STRATEGIC ANALYSIS OF THE IMPACT OF A POWERFUL NEW INDUSTRY ENTRANT ON AN OPEN STANDARDS-BASED COMPANY'S BUSINESS

by

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ABSTRACT

Google Earth is an increasingly popular geospatial application that lets users create, share and visualise maps in Google's proprietary Keyhole Mark-Up Language (KML). KML is similar to but incompatible with Open Geospatial Consortium's (OGC) open standard Geography Mark-Up Language (GML). This project aims to determine the best strategic response to the impact that KML may have on a company, Galdos Systems, whose business is based on OGC standards. The current situation is analysed on three levels: the Geographic Information Systems (GIS) industry, the OGC-related industry segment, and the firm. In addition, an application of the theories on diffusion of innovation and economics of technology standards assesses the potential of KML to substitute for GML. The analysis concludes that KML is not a threat to Galdos, and that Galdos should treat KML as an opportunity to be approached using real-options reasoning and within the context of their current strategy.

Keywords: *Galdos, Open Geospatial Consortium, OGC standards, Geographic Information Systems, GIS industry, Google Earth, Keyhole Mark-Up Language, KML*

DEDICATION

To my family who has encouraged and supported me throughout my life.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

GLOSSARY

Term	Definition
ASP	Application Service Provider
ASV	Application Software Vendor
Catalogue Services	OGC specification for catalogue services
CEO	Chief Executive Officer
CIPP	Critical Infrastructure Planning and Protection
Client	When used to describe a software program, it indicates a software program that makes use of other software programs referred to as servers.
COTS	Commercial Off The Shelf
CRS	Coordinate Reference System
Data model	A model that defines the structure and semantics of an organisation's data
DBMS	Database Management System
DOI	Diffusion Of Innovation
ERP	Enterprise Resource Planning
ESRI	Environmental Systems Research Institute
EU	European Union
Feature	Feature is a term used to describe a geographic object.
FME	Feature Manipulation Engine (Safe Software's product)
Geospatial data	Geospatial data identifies the geographic location and characteristics of natural or man-made features and boundaries on the earth. This information is gathered from remote sensing, mapping, and surveying and other technologies.
Geospatial technology	Geospatial technologies capture, store, manage, integrate, display, analyse and otherwise assist in the interpretation of this data in its entire context for better decision-making
GIS	A GIS is a computerised database management system used for capture, storage, retrieval, manipulation, analysis and display of spatial data.
GML	Geography Mark-Up Language – an OGC specification

Term	Definition
GUI	Graphical User Interface
HTTP	Hypertext Transfer Protocol
IDE	Integrated Development Environment
ILM	Integrated Land Management
IRM	Integrated Resource Management
INSPIRE	Infrastructure for Spatial Information in Europe
ISO	International Standards Organisation
ISP	Internet Service Provider
IT	Information Technology
ITS	Intelligent Transportation Systems
KML	Keyhole Mark-Up Language
LBS	Location-Based Services
MS	Microsoft
NASA	National Aeronautics and Space Administration
NGA	National Geospatial-Intelligence Agency
NPV	Net Present Value
OASIS	Organisation for the Advancement of Structured Information Standards – a standards body
OGC	Open Geospatial Consortium – the main standards body in the field of geospatial services (software)
OMG	Object Management Group – a standards body
OS	Operating System
R&D	Research & Development
RFP	Request for Proposal
SCOTS	Standards-based COTS
Server	When used to describe a software program, it indicates a software program that services requests from other software programs referred to as clients.
Simple-features geospatial applications	Geospatial applications with simple data models
STAR	Strategic Technology Assessment Review – a manager's toolkit for applying real options qualitatively
SVG	Scalable Vector Graphics
Style	A set of instructions for styling raw geographic data to a map

Term	Definition
Styling	The (computer) process of generating a map from raw geographic data by applying styles
TC	Technical Committee
TIGER	Topologically Integrated Geographic Encoding and Referencing System – TIGER/Line is US Census Bureau's data format currently in use
USD	United States Dollar
W3C	World Wide Web Consortium – a standards body that has published numerous software standards for the Internet
WFS	Web Feature Service – an OGC specification
WGS84	World Geodetic System 1984 – a popular CRS
WMS	Web Map Service – an OGC specification
XML	eXtensible Mark-Up Language – the standard syntax for encoding data on the Internet
XML grammar	A set of XML elements that define a user-specific vocabulary and its semantics
XML schema	A W3C specification that enables defining XML grammars

1 INTRODUCTION

1.1 Background

1.1.1 Geographic Information Systems (GIS)

Geographic Information Systems (GIS) is defined as a "technology that manages, analyses, and disseminates geographic knowledge" (Sutton, 2005, ¶ 5). Geographic knowledge has a distinguishing spatial component that describes the location of objects (referred to as features). For example, maps, which are the most common way of working with GIS, describe the location of features such as roads and building blocks. Typical GIS applications include mapping applications which help a user to find a geographic feature or pattern, find what is inside or nearby a region, or to map change ("What Can You Do with GIS", n.d.).

The GIS industry is a part of the wider information technology (IT) industry. GIS companies supply geographic data, specialised GIS hardware, software and/or services to businesses, governments and consumers. GIS technology has long been considered a niche technology with geospatial professionals as its primary market. However, recently, GIS companies have been more successful at approaching markets with less technically savvy users such as real estate and finance. Web applications such as MapQuest, Google Earth and Google Maps have succeeded in making the technology accessible to ordinary web users.

Throughout the industry's history, GIS software applications have evolved from custom solutions to customer off the shelf (COTS) software products, to standards-based COTS (SCOTS) and lastly to web applications. The main driver for technology standardisation was customers who were dissatisfied with the high switching costs between mutually incompatible COTS applications. The rise of the Internet also increased the need for standardisation as disparate GISs required protocols to communicate with each other. The next section introduces the organisation that leads this worldwide standardisation in the GIS field.

1.1.2 Open Geospatial Consortium (OGC)

Open Geospatial Consortium (OGC) brings together organisations in the private and public sector to develop and diffuse open standards for the field of GIS software.[1] Founded in 1994, OGC has since grown to 307 members, including various levels of government (e.g. national, provincial/state, municipal), universities, governmental institutions (e.g. National Aeronautics and Space Administration [NASA], US Census Bureau), and corporations (e.g. Environmental Systems Research Institute [ESRI], Microsoft, and Oracle) ("OGC About us", n.d.; "OGC Members – Listed by Name", n.d.). Many OGC members implement OGC standards in their products and thus facilitate the diffusion of the standards. The governments of US and Canada often sponsor projects in which OGC members experiment and develop new specifications, some of which become adopted standards. OGC is a non-profit organisation that relies on the voluntary work of its members. The consortium strives to reach all major decisions through consensus ("OGC Vision & Mission", n.d.).

1.1.3 Relevant OGC Standards

This section introduces the OGC software standards relevant to this discussion: Geography Mark-Up Language (GML), Web Feature Service (WFS), Web Map Service (WMS) and Catalogue Services. These standards are understood best in the context of wider IT trends that provided the technological infrastructure upon which OGC based its standards. In particular, eXtensible Mark-Up Language (XML) and web services are the two key infrastructure technologies that have enabled the creation of OGC standards. Both XML and web services are

[1] Refer to Appendix A for a definition of open standards.

specifications of the World Wide Web Consortium (W3C), one of the leading standards organisations for the Internet.

XML is a data format that defines a syntax for encoding data. The power of XML derives from its extensibility, i.e. ability to encode arbitrary application-specific languages in XML, and from its being a worldwide standard for encoding data. This enables software applications to easily read each other's data, although not to understand its semantics too. XML Schema is an accompanying language that enables users to define XML grammars that capture the semantics of their applications.[2] Software applications can be developed that understand the semantics of a specific grammar and utilise this knowledge to store, process or visualise data conforming to the grammar.

The web services technology defines how software applications can exchange messages in XML over the Internet. Similarly to XML, this technology derives its significance from the fact that it is a standard. It defines a foundation protocol upon which application-specific protocols can be layered. XML supports web services, because it enables software applications to read and write messages that they exchange.

GML, the most important OGC standard, builds on XML and XML Schema to provide a GIS-specific base grammar that defines elements common to all or most geospatial applications (e.g. definition of geometric shapes such as curves and surfaces). The extensibility of GML enables grammar designers to create "GML application schemas", i.e. extensions of the GML base grammar that are tailored to the needs of their application domains (Cox, Daisey, Lake, Portele, & Whiteside, 2004).

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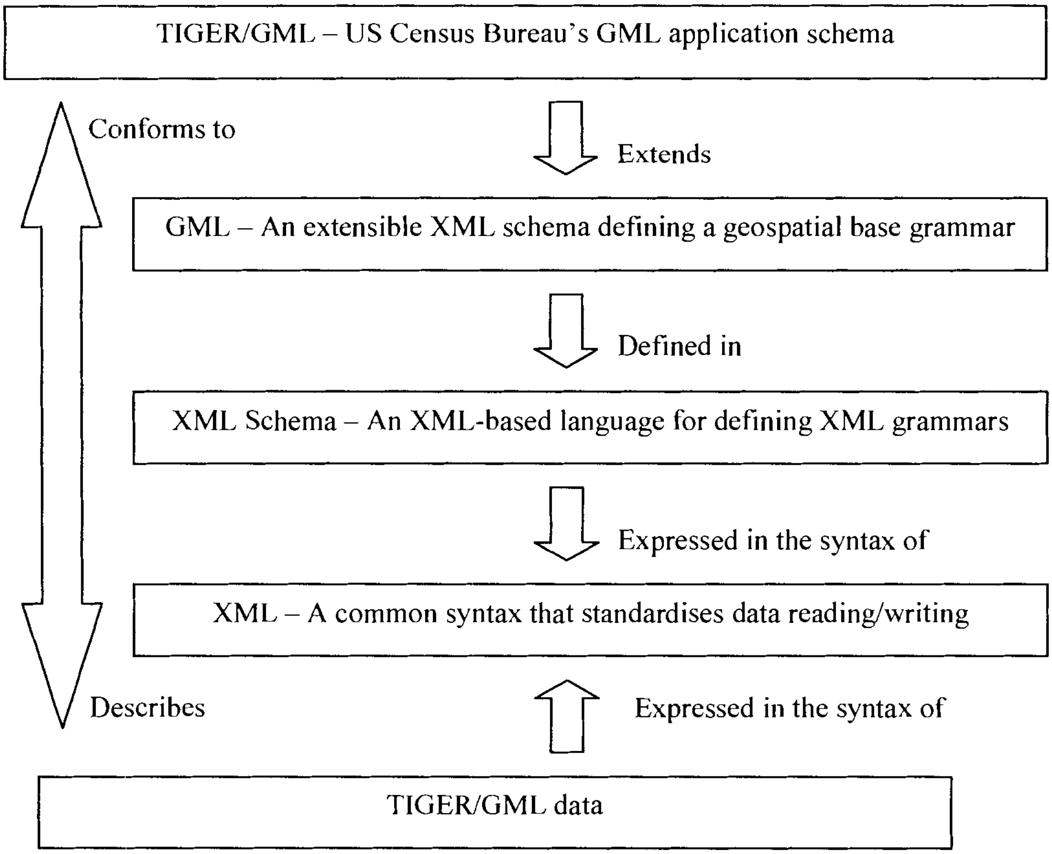
[2] The terms schema and grammar are often used interchangeably, although XML schema is only one language in which XML grammars can be defined. Other languages that serve the same purpose are not relevant to this discussion.

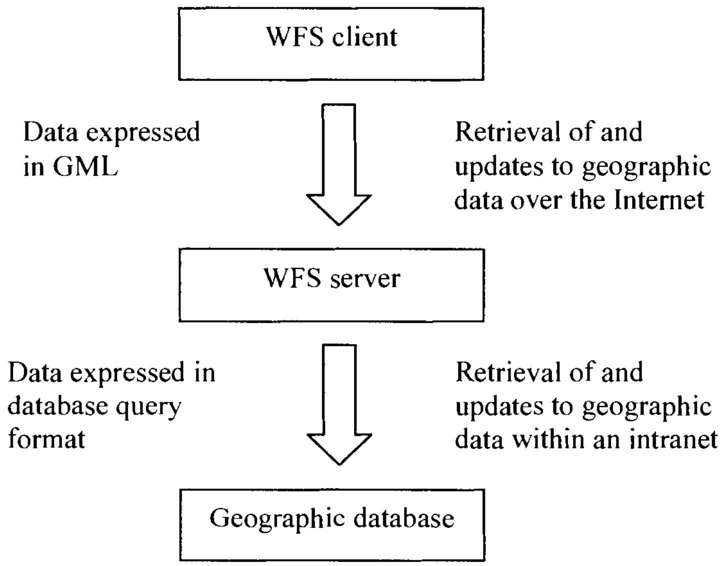
For example, US Census Bureau has defined a GML application schema (TIGER/GML) that describes the data that this organisation collects. It has also produced TIGER/GML data files that conform to this schema. A software vendor wishing to make its software work with TIGER/GML data needs to "enable" (i.e. program) the software for the TIGER/GML schema. The GML base simplifies the work of software developers because it standardises the basic elements of any geospatial grammar. Hence, software needs to be enabled for them only once regardless of how many GML application schemas are supported. Figure 1-1 illustrates how the TIGER/GML application schema and data relate to each other, as well as to GML, XML Schema and XML.

Figure 1-1 Understanding the Extensibility of GML on the Example of TIGER/GML



Complementary to GML is the OGC WFS specification, which defines a web services' interface for the retrieval and manipulation of geographic data expressed in GML. The data is usually stored in a database. As shown in Figure 1-2, the WFS specification defines the interaction between a WFS server and its clients. A "WFS client" is a software application that is capable of issuing requests conforming to the WFS interface, while a "WFS server" is a software application that services those requests. A WFS client can retrieve and update geographic data of an organisation that deploys a WFS server on the Internet. This data is expressed in GML, which abstracts the actual data format of the database where the data is stored and that the WFS server provides access to. The GML-WFS tandem is a very significant development in the GIS industry, as it enables disparate GISs to exchange geographic data over the Internet, i.e. to be interoperable. Widespread interoperability requires that many geospatial software applications support these two standards. A growing OGC global membership and the recent acceptance of GML by the International Standards Organisation (ISO) are encouraging developments.

Figure 1-2 The Role of a Web Feature Service



Another important OGC specification, Web Map Service, defines a web services interface for the retrieval of maps in various image formats over the Internet (De La Beaujardiere, 2004). The difference between GML data and a map is that GML encodes raw geographic data while a map is the presentation of the data. The same data may have different presentations – the same geographic region may be presented in differently "styled" maps. Styling is the verb used to describe the process of generating a map from raw data by applying instructions that determine its appearance. A "style" corresponds to a single set of instructions with which a map can be styled. The WMS defines an interface for accessing maps, but not how these maps are created. For example, they may be cropped from existing maps, or styled from raw data in real time. The WMS interface is not supported by all GIS mapping software, e.g. MapQuest, Google Maps and Google Earth are not WMS-compliant.

At last, the OGC Catalogue Services specification defines an interface for publishing and discovering metadata (data that describes other data) about geospatial data, services and related information (Nebert & Whiteside, 2005). For example, web addresses of WFSs, WMSs and catalogue services can be published in and discovered through a catalogue service. With a catalogue, users can discover the address of a web service of interest when the need arises instead of having to obtain it from some source in advance. Querying an OGC catalogue is conceptually similar to querying a library catalogue or a directory.

1.1.4 Galdos Systems

The client company for this project, Galdos Systems (Galdos), is a prominent OGC member, an active participant in the development of OGC standards and a provider of OGC-compliant software and services. Galdos is a young, privately owned company with approx. 15 employees as of 2006. It was founded in 1998 by Ron Lake, one of the creators of GML. Galdos' ambition is to be a leading supplier of the "Geo-Web" infrastructure ("About Galdos", n.d.). The Geo-Web is the vision of "a world in which we have instant and global access to geographic information that flows in near real time from widely distributed data providers to a larger audience of data consumers" (Lake, n.d., ¶ 14). Geo-Web requires interoperable software systems. OGC-compliant products enable the Geo-Web by providing the interoperability.

Galdos' customers have been mainly early adopters of the OGC technology, and among them primarily large governmental organisations with complex "data models" such as the US Census Bureau and the Ontario Ministry of Natural Resources. A data model defines the structure and the semantics of the data that an organisation collects, maintains, uses and/or disseminates.[3] Galdos' software products implement the aforementioned four standards, GML, WFS, WMS and

[3] Section 3.1.3 describes the main difference between simple and complex data models.

OGC Catalogue Services. As Galdos' business is based entirely on OGC standards, its fate is inextricably linked to the success of the standards' adoption.

1.1.5 Challenges in the Adoption of OGC Standards

The adoption of OGC standards has been advancing slowly due to a number of challenges. First, GML is a comprehensive technical specification, which appears complex to neophytes. Also, the products are not easy-to-use and have few or no complements. So, the entry barrier to someone wishing to experiment or make use of the OGC standards is relatively high. This reduces the number of organisations and people capable of adopting the standards by themselves (e.g. by deploying open-source software similarly to how organisations now deploy open-source Apache web servers).

