited basis, beginning with planned variations to test feasibility of various options.*** In addition, ***TIC's program plan should exhibit a strong strategic element, learning capability, and flexibility.*** Many of the successful international partnerships investigated for this study showed a history of careful experimentation prior to implementation of a full-scale program, the use of planning grants or other forms of seed awards for promising opportunities, and/or a period of review of, and feedback from, existing centers leading to revisions in the program's features (see Appendices D and F to this report for examples). Once the TIC program unit has been set up and staffed, it should engage in systematic efforts to identify the most promising opportunities for successful TICs in the

Kingdom. As will be seen in the more detailed recommendations to follow in the next chapter, TICs are likely to take a variety of structural forms, locations, and technical foci. Identifying promising opportunities could be done through several means, including the support of industry-university workshops on specific industry problems, possibly facilitated by appropriate industry or professional associations. TIC program funds should be made available for this purpose. Also, special awards should be designed to attract proposals from university faculty already working successfully with industry. These would be planning grants or feasibility studies enabling existing, successful small-scale working relationships to experiment with ways of expanding this successful experience into a full-scale TIC, resulting in a proposal for a full-scale TIC. Beyond these exploratory efforts, the TIC program staff should also identify three or four variations of the basic form of centers detailed in the next chapter and seek proposals for funding of "planned variations" of centers, specifically designed to test the strengths and weaknesses of different variations of the basic TIC theme. These experimental centers would be carefully observed by TIC program staff to identify the strengths and weaknesses of each variation, with the objective of developing lessons learned for future cohorts of TIC awards.

Types and sizes of TIC awards should be flexible to address range of different center requirements and problem foci. This recommendation arises directly and obviously from the several points and recommendations already made: centers are likely to vary considerably depending on their location, problem focus, and other factors, so the TIC program award structure should have sufficient flexibility to adapt to different kinds of opportunities.

TIC awards should constitute a significant investment: 10-20M SR total budget per center per year including up to 50% co-investment by partners. Stakeholders made it clear that TIC awards will have to be sufficiently large to provide the visibility and, through the quality of the work involved, the flexibility and prestige that will attract university faculty and industry. Co-investment by partnering institutions is important to ensure commitment to a center, although the absolute size of the commitment is less important than whether in every case it represents a serious commitment by the involved parties. Small businesses obviously can demonstrate commitment with far fewer resources than larger companies, universities, or government laboratories. Commitment need not take the form of cash support, but in-kind contributions such as faculty time, equipment and facilities, or staff with special technical skills all could suffice.

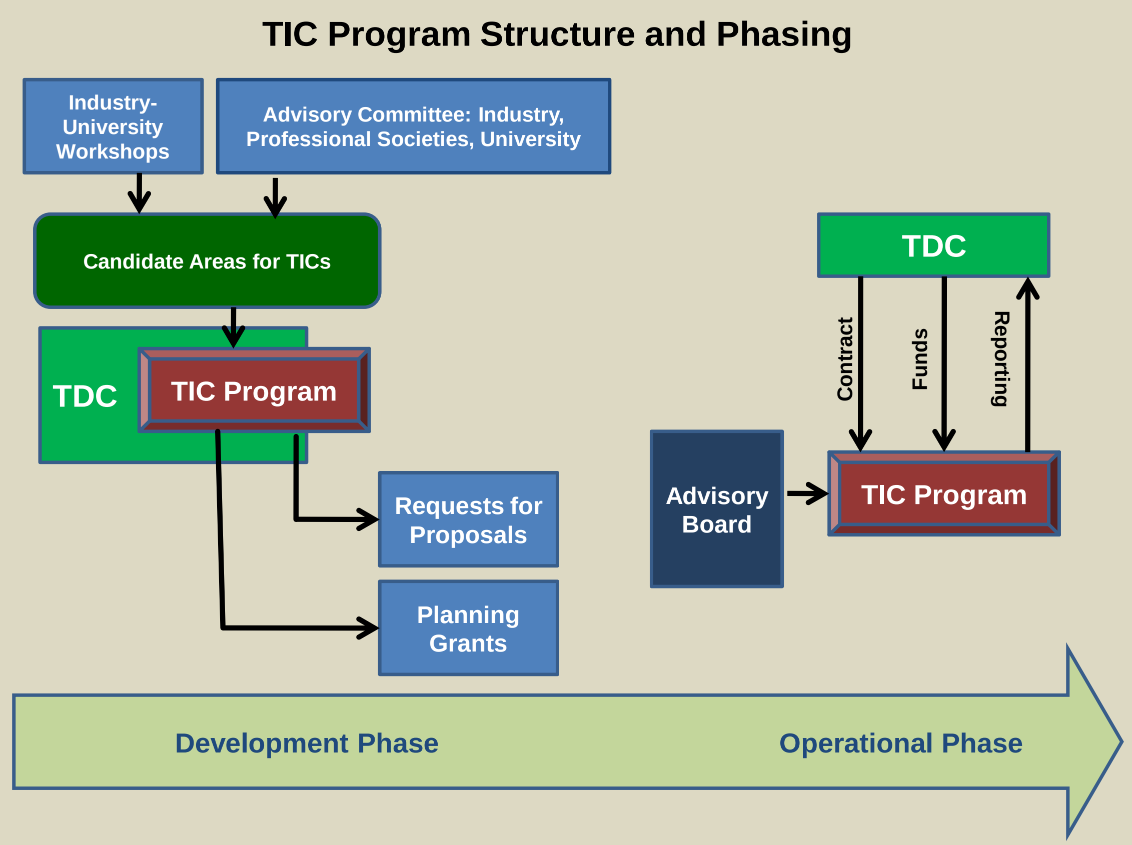
VI. RECOMMENDATIONS FOR DETAILED TIC PROGRAM AND CENTER DESIGN

TIC Program Initiation and Phasing

We recommend that the TIC Program be implemented in two phases, developmental and operational. In the developmental phase, which would extend for 3-5 years beginning in 2009, emphasis should be placed on building a solid foundation upon which the "steady state" or operational phase will rest. This period will be one of experimentation, learning, and capacity-building. It will require flexibility and patience among stakeholders eager to see results, because the major goals of the program cannot be achieved over the short term. It will also require close collaboration among TIC program staff and representatives from industry, universities, professional and technical societies, and other stakeholder groups. At the end of the development phase, it will be essential to the future success of the TIC program that a number of milestones be achieved:

- Four to six TICs will have been established and can demonstrate considerable success toward the achievement of TIC program objectives.
- Funded TICs show that teams of university faculty and students can work effectively in close collaboration with industry on industry-identified problems.
- TIC-industry interactions will have resulted in demonstrable increases in the level of trust and mutual respect between university faculty and industry researchers.
- TICs and the companies they work with will be able to illustrate the benefits of their collaborations in the form of promising or actual solutions to selected industry problems.
- The first cohorts of graduates trained in TIC research projects will be in demand for jobs requiring experience with industry problems, team-based research, research management, and technology commercialization processes.
- TIC faculty and staff will be able to demonstrate knowledge and skills associated with technology management, research planning and management, and management of collaborative projects that involve university faculty and industry.

Achieving these milestones will be a major challenge for both the TIC program staff and for individual centers. It is therefore crucial that the TIC program be organized, staffed, planned, and managed carefully with these milestones in mind. The initial cohort of TICs, funded during the program's development phase, must be carefully selected, designed, and nurtured so that strong indicators of their eventual success will be evident within 3-5 years of their initiation. The following diagram and description summarize our recommendations for the TIC program structure and phasing. We offer detailed recommendations for these elements of the TIC program's development phase in the following section.



In the development phase, TIC remains part of TDC. Effort is focused on identifying problem areas for TICs that reflect industry interest and evidence of mutual trust between faculty and relevant firms, such as university experience working with industry, and a history of successful interactions to build upon. TIC Program strategies will include industry-university workshops funded by TIC in collaboration with professional/technical societies, industry associations, university representatives, and input from the TIC Advisory Committee, populated by representatives from key stakeholders. Outputs during this phase will include planning and seed grants, requests for proposals.

In the operational phase, the TIC Program is operated by a separate organization under contract to TDC. The Advisory Board will have strong but not statutory influence over TIC strategies, priorities, and plans.

TIC Program Design

This section details our recommendations for the following elements of the TIC Program: structure, staffing, costs, and legal/procedural matters. Where possible, we accompany these detailed recommendations with examples drawn from either the Australian Cooperative Research Centres Program and/or the U.S. Engineering Research Centers Program. Our analysis of international industry-university cooperative research centers, together with discussions with our KACST client, let us to identify the Australian CRCs as the most appropriate single example of a highly successful program with goals similar to those of the TIC Program. Accordingly, in Volume II of this report we provide a number of examples of official documents employed by the CRC Program as highly detailed guides, if not templates, for the TIC Program.

Because our recommendations are based on what we consider the essential activities to be performed by the TIC Program, we repeat these key features here.

- ***The TIC funding agency staff must have a strong planning, monitoring, and evaluation capability.***
- ***The TIC program should be introduced on a phased, limited basis, beginning with planned variations to test feasibility of various options.***
- ***TIC's program plan should exhibit a strong strategic element, learning capability, and flexibility.***
- ***Initial TIC awards should include several with strong potential for generating evidence of successful outcomes.***
- ***Types and sizes of TIC awards should be flexible to address a range of different center requirements and problem foci.***
- ***TIC awards should constitute a significant investment: 10-20M SR total budget per center per year including up to 50% co-investment by partners.***

