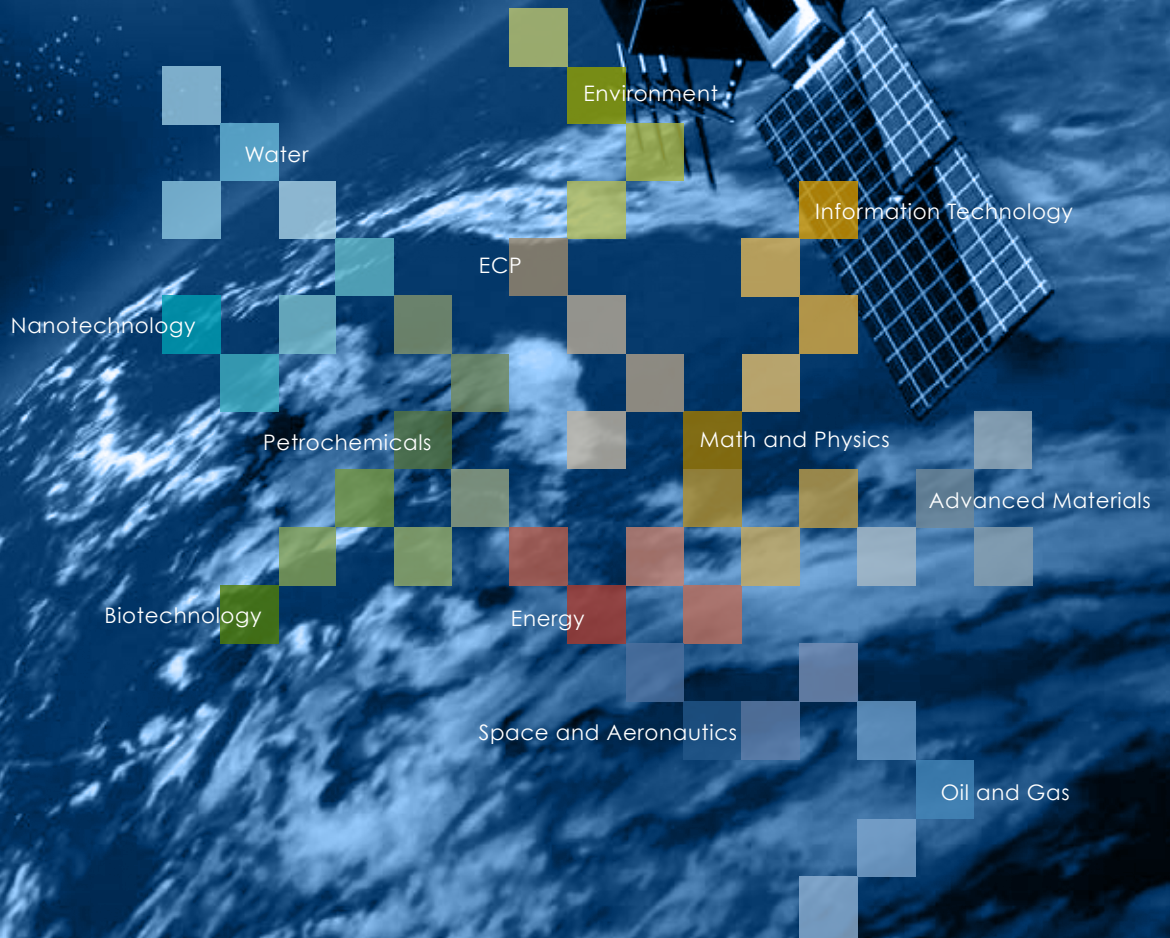


Kingdom of Saudi Arabia



## Strategic Priorities for Space and Aeronautics Technology Program



مدينة الملك عبدالعزيز  
للعلوم والتقنية KACST  
King Abdulaziz City for Science and Technology

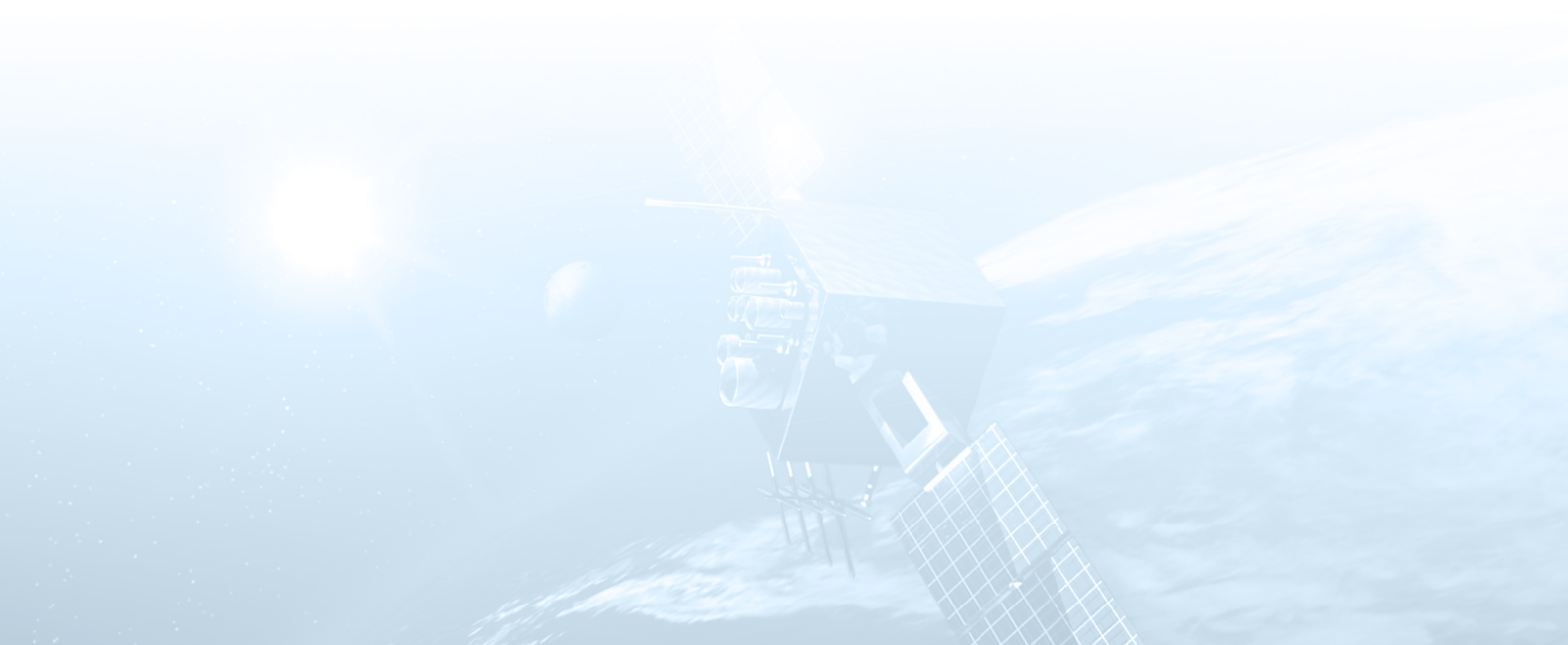


Kingdom of Saudi Arabia  
Ministry of Economy and Planning  
<http://www.mep.gov.sa>

Kingdom of Saudi Arabia

King Abdulaziz City for Science and Technology

Ministry of Economy and Planning



Strategic Priorities for Space and Aeronautics Technology Program

## Contents



<b>Executive Summary</b>	4
<b>Introduction</b>	6
Background	6
Scope	6
Process	8
<b>Strategic Context</b>	10
Capabilities in the Kingdom	11
Space and Aeronautic R&D Indicators	12
Summary of Strengths, Weaknesses, Opportunities and Threats (SWOT)	23
<b>Program Strategy</b>	24
Vision	24
Mission	24
Values	25
Strategic Objectives	25
<b>Program Management</b>	34
Program Organization	34
Strategic Management Office (SMO)	36
Project Management	37
Work Breakdown Structure	38
Schedule Control	40
Change Control	40
Configuration and Data Management	41
Product Assurance	42
Key Performance Indicators	43

# Contents

Risk Management	45
Progress Reporting	48
Reviews	48
Property Control	49
<b>Appendix A - Acronyms</b>	50
<b>Appendix B: Plan Development Process</b>	52
Planning Project Core Team	53
Workshop Participants	54
Acknowledgements	55

## Executive summary

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 document is the strategic priorities for one of these programs, the Space and Aeronautics Program.

---

This document presents the strategic plan for the development of space and aeronautical capabilities for the Kingdom of Saudi Arabia, over the 5 year period from 2008-2012 led by the King Abdulaziz City for Science and Technology (KACST). This plan encompasses all R&D and industrialization aspects of these sectors, including civil but excluding military aviation. The strategic program is to be managed by a Space Program Management Office (SPMO) to be formed within KACST, along with a group of stakeholders consisting of critical engineering departments in the Kingdom's universities, government units related to aviation and aeronautics, and members of the Kingdom's industrial base.

The vision for the program is:

“Over the next five years, with the strategic support of other key stakeholders, is to become a regional leader in space and aeronautical activities not limited to research and development and will support the needs of national security and sustainable development within the Kingdom of Saudi Arabia (KSA) in these disciplines”.

Seven high priority strategic objectives have been established:

- To develop into the leading provider of commercial and Earth Observation (EO) products within the region.
- To enhance significantly the Geographical Information System (GIS)

capabilities for both national and regional development.

- To implement an optimized, responsive, and advanced civilian Earth Observation satellite system to provide key data for the region.
- To design and develop advanced aeronautical platforms for research and commercialization.
- To become the leading provider of numerical simulation services for aerospace objectives within the region.
- To create a thriving commercial space and aeronautical sector within the Kingdom of Saudi Arabia (KSA) capable of executing advanced technology programs.
- To research and develop specific advanced enabling technology in order to develop intellectual property (IP) for longer term international collaboration, commercial exploitation or to support stakeholder strategic programs.

The projects necessary to achieve these high priority objectives will be authorized during the second half of 2008 after a feasibility study and baseline definition are conducted during 2008. All associated development and test programs are planned to be completed by the end of 2011.

Four medium priority strategic objectives have been established:

- To become a participant in international or regional aerospace science missions.
- To exploit the downstream opportunities opened up by the introduction of space systems provided by other aerospace organisations.
- To raise the level of aerospace higher education and training programs within the Kingdom of Saudi Arabia (KSA) and to expand interest and resources in the space

and aeronautical sectors.

- To promote the wider national use of space and aeronautical projects and services within government, industry and the general public.

The projects necessary to achieve these medium priority objectives will be authorized during the second half of 2009 after the feasibility study and baseline definition are conducted during 2009. The majority of associated development and testing programs will be completed by the end of 2012.

The process has been constructed on the basis of maximizing the synergies brought by each of the stakeholders to create a unified Strategic Plan. The intent is to build a consensus of stakeholder acceptance of the plan so that the implementation will attract the full co-operation and support of the stakeholders. It is recommended that a Memorandum of Understanding (MOU) be drawn up to reflect the agreement between the stakeholders and to establish the future working relations for the implementation phase. The MOU will also outline the estimated balance of public and private financing that form the basis of funding for space and aeronautical initiatives in the Kingdom.

### Background

King Abdulaziz City for Science and Technology (KACST) was directed by its charter of 1986 to “propose a national policy for the development of science and technology and to devise the strategy and plans necessary to implement them.” In accordance with this charter, KACST launched a comprehensive effort in collaboration with the Ministry of Economy and Planning (MoEP), to develop a long-term national policy

on science and technology. In July 2002, the Council of Ministers approved the national policy for science and technology, entitled “The Comprehensive, Long-Term, National Science and Technology Policy.”

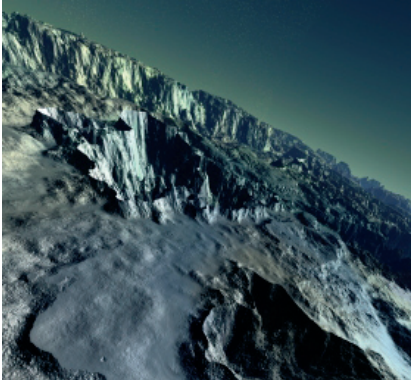
Then KACST and MoEP embarked on a national effort in collaboration with stakeholders to develop the national plan for science, technology and innovation (STI), which drew up the broad lines and future directions of science, technology, and innovation in the Kingdom, considering the role of KACST as well as that of universities, government, industry and society at large.

### Scope

This document presents the strategic plan for the development of space and aeronautical capabilities for the Kingdom of Saudi Arabia led by the King Abdulaziz City for Science and Technology (KACST), over the 5 year period from 2008-2012. This plan encompasses all R&D and industrialization aspects of these sectors, including civil but excluding military aviation. It defines the strategic objectives to be achieved and the role of KACST and other stakeholders and partners in organizing and establishing projects, initiatives, and partnerships both within Saudi Arabia and with international collaborators. It is derived from the objectives of the National Plan for Science and Technology as defined by the National Policy for Science and Technology, which stated an objective to be:

“.....to direct scientific research and technical development to secure the strategic needs of defence and national security with attention to scientific research and technological development.”

