Global Headquarters: 5 Speen Street Framingham, MA 01701 USA P.508.872.8200 F.508.935.4015 www.idc.com

WHITE PAPER

Oracle 10*g*: Spatial Capabilities for Enterprise Solutions

Sponsored by: Oracle Corporation

David Sonnen (ISSI) Henry D. Morris

February 2005

EXECUTIVE SUMMARY

Today, spatial information management (SIM) technology is quickly migrating from specialized geographic information applications to broad relevance within IT ecosystems. This migration requires a spatially enabled IT infrastructure. Anticipating this requirement, Oracle has systematically integrated spatial capabilities into its entire technology stack since 1996. Looking forward, IDC expects Oracle's spatial capabilities to impact both geospatial and broad IT markets in the following ways:

- Increase geospatial presence within IT infrastructure, operational applications, and business analytics
- Increase emphasis within spatially enabled systems on such enterprise issues as data quality, security, and process-based integration
- Accelerate SIM market growth through broadly integrated geospatial capabilities within enterprise applications (Oracle is positioned to contribute to this growth through its service oriented architecture [SOA] integration environment; broad spatial capabilities; and growing spatially oriented partner network.)
- Accelerate the acceptance of location-determining technologies such as Global Positioning System (GPS), radio frequency identification (RFID), wireless LAN (WLAN), intelligent networked sensors, and cellular networks within enterprise systems
- Provide a near-term competitive advantage for Oracle that will motivate other IT infrastructure players to integrate spatial technologies into their offerings

To summarize, IDC expects Oracle to expand its presence from a role in spatial database management to a broader role as a provider of spatial capabilities for enterprise systems. This role will include not only a broadening of geospatial offerings but also new offerings in "biospatial" domains such as genomics, medical imaging, molecular chemistry, and life sciences.

IN THIS WHITE PAPER

In this paper, IDC outlines Oracle's spatial strategy and capabilities. We begin by outlining current spatial information management (SIM) market dynamics, then we discuss Oracle's specific capabilities and their impacts on the SIM industry. We close with a brief case study of Oracle's role within the British national mapping agency, Ordnance Survey.

To establish a proper context, one must understand that Oracle's spatial capabilities are an integral part of its broad information management strategy and products rather than a specialized application. Oracle has incorporated spatial data types, operators, language extensions and APIs, analysis functions, and visualization features into its standard database, application server, and development tools.

To establish a proper context, one must understand that Oracle's spatial capabilities are an integral part of its broad information management strategy and products rather than a specialized application.

We must also note that Oracle is already a known quantity among SIM users. In four separate surveys since 1999, IDC has found that Oracle holds about an 80–90% share of the overall geospatial database management market within medium-sized and large organizations.

SITUATION OVERVIEW

Definitions

Before we can discuss the spatial information market or Oracle's spatial capabilities, we have to define three key terms — spatial, geospatial, and geographic information system (GIS) — within the context of information technology. IDC defines these terms as follows:

- **Spatial.** Spatial data represents things that exist in space. Examples include data representing roads, property boundaries, X-rays, machine parts, or molecules. Spatial technologies store, manage, analyze, and display spatial data. Spatial applications areas include GIS, computer-aided design/manufacturing, genomics, medical imaging, molecular chemistry, and most life sciences.

- **Geospatial.** Geospatial data represents things that are referenced to a location on the earth. Examples include data representing roads, rivers, property boundaries, or building footprints. Geospatial technologies are the subset of spatial technologies that store, manage, analyze, and display geospatial data. Geospatial applications areas include GIS, location-based services, seismic survey, and geospatially enabled enterprise applications.

- **GIS.** GIS is an information system or application that stores, manages, or analyzes data that represents geospatial features and that supports geocentric workflows.

Enterprise Geospatial Systems

Oracle further identifies specific system characteristics for enterprise-class systems that require geospatial capabilities. Oracle sees enterprise geospatial systems as a class of geospatially enabled solutions that have one or more of the following characteristics:

- **Scope.** These systems encompass a broad range of data, including geospatial data, and support more than one application, organization, or set of processes. They typically support more than one type of spatial information (e.g., vector, raster, grid, and associated nonspatial data).
- **Accessibility.** Data is accessible to applications through standard programming languages, open APIs, development tools, and application-independent schemas.
- **Scale.** Applications support large data sets ranging from near-terabyte to petabytes and user communities ranging from hundreds to tens of thousands.
- **Security.** The shared nature of these systems requires deep, multilevel security mechanisms.

