Kingdom of Saudi Arabia

Strategic Priorities for Information Technology Program

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The National Policy for Science and Technology, approved by the Council of Ministers in 1423 H (2002 G), defined 11 programs for localization and development of strategic technologies that are essential for the Kingdom's future development. This roadmap is the plan for one of these programs, the Information Technology Program.

This plan is complementary to The National Information & Communication Technology Plan (NICTP): The Vision Towards the Information Society, prepared by the Ministry of Communications and Information Technology in 2004, which described the importance of information technology (IT) for the Kingdom, assessed the strengths and weaknesses for the Kingdom in IT, and set out a vision and goals in the IT area. While that plan focuses on the application and use of IT, this document focuses more narrowly on IT research and innovation.

Information technology is a particularly important technology for the Kingdom of Saudi Arabia (KSA). IT has been a key driver of productivity growth and economic growth in many countries around the world. IT development generates productivity growth throughout the economy by facilitating the rapid dissemination of information, by refocusing the workforce on higher value activities, by creating new services, and by aiding education and training. IT, especially computer modeling, data analysis, and databases, also enables advances in almost all fields of science and technology. The competitiveness of the Kingdom as it moves into knowledge-based industries, such as finance, telecommunications, health care, and education, relies heavily on IT.

This plan is based on input from the users and stakeholders for information technology in the Kingdom, including government agencies, industry, and universities that use IT or IT R&D. The planning process:

- Identified the key needs of the Kingdom for IT research and innovation.
- Assessed the strengths, weaknesses, opportunities, and threats for the program, including an analysis of KSA IT publications and patents and an assessment of international research institutes.
- Defined a mission and vision for the Kingdom's IT program.
- Defined the key technologies and other program areas needed to address

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the Kingdom's needs in IT research and innovation.

Among the key needs in the Kingdom identified in process are:

- Arabic language software, including needs for translation, Arabic search engines, speech recognition, text-to-speech and Arabic Internet domain names.
- Medical informatics.
- Oil & Gas software and applications, including but not limited to process automation, simulation, visualization, performance optimization, experts systems and intelligent oil fields.
- IT security, including Internet resiliency and the ability to respond to security threats and events.
- Authentication for e-government and e-commerce.
- Advanced networks.
- E-government applications.
- E-Learning applications and content.
- Hajj-related applications, including databases, simulation models, geographic information systems, and applications of radio frequency identification (RFID) to crowd control.
- Process automation and business process management (BPM).

In addition to the technical needs, workshop participants identified a large number of areas where policies need to be changed or barriers removed to facilitate IT innovation. These needs include:

- Policies to facilitate R&D collaboration between KACST, universities, and industry.
- Policy and organizational changes in universities to improve the ability of faculty members to conduct research.
- Expanded human resources for IT R&D.
- Improved knowledge of international technology developments.
- Expanded international collaboration, including cooperation between Saudi universities and world universities.
- Saudi participation in international standardization bodies.
- Studies of the social aspects of ICT.
- Small business contracting preferences to support innovative small companies.

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The priority technology areas that emerged from this process are as follows:

- **Speech and Language**

– Speech (including speech recognition, synthesis, speaker verification/ identification and speech resources).

– Text (including computational linguistics, machine translation, statistical language modeling, information retrieval and web search engines and text mining, language resources).

– Special needs applications (including sign language, and the Braille system).

– Arabic document processing and optical character recognition (OCR).

- **High Performance Computing**

– Supercomputing architecture & software.

– Supercomputing applications.

– Computer simulation.

– Computer modeling.

- **Computer Systems and Networks**

– Computer Networks.

– IT security and privacy.

– Database Systems.

– Operating Systems.

- **Software Engineering and inovated Systems**

– Local applications/localization.

– Open source software (OSS) engineering.

– System analysis and design.

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The IT Research and Innovation Program consists of a program leadership function, responsible for overall planning, management, and cross-cutting issues, and four priority technical areas corresponding to the fields above: Language and Speech; High Performance Computing; Computer Systems and Networks; and Software Engineering and Innovated Systems.

Within each technical area, projects will include KACST-university-industry projects to develop innovative pilot applications, university-industry technology innovation centers, and university grants in strategic areas.

The IT Program will be directed by a Program Manager, who will be responsible for the overall execution of the plan. The Information Technology Research and Innovation Advisory Committee, with stakeholder membership, will oversee the implementation of the plan. It will establish and review performance metrics and provide advice on the portfolio of projects. The Committee will advise the Program Manager and will report to the National S&T Plan Supervisory Committee, which will oversee all of the Strategic Technology Programs.

Introduction

Background

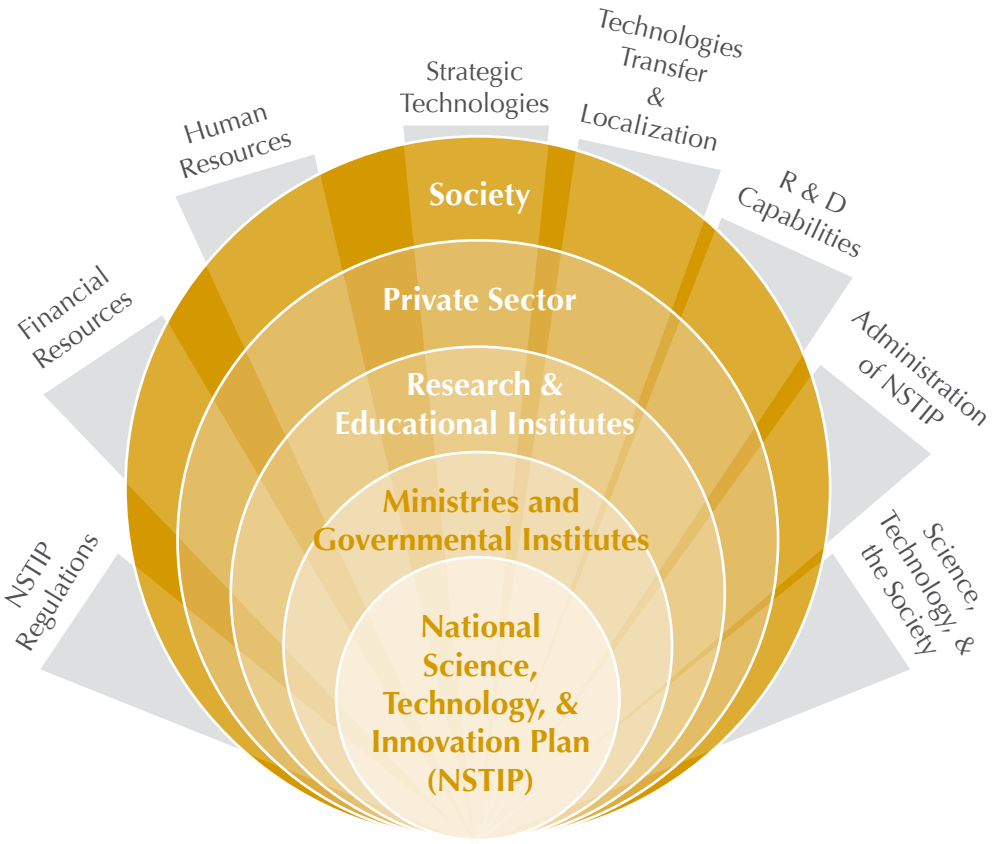
KACST was directed by a 1986 Royal Decree to "propose a national policy for the development of science and technology and to devise the strategy and plans necessary to implement them." In July 2002, the Council of Ministers approved the national plan for science and technology, which drew up the broad lines and future direction of science, technology, and innovation (STI) in the Kingdom, considering the role of KACST as well as that of universities, government, industry, and society.