Second, governmental organisations with complex data models form a significant share of early adopters. They tend to source the OGC technology through projects that span several months. Companies whose main business is supplying OGC-compatible products are small, and therefore they can conduct a limited number of such projects at the same time.

Third, the technology has not reached a critical mass to make it a requirement for doing business. The early adopters are adopting the OGC technologies cautiously and, to some degree, experimentally. For example, some governmental organisations have made their data accessible on the web through the WFS interface to enable the data users to experimentally access the data using OGC standards, but this has not yet become the standard way of distributing data.

Reacting to criticism about the perceived complexity of GML, OGC released a simplified GML specification "profile" branded "Simple-Features GML Profile" in 2005. A specification profile is a specification subset tailored to the needs of a particular group of users who do not need the entire specification. It is presently unclear how this move will influence the adoption of

GML. At the same time, a powerful company with OGC standards-incompatible products entered the GIS radar screen.

1.1.6 Google - A Powerful New Entrant

Google is a company that rose to prominence through the phenomenal success of its web search engine. Its share of US web searches reached 52% in June of 2005 ("Google's Leap", 2005). Google went public in 2004 with the starting share price of $85, which rose above $300 in 2005 to approx. $430 in January 2006 ("What a lot of", 2005; "Google Stock Quote on Yahoo! Finance", n.d.). Most revenues are generated through the placement of small ads that accompany search hits. In the first quarter of 2005, Google earned revenues in the amount of USD 1.3 billion, 93% more than in the same period a year earlier, and a profit of USD 369 million for the same quarter ("The online ad attack", 2005). The rise of Google has been so impressive that Microsoft considers Google to be its main rival ("Sir Bill", 2004).

Google's debut in the GIS market came with its acquisition of a satellite imagery company Keyhole in October 2004 (Hines, 2004). Keyhole had developed an application that lets users view geographic images collected from satellites and airplanes. Google repackaged the technology and released it as Google Earth. Launched in February 2005, Google Maps strengthened Google's presence in the GIS market (Elgin, 2005). This web application enables locating addresses, viewing them on a map, getting driving directions, etc. Ordinary web users received both applications enthusiastically, leading to their rapid adoption.

1.1.7 Google Earth

Google Earth is an easy-to-use web application that combines satellite images, maps and the Google search engine. Through its elegant graphical user interface (GUI), users can easily locate a place (e.g. a school or restaurant) and view the area in a combination of photographic satellite images and maps overlaid on top of them. Google Earth enables the user to navigate the earth in 3D, which makes an appealing visual effect. In a novel business approach for the GIS industry, Google Earth also allows users to create and share maps. Google Earth is a sophisticated web application that retrieves data from Google web servers in real time ("Google Earth", n.d.).

For non-commercial use, Google Earth is free. It is promoted as a tool for exploring, searching and discovering. Modestly priced at USD $20, Google Earth Plus adds support for global position system (GPS) devices and features such as better printing. The professional version intended for commercial use and priced at $400 is promoted as "the ultimate research, presentation and collaboration tool for location information" ("Google Earth Home", n.d.). Industries in which Google Earth is used include commercial and residential real estate, architecture, construction, engineering, insurance, media, defence and intelligence, homeland security, state and local government ("Google Earth Pro", n.d.).

Google Earth uses Google's proprietary Keyhole Mark-Up Language (KML) for encoding geographic data and styling instructions (i.e. styles). Both data and styles are needed to generate maps overlaid on top of satellite images. The use of KML is free, which makes it possible for anyone to prepare KML data files and use them in Google Earth. Google describes KML as a "data exchange format [that] lets you share useful annotations and view thousands of data points created by Google Earth users" ("Google Earth", n.d.). Therefore, Google is encouraging the public to create and share geographic data in KML. Many ordinary web users are increasingly using KML for this purpose.

1.1.8 OGC's Perceptions of Google Earth and KML

OGC members are ambivalent about Google Earth and KML. On the positive side, the appearance of Google promotes the GIS industry and may help it appeal to corporate and consumer channels, which could lead the industry to a period of hypergrowth (Burggraf D., personal communication, January 2006; Schell, 2005). Raising awareness about GIS may also attract investors, which would improve the availability of funds for GIS start-ups, most of which have had to survive by doing projects for the government and other clients.

A reason for concern is the fact that Google Earth does not use any of the open standards that OGC has developed, at least not in a way envisioned by OGC. KML actually borrows the geometry model (a model for expressing shapes such as points and lines) from GML, which makes the two languages not only conceptually but also syntactically similar, but it does so in a GML-incompatible way. Google Earth uses geographic data encoded in KML instead of GML, and retrieves it from Google servers through a proprietary web services interface instead of WFS. Similarly, though less importantly, it could use WMS for the retrieval of satellite images, and OGC Catalogue Services for the discovery of alternative sources of geographic data and maps. However, the issue is not merely that Google Earth does not use OGC standards, but also that the rapid adoption of Google Earth and KML might come at the expense of OGC standards, in particular GML.

KML is a much smaller language than GML and therefore easier to learn, although at the cost of being less expressive. Google Earth's ease-of-use conveys a great advantage to KML because GML does not have a software application that would popularise it on the same scale. Given Google's enormous market power and the growing community of KML users, it is possible to conceive a future with KML as the dominant language in geospatial applications where the richness of GML is not needed. It has been argued that the Pareto distribution[4] applies to the complexity of geospatial data models, so that as much as 80% of them are simple. One could speculate that a simple language such as KML may be used in those 80% of data models. What does this all mean for Galdos as a company that bases its business on GML and related standards?

[4] The reader is invited to visit http://en.wikipedia.org/wiki/Pareto_distribution for more information on the Pareto distribution.

1.2 Purpose and Structure

This research has two objectives both of which focus on KML's impact on Galdos' business. The primary objective is to rigorously examine the threat to Galdos from the rapid adoption of KML and to determine the best strategic response should this threat be substantial. The secondary objective is to assess whether and how Galdos should approach KML as an opportunity.

The analysis proceeds on three levels: the GIS industry, the OGC-related industry segment, and the firm. It starts by examining the possibility that KML will become a substitute technology for GML in Chapter 3. This hypothetical development affects the analysis of the OGC-related industry segment and the analysis of Galdos' strategic alternatives. The likelihood of this happening is assessed through the lenses of the theories on diffusion of innovation (DOI) and economics of technology standards (Rogers, 1983; Fichman & Kemerer, 1993).

An industry analysis in Chapter 4 begins on the level of the entire GIS industry by describing the industry size, structure, growth, value chains, and the supply chain in which the OGC-related industry segment participates. This provides a context for the subsequent environmental analysis on the level of the OGC-related industry segment. The attractiveness of this industry segment is assessed using an extended Porter's Five Forces framework (Porter, 1980). The potential of KML to substitute for GML plays an important role in the "threat of substitutes" part of this analysis. The industry analysis also compares the location of the OGC technology along the technology adoption life cycle to that of the entire GIS technology.

At the firm level, an internal company analysis in Chapter 5 examines Galdos' strengths and weaknesses, which shape the choices that Galdos has at its disposal. Leonard's (1998) theory on core capabilities is used on this level to examine whether Galdos currently has inimitable capabilities that can provide a sustainable competitive advantage. This part concludes with an assessment of Galdos' current strategy, which provides context for devising a strategic response to the impact of KML on Galdos' business.

By the end of the three-level analysis, the reader gains an accurate picture of KML's threat to Galdos, the attractiveness of the OGC-related industry segment, Galdos' strategy and capabilities, and the location of the OGC technology in the technology adoption life cycle and its implications for Galdos. The subsequent analysis of the strategic response to KML in Chapter 6 considers not only the findings from the three-level analysis but also the possibility for Galdos to treat KML as an opportunity. Vining and Meredith's (2000) multi-goal analysis, Kaplan and Norton's (1996) balanced scorecard and the scenario analysis form the theoretical basis for determining the strategic alternative that satisfies Galdos' strategic goals best across three scenarios. This analysis produces strategic recommendations for Galdos, supported by the theories on real options and the stage-gate process (Luehrman, 1998; McGrath & MacMillan, 2000; Cooper, 2000). The concluding chapter summarises the entire analysis and the recommendations.

Moore's (2002, 2004) chasm model, an enhancement of Rogers' (1983) technology adoption life cycle model, is applied throughout the entire analysis. This serves a number of purposes. First, it points to the potential for growth in the short- and long-term. Then, it helps to assess the current and future challenges in the adoption of analysed technologies. This model also enables an assessment of the validity of current Galdos' strategy, which builds a robust platform for finding the best strategic response to KML's impact on Galdos' business. Finally, this model is used in crafting the strategic recommendations in Chapter 6 and Chapter 7.

1.3 Scope

This is not a complete strategic analysis for Galdos. The scope is limited to the impact that Google Earth and KML may have on Galdos' business. There are many other opportunities and threats that are not considered. However, Galdos' current strategy is analysed in order to be able to determine the best strategic response to Google Earth and KML within the context of the current strategy or another potentially superior strategy. This generic part of the analysis could be used to assess other opportunities and threats in the future.

The author is assuming that both Galdos and Google will continue pursuing their current GIS-based lines of business. Hence, no drastic measures such as abandoning entire product lines are considered. Google has no apparent reason to forsake rents associated with Google Earth, while Galdos couldn't afford to withdraw from their current GIS lines of business because the whole company depends on these four products.

Google is not a pure-play GIS company. In fact, its foray into the GIS technology is a recent development. In the context of this research, the analysis of Google is limited to the GIS part of its business. The author has not been able to ascertain the existence of a distinct GIS division within Google. Hence, any reference to Google as a company in this document refers to the GIS part of its business, unless otherwise stated.

The implications of this analysis are not limited to any particular region of the world. The use of OGC standards is a global phenomenon. Further, Galdos and its competitors have international customers. The analysis draws attention to the geographic scope only where the location makes a difference.

OGC standards are software standards, and Galdos is a software company. The analysis therefore focuses on the software part of the GIS technology. Since GIS software is often accompanied by consulting services, the latter is also included in the discussion.

In this research, the author relied on publicly available material, his own judgment formed by his work experience with OGC technologies as a former Galdos employee, and the input from Galdos as communicated by the company contact person. The latter was very limited, for confidentiality reasons and because of the limited time the company contact person had available for this project. This means that the author had to infer some key points in the analysis (e.g. the current company strategic direction) instead of being given those by Galdos.

This research concludes by proposing a general strategic direction with high-level recommendations for implementation. This is not meant to be a detailed implementation plan, because of the high uncertainty that characterises the future and because it is outside the scope of this research. A follow-up research project can be commissioned to work out a more detailed set of recommendations in closer cooperation with Galdos.

1.4 Terminology

It has become fashionable to use terms "geospatial" and "location-based" as adjectives instead of the more traditional GIS. For example, the OGC web site states that their standards address "geospatial and location-based services" ("Open Geospatial Consortium", n.d., ¶ 1). Throughout this document, GIS and geospatial are used interchangeably as adjectives (e.g. GIS professionals or geospatial professionals). The adjective "geographic" is also used to describe geospatial or GIS data. The term location-based has a narrower scope, as it implies the use of a mobile device whose location may change over time. Location-based software and services represent a subset of the GIS industry.

2 LITERATURE REVIEW

Section 1.2 mentions a number of business theories, concepts and tools used in this research: Moore's chasm model, Rogers' diffusion of innovation, economics of technology standards, Porter's Five Forces, Leonard's core capabilities, multi-goal analysis, balanced scorecard and scenario analysis. This chapter provides a review of these concepts at the level necessary for understanding the analysis that they support. In addition, the review of each concept references the parts of this document where the concept is utilised.

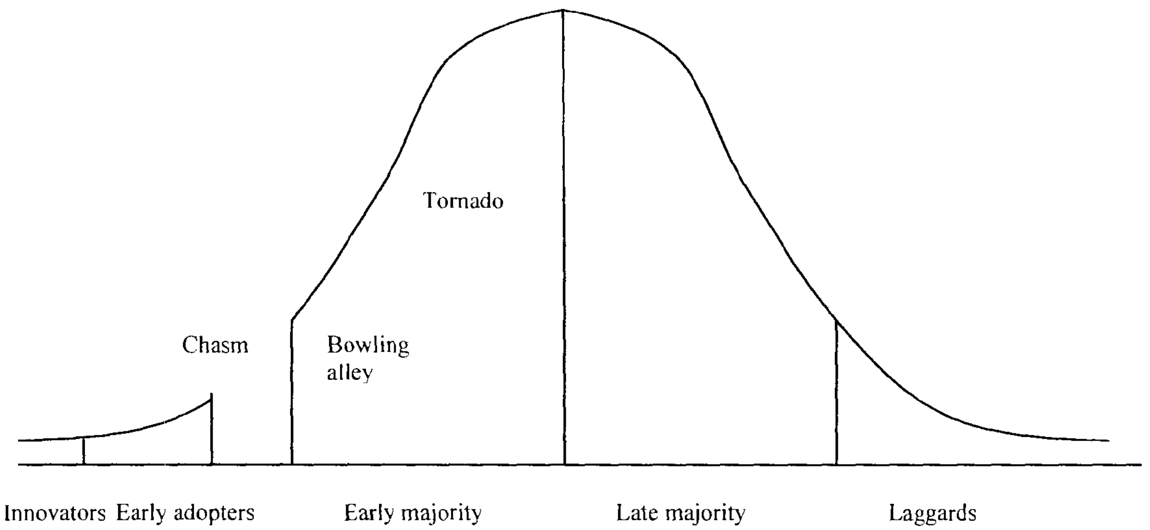
2.1 Moore's Chasm Model

Moore's chasm model has implications for all parts of this research. This model builds on Rogers' technology adoption life cycle (1983), another model that is commonly used to understand the acceptance of new products. The two models suggest that the potential users of a new technology can be divided into five groups: innovators, early adopters, early majority, late majority and laggards (Moore, 2002).

Innovators use a new technology for the technology's sake. Early adopters are, in contrast, not technologists, but they buy into the promise or dream of the new technology. They are also called visionaries. The early majority consists of customers who will buy the new technology only after it has been proven to work and preferably from the market leaders. They also expect turn-key solutions and are not willing to put up with complexity. The late majority is similar to the early majority except that they tend to be even more risk-averse and want to buy only from well-established companies who provide lots of support. Laggards are potential users who don't want to know about the new technology at all, though they wouldn't mind using it if it were hidden inside other easy-to-use products (Moore, 2002).

The early majority amounts to approximately one third of all potential users, and therefore represents a significant source of revenues. The road to the early majority for a new technology contains a number of challenges. First, the new technology has to be championed by innovators and then adopted by visionaries. However, it is the transition from the early adopters to the early majority that many companies fail to accomplish. This problem arises because the two adoption groups do not reference each other for their purchasing decisions. Further, they relate to a new technology in different ways and have different expectations from it. Moore (2002) refers to this as the "chasm" between the early adopters and the early majority. The manifestation of this problem has been observed among many high-tech start-ups who came up with interesting new products but failed to move beyond the early adopters. Their sales slumped as they entered the chasm between the early adopters and the early majority. Unaware of the reasons for disappointing sales, they often reacted in counterproductive ways thereby digging themselves deeper in the chasm. The chasm model proposes how to approach each of the five adoption groups, and in particular, how to cross the chasm (Moore, 2002). Figure 2-1 illustrates the chasm between the early adopters and early majority in the technology adoption life cycle.

Figure 2-1 Chasm in the Technology Adoption Life Cycle



Based on Moore (2002)

The questions of how to compete in the markets of early adopters and early majority, and how to cross successfully from one to the other are of a particular interest to this analysis. A market leader in one adoption group is not necessarily the leader in the next group. This is why the strategy has to be continuously adjusted relative to the position in the technology adoption life cycle (Moore, 2002). The first three adoption groups are discussed in more detail below.

The innovators are technology enthusiasts who, as mentioned, experiment with technology for its own sake. They do not bring in revenues, but they can promote a new technology because of their reputation for being on the cutting edge. It is important to get the endorsement of innovators to reach the early adopters (Moore, 2002).

The early adopters do not buy into the technology as much as they buy into the dream that the technology represents. This is why they are also referred to as visionaries. They have high expectations from the technology and are willing to adopt it before the rest of the world does because they are hoping to gain a competitive advantage from it. They bring first tangible revenues to the vendors of the new technology typically through projects in which the two sides collaborate closely. This enables the technology vendors to improve their new technology, but visionaries tend to be very demanding customers who are never quite satisfied, which drains the technology vendors' resources. No sophisticated marketing is necessary, as visionaries usually find the technology vendors after having heard about the technology from visionaries (Moore, 2002).

To further grow their profits, technology vendors must pursue the early majority, which Moore also refers to as the "pragmatists". The pragmatists are a tough nut to crack because they do not reference the early adopters or the innovators when deciding what technology to purchase. Like visionaries, they do not care much about the new technology, but unlike them they care about not upsetting their existing technology systems. Pragmatists want to buy a proven technology preferably from a market leader. They expect a turn-key solution that can be easily deployed in their technology infrastructure. This requires a "whole product", which consists of the core product and all the complementing products, customisations and services that would compel a pragmatist to purchase the core product. Indeed, a pragmatist looks for complementors, partners, alliances and user testimonials when deciding whether to purchase a product (Moore, 2002).