Oracle has staked out the enterprise and Web services as its competitive domain and intends to focus its considerable enterprise IT capabilities on enterprise-class geospatial markets.

Geospatial Markets

Today, geospatial technologies are increasingly shaped by a broad IT integration imperative: the driving need to orchestrate information to support business processes. This means that geospatial capabilities will have to be tightly integrated into applications as those capabilities are needed and managed as part of secure, adaptable information systems.

Going forward, information will be managed and accessed within service oriented architectures and standards-based integration platforms. This standards-based environment will allow information systems to freely exchange data and business logic to create information that supports dynamic business processes in real time.

Going forward, information will be managed and accessed within service oriented architectures and standards-based integration platforms.

Major IT infrastructure players such as Oracle, IBM, Microsoft, Siebel, and SAP are already delivering integration platforms that address this open, real-time business requirement. Some of these platforms have at least some geospatial capabilities.

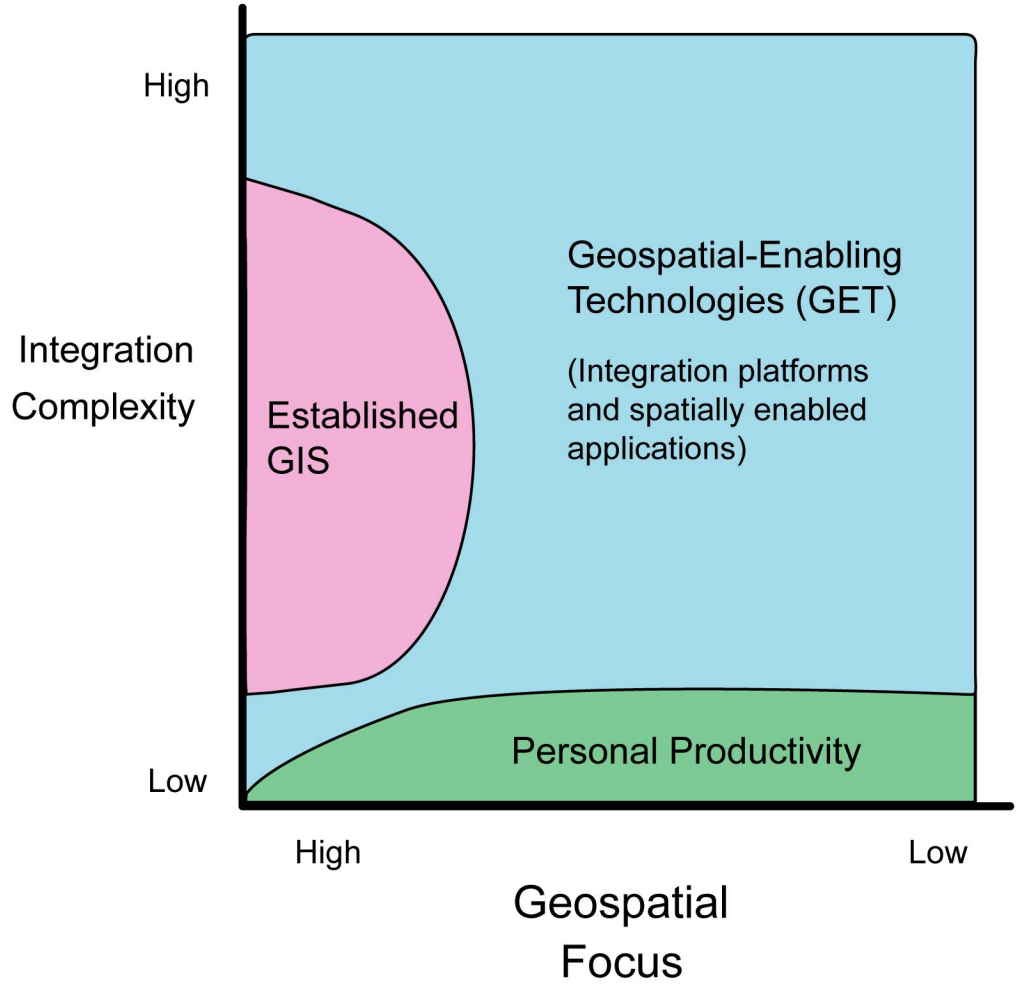
Oracle has developed the deepest spatial capabilities among the IT infrastructure players. The vendor includes foundation-level spatial features, at no additional cost, in each database and application server. It offers extensive foundation-level spatial data-handling capabilities as a feature set throughout its technology stack and design tools. Because spatial features are an integral part of Oracle's technology stack, its Java IDE (JDeveloper) and business intelligence toolset (Discoverer)

include spatial analysis using Oracle's standard features. Oracle also offers additional advanced spatial capabilities through its dedicated spatial capability set: Oracle Spatial.