The plan, depicted in Figure 1, encompasses:

1. Strategic and advanced technologies
2. Scientific research and technical development capabilities
3. Transfer, development and localizing technology
4. Science, technology and society
5. Scientific and technical human resources
6. Diversifying financial support resources
7. Science, technology and innovation system
8. Institutional structures for science, technology and innovation

Introduction

Figure 1: Science and Technology Plan



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

1. Water
2. Oil & Gas
3. Petrochemicals
4. Nanotechnology
5. Biotechnology
6. Information Technology
7. Electronics, Communication, & Photonics
8. Space and Aeronautics
9. Energy
10. Environment
11. Advanced Materials

Each plan establishes a mission and vision, identifies stakeholders and users, and determines the highest priority technical areas for the Kingdom.

Information technology (IT) is an especially important technology for the Kingdom of Saudi Arabia (KSA). IT has been a key driver of productivity growth and economic growth in many countries around the world, including the United States, India, Ireland, and Finland. IT development generates productivity growth throughout the economy by facilitating the rapid dissemination of information, by refocusing the workforce on higher value activities, by creating new services, and by aiding education and training. IT, especially computer

modeling, data analysis, and databases, also enables advances in almost all fields of science and technology.

In 2004, the Ministry of Communications and Information Technology produced The National Information Technology Plan: The Vision Towards the Information Society, which described the importance of IT for the Kingdom, assessed the strengths and weaknesses of the Kingdom in IT, and set out a vision and goals in the IT area. As noted in this plan, the competitiveness of the Kingdom in knowledge-based industries (KBIs), such as finance, telecommunications, health care, and education, relies heavily on IT.

Program Scope

The scope of this plan is national: it is an IT research and innovation plan for the Kingdom of Saudi Arabia. The plan involves universities, industry, and government stakeholders. KACST has overall responsibility for the development and execution of the plan.

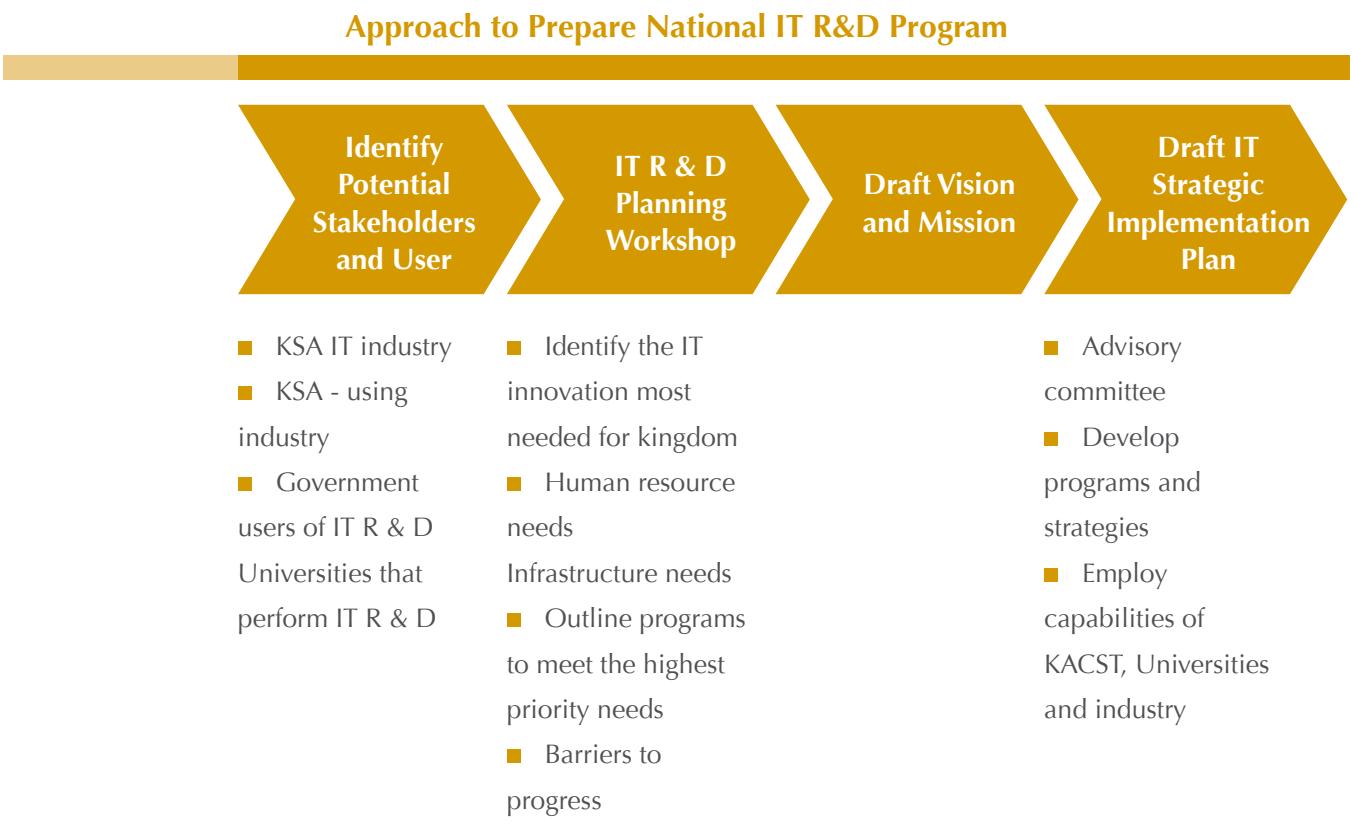
This plan is complementary to The National Information Technology Plan. While that plan focuses primarily on the application and use of IT, this document focuses more narrowly on IT research and innovation. It focuses on the strategic priorities for advancing the Kingdom's position in IT. These include identifying the technology areas that are most critical for the Kingdom, and as well as the needs for human resources and policy changes to advance the position of the Kingdom in IT.

Plan Development Process

The development of this plan (outlined in Figure 2) began with identifying the stakeholders and users of IT research and innovation in the Kingdom, creating vision and mission statements, and conducting background research on the current position of the Kingdom in IT and on the role of other IT research institutes around the world. A two-day workshop was held with stakeholders and users of IT research and innovation. This workshop, with over 50 total participants, represented the first time the IT research community and user community had come together to discuss the future needs and opportunities for IT innovation in the Kingdom. The agenda and participants in this workshop are shown in Appendix A. The first day of the workshop focused on hearing from industry, government agencies, and research institutions about

their needs for advances in information technology. The second day gathered input from these same groups on the IT research and innovation programs needed in the Kingdom. Following the workshop, KACST staff and consultants developed a draft plan, which was reviewed by the newly formed National IT Research and Innovation Advisory Committee. The advisory committee's comments were then incorporated into this final plan.

Figure 2: Approach to Prepare National IT R&D Program



Strategic Context

KSA IT R&D Needs

The National Workshop identified a wide number of IT research and innovation needs for the Kingdom. These included needs from the IT sector, telecommunications sector, petroleum industry, health sector, several government agencies, and universities. A sampling of the IT needs include:

- Arabic language software, including needs for translation, Arabic search engines, speech recognition, text-to-speech and Arabic Internet domain names.
- Medical informatics.
- Oil & Gas software and applications, including but not limited to process automation, simulation, visualization, performance optimization, experts systems and intelligence oil fields.
- IT security, including Internet resiliency and the ability to respond to security threats and events.
- Authentication for e-government and e-commerce.
- Advanced networks.
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- E-Learning applications and content.
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In addition to the technical needs, workshop participants identified a large number of areas where policies need to be changed or barriers removed. These needs include:

- Policies to facilitate R&D collaboration between KACST, universities, and industry.
- Policy and organizational changes in universities to improve the ability of faculty members to conduct research.
- Expanded human resources for IT R&D.
- Improved knowledge of international technology developments.
- Expanded international collaboration, including cooperation between Saudi universities and world universities.
- Saudi participation in international standardization bodies.
- Studies of the social aspects of ICT.
- Small business contracting preferences to support innovative small companies.