## Introduction



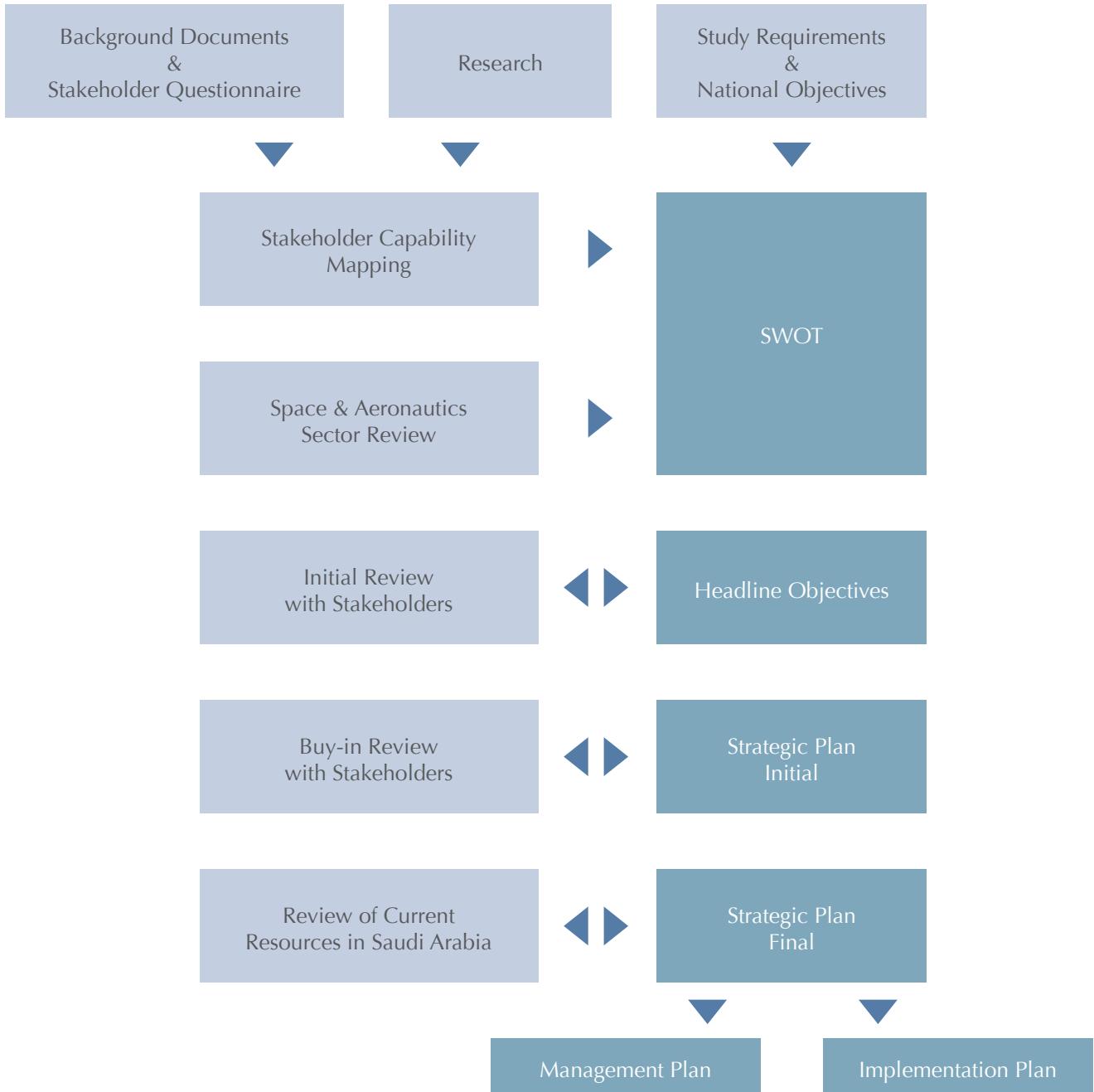
In addition to the Space Program Management Office (SPMO), which is a new office to be formed to manage the program, the stakeholders will be representatives from key institutional sectors of the Kingdom. Among the stakeholders will be representatives from critical engineering departments in the Kingdom's universities as well as from industry. The Kingdom's agencies for governance of civilian aviation and aeronautics are also stakeholders. The range of key stakeholders is necessary to fulfill the breadth of the scope of the space and aeronautics program.



## Process

The process used for generating this space and aeronautics strategic development plan is shown in diagrammatic form in figure 1:

Figure 1: Process Flow Chart



## Introduction



The process has been constructed on the basis of maximizing the synergies brought by each of the stakeholders to create a unified strategic plan. The intent is to build a consensus of stakeholder acceptance of the plan so that the implementation will attract the full co-operation and support of the stakeholders. It is recommended that a Memorandum of Understanding (MOU) be drawn up to reflect this agreement between the stakeholders and to establish the future working relations for the implementation phase.

## Strategic Context

The international space and aeronautics sector is characterized by accelerating technological advancement and increasing competition. The Kingdom of Saudi Arabia seeks to become a regional leader in critical areas of this sector. The major thrusts in this sector are the following:

- Space:
  - Earth Observation.
  - Navigation.
  - Telecommunications.
  - Science.
  - Launch Services.
- Aeronautical and Aviation:
  - Very light aircraft.
  - Unmanned Aerial Vehicles.

Earth Observation (EO) is a well established scientific and technical field. In many ways, it is a common link between the major areas of the space sector as it relies on the fundamental technical platforms that support these areas. There are generations of imaging satellites dating back to the 1960's that provide detailed data on the earth's topography and atmospheric and weather system dynamics. Due to the increasing sophistication of current and planned generations of imaging satellites, there is a growing set of applications derived from earth observation platforms. The applications include, for example, monitoring biosphere changes, solid earth topography, interior characteristics, and natural resources, and improving geographical information systems. In addition to the increase in specific applications, there is a broader trend in the characteristics of satellites themselves. Major space

agencies are planning for smaller satellites with more specific functionalities to be launched more frequently.

Satellites as well as their complementary technologies are becoming increasingly decentralized. Until the late 1980's only the United States, the former Soviet Union and the European Space Agency operated EO satellites. Currently more than 20 nations, including the Kingdom of Saudi Arabia operate EO satellites. In the early stages of this transformation, many nations simply purchased satellites. Today, not only are satellites distributed among more nations, the technical capability to develop and maintain satellite systems and the data processing platforms to support them are also more broadly distributed. The distribution of capability and the growing specification of satellite functions has resulted in increasing international collaboration on space-based initiatives. There are a number of international organizations coordinating space-based earth observation projects among several participating nations. This trend presents yet another mechanism for strategic partnerships among nations and for accelerated development of individual nations' technical capacity through collective learning and interdependence.

Another consequence of the decreasing size of individual satellite projects and the diffusion of satellite technology is the increasing role of the private sector. There is growing private sector involvement in space-based projects coinciding with a slackening of state control and decreasing capital investment requirements. The emergence of privately financed earth observation and space-based initiatives is another fundamental shift in the space and aeronautics sector that represents an enormous potential for increased participation and technical specialization in niche markets among many nations such as the Kingdom. This trend demonstrates

the importance of having a balance between state and private investment in space-based initiatives. State funded initiatives will be required to specifically address key needs of individual nations. Private funding, however, will foster broad commercialization of specific technologies and the development of niche specialties.

There are significant trends underway in aeronautics and aviation as well. For example, there is an increasing need to manage the ever growing demand for global air travel. Some of the challenges associated with that are devising more efficient air traffic management systems and developing new business models to accommodate the changing landscape of air travel generally. Another component of the aeronautics and aviation sector is in the development of new kinds of aircraft that serve a variety of functions. Unmanned Aerial Vehicles (UAV), for example, are used in a host of applications relevant to security surveillance and monitoring the atmosphere, weather, and natural resources. Another example is very light jets, which are currently generating considerable interest among major aircraft manufacturers. The reduction in weight is directly correlated with the reduction in fuel consumption, which is of international concern. As a result, there are significant opportunities to develop specific skills and contribute to this increasingly large and complex global supply chain.

### **Capabilities in the Kingdom**

The vision of KACST, along with its strategic stakeholders, is to have the Kingdom of Saudi Arabia be a regional leader in space and aeronautical activities. In the current global context of the space and aeronautical sector, the Kingdom is well poised to realize this vision. The Kingdom of Saudi Arabia currently has well established critical capacities in the space and aeronautics sector. The stakeholders of the Strategic Development Plan each

offer unique specialties that contribute to the Kingdom's capacity. The combination of university and government based research and technical capacities combined with an industrial focus on technical applications and commercialization provide a substantial foundation for further development of the space and aeronautical sector in the Kingdom.

KACST Space Research Institute (SRI) is composed of an array of centers dedicated to satellite technologies, including monitoring, communications, and data processing. In addition, there are centers dedicated to material testing for aeronautical applications, and numerical modeling and simulation, including computational fluid dynamics and finite element modeling. Importantly, KACST SRI currently supports a generation of Saudi satellites, having already crossed the barriers to entry to successful space systems programs. These core competencies are complemented by the research and development taking place in the Kingdom's major universities: King Abdulaziz University (KAU), King Fahd University of Petroleum and Minerals (KFUPM) and King Saud University (KSU). KAU and KFUPM have departments specifically dedicated to aeronautical and aerospace engineering. There is significant existing research and established competence in theoretical and computational fluid dynamics and thermodynamics. The mechanical engineering department at King Saud University offers relevant competencies in material characterization, solid mechanics and heat transfer.

The Kingdom's industrial stakeholders offer considerable

capabilities in manufacturing and flight systems modification as well as specific components relevant to satellite systems and advanced aircraft. In addition to general industrial expertise in electronic systems and components, the Advanced Electronic Company specializes in the manufacture, testing, and inspection of electronic components for military vehicles including advanced fighter aircraft. The Al Salam Aircraft Company has considerable experience and expertise in heavy maintenance and modification on both civilian and military aircraft. In addition, Al Salam offers competency in avionics and aircraft communication systems. The other industrial partners, Saudi Aramco and SABIC offer large scale industrial experience and significant resources to support relevant components of the space development plan. The oil and natural gas industry as well as the petrochemical industry are also natural customers of advanced earth observation technologies, which are a key component of the strategic plan.

### Space and Aeronautic R&D Indicators

#### Overview

Publication and patent activity are widely used as indicators of research output and invention.<sup>1</sup> The frequency with which publications and patents are cited by others (forward citations) is used as a measure of impact. Co-authoring relationships are used as an indicator of scientific collaboration. Although there is general agreement that these are useful indicators, it is important to recognize that they are not by themselves complete indicators of R&D output or quality.<sup>2</sup> Several indicators are used here to provide measures of science

---

1 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.

2 For example, they do not cover research results that are presented on conferences, technical reports, or new technology that is protected by copyrights rather than patents.



and technology output, impact, and collaboration in fields related to the KSA space and aeronautics program.

The overall field, “space and aeronautic technology”, as well as sub-topics of interest to the Kingdom, were defined in close consultation with KACST researchers and other KSA stakeholders. The KSA space and aeronautic technologies program identifies five sub-topics — remote sensing and geographic information systems, space platforms, aeronautical platforms, numerical simulation, and enabling technologies — as relevant to KSA strategic priorities. Lists of keywords were used to develop search queries to develop databases of publications and patents in these areas.<sup>3</sup> Space and aeronautic 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 the identified sub-topics. These databases of KSA-relevant space and aeronautic fields were then used to analyze the position of the Kingdom in these fields.

### **Space and Aeronautic Publication Activity**

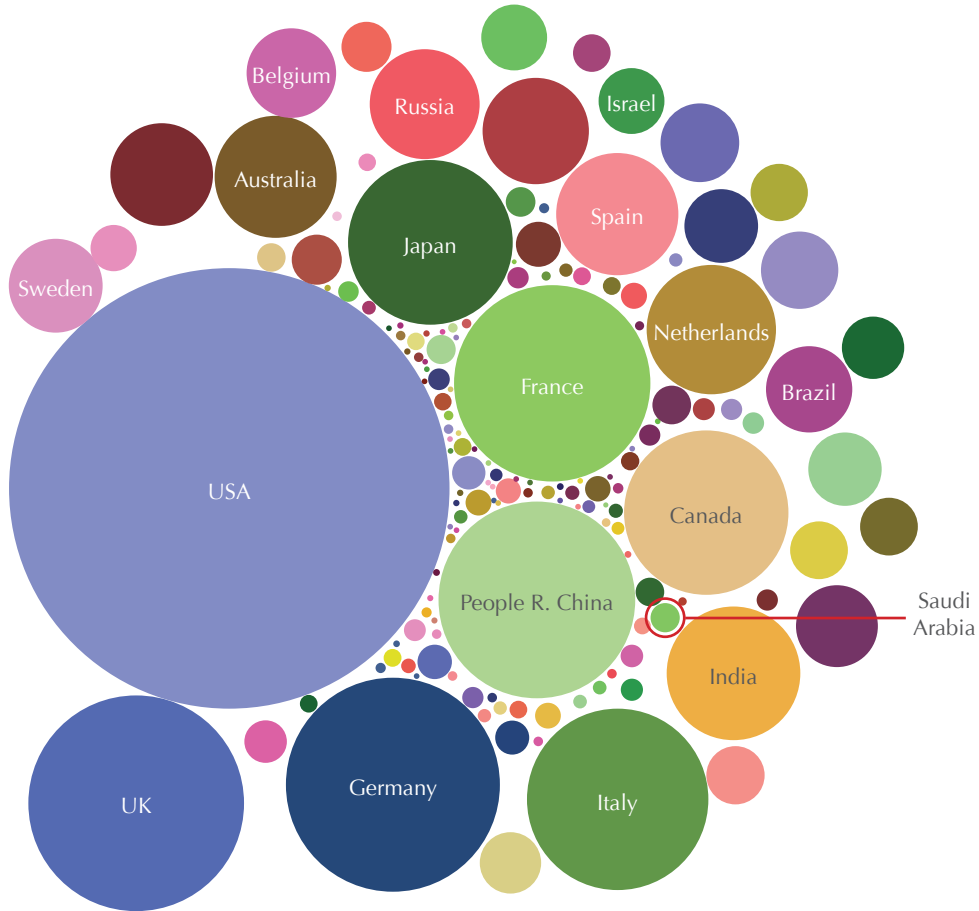
Between 2005 and 2007, there were 17840 articles published worldwide related to KSA space and aeronautic R&D priorities. As illustrated in figure 2, the United States was the world’s largest producer of related articles, generating 6791 articles over this time period. The United Kingdom was a distant second, producing 1617 articles, followed by Germany and the Peoples Republic of China with 1579 and 1437 articles respectively. Saudi Arabia was the 48th largest producer of publications, producing 24 articles.<sup>4</sup>

---

<sup>3</sup> 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 and it has been argued that the U.S. market is so large that most important inventions from around the world are patented there.

<sup>4</sup> 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.

Figure 2: Space and Aeronautics Activity



As shown in table 1 remote sensing and geographic information systems accounts for the largest share of space and aeronautic related publications (8421)

followed by space platforms (4788), enabling technologies (3446), aeronautical platforms (2847) and numerical simulations (981).