How does the geospatial market map out? As shown in Figure 1, the market will organize around three major sectors: established GIS, geospatial-enabling technologies (GET), and personal productivity (i.e., simple Web-based and desktop applications).

FIGURE 1

SIM Market Map



Source: IDC and ISSI, 2005

Established GIS

Established GIS centers around an information systems approach to storing, managing, and applying data that represents geographic features and supports geocentric workflows (e.g., land records management, management of natural resources, utility asset management, and some applications within homeland security/defense).

The GIS sector is relatively mature with a knowledgeable and dedicated user community. This sector includes a tight-knit group of talented and passionate GIS technologists, a dynamic vendor community, a variety of user groups, meaningful standards activities, and well-established industry magazines and events. It will continue to grow and serve its community and geocentric workflows into the foreseeable future. Oracle will continue to participate in that growth.

Oracle's role has been to act as a repository for both spatial and nonspatial data. Today, Oracle's broad capabilities are increasingly used to integrate a wider range of spatial data into the rest of an enterprise's information. IDC has found a number of national mapping agencies, land management organizations, local governments, utilities, and telcos that use Oracle along with third-party GIS tools to extend GIS capabilities across enterprisewide systems. Oracle facilitates this GIS integration through a set of spatial and data management capabilities, including version management, persistent topology, network management, raster data management, geocoding, routing, visualization, and spatial business intelligence analysis operators.

Every major GIS vendor has supported Oracle's spatially enabled data management for nearly a decade. Today, Oracle's spatial integration platform goes beyond a spatial repository. It also enables both established GIS and emerging spatial application component vendors to extend spatial capabilities into IT infrastructure. For example, Autodesk now resells Oracle and depends on Oracle as the primary integration platform for Autodesk infrastructure and GIS solutions. Leica and PCI Geomatics are developing raster toolsets for large image repositories. Emerging spatial component providers such as Acquis, Geodan, eSpatial, IONIC, and Fichtner offer market-specific solutions that exploit Oracle's spatial platform. IDC has also found that systems integrators such as Northrop Grumman, Booz Allen Hamilton, and Lockheed Martin are increasingly using Oracle's spatial integration platform for large projects.

Geospatial-Enabling Technologies

Geospatial-enabling technologies (GET) are necessarily less well defined. GET is about adding geospatial data and capabilities to the broad spectrum of information systems. GET applications and workflows are not geocentric; however, geospatial information has value and is sometimes essential. Examples include risk assessment and mitigation, transportation, logistics, defense/homeland security, sales force automation, and CRM.

Oracle has staked out a strong GET position, and other major vendors such as IBM, SAP, and Siebel are trying to close the competitive gap. However, to date, no other IT infrastructure vendor has integrated geospatial capabilities into its technology stack as deeply as Oracle. For example, Oracle has extended its geospatial capabilities throughout its Oracle eBusiness Suite applications and offers spatially enabled Business Process Execution Language for Web Services (BPEL4WS).

Geospatial vendors are moving to stake out their own areas for growth by offering new integration capabilities for enterprise systems. They may either compete with Oracle or work to complement Oracle's capabilities. Success for these vendors will depend on the ability to deliver simple, seamless, and inexpensive geospatial capabilities to support business processes within established IT infrastructures.

The potential GET user base is orders of magnitude larger than that of GIS and consequently has the potential to become a strong revenue producer. Revenue will be realized from a broadened addressable market for applications, primarily from incremental sales of spatially enabled software and services.