To cross the chasm from the early adopters to the pragmatists, a company has to first select a beachhead market niche with a compelling need for the technology and which is currently not served by any competitor. Then it needs to develop the whole product for this niche and, after having conquered it, move on to the "adjacent" niches (adjacency means in this case that the new niche references the previous niche in purchasing decisions). The metaphor Moore uses for this is hitting the head bowling pin in a bowling alley. The bowling alley is the area of market niches that follows the chasm. It requires a focused marketing approach that does not pursue all sales but strives to develop a close relationship with the pragmatists that will help the company build the whole product for their respective market niches. Economic buyers and end users are the main target of marketing in this phase, because IT departments have no interest in adopting a new technology ahead of the rest of the market (Moore, 2002, 2004).

While it is important to conquer such market niches to cross the chasm, they do not represent all pragmatists. On the contrary, the majority of pragmatists wait for a critical mass of technology users to form before adopting the technology. When this tipping point is reached, the market switches to the new technology en masse. Moore uses the "tornado" metaphor for the period of hypergrowth that results from the mass adoption. During this phase, companies should "attack their competition ruthlessly, expand [their] distribution channel as fast as possible and ignore the customer" (Moore, 2004, p. 75). The whole product should be commoditised for general-purpose use. Unlike the bowling alley phase, the target customers are infrastructure (technical) buyers who want to simplify their work with a proven technology. Moore calls the company that wins this race a "gorilla" (e.g. Intel in the market of computer chips), as its products become synonymous with the technology (Moore, 2004).

It is worthwhile to make an additional point about the difference between an application and a platform that can host applications (OGC technologies and Google Earth/KML are platforms). Companies must market a platform technology through applications to end users because, as mentioned, end users are more likely to adopt discontinuous innovations in the bowling alley. Platform technologies have an advantage when mass adoption occurs because they can "participate in many value chains at the same time" while applications must conquer niche by niche (Moore, 2002, p. 86). This kind of technology is, however, the hardest to get across the chasm (Moore, 2002).

2.2 Diffusion of Innovation (DOI) and Economics of Technology Standards

Theories on DOI and economics of technology standards support the Chapter 3 analysis of the potential that KML will replace GML as a dominant language for the encoding of geographic data. These two theories are used together in Fichman and Kemerer's (1993) analysis of the adoption of the object-orientation software engineering process. In their paper, they assess the object-orientation from both perspectives and compare the results to the results of other historic software engineering processes in order to find analogies (Fichman & Kemerer, 1993). Here, qualitative conclusions are drawn in Chapter 3, without making comparisons to similar historic cases, but this does not negate the usefulness of insights stemming from this analysis.

The DOI perspective makes use of Rogers' (1983) five generic innovation attributes that influence the adoption rate: relative advantage, compatibility, complexity, trialability and observability. These attributes were derived from hundreds of studies of innovation diffusion. They apply to both individuals and organisations (Fichman & Kemerer, 1993). Table 2-1 defines the five attributes. In Section 3.1, KML is analysed through the lens of these five attributes to determine its adoptability.

Technologies such as KML are subject to increasing returns to adoption. This means that the value of KML to a user is commensurate with the size of the KML user base. Table 2-2 lists economic factors that influence the technology adoption process (Fichman & Kemerer, 1993). By analysing how KML fares from these four perspectives one can gain more insight into whether KML is likely to reach the critical mass of users necessary to become the dominant language for the encoding of geographic data.

Table 2-1 Rogers' Attributes of Innovations

Attribute of Innovations	Explanation
Relative advantage	The innovation is technically superior (in terms of cost, functionality, "image", etc.") than the technology it supersedes
Compatibility	The innovation is compatible with existing values, skills, and work practices of potential adopters
Complexity	The innovation is relatively difficult to understand and use
Trialability	The innovation can be experimented with on a trial basis without undue effort and expense; it can be implemented incrementally and still provide a net positive benefit
Observability	The results and benefits of the innovation's use can be easily observed and communicated to others

Based on Rogers (1983), and Fichman and Kemerer (1993, p. 10)

Table 2-2 Economic Factors Affecting Technology Adoption

Economic Factor	Explanation
Prior Technology Drag	A prior technology provides significant network benefits because of a large and mature installed base.
Irreversibility of Investments	Adoption of the technology requires irreversible investments in areas such as products, training, and accumulated project experience.
Sponsorship	A single entity (person, organisation, consortium) exist to define the technology, set standards, subsidise early adopters, and otherwise promote adoption of the new technology.
Expectations	The technology benefits from an extended period of widespread expectations that it will be pervasively adopted in the future.

Based on the review of pertinent literature by Fichman and Kemerer (1993, p. 10)

2.3 Extended Porter's Five Forces Framework

Porter's Five Forces framework is used to determine the attractiveness of an industry by looking at the main forces that influence it: the bargaining power of suppliers and customers, threat of substitutes and new entrants, and the rivalry among existing competitors (Porter, 1980).

Two additional forces, the government and the complementors, are scrutinised because they are relevant to the analysed industry. This framework is used in Section 4.7 to analyse the attractiveness of the global OGC-related GIS industry segment.

2.4 Core Capabilities

Dorothy Leonard (1998) defines core capabilities as capabilities that "constitute a competitive advantage for a firm; they have been built up over time and cannot be easily imitated" (p. 4). In contrast, enabling capabilities merely enable the company to compete at an average level of competitiveness in the industry, while supplemental capabilities are valuable yet imitable. Capabilities are formed through a system that has four dimensions: skills and knowledge base, physical technical systems, managerial systems and values and norms. Leonard's theory on capabilities is utilised in Section 5.5 of this report in the internal analysis of Galdos.

2.5 Multi-Goal Analysis, Balanced Scorecard and Scenario Analysis

Boardman and Vining (2004) discuss the multi-goal analysis as an approach that enables assessing strategic alternatives against strategic goals in a qualitative manner, i.e. without being able to monetise the outcomes (Vining & Meredith, 2000). In this approach, the balanced scorecard is enhanced to include a company's strategic goals (Kaplan & Norton, 2001). The standard balanced scorecard uses four interrelated perspectives to break down an organisation's strategy into measurable goals (Kaplan & Norton, 1996):

1. Financial perspective – How does the company look to shareholders?
2. Customer perspective – How does the company look to customers?
3. Internal perspective – What business processes must the company excel at?
4. Learning and growth perspective – What areas must the company continue acquiring expertise in to remain or become competitive?

Scenario analysis complements this approach by testing the findings of a multi-goal analysis under different scenarios of future developments. Scenarios should be derived from the environmental analysis. Typically, three scenarios are constructed, the best-case scenario, the worst-case scenario and the most likely scenario (Boardman & Vining, 2004). These theories are utilised in the Chapter 6 assessment of the strategic response to KML.

2.6 Managing the Uncertainty of Innovation

The secondary purpose of this research is to analyse the opportunity stemming from the KML technology. For Galdos, exploiting an opportunity in this domain requires innovation, i.e. research & development (R&D) and subsequent commercialisation. The outcome of innovation is generally highly uncertain. The concepts of real options and the stage-gate process may help the company manage this uncertainty. The use of these theories by Galdos is discussed in the strategic recommendations in Chapter 6 and Chapter 7.

2.6.1 Quantitative Real Options

The real-options approach helps in making a decision whether an R&D investment is worth undertaking. The basic idea behind real options is that investing in an R&D project is comparable to investing into a financial option (an option to buy an asset at a pre-stated price at some point in the future). This value increases with increased uncertainty. The value of an R&D project is then computed as the value of the option to pursue the project given a number of decision points during the project at which the decision maker can decide to continue or terminate the project. The value of a real option for an R&D project is normally higher than the net present value (NPV) of the R&D project, because it includes the contingency associated with the right to continue investing at predefined milestones only if the circumstances look propitious (because the resources are not locked in until the completion of the project). In other words, the fact that the company can terminate a project before its completion and thus avert a maximum loss has a value in itself, reflected in the computed value of a real option (Luehrman, 1998).

The quantitative real-options approach is suitable for companies that justify investment decisions using financial analysis. It is particularly suitable when uncertainty is high and a large-scale investment can be delayed until further information is obtained. Start-ups such as Galdos are less likely to do a thorough financial analysis for reasons such as lack of historic data for comparison, lack of experience and lack of information about the potential pay-offs. When the financial figures are too uncertain, it is possible and often preferable to apply a qualitative real-options approach.

2.6.2 Qualitative Real Options

Strategic technology assessment review (STAR) is a process that enables a qualitative assessment of all important variables that affect making decisions with regards to initiating new R&D projects. It involves getting people from different departments (engineering, marketing, sales, operations, etc.) with diverse perspectives to meet and discuss the pros and cons of a proposed R&D project. The STAR toolkit contains 15 tables with questions for assessing the cumulative revenue potential, commercialisation costs and development costs.[5] Conceptually, the value of the option of pursuing a project equals the value of the potential upside from the commercialisation of the technology (derived from the cumulative revenue and commercialisation costs) minus the development costs. With this toolkit, the value can be expressed qualitatively, which is especially convenient when decisions have to be made quickly and without access to accurate quantitative information. This approach is the most useful when a company has to select which projects to pursue from a number of candidate projects (McGrath & MacMillan, 2000).

[5] The reader is referred to the referenced paper for the tabulated questions.

2.6.3 Stage-Gate Process

The stage-gate process is a "blueprint for managing the new-product process to improve effectiveness and efficiency" (Cooper, 2000, p. 58). It divides the new-product development into five stages. Each subsequent phase carries a larger investment and commitment. The phases consist of cross-functional and parallel activities. At the beginning of each stage there is a gate for quality control and as a Go/Kill checkpoint. The project advances from one stage to the next only if it satisfies the criteria. The majority of U.S. product developers utilise this process (Cooper, 2000).

In the scoping stage, the preliminary technical, market, financial and business assessments of a new idea take place. In the second stage, a thorough business case has to be built to justify the actual product development, which occurs in the third stage. Product development also includes devising the manufacturing, marketing and operating plans. Testing and validation of the new product, its marketing and production occurs in the fourth stage. The last stage entails the product launch, i.e. its full commercialisation. These stages are conceptual. Each stage involves activities whose specifics may vary from company to company (Cooper, 2000).

The real-options and stage-gate approaches complement each other. The financial valuation of real options takes into account that a project can be cancelled at gates. Real-options evaluation, qualitative or quantitative, can be performed at the first gate to determine if a project should be pursued. Hauser and Zettelmeyer (1997) argue that "options thinking" helps business units select projects that are in the best interest of the firm. Cooper (2000) suggests that a success in new-product development depends on two criteria, the ability to assess what projects to pursue and the ability to execute the selected projects well. Real options and the stage-gate process help in meeting these two criteria. Further, the concepts that they embody are applicable not only to the level of a project but also to that of a strategy, which makes them useful for this analysis.

2.7 Summary

This chapter described a number of business theories, concepts and tools needed for understanding the research and its results. Rogers' (1983) DOI theory and the theory on the economics of technology standards are used in the next chapter to assess the possibility that KML will substitute for GML in geospatial applications (Fichman & Kemerer, 1993). Moore's (2002, 2004) chasm model is used throughout this document, as described in Section 1.2, and on all three levels of the analysis. The next chapter uses this model to describe the location of Google Earth and KML in the technology adoption life cycle. The extended Porter's Five Forces framework is utilised in the Section 4.7 environmental analysis of the OGC-related industry segment of the GIS industry (Porter, 1980). Leonard's (1998) theory on core capabilities supports the firm-level analysis in Chapter 5. The solution analysis in Chapter 6 relies on the multi-goal analysis, balanced scorecard and scenario analysis (Vining & Meredith, 2000; Kaplan & Norton, 1996). The theories on real options and the stage-gate process form part of the strategic recommendations in Chapter 6 and Chapter 7 (Luehrman, 1998; McGrath & MacMillan, 2000; Cooper, 2000).

3 IS GOOGLE EARTH A THREAT TO GEOGRAPHY MARK-UP LANGUAGE (GML)?

This chapter analyses the dynamics of the KML adoption as it relates to the adoption of GML to determine if and to what extent KML could substitute for GML. This has implications for the analysis on the level of the OGC-related industry segment in Section 4.7 and for the solution analysis in Chapter 6. Two complementary perspectives are employed for this purpose. One is the perspective of diffusion of innovations and the other that of economics of technology standards. They are described in Section 2.2. A description of the Google Earth and KML technology necessary for performing this analysis is given in Section 3.1.

The adoption of KML does not preclude a parallel use of GML or other geospatial data formats. For example, geographic data stored in a database may be exported in various formats such as GML, KML or ESRI Shape files, depending on the destination for the data. If the data is retrieved to be sent to an organisation that has standardised on GML, then the data will be exported in GML. It would be unnecessary to analyse whether KML can replace GML in applications for which KML is unusable due to its grammar's limited expressiveness. Therefore, this analysis focuses on geospatial applications with simple data models in which the geographic features can be expressed in either KML or GML (referred to as "simple-features geospatial applications").

An important assumption in this analysis is that KML will remain incompatible with GML. In theory, Google could change KML to be a GML profile and thus become compatible with GML, which would render this analysis redundant. Such development is, however, very unlikely because it would make the new KML versions backward-incompatible.

3.1 Google Earth and Keyhole Mark-Up Language (KML) Technology Description

This section expands the description of Google Earth and KML from Chapter 1. The technology, its strengths and weaknesses relative to GML, and ways of use are discussed. Special attention is paid to what makes this technology appealing to its users. In addition, its location along the technology adoption curve is scrutinised. The information in this section enables an analysis of KML's potential to substitute for GML in the remainder of this chapter.

3.1.1 Creation, Sharing and Visualisation of KML Data

Google Earth uses KML for encoding the maps that appear overlaid on top of satellite images. To view these maps one needs to select the "layers" of interest in Google Earth's GUI. A layer corresponds to a type of geographic feature (e.g. road, hospital). The KML data used to display these maps can be created and shared in a number of ways.

The default source of KML data is Google web servers that stream the data to "Google Earth clients" whenever a user selects to view a layer. The term Google Earth client refers to the Google Earth software application that a user installs on her computer. Google Earth allows users to create and share their own KML content. In Google Earth, a user may add annotations and geographic features directly on satellite imagery, and email the map content as a KML file to a friend or business associate. Map content can also be saved as a KML file on the hard drive and subsequently shared freely over the Internet like other digital content. A user can find a map of interest on the Internet, load the respective KML file into her Google Earth client and view the map. Google Earth also provides an automated way of sharing data through "network links", users' web servers that serve up KML data in a way similar to Google's own web servers. To create KML content, users need not rely solely on Google Earth. They can also create it in text/XML editors or their custom built software applications. Popular software applications such as ESRI ArcWeb and Safe Software's FME already support exporting data from databases to KML files (Flood, 2005; "Formats supported by FME", n.d.).

3.1.2 Extensibility

KML is extensible because it has its own schema for defining new types of geographic features that extend the pre-defined generic types. In other words, KML can be used just like GML to define domain-specific grammars. For example, GPS users can define a grammar tailored to GPS applications and then create and exchange KML files that adhere to the grammar. It is exactly this capability of KML that makes it a potential competitor to GML. There are, however, some limitations as to what KML as a language can express.

3.1.3 Expressiveness

Unlike GML, KML can express only "simple properties" of geographic features. For example, a geographic feature *Road* can have properties *length* and *width*. These are simple properties because their values are atomic, i.e. they cannot be decomposed into other objects. To illustrate the opposite, the *Name* object may be defined as a complex value with properties *firstName* and *lastName*. Here, the *Name* object is not atomic, because it consists of other objects. Many geospatial applications have simple data models, which involve only simple properties. Theoretically, they could use KML instead of GML. The schema in which new geographic feature types are defined differs between GML and KML. GML relies on the W3C XML Schema standard, while KML uses a much simpler schema, which is however not based on standards.

KML's geometry model represents a subset of GML's equivalent, and in fact it is "borrowed" directly from GML. Supported geometries include point, linear line and polygon in 3D space. While GML also supports non-linear geometries such as arcs and Bézier curves, most available geospatial data uses only linear geometries. Geometries are always defined in a coordinate reference system (CRS). KML currently supports only WGS84, the CRS in use in

Google Earth, while GML supports arbitrary CRS (Lake, n.d., 2005a). Geospatial data is generally maintained in many different CRSs (e.g. the United Kingdom's geospatial data is usually kept in the British National Grid reference system).

3.1.4 Content and Presentation

One important distinction between GML and KML is that the latter combines content and presentation while the former only defines content. For example, a KML file may define both geometric shapes and how they will be drawn in Google Earth. Presentation elements in KML reflect visualisation capabilities of Google Earth. This makes the use of KML dependent on Google Earth or an application with comparable visualisation capabilities. This could change in the future if presentation is decoupled from content in KML.

3.1.5 Role of KML-Compatible Software Applications

A language such as KML is meaningless without software that can store, process and visualise data expressed in it. In fact, one can argue that the features of the software products that manipulate and especially those that visualise geospatial data have more influence on the adoption of a language than the language capabilities themselves. Consequently, Google Earth has a large role in the popularity of KML. Google Earth is a consumer-oriented product, while KML is merely an enabling technology that is a part of that product (at least for now). As mentioned, renowned GIS companies ESRI and Safe Software have added support for KML in their products. Other GIS software companies are likely to follow in their footsteps soon.