Strategic Context

This plan focuses on technical needs but also includes steps to address non-technical needs, although some of these are primarily the responsibilities of other organizations.

Stakeholders Roles

The stakeholders for the IT Research and Innovation Program include KACST, KSA universities, various independent or specialized research institutes, other government agencies, and private companies. Table 1 shows the roles of these stakeholders in the program.

Table 1: Stakeholders Roles

Stakeholders	Role
KACST	■ Plan, coordinate and manage the program
	■ Conduct applied research, technology transfer and prototype applications development
	■ Manage and participate in national projects
	■ Provide support for university and industrial participation in national projects
	■ Provide and manage national research facilities such as high performance computing and networking
	■ Provide advice and services to government on science and technology.
Universities	■ Create new basic and applied scientific knowledge
	■ Train students in science and engineering
	■ Host and participate in Technology Innovation Centers
	■ Participate in collaborative projects
Independent or Government Specialized Research Centers	■ Create new applied scientific knowledge
	■ Participate in collaborative projects
Ministries and Government Agencies	■ Operational and implementation IT projects
	■ Provide input to program on government R&D needs
	■ Reduce regulatory and procedural barriers to R&D and innovation
	■ Support R&D in universities and industry
Private Sector	■ Develop and commercialize products & processes resulting from the program.
	■ Communicate company needs to program
	■ Support and participate in collaborative R&D projects.
	■ Support and participate in the Technology Innovation Centers

Analysis of Comparable IT R&D Institutes

As part of the background work for this plan, the planning team reviewed several other information technology research laboratories around the world, selected to include a mix of government-supported laboratories with functions similar to that of KACST's IT program. They included:

- Canada's National Research Council (NRC) Institute for Information Technology (NRC-IIT).
- The Institute for Language and Speech Processing (ILSP), in Greece.
- India's Centre for Development of Advanced Computing (C-DAC).
- The Meraka Institute (MI), in South Africa.
- The Information Technology Laboratory (ITL) at the National Institute of Standards and Technology (NIST).

These institutes are working in a range of technical areas similar to those considered for this plan, including:

- Artificial intelligence.
- Security and privacy.
- Language and speech technologies.
- Software engineering.
- High performance and scientific computing.
- Networking and internet software.
- Geoinformatics and remote sensing research.
- Digital library and digital information access.
- E-Government and e-commerce.
- Educational technologies.
- Medical informatics.

The institutes vary considerably in staff size, ranging from under 100 to several thousand. A full description of these laboratories' programs can be found in a separate document.[1]

Analysis of IT Publications and Patents

Information technology is a broad field that encompasses many different research and application areas, such as computer science, electrical engineering, telecommunications, and optics. The overall field, "information technology", as well as sub-topics, were defined in close consultation with KACST researchers and other KSA stakeholders, who provided detailed lists of keyword terms that were used to query publication and patent databases.[2] The KSA information technology program identified four major application sub-topics: speech and language, scientific computing, computer systems and networks, and software engineering and innovated systems. Information technology is a fast moving field, so the scope of this study was restricted to only recent publication (2005-2007) and patent (2002-2006) activity in these fields.

There is general agreement that publications and patents strongly correlate with scientific research capacity, although publication and patent counts alone do not fully represent the quality or scope of research. Nonetheless, publication and patent activity have long been used as indicators for knowledge creation and research output.[3] Several indicators are presented

1 Strategic Review: Information Technology. Report prepared by SRI International for KACST.

2 ISI Web of Science and Delphion were queried for scientific publication and U.S. patent application data, respectively. The ISI Web of Science is a database of peer-reviewed articles in major scientific journals from around the world. Delphion is a searchable database of global patent activity, including the U.S. Patent and Trademark Office (USPTO). The USPTO is one of the world's major granters of patents. Because the U.S. market is so large, most important inventions from around the world are patented there.

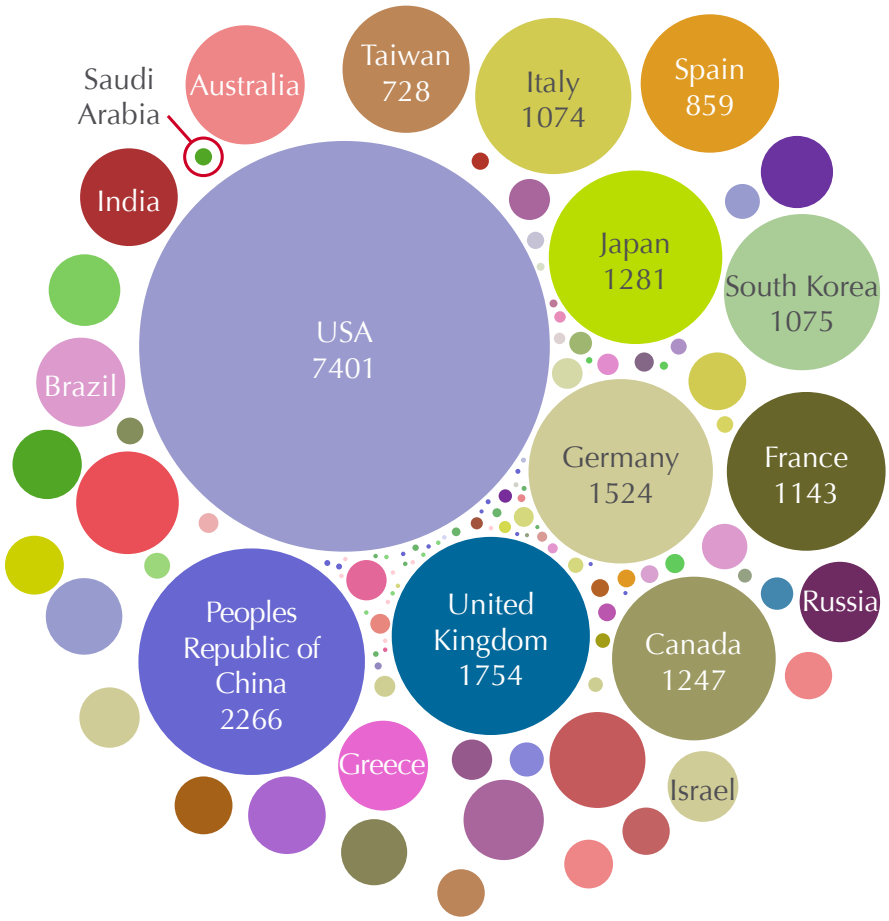
3 Seminal research in the use of publications as a measure of scientific productivity includes A.J. Lotka, "The frequency distribution of scientific productivity," Journal of the Washington Academy of Sciences, vol 16 (1926); D. Price, Little Science, Big Science, (New York: Columbia university Press, 1963); J.R. Cole and S Cole, Social Stratification in Science, (Chicago: The University of Chicago Press, 1973); J. Gaston, The reward system in British and American science, (New York: John Wiley (1978); and M.F. Fox, "Publication productivity among scientists: a critical review," Social Studies of Science, vol 13, 1983.

below. These include forward citations, which are the frequency at which publications and patents are cited by others and are an indicator of impact, and co-authoring relationships, which are an indicator of scientific collaboration. Together, these indicators provide measures of collaboration, globalization, and impact of science and technology research in fields related to the KSA information technology program.