Table 1: Space and Aeronautic Sub Topics (2005-2007)

Sub-Topic	Publications
Remote Sensing and Geographic Information Systems	8400
Space Platforms	4051
Enabling Technologies	3442
Aeronautical Platforms	2872
Numerical Simulation	937

## Strategic Context

### Benchmark Countries

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, the Netherlands had the highest average publication impact of

all countries at 2.55 followed by France (2.42), Germany (2.29), and the UK (2.22). The average publication impact for Saudi Arabia was 0.33 with only 8 citations of 24 articles. Saudi Arabia's most highly cited article, "Statistical processing of large image sequences"<sup>5</sup>, was produced in collaboration with researchers in the UK and Canada. Table 2 presents publication and citation counts for benchmark countries.<sup>6</sup>

Table 2: Benchmark Countries Publication Impact (2005-2007)

Country	Publications	Total Citations	Average Publication Impact
Netherlands	627	1601	2.55
France	1446	3496	2.42
Germany	1697	3878	2.29
UK	1739	3866	2.22
USA	7195	15888	2.21
Canada	995	2135	2.15
Italy	1202	2299	1.91
South Africa	133	240	1.80
Japan	995	1352	1.36
Peoples R. China	1454	1364	0.94
India	681	622	0.91
Iran	90	77	0.86
Jordan	18	14	0.78
Kuwait	14	7	0.50
Saudi Arabia	24	8	0.33
United Arab Emirates	14	1.50	0.21
Egypt	31	1.42	0.16

5 Khellah, F, Fieguth, P, Murray, ML, Allen, M. 2005. Statistical processing of large image sequences. IEEE Trans. Image Process., 14 (1): 80-93.

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





### **Space and Aeronautics Research Organizations**

As shown in table 3, the three institutions producing the largest number of publications related to space and aeronautic technology R&D are the National Aeronautics and Space Administration (811), the Chinese Academy of Sciences (494), and the California Institute of Technology (345). NASA is the number one producer of publications in all sub-topic fields except remote sensing, in which the Chinese Academy of Sciences is the leader. For the institutions on this list, authors from NASA have generated the papers with the largest number of citations (2521 citations) followed by the California Institute of Technology (1235 citations), and NOAA (862 citations).

Table 3: Space and Aeronautic Technology R&D Organizations (2005-2007)

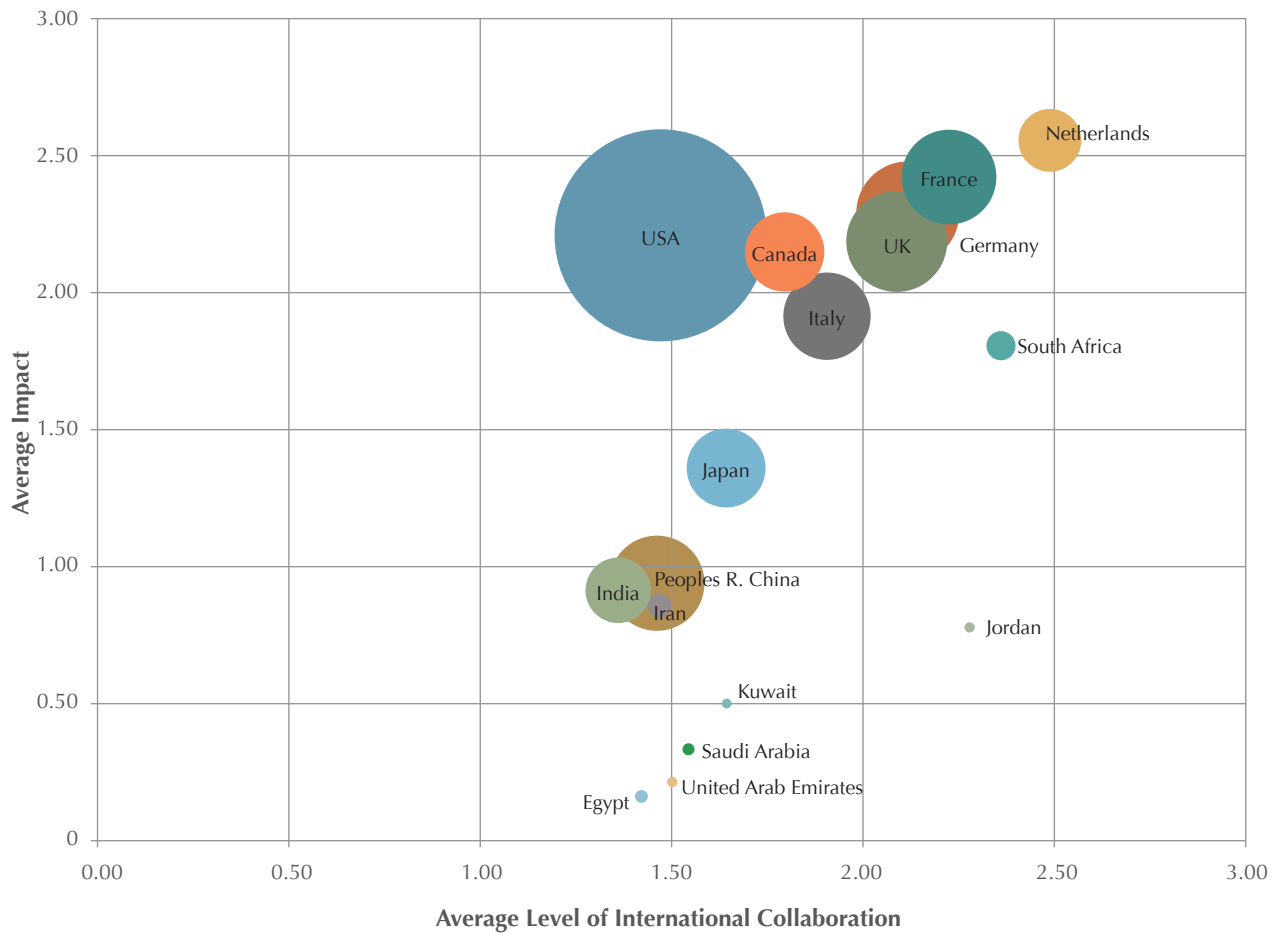
Institution	Total Publications	Average Impact	Remote Sensing and Geographic Information Systems	Space Platforms	Enabling Technologies	Aeronautical Platforms	Numerical Simulation
NASA	811	3.11	280	262	186	135	89
Chinese Acad Sci	494	1.15	359	80	69	12	8
CALTECH	345	3.58	101	166	67	25	44
Univ Texas	284	1.82	133	56	45	55	22
Univ Colorado	239	3.41	92	59	64	41	18
NOAA	233	3.70	87	56	51	62	10
USDA	229	2.23	178	17	40	9	5
Univ Maryland	215	2.53	106	49	32	33	12
CNR	197	2.23	98	67	75	7	9
CNRS	192	2.95	55	63	56	20	16
Univ Florida	161	1.45	98	17	19	29	8
USN	153	2.61	49	33	28	52	13
Russian Acad Sci	153	1.07	51	45	41	12	16
Univ Paris	152	4.03	67	35	62	5	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 3 plots a

country's level of international collaboration (horizontal axis) against the average impact of its publications (vertical axis). Countries, such as the Netherlands and France, that show significant international collaborative activity also tend to produce papers with a higher average impact.

Figure 3: Space and Aeronautics International Collaboration and Publication Impact (2005-2007)



## Strategic Context

### KSA Collaboration Activity

As shown in table 4, authors affiliated with KSA institutions collaborated on more than one article with authors from the United States, Pakistan, and the United

Kingdom. KSA authors collaborated on individual publications with authors from Canada, Egypt, Iran, Italy, Jordan, and Turkey.

Table 4: KSA Publication Collaborators (2005-2007)

Country	Number of Publications
United States	3
Pakistan	2
UK	2
Canada	1
Egypt	1
Iran	1
Italy	1
Jordan	1
Turkey	1

### Space and Aeronautic Technology Journals

Table 5 presents journals that have published the greatest

number of articles in the KSA space and aeronautics sub-fields from 2005-2007.

Table 5: Space and Aeronautics Journals (2005-2007)

Journal	Publications
JOURNAL OF AIRCRAFT	68
JOURNAL OF GUIDANCE CONTROL AND DYNAMICS	40
ACTA ASTRONAUTICA	35
JOURNAL OF GEOPHYSICAL RESEARCH-SPACE PHYSICS	34
JOURNAL OF SPACECRAFT AND ROCKETS	34
AIAA JOURNAL	24
ASTRONOMY & ASTROPHYSICS	23
PLANETARY AND SPACE SCIENCE	20
AIRCRAFT ENGINEERING AND AEROSPACE TECHNOLOGY	18
ICARUS	16

Numerical Simulation

	Journal	Publications
Space Platforms	ACTA ASTRONAUTICA	232
	IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING	109
	JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES	105
	GEOPHYSICAL RESEARCH LETTERS	95
	ANNALES GEOPHYSICAE	88
	JOURNAL OF SPACECRAFT AND ROCKETS	84
	INTERNATIONAL JOURNAL OF REMOTE SENSING	79
	JOURNAL OF GUIDANCE CONTROL AND DYNAMICS	73
	INTERNATIONAL JOURNAL OF SATELLITE COMMUNICATIONS AND NETWORKING	63
	REMOTE SENSING OF ENVIRONMENT	52
Remote Sensing and GIS	IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING	379
	INTERNATIONAL JOURNAL OF REMOTE SENSING	357
	REMOTE SENSING OF ENVIRONMENT	321
	ISPRS JOURNAL OF PHOTOGRAMMETRY AND REMOTE SENSING	111
	ENVIRONMENTAL MONITORING AND ASSESSMENT	100
	JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES	98
	GEOPHYSICAL RESEARCH LETTERS	97
	ENVIRONMENTAL GEOLOGY	85
	PHOTOGRAMMETRIC ENGINEERING AND REMOTE SENSING	84
	INTERNATIONAL JOURNAL OF GEOGRAPHICAL INFORMATION SCIENCE	84
Enabling Technologies	JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES	151
	APPLIED OPTICS	122
	IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING	100
	GEOPHYSICAL RESEARCH LETTERS	94
	REMOTE SENSING OF ENVIRONMENT	63
	IEEE GEOSCIENCE AND REMOTE SENSING LETTERS	62
	PHYSICA B-CONDENSED MATTER	54
	INTERNATIONAL JOURNAL OF REMOTE SENSING	51
	ATMOSPHERIC CHEMISTRY AND PHYSICS	46
	OPTICS EXPRESS	44

	Journal	Publications
Aeronautical Platforms	JOURNAL OF AIRCRAFT	240
	JOURNAL OF GUIDANCE CONTROL AND DYNAMICS	96
	AERONAUTICAL JOURNAL	70
	AIAA JOURNAL	70
	JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES	49
	PROCEEDINGS OF THE INSTITUTION OF MECHANICAL ENGINEERS PART G-JOURNAL OF AEROSPACE ENGINEERING	44
	AEROSPACE SCIENCE AND TECHNOLOGY	43
	AIRCRAFT ENGINEERING AND AEROSPACE TECHNOLOGY	42
	JOURNAL OF THE AMERICAN HELICOPTER SOCIETY	39
	AVIATION SPACE AND ENVIRONMENTAL MEDICINE	39

### Space and Aeronautic Patent Activity

Between 2002 and 2006, there were 5,584 space and aeronautic related patent applications filed with the United States Patent Office (USPTO). As shown in table 6, the majority of these (3,914) listed at least one inventor from the United States. Other countries with a significant number of inventors include: France (377

applications), Japan (317 applications), and Germany (247 applications). The most cited space and aeronautic related patent application (54 citations): “Structural reinforcing member with ribbed thermally expansible foaming material,”<sup>7</sup> listed only inventors from the United States. No space and aeronautic related patent applications listed an inventor from Saudi Arabia.

Table 6: Space and Aeronautics Patents Applications (2002-2006)

Country	Remote Sensing and GIS	Space Platforms	Aeronautical Platforms	Numerical Simulation	Enabling Technologies	Total
United States	140	1818	1886	26	168	3914
France	5	81	285	1	8	377
Japan	2	237	77	0	2	317
Germany	5	60	176	0	10	247
United Kingdom	3	70	114	2	7	189

<sup>7</sup> Fitzgerald, Gerald E., Stratman, Randy, Chang, Chin-Jui, U.S. Patent Application # 20020074827, 2002.

## Strategic Context

Country	Remote Sensing and GIS	Space Platforms	Aeronautical Platforms	Numerical Simulation	Enabling Technologies	Total
Canada	9	63	88	0	12	172
Italy	2	6	29	0	2	39
India	3	13	3	0	0	19
Netherlands	0	9	6	0	1	15
China	1	2	8	0	2	13
Saudi Arabia	0	0	0	0	0	0

While the majority of the space and aeronautics related patent applications are defined as individually owned patent applications by the United States Patent Office, institutions are designated as the patent assignee on a significant number of applications. These institutions, which have records as inventors in technology fields related to KSA space and aeronautics priorities, could

be future targets for collaboration. As shown in table 7, Boeing Company is listed as the patent assignee on 100 space and aeronautic related patent applications followed by Honeywell International Inc. (50 applications), Hughes Electronics Corporation (46 applications), and Airbus France (44 applications).

Table 7: Leading Space and Aeronautics Patent Assignees (2002-2006)

USTPO Assignee	No. of Patents Apps.
Individually Owned Patents	3977
Boeing Company	100
Honeywell International Inc.	50
Hughes Electronics Corporation	46
Airbus France	44
Alcatel	41
International Business Machines Co.	40
Snecma Moteurs	31
Lockheed Martin Corporation	21
General Electric Company	20

### **Summary of Strengths, Weaknesses, Opportunities and Threats (SWOT)**

KACST SRI and its strategic stakeholders are well poised to pursue the Kingdom's aim of becoming a regional leader in space and aeronautical technologies. The experience of the Space Research Institute in successfully supporting a fleet of Saudi satellites is a particular strength of the Kingdom. The strong and continuing financial support of the Saudi government is also a considerable strength of the space and aeronautical development plan. The financial strength of Saudi oil and gas and petrochemical industries combined with their desire to utilize the proposed technical products is a unique advantage of the space and aeronautics plan.