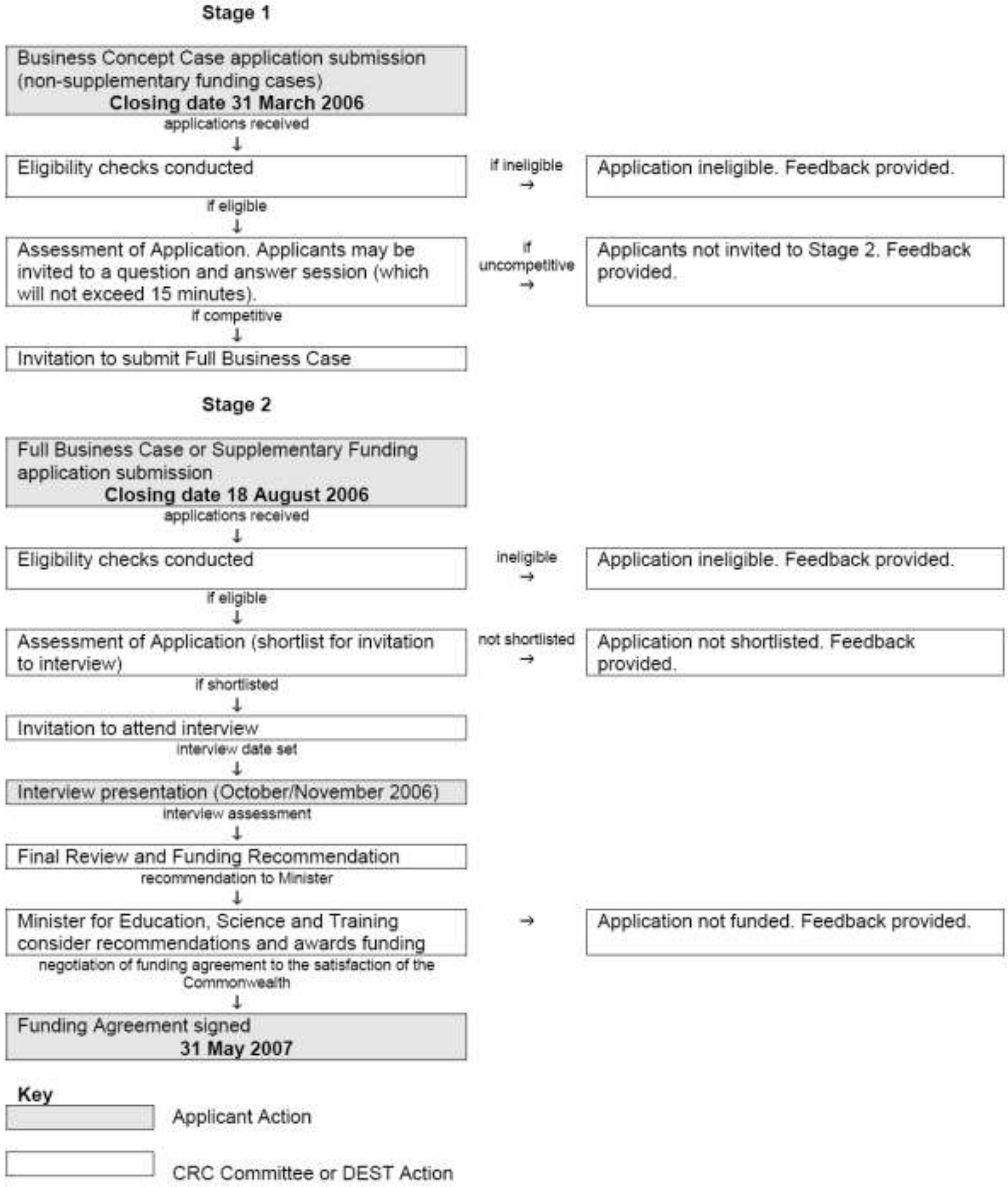
The first three requirements have important implications for staffing the TIC program office. Top management should have experience with strategic planning of research programs and familiarity with both university and industry incentive structures, preferably gained from actual experience working in both settings. The office should be staffed initially with 2 to 3 Program Managers, each responsible for 2-3 TICs. Program Managers should have technical backgrounds, preferably research and management experience in fields broadly related to the areas in which TICs are expected to be working. Ideally, they would be familiar with both university and industry contexts. We also recommend that the office retain one staff person trained specifically in research program planning and evaluation; this staff person will develop information essential for tracking the activities and outputs of funded centers so that problems can be identified quickly and support provided for solving them before the involved center is unable to function.

The fourth requirement, selecting locations for TICs especially likely to succeed, will require strong input from the Program's Advisory Committee, on which stakeholders from industry, universities, and technical/professional societies should be represented. This input will be critical for this and a number of Program activities, such as: developing strategies for developing strong proposals for initial TICs that are highly likely to succeed; finalizing formal requirements for TIC proposals and for Center operations that recognize the complex set of challenges that face both universities and businesses interested in research collaborations; developing a "portfolio" of TICs that address an appropriate range of industry problems and academic realities; and dealing quickly and effectively with the many problems likely to arise as the TIC Program evolves; legitimizing and publicizing the TIC Program beyond the immediate stakeholders represented on the Advisory Committee.

The fifth and sixth requirements address the types, sizes, and specific requirements for awards made to TICs. As noted earlier, we recommend strongly that during the Program's developmental phase an experimental, planned variation approach be taken that includes small planning grants to develop existing "pockets" of university-industry research collaboration to the point where a strong proposal to the TIC Program can be prepared; and the deliberate support of a variety of different center arrangements, e.g., small vs. large firms involved, multiple vs. single universities involved, locating near a university vs. near one or more companies involved in the proposed collaboration. The latter strategy, if carefully planned and evaluated, will provide the TIC Program with important information about which forms of centers work better under different circumstances, and thus provide "lessons learned" that will inform future program planning and award decisions. While no existing international program offers a specific model to guide the design of the TIC Program, we believe that Australia's CRC Program provides a sound basis on which the costing of the TIC Program, its awards portfolio, and proposal requirements, and review procedures can be built.

The Australian CRC Program and the U.S. Engineering Research Centers both issue periodic solicitations for proposals from eligible institutions. These solicitations are quite detailed and describe the program's goals and objectives, eligibility requirements, proposal guidelines, legal and budgetary requirements, and proposal review procedures and criteria. The CRC Program offers useful templates for TIC to consider in developing its own solicitation and proposal review procedures. A detailed call for applications is issued for each round of CRCs. The process is illustrated in the following chart, taken from the 2006 Selection Round Guidelines for Applicants (Volume II, Appendix D-6):

Figure 1: CRC Programme Selection Process 2006



The review process after three years is outlined in Appendix D-7. The Third Year Review is designed to help a CRC to:

- examine its overall performance and strategic direction in the context of the end-user requirements;
- assess the performance of individual projects, and determine whether a project needs to be continued, discontinued, refocussed or reviewed at a later stage; and
- identify areas where resources need to be reallocated in order to achieve the intended outcomes.

The Review also assists the Commonwealth to:

- make decisions about the continued funding of a CRC; and
- identify non-confidential systemic issues and best practices for the purpose of sharing these with other CRCs to assist them to manage similar issues.

Third Year Reviews have been established to allow a reasonable timeframe for assessing CRC's performance following its establishment, and at the same time for implementing new directions for the remainder of the contract period, if necessary.