Global Information Technology Publication Activity

Between 2005 and 2007, there were 22220 articles published worldwide in information technology fields related to KSA IT research priorities.[4] The United States was the world's largest producer of related articles, generating 7401 articles over this time period. The People's Republic of China was second, producing 2266 articles followed by the United Kingdom and Germany with 1754 and 1524 articles respectively. Saudi Arabia was tied for the 49th largest producer of publications, producing 24 articles, or one tenth of one percent of all publications. Figure 3 shows the number of publications produced by selected countries over this time period.[5]

Figure 3: IT Publications (2005-2007)



4 Throughout this section, "information technology" refers only to the subset of information technology defined by the KSA IT program.

5 A publication is assigned to a country if any of the publication's author's affiliations are located in that country. Because publications often have multiple authors, a single publication may be assigned to multiple countries. Aggregate figures, such as total global publication output, count each publication only once, but adding up sub-totals may yield a result larger than the reported total due to multiple counting.

As shown in table 2, scientific computing accounts for the largest share of information technology related publications (9864) followed by computer systems and networks (6477), software engineering and innovated systems (3456), and speech and language (2992).

Table 2: Information Technology Sub-Topics (2005-2007)

Sub-Topic	Publications
Scientific Computing	9864
Computer Systems and Networks	6477
Software Engineering and Innovation Systems	3456
Speech and Language	2992

Benchmark Country Publication Impact

Average publication impact is calculated as the number of citations of articles from a particular country divided by the total number of articles published by authors from that country. For instance, a country that published 50 articles that were cited 100 times would have an average publication impact of two. Between 2005 and 2007, Germany had the highest average publication impact of all countries at 1.45 followed by the United Kingdom (1.40), Australia (1.39), and Ireland (1.32). The average publication impact for Saudi Arabia was 0.13 with only three citations of its 24 articles. By this measure, the information technology articles that were published by authors affiliated with KSA institutions appear to have a lower impact when compared with those from leading countries. Table 3 presents publication and citation counts for benchmark countries.[6]

6 Benchmark countries include global leaders in terms of total information technology output in addition to a list of specific countries provided by KACST.

Table 3: Benchmark Country Information Technology Publication Impact (2005-2007)

Country	Publications	Total Citations	Average Publication Impact
Germany	1524	2215	1.45
Australia	657	913	1.39
UK	1754	2401	1.37
Ireland	122	161	1.32
USA	7401	8973	1.21
Canada	1247	1379	1.11
France	1143	1213	1.06
Japan	1281	1108	0.86
Italy	1074	892	0.83
Spain	859	689	0.80
Peoples R China	2266	1456	0.64
Egypt	38	24	0.63
South Africa	78	48	0.62
India	454	261	0.57
South Korea	1075	318	0.30
Malaysia	56	15	0.27
Saudi Arabia	24	3	0.13

Information Technology Research Organizations

Information technology publications are produced at thousands of research institutions in more than 120 countries. As shown in table 4, the three institutions producing the largest number of publications in the technical areas related to the KSA information technology program are the Chinese Academy of Sciences (336), the University of Texas (333), and Tsing Hua University (233). The Chinese Academy of Sciences is the number one producer of scientific computing publications, while Tsing Hua Univeristy is the leader in speech and language and the University of Texas is the leader in both computer systems and networks and software engineering and innovated systems.

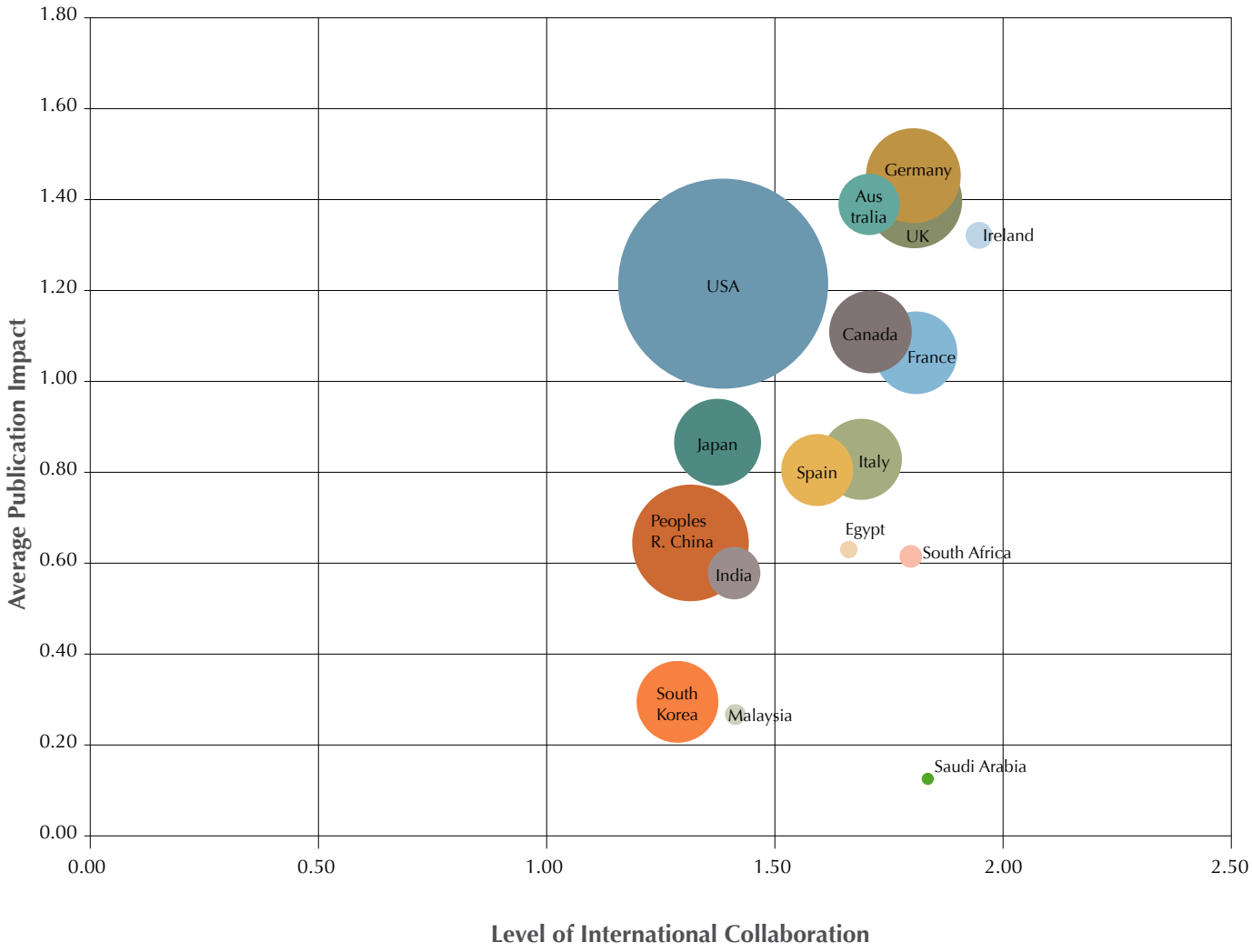
Table 4: Global Information Technology Research Organizations (2005 - 2007)

Institution	Total Publications	Average Impact	Scientific Computing	Computer Systems and Networks	Software Engineering and innovated Systems	Speech and Language
Chinese Acad Sci	336	0.63	188	76	39	42
Univ Texas	333	1.36	174	85	45	39
Tsing Hua University	233	0.78	98	76	22	43
Univ Illinois	196	1.48	110	58	13	20
Univ Washington	192	1.86	91	46	29	29
Univ Florida	185	0.77	93	56	25	16
MIT	180	2.25	84	53	20	30
Univ Maryland	171	1.49	84	51	17	25
Univ Calif Berkeley	170	1.74	112	33	25	7
Univ Sci & Technol China	168	1.67	82	66	16	6

International Collaboration and Publication Impact

For countries with a similar level of publication activity, those countries with a high level of international collaboration also tend to produce publications with a high level of impact. International collaboration is calculated as the average number of countries represented per publication, based on authors' addresses. Figure 4 plots a country's level of international collaboration (horizontal axis) against the average impact of its publications (vertical axis). Countries such as Germany and the United Kingdom, which show significant international collaborative activity, also tend to produce papers with a higher average impact.