Personal Productivity

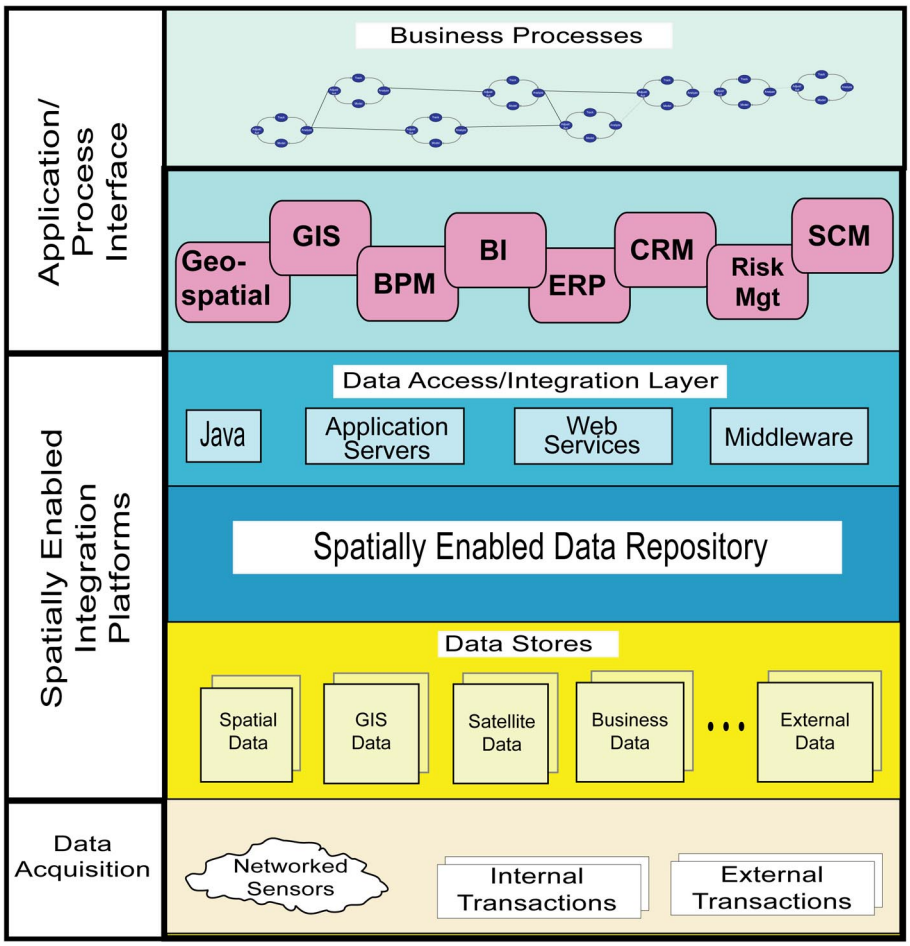
At the simpler end of the market, targeted Web services such as AOL MapQuest or Microsoft MapPoint.NET will continue to grow. Also, easy-to-use desktop applications such as Microsoft MapPoint will continue to spread among business users. Revenue will be realized from consumer-oriented business models and Web service subscriptions. Oracle will continue to provide foundation technology for companies providing services in this segment.

Technology Relationships

As SIM technology migrates deeper into enterprise systems, spatial capabilities will have to be integrated into every aspect of the full technology stack. As shown in Figure 2, formerly separate technologies such as database management and data access are merging into comprehensive integration platforms. As these integration platforms evolve, boundaries between technologies blur. Over the next few years, formerly separate geospatial technologies will be integrated into the whole enterprise stack.

FIGURE 2

SIM Technology Relationships



Source: IDC and ISSI, 2005

Application/Process Interface

The application/process interface represents the point where people involved in a business process use applications to support their activities. The application layer represents the business logic needed to assemble, analyze, and display data for specific user requirements. The application layer also includes capabilities for collaboration and portals for searching and assembling data from Internet-wide sources.

Data Acquisition

The data layers contain the many sources of data relevant to an enterprise. Most organizations own their corporate data and also tap external data for specific information used in their business processes. GIS users often have built significant spatial data collections that represent infrastructure, land, or other physical entities of interest to their organizations. This data is an extremely valuable resource.

Increasingly, transactions about physical things will be captured by sensor networks. These networks will augment or even replace some labor-intensive activities, such as inventory control and timekeeping.

Spatially Enabled Integration Platforms

Data access, management, and application services are merging into broad integration platforms.

Data access, management, and application services are merging into broad integration platforms. Data access and integration platforms such as IBM's DB2/WebSphere/ESB, Microsoft's .NET, and Oracle's 10*g* provide robust access to data from most sources. These platforms increasingly support complex data types, including spatial data, and increasingly serve applications to the application/process interface. As with the enterprise IT platform, the value of a Web services infrastructure is directly affected by how fully those services incorporate spatial capabilities.

As with the enterprise IT platform, the value of a Web services infrastructure is directly affected by how fully those services incorporate spatial capabilities.

Most spatial data is now managed in a commercial database rather than in proprietary data stores. Oracle and IBM have added the ability to store, query, and manage geospatial data as native data types. Oracle further supports network and other vector data models with persistent topology. Microsoft is adding support for user-defined data types and stored procedures to the next release of SQL Server.