Each CRC is responsible for commissioning and funding its Third Year Review. The CRC must ensure that the Third Year Review is both independent and cost-effective. It is expected that the visit of the Independent Panel should take no more than two or three working days and that the review will be held primarily at the CRC's headquarters. Economic impact assessment templates have been developed by the CRC Association and a set of standard questions have been provided for those CRCs intending to conduct an industry survey.

TIC Center Design

As the above TIC Program design recommendations suggest, we envision a range of different "models" for TICs that will reflect different university capabilities, different industry problems and needs, and different existing industry-university interactions that offer promising foundations for a TIC. Despite these important variations, it is crucial that all centers meet certain basic requirements as presented and discussed in the previous chapter:

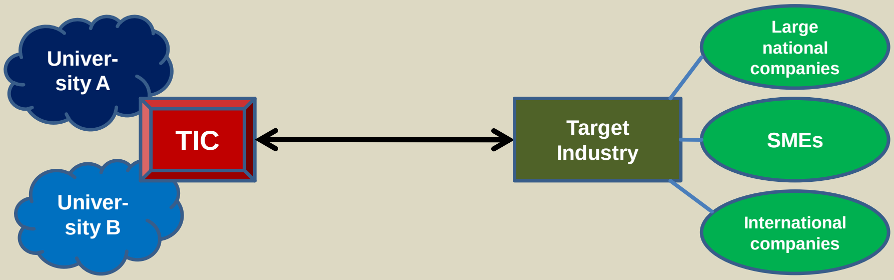
Center research must demonstrate alignment with KSA national priorities.
Successful centers must meet standards of research excellence, human and social capital development, and industry relevance.
Centers must plan strategically to achieve integration of research, education, and technology transfer.
Center activities must reflect central roles for interdisciplinarity, collaboration, and industry orientation.
Collaborating parties must demonstrate commitment to the TIC via co-investment/cost sharing.
No single TIC "model" is likely to fit all situations.

Centers should be affiliated with universities, but may be organized and managed outside the normal university structure.
Centers should promote engagement of women in all activities.
Centers should offer incentives for small and medium-sized companies as well as large firms.

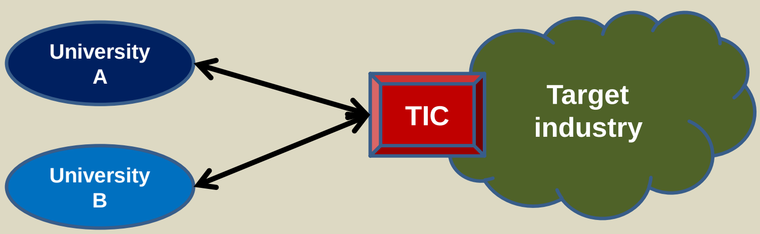
As an example of variations that might be expected among TICs, the following diagram depicts two different styles of centers, one emphasizing the development of human capital and other basic capacities and one emphasizing technology commercialization. As we have argued, both of these outcomes are essential products of the TIC Program as a whole, but individual centers may choose to emphasize one over the other, depending on the history of the involved parties and their relative areas of expertise. Whatever variant a center chooses, we offer the following specific recommendations for center structure, costing, staffing, and legal/procedural matters. These recommendations, we believe, will maximize the likelihood that individual centers adhere to the general requirements for success just listed and, accordingly, will achieve their intended goals. Our recommendations are enriched by specific examples drawn from the Australian CRC Program and the U.S. Engineering Research Centers Program.

TIC Center Models

Model A: Primary objective of capacity building



Model B: Primary objective of commercializable technology/products/IP



In the capacity building model, TICs are closely associated with universities but research programs are driven by industry problems. Emphasis is on developing university capacity to work with industry, develop team approaches to research, entrepreneurial capacity and resources among university faculty, IP management capacity, and coursework and experience for students in technology development and commercialization.

In the commercialization model, TICs are closely affiliated with industry and draw on universities for faculty and students to work on industry-driven problems. This model assumes that the involved universities have acquired the capacity to contribute effectively to industry problem-solving and work collaborative with industry researchers in an atmosphere of mutual trust.

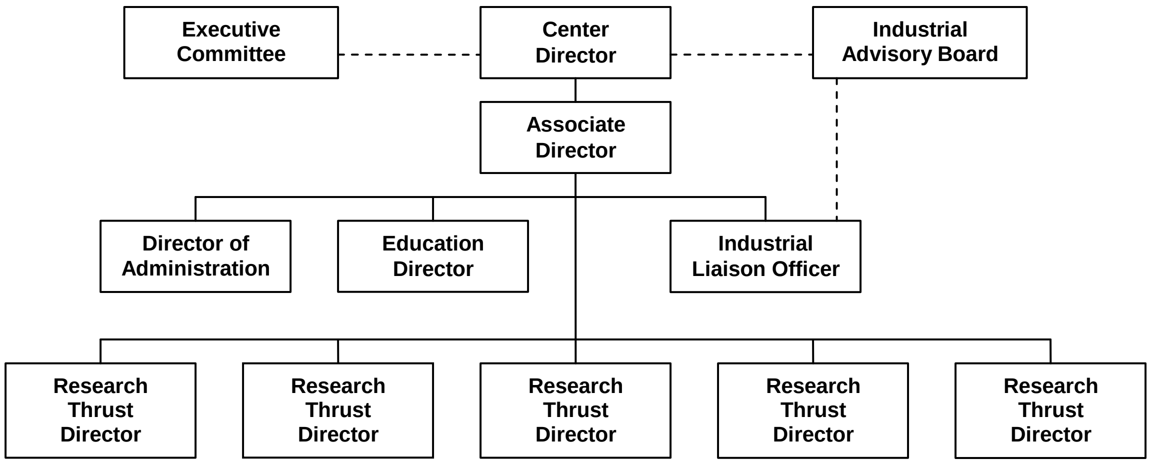
Center Organization

The Center Director should be the Principal Investigator (PI) of the award and has primary responsibility for administering the award in accordance with the legal form of the award. Because of the substantial educational role expected of TICs, it is desirable that the Director should be a member of the engineering faculty or have some experience with higher education. This by no means precludes the Director from being hired away from a career in industry; indeed, many successful directors of U.S. Engineering Research Centers have industrial experience. Based on the ERC model, the Director's leadership team should consist of:

one or more Associate Directors, leaders of research teams (typically 3-5) who will conduct and manage research performed by the center,
an Administrative Director responsible for the day-to-day administration and financial management of the center,
an Industrial Liaison Officer or coordinator who develops and maintains industrial membership in the center and collaborative interactions with firms, and
an Associate Director for Education, a faculty member who leads curriculum development efforts.

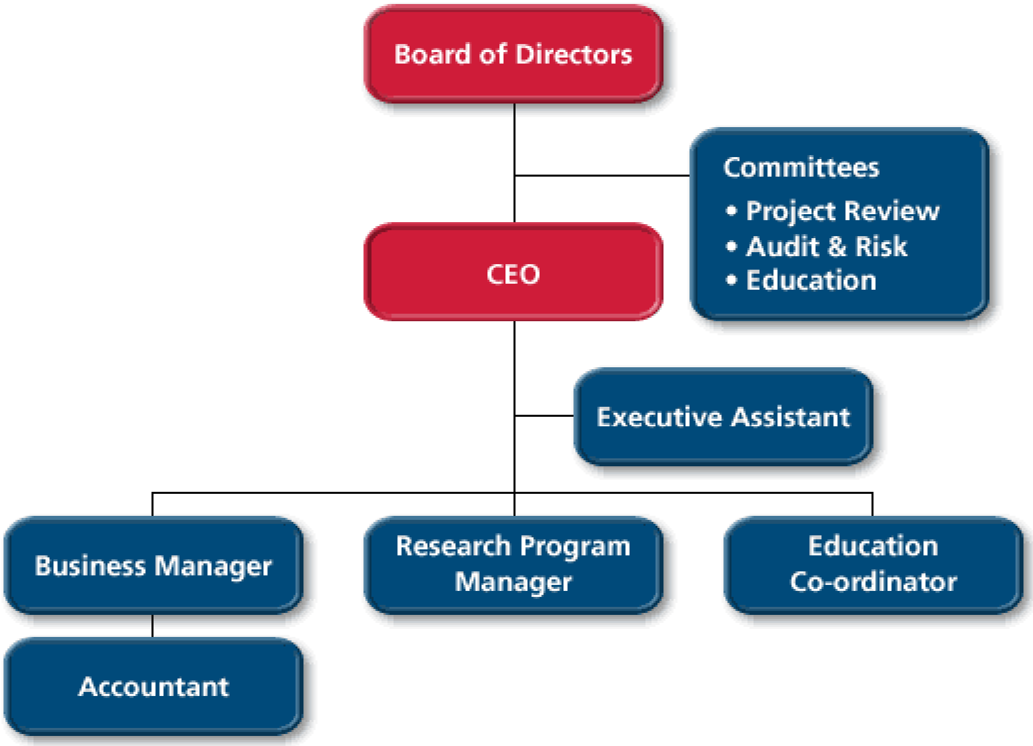
We expect TICs to be large, complex organizations that will require a substantial amount of sharing of managerial work among center leadership, as well as delegation by the Director to the Associate/Deputy Director, research thrust leaders, Industrial Liaison Officer, Education Director, and Director of Administration. Once a center is in operation, companies associated with the center should identify representatives to the center's Industrial Advisory Board (IAB), which should meet periodically to hear about the center's research progress and offer input for new research directions. IABs can form subcommittees that work more intensively with the center's research thrust leaders and, sometimes, with specific projects. On a continuing basis, one of the most effective mechanisms for ensuring that knowledge and ideas flow in both directions is through personnel exchanges, particularly visiting researchers from industry working in the center lab and faculty and student internships in industry. The organizational structure of a typical Engineering Research Center is shown below.

Organizational Structure of a Typical ERC



An alternative, somewhat simpler model from an Australian CRC is:

AutoCRC Ltd Organisation



Center Staffing

The Center Director or CEO will be the key to a successful TIC. Whether recruited from outside the university or a senior faculty with an established research program, the Director should possess a number of characteristics that experience has shown are important for the center's success. He or she will hold a Ph.D. in a relevant field of engineering or science; if a faculty member, will have industry experience; will have tenure and be widely recognized for scholarly achievements. Some management experience is highly recommended. It is critical that the Director be able to articulate and "sell" the center's vision to a wide range of audiences, especially to potential sponsors of the center from government and industry as well as within the university, energizing them to contribute to realizing the vision.

Experience with U.S. Engineering Research Centers has shown that successful Directors have the following leadership traits:

- the ability to articulate a vision for the center that is shared with industry and the faculty and that is flexible enough to evolve over time with the developments of the center and the field;

- a clear perception of the current status of the field and a vision of future advancements and a strategy to achieve them;
- the ability to recognize intellectual needs and identify needed talents, both internal and external to the university faculty, and to form and sustain a cross-disciplinary team over time; and
- the ability to lead without coercion.

Finally, the Director should be a team-oriented coalition-builder with good interpersonal skills: diplomatic, tactful, empathetic. Clearly, this is a very demanding job requiring a rare mix of research, managerial, and interpersonal skills, strong determination to make the center succeed, and the willingness to make personal sacrifices to accomplish this.