Figure 4: International Collaboration and Publication Impact in Information Technology (2005 - 2007)



KSA Collaboration Activity

As shown in table 5, KSA-affiliated authors collaborated on more than one article with authors from: the United States (7 publications), UK (2 publications) and Canada (2 publications). KSA authors collaborated on one article with authors from: Egypt, Germany, Jordan, Kuwait, Oman, Pakistan, Spain, Turkey, and the United Arab Emirates.

Table 5: KSA Publication Collaborators (2005 - 2007)

Country	Number of Publications
United States	7
United Kingdom	2
Canada	2
Egypt	1
Germany	1
Jordan	1
Kuwait	1
Oman	1
Pakistan	1
Spain	1
Turkey	1
UAE	1

Information Technology Journals

Table 6 presents journals with a significant level of publication activity related to KSA information technology sub-fields from 2005-2007.

Table 6: Information Technology Journals (2005 - 2007)

	Journal	Publications
Scientific Computing	Physical Review A	269
	Journal Of Chemical Physics	115
	Physical Review Letters	109
	Physical Review B	106
	Ecological Modelling	100
	Concurrency And Computation-practice & Experience	96
	Atmospheric Environment	94
	Future Generation Computer Systems-the International Journal Of Grid Computing Theory Methods And Applications	83
	Journal Of Computational Physics	59
	Environmental Science & Technology	59

	Journal	Publications
Computer Systems And Networks	Computer Communications	182
	Physical Review A	112
	Ieee Transactions On Mobile Computing	105
	Computer Networks	90
	Ieee Transactions On Wireless Communications	76
	Ieice Transactions On Communications	75
	Journal Of Biological Chemistry	73
	Drug Metabolism And Disposition	67
	Ieee Transactions On Information Theory	67
	Ieee Transactions On Vehicular Technology	57
Software Engineering And Innovated Systems	Journal Of Systems And Software	56
	Information And Software Technology	33
	International Journal Of Advanced Manufacturing Technology	33
	Bmc Bioinformatics	26
	Science Of Computer Programming	24
	Ieee Transactions On Nuclear Science	23
	Ieee Transactions On Software Engineering	23
	Nuclear Instruments & Methods In Physics Research Section A-accelerators	22
	Ieee Software	21
	International Journal Of Software Engineering And Knowledge Engineering	16
Speech And Language	Ieee Transactions On Audio Speech And Language Processing	182
	Speech Communication	111
	Ieice Transactions On Information And Systems	87
	Journal Of The Acoustical Society Of America	68
	Accessing Multilingual Information Repositories	53
	Computer Speech And Language	49
	Information Processing & Management	48
	Text, Speech And Dialogue, Proceedings	44
	Advances In Natural Language Processing, Proceedings	41
	Bmc Bioinformatics	41

Information Technology Patent Activity

Between 2002 and 2006, there were 13085 information technology related patent applications filed with the United States Patent Office (USPTO).[7] As shown in table 7, the majority of these (9075) listed at least one inventor from the United States. Other countries with a significant number of inventors include: Japan (1166 applications), Germany (517 applications), and Canada (481 applications). Six information technology-related patent applications listed an inventor from Saudi Arabia.

Table 7: Information Technology Patents (2002 - 2006)

Country	Speech and Language	Scientific Computing	Computer Systems and Networks	Software Engineering and Innovated Systems	Total
United States	2739	1696	4119	942	9075
Japan	487	130	519	28	1166
Germany	181	82	211	58	517
Canada	108	112	242	29	481
United Kingdom	131	85	207	43	458
South Korea	98	32	252	6	384
France	62	58	111	24	247
China	91	22	66	12	185
India	29	24	52	20	112
Australia	36	21	50	11	110
Italy	13	10	34	5	59
Ireland	7	3	14	2	26
Spain	14	1	11	1	26
Egypt	5	0	1	0	6
Saudi Arabia	1	2	2	1	6
Malaysia	0	1	3	1	5
South Africa	0	1	3	0	4

7 In the information technology field, patent application-based statistics may be biased towards hardware-oriented inventions. Because software is often protected via other mechanisms, such as copyright, these types of inventions may be underrepresented.

Strategic Context

While the majority of the information technology-related patent applications are defined as individually owned patent applications (8225 applications) by the United States Patent Office, institutions are designated as the patent assignee on a significant number of applications. With established records of innovation-related activity in information technology fields related to KSA strategic priorities, these institutions could be future targets for collaborative outreach efforts. As shown in table 8, International Business Machines (IBM) Company is listed as the patent assignee on 835 information technology-related patent applications followed by Microsoft Corporation (343 applications), Samsung Electronics (146 applications), and Fujitsu Limited (73 applications).

Table 8: Leading Information Technology Patent Assignees (2002-2006)

USTPO Assignee	No. of Patents Apps.
Individually Owned Patents	8225
International Business Machines Company	835
Microsoft Corporation	343
Samsung Electronics	146
Fujitsu Limited	73
Canon Kabushiki Kaisha	71
Xerox Corporation	71
NEC Corporation	63
Sun Microsystems	62
Konnklijke Phillips Electronics N.V.	57

SWOT Analysis for KSA IT Research and Innovation Program

This section presents a SWOT (strengths, weaknesses, opportunities, and threats) analysis of the Saudi Arabia IT research and innovation program relative to achieving its vision. In a SWOT analysis, terms are defined as follows:

- **Strengths:** attributes of the organization that are helpful to achieving the objective.
- **Weaknesses:** attributes of the organization that are harmful to achieving the objective.
- **Opportunities:** external conditions that are helpful to achieving the objective.
- **Threats:** external conditions that are harmful to achieving the objective.

Strengths and weaknesses are internal to the organization while opportunities and threats are external to the organization. For the purpose of this analysis, the "organization" is the Saudi IT research and innovation program, including KACST, universities, other government agencies, and companies.

Table 9: SWOT Analysis

	Helpful	Harmful
Internal	**Strengths:** ■ ample financial resources ■ some good people with good IT and business skills ■ universities with some capabilities ■ some growing IT companies ■ some large industrial companies and government agencies with specialized IT needs	**Weaknesses:** ■ weak overall position in IT science and technology ■ IT not recognized as an industry by lending institutions ■ generally weak IT human resources base in IT and in R&D management ■ underutilization of women in IT research and innovation ■ weak international linkages ■ weak research in industry ■ weak industry-government- university linkages ■ little track record of successful innovation ■ the KSA IT industry is not focused on the global market and large local companies. ■ weak IT hardware sector ■ lack of trust in local products ■ weak intellectual property protection (patent and copyright), especially for small innovators

Strategic Context

	Helpful	Harmful
External	**Opportunities:** ■ large KSA market for IT services ■ young KSA population with good market growth potential ■ increased national priority on science and technology ■ growing KSA and global importance of IT and knowledge-based industries ■ growing domestic and international markets in the Gulf region and beyond ■ demand for Arabic language products ■ potential to collaborate internationally	**Threats:** ■ weak primary school education ■ international competition ■ other countries moving faster ■ other countries, such as India, have lower costs ■ constraints on needed reforms ■ financial or policy changes could lead to instability in funding for IT S&T

The overall strengths of the Kingdom in IT research and innovation are its financial resources, and the fact that there are some capabilities in the Kingdoms universities and laboratories. The programs stakeholders also have some unique needs, such as Arabic language software or Hajj applications that present an opportunity for Saudi companies to establish a competitive advantage.