The limited size of the technical workforce in the Kingdom is a weakness that affects all of the strategic technology plans. This shortage of technical workers is compounded by a relative weak ability of the Kingdom's universities to attract and train students in relevant fields such as advanced mathematics, physics and material science. Notwithstanding the shared technical interests between the universities and industry in the Kingdom, there is little substantive collaboration or linkages between the two. That internal discord contributes to a lack of international scientific collaboration which limits the speed with which KACST SRI and the Kingdom can become truly viable members of the international space community.

The current global environment of the space and aeronautics sector provides significant opportunities for Saudi space as well. The Kingdom is well-positioned to contribute to regional development of space technological systems. There are also significant opportunities to commercialize Saudi technologies particularly related to the constellation of Saudi Comsat

satellites and Global Navigation Satellite Systems applications. The region's relative weakness in the collection and processing of atmospheric data is an opportunity for the Kingdom to become one of the leading providers of such services.

The lack of internal collaboration and limited workforce development is the principal threat to Saudi space science. As is the case in all technologies, the Kingdom faces considerable competition from other developing nations, most notably India and China. In addition, the Kingdom's limited international profile in complex space science projects could lead to it being left out of maturing markets and international collaborative partnerships.

On balance, the Kingdom possesses considerable strengths and there are ample opportunities to develop regional prominence in space and aeronautical sciences. It will require efficient collaboration between the KACST Space Research Institute and its stakeholders to overcome the structural weaknesses of the Kingdom and reduce the external threats it faces. This effort will require a concerted alignment behind the singular vision and mission of the space and aeronautical strategic development plan.



### Vision

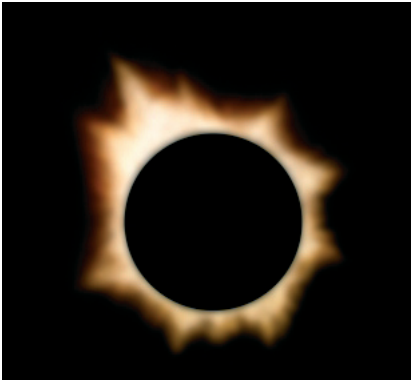
“Over the next five years the Saudi Space and Aeronautics Program, with the strategic support of key stakeholders, will become a regional leader in space and aeronautical activities not limited to research and development, and will support the needs of national security and sustainable development within the Kingdom of Saudi Arabia in these disciplines”.

### Mission

The mission of the Space and Aeronautics Program is to enhance the position of the Kingdom in space and aeronautics technologies and systems, through a nationally and internationally collaborative program of research, development, and technology transfer.

The vision shall be achieved by:

- Developing capabilities in sectors in which the stakeholders have existing expertise.
- Broadening capabilities by moving into sectors where the stakeholders have little or no current involvement and which support the vision.
- Implementing a number of challenging projects and initiatives specifically chosen to achieve the vision. These will:
  - Raise stakeholder profiles nationally, regionally and internationally.
  - Allow stakeholders to join and become active in regional and global forums.
  - Promote international collaboration with companies and universities
  - Focus R & D and develop products and IP.
  - Stimulate sustainable industrial expansion.
- Promoting and encouraging an expansion of space and aeronautical related education and training.
- Expanding the range of existing and stimulate new private and joint venture companies.
- Promoting wider use of space and aeronautical applications within government, industry and the general public.
- Establishing aeronautical or aerospace research groups at the three stakeholder universities to support the plan and to encourage an increase in the numbers and quality of graduates in relevant disciplines.



The program will be led by the PMO with support of the other stakeholders and will cover major projects and capital investments in the space and aeronautical development sector. However individual stakeholders would still be able to perform their own smaller programs, make independent capital investments in space and aeronautics, and diversify into non-space and non-aeronautical sectors. As a guideline, major strategic projects and capital investments are considered to be those greater than US \$100K and smaller projects and capital investments are those less than US \$100K.

Among the stakeholders are the relevant engineering departments of major KSA universities. To ensure that the activities in these departments are directed towards the achievement of the strategic plan and are given the right priority and resources, it is proposed to establish aeronautical or aerospace research groups in these departments, funded by KACST and initially providing 100 percent support from the plan. The scope, resources, and specializations of each of these centers will be defined by the SMO in conjunction with each university in early 2008.

### Values

The Program's core values are:

- Excellence of work.
- Professional integrity and ethical behaviour.
- Openness with all stakeholders.
- Commitment to achieving objectives.
- Quality of products.
- Sustainability of activities.

Core values have been generated to capture the key characteristics of the participants necessary to achieve successfully the vision statement.

### Strategic Objectives

Eleven strategic objectives have been derived by the stakeholders and are defined in this section:

- Seven high priority objectives. These are each of equal priority and are considered essential to achieving the vision statement.
- Four medium priority objectives. These are each of equal priority and are considered important to achieving the vision statement.

For each objective a rationale is provided together with policies, projects, and initiatives to be considered as part of the implementation.

### High Priority Strategic Objectives

#### Strategic Objective 1

To develop into the leading provider of commercial Earth Observation products within the region.

#### Rationale

This objective is a logical development of current Earth Observation capabilities within KACST. It supports a national objective of providing for sustainable development within KSA and will provide enhanced support to national objectives of securing the strategic needs in defense, national security and domestic civilian topographic data needs. There is considerable potential for exploiting products commercially beyond KSA and for developing international collaboration.

#### Policies, Projects and Initiatives

KACST Space Research Institute will collaborate with the Satellite Technology Centre (STC) and the Saudi Centre for Remote Sensing (SCRS) to maintain and develop a fleet of satellites to provide critical data in support of KSA national security and domestic needs. The responsibilities of STC and SCRS will focus on satellite development and data processing respectively.

STC will continue to control the Saudisat 3 satellite and will orchestrate the research, development and support of the next generation of satellites - Saudisat 4, 5 and 6. SCRS, in conjunction with the Numerical Studies Center (NSC), will play a lead role in the development of data gathering and processing systems to support the key needs of the Kingdom. The key policies, projects and initiatives are:

- STC to continue to control the Saudisat 3 satellite throughout the period of the strategic plan.
- SCRS to upgrade the Ground Segment to collect data from future planned Saudisat 4, 5, 6.
- SCRS to build a fast accessed national database for EO satellite images including collecting and archiving data from:
  - Externally sourced data (under license).
  - Data from Saudisat 3.
  - Vdata from the next generation Saudisat 4, 5, 6 as they become operational during the 5 year period (see also objective 3).
- SCRS to collaborate with another EO operator to maximise the synergistic return of data from an enlarged family of satellites and to develop advanced EO products in conjunction with objectives 2 and 3.
- SCRS to establish and operate an Atmospheric Monitoring and/or Hazard Warning Unit in conjunction with other countries to provide emergency response information to civil defence authorities and international organizations with timely products and services. Examples of products and services are:
  - Identifying offshore hydrocarbon seepage and oil slicks.
  - Pipeline zone integrity monitoring.
  - Identifying flood hazard areas and damage assessment.
  - Food security status.
  - Monitoring forest and scrubland fires.
  - Earthquake prediction and damage assessment.
  - Prediction and monitoring of desert locust outbreaks.
- SCRS to provide a leading role in environmental and biodiversity monitoring in KSA and the region, including the provision of data and products for:
  - Identifying habitats and land cover changes (including desertification).
  - Plant diversity mapping.

## Program Strategy

- Land and soil degradation.
- Coastal zone degradation.
- Coral reef monitoring.
- Coastal lagoon monitoring.
- Effluent mapping.
- SCRS to support national and regional mapping and management of resources, with data and products (with support from KACST's Geographical Information Systems Center (GISC)) for:
  - Crop inventory and production forecasting.
  - Water management and irrigation scheduling.
  - Precision farming.
  - Pastureland management.
  - Mineral exploration.
- Monitoring urban development.

### Strategic Objective 2

To develop into the leading provider of commercial Earth Observation products within the region.

#### Rationale

GISC already has systems and infrastructure in place for national institutional applications together with an existing and active stakeholder network. This objective supports a national objective of providing for sustainable development within KSA and should provide enhanced support to a national objective of securing the strategic needs of defense and national security. There is significant potential for regional development and commercialization. There is also potential for exploiting products commercially beyond KSA and for developing international collaboration.

#### Policies, projects and initiatives

The particular policies, projects and initiatives planned are for:

- GISC to build a fast access national database for GIS products, including unifying the standards and

specifications for all Saudi GIS users and consolidating base maps, digital elevation models (DEMs) and ground control points (GCP)s already available for national and regional use.

- GISC, with NSC support and international cooperation with advanced research centers elsewhere in the world, to conduct research and develop specialized GIS software for:

- Auto generation of ortho-rectified satellite images.
- Generation of specialized 3D visualization products.
- Land cover change detection applications.

- GISC in conjunction with SCRS, to develop and provide the web-based GIS framework for the delivery of EO data, products and services (see strategic objective 1), including:

- 'Google earth' or similarly based applications for displaying data coverages and on-line ordering.
- User-specific monitoring systems linked to environmental and resource management applications (e.g. coastal zone degradation, irrigation efficiency, crop stress).

- GISC in conjunction with SCRS, to develop an end-to-end web-based GIS software system for the operational services to be provided by the Monitoring and/ or Hazard Warning Unit (see strategic objective 1).

- SCRS and GISC to provide a commercial outlet for EO based GIS products regionally.

### Strategic Objective 3

To implement an optimized, responsive and advanced civilian Earth Observation satellite system to provide key data for the region.

#### Rationale

This objective involves introducing new and advanced systems which contribute new information regionally or globally and raise the stakeholders profile internationally. It supports a national objective for providing for



sustainable development within KSA and enhances prospects for international collaboration and has the potential for training and technology transfer. Advanced systems are now becoming available for civil and commercial use from satellite suppliers.

### **Policies, Projects and Initiatives**

The particular policies, projects and initiatives planned are for:

- STC to continue to develop, launch, and operate Saudisat 4 with an advanced multi-spectral imaging capability.
- Stakeholders to study, develop, launch, and operate with international collaborators a regionally optimized hyper-spectral mission (Saudisat 5), justified on the basis of:
  - Strong applications potential within KSA and regionally, including coastal and offshore monitoring (oil slicks with thermal channels), mineral exploration, vegetation characterization and monitoring.
  - High number of cloud free days favorable to the operation and use of narrow band optical imaging.
  - Very few hyperspectral instruments currently operate in space, so there is the prospect of developing a world-leading position (note: the Surrey Satellite Technology Ltd/European Space Agency (SSTL/ ESA) experimental Compact High Resolution Imaging Spectrometer (CHRIS) instrument is currently the only high resolution, 18m, imaging spectrometer in space).
  - Excellent prospects for collaborating with international partners in instrument development, operations and applications.
- Stakeholders to study alternative candidate missions for an additional advanced EO satellite (Saudisat 6), including the following:
  - A latitude optimized synthetic aperture radar (SAR) mission, which would provide an all-weather mapping and surveillance capability, together with special capabilities for ship tracking, oil slick detection, subsidence mapping and earthquake prediction.
  - A regionally optimized atmospheric chemistry mission, primarily aimed at monitoring ozone and levels of atmospheric pollution.

### **Strategic Objective 4**

To design and develop advanced aeronautical platforms for research and commercialization.

### Rationale

This objective expands and extends current capability within KACST's Aeronautics Technology Center (ATC), and universities. The development of a research and development agenda in advanced aeronautical technologies will complement the civilian and commercial efforts in Earth Observation systems. Expertise in advanced aeronautical systems supports the national objective of providing for sustainable development within KSA and has the potential for Saudi industrial involvement and international collaboration.

### Policies, Projects and Initiatives

The advanced aeronautical systems initiative will be anchored in the development of unmanned aerial vehicles (UAV) and light aircraft that will enable a range of technological capabilities relevant to the key needs of the Kingdom:

- Surveillance and atmospheric measurements with electro optic payloads and both remotely and fully autonomous flight control systems.
- Development of solar and electric power sources for UAVs.
- Development of control systems capable of dynamic data processing and communication systems with UAVs.
- In collaboration with the General Authority for Civil Aviation, develop regulatory policy to integrate UAVs into Saudi military and civilian airspace.
- KSA universities and companies to design, implement and test modifications to a light aircraft or helicopter for specialist applications. Potential missions to be studied will include:
  - Design, implement, and test modifications to an aircraft for atmospheric pollution measurement applications.
  - Design, implement, and test advanced modifications to a light aircraft for pest control operations (e.g. spraying

of desert locust spraying).

- Design, implement, and test modifications to a light aircraft for emergency response in desert operations.
- Design, implement, and test modifications to a light aircraft for SAR operations.

### Strategic Objective 5

To become the leading provider of numerical simulation services for aerospace objectives within the region.

### Rationale

The KACST Numerical Studies Center (NSC) has existing capabilities and facilities for Computational Fluid Dynamics and Finite Element modeling and analyses. Further development of numerical simulation and computational capacity within the Kingdom will enhance the potential for commercialization in the aerospace industry and related technical areas. Capacity development in these critical fields serve as a compliment to several major projects proposed in the Kingdom's strategic plan. This is particularly true of strategic objectives in Earth Observation platforms and Geographical Information Systems.

### Policies, Projects and Initiatives

The particular policies, projects, and initiatives planned are for:

- NSC to develop research and develop specialised software in collaboration with external software companies in support of GIS objective 2 and objective 6.
- NSC to provide numerical analyses expertise to space and aeronautical projects as defined under objectives 1, 3. Required numerical support includes :
  - Structural analyses (static and dynamic).
  - Thermal analyses (steady state and diurnal).
  - Mission and orbit analyses.
  - Aerodynamics and thermodynamics.

- Radiation analyses.
- EMC/ ESD analyses.
- Fault free control analyses and algorithms (for on board software).
- NSC to market and provide training and consultancy on numerical analysis techniques to universities, external organisations, and companies and to become a regional producer and supplier of numerical software.

### Strategic Objective 6

To create a thriving commercial space and aeronautical sector within the KSA capable of executing advanced technology programs.

#### Rationale

This objective builds on the capabilities of the existing industrial stakeholders and promotes the involvement of new and existing companies other than the stakeholders. In particular it encourages and motivates interplay between academic and local industries. It supports a national objective for providing for sustainable development within KSA. An active and mature aerospace industry will help focus academic activities and will be of mutual benefit.