The Director of Technology Transfer or ILO should have industry experience, and should have the freedom to build meaningful relationships on an ongoing basis with companies interested in the center's research and technology. The ILO must be able to work closely with the research and education activities of the center because these functions are integral to technology transfer: research should be cooperative with industry, and students should be closely involved with industry through their center research and through internships with member companies.

TIC education programs should:

- encourage students to work in teams by having them work on projects that require inputs from a variety of research fields;
- interact directly with industrial researchers both on campus and in company research labs;
- develop new undergraduate and graduate degree programs and curricula that incorporate center research results.

A PhD should be a requirement for this role, both to gain the respect of center researchers and to provide the background necessary for involvement in curriculum development. The education director should be a full member of the center's senior leadership, together with the directors of research and technology transfer.

The Administrative Director (AD) of a TIC must be able to hold the administrative functions of the center together. To preserve the Center Director's time, he or she will necessarily delegate a great many responsibilities to the AD. Typically, the AD would be expected to:

- Assist the Center Director in the overall management of the TIC;
- Act as the guardian and expert on rules, regulations, and policies of the center;
- Serve as the information gatekeeper and resource for all members of the center; and
- Be the center's financial and personnel manager.

The tasks that are most frequently delegated to the AD include event management, communications, routine accounting and payroll documents, facilities management, and tours of the center. The AD brings an important operational perspective to strategic planning: considerations such as staffing and personnel requirements of the plan against relevant rules and regulations, and budget constraints and requirements. Usually the AD is responsible for managing the center's finances and as such is the authorized representative of the Center Director and has full signature authority.

TIC Center Cost Model

The TIC center cost model is based on careful evaluation of operating costs for a variety of international centers in the table below. Some of the centers are similar to what is being proposed for TICs – such as the U.S. NSF Engineering Research Centers (ERC) and the new U.S. Department of Energy Frontiers Research Center (EFRC) – these are multiple multi-year programs. While the Fraunhofer Institutes are also part of a large program, they differ substantially from other centers program in their funding source – a larger proportion comes from industry because they primarily serve the industrial needs, rather than curiosity driven fundamental research supplemented by industrial priorities. Some of the other centers are somewhat unique – the Belgian IMEC, and the Japanese INQIE, the U.S. NSF Center for Chemical Innovation (CCI) which are either a single center, or part of a small cohort but with unique funding model.

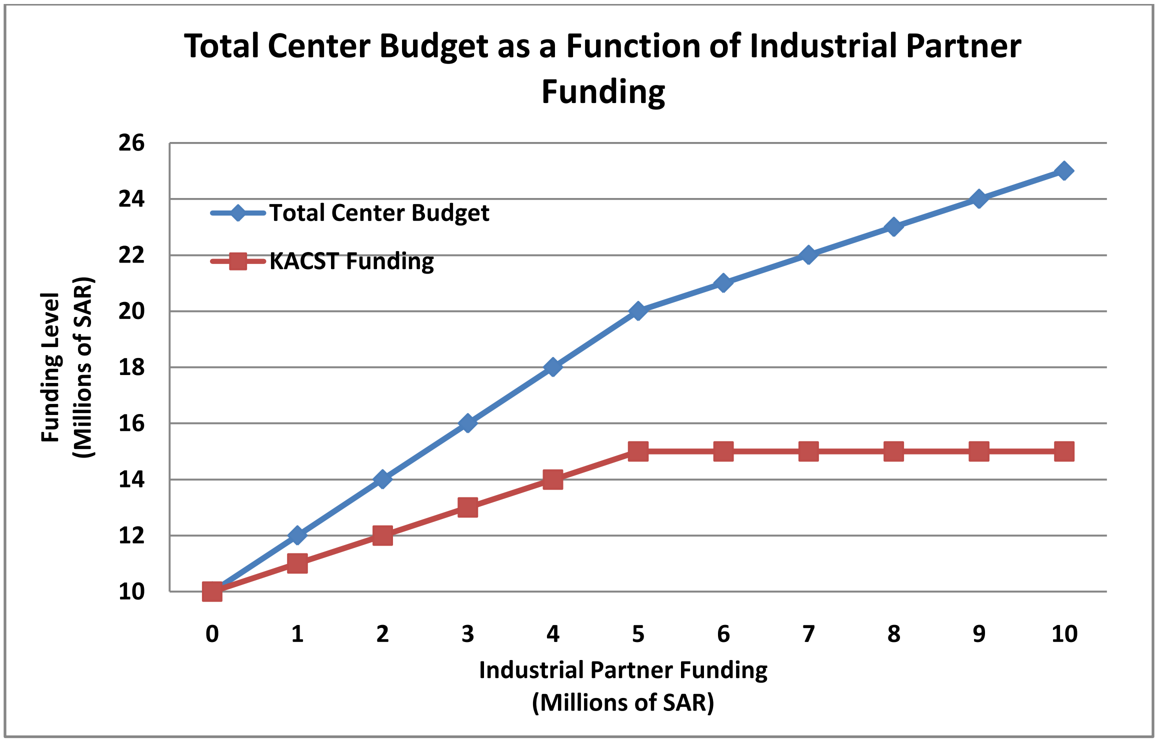
Center	Annual Budget in US $	Description
US NSF Engineering Research Centers	$3.25 M – increases annually by 0.25 to max of $4.25 M in 5 years	Approx. 50% for research, 50% for outreach (educational and industrial)
US DoE Energy Frontiers Research Centers	$2-5 M annually – amount up to proposer	No requirement for outreach budget – public outreach desirable
Fraunhofer Institutes	Data not fully available for all 42 centers– 3 centers have budgets ranging from a low of 3.8M € to 50 M €	No requirement for outreach – about 50% for most centers from industry
Belgium Inter University Microelectronics Center (IMEC)	$ 320M	Large single institution, with large capital requirements for semi-conductor fab – major Belgian govt. + EU funding + industrial consortium funding
Japan INQIE	$8 M first 3 years - $16 M next 2 years	Govt. 50% + Industrial consortium 50%
US NSF Center for Chemical Innovation	$4 M for 5 years – possible renewal for another 5 year period	Multi-institution budget with overhead, and modest educational outreach (<5%) requirements
KSA MoHE SCORE	Average for 9 centers - $2.7 M annually (10M SAR) – range from $0.25 M to $4.5 M	Salaries average 50% of the budget, while equipment average 25% of the budget, rest for materials and supplies, travel, conferences, etc.
Australian CRC	Average of A$2 M (US$ 1.3-1.8M, depending on currency exchange rate) per year for 7 years	Salaries average 60%, equipment 25%, consumables 15%