3.1.6 Anatomy of Google Earth's Success

The anatomy of Google Earth's success deserves to be examined further to prepare the reader for the DOI-based analysis of KML adoption in Section 3.2. What distinguishes Google Earth from other GIS software is the following combination of attributes:

1. It is free for non-commercial use and affordable for commercial use
2. It is accessible for download
3. It is easy to use and efficient
4. A web service for satellite imagery and maps is bundled transparently and at no charge with the software
5. Google Earth enables easy sharing of data, which stimulates consumers' co-creation and sharing of content

There are other GIS software products that have some of these features, but none that has all of them. For example, open-source software is free but not easy to use. NASA has released a similar software application World Wind, but it is more resource intensive resulting in poorer performance for most users (Burggraf D., personal communication, February 2006). Sophisticated and GML-compatible GIS applications exist, but they are not affordable and do not come with data. This implies that GML has no comparable consumer-oriented software application that would popularise its use.

3.1.7 The Technology Adoption Perspective

The "mainstream" GIS technology is in the bowling alley part of the technology adoption life cycle. Technologies such as Google Earth raise the GIS profile among pragmatic users, i.e. businesses and consumers (Burggraf D., personal communication, January 2006). Moore (2004, p. 56) argues that only easy-to-use GIS software applications can compete in the tornado phase. This suggests that Google Earth could contribute to bringing the GIS technology closer to the tornado phase.

3.2 Analysis from the DOI Perspective

The analysis from the DOI perspective scrutinises the adoptability of KML by individuals and organisations. The adoptability is assessed by looking at how KML fares along Rogers' (1983) five innovation attributes: relative advantage, compatibility, complexity, trialability and observability. These attributes are explained in Section 2.2.

3.2.1 Relative Advantage (Negative)

The description of KML in Section 3.1 alludes to the reasons for its inferiority relative to GML. They include limited expressiveness, support for only one CRS (WGS84), non-standard schema language for defining geographic feature types and tight coupling with Google Earth as the visualisation tool. Factors that could cause the gap to narrow include changes to KML design and the capability to display KML in other GIS software. In summary, KML is competitively disadvantaged relative to GML.

3.2.2 Compatibility (Moderate to High)

Both KML and GML are XML-based, so people who work with them need to have a basic working knowledge with XML (e.g. the use of XML editors and parsers). Their syntax for defining geographic features differs somewhat, but for someone who knows GML learning KML is relatively simple. The use of KML in Google Earth is straightforward. A user needs to load a file that she has created or obtained from another source in order to view it in Google Earth. This is similar to how a geographic data set in any language would be used. Therefore, KML is largely compatible with existing values, skills, and work practices of potential adopters. Looking ahead, this is not likely to change.

3.2.3 Complexity (Low)

KML's initial adoption rate was higher than GML's mainly because of its much smaller grammar and its ease of use with the freely available Google Earth client. However, KML was initially scantily documented, and did not reveal its underlying schema, making it more difficult, if not impossible, to provide a complex GIS solution (Burggraf D., personal communication, January 2006). Recently, Google has made available updated documentation ("Google Earth KML Documentation", n.d.). KML is also easier to visualise because Google Earth makes it simple. GML as a language has the capability to be visualised in a larger variety of ways than

KML because it is not tied to a particular piece of visualisation software, but, as mentioned in Section 3.1.6, it lacks a popular consumer-oriented software application comparable to Google Earth. Overall, KML as a language is simpler than GML, and its use in Google Earth is simpler too.

Long-term, the use of GML may become simpler with the increasing availability of GML-enabled software applications, and KML more complex as it matures (this happened to GML, which considerably increased in complexity from version 2 to 3). Also, OGC has recently released a simple-features GML profile whose intent is to simplify the use of GML. The complexity gap may therefore shrink in the future, but KML is unlikely to ever become as comprehensive as GML.

3.2.4 Trialability (High)

KML scores higher than GML on the trialability dimension because GML lacks a popular consumer-oriented software application comparable to Google Earth. Also, the fact that KML is designed for Google Earth eliminates the kind of confusion that can arise from the need to choose from a variety of tools that support GML. Long-term, the trialability of GML may improve with the increasing availability of GML-enabled software applications.

3.2.5 Observability (High)

The results and benefits of the KML's use can be easily observed and communicated to others. Google Earth visualises the results with little effort for the user. Section 3.1.1 describes different ways for creating and sharing KML data.

There is nothing in GML that would inherently prevent its results and benefits from being observed and communicated to others. Sharing of GML data is possible through the WFS interface. Further, GML can be visualised in graphical applications that understand it, or by transforming it to another format such as Scaleable Vector Graphics (SVG), which is viewable in a web browser. However, GML lacks a popular consumer-oriented software application comparable to Google Earth. This means that KML scores higher on the observability dimension. However, long-term the observability of GML may improve with the increasing availability of GML-enabled software applications.

3.2.6 Summary

KML's advantages relative to GML are its simplicity, trialability and observability, though long-term the gap may diminish. Compatibility-wise, the situation can be considered neutral because a reasonable amount of learning and software enhancement is needed. However, KML is technically inferior to GML, a consequence of KML's simplicity and coupling with Google Earth. The real question then is whether KML can satisfy the less demanding requirements of simple-features geospatial applications. The analysis shows that short-term KML is unlikely to be used for encoding geographic data other than for visualisation in Google Earth. However, the use of KML could spread in simple-features geospatial applications in the long-term if Google makes appropriate changes to KML's design and if other graphical applications become capable of displaying KML-based maps. Table 3-1 summarises the results of the DOI analysis for the present and long-term.

Table 3-1 Overview of KML's Performance on Attributes of Innovations Relative to GML

Attribute of Innovations	KML Presently	KML Long-Term
Relative advantage	As a language, KML is inferior to GML	The gap could narrow with improved KML capabilities. The tight coupling with Google Earth can be neutralised by more visualisation support for KML in other GIS software.
Compatibility	Similar to GML so easy to understand. Enabling software to both read and write KML is not difficult.	With increasing adoption of KML the compatibility dimension can only improve.
Complexity	KML is simpler than GML to understand and use because it has a smaller grammar and Google Earth as a visualisation client.	The gap could narrow with the growing availability of GML-enabled software and adoption of simple-feature GML profile. Also, KML's complexity may increase as it matures.
Trialability	Google Earth enables easy trialability for KML.	GML's trialability may improve with a growing number of GML-compatible applications.
Observability	Google Earth enables easy visualisation and sharing of data.	GML's observability may improve with a growing number of GML-compatible applications.

The innovation attributes are based on Rogers (1983)

3.3 Analysis from the Economics of Technology Standards' Perspective

The economics of technology standards' perspective complements the DOI perspective from the previous section by analysing the value of KML to the entire community of potential users. Specifically, it scrutinises how KML fares along four economic factors: prior technology drag, irreversibility of investments, sponsorship and expectations (Fichman & Kemerer, 1993). These factors are explained in Section 2.2.

3.3.1 Prior Technology Drag (Weak)

GML does not have a mature installed base. Many organisations are only starting to use GML in production. Those organisations that have been the most interested in GML are also the ones that could not use KML due to its poorer expressiveness. Therefore, the prior technology drag among potential KML users is very low.

3.3.2 Irreversibility of Investments (Low to Moderate)

Software applications need to be enabled for KML and individuals educated about the language capabilities. Therefore, some irreversible investment needs to be undertaken. The required amount of investment is relatively low though, because most organisations already have experience with XML, the language that KML is based on, and perhaps with GML, the language that KML resembles. The fact that ESRI and Safe Software have already enabled their products for KML further points to the relative ease of adding support for it.

3.3.3 Sponsorship (Strong)

Google controls KML and Google Earth. The use of Google Earth and KML for non-commercial purposes is free. For example, one can develop a KML-compatible software application without having to pay any royalty to Google. The sponsorship of Google as the owner of the technology has made a tremendous positive impact on its rapid adoption.

3.3.4 Expectations (Low to Moderate)

The expectations are high for Google Earth to be a profitable Google venture and a popular GIS software application. Factors fuelling these expectations are Google's strong brand and market power, the appealing GUI of Google Earth and the enthusiastic reception of Google Earth by many ordinary web users. KML is clearly piggybacking on this momentum. However, author's survey of on-line articles and blogs has not revealed any high expectations on KML's pervasive use outside the context of Google Earth. Importantly, Google has not declared any such intentions either. This said, there are some blogs that compare KML favourably to GML. While these blogs may contain incomplete or inaccurate assessments of the two languages, they might influence the public's opinion toward favouring KML as a general-purpose solution. Therefore, the expectations on KML's adoption in simple-features geospatial applications beyond Google Earth are low to moderate.

3.3.5 Summary

Table 3-2 summarises the findings from the perspective of the economics of technology standards. KML is in a favourable position, as the prior technology drag is weak, the amount of irreversible investment is reasonable and strong sponsorship is present. However, there are presently no strong expectations for KML's becoming the standard language for the encoding of simple-features geospatial applications because KML is still viewed as being married to Google Earth.

Table 3-2 Overview of KML's Performance on the Factors of Technology Standards' Economics

Economic Factor	KML
Prior Technology Drag	Weak
Irreversibility of Investments	Low to Moderate
Sponsorship	Strong
Expectations	Low to Moderate

The economic factors are based on the literature review by Fichman and Kemerer (1993)

3.4 Overall Assessment

The two perspectives analysed in Section 3.2 and Section 3.3 shed light on the main obstacles to KML's becoming a dominant language for encoding data in simple-features geospatial applications: its support for only a single CRS and its tight coupling with Google Earth for visualisation. The expectations for KML's pervasive adoption at the expense of GML are presently low-to-moderate. A growing support for KML in other GIS applications and some design changes in KML might increase expectations and turn KML from a niche to a dominant technology in simple-features geospatial applications. These findings influence the analysis of the OGC-related industry segment in the next chapter and the analysis of Galdos' strategic alternatives in Chapter 6.

4 INDUSTRY ANALYSIS

This industry analysis is performed on two levels, namely: the global GIS industry and the global industry segment representing vendors of OGC-compliant products. The goal of this chapter is to elucidate the most important characteristics of the GIS industry such as the structure, size, growth potential, the value creation, the interrelationship of suppliers and customers, and the attractiveness of the OGC-related industry segment in which Galdos competes. By the end of this chapter the reader will have an insight into the opportunities and threats present in Galdos' environment.

The GIS industry is a recognised industry for which there is available market research. In contrast, the OGC-related industry segment is a relatively new phenomenon not well researched. This implies that no market size and growth figures are available for the latter. Instead, this analysis describes the historic and future growth trends of the OGC-related industry segment using Moore's (2002) technology adoption life cycle model.

4.1 GIS Industry Structure, Size and Growth

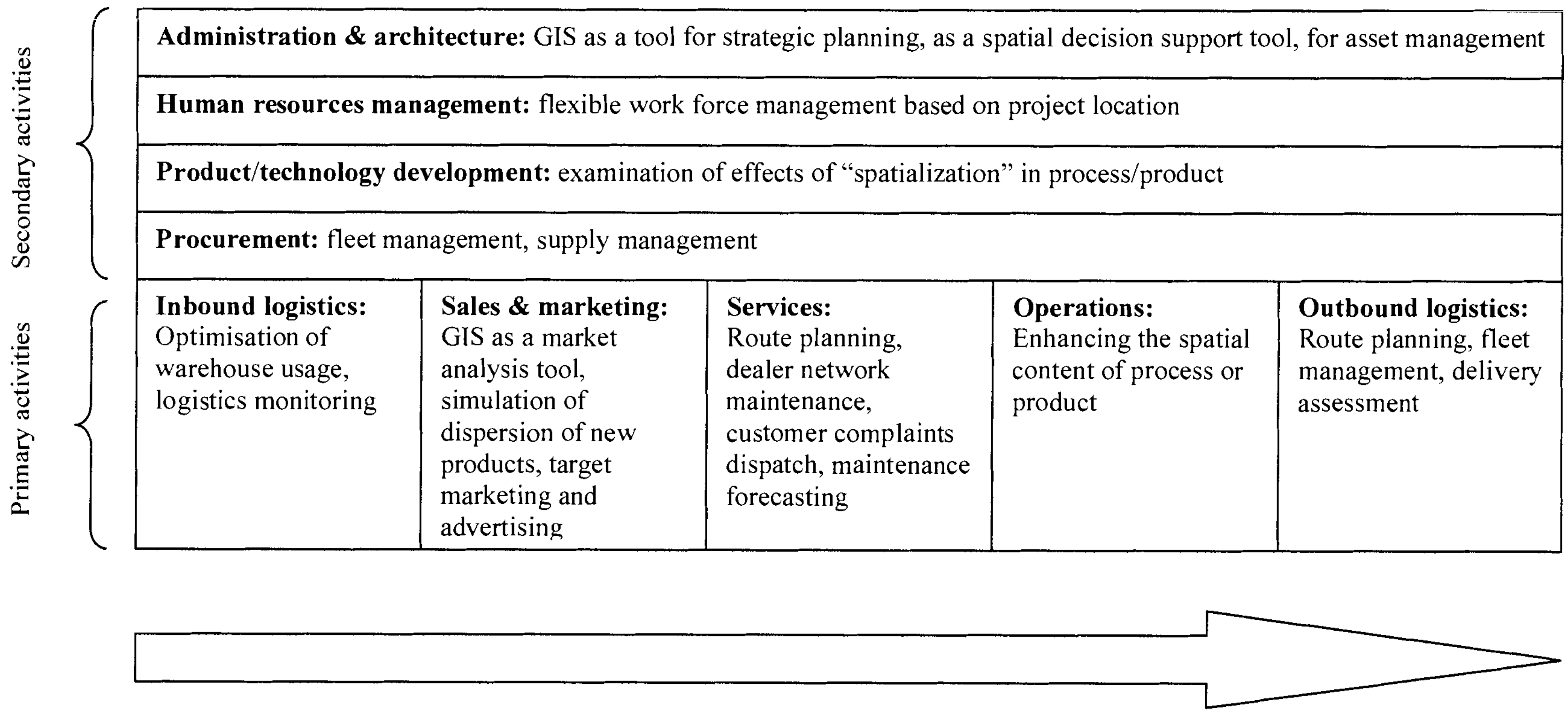
GIS is a sizeable and growing industry. GIS market size was estimated at USD 2.02 billion in 2004, with an annual growth of 9.7%. Software accounted for 64% of this revenue, services for 22%, data products for 8%, hardware for 4% and other for 2% (Tarafdar, Kumar, Mishra, Sengupta, 2004). GIS is an oligopoly with two companies, ESRI and Intergraph, accounting for almost 50% of all software revenues ("Daratech Forecasts", 2004).

4.2 Role of GIS in an Organisation's Value Chain

The concept of a value chain helps us in understanding the GIS industry. The value chain identifies "activities within and around an organisation that together create a product or service" (Johnson & Scholes, 2002, p. 160). Two value chains are presented in this section, one describing the possible applications of the GIS technology in the primary and secondary activities of a typical business organisation (Figure 4-1), and the other describing the value creation along the supply chain of an organisation (Figure 4-2).

Figure 4-1 describes the possible uses of GIS technology in a generic organisation's value chain, as identified by Hendriks (1998) in his adaptation of Porter's value chain model (Porter & Millar, 1985). It follows clearly from this description that the GIS technology can be used in any primary or secondary activity of an organisation. GIS can, therefore, be considered a part of the IT infrastructure of a firm. GIS companies have a place in the value chain of the IT infrastructure just like vendors of databases and spreadsheets (Francica, 2004).

Figure 4-1 The Multiple Roles of GIS in a Generic Organisation's Value Chain



Based on Hendriks (1998), and Porter and Millar (1985)

4.3 GIS Value Chain

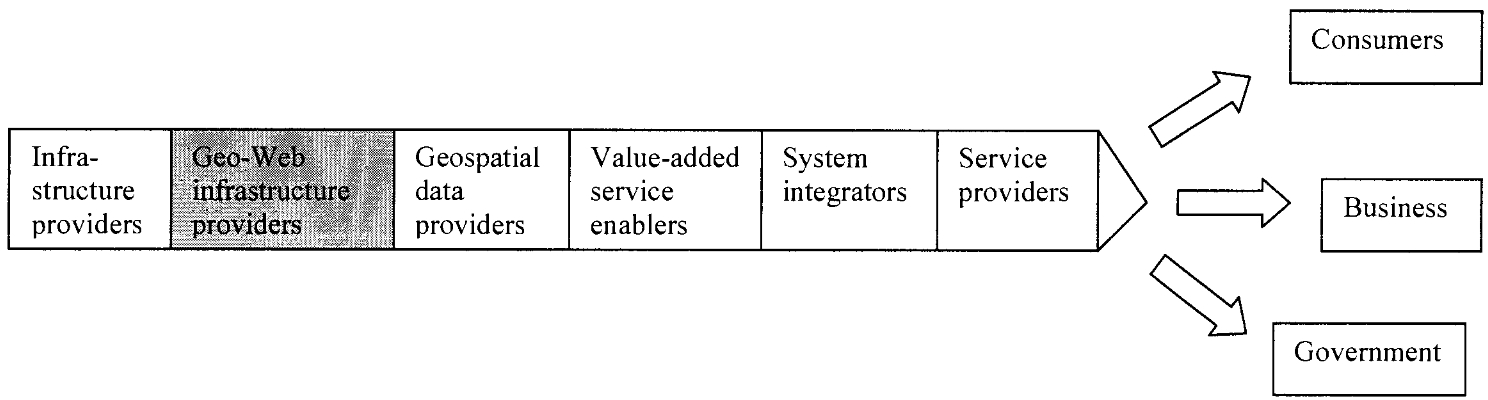
Van Blankenstein (2003) defines the GIS value chain as consisting of four main activities: data, organisation, analysis and knowledge. The first activity focuses on the acquisition of geographic data in digital form. Data organisation "transforms raw data into organised sets of information" and creates software application to operate on this information (Van Blankenstein, 2003, p. 30). The output of this phase feeds into the analysis phase, which involves querying, analysing and presenting information to satisfy the "underlying business requirements" (Van Blankenstein, 2003, p. 34). At the last stage the knowledge created by analysis is utilised for decision making. Higher-level systems such as Enterprise Resource Planning (ERP) applications may integrate the output of the GIS value chain in an organisation's IT value chain.