#### Policies, Projects and Initiatives

The particular policies, projects, and initiatives planned are for:

- KACST to perform surveys to determine and evaluate the local industrial infrastructure and hence provide necessary support to it according to the needs of aerospace development.
- KACST to become a strategic shareholder in a new service company formed to provide services for geo comsats. This company could also become a supplier of space equipment and subsystems into the project as part of a strategic shareholding.

- KACST to form an joint venture company to commercialize the Saudicomsat constellation.
- STC and ATC under the auspices of KACST to establish joint-ventures with KSA companies that utilize the acquired technologies, .e.g., space and airborne platforms.
- KACST to form an joint venture company to commercialize EO/ GIS products throughout the region (see objectives 1 and 2).

### Strategic Objective 7

To research and develop specific advanced enabling technologies in order to develop IP for longer term international collaboration, commercial exploitation or to support stakeholder strategic programs.

#### Rationale

Research and development in aerospace needs to be focused in accordance with the strategic vision and other strategic objectives. In particular it is essential that it is used to provide assets such as IP that can be exploited in the future. Also it will be necessary to provide R&D in support of other strategic objectives.

#### Policies, Projects and Initiatives

The particular policies, projects and initiatives planned are for:

- STC, NSC, and KSA universities to perform detailed R&D studies and develop key IP and products related to satellites, e.g.
  - Interferometry.
  - Reflectometry.
  - Close formation flying between satellites.
  - LIDARs (including Doppler).
  - Experimental on board wireless data systems for satellites.
  - Space ISLs.



- Electric propulsion.
- Laser ranging between satellites.
- Experimental space robotics including tele-operation.
- Deep drilling operations (lunar and asteroids).
- ATC, NSC, and KSA universities will perform detailed studies in order to identify key technologies related to aeronautical vehicles.

### Medium Priority Strategic Objectives

#### Strategic Objective 8

To become a participant in international or regional aerospace science missions.

#### Rationale

This objective would extend aerospace involvement into a new sector that offers wide potential for international collaboration with major agencies or universities. It could be developed into a flagship project in particular in support of Strategic Objective 10. It requires an interested user to emerge from the KSA science community.

#### Policies, Projects and Initiatives

The particular policies, projects and initiatives planned are for:

- STC to collaborate in a Phase A/B of a space science mission. Potential examples are:
  - An early warning satellite for severe solar activity -- Solar & Heliospheric Observatory (SOHO) replacement.
  - A tracking satellite for potential Earth collision asteroid Apophis.
  - A satellite to characterise interstellar dust.
  - Equipment for impactor/ deep drilling (lunar orbiter or lander).
- ATC to collaborate on an aeronautical science mission. Potential example is:
  - high altitude contrails.

#### Strategic Objective 9

To exploit the downstream opportunities created by more mature Global Navigation Satellite Systems in Europe and the United States.



### Rationale

Other aerospace organizations are planning large capital investment in space systems. Examples include the new Global Navigation Satellite System (GNSS) satellites such as the European Union's Galileo, the United States' NAVSTAR GPS III as well as space tourism ventures such as Britain's Virgin Galactic. Although these will offer limited or minimal upstream opportunities for the stakeholders, there will be extensive opportunities for commercial downstream development with much easier market entry and lower capital investment requirements. In addition, involvement would be extended to new aerospace sectors and the strategic objective also supports a national objective for providing for sustainable development within KSA.

### Policies, Projects and Initiatives

The particular policies, projects and initiatives planned are for:

- STC and KSA companies to develop terrestrial equipment, software, systems, and services for these space systems. Examples include:
  - Tracking of high value containers and packets via GNSS and SaudicomSat.
  - Tracking and control of aircraft, trains and vehicles using GNSS and GEO comsats.
  - Testing and maintenance of commercial space tourism vehicles.
- GACA to provide a regulatory and operational environment for testing and operations of the above airborne services.

### Strategic Objective 10

To raise the level of aerospace higher education and training programs within the Kingdom of Saudi Arabia (KSA) and to expand interest and resources in the space and aeronautical sectors.

### Rationale

This objective is necessary to ensure the flow of suitably trained qualified personnel into the space and aeronautical organizations that will be expanding under this strategic plan. This will require close cooperation with the Ministry of Higher Education and initiatives should make use of the new and challenging programs contained within this plan to raise aerospace awareness among the student population. The objective also supports a national objective for providing for sustainable development within KSA.

### Policies, projects and initiatives

The particular policies, projects and initiatives planned are for:

- KACST to enhance its education coordination programs to include :
  - Collaborating with the Ministry of Higher Education in developing and executing technical programmes in the curriculum that relate and promote interest in space and aeronautics and in increasing the number of qualified graduates and technicians for the space and aeronautical sectors. Another goal is to increase the retention and attract postgraduates from abroad.
  - Organising a programme of visits by students to all stakeholders to promote interest and participation in space and aeronautical activities.
  - Providing short or dedicated education and training courses in aerospace related disciplines.
- KACST to establish aeronautical or aerospace research groups at KSA universities in support of this plan and to use these centers to encourage interest and expansion in undergraduate and post graduate courses at these universities in relevant disciplines.



### **Strategic Objective 11**

To promote the wider national use of space and aeronautical projects and services within government, industry, and the general public.

#### **Rationale**

This objective is necessary to ensure widespread support for the space and aeronautical sectors throughout KSA. Initiatives should make use of the new and challenging programs contained within this plan. The objective also supports a national objective for providing for sustainable development within KSA.

#### **Policies, Projects and Initiatives**

The particular policies, projects, and initiatives planned are for:

- KACST to extend its public relations department to:
  - Increase awareness among Saudi government agencies of space and aeronautical products, such as by circulating newsletters and organising seminars.
  - Increase awareness among the Saudi industry of space and aeronautical products such as by arranging visits and organising seminars.
  - Raise awareness within the general public of space and aeronautics by encouraging broadcasters to make space and aeronautical programs and by arranging exhibitions.

## Program Management

KACST will form a Space Program Management Office (SPMO) to oversee the activities and progress of the Kingdom's strategic plan for space and aeronautics. The SPMO will consist of a combination of personnel with technical and managerial expertise. Members of the SPMO will be given specialized training courses to help with the successful implementation of the strategic plan. The SPMO will have overall responsibility for all

the projects and initiatives under the strategic plan and will also serve to coordinate the efforts and communications of the stakeholders and relevant organizations. The SPMO (or its parent body) shall have sufficient legal powers to enter into collaborative agreements with international partners and agencies although private financing, shareholding, and associated contractual commitments shall be the responsibility of the private

or joint venture companies. The SPMO will manage and control three aeronautical or aerospace groups to be established in the early phases in direct support of the plan at stakeholder universities.

---

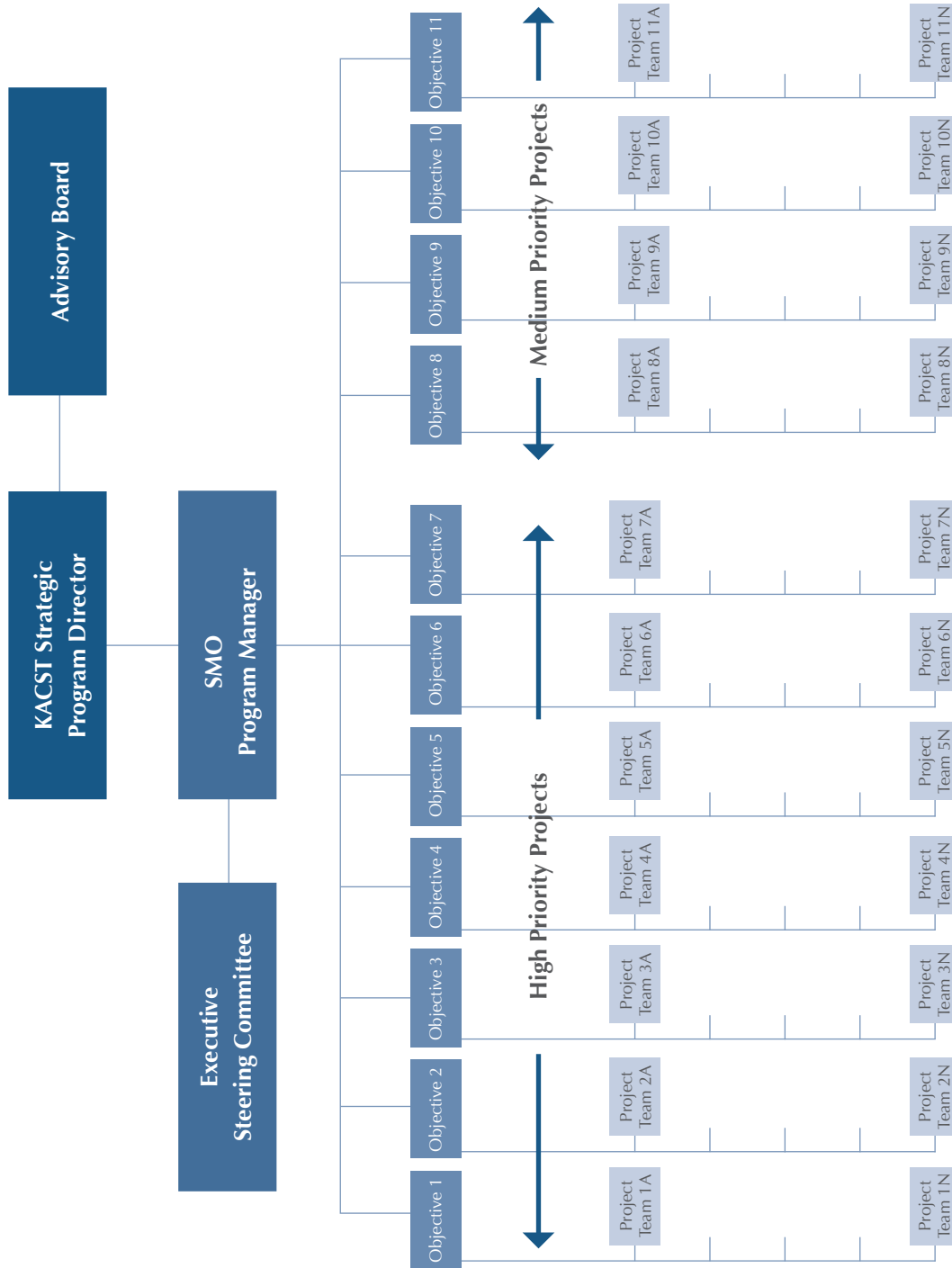
The Space Program Manager will lead the SPMO and will formally report to the KACST Strategic Program Director and the KACST Advisory Board every six months on the progress of the Program. An Executive Steering committee shall be formed consisting of senior managers from each of the stakeholders. The purpose of this committee shall be to keep abreast of relevant emerging technologies and to monitor the progress of the major activities outlined by the strategic plan. This committee shall meet quarterly under the chairmanship of the SPMO Program Manager.

### **Program Organization**

The overall management and reporting structure is shown in Figure 4. The SPMO Program Manager reports formally to the KASCT Strategic Program Director and to the Advisory Board. The Executive Steering Committee assists the SPMO Program Manager. The various project teams are grouped according to the strategic objectives with the High Priority objectives 1-7 being established at the start of the program and the Medium Priority objective teams being phased in during the program as soon as resources allow.

# Program Management

Figure 4: Overall Management and Reporting Structure

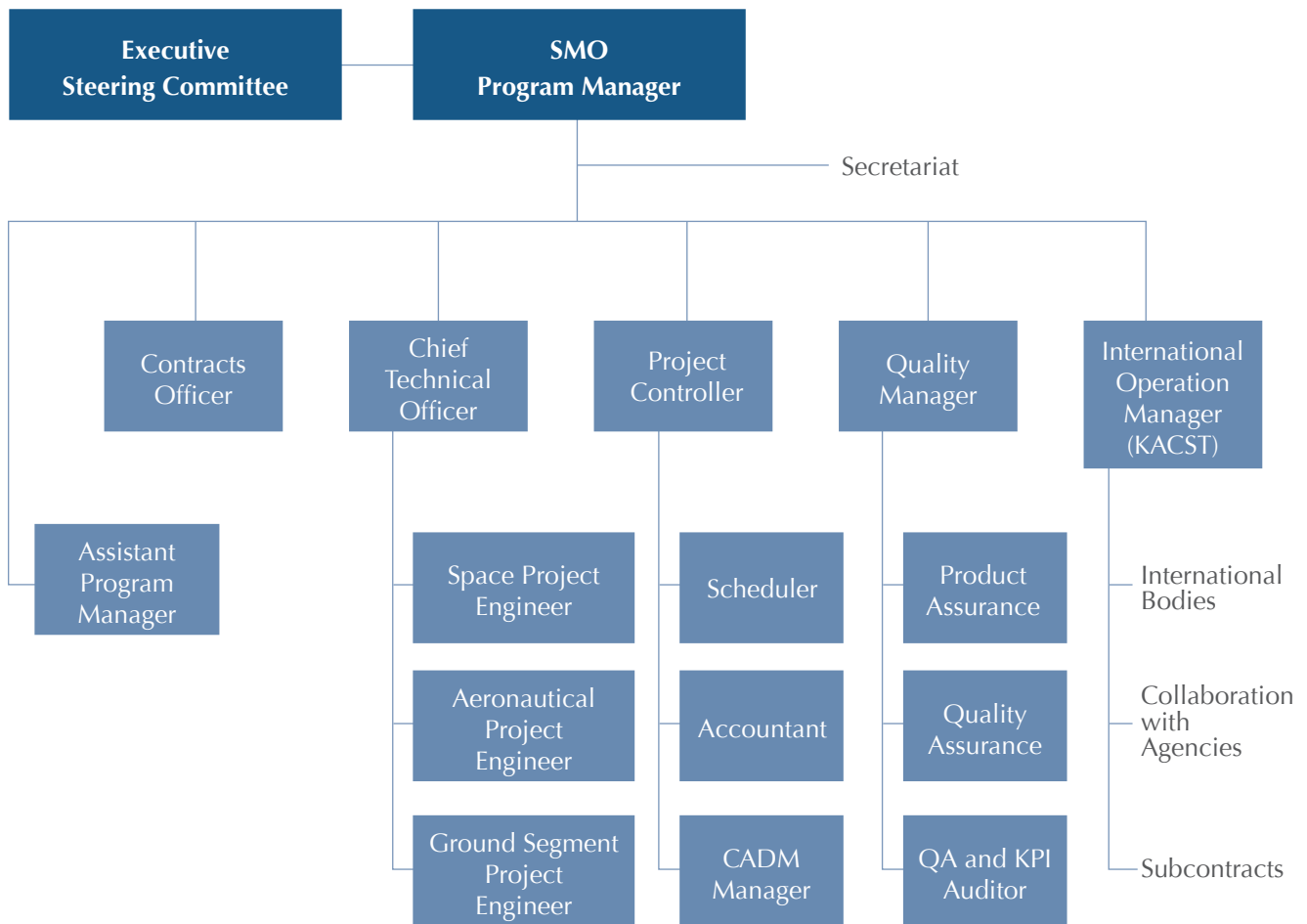


## Strategic Management Office (SPMO)

The SPMO organization is as shown in Figure 5. It is a matrix organization with line functions of Contracts, Engineering, Project Control, Quality and International relations being coordinated by the Program Manager to oversee and act as customers for the individual project

teams formed within the stakeholders. When the number of projects and their scope becomes excessive, an Assistant Program Managers will be added to support and act for the Program Manager for individual projects or a range of projects.