Most U.S. centers include large overhead on direct costs (which includes all budgetary items except capital equipment, and graduate tuition), so money available for pure research is substantially less than total operating budget. In evaluating Saudi university research funding models, it is evident that overhead costs are not included and all money can go directly into salaries, equipment, consumables, travel, and other categories. Therefore, in principle a smaller budget can fund the same level of research activities as in U.S. centers programs. It is important however to ensure that this program has high visibility and attractiveness. Hence our recommendation is to fund it at the SAR 10M – 15M annually.

One of the primary design elements of TIC funding should be to attract industrial partners, both for prioritizing research, and also for transfer of knowledge and benefits to society. Hence our proposed model of funding each center has two components:

Annual Base funding: SAR 10M +/- performance based merit increments/decrements. In the developmental phase of the TIC Program, this base funding should remain fixed and not be subject to merit reviews. In the steady state operational phase, each center can get incremental funding of 10% depending on superior review, or decreased funding of 10% based on below average review, with average reviews left at the previous level of funding. This incentive scheme is extremely important for centers to be responsive to annual review feedback.

Industrial Partners Program: Industrial funding matched 1:1 from KACST up to a limit of SAR 5M annually. The graph below shows the result of industry matching funds for total TIC budgets. This model is based partially on the Fraunhofer model of matching industrial funding with one exception – the slopes of the Fraunhofer matching model is designed to keep the proportion of industrial funding within a fixed range – not too low since the Institutes are meant to serve industry, but not too high since the Institutes are also meant to have some autonomy from industrial needs in their overall direction. In the KSA context, since many industries are not sufficiently mature, it is less likely that industrial money will overwhelm early TICs. Hence the matching funds model is simplified to 1:1 matching. At a later stage, it would be possible to switch to the Fraunhofer model of low-high-low slopes for matching funds.



TIC base funding should cover the following categories:

- Salaries: Principal Investigators, Faculty, Senior Personnel including technical and computer related staff, secretarial and administrative staff, Post-doctoral researchers, graduate students (if not funded through other sources), and undergraduates (involved in research not funded directly), and visitors to the center
- Permanent equipment
- Materials and supplies
- Travel – categorized into domestic and international by center personnel, and visitors and consultants to center
- Publications, documentation, dissemination, databases etc.
- Consultant services

- Computer services (if outsourced outside the university)
- Sub-awards to other institutions (academic or non-academic).

Base funding should not include infrastructure and building costs (see below).
Industrial Partners Funding is crucial to the TIC program design. Industrial partners can contribute in cash, equipment, or in-kind donation of time (auditable records need to be provided to the center in this instance).
Infrastructure needs can be articulated in the proposal, but would require co-investment from home institution. The Industrial Partners matching fund from KACST can be partially or wholly used for infrastructure needs provided there is a justifiable need for it.
Approximately 20% of center funding will be required for administrative and management costs, including the following critical activities:

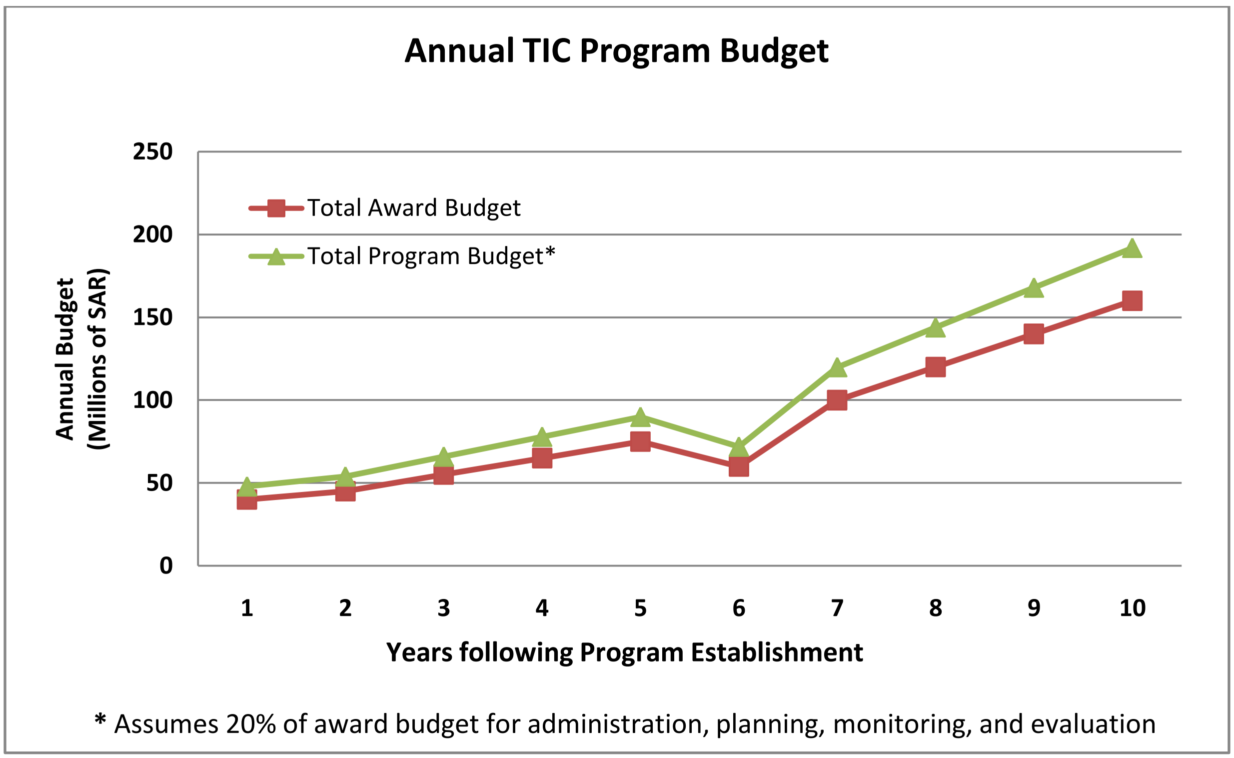
- Program monitoring – continual contact between KACST and TICs; annual upload of data from TICs; analysis of data in advance of annual site visits; periodic visits by program monitors to TIC sites
- Annual site visit – conducted by a team of technical and non-technical center management experts – each review would be over a period of 1.5 days.