4.4 GIS Supply Chain

Figure 4-2 presents the GIS software supply chain to a customer that can be a business, government or consumer (these three are referred to as "end customers"). It is adapted from the "geo-processing value chain for the net" (Evans, 1999, appendix B). The only addition is the Geo-Web Infrastructure Providers entity. Geo-Web is defined in Section 1.1.4 as "a world in which we have instant and global access to geographic information that flows in near real time from widely distributed data providers to a larger audience of data consumers" (Lake, n.d., ¶ 14). Geo-Web infrastructure comprises software products that enable this vision by making disparate GISs interoperable.

The first entity includes the providers of network, hardware and software infrastructure. Internet service providers (ISP), hardware manufacturers, vendors of operating systems (OS) and other software – they all belong to this group. The infrastructure supplied by these companies is used in the rest of the supply chain (Evans, 1999).

Figure 4-2 GIS Software Supply Chain



Based on Evans (1999)

The Geo-Web Infrastructure Providers entity includes companies whose software products facilitate the creation of the Geo-Web. OGC-compliant software vendors such as Galdos belong to this group, as the whole purpose of OGC standards is to bring about the vision of the Geo-Web. The definition of this entity intentionally allows for OGC-incompliant products to be a part of the Geo-Web infrastructure because the creation of the Geo-Web is a process in progress during which alternatives to OGC-compliant products may become widely adopted too.

Google GIS technology is an example of such a parallel Geo-Web infrastructure because of the global and instant access to anyone on the Internet and especially because of the possibility to share KML data files using web services. Its disadvantage is that the interoperability between Google Earth and other geospatial software applications is presently poor. However, it is expected that other geospatial software applications will become compatible with KML and Google Earth in order to benefit from Google Earth's popularity, which would integrate Google Earth in the Geo-Web without its being OGC-compliant. Because Google Earth is a piece of software that conceptually builds the Geo-Web infrastructure, it is considered a part of the Geo-Web Infrastructure Providers entity in the GIS supply chain. Note that Google Earth also belongs to the Service Providers group described below.

Geo-Web infrastructure providers occupy the 2nd place in the supply chain because their products enable the entities down the supply chain to participate in the Geo-Web. End customers who want to enable their available GIS COTS software for the Geo-Web may purchase Geo-Web infrastructure products for this purpose (e.g. a Web Feature Service product may enable an in-house Oracle database for the Geo-Web). All activities in the four-stage GIS value chain described in Section 4.3 can potentially make use of the Geo-Web infrastructure.

Geospatial Data Providers supply both foundation and domain-specific data (Evans, 1999). They may use products from Geo-Web Infrastructure Providers to enable the data for use in the Geo-Web. For example, they could sell their data in the GML format and exchange it through the WFS interface. In fact, this is one of the most important factors in current Galdos' strategy that will be discussed in Section 5.7.

Value-Added Service Enablers supply geospatial information products, enabling services and niche applications to integrators and service providers. Therefore, their customers are entities down the GIS supply chain except the end customers. For example, a gazetteer web service can act as a web dictionary of geographical names to other GIS web services or web sites to which users have direct access.

System Integrators integrate software components into custom systems for service providers and end customers. In a typical bidding process for a government project, system integrators often partner with software component providers to deliver solutions together. They are interested in "developer productivity, easy maintenance, architectural options, platform independence, etc" (Evans, 1999, appendix B). Consequently, they are in favour of using standards-based software (Evans, 1999).

Service Providers supply final products and services to the end customers (Evans, 1999). This group includes Application Service Providers (ASP) and Application Software Vendors (ASV) such as ESRI and Intergraph. OGC-compliant Geo-Web infrastructure providers supply complements to products of some service providers. Refer to Section 4.7.8 for more details on complementors. A service provider that chooses to develop support for OGC standards in its products by itself is a Geo-Web infrastructure provider too.

4.5 GIS Technology Adoption Life Cycle

The GIS technology was long considered a niche reserved for geospatial professionals and relatively unknown outside of that esoteric circle. Some inroads into business applications have indeed been made, although not on a large scale. Moore (2004, p. 55–57) suggests that ESRI is the market leader in the bowling alley phase having conquered numerous market niches. Moore also remarks that ESRI may have "fallen in love" with vertical markets and forgotten about the tornado that lies ahead. The problem that ESRI has is that its products are too specific and complex to be adopted as a new generic paradigm in the tornado. The chief executive officer (CEO) of OGC, David Schell (2005), argues a related point that the GIS industry has to learn how to market to consumers and corporate channels in order to experience the hypergrowth characteristic to a tornado. It is possible to speculate that Google and Microsoft are competing for leadership in the tornado that may start in the near future. Therefore, the GIS technology is currently moving from the bowling alley to the tornado phase.

4.6 OGC Technology Adoption Life Cycle

It would be erroneous to imply that the OGC technology, being a subset of GIS, is also in the bowling alley waiting to be "whirled" into a tornado. There is no evidence to suggest that whole products for niche markets are available yet. Further, the products are still mostly generic and many customers are early adopters that are adopting the technology somewhat experimentally and in anticipation of its impending ubiquity. However, recent government-led standardisation efforts and the appearance of simplified products indicate that the OGC technology vendors will start crossing the chasm soon. These points are further elaborated in the environmental analysis that follows.

4.7 Extended Porter's Five Forces Analysis of the Global OGC Geo-Web Industry

This section conducts an environmental analysis using an extended version of Porter's Five Forces with government and complementors as two additional forces. This framework, introduced in Section 2.3, is applied to the OGC-related industry segment because its business environment has peculiar characteristics not shared by the rest of the GIS industry. The boundaries of this industry segment, branded as the "OGC Geo-Web", are defined in the following section.

4.7.1 OGC Geo-Web Industry

Grant (1998) suggests that an industry's market defines the industry boundaries and that the boundaries of a market are defined by substitutability on both the demand and the supply side. A typical customer already has a large investment in proprietary GIS COTS software. By purchasing Geo-Web infrastructure products the customer's geospatial IT infrastructure becomes connected to (i.e. enabled for) the Geo-Web. For example, they may make their geospatial data accessible via a WFS interface or maps retrievable through the WMS interface. They can also access other organisations' web services such as WFS and WMS over the Internet.

The OGC Geo-Web industry comprises companies that supply customers with OGC-compliant infrastructure products for the Geo-Web (e.g. OGC-compliant web services software). This industry represents a considerable subset of the Geo-Web infrastructure providers group identified in Section 4.4. The core of this industry consists of the pure-play providers of the Geo-Web infrastructure products such as Galdos. Also included are substitutes on the demand side: COTS vendors that enable their products for the Geo-Web by themselves and software development firms that develop OGC-compliant custom solutions for customers.

The main reason for defining the boundaries of this industry along the OGC-compliance is the fact that a customer interested in using standards-based software products is unlikely to choose an OGC-incompliant Geo-Web infrastructure product because of a price difference. For now, GIS standardisation is synonymous with OGC standards. However, OGC-incompliant Geo-Web infrastructure products such as Google Earth are considered potential substitutes and analysed as such in Section 4.7.4. The case for Google Earth's being a substitute for the OGC

Geo-Web follows from the aforementioned chasm in the adoption of OGC standards. Whereas substitutability does not exist among the early adopters of standards-based products, the pragmatic early majority is still not compelled that OGC-compliance is a must-have feature for a GIS product. Thus, Google Earth and KML may appear to the pragmatists as substitutes to OGC Geo-Web infrastructure products. While keeping this dichotomy in mind, the analysis proceeds with the stated boundaries of the OGC Geo-Web industry.

4.7.2 Bargaining Power of Suppliers (Low to Moderate)

Companies in the OGC Geo-Web industry sell software and accompanying services. Suppliers for software companies may supply equipment, software, data, industry standards and technical expertise. The bargaining power of these suppliers is discussed in the next several sections.

4.7.2.1 Suppliers of Computer Equipment (Low)

Computer equipment has become a commodity due to fierce competition, so the power of these suppliers is and will likely remain very low.

4.7.2.2 Suppliers of Software Tools for Company Operations (Low)

This group includes suppliers of software tools that are used in the creation of products, but do not become a part of the product nor are they used in conjunction with the product at run-time. For example, these include integrated development environments (IDE) (e.g. JDeveloper, Eclipse), XML editors (e.g. XMLSpy), project management tools (e.g. MS Project), accounting software, etc. Generally speaking, the bargaining power of these suppliers is low because of the availability of competing products, and because of low to moderate switching costs. Some of these products are open-source and distributed at no charge (e.g. Eclipse IDE). The commercial products are usually shrink-wrap, so there is no customisation for any particular customer, which further decreases switching costs. Looking forward, many of these tools will get commoditised, and therefore the bargaining power of these suppliers will remain low.

4.7.2.3 Suppliers of Software used in OGC Geo-Web Products (Low to Moderate)

Most software libraries and applications used in OGC Geo-Web infrastructure products are open source and free, which implies low power on the suppliers' side. However, some companies in the OGC Geo Web industry embed commercial 3rd-party software products in their own products. This provides some additional capability that a company hasn't developed on its own and that does not exist in the open source arena. The bargaining power of such suppliers is case-specific. It may be high if the capability in question is rare, but the chance of this happening is in itself rare. The open-source movement has, however, eroded the bargaining power of many software suppliers, except when patents are involved (e.g. some image formats are patented). Overall, it is expected that the basic building blocks of software applications will continue getting commoditised, which will lower the bargaining power of this supplier group.

4.7.2.4 Contractors and Firms as Technical-Expertise Suppliers (Moderate)

The OGC Geo-Web companies may require the expertise of contractors and firms to design and develop their products. This expertise is often sourced on an as-needed basis. The bargaining power of these suppliers is commensurate with the uniqueness of the expertise in question. A good reputation may also contribute to the suppliers' bargaining power. As the companies customise their products for various vertical markets in the future, the demand for these suppliers may grow in number and diversity. Some of the firms may become strategic partners over time, while contractors may become permanent employees. Because of the expertise that these suppliers may have, their bargaining power is considered moderate.

4.7.2.5 Suppliers of Industry Standards (Low to Moderate)

OGC serves as the main source of standards for the OGC Geo-Web companies. OGC standards do not exist in a vacuum though. Organisations such as ISO, W3C, Object Management Group (OMG) and Organisation for the Advancement of Structured Information Standards (OASIS) have published standards that support, influence and complement OGC standards. For example, ISO geospatial standards have influenced OGC's, W3C standards support OGC standards (i.e. OGC standards are based on many W3C standards) and OASIS' standards complement OGC standards (e.g. eXtensible Access Control Mark-Up Language [XACML]).

These suppliers are non-profit, but since the IT and GIS industries choose to comply with their standards their influence is non-negligible. However, although they could theoretically exert considerable power because of the high switching costs, their procedures oblige them to make decisions in a collaborative manner and with the goal of satisfying the needs of the standards' users. The users of their standards are also participants in the standards' creation (the industry is supplying standards to itself), which further diminishes the influence of these suppliers in relation to the companies. Therefore, these organisations can, perhaps paradoxically, have a greater impact on companies earlier in the standards' adoption process than when the standards are in widespread use and in a stable state. Therefore, the bargaining power of OGC is moderate. The influence of other standards' suppliers is low to moderate.

4.7.3 Bargaining Power of Customers (Moderate to High)

Buyers of OGC Geo-Web infrastructure products are entities down the supply chain as identified in Section 4.4: geospatial data producers, value-added service enablers, system integrators, service providers as well as various levels of government, businesses and consumers. The majority of early customers have been various levels of government that are interested in the

OGC standardisation efforts. Pragmatists as an adoption group are still rare customers. The bargaining power of customers varies from moderate to high.

The sales process for customers in government usually involves bidding for projects in response to requests for proposal (RFP). Since bidders do not know the offers of other bidders, they sometime over-promise in order to win the project. Knowing this, customers also tend to be demanding in their RFPs. Bidders, for their part, are very eager to win any customer because they are small companies that depend on a steady stream of projects for survival. This contributes to high bargaining power for customers.

Since the OGC Geo-Web infrastructure products are based on standards, the switching costs should be low, thereby shifting the balance of power toward buyers. However, the level of compliance with OGC standards is not uniform across all products. It is not uncommon that two officially OGC-compliant products (certified by OGC) do not support the OGC standards to the same extent. OGC compliance testing certifies a reasonable level of compliance, but due to the complexity and comprehensiveness of some OGC standards such as GML it cannot guarantee complete compliance. Differentiation between products may also exist in areas such as scalability, performance, feature richness and ease of use. These forces somewhat moderate the bargaining power of customers.

A number of open-source software alternatives have come into being in the last few years.[6] Customers point to the existence of open-source alternatives in order to lower the prices. However, many customers are also not experts in OGC technologies and purchase products together with consulting services. Companies such as DM Solutions provide consulting services on top of open-source OGC-compliant software. Commercial Geo-Web infrastructure providers claim that open-source software is not on a par with commercial analogues, but the veracity of

[6] Some well known examples are GeoTools (http://geotools.org/) and deegree (http://deegree.sourceforge.net/).

this argument is debatable. Currently low in influence, the open-source alternatives are likely to become a stronger force toward increasing the customers' bargaining power in the long-term (Burggraf D., personal communication, January 2006).

OGC-compliant products are a relatively new product category. There is insufficient awareness about the technology outside the GIS industry. Further, the technology has been used mostly experimentally even inside GIS. This means that demand is not strong and OGC web services companies are working hard to increase sales. According to the chasm model, early adopters and early pragmatists are demanding customers (Moore, 2002). On the other hand, government intervention such as the recent European Commission's Infrastructure for Spatial Information in Europe (INSPIRE) initiative to standardise the geospatial infrastructure using OGC standards will strengthen demand ("INSPIRE European Geo-Portal", n.d.). The bargaining power of customers will decrease somewhat as the OGC standards' adoption advances.

The customers' lack of knowledge about the products and their capabilities may ironically prevent some OGC Geo-Web infrastructure suppliers from capitalising on their cutting edge capabilities. All companies praise their products, yet a customer can't really appreciate the differences until the product is installed, when it may be too late. This decreases the potential of companies for exacting a higher price for better products, thereby contributing to the bargaining power of customers. In the long run, company reputations will get established preventing this distortion.

Looking forward, events may take place that would affect the bargaining power of customers both positively and negatively. The bargaining power of early adopters, currently moderate to high, will decrease as the adoption rate picks up. The bargaining power of pragmatic customers is presently even higher than that of early adopters, because the former are not convinced that they should use OGC-compliant software products. This situation should improve as OGC Geo-Web companies cross the chasm. The forces in favour of the OGC Geo-Web companies will be countered by increased competition. Assuming that the OGC Geo-Web companies will cross the chasm and reach the tornado, the power of customers will decrease drastically (Moore, 2004).

4.7.4 Threat of Substitutes (Low to Moderate)

The threat of substitutes is low to moderate. Regional substitutes would be possible if another world region (e.g. European Union) were developing its own geospatial standards. However, this is not the case. On the contrary, the EU and North American governments officially support the adoption of OGC standards, for which there is also great interest in other parts of the world, especially Asia and Australia. Therefore, it is unlikely that any competing official geospatial standards will appear.

OGC-incompliant Geo-Web infrastructure products such as Google Earth and Maps, Yahoo Maps and Microsoft Virtual Earth build the Geo-Web without conforming to OGC standards. Pragmatic customers may consider them potential substitutes to OGC Geo-Web infrastructure products. If compliance with OGC standards becomes more important for pragmatists in the future, the substitutability should decrease over time. Google Earth stands out among the OGC-incompliant Geo-Web group because of the fact that KML might replace GML in simple-features geospatial applications as discussed in Chapter 3, but the probability is low.

4.7.5 Threat of Entry (Moderate to High)

Barriers to entry are relatively low. OGC standards are free and accessible documents that anyone can implement royalty-free, but they are also comprehensive. The market is growing and creating room for more competitors. Because of the lower switching costs caused by interface standardisation, the first-mover advantage is of limited value. Current competitors enjoy certain economies of learning, but they are of decreasing value as more organisations learn the OGC standards.