There are many weaknesses, however. Research institutes, including universities, government, and industry, do not rank among the top worldwide institutions. Human resources for IT research and innovation are generally weak. Saudi researchers have weak patterns of collaboration with others in the Kingdom, their counterparts in industry, or in other countries. There is little track record of successful innovation.

There are opportunities due to the growing importance of IT to the KSA economy and knowledge-based industries, and in the growth potential of many Arabic speaking and Islamic markets, especially in the Gulf region. The main threat is that international competitors are not standing still, and, indeed, seem to be moving faster than Saudi Arabia.

Higher Strategy

This section provides the vision for the Kingdom in IT research and innovation, and the mission, values, and strategic goals for the program.

Vision

The vision for KSA IT research and innovation is:

The Kingdom of Saudi Arabia will be recognized as an innovator in IT, with innovative companies, universities that conduct leading edge research and produce world class graduates; a national laboratory system that serves government, universities and industry; and effective linkages between all elements of the system. The Kingdom will be a regional leader across a broad range of IT areas and will be a world leader in areas of special importance to the Kingdom.

This vision focuses on the establishment of an effective innovation system in which research and invention need to lead to economic and social benefits for the Kingdom. To achieve this, it is essential to have strong and mutually beneficial linkages between universities, government, and industry.

Mission

The mission for the KSA IT research and innovation program is:

To enhance the Kingdom's scientific and technological level in information technology and the application of information technology to the Kingdom's economic and social needs through a coordinated program of research, development, localization, and transfer of technology.

Program Values and Culture

To achieve excellence, the program will develop an internal culture through both the sponsorship of its leadership and commitment of its operational teams, based on the following values:

- Excellence of work.
- Professional integrity and ethical behavior.
- Openness and transparency.
- Commitment to achieving objectives.
- Support of creativity and innovation.
- Teamwork and collaboration.

Program Strategic Goals

The strategic goals of the program are:

- To support an expanding and innovative KSA IT industry.
- To advance IT capabilities to meet critical needs in the Kingdom, in areas such as computer networking, and security.
- To develop innovative high quality IT applications to meet specialized needs in the Kingdom, such as for the oil and gas industry, and Islamic applications.
- To adapt and localize IT applications for e-services and e-business.
- To contribute to the global open source software movement.
- To develop world class capabilities in language technologies, especially applied to serve the Arabic Language.
- To improve scientific and supercomputing to expand the Kingdom's capabilities in science and engineering through modeling, simulation, and visualization.

Selection Process

The process for selecting the technologies was as follows. A two-day workshop was held with stakeholders and users of IT research and innovation. The first day of the workshop focused on hearing from industry, government agencies, and research institutions about their needs for advances in information technology.

The second day gathered input from these same groups on the priority technology areas and steps required to meet the needs of the Kingdom. Based on this input, KACST staff and consultants refined the list of critical technology areas for the Kingdom. The technology areas were reviewed by the National IT Research and Innovation Advisory Committee, and revised in response to those comments.

Selected Technology Areas

- **Speech and Language**

- Speech (including speech recognition, synthesis, speaker verification/ identification and speech resources).
- Text (including computational linguistics, machine translation, statistical language modeling, information retrieval and web search engines and text mining, language resources).
- Special needs applications (including sign language, and the Braille system).
- Arabic document processing and optical character recognition (OCR).

- **High Performance Computing**

- Supercomputing architecture & software.
- Supercomputing applications.
- Computer simulation.

Technology Areas

- Computer modeling.

- **Computer Systems and Networks**
- Computer networks.
- IT security and privacy.
- Database systems.
- Operating systems.

- **Software Engineering and Innovated Systems**
- Local applications/localization.
- Open source software (OSS) engineering.
- System analysis and design.

Program Structure

The IT Research and Innovation Program consists of a program leadership function, responsible for overall planning and management, and four priority subprograms addressing key technical areas. These are areas are:

- Language and Speech Program.
- High Performance Computing.
- Computer Systems and Networks.
- Software Engineering and Innovated Systems.

Within each technical area, three general types of projects predominate: projects to develop innovative pilot applications, university-industry technology innovation centers, and university grants in strategic areas. The national pilot application programs bring together KACST, university technologists, and technology companies to develop prototypes of advanced technology that serve a specific need. The output is expected to be a prototype new technology that can rapidly be commercialized. KACST will evaluate the programs annually, and modify or discontinue the programs as necessary depending on the achievement of milestones.

The university-industry technology innovation centers focus on conducting applied research and innovation in areas of industry interest. The centers will typically be supported primarily by government funds, but will have funding from industry, as well as an industrial advisory board. The centers will involve both undergraduate and graduate students in the research. The output will be new knowledge and technology, but equally importantly, students who are

trained in conducting research on projects with direct relevance to industry and other users.

The university grants in strategic areas will fund individual investigators or small teams on IT research projects of strategic importance. These will differ from the general KACST university grants in that they are aligned with the goals of the IT Research and Innovation program. They differ from the pilot applications in that they are focused on important research topics rather than directly on applications, and differ from the university-industry centers in that they are individual projects rather than centers.

Program Leadership

Charter and Scope

The program leadership function is responsible for overall planning, management, and evaluation of the program, as well as for addressing key policy issues and barriers to success in IT research and innovation.

Strategic Goals and Objectives

The goals and objective for this subprogram are to:

- Periodically review and update overall plans for the program.
- Oversee implementation of the program.
- Encourage the adoption of policies and programs to expand human resources for IT research and innovation, including:
  - removing barriers to hiring/retaining key staff.
  - advocating changes to pre-college education, advocating improvements to college IT training.
  - expanding role of women in IT research and innovation, and
- Expand R&D collaboration between KACST, universities, and industry, and make policy changes to improve the ability of university faculty members to conduct research.
- Improve KSA knowledge of international technology developments and KSA participation in international research and standardization activities.

Language and Speech

Charter and Scope

The Language and Speech Program will be a national program to develop world-class capabilities in language technologies, especially focused on the Arabic Language. The scope of work will include:

- Speech (recognition, synthesis, speaker verification/identification, speech resources).
- Text (computational linguistics, machine translation, statistical language modeling, information retrieval and web search engines and text mining).
- Special needs applications (sign language, Braille).
- Arabic document processing and Optical character recognition (OCR).

Strategic Goals and Objectives

The goals are to provide the following benefits to the Kingdom:

- Making speech-based technologies accessible to Arabic (especially Gulf Arabic) speakers, with applications such as phone-based e-commerce services.
- Making the retrieval of text-based information easier, such as through answers to questions posed in Arabic.
- Making knowledge in other languages more accessible to Arabic speakers.
- Making Arabic knowledge and culture more accessible to the rest of the world via translation.
- Making government services more available to non-Arabic speakers, both for guest workers and for Hajjis.
- Creating products and technology with export potential in world markets, especially Arabic-speaking countries.

Program Structure

The program will driven by a focus on specific applications:

- Pilot applications for speech recognition and synthesis, including telephone banking and airline reservations.
- Speech and language technologies with potential for developing commercial applications and successful, internationally competitive companies.
- Applications of language technologies to government needs, such as managing Hajj and Umrah.

Computer Systems

Charter and Scope

This is a program to conduct research that addresses problems in computer systems-related areas that are needed by the kingdom. These include:

- Computer networking (both wired and wireless).
- IT security (including data security, applications and services security, security Infrastructure standards and policies).
- Database systems.
- Operating systems.

Strategic Goals and Objectives

The strategic goals of the computer systems area are to:

- Develop stronger IT security for the Kingdom through technological adaptation, innovation, and training of skilled personnel. IT security is essential for the Kingdom to benefit from IT in such areas as e-business, e-government, and health application. IT security is also important for national security.
- Improve the quality of networking in Kingdom and develop the capacity and expertise to be a leader in networking. Advanced networks are key to information society and underlie e-business, e-government, e-learning, and scientific computing. Computer networks in the Kingdom are currently below international standards.