TIC Program Cost Model

As noted in a previous section of this report, we recommend that the TIC Program be implemented in two phases: a five-year development phase and a "steady state" operational phase. During the developmental phase, awards to an initial group of carefully selected centers will be accompanied by awards for feasibility studies and for seed grants to develop the mutual trust and understanding that must precede initiation and implementation of a successful TIC. We recommend that the program be "kicked off" with the award of three TICs, very carefully chosen to ensure that these centers will produce clear evidence within a few years of the capacity to engage in effective industry-university research collaboration, problem solving, and education and training for industry needs. During the development phase, additional awards should be made to develop and test the feasibility of promising centers and to provide seed or development funding for ideas that could lead to solid proposals for TICs. Also during this phase, money should be available for planning workshops, stakeholder meetings, and industry-university conferences focused on mutual problems. We recommend that, over the five-year development phase, the TIC Program fund one additional TIC each year for the next four years following the initial award of three centers. In addition, SAR 5 million should budgeted annually (after allowing for SAR 10 million in the first year) for program development studies, feasibility studies, and seed grants. Each TIC would be funded for a total of five years, assuming favorable periodic reviews of performance, and would be eligible to apply for a second award.

In the operational phase, we recommend funding an additional set of two TICs each year, and no significant funding for feasibility studies (although it would be wise to hold aside a small amount each year to help develop unexpectedly promising ideas or pre-proposals). In year 6, the initial 3 TICs will be terminated (unless they compete successfully for a follow-on award). In years 7-10, one TIC will be terminated and two additional TICs funded annually. We also recommend that additional Program funding, approximately 20% of total annual awards, be budgeted for TIC Program administration, planning, monitoring, and evaluation—key ingredients that will be essential to the long-term success of the program.

The following chart summarizes these recommendations and the assumptions underlying them in the form of annual funding requirements for the TIC Program.



Legal/Procedural Rules and Regulations

The Australian CRC model provides a sample of the guidelines and regulations which might form a useful starting point for consideration of what might be appropriate for the TICs. These include:

1. A constitution template that provides guidance for the way a CRC should address such governance issues as:
    - the objects of the organization;
    - the treatment and ownership of income and property;
    - membership of the company and the governing board;
    - the calling, procedures and voting requirements of meetings by the board;
    - appointment and removal of directors;
    - powers and duties of directors;
    - remuneration of directors;
    - proceedings of directors;
    - management
    - record-keeping and reporting;
    - audit and accounts; and
    - winding up of the organization.
    -

    Full details are provided at Appendix D-2.

2. A CRC participation agreement template (Appendix D-3) which provides guidance on an appropriate form of legal agreement between all members of the CRC, including:
    - Centre objectives;
    - relationship of the parties;
    - Centre resources, including contributions, assets and budgeting;
    - Centre accounting and reporting;
    - project provisions including initiation, selection, treatment of background IP, funding, management, withdrawal and termination;
    - Centre outcomes including commercialisation of IP;
    - allocation of risk;
    - Government agreement liabilities and obligations; and
    - dispute resolution.

3. The required components of a legally binding contract between the Government and the CRC (Appendix D-4), addressing:
    - term of contract
    - payment of Commonwealth funding
    - entitlement to Commonwealth funding
    - management, governance and activities of the CRC
    - contributions
    - application of Commonwealth funding and contributions
    - other financial assistance
    - accounting for Commonwealth funding and contributions
    - liaison

- intellectual property
- publications, publicity and use of CRC indicia
- conflict of interest
- confidential information
- reporting and monitoring
- performance review
- content and format of reports
- effect of expiration or termination of contract
- assignment and sub-contracting
- relationship with Commonwealth
- insurance
- indemnity
- access to premises and records
- compliance with law and policy
- safe and ethical research
- dispute resolution.

4. Annual Report Guidelines (Appendix D-5) which specify the required content of the report:
   - Executive Summary addressing the context and major developments during the year
   - Contribution to National Research Priorities
   - Governance and Management
   - Research Programs including research activities, achievements and collaborations
   - Commercialisation and Utilisation strategies, activities and Intellectual Property Managemen*t*
   - *Communication Strategy*
   - *End-user Involvement and CRC Impact on End-users*
   - Education and Training.