Figure 5: The SMO Organization



## Program Management

The roles and responsibilities of the key members of the SPMO team are defined below.

The SPMO Program Manager has full delegated responsibility for the execution of the overall program and is the formal point of contact together with the Contracts Officer. Formal communications signed by the Program Manager and the Contracts Officer will be binding. The Program Manager reports on the status of the program to the Strategic Program Director representing KACST Management and the Advisory Committee. The Strategic Program Director can implement actions which fall outside the authority of the Program Manager if necessary. This reporting loop can be fast-tracked if an emergency situation arises.

Reporting to the SPMO Program Manager are:

- The **SPMO Contracts Officer** is responsible for all commercial, legal and contractual aspects of the program and assists and advises the Program Manager in all such matters during negotiation and execution. His approval is required together with the Program Manager on all binding commitments.
- The **SPMO International Operations Manager** is responsible for managing all agreements with external aerospace agencies and bodies and companies and is also responsible for overseeing all contracts involving companies outside KSA. This Manager is seconded from the KACST International Cooperation Department.
- The **SPMO Project Controller** is responsible for schedule, cost and configuration control for the program. The Project Controller will be supported by a scheduler, CADM Manager and project accountant.
- The **SPMO Assistant Program Managers (APMs)** support the Program Manager in managing the performance of individual projects or a range of projects. The number of APMs will be dependent on the number

of projects underway within the stakeholder's project teams and in particular the numbers in later phases of development (i.e., Phase B onwards).

- The **SPMO Chief Technical Officer** is responsible for the technical performance of the program and is the overall Design Authority. The CTO is supported by specialist senior engineers:
  - A **Senior Space Systems Engineer** is responsible for all systems requirements and technical performance of the space-related projects.
  - A **Senior Aeronautical Systems Engineer** is responsible for all systems requirements and the technical performance of the aeronautical related projects.
  - A **Senior Terrestrial Systems Engineer** is responsible for all systems requirements and the technical performance of terrestrial projects (e.g. Ground segments, GIS).
- The **SPMO Quality Manager** is responsible for the quality and product assurance aspects of the program and is supported by personnel as follows:
  - A **Senior PA Engineer** is responsible for overseeing all PA matters on the projects.
  - A **Senior QA Engineer** is responsible for overseeing all QA matters on the projects.
  - A **Senior QC Engineer** is responsible for auditing and KPI monitoring.

## Project Management

### Projects

Each Project will be negotiated and authorized prior to formal start and a definitive charter will be executed between the SMO and individual stakeholder Project Teams. The emphasis will be on actively monitoring project performance without duplicating functions. Each charter will contain:

- Contract Terms and Conditions.
- Statement of Work.
- Specifications (where applicable).



Project Management requirements for subcontractors shall be contained with the respective Statement of Work. The subcontractor's management of the program shall be in accordance with a Project Management Plan (PMP) to be developed by each Project in compliance with the SPMO requirements and to be approved by the SPMO Program Manager.

Each project team is required to establish and apply a program control system that provides the milestone payment status, as well as the planning and technical data necessary to adequately manage the program. Each project team will hold a monthly meeting or teleconference with the SPMO to discuss the progress in the project.

The project team is required to establish and apply a Business Management System that provides the following functions:

- Contract Monitoring and Finance Control.
- Schedule Status Control.
- Action Item Control.
- Configuration and Data Management.
- Meeting Coordination.
- Project Reporting.

### **External contracts and collaborations**

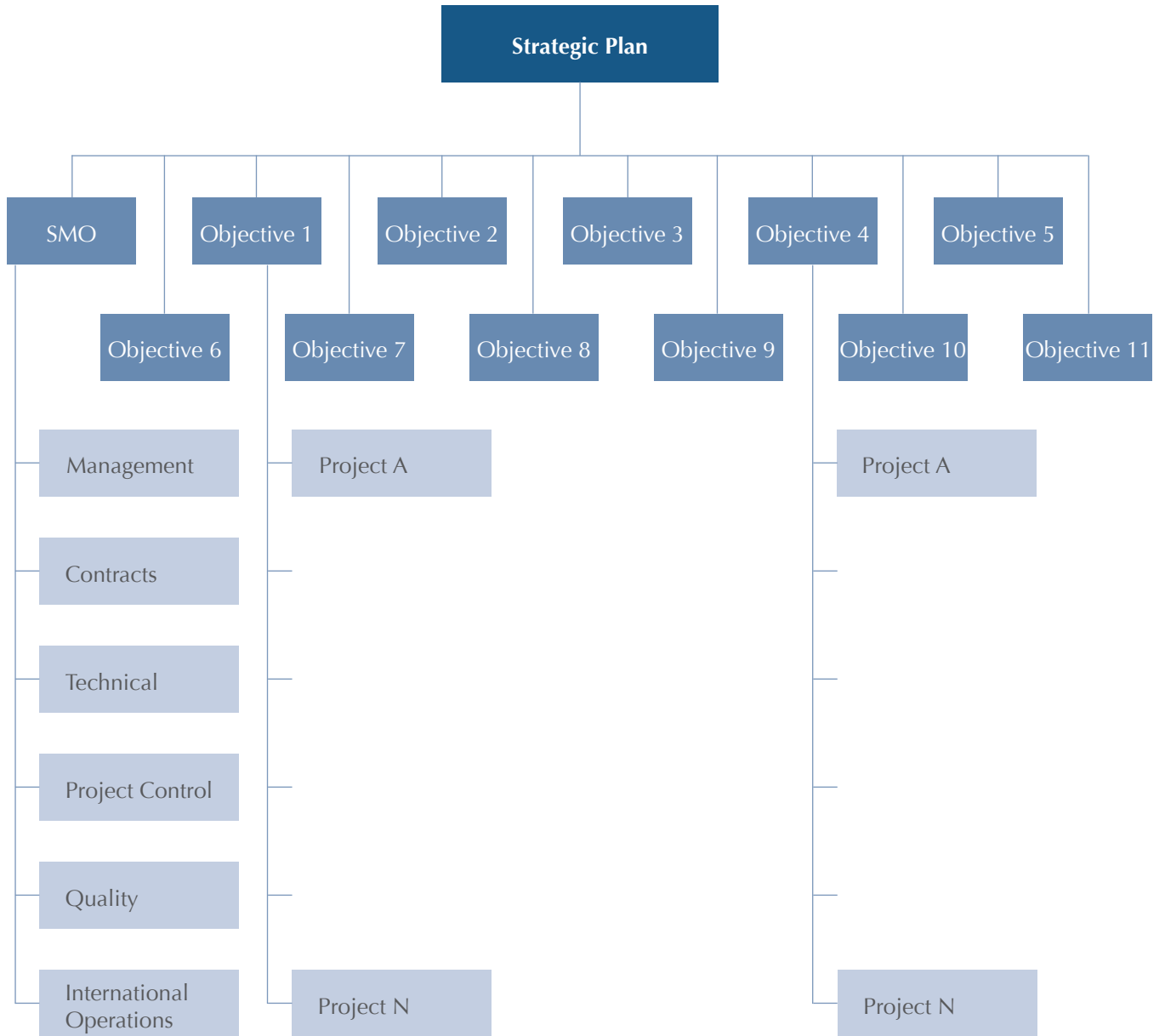
These shall be negotiated and controlled by the SPMO International Operations Manager with the involvement of individual project teams.

### **Work Breakdown Structure**

Work and activities are broken down into a logical Work Breakdown Structure as shown in Figure 6. Activities are grouped into twelve work areas covering the activities of the SMO and of the eleven strategic objectives.

The next level contains work packages covering disciplines within the SMO and individual projects. Each project will be required to define a Work Breakdown Structure in accordance with this overall structure and an SMO defined numbering system.

Figure 6: Overall Work Breakdown Structure





### Schedule Control

Ensuring on-time delivery of the strategic objectives is a major function of the SMO and the individual project teams. The project teams shall establish project networks showing activities, links, and dependencies identified. The SMO shall establish a Master Network showing major and milestones activities and links between projects. Updates to the program master network and lower levels schedules will be performed monthly and they will be regularly subjected to Critical Path Analysis (CPA). The SMO shall establish Microsoft Project as the standard scheduling software throughout the program.

The progress of completing activities shall then be carefully reviewed, deviations from the planned completion date will be identified, and the appropriate management action will be taken either at SMO or project level depending upon the gravity of the situation. The derivation of the schedule will take in to account the major program milestones. These milestones will include major business and design reviews, deliveries and funding authorization.

The schedule control will, in particular, ensure the following:

- Effective communication of current plans and schedules to the staff ultimately responsible for the execution of the work.
- Adherence to the requirements of these plans and schedules.
- Use of these plans to control actively the execution of the work not merely for recording progress.
- Real time reporting of any actual or foreseeable deviation from the plan.
- Effective processing of such reported deviations including the definition and implementation of any required corrective action.

- Preparation and maintenance of a list of project milestones (major events).

Each project will identify a schedule contingency to increase the likelihood of on time delivery. This contingency will then be managed carefully to ensure that project evolution has limited impact on these key stages in the project. The contingency taken in the schedule will take into account any factors highlighted in the risk management process.

The SMO will regularly assess the overall project schedule status, taking into account the actual accomplishment of all project work as well as problems encountered, and shall report quarterly to the Strategic Program Director.

The analyses will be performed to produce:

- Schedule Report including CPA.
- Detailed and summary bar charts.
- Trend analyses of major programme milestones and dependencies.

The SMO will provide a Schedule Report as part of a Quarterly Report. The SMO will advise the Strategic Program Director immediately if a seriously situation arises likely to adversely affect the program and will investigate and implement corrective action as appropriate.

### Change Control

The SMO will establish and maintain a system for managing the following types of changes to the SMO and subcontracts. Requirements will be flowed down to Project Teams via the appropriate Statement of Work. This system will be administered by the SMO Project Controller:

- Change to Technical Requirements.
- Change to the Scope of Work (additions or deletions).
- Change to the Delivery Requirements (schedule).

The system shall provide the interface link between the SMO's internal change control procedures. The main features of the contract change control system are as follows.

### Project Change Notice (PCN)

Any change raised by the projects, either on its own initiative or at the SMO request, shall be submitted to the SMO for Approval. The SMO will notify the Project of its acceptance or rejection of a PCN within 15 working days of receipt. Signature of a PCN by the SMO authorized representatives constitutes approval of the change and renders it enforceable. If the Project implements a change prior to any SMO approval, this shall be at its own risk.

### Waivers and Deviations

If, during the execution of the Subcontracts, the Contractor desires to depart from the requirements in the technical requirements for a specific item or a limited number of items, a Request for Deviation/ Waiver (RDW) is required be submitted to the SMO.

### Recording and Tracking

The Change Control System will include provisions for recording, tracking and reporting on status of PCN's and RDW's.

## Configuration and Data Management

### Configuration Management

The objectives of the configuration control system are to:

- Ensure that all documents which define the functional and physical characteristics of project equipment are uniquely identified.
- Ensure that the design and build standard of the equipment can be defined at any point in the program.
- Ensure that effective change control is established

and maintained.

- Ensure that all affected participants are aware of the impact of proposed changes, and participate in their evaluation.

### Configuration Items

In order to implement an effective configuration management system, a tree of Configuration Items will be created, to separate the elements of each project into smaller subsets for the purpose of controlling their physical and functional characteristics. Each Configured Item will be identified with a unique reference number to denote its hierarchical position within the program.

### Part Marking

All hardware and software data carriers will be identified by a non-ambiguous reference number.

### Baselines

Design baselines, a set of control documents defining the physical and functional characteristics of a configured item, shall be established by the Project corresponding with critical milestones of the project (e.g. Baseline Design Review, Preliminary Design Review, Critical Design Review, etc.). A baseline shall be a point of departure for the control of subsequent performance, design, and build changes. The design standard of a configured item shall be the design baseline plus approved changes.

### Configuration Accounting

The following records and listings shall represent the major elements of the configuration accounting task:

- Maintaining a record for each configured item.
- Maintaining a register for all changes.
- Providing an historical record of the alterations made to each document.
- Providing an As Built Configuration List as part of the

## Program Management

Acceptance Data Package for each CI to be delivered. This is the build standard and will be verified against the design standard and any differences reconciled.

### Documentation Management

The SMO shall establish and maintain a documentation and test data control system for the program. A document list shall be prepared by each project showing deliverable documentation to the SMO. An example list is contained in Appendix A

Deliverable documentation shall be submitted under one of the following criteria:

- **For Information:** Routine documentation which will be evaluated by SMO to determine current program status, progress, and future planning requirements.
- **For Review:** Documentation to be evaluated by SMO for acceptance or rejection prior to its intended use.
- **For Approval:** Documentation that requires written approval from SMO before its acceptance or intended use.

Revision to any formally deliverable document shall be subject to the same submission criteria as applied to the initial release of that document.

### Product Assurance

#### Product Assurance activities

The SMO will establish an organization under the Product Assurance Manager to plan, organize, and control all activities in such a manner that objectives are systematically achieved and any deficiencies are detected, corrected, and prevented from occurrence.