4.7.6 Rivalry among Existing Competitors (Low to Moderate)

The rivalry among OGC Geo-Web infrastructure providers is low to moderate, as the adoption of OGC standards is still in early stages. The potential market is large, both geographically (the entire world) and application-wise, while the market penetration is low. The number of competitors is small considering the global nature of the technology. For example, some RFPs relating to the OGC Geo-Web technology attract only a few serious bidders (Burggraf D., personal communication, January 2006). Many companies are diversifying geographically, e.g. Galdos has customers on three continents ("Galdos press releases", n.d.). However, companies typically enjoy an advantage in their domestic markets (e.g. Ionic is popular in Europe) (Burggraf D., personal communication, February 2006). Some companies have focused on delivering easy-to-use products for the 80% of the market with simple data models while others appeal to customers with complex data models (Burggraf D., personal communication, January 2006). Competition is presently not price-based. Looking ahead, the competition will intensify because of the growing number of competitors and their globalisation.

4.7.7 Power of Government (High)

Governments have been an important force for the OGC Geo-Web industry. Being heavy GIS users and therefore important customers, they were the first ones interested in interoperability between disparate GISs used in different governmental agencies. Consequently, they supported the standardisation efforts by providing funds and participating in development projects. For example, Canada sponsored OGC's work through the GeoInnovations program, while in the US the funding has mainly come through the sponsorship of governmental agencies such as US Department of Transportation, NASA and National Geospatial-Intelligence Agency (NGA).

The US, Canadian and EU governments are also the early adopters of the OGC Geo-Web infrastructure products. They contribute to the adoption of OGC standards across the entire GIS supply chain by giving preferential treatment to OGC-compliant software products. For example, the aforementioned European Commission's INSPIRE initiative calls for an EU-wide standardisation of the geospatial infrastructure using OGC standards. Therefore, the three governments have been the main drivers of OGC-led standardisation. Long-term the share of businesses and consumers in the GIS market will grow at the expense of government, which may somewhat lessen the government influence.

Developments such as the INSPIRE initiative are important because they force technology adoption, but they don't choose the market leader. The decision on which company's products to buy rests on the shoulder of each individual governmental organisation that is affected by this directive. According to Moore (2002), economic buyers in these organisations will make the purchase decisions. In many cases, this may happen through a formal bidding process.

Government regulation can be thought of as a move that narrows the chasm. This phenomenon is not specifically discussed by Moore, but it is obvious that the INSPIRE initiative will force some government organisations to adopt OGC technology earlier than they would do so on their own. This may increase the demand drastically, yet the existing OGC technology vendors will find it difficult to satisfy this demand without established distribution channels. Vendors with easy-to-use and automated products such as Ionic may find it easier to meet the growing demand relative to vendors whose sales require heavy consulting, because consulting does not scale well. In geographical markets where the adoption is less regulated such as North America, the technology adoption may experience a larger chasm. Once the chasm is crossed, the fact that governments give preferential treatment to OGC-compliant product vendors will enable the bowling alley effect that may ultimately lead to a tornado. This point is revisited in Section 5.7.

4.7.8 Power of Complementors (Low)

Many OGC Geo-Web infrastructure products work in tandem with other software products. For example, a Catalogue Service needs a database such as Oracle for its operations. In some cases, the whole purpose of an OGC Geo-Web infrastructure product is to enables access to an existing software product through an OGC-compliant interface. For example, a WFS server may be installed on an Oracle database and thus enable access to the data stored in the Oracle database through the WFS interface. In most cases, customers already have an investment in a database management system (DBMS) that they want to preserve. This means that the OGC Geo-Web infrastructure products must work with whatever DBMSs customers happen to have. Most of these DBMSs are "spatially enabled", i.e. it is possible to invoke spatial queries such as "get all objects within a bounding box" on stored data. Best known DBMSs are Oracle with Oracle Spatial, PostGREs and ESRI ArcSDE. Grant (1998) defines that "a player is your complementor if customers value your product more when they have the other player's product than when they have your product alone" (p. 73). DBMSs, spatially enabled or not, are not only complementary products but they are also necessary for OGC Geo-Web web services products to function.

This type of complementors is influential in the sense that a company's products must support the complement that a customer is using for the customer to purchase the products. However, once an OGC Geo-Web infrastructure product supports a particular complement, the complementor has little influence unless it chooses to become a competitor to or a customer to OGC Geo-Web companies. Therefore, the influence of complementors that are neither competitors nor customers is low.

4.7.9 Overall Assessment (Moderate to High Attractiveness)

The attractiveness of the global OGC Geo-Web industry is moderate to high. Factors that contribute to attractiveness include low-to-moderate power of suppliers and substitutes, low–to-moderate rivalry among existing competitors, low power of complementors and strong positive influence of governments, in particular in North America and Europe. The negative forces are the moderate-to-high threat of entry and power of customers. Figure 4-3 summarises the findings.

As the industry is crossing the chasm, the power of both the early adopters and the early majority segments will continue decreasing due to increasing product differentiation and brand creation. However, competitive rivalry is likely to increase too. If the OGC technology is widely adopted outside the governmental customer base (i.e. in products for businesses and consumers), the industry could enter a period of hypergrowth, thereby further increasing its attractiveness (Moore, 2004).

Figure 4-3 Extended Porter's Five Forces of the Global OGC Geo-Web Industry

Power of Government

High

(+) EU standardises on OGC standards
(+) USA and Canada favour OGC compliance
(+) Other countries follow
(-) Government agencies that collect and disseminate data contribute to the standards diffusion (the bowling alley effect)

Threat of Entry

Moderate to High

(+) Low capital requirements
(+) Still little product differentiation
(+) Brands unknown outside of GIS
(-) Strong economies of learning

Power of Complementors

Low

(-) Complementors' products are already available
(-) Complementors cannot prevent OGC Geo-Web infrastructure software running on top of their products

Bargaining Power of Suppliers

Low to Moderate

(-) Most supplies are getting commoditised
(+) Specialised knowledge may be required in production
(-) Industry standards change little once adopted

Rivalry among Existing Competitors

Low to Moderate

(-) Low penetration of global market
(+) Some companies operate globally
(-) Low concentration of competitors
(-) Concentrated knowledge of OGC standards
(+) The perceived diversity of competitors is low (due to standardisation)

Bargaining Power of Customer

Moderate to High

(+) Project bidding process favours the customer
(+) New technology but
(-) government's standardisation will stimulate demand
(+) Low switching costs because of standards but
(-) products do not have the same level of standards-compliance
(+) Open-source alternatives
(+) Buyers' incomplete or inaccurate information makes them underestimate the work required to make their IT infrastructure OGC compatible

Threat of Substitute Products

Low to Moderate

(-) No current substitutes to OGC standards
(+) Products of software giants pose a very small risk

4.8 Summary

The GIS industry generates USD 2.02 billion in annual sales, and it is growing at an approximate annual rate of 10%. The GIS technology has possible applications in all activities of an organisation's value chain. Consumer-oriented companies such as Microsoft and Google have recently entered the GIS market, thereby facilitating the transition of the GIS technology from the bowling alley to the tornado in Moore's (2002) technology adoption life cycle. The GIS industry supply chain categorises companies such as Galdos as providers of OGC-compliant Geo-Web infrastructure products to data providers, value-added service enablers, system integrators, service providers and the end customers consisting of businesses, governments and consumers. Providers of OGC-compliant Geo-Web infrastructure products form a moderately-to-highly attractive industry segment, referred to as the OGC Geo-Web. Environmental forces that noticeably increase attractiveness are government-led standardisation efforts, as well as low-to-moderate threat of substitutes, bargaining power of suppliers and rivalry among competitors. However, customers have a moderate-to-high bargaining power and the threat of entry is similarly high. From the technology adoption perspective, the OGC Geo-Web companies are now facing the difficult task of chasm crossing from the early adopters to the pragmatic users, who represent an attractive one third of all potential users (Moore, 2002).

This chapter informs the internal analysis in the next chapter in a number of ways. The location of the OGC technology in the technology adoption life cycle enables an analysis of Galdos' current and future customers, which helps in validating Galdos' current strategy. The environmental analysis of the OGC Geo-Web industry segment supports an assessment of Galdos' core capabilities and its current strategy.

5 INTERNAL ANALYSIS OF GALDOS

This chapter expands the analysis of Galdos from Section 1.1.4. The goal is to examine all internal aspects that may be relevant to the analysis of the best strategic response to KML in Chapter 6, including Galdos' products and services, Galdos' participation in the work of OGC, the annual Geo-Web conference Galdos organises, the core markets and core capabilities, and the financial situation. In addition, the concluding section formulates and assesses the validity of Galdos' current strategy, which provides a context for determining the strategic response to KML.

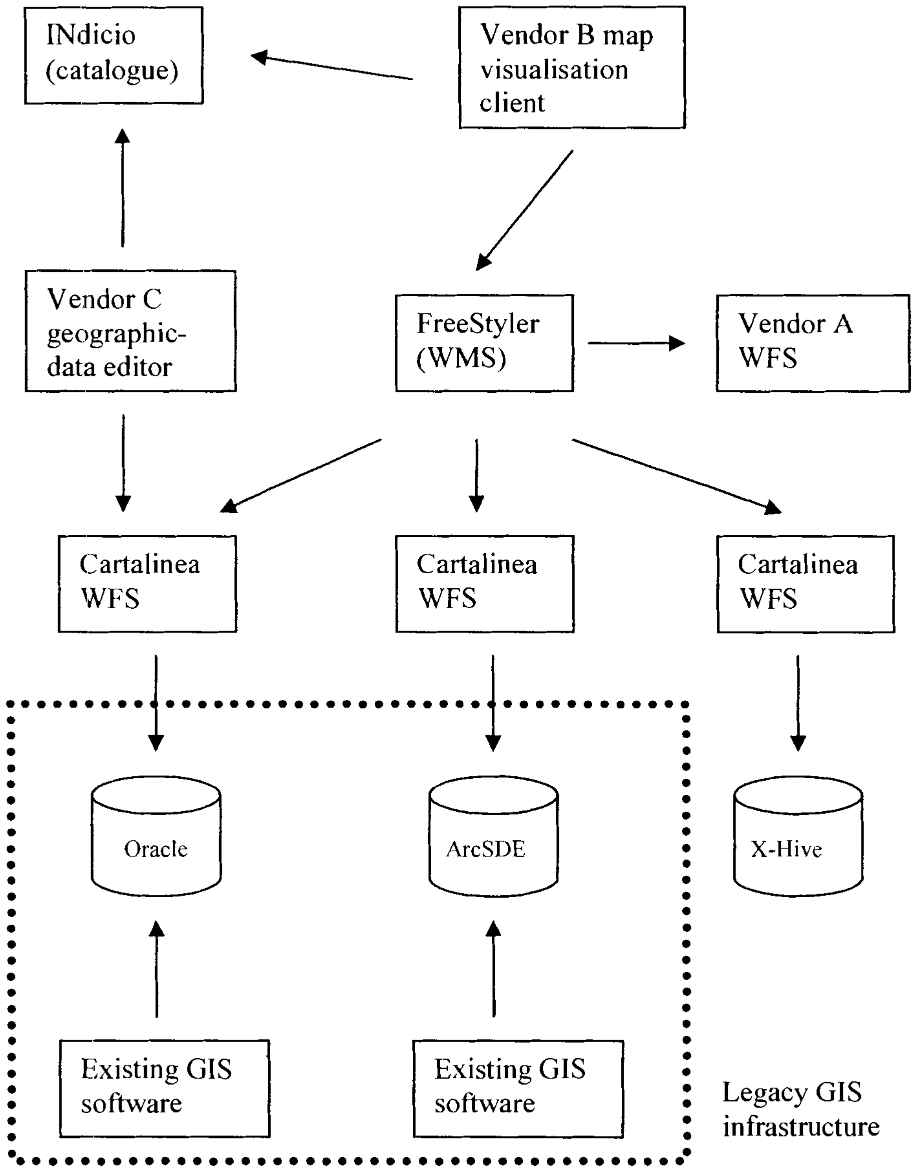
5.1 Products and Services

Galdos offers four products that are compliant with the OGC standards described in Section 1.1.3. Galdos' flagship product, Cartalinea, is a WFS implementation. FreeStyler is a bundle consisting of a WMS implementation and a style editor. INdicio is an implementation of the Catalogue Services specification. Finally, GMLsdk is an application programming interface (API) that enables companies to develop software that reads and writes GML data ("Galdos products", n.d.).

Figure 5-1 describes the interactions between Galdos' products and other products in the Geo-Web. Discs and boxes indicate software applications, while arrows indicate the use of one software application by another (the arrow head indicates a software application that is in use). The discs at the bottom represent various DBMSs such as Oracle, X-Hive and ArcSDE. Oracle or ArcSDE are usually present at the customer premises as a part of the customer's legacy GIS infrastructure. X-Hive is an exception because it is bundled with Cartalinea. Cartalinea accesses and manipulates data in a DBMS on behalf of WFS clients such as geographic-data editors and

WMSs. FreeStyler is shown here as retrieving geographic data from WFSs before styling the data to maps on behalf of map visualisation clients. INdicio, shown in the top left corner, serves as a catalogue on the web that enables web applications to discover WFS and WMS services.

Figure 5-1 Interactions between Galdos' Products and other Products in the Geo-Web



Based on ("Galdos products", n.d.)

Unlike the first three products, GMLsdk is not a web service. It is an API that can be used to enable software applications for work with GML. This is the latest product that Galdos has released. A similar API, albeit developed in a different language, was released under an open-source license in 2001 to promote the use of GML ("GML4J", n.d.).

Galdos started out as a services company that gradually developed its products through projects. Consulting still represents a significant activity for Galdos. Consulting services such as the design of a GML schema often accompany the sale of products, because customers have complex data models that need to be described in GML before the products can be deployed. For example, in a project for Ontario Ministry of Natural Resources (MNR) Galdos developed a GML application schema for MNR's elaborate data model and configured Cartalinea to allow access to the MNR database through the WFS interface and the GML application schema ("Galdos press releases", n.d.).

Consulting activities are not necessarily tied to the sales of products. Some customers hire Galdos to develop GML application schemas but do not purchase any Galdos' products. Galdos also develops custom software components and tools compliant with OGC standards. For example, Galdos developed a software component for work with GML that a customer embedded in its software.

Galdos also provides training in GML and XML to its customers. Galdos has developed courses about these two technologies for managers and technical personnel ("Galdos training & education", n.d.). These courses play an important role in the diffusion of OGC standards and generation of demand for Galdos' products.

Not all parts of Galdos' business are equally relevant to the analysis of its strategic response to KML. Since KML is a potential substitute for GML, the GML-related parts of Galdos' business are more affected. As shown in Table 5-1, the most affected parts are Cartalinea, which can enable access to data in KML, and FreeStyler, which can define the presentation of KML data and style the KML data to maps. Consulting services that accompany the sales of these two products and those that aim at developing custom KML software components and tools are also affected to a large degree.

Table 5-1 Components of Galdos' Business Potentially Affected by KML

Component	Description	Affected by KML?
Cartalinea (WFS)	A web feature service exchanges data in GML or other formats such as KML	Yes
FreeStyler (WMS)	FreeStyler is relevant for two reasons. First, it could style KML data to maps (this is what Google Earth does). Second, its style editor could support the creation of styles, i.e. presentational details, for KML data (KML combines data with presentational elements – see Section 3.1.4).	Yes
INdicio (Catalogue)	A catalogue may contain metadata about KML files, but it does not support KML directly. However, Google Earth could make use of a catalogue to find KML data files.	Maybe
GMLsdk	The name ties the product to GML. Galdos could release a "KMLsdk", but that would be a new product.	No
Consulting	Any consulting related to GML, Cartalinea and FreeStyler may be affected.	Largely
Training/education	Galdos educates organisations about GML. It is not clear if there is a business case for KML courses.	Maybe

5.2 Participation in OGC's Work

Galdos is an OGC technical committee (TC) member ("OGC Members – Listed by Name", n.d.). This means that the company has the right to participate in the development and acceptance of technical specifications. Galdos has relied on this status to lead and contribute to the development of a number of specifications. Most notably, Galdos has led the development of GML and contributed to the development of WFS, WMS and Catalogue Services. Galdos uses its intimate knowledge of these specifications to build products highly compliant with them and to deliver services to organisations interested in these standards.

5.3 GeoWeb Conference

GeoWeb is an annual conference that Galdos instituted in 2001 and which brings together organisations and individuals interested in OGC standards. It is presently the only conference that focuses primarily on OGC standards. Galdos benefits from it in a number of ways. It serves as a promotion vehicle and it enables Galdos to sense the level of interest in the OGC standards. Interesting technical and non-technical ideas get presented, and important contacts are made. Some companies showcase their products at the conference. Workshops and courses are available to educate novices about OGC standards. The Geo-Web 2006 conference will be sponsored by Microsoft and Oracle among others. KML has been identified as technology worthy of discussion in the call for papers announcement under the mark-up and visualisation theme ("GeoWeb 2006 Call for Papers", n.d.). It is expected that one of the main discussion points will be the relationship between KML and GML (Burggraf D., personal communication, February 2006).