High Performance Computing

Charter and Scope

This is a national effort to improve scientific computing in the Kingdom. Scientific computing involves applications of computing to science and engineering in such as areas a modeling, simulation, and visualization.

The scope includes:

- Infrastructure (supercomputing and a research network among leading universities and scientific organizations that will serve as a test bed).
- Human resource development (people trained in scientific computing).
- Tools acquisition and development and code optimization.
- Development of easy procedures for shared use of computing resources (by universities, companies).
- Awareness/outreach program to let people know the availability and potential applications of scientific computing.
- Links to international centers, workshops and travel for international collaboration.
- A network of scientific computing users and researchers.
- A scientific computing research center of excellence at a university, involving industry partners.

Strategic Goals and Objectives

The goal of the program is to improve the application of scientific computing in the Kingdom in order to enable advances in many areas of science and engineering and to solve critical KSA problems such as:

- Geologic and other environmental modeling.
- Hajj modeling.
- Modeling urban growth.
- Molecular modeling for biology and petrochemicals.
- Oil & gas simulation and visualization applications.

Objectives include:

- Establishing an scientific computing user facility (available to university, KACST, and industry researchers) in the Kingdom.
- Developing the expertise to apply computing to science and engineering problems.

Software Engineering and Innovated Systems

Charter and Scope

This program is to develop innovative and high quality IT applications that serve the needs of the kingdom. Areas of special focus are:

- The development of IT applications to contribute to the efficiency, quality, and safety of Hajj & Umrah, and other Islamic applications. This includes the development or integration of technologies for monitoring, identifying, tracking, counting, simulating, crowd management, awareness/education, help/guidance, data collection/processing, data banks.
- The development and localization of Open Source Software (OSS). This would include establishment of OSS software engineering methodology; localization of OSS to Saudi needs; establishing a Technology Innovation Center for OSS; certifying OSS, and establishing a repository for OSS.
- IT applications for the oil and gas industry, including business and management applications.
- E-government, E-commerce, E-learning, E-Health.

Strategic Goals and Objectives

Strategic goals are:

- To develop technologies to improve the efficiency, quality, and safety of Hajj & Umrah in order to reduce risks to pilgrims and to the Kingdom, reduce costs, and enhance the reputation of the Kingdom as well as enhancing the ability of Muslims to fulfill their goals. Technologies developed for Hajj and Umrah may lead to other commercial applications that will provide economic benefits to the Kingdom.

- To advance OSS to contribute to the worldwide research community and economic development of KSA. Open source software is low cost and is potentially more reliable and secure than proprietary software. Expanding open source software in areas of special importance to the Kingdom can provide widespread public benefits to the Kingdom. OSS is also important for training software developers because they can see and modify the source code to understand how the software works. Areas of focus for open source applications will include e-learning, e-commerce, and e-government.

- Develop IT applications for the oil and gas industry, including business and management applications.
- Develop other unique applications for Saudi Arabia.

Operational Plans

Operational plans include a portfolio management plan, a technology transfer plan, a quality management plan, a human resources plan, a communications plan, and a risk management plan.

Portfolio Management

The IT Research and Innovation Program will include a variety of projects with different goals and objectives. The program will aim to achieve a balance across multiple objectives. Some factors to be considered in program balance include:

- The balance between projects to achieve an immediate objective versus building long-term capacity (especially human resources) for the program.
- The balance between meeting the needs of existing companies versus establishing new technology-based industries in the Kingdom.
- The balance between low-risk incremental projects and high risk/high return projects.
- The balance among different national needs and major stakeholders (government agencies, IT companies, telecommunication companies, universities).

The program manager and advisory committee will review the program to ensure that it maintains an appropriate balance among these factors.

Technology Transfer Plan

The IT research and innovation program will follow internationally recognized best practices in technology transfer. Key elements of the program that are designed to facilitate technology transfer are:

- **Involvement of users in the program design:** this occurs through user

participation in planning workshops and user involvement in the IT advisory committee. It is well recognized that user involvement in the research design leads to research and outcomes that are more likely to meet the needs of users, and thus are more likely to lead to successful innovation.

- **National programs focused on the development of advanced pilot application projects:** the projects involve universities as well as companies, and knowledge is transferred to the companies in the course of the project. This is a proven method for developing technologies that serve a need and can be transferred readily to government or commercial users.

- **The use of university/industry centers as a major research mechanism throughout the plan:** industry involvement in these centers (providing advice and funding) will encourage university research to be focused on user needs, increasing the likelihood of technology transfer. These centers will also transfer knowledge to industry though the training and graduation of students (who have been trained on problems of interest to industry), who then take jobs in companies or form their own companies.
- **The linkage between the IT program and technology business incubators and other programs to aid the start-up of new IT companies.**

Quality Management Plan

The IT research and innovation program will follow international best practice quality management processes for science and technology programs. Elements of the quality management plan include:

- Advisory committee review of the overall program design and budget.
- Competitive, peer-reviewed selection processes for university-based research centers and projects.
- Annual reviews of technology development projects to ensure that milestones are being met.
- Periodic (every 5 years) subprogram evaluations conducted by a review committee supported by an experienced evaluator.

Procedures will be developed for disclosing and managing potential conflicts of interest among reviewers. In many cases, some international experts will be used on review panels to reduce possible conflicts of interest and to provide an independent external assessment.

Human Resources Plan

As noted in the SWOT analysis, human resources are a critical barrier for the success of the IT Research and Innovation program. The availability of skilled people, including both researchers and technical managers and leaders, is likely to limit the growth and success of KSA IT programs. The plan will require substantial numbers of IT professionals, including additional researchers, technical managers, and technical leaders at KACST, at universities and at companies. A central task of the program management function will be to address this issue.

To achieve the goals of the program, KACST will need to hire or develop additional program managers with the skills to lead national programs. To do this KACST will need additional flexibility with respect to compensation packages, speed of hiring, and ability to hire international staff.

Universities and companies will need additional researchers and software engineers with the skills to develop innovative technologies. This will require broader changes, some of which are outside of the scope of this plan. As part of the activities in this plan, the IT research and innovation program will:

- Analyze IT human resource issues and advocate

changes to improve the quality of math and science education in primary and secondary education.

- Work with the other agencies to improve the quality of undergraduate IT education, especially at regional universities.
- Work with new universities to develop research and education programs that especially match the Kingdom's IT research and innovation needs.
- Work to expand the contribution of women to IT research and innovation. There are specific goals to increase the numbers of women IT faculty members and researchers in the Kingdom.
- Work to change policies to allow more international hiring, to bring specialized expertise to the Kingdom.
- Support training for researchers to become R&D managers and leaders.

At the undergraduate and especially graduate level, this plan is designed to help increase the numbers of IT researchers through its emphasis on university-industry centers. These centers are designed to train new students with research and innovation skills needed by research organizations and industry.

Communications Management Plan

The purpose of the communications management plan is to provide appropriate information to the program participants and stakeholders. One element of the communications plan is to improve communication throughout the KSA IT research and innovation community and to expand collaboration among members of the community. Aspects of this include:

- There will be a public website with information on program goals, accomplishments, funding opportunities, and other news.
- Periodic workshops will be held with users and stakeholders to define future program needs.
- Requests for proposals (for university centers, grants, and pilot application development programs) will be announced to the public.
- The program advisory board will review and comment on the program, and advisory board reports will be made public on the website.
- The program will sponsor workshops, conferences, and professional society activities to expand communication and networking throughout the community.
- Presentations on the program will be made at national and international conferences.