A Product Assurance Plan will be designed as success oriented and the quality requirements shall be implemented to assure that:

- Strategic objectives are met within the period of the plan.

- Each project achieves the required functional and operational reliability.
- The design and developments are traceable (as built versus as designed).
- The formal verification processes (qualification) are traceable.
- Requirements are verified.
- Key Performance Indicators are achieved.

The Product Assurance Plan will document:

- The PA organisation.
- The authority and independence of PA management.
- Status reporting.
- Personnel and training.
- Program audits.
- Rights of access.
- Design assurance.
- Components, materials, mechanical parts and processes.
- PA implementation.
- Risk management.
- Design control.
- Control of critical items.
- Documentation and data control.
- Configuration management.
- Subcontractor and supplier control.
- PA interfaces.

### Quality Assurance

Quality Assurance activities shall be performed according to EN ISO 9001:2000 and KACST internal procedures. They shall encompass monitoring and auditing as appropriate of:

- Feasibility studies.
- Development.
- Procurement.
- Manufacturing.
- Production.

- Test.
  - Launch and flight.
  - Handling, storage, transport and maintenance
- Quality control functions shall include:
- Metrology and calibration.
  - Non conformance control.
  - Traceability and changes.

## Key Performance Indicators

Key Performance Indicators (KPIs) are defined overall and for each objective (see Table 8). Each KPI will be monitored on a monthly basis by the SMO and formally reviewed and reported every three months. The SMO shall be responsible for taking action if achievement of a particular KPI is at risk of not being achieved.

Table 8: Key Performance Indicators

Subject	Key Performance Indicator	Success Criteria
Overall Vision	Comparison with regional aeronautical institutes and agencies based on a formula using the following metrics: No of aircraft flight tested over 5 year period No of instruments flight tested over 5 year period Contribution of knowledge to international or regional aeronautical bodies Number of aeronautical qualified persons employed within country Annual commercial sales of aeronautical products  Support to KSA on national defence	Overall first within region after five years  Overall first within region after five years  Major contribution considered made to national defence as judged by the responsible ministries
	Support to sustainable development Order book for commercial aerospace products Numbers of aerospace related staff employed within country Number of aerospace qualified persons employed within country	Major contribution made to sustainable development as judged by the responsible ministries
Strategic Objective 1	Percentage of EO data provided regionally Number of customers regionally for EO images Number of EO products offered	Increase of 40% per annum Increase of 60% per annum Increase of 40% per annum
Strategic Objective 2	Number of GIS customers Number of GIS products Number sales of GIS products	Increase of 40% per annum Increase of 60% per annum Increase of 40% per annum
Strategic Objective 3	Design Reviews for satellites (BDR, PDR, CDR, AR) Launch and in-orbit commissioning of satellites	Satisfactory completion Satisfactory completion

Subject	Key Performance Indicator	Success Criteria
Strategic Objective 4	Design Reviews for platforms (BDR, PDR,CDR, AR)	Satisfactory completion
	Launch and in-orbit commissioning of satellites	Satisfactory completion
	Design Reviews for UAVs and manned aircraft (BDR, PDR,CDR, AR)	Satisfactory completion
	Completion of flight test programme (UAVs and manned aircraft)	Satisfactory completion
Strategic Objective 5	Number of NSC customers	Increase of 40% per annum
	Number of NSC products	Increase of 60% per annum
	Annual sales of NSC products	Increase of 40% per annum
Strategic Objective 6	Number of aerospace companies	Increase of 200% per five year period
	Number of annual aerospace sales	Increase of 40% per annum
	Number of staff in aerospace companies	Increase of 40% per annum
Strategic Objective 7	Number of patents	Increase of 200% per five year period
	Number of papers published in international recognised publications	Increase of 200% per five year period
Strategic Objective 8	Agreement with international collaborator	Signed
	Design Reviews	Satisfactory completion
	Launch and in-orbit commissioning of satellite or	Satisfactory completion
	Completion of flight test programme (UAVs and manned aircraft)	
Strategic Objective 9	No of new products developed	10
	Annual income from sales of new products	\$10M
Strategic Objective 10	Number of students per annum studying to a curriculum which relates and promote interest in space and aeronautics	Greater than 1000 per annum
	Number of aerospace qualified graduates per annum	Increase of 100% per five year period
	Number of aerospace qualified technicians per annum	Increase of 100% per five year period
	Number of training courses x persons attending per annum	Increase of 40% per annum

Subject	Key Performance Indicator	Success Criteria
Strategic Objective 11	Number of newsletters circulated per month to interested parties in government and industry	4 after second year thereafter increasing to 10 at fifth year
	Number of interested parties in government and industry on circulation list	100 after second year thereafter increasing to 400 at fifth year
	Number of seminars x attendance per annum	500 after second year thereafter increasing to 2000 at fifth year
	Number of hours of aeronautical and space related TV broadcast within KSA	10 hours after second year thereafter increasing to 25 at fifth year

## Risk Management

Risk Management will be implemented by the SMO throughout the program and requirements will be flowed down to individual projects. The Risk Management process is designed to improve the probability of successful project execution (i.e. satisfactory technical performance, timely delivery, costs within budgets) by identifying problems before they occur and by proactively taking mitigating actions, if considered appropriate, to reduce their impact.

## Approach

The approach adopted is to:

- identify potential events which could effect the planned progress of activities, to identify a likelihood of each event occurring (i.e. Probability) and to quantify the potential impact on schedule, cost and performance (i.e. Gravity) if it does.
- evaluate potential actions to mitigate the impact of such events and to quantify improvements on Probability and Gravity parameters.
- review and update the register of significant risks

and their Probability/ Gravity periodically and to take decisions on implementing mitigation action when necessary.

The authority for managing the process is the SMO Program Manager who can decide to implement mitigating actions or changes within the boundaries of the program cost budget. The authorities for managing the process at individual project level are the Project Managers who are required to report regularly to the SMO on the status of their most significant risks. The process is shown in Figure 7.

## Levels of Probability for Risk Occurrence

Probability that an unexpected event (a risk) occurs is measured according to three levels:

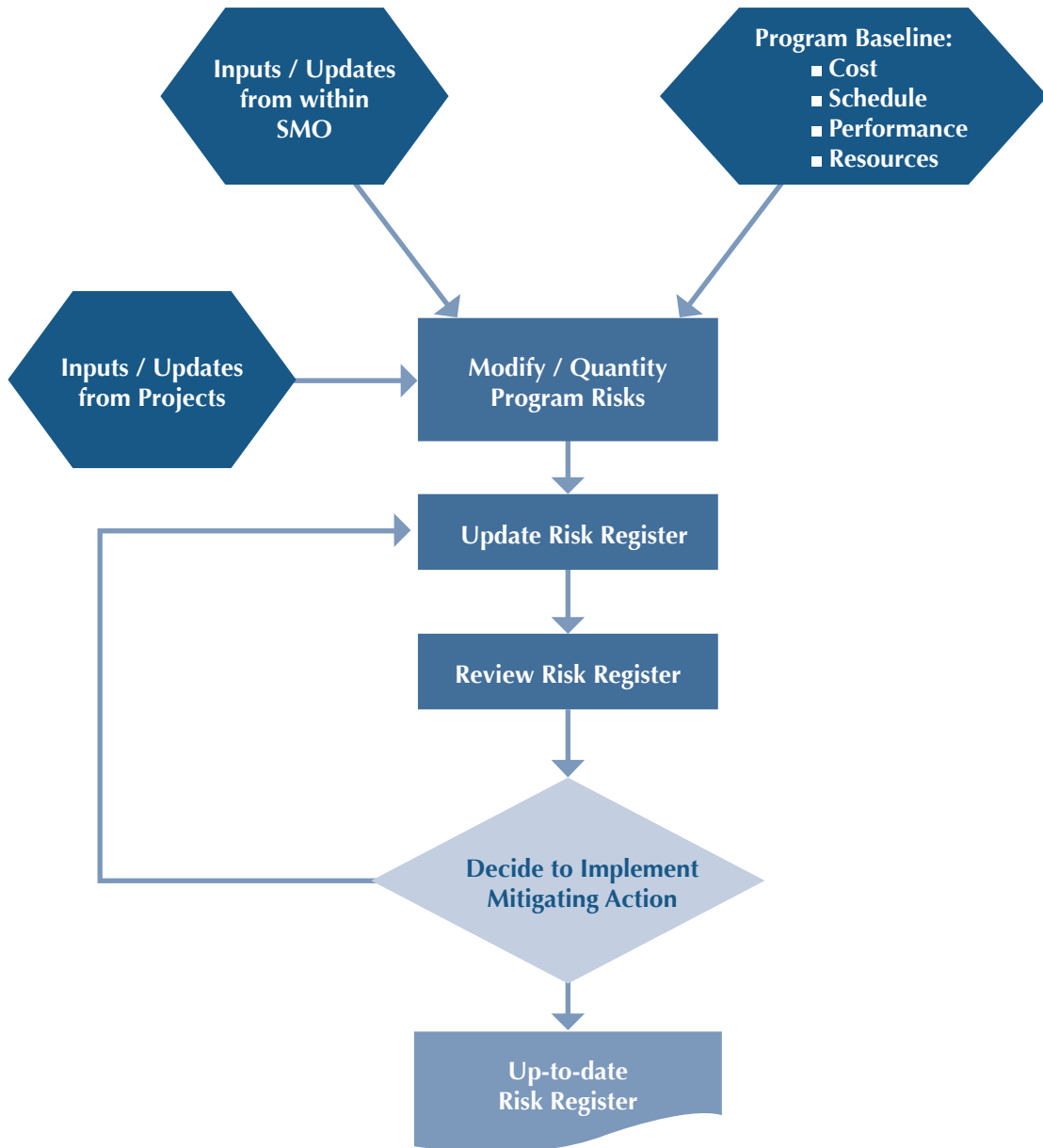
- Level 1 (low): probability of occurrence in the range 0-10%.
- Level 2 (low/ medium): probability of occurrence in the range 10-30%.
- Level 3 (medium): probability of occurrence in the range 30-50%.

# Program Management

■ Level 4 (medium/ high): probability of occurrence in the range 50-70%

■ Level 5 (high): probability of occurrence in the range 70-100%

Figure 7: Risk Management Process



## Levels of Gravity for Risk Impact

Gravity is also defined by five levels (1 = low, 3 = medium, 5 = high), according to the cost, planning and

performance impacts. Table 9 shows the scale applicable to the program.

Table 9: Gravity Table for Strategic Development Program

Impact	Level 1	Level 2	Level 3	Level 4	Level 5
Technical	Performance degraded but project requirements still achieved	Project requirements not achieved but does not affect the strategic plan	Requirement not achieved but the impact may be accepted by SMO	SMO Requirement not achieved with serious significant on the strategic plan and unlikely to be acceptable by SMO	Requirement not achieved with impact on strategic plan not acceptable by SMO
Schedule	Delay $\leq$ 2 weeks on delivery	2 weeks < Delay < 1 month on delivery	1 month < Delay < 3 months on delivery	3 months < Delay < 6 months on delivery	Delay $\geq$ 6 months on delivery

Note: A risk may have at the same time technical and/or schedule and/or cost impacts. The level of gravity of the risk is given by the higher impact.

Development Program and managed by the SMO. The most critical risks shall be reported monthly.

### Risk Register

A specific risk register shall be produced for the Strategic

### Acceptability/Non-acceptability of Risks

Risks shall be evaluated as shown in Figure 8.

Figure 8: Domain of Acceptability/Non-acceptability

Probability						
5	Yellow	Orange	Red	Red	Red	
4	Green	Yellow	Orange	Red	Red	
3	Green	Green	Yellow	Orange	Red	
2	Green	Green	Green	Yellow	Orange	
1	Green	Green	Green	Green	Yellow	
	1	2	3	4	5	Gravity



Action Required:

- Red Zone: Unacceptable--Major risk to program, immediate project management action required.
- Orange Zone: Unacceptable--Significant risk to program, urgent project management action required.
- Yellow Zone: Unacceptable--Risk to program, mitigation action required by work package manager.
- Green Zone: Acceptable--Acceptable risk to program, work package manager to monitor.

### Progress Reporting

#### Program Progress Report and Reviews

The SMO Program Manager shall submit a concise report covering key program and strategic issues to the Strategic Program Director and the Advisory Board prior to reviews. The content of the report shall include:

- Project status:
  - Technical.
  - Schedule.
  - External interface.
- Program Schedule summary including CPA and milestone achievement.
- Main outstanding risk issues.
- Status of Key Performance Indicators.
- Funding/cost status.

A Quarterly Progress Review shall be held between the SMO and the Steering Committee chaired by the SMO Program Manager. A six monthly review shall be held between the SMO and the KACST Management and the Advisory Boards chaired by the KACST Strategic Program Director to address key program and strategic issues. The former will occur one day before the latter when they are scheduled at similar times. Typically these reviews will rotate between the sites of the stakeholders so that Management can also see progress on a site-by-site basis.

#### Project Progress Report and Meetings

Project Managers are required to submit a concise Progress Report to the SMO five working days prior to Progress Meetings which will be held at monthly intervals. The content of the report shall include:

- SOFTQ Report (Successes, Opportunities, Failures, Threats, Quality).
- Project Schedule summary.
- Key Technical summary.
- Update to Risk Register.
- Cost status.
- Action Item status.
- Change status.
- Non Conformance status.

Ad Hoc meetings may be convened by the SMO or the Project Teams to resolve particular issues or external interfaces.

#### Emergency reporting

The SMO Program Manager shall immediately notify the Strategic Program Director of any event that puts the achievement of the strategic plan at risk. This requirement is flown down to individual project managers concerning their delivery schedule. The SMO shall be notified by project managers of any major emergency events immediately they becoming apparent.

### Reviews

#### Project Design Reviews

SMO appointed chairmen (typically the SMO Program Manager or Assistant Program Managers) together with review boards of appointed specialists will perform design reviews on the projects. These reviews will consist of:

- Baseline Design Review (BDR).
- Preliminary Design Review (PDR).
- Critical Design Review (CDR).
- Acceptance Review (AR).