Traditionally, individual applications have provided data access. For example, a report generator would convert a user's query to SQL and parse it to a specific database. Then, the report generator would format the resulting data set into a report useful for the user.

Driven by integration requirements, data access today is largely independent of applications. It is increasingly accomplished using standards-based tools such as SQL, XML, XQuery, and Java.

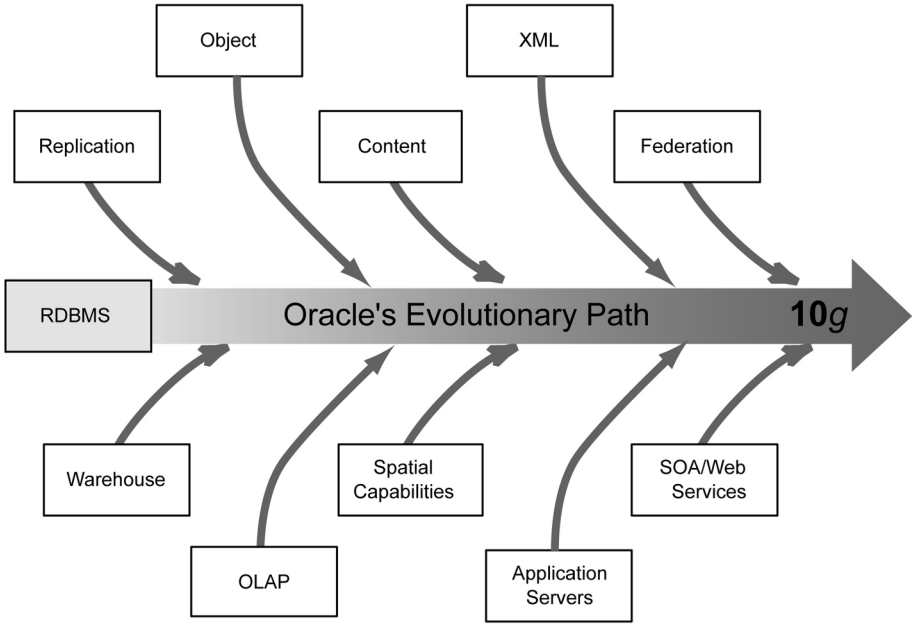
ORACLE SPATIAL TECHNOLOGY

Oracle supports information systems that range from workgroup to multienterprise systems.

To understand how Oracle supports these systems, one must understand how Oracle has evolved from its beginnings as a relational database vendor. As shown in Figure 3, in the past several years, Oracle has added a number of capabilities that facilitate enterprise implementations.

FIGURE 3

Oracle's Evolution Toward Enterprise Spatial Integration



Source: IDC and ISSI, 2005

One of those capabilities is "spatial." Oracle first added a spatial capability in 1996 — a rudimentary point feature handler with a grand name: "helical hyperspatial" code or just "HH." HH code allowed the Canadian Hydrographic Survey to store, index, and display millions of bathyspheric data points. HH code is long gone, as are the cumbersome relational representations of earlier versions.

Today, Oracle is now in its third generation of spatial capabilities, and with Oracle 10*g*, spatial capabilities are integrated throughout the entire technology stack. These capabilities include self-tuning R-tree indexing, scalable partitioning for multiterabyte data sets, and Real Applications Cluster (RAC) support for near-linear scalability for high-availability and high-performance systems. Oracle 10*g* enhances Oracle's SOA infrastructure with spatial capabilities.

We begin our discussion of Oracle's spatial technology with a brief overview of Oracle's 10*g* capabilities.

Oracle 10*g* Overview

Oracle 10*g* will have a significant impact on spatial deployments. The "*g*" in Oracle 10*g* stands for "grid" — a deep enterprise information management strategy. From a spatial perspective, Oracle's 10*g* strategy and capabilities are important because they facilitate the integration of geospatial capabilities within enterprise computing environments. (For details, see *USGS Adopts Oracle Grid Computing*, IDC case study #4278, November 2004.)

It is important to note that many of Oracle's enterprise integration features, such as security, cluster support, and index/data partitioning, are available only if applications use Oracle's spatial data types and operators.

It is important to note that many of Oracle's enterprise integration features, such as security, cluster support, and index/data partitioning, are available only if applications use Oracle's spatial data types and operators.