5.4 Company Markets

The OGC standards are being adopted globally and Galdos strives to be a global provider of OGC-compliant products and services. In Europe and Asia, Galdos relies on independent distributors. Galdos frequently partners with other firms when bidding for projects. Galdos' core market segments are: integrated resource management (IRM), integrated land management (ILM), telematics, intelligent transportation systems (ITS), location-based services (LBS), and critical infrastructure planning and protection (CIPP) ("Galdos markets", n.d.).

Many Galdos' customers are governmental organisations. In Asia, the customers include Korea Telecom and Korea Research Institute of Ships & Ocean Engineering. In Europe, the following organisations have purchased Galdos products and services: European Union Satellite Centre, Cartographic Institute of Catalonia, and United Kingdom Hydrographic Office. North America represents the most significant market with customers such as Statistics Canada, LizardTech, Government of British Columbia Ministry of Sustainable Resource Management, Ontario Ministry of National Resources and US Census Bureau ("Galdos press releases", n.d.).

Most customers hire Galdos to design GML application schemas for their data and purchase Cartalinea Web Feature Service to enable access to their data on the web. These customers tolerate complexity, partly because their own business requirements are complex and partly because the technology is new. Consequently, Galdos has been able to approach these customers with heavy consulting component and software products that can deal with the complex business requirements. Galdos' products are a platform technology that requires applications to reach end users (see the end of Section 2.1). These applications can be found in the aforementioned six core market segments, where the customers of Galdos' products are scattered.

From the perspective of the technology adoption life cycle, most Galdos' customers are early adopters, while some are pragmatists who are adopting GML because it solves a pressing problem for which there is no alternative solution. Galdos enjoys a very strong reputation among its customers. To cross the chasm successfully, Galdos needs to pick a market niche as a beachhead market, and gradually assemble a whole product for this niche in order to conquer it. Then it has to take the same approach to other related market niches until the market becomes a mass market leading to hypergrowth (Moore, 2002, 2004).

Judging by the types of current customers, the beachhead market niche would certainly have to be characterised by complex data models. Such data models require sophisticated implementations of Web Feature Service and accompanying consulting, which is what Galdos specialises in. This is in contrast to most of its competitors who offer less sophisticated products for simpler business requirements.

5.5 Core Capabilities

Leonard's (1995) concept of core and enabling capabilities is introduced in Section 2.4. This section identifies significant Galdos' capabilities and discusses whether they should be considered enabling or core capabilities. Galdos' strength is its ability to be a leading visionary for the GIS industry in the Internet era, to incorporate its vision in OGC standards, and to devise a profitable business model based on OGC-compliant products and accompanying services. Galdos enjoys a unique reputation in the global GIS community for its capabilities in designing complex GML application schemas and developing OGC-compliant software that can "handle" these complex schemas. This enables Galdos to win contracts with customers who have complex requirements. Galdos is the leader in the high-end OGC technology market segment (Burggraf D., personal communication, January 2006). It is apparent that the capabilities and the resulting reputation represent a competitive advantage for Galdos. However, this evidence is insufficient to infer that Galdos currently has a core capability.

The reliance of Galdos' business model on OGC standards is a "double-edged sword". On the one hand, the OGC is a vehicle for getting Galdos' ideas adopted by the GIS community. On the other hand, ideas codified into standards are imitable. As described in Table 5-2, the intangible skills are the least imitable. Design of complex GML application schemas is a skill that is acquired through practice, and is therefore moderately imitable. Galdos' established position in the OGC is an advantage, but it relates foremost to OGC standards, which are imitable knowledge. A mere knowledge of OGC standards and software development is imitable. These points suggest that Galdos currently has no core capability that can provide a sustainable competitive advantage.

Table 5-2 Imitability of Galdos' Skills and Knowledge

Skill / knowledge	Imitable?
Vision of GIS future	No, but ideas become imitable when codified in standards
Knowledge of OGC standards	Yes
Design of complex GML application schemas	Yes, this skill can be acquired through practice, i.e. it can be imitated with a reasonable effort
Knowledge of software development	Yes
Design and implementation of software compliant with complex GML application schemas	Yes, because implementing OGC standards is possible with generally available skills
Ability to participate in the standards' development	Yes, because any organisation can become an OGC member and contribute its ideas, although first-movers have established leading positions on OGC committees through which they exert influence

The implication is that Galdos' current competitive advantage and the resulting leadership position in the high-end OGC technology market may be difficult to sustain. So far Galdos has enjoyed the benefits of being an aggressive first mover in a young industry segment with a low concentration of competitors. However, barriers to entry are relatively low and the industry segment is relatively attractive (see Section 4.7 environmental analysis). Competitors with similar capabilities may enter the market and existing competitors may improve their capabilities, thereby eroding Galdos' competitive advantage.

5.6 Finances

No direct information was available on the financial situation of Galdos. Galdos' web site does feature a web page for investors, which indicates that the company is interested in obtaining external financing ("Galdos investor info", n.d.). Press releases do not reveal if Galdos has had previous rounds of financing ("Galdos press releases", n.d.). These findings suggest that so far

Galdos has likely not had external financing and has probably sustained itself by performing projects, which is common for GIS start-ups.

5.7 Assessment of Galdos' Current Strategic Direction

Before analysing Galdos' strategic response to KML it is important to clarify the general strategic direction that Galdos is pursuing, as it will influence the outcome of that analysis. No direct internal information was available on the Galdos' strategy. Galdos' mission does state, however, that Galdos aspires "to power the Geo-Web as the leading supplier of interoperable geospatial software tools, products and services" ("About Galdos", n.d.). The current types of customers and the products that Galdos has suggest that it wants to be the leader in sophisticated and highly OGC-compliant products that satisfy the needs of the most demanding customers. In other words, Galdos aspires to be the leading supplier of the high-end OGC technology market segment. It currently faces very little competition in this market segment. Also, this market segment has a great need for Galdos to make their geospatial data models and related IT infrastructure OGC-compliant.

There are two alternatives to how Galdos could cross the chasm, different only in the boundaries of the beachhead market niche, i.e. "the king pin".[7] In both alternatives, the king pin includes governmental organisations that collect and disseminate data (e.g. US Census Bureau). There is less clarity as to whether the scope of the king pin market should be narrowed down to a particular vertical market (e.g. integrated land management). If so, the markets adjacent to the king pin market would be governmental organisations that collect and disseminate data in other vertical markets. In either case, once GML becomes the standard encoding for their data and WFS the standard interface for access to the data, entities down the supply chain will have to adopt the same standards as a requirement for doing business. This will create adjacent niche

[7] Determining the precise boundaries of the beachhead market niche is outside the scope of this research.

markets that will enable Galdos to conquer the bowling alley. This provides a context for the remainder of the analysis in which Galdos' best strategic response to KML is determined.

Galdos is an innovative company that has a culture of technology experimentation. It may be able to use its innovativeness and the current leadership position for developing a core capability that it currently lacks.[8] However, Galdos may be able to conquer the market niches of the "bowling alley" even without having a core capability. Moore (2002) suggests that the first-mover advantage may enable the company to become entrenched in the "bowling alley" market niches, thereby preventing even powerful competitors from effectively competing for market share. In any case, Galdos should be mindful of the unlikely sustainability of its competitive advantage.

5.8 Summary

The internal analysis reveals that Galdos excels at the design of complex GML application schemas and the development of highly OGC-compliant software products. This capability creates a competitive advantage that currently enables Galdos to fulfill its mission of being the leader in the high-end OGC technology market segment. An analysis of Galdos' markets further reveals that Galdos is probably on the right track to cross the chasm toward the pragmatic users. However, Galdos does not have a core capability that would provide it with a sustainable competitive advantage because an aggressive competitor could imitate Galdos' capabilities with a reasonable effort. Furthermore, Galdos should pay attention to the boundaries of the beachhead market niche during chasm crossing. In addition, it appears that Galdos has not had external financing, which could mean that it is not rich in financial resources. These findings influence the definition of Galdos' strategic alternatives and strategic goals in the next chapter.

[8] Devising a strategy that builds core capabilities is outside the scope of this research.

6 STRATEGIC RESPONSE TO KML

This chapter relies on the analysis from previous chapters to determine how to exploit the opportunity associated with KML ("KML opportunity"). First, a number of strategic alternatives for Galdos are generated. Then, three possible future scenarios are identified. The suitability of alternatives is assessed in terms of how well they satisfy Galdos' strategic goals across the three scenarios. The chapter concludes by selecting the alternative that has the most potential upside and by recommending an approach that helps Galdos limit the downside resulting from the uncertainty of entering KML markets.

6.1 Generating Strategic Alternatives for Galdos

This section proposes a number of strategic alternatives for Galdos for managing the impact of KML. One underlying assumption is that Google Earth is rapidly becoming a popular geospatial application that will host a lucrative market for complementors. This creates an opportunity for Galdos to develop products and services for Google Earth markets.

One hypothetical strategic response to KML is to simplify the use of GML and thus attempt to mitigate KML's advantage in ease-of-use relative to GML. However, KML does not threaten Galdos' business because KML is very unlikely to ever be used in complex geospatial applications that characterise Galdos' target markets. Furthermore, as shown in Chapter 3, KML, in its current form, does not threaten even lower OGC technology market segments. Therefore, Galdos should either ignore KML or treat it as an opportunity.

There are a number of arguments in favour of integrating KML in Galdos' products and services. Google Earth is a platform for developing vertical applications, which will participate in numerous vertical markets. Galdos may be able to apply its expertise in building interoperable geospatial web services to this new market. The similarity between GML and KML contributes to this possibility. Moreover, it is possible that the two presently separate worlds of OGC technologies and Google Earth will start to converge. For example, Google Earth could become capable of retrieving data from WFS implementations such as Cartalinea. Being a well-regarded company in the OGC technology market and with products that could support the technological convergence, Galdos is well positioned to capitalise on opportunities in this domain. Experience gained in KML markets could prove useful in approaching pragmatic customers in the OGC technology markets. Finally, Google Earth and KML are important technologies that are bringing the GIS industry closer to a tornado, which points to a large business opportunity too attractive to be ignored and which falls within Galdos' broader mission.

Galdos should continue pursuing the high-end OGC technology market segment regardless of the strategic response to KML. As shown in Chapter 4, the global OGC Geo-Web industry is moderately-to-highly attractive. Further, the industry is expected to grow significantly as pragmatists adopt the OGC technology. Galdos is the leading company in the high-end OGC technology market, and it appears to be on the right track to cross the chasm (see Section 5.7). Although Galdos currently does not have a core capability (see Section 5.5), its competitive advantage in the high-end OGC technology market segment is considerable and may allow enough time for Galdos to conquer the market niches in the bowling alley. Galdos does need to determine the appropriate boundaries of the beachhead market segment for chasm crossing in the high-end OGC technology market.

The real question is therefore what to do with regards to KML in the context of the current strategy. Table 6-1 summarises the proposed mutually-exclusive strategic alternatives, which reflect a progressively increasing commitment to the KML technology for Galdos. Table

6-2 further clarifies the alternatives by elaborating the purpose for each one of them. The following subsections provide additional details about these four alternatives.

Table 6-1 Strategic Alternatives for Galdos

Name	Description	High-Level Purpose
Status quo	• Continue pursuing high-end OGC technology markets • Ignore the KML opportunity	Focus on being the leader in high-end OGC technology market during and after the chasm crossing
Internal KML experiments	• Continue pursuing high-end OGC technology markets • Conduct internal projects that build KML competence • Do not implement any KML-compatible software for customers	Develop basic KML competence
Support for KML in products	• Continue pursuing high-end OGC technology markets • Conduct internal projects that build KML competence • Develop support for KML data import/export in products	Enable users to exchange data in KML and potentially Galdos' products to be used as components in KML solutions
Active pursuit of KML markets	• Continue pursuing high-end OGC technology markets • Conduct internal projects that build KML competence • Develop support for KML data import/export • Conduct external KML projects for customers and perhaps with business partners. Some projects are experimental while others develop KML-based solutions. Support for KML data import/export could be developed in such a project.	Pursue all possible opportunities in the KML market

Table 6-2 Purpose of Strategic Alternatives[9]

Alternative	Purposes					
	Pursue high-end OGC technology market	Build a competence in KML	Enable the use of Galdos' products in KML solutions	Develop solutions for KML market	Build a competence in marketing to pragmatists	Generate revenue from KML markets
Status quo	✓					
Internal KML experiments	✓	✓				
Support for KML in products	✓	✓	✓			✓
Active pursuit of KML markets	✓	✓	✓	✓	✓	✓

[9] A checkmark indicates that an alternative has the specified purpose.

Galdos could also encourage users to co-create product add-ons (e.g. a support module for KML) and complements by exposing an open programming interface to its software applications. Moore (2002) cites the creation of the whole product as a necessary requirement to cross the chasm. However, the current lack of serious competition in the high-end OGC technology market segment could mean that Galdos is able to generate more value by providing complements on its own. The downside of providing complements on its own is that it may slow down the creation of the whole product, which might jeopardise the leadership in the bowling alley. Since this alternative is more related to the general strategy of Galdos than to the threat of KML per se, it is excluded from further analysis.

6.1.1 Status Quo

The status quo alternative keeps Galdos focused on the high-end OGC technology market, thereby making it easier for it to remain the leader in the high-end OGC technology market during and after the chasm crossing. Much potential for revenue growth remains within this growing segment. And, since KML is very unlikely to be used in this market segment, Galdos does not need to undertake any protective measures against KML competitors. However, Galdos' profitability in this segment will likely erode as the market growth slows given that their technology solutions are imitable. Thus, the downside of the status quo alternative is that Galdos would not exploit the KML opportunity, which would enable further growth. The status quo represents the most feasible alternative because it involves no changes and Galdos' limited resources are used in a focused manner.

6.1.2 Internal KML Experiments

This alternative enables Galdos to build a KML competence through internal projects tailored to Galdos' needs and capabilities, but it does not include an application of the acquired competence. For example, Galdos can experiment with conversion between KML and GML. The

KML competence stemming from these experiments may serve Galdos in the future should more involvement in the KML technology be deemed desirable. Galdos can also showcase the findings at its Geo-Web conference. In this alternative, Galdos continues to vigorously pursue the high-end OGC technology market. The feasibility of this alternative is high, because Galdos' culture favours such experimentation.

6.1.3 Support for KML in Products

In this alternative, Galdos enables Cartalinea and perhaps FreeStyler to import/export data in KML, but the marketing is still oriented toward the high-end OGC technology market. GIS companies, ESRI and Safe Software, have added a similar capability to their products. This move is unlikely to earn Galdos new customers in the existing target market, although some users may experiment with this capability on their own. Galdos may use the user feedback to determine a future course of action.

Providing support for KML could, however, make Galdos' products more appealing to markets that value KML compatibility. Initially, these markets may include providers of vertical solutions for Google Earth. These providers may prefer to source standards-based technology that is also compatible with KML rather than custom KML solutions. Providing support for KML would enable Galdos to benefit from these opportunities in the future without initially committing a lot of resources.

Galdos needs to develop a basic competence in KML to be able to add support for KML in its products. Therefore, this alternative implies conducting internal KML experiments aimed at developing a basic competence in KML. This alternative does not change, at least initially, the general direction of Galdos' strategy aimed at the high-end OGC technology market. It is moderately feasible, because Galdos may be able to develop this capability using its existing resources, but it would further stretch its limited resources. Obtaining outside funding for this particular development is infeasible.

6.1.4 Active Pursuit of KML Markets

In this alternative, Galdos proactively pursues KML markets with software components and solutions that target KML applications. The software and expertise required for this approach is developed through projects conducted with other organisations. The projects may be funded by customers, or by Galdos and perhaps its partners. OGC may act as a vehicle for some of these projects. Business requirements for such projects would mainly come from customers and partners.

Galdos may be able to generate revenues by selling solutions for the KML markets and Galdos' products as components to other developers of KML solutions. Galdos should pay attention to keeping the expertise and software developed through these projects inside the company. Also, Galdos may be able to build expertise in marketing to pragmatists.

This alternative includes, to some degree, conducting internal KML experiments and providing support for KML in products. It is possible that external KML projects take the place of some internal projects in KML competence building. Also, support for KML in products can be developed in one or more external KML projects. The feasibility of this alternative is moderate because projects are either entirely or partly funded by other organisations, and Galdos needs to commit human resources to the projects.

6.2 Identifying Possible Future Scenarios

The environmental analysis in Section 4.7 shows that the global OGC Geo-Web industry is moderately-to-highly attractive and that Galdos has no serious competitor in its high-end OGC technology market segment. Within the context of this research, the main uncertainty about

Galdos' business is related to the potential for Galdos to benefit from an entry into the market for KML solutions. The scenario analysis should therefore consider this potential.

It is possible to devise future scenarios that reflect different levels of adoption of KML at the expense of GML in simple-features geospatial applications. The worst-case scenario could assume KML's dominance in simple-features geospatial applications, the best-case scenario KML's becoming a GML profile, and the most likely scenario KML's remaining a niche technology. However, such scenarios would not sufficiently influence the decision which alternative to pursue. For example, a dominance of KML in simple-feature geospatial applications could affect the size of the market for KML solutions, but the consequences for Galdos would not be apparent. Galdos' interest in KML is rooted in the possibility to use Galdos' products and service in the development of software solutions for the KML market. It is therefore preferable to define scenarios that reflect varying degrees of demand for Galdos' products and services in the market for KML solutions.