Another element of the plan is to define appropriate communications within the management structure of the plan. It is especially important that information about risks or difficulties in the program, such as delays, lack of resources, or non-attainment of goals be rapidly communicated to higher levels of management. A general principle is that management should never be surprised by bad news.

Risk Management Plan

The program presented here is an ambitious program that will challenge the capabilities of the Kingdom. There are several types of risks that could prevent attainment of program goals, including technical risks, market risks, and financial risk.

One source of technical risk -- risk to attainment of technical goals – is, as described above, the lack of adequate human resources to implement the program. Approaches to managing this risk are:

- Changing policies to attract people with the needed skills. This may involve raising salaries and recruiting internationally.
- Delaying or phasing in some program elements if

people are cannot be hired.

- Expanding the pool of people with needed skills through education and training programs, such as university IT research centers (see human resources plan).

Another cause of technical risk is overly ambitious goals. The way to address this risk is to have an independent review of technical goals to ensure they are feasible, and to adjust technical goals if milestones are not being met.

Market risk is the risk that projects, while technically successful, do not lead to successful products because of poorly understood or changing market conditions, such as the development of other technical approaches. A way to address this risk is through:

- Designing programs based on carefully considered market needs.
- Monitoring international technology and market developments.
- Continual readjustment of plans in responses to changes in the environment.

Financial risk is the risk of funding shortfalls or cost overruns. The way to address risks in this area is through careful program planning and monitoring, and early identification of possible cost overruns. Another financial risk is due to changes in the plan or funding due to political or policy changes. It will be important for the plan management to maintain communication with policy leaders to ensure they are aware of the accomplishments of the program and to get early warning of any policy changes that may affect the program.

Implementation of the Plans

Within KACST, the IT program will be responsible for the overall execution of the plan. Some portions of the plan may be managed by other parts of KACST. For example, the technology innovation centers and technology incubators may be managed by the Technology Development Center, which may specialize in the management of these kinds of programs. In this case, the IT program's role will be to provide technical input to the design and evaluation of these programs rather than to manage.

Many aspects of the plan represent new functions for the IT program, especially in developing and managing national technology programs that include industry and universities and may involve international collaborations. A major task for the first year of the program will be, in addition to detailed program planning, for the IT program to acquire or develop the necessary skills through hiring or training. Although it is critical to rapidly start new research programs, it is essential to build the skills necessary to lead and develop these programs, and to plan them carefully. As part of the initial activities under this plan, CERI staff members will visit programs of a similar nature elsewhere in the world to discuss their management practices and lessons learned.

The Information Technology Research and Innovation Advisory Committee will oversee the implementation of the plan. It will meet approximately four times a year and review progress in the program and approve updates to the plan as necessary. Key performance indicators will be established for each subprogram. General performance indicators include:

- Growth or establishment of technology-based businesses due to the IT program.
- Amount of revenue and jobs created.
- Successful importation of technology resulting in new businesses or applications.

Implementation of the Plans

- Movement of projects to incubators.
- Contribution to OSS applied in Kingdom.
- Licenses and licensing revenue to universities and research institutes.
- IT-related patents and copyrights.
- Private sector funding of university and KACST IT research (indicates the value private sector places on university or KACST IT R&D).
- Number and level of presentations in international conferences.
- Changes in policies (described previously) to improve IT innovation.
- Number and impact of publications.
- Extent of domestic and international R&D collaborations.
- Numbers of IT advanced degrees awarded.

In the near term, the committee will monitor the establishment of the program and projects, and the progress of the projects towards their milestones.

The advisory committee will also sponsor and oversee studies of emerging areas of IT to serve as the basis for developing new program areas. This plan is intended to be a dynamic document that will be updated at least annually and more frequently if required. In addition to the advisory committee input, it is expected that workshops with the research community, users, industry and other stakeholders will also contribute to both a continual evolution of the plan as well as a stronger IT research and innovation network in the Kingdom.

Appendix A: Plan Development Process

The process of developing this plan included a two-day stakeholder workshop that focused on IT innovation needs in the Kingdom and on defining programs to meet those needs. Following the workshop, KACST prepared a draft plan with the assistance of SRI International. As part of the planning process, the "Information Technology Research and Innovation Advisory Committee" was formed, and the committee met to review and comment on the draft plan. The advisory committee members are listed below. Workshop participants and advisory committee members represented themselves as individuals, and did not necessarily represent their organizations.

Table A-1: IT Research and Innovation Advisory Committee Members

Name	Organization
Ibraheem Alqadi	Communications and Information Technology Commission
Hamad Alyousefi	Ministry of Defense and Aviation
Khaled Albiyari	Advanced Electronics Company
Khaled Alghoneim	Alelm Company
Khaled Faqeeh	King Abdulaziz University
Sami Alwakeel	King Saud University
Tareq Alabbadi	Microsoft – Innovation Center
Ali Almazzah	Saudi Telecom Company
Omar Alturki	King Fahd University of Petroleum and Minerals
Mohammed Alsheibai	Ministry of Interior
Mohammed Alqassem	Ministry of Communications and Information Technology

Appendix A: Plan Development Process

Table A-2: Workshop Participants

Name	Affiliation
Abdulrahman Aljadhai	Al-Elm
Mohammed Alsuhaibani	Alrasheed Consultants
Jamal AlDabal	Aramco
Faisal Alshuraidah	Aramco
Ahmaed Morsy	Cairo Microsoft Innovation Center
Abduallah Almulaise	CBA
Mohammed Rasheed	CEO Ezah Tops Tech.
Sulaiman Mirdad	CITC
Ibraheem Alfuraih	CITC
Ayman Foyowmi	CTECB
Anis Koubaa	Imam Univ.
Mohamed Alarbi	Imam Univ.
Imad A. AlSghaiyer	Imam Univ.
Miled Tezeghdanti	Imam Univ.
Laith Alsulaiman	Imam Univ.
Areej Alhogail	Imam Univ.
Manar Almusallam	Imam Univ.
Khalid Alshalfan	Imam Univ.
AbdulMohsen AlThubaity	Information Center
Hesham Bin Abbas	KACST
Mishaal AlKadhi	KACST
Abdulaziz Alsuqair	KACST
Romaih AlRomaih	KACST
Mohssen Alabbadi	KACST
Saeed Alhaznawi	KACST
Walid Molla	KACST
Mohammed Alhaddad	KAU
Arwa Alaama	KAU
Khalid Hosain	KAU

Appendix A: Plan Development Process

Name	Affiliation
Kamal Jambi	KAU
Fatmah Baothman	KAU
Uthman Baroudi	KFUPM
Jarallah Alghamdi	KFUPM
Husni Almuhtaseb	KFUPM
Abdulwahab Alabdulwahab	King Faisal Special Hospital
Mansour Alsulaiman	KSU
Yousef Alohali	KSU
Sami Alhomod	KSU
Abdulrahman Albarrak	KSU
AbdulMalik AlSalman	KSU
Nadia Alghreimil	KSU
Ammar Abuthuraya	Microsoft
Majid M. Altuwaijri	NGHA
Naser Alodan	Public Pension Agency
Zahair Radwan	Royal Saudi Navy
Nicolo Sorbsina	SAGIA
Saad Alkasabi	Saudi Food and Drug Authority
Ali AlGarni	STC
Esam Ali Khan	Umm Alqura Univ.

Appendix A: Plan Development Process

The management team for the planning project from KACST are:

Table A-3: Planning Project Core Team

Name
Mohamed Alkanhal
Mansour Alghamdi
Ashraf Alkhairy
Ibraheem Alkharashi
Mohsen Alabadi
Rumaih Alrumaih
Mohammed Almanie
Mohammed Khorsheed
Abdulrahman Almuhareb
Abdulaziz Alhargan
Waleed Alsanie
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Doc. No. 17P0001-PLN-0001-ER01