### Lower level Reviews

Individual projects will conduct a series of lower level design reviews. The reviews will be planned, organized, and managed by the project teams and will be occasions where the responsible parties for each item under review formally concur about the equipment status, having previously had the opportunity to evaluate the applicable documentation. The SMO shall be invited to attend and may serve as a member of the review board for some reviews.

### Property Control

The SMO will implement a Property Control System to account for all owned property funded by the Strategic Program. The system will operate in such a way that:

- The existence, location and working condition of all property, both fixed and movable, can be verified.
- Changes in financial values, resulting from acquisitions, disposals and items written off are recorded.
- Financial reconciliation can be made and status reports prepared for incorporation into the SMO annual accounts.

All property shall be physically labeled with a unique inventory number and statement of ownership. The numbering system shall operate throughout the program with a centralized overall record held by the SMO in the form of a computerized database.

All projects shall be required to operate a Property Control system compatible with the requirements. Any disposal programme hardware will be agreed with SMO prior to the event.

The inventory control system shall be capable of providing reports containing the following information:

- Item description.
- Unique Item Registration/ Inventory Number.
- Physical location.

The SMO has the right to audit the project inventory and to have physical checks at project premises.

## Appendix A - Acronyms

ACWP	Actual Cost of Work Performed
AEC	Advanced Electronic Company
AR	Acceptance Review
ACWP	Actual Cost of Work Performed.
ATC	Aeronautics Technology Center (KACST SRI)
BCP	Baseline Cost Plan
BDR	Baseline Design Review
CAD	Computer Aided Design
CADM	Configuration and Data Management
CCB	Change Control Board
CDR	Critical Design Review
CI	Configured Item
CPA	Critical Path Analysis
CTO	Chief Technical Officer
DRL	Document Requirements List
EAC	Estimate at Completion
EIDP	End Item Data Pack
EMC	Electromagnetic Compatibility
ETC	Estimate to Complete
ESD	Electrostatic Discharge
FMECA	Failure Modes, Effects and Criticality Analysis
GACA	General Authority for Civil Aviation
GEO Comsats	define
GIS	Geographical Information System
GISC	Geographical Information Systems Center (KACST SRI)
IP	Intellectual property
KACST	King Abdulaziz City of Science and Technology
KAAU	King Abdulaziz University
KFUPM	King Fahd University for Petroleum and Minerals
KPI	Key Performance Indicator
KSA	The Kingdom of Saudi Arabia

## Appendix A - Acronyms

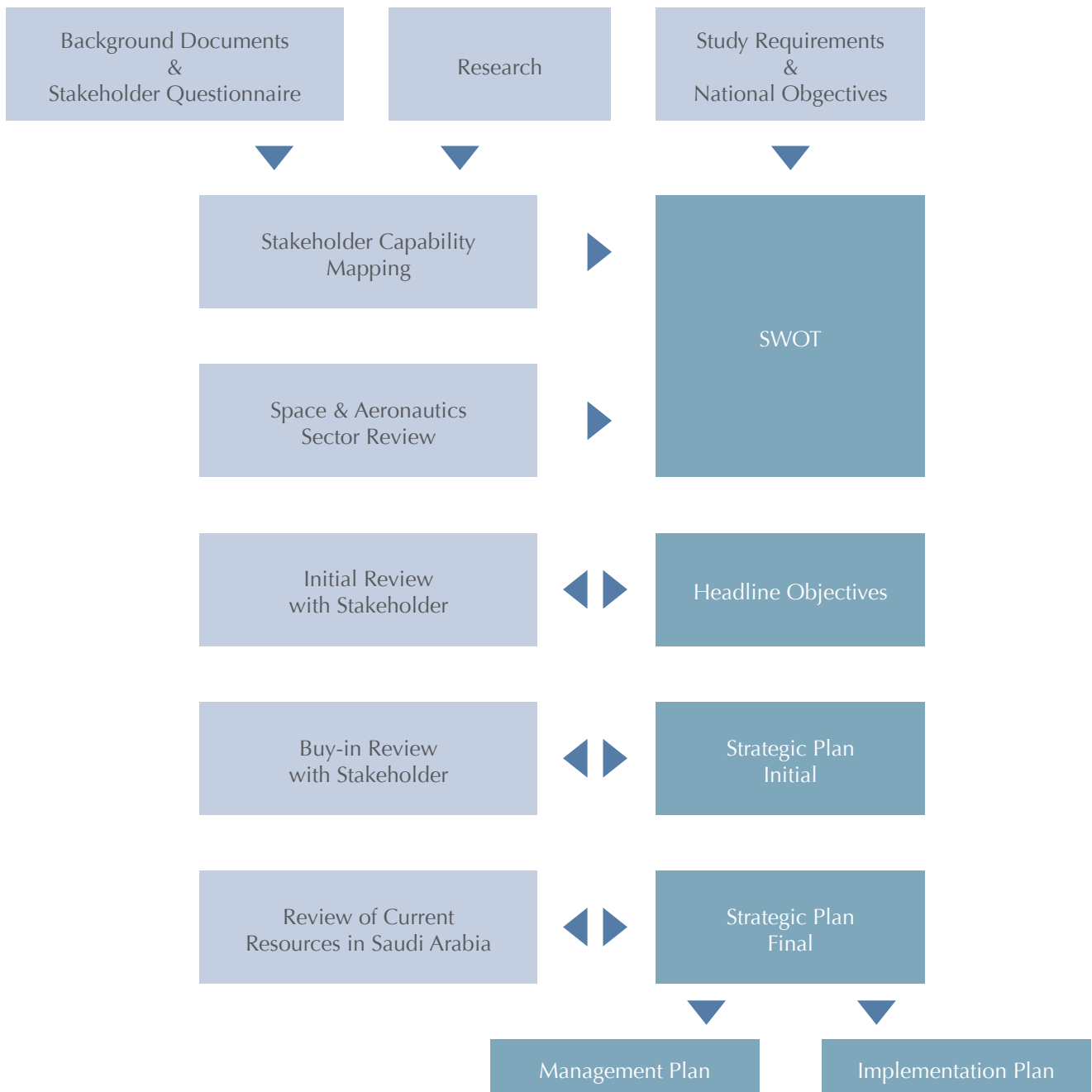
KSU	King Saud University
NSC	Numerical Studies Center (KACST SRI)
OSO	Outer Space Office
PA	Product Assurance
PCN	Project Change Note
PDR	Preliminary Design Review
PMI	Project Management Institute
PMP	Project Management Plan
QA	Quality Assurance
QC	Quality Control
R&D	Research and Development
RDW	Request for Waiver or Deviation
SCRS	Saudi Center for Remote Sensing (KACST SRI)
SMO	Strategic Management Office
SOFTQ	Successes, Opportunities, Failures, Threats, Quality
SOW	Statement of Work
SRI	Space Research Institute (KACST)
STC	Satellite Technology Centre (KACST SRI)
TRB	Test Review Board
TRR	Test Readiness Review
WBS	Work Breakdown Structure

## Appendix B: Plan Development Process

The process used for generating this space and aeronautics strategic development plan is shown in diagrammatic

form in flow chart figure B1:

Figure B1: Process Flow Chart Figure



The process has been constructed on the basis of maximizing the synergies brought by each of the stakeholders to create a unified strategic plan. The intent is to build stakeholder consensus on the acceptability of the plan so that the implementation will attract the full cooperation and support of the stakeholders. It is recommended that a Memorandum of Understanding (MOU) be drawn up to reflect this agreement between the stakeholders and to establish the future working relations for the implementation phase.

### Planning Project Core Team

The KACST members of the planning project management team are :

Name
Dr. Khaled Alhussan
Dr. Abdulaziz Alsugair
Eng. Waleed Mulla
Mr. Fahad Algernass
Eng. Adil Alomair
Eng. Fawzan Alharby
Eng. Rames Alshehry
Mr. Mohammad Alwhaiby
Eng. Salah Redwan
Eng. Saud Algahtany
Eng. Abdulaziz Aljewair
Mr. Mohammad Bin Mahfoodh
Dr. Abdullah Almudaimiegh

## Appendix B: Plan Development Process

### Workshop Participants

Name	Affiliation
Dr. Ibraheem Alqadhy	King Abdulaziz University
Dr.K haled Aljuhaneer	King Abdulaziz University
Dr. Mohammad Omar Budair	King Fahd University of Petroleum & Minerals
Dr. Bakeer Yalbas	King Fahd University of Petroleum & Minerals
Dr. Ayman Qassem	King Fahd University of Petroleum & Minerals
Dr. Ahmmad Alqarnee	King Fahd University of Petroleum & Minerals
Dr.Abdulla Alqarnee	King Fahd University of Petroleum & Minerals
Eng.Adil Aloofoe	General Authority for Civil Aviation
Eng. Tareq Fayraq	General Authority for Civil Aviation
Dr. Abdulhakeem Almajed	King Saud University
Dr. Yahya Shakwa	Advanced Electronic Company
Eng.Akram Ahmad	Advanced Electronic Company
ENG. Khaled Aljaaweeny	Advanced Electronic Company
ENG. Ibraheem Alnassar	Alsalam Aircraft Company
Mr. Abdulaziz Alomran	Alsalam Aircraft Company
Dr. Mohammad Alhameedah	Aramco Company
Dr. Abdullah Alqarny	Ministry Of Municipalities & Rural Affairs
Dr. Mohammad Qary	King Abdulaziz University
Dr. Naser Salma	King Saud University
Eng. Talat Albar	Madinah City Municipality
Dr. Abdulqader Alsery	Alhasebah Technology Company
Dr. Naser Alhumaid	King Fahd University of Petroleum & Minerals
Eng. Abdulsalam Abdulaal	Saudi Telecom Company
Dr. Samy Zaydan	Makah & Almadinah development Commission
Saeed Alhaznawi	King Abdulaziz City for Science and Technology

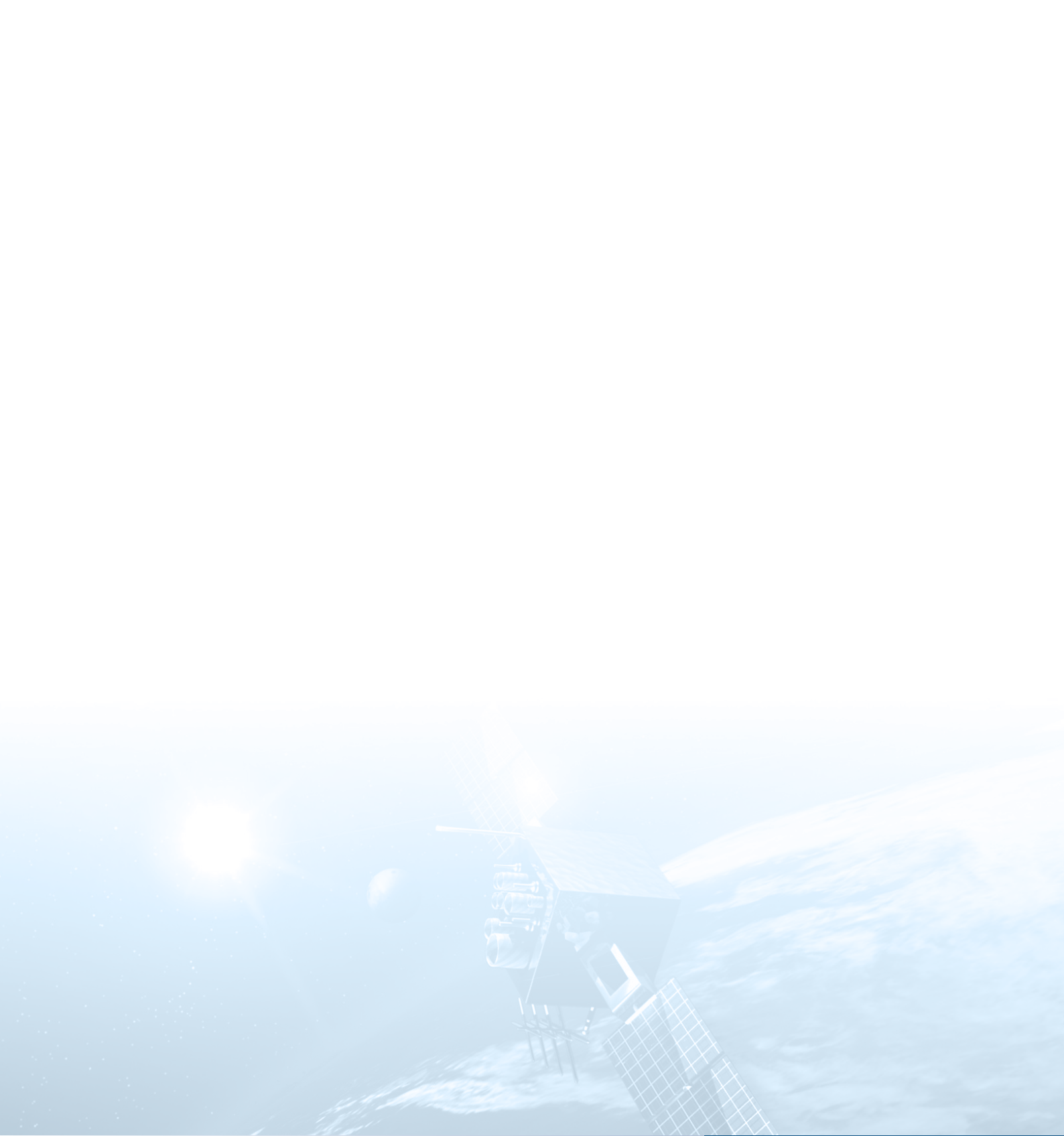


### Acknowledgements

We would like to thank our stakeholders for their assistance with this project.

- King Fahd University of Petroleum & Minerals
- King Saud University
- King Abdulaziz University
- General Authority for Civil Aviation
- Ministry Of Municipalities & Rural Affairs
- Madinah City Municipality
- Makah & Almadinah Improvement Commission
- Aramco Company
- Saudi Telecom Company
- Alhasebah Technology Company
- Advanced Electronic Company
- Alsalam Aircraft Company





Tel 488 3555 - 488 3444  
Fax 488 3756  
P.O. Box 6086 Riyadh 11442  
Kingdom of Saudi Arabia  
[www.kacst.edu.sa](http://www.kacst.edu.sa)

King Abdulaziz City for Science and Technology  
Doc. No. 19P0001-PLN-0001-ER01