The best-case scenario for Galdos is that developers of software solutions for the KML market source Galdos' services and adopt Galdos' products in large numbers, instead of Galdos competitors' products or custom made products for KML. The most likely scenario is that Galdos' products and services are used in the development of those KML software solutions that need to interface with complex OGC-compliant software applications. This scenario is the most likely because Galdos' entry into the KML market would be the easiest in areas related to Galdos' leadership position in complex OGC technology applications. The worst-case scenario for Galdos is that software solutions for the KML market do not generate demand for Galdos' products or services.

The first two scenarios make a reasonable assumption that use of Galdos' products and services in the development of KML software solutions is possible. Google Earth could become compliant with the relevant OGC web services (WFS, WMS and/or Catalogue Service). It is also possible, although much less likely, that KML will become a GML profile. However, even if Google Earth does not become OGC-compliant, Galdos' products could be used in KML solutions by building "adapter" software between OGC web services and Google Earth. This adapter software would translate between Google Earth's interface and OGC web services' interface. From the services perspective, developers of KML software solutions could hire Galdos to develop KML components and solutions. Therefore, Galdos' products and services can be used in the development of KML solutions even with Google Earth's being OGC-incompliant.

6.3 Developing Evaluation Criteria

The criteria for the evaluation of Galdos' strategic alternatives consist of strategic goals that are framed in a balanced scorecard. See Section 2.5 for a description of the balanced scorecard. As shown in Table 6-3, there are four strategic goals, one for each balanced scorecard perspective: high profit growth, high-end market leadership, excelling at marketing to pragmatists, and technology experimentation. These goals are derived from the literature review in Chapter 2 and Galdos' internal analysis in Chapter 5.

Table 6-3 Galdos' Strategic Goals

	Goal	Weighting	Description
Financial	**High profit growth**	Medium to high	This goal represents Galdos' desire to appeal to investors, which is apparent in the "investor info" page on their web site ("Galdos investor info", n.d.). This goal is an immediate one, but Galdos must be ready to temper its growth expectations while the chasm is being crossed, and increase the expectations when the industry approaches the tornado phase. While very important, this goal is secondary to Galdos' ambition to be the high-end market leader.
Customer	**High-end market leader**	High	Galdos' target market and mission statement indicate that it wants to be the leading supplier of the high-end Geo-Web products. The market share can be a suitable metric, but obtaining accurate information about market share is very difficult. Galdos can infer its success along this dimension by comparing the numbers and types of customers to competitors'.
Internal	**Marketing to pragmatists**	Medium	To successfully cross the chasm, Galdos wants to excel at marketing to pragmatists who expect a whole product from an established company, as well as quality and reliable products with available complements and with no lock-in (standards-compliant).
Learning & growth	**Technology experiment ation**	Low to medium	Galdos wants to remain involved in OGC standards development to be on top of the new technologies and to be able to influence them. In addition, it needs to experiment with any technology that may be relevant to its business.

6.4 Evaluation of Strategic Alternatives

Boardman and Vining (2004) propose that the balanced scorecard be evaluated for each scenario. Since the scenarios have a limited impact on the evaluation results, a single matrix describes the evaluation of strategic alternatives as shown in Table 6-4. Where the scenarios do make a difference or where there is uncertainty about the outcomes, the text is emphasised in bold letters.

Table 6-4 Evaluation with the Balanced Scorecard

Alternative	Strategic Goal			
	High profit growth	**High-end market leader**	**Marketing to pragmatists**	**Technology experimentation**
Status quo	Depends on the success in the bowling alley and later on in the tornado in all three scenarios	Pursuing the high-end OGC technology market contributes to this goal in all three scenarios	Galdos learns how to market to the pragmatic users of OGC technology in all three scenarios	Keeps the company involved in OGC standards' development
Internal KML experiments	Same as in status quo. Internal KML experiments do not make a difference in all three scenarios.	Same as in status quo. Internal KML experiments do not make a difference in all three scenarios.	Same as in status quo. Internal KML experiments do not make a difference in all three scenarios.	Same as in status quo. In addition, experimenting with KML is in accordance with Galdos' strategy. The scenarios do not influence the performance along this dimension.
Support for KML in products	Same as in status quo. In addition, the use of Galdos' products as components in KML solutions might increase the sales and profit. **The outcome improves from worst- to best-case scenarios.**	Same as in status quo. **In addition, it is uncertain how large the high-end KML market will be, and whether it will significantly influence Galdos' market share in the overall high-end Geo-Web market. The outcome improves from worst- to best-case scenarios.**	Same as in status quo. In addition, Galdos may acquire experience in marketing to pragmatic KML users and service providers. **The outcome improves from worst- to best-case scenarios.**	
Active pursuit of KML markets	Same as in support for KML in products. In addition, building KML solutions may increase profits further. **The outcome improves from worst- to best-case scenarios.**	Same as in support for KML in products. In addition, building KML solutions might enhance the market share in the high-end market. **The outcome improves from worst- to best-case scenarios.**	Same as in support for KML in products. In addition, building KML solutions might provide more experience in marketing to pragmatists. **The outcome improves from worst- to best-case scenarios.**	

A qualitative assessment of these results, using checkmarks to indicate benefits and criss-crosses to indicate costs, is presented in Table 6-5. Cells that contain parentheses represent uncertain outcomes that may depend on scenarios. The increasing volatility of the outcomes of the last two alternatives is also evident in the risk column. The values in the feasibility column reflect the feasibility to implement strategic alternatives as discussed in Section 6.1.

Table 6-5 Qualitative Assessment of the Balanced Scorecard[10]

Alternative	Goals				Costs	
	High profit growth	High-end market leader	Marketing to pragmatists	Tech. experiment.	Risk	Feasibility
Status quo	✓	✓	✓	✓	✗	
Internal KML experiments	✓	✓	✓	✓✓	✗	✗
Support for KML in products	✓(✓)	✓ (✓)	✓(✓)	✓✓	✗✗	✗✗
Active pursuit of KML markets	✓(✓✓)	✓(✓✓)	✓(✓✓)	✓✓	✗✗✗	✗✗

The most important goal of high-end market leadership is met across all alternatives and scenarios within the context of OGC technology markets. The impact of an entry into KML markets on Galdos' market share in the high-end Geo-Web market is uncertain. It has the potential to strengthen Galdos' leadership position by capturing the high-end KML market, but the downside is that a market share in the high-end OGC technology market might decrease if too many resources are directed toward KML markets. Also, it is not obvious how large the high-end KML market will be relative to the high-end OGC technology market. From the scenario perspective, the outcome improves for Galdos going from the worst- to the best-case scenario.

[10] Checkmarks and criss-crosses represent positive and negative units, respectively. The numbers of checkmarks or criss-crosses used can be compared within a column but not across columns.

The second most important goal of high profit growth also faces a potential upside in the last two alternatives. There is a lot of risk associated with these two alternatives. If Galdos fails to approach KML markets, or the worst-case scenario materialises, the pursuit of the last two alternatives would represent a waste of resources. However, the costs of the last two alternatives can be shared, at least partly, with partners. From the scenario perspective, the outcome improves for Galdos going from the worst- to the best-case scenario.

The moderately important goal of excelling at marketing to pragmatists can potentially be better met with experience gained in selling KML solutions to pragmatists. The resulting benefit is not large enough on its own to justify the risk of choosing the last two alternatives. Rather, an improved marketing capability could be considered a positive consequence of an involvement in KML markets. The relatively least important goal of technology experimentation favours experimentation with KML, but does not help in selecting between the last three alternatives.

6.5 Summary

In selecting the best alternative, one has to consider a number of factors. First, each subsequent alternative represents an increasing commitment to KML technology and markets for Galdos. Second, the weightings of strategic goals vary. The goals of high profit growth and high-end market leadership carry the most weight. Third, the potential upside, the downside and the uncertainty grow with each subsequent alternative along the three most important strategic goals. The downside resulting from the worst-case scenario (no demand for Galdos' products or services) or Galdos' inability to exploit the KML opportunity can be contained with real-options thinking. As described in Section 2.6, real-options thinking calls for gradual investments in R&D projects at pre-defined milestones depending on the success of previous investments. This approach would enable Galdos to keep the potential upside of its involvement in KML technology and markets while limiting the downside. Further, the value of a real option increases with uncertainty. The uncertainty and the potential upside are the greatest for the last alternative, and thus it has the greatest value for Galdos. Consequently, an active pursuit of KML markets using real-options thinking and staged decision and investment points is the best strategic alternative for Galdos.

7 CONCLUSION

This analysis sought to determine the best strategic response for Galdos to the impact of KML on its OGC standards-based business. The primary purpose was to assess the threat of KML to Galdos' business and devise a strategy for managing it. The secondary purpose was to determine how Galdos could approach exploiting the KML opportunity.

First, the potential of KML to substitute for GML was analysed in Chapter 3. It was found that KML might substitute for GML in simple-features geospatial applications given certain design changes and decoupling from Google Earth. Importantly, the analysis satisfied its primary purpose by concluding that KML was very unlikely to threaten Galdos' business because KML could not be used on the complex data models in which Galdos specialises. The focus of the analysis then shifted to understanding Galdos' current strategy and ways of exploiting the KML opportunity within the context of the current strategy.

The subsequent analysis proceeded on three levels: the GIS industry, the global OGC Geo-Web industry segment, and Galdos. In Chapter 4 industry analysis, GIS was found to be an industry growing at a moderate annual rate of approx. 10%. This growth rate could increase substantially as the GIS technology enters the realm of consumer- and business-oriented software applications. The environmental analysis on the level of the global OGC Geo-Web industry found this industry segment to be moderately-to-highly attractive, with Galdos as the competition-free leader in the high-end market segment. These findings and the Chapter 5 internal analysis led to a validation of Galdos' current strategy of focusing on the high-end OGC technology market segment. However, Galdos does need to carefully determine the boundaries of the beachhead market niche for chasm crossing. In addition, Galdos must be mindful of the fact that an aggressive competitor could imitate its capabilities.

The secondary purpose of this research was fulfilled in Chapter 6 by determining the best strategic alternative that exploits the KML opportunity while satisfying Galdos' goals. Four strategic alternatives were proposed:

1. Status quo – Keep focusing on the high-end OGC technology market
2. Internal KML projects – Build competence in KML while pursuing high-end OGC technology market
3. Support for KML in products – All of the above to some degree and also enable the use of products in KML software solutions by making them compatible with KML
4. Active pursuit of KML markets – All of the above to some degree and also participate in external projects, experimental ones and those that build production-ready KML software solutions

Three scenarios were constructed to represent the possible future levels of demand for Galdos' products and services in the development of KML solutions. The criteria for assessing the alternatives were formulated as four strategic goals (specified here in the descending order of importance): Geo-Web high-end market leadership, high profit growth, gaining expertise in marketing to pragmatic users and technological experimentation. Each subsequent alternative represents an increasing commitment to KML technology and markets. The potential upside grows with each subsequent alternative, but so does the uncertainty of outcomes. The devised scenarios merely amplify the uncertainty. Given that the uncertainty and the potential upside grow with each subsequent alternative, it was concluded that a real-options approach would assign the greatest value to the last alternative. The real-options approach assumes that Galdos will invest in this alternative gradually and only if the circumstances look propitious. This limits the potential downside resulting from the uncertainty, including that caused by scenarios. Therefore, an active pursuit of KML markets was deemed to be the best alternative across all scenarios.

7.1 Recommended Strategy

Galdos should actively pursue KML markets while continuing to be the leader in the high-end OGC technology market segment. The latter represents a continuation of Galdos' current strategy that builds on Galdos' capabilities and its leadership in the high-end market segment of a moderately-to-highly attractive industry. Exploiting the KML opportunity makes sense because Galdos has the potential to apply its expertise and products to KML software solutions, which can lead to increased profits and an enhanced market share in the high-end Geo-Web market. Foregoing the potential upside from KML markets could incur a large opportunity cost and help Galdos' competitors increase their market share at the expense of Galdos. Furthermore, since Galdos' current capabilities are imitable, growth resulting from entering KML markets may offset the negative effects of the eroding competitive advantage in the high-end OGC technology market. Galdos should adopt real-options thinking in its pursuit of KML markets due to its limited resources and to limit the potential downside from risky KML ventures.

7.2 Implementation Recommendations

Galdos' main and immediate strategic goal is to "cross the chasm" from their "early adopter" customer segments to "pragmatist" customer segments and to conquer the "bowling alley" in the OGC technology market. The chasm and bowling alley are two phases in Moore's (2002, 2004) technology adoption life cycle, described in detail in Section 2.1. The chasm is a phase of low demand for a new technology, resulting from the difficulty to get the pragmatic customers to adopt the new technology because they have different expectations from early adopters. The bowling alley is a metaphor for a post-chasm phase in the technology adoption life cycle in which a company conquers adjacent market niches starting with the beachhead market niche, the analogue of the "king pin". Moore contends that determining the appropriate beachhead market niche is essential for successful chasm crossing. This market niche has to be in great need for Galdos' products, without a competitor already serving the market, and adjacent to other market niches that Galdos can approach in the future. Galdos' target market of high-end OGC technology appears to fit this description. Galdos should pay attention to the need to precisely define the boundaries of the beachhead market niche. In addition, Galdos needs to pay attention to the fact that quick chasm crossing does not necessarily imply large profits, and that fast followers can erode its leadership in the high-end market segment (Moore, 2002, 2004).

The recommended KML strategy involves building competence in KML, providing support for KML in Galdos' products and actively pursuing projects with other organisations in which existing products will be enabled and new products developed for use in KML software solutions. In addition, Galdos may (co)develop entire KML software solutions. The projects may be funded by customers, or partly by partners. Marketing requirements are likely to come from customers and partners, although Galdos can also come up with ideas of its own. Galdos should retain the intellectual property developed in these projects.

Galdos' employees can be one important source of ideas for KML-related products and projects. Galdos should encourage its employees to brainstorm new ideas. Participation should be stimulated with incentives, e.g. people who come up with good ideas may get a financial reward if the idea is implemented. This can become a regular part of Galdos' human resources management.

Ideas should also be sourced from the environment. For example, the Geo-Web conference can play an important role in the exchange of KML-related ideas and establishing contacts with potential partners, especially since the scope of the conference now officially includes KML. It is possible that joint projects will result from the contacts established at this and other conferences. The OGC and customers may serve as another source of ideas. Galdos may also approach Google for this purpose.

In pursuing the KML opportunity, Galdos should adopt real-options thinking. To do so, they should start with a small commitment (e.g. building KML expertise, conducting small experiments) and then gradually increase the commitment depending on the success of their initial efforts. Galdos has limited resources and will likely have to rely on partners or customers to spread the cost and risk of KML-related projects. This situation may change if Galdos obtains venture capital. Farming out projects to the open-source community, colleges and universities may help reduce their costs, but may bring other problems related to intellectual property, confidentiality and quality.

Galdos may use the stage-gate process for conducting projects where new products will be developed (Cooper, 2000). This process applies real-options thinking to the level of individual projects. The STAR toolkit for a qualitative real-options assessment of R&D projects might be useful to Galdos in assessing and comparing R&D ideas from the internal perspective. It is important the Galdos involve a cross-functional team in applying the STAR toolkit so that ideas can be analysed from many angles (McGrath & MacMillan, 2000).

In order to follow the strategy recommended in this project, Galdos' capabilities will have to be enhanced to encompass KML. This should be possible because Google Earth and KML are similar to OGC technologies. Galdos may find it more difficult to approach customers with requirements different from those of current customers. Indeed, this increases the risk that Galdos will not be able to create products that satisfy the customer needs in KML markets. Galdos must minimise this risk through partnerships with companies that have the necessary marketing expertise.

APPENDICES

Appendix A – Open Standards

IT standards are agreements that define how information is exchanged or transferred. A standards' setting organisation (SSO) is an organisation that is involved in setting standards. A consortium such as OGC is an SSO that is not recognised by a government, although governments may work with it (Krechner, 2006).

What are the requirements for a standard to be considered open? Standards' creators, implementers and users have different perspectives on this. Krechner (2006) amalgamates their perspectives into 10 requirements:

1. Open Meeting – All can take part in the development of standards, i.e. nobody is barred from joining (though joining may involve a fee).
2. Consensus – There is no domination of any interest group in the decision-making process.
3. Due Process – It usually involves balloting and an appeals process for resolving issues.
4. Open World – The same standard applies worldwide.
5. Open IPR – Different SSOs approach the IPR topic differently. In the best case for standards implementers, the use is royalty-free.
6. Open Change – Changes to existing standards are approved in a forum that supports requirements 1-5.
7. Open Documents – This implies availability of and easy access to committee documents and finished standards.
8. Open Interface – It is possible to create extensions of subsets. This diminishes the dependency on implementations and thus benefits the user.
9. Open Use – This refers to the assurance (e.g. compliance certification) a user requires to use an implementation.
10. Ongoing Support – The SSO should support its standards as long as there is user interest in them.

It should be noted that these requirements are not universally accepted mandatory requirements for an open standard. Different SSOs may satisfy these requirements to varying degrees. OGC does, however, fully meet these requirements. Its standards may therefore be considered true open standards.

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