Highlights from Oracle's 10*g* strategy/capabilities include:

- **SOA/Web Services support.** SOA and Web Services are changing the economics of integration — reducing integration costs while increasing business agility. Through a number of surveys and research projects, IDC has found that SOA and Web Services represent the majority of new application initiatives and have not yet peaked. Oracle anticipated the requirement for SOA and Web Services and has implemented the necessary capabilities within Oracle Application Server 10*g*. These incorporate J2EE 1.4 Web Services standards for messaging reliability, transactions, coordination, and security. In addition to these J2EE standards, they include message-based integration; modular/pluggable components; XML interfaces; and BPEL design, development, and implementation capabilities. IDC expects SOA/Web Services to become a key basis for competition among IT infrastructure providers and, consequently, to continue to receive attention from Oracle.

- **Security.** Oracle takes security seriously. Oracle Database 10*g* provides end-to-end security technology, including Virtual Private Database, Fine Grained Auditing, encryption APIs, secure application roles, proxy authentication, global application context, and the ability to support directory-based application user management. In addition, Oracle offers two add-on security options for Oracle Database 10*g*. Oracle Advanced Security enables strong authentication and network encryption. Oracle Label Security enables row-level security and deploys an infrastructure for managing security clearances to control access to critical business data. Oracle Label Security can also be used with Oracle Identity Management to deploy security clearance management for the entire enterprise and centrally control access to databases using sensitivity labels.

- **Cluster support.** Oracle 10*g* is designed to operate effectively on low-cost servers, which, in the event of server failure, can be treated as disposable at the physical level. Oracle 10*g* supports clusters of up to 64 nodes independent of any third-party clustering software. Nodes can be added or dropped in flight. Oracle provides the ability to clone a server instance and implement it on a different node to simplify the provisioning of nodes in a server farm. The U.S. Geological Survey (USGS) uses this capability extensively within its 60-server datacenter.

- **Federated data.** Although Oracle has supported data federation for some years, 10*g* is really the first time the company has described data federation as a viable strategy (as opposed to Oracle's traditional single data store approach). Oracle has strong support for various types of nonrelational data, including spatial data, and now provides an XQuery capability (that will not become a default part of the package until the XQuery standard itself has stabilized). The single data source strategy is also supplemented in Oracle 10*g* through the raising of limits to permit "massive database" support up to 8 million terabytes, with several other limits also raised correspondingly. This capability is important for systems that handle many diverse data sources. Intelligence systems within the National Geospatial-Intelligence Agency are an interesting example.

- **Manageability and tuning.** In earlier releases, Oracle gained a reputation for requiring higher-than-average administration and management resources. The previous Oracle 9*i* went some way to removing this objection, and in Oracle 10*g* there has been another step improvement. Many parameters that are environment dependent are now configured by the system itself and have become invisible to DBAs. Additionally, the system now keeps a record of many metrics in its own statistics data warehouse, which it uses to derive suggested changes to the infrastructure. At this release, these are advisory only, but the future intention is for the system to become self-tuning. Further enhancements to the optimizer likewise provide advice on the building or dropping of indexes and the creation of materialized views, which become physical tables that represent a logical view and are dynamically updated as the underlying data changes. This property is important for large, high transaction rate systems such as that of Great Britain's Ordnance Survey. (See the Ordnance Survey case study at the end of this paper for details.)

Oracle Spatial Capabilities

Oracle has rolled most spatial features into Oracle 10*g* Enterprise and Oracle 10*g* Standard as a no-cost feature set called Oracle Locator. This means that many applications can be spatially enabled using standard components that are present at no additional cost in every Oracle database and application server. Specific Locator features include:

- Object types that describe and support geospatial features such as points, lines, and polygons
- Self-tuning R-tree indexing that is integrated into Oracle's database servers
- Spatial operators that use the spatial index to perform spatial queries
- Storage, management, and use of geodetic data
- Open, standard SQL; XML; and XQuery access to spatial operations and data

IDC expects that Oracle will soon enhance Oracle 10*g* Locator spatial functions that are important to business mapping applications. These expanded capabilities are likely to include:

- Deeper spatial integration with Oracle Application Server 10*g* and Oracle Business Suite
- Direct linkages to geospatial data sets from companies such as NAVTEQ and Tele Atlas

Oracle 10g Locator and Spatial

Oracle Locator is best suited for spatially enabling the majority of enterprise applications that have relatively straightforward geospatial requirements. Oracle 10*g* Standard Edition with Locator provides foundation-level geospatial data management. A number of solution providers and ISVs have embedded Locator into their own solutions. These solutions are generally targeted at price-sensitive customers such as local governments.

Oracle Locator is best suited for spatially enabling the majority of enterprise applications that have relatively straightforward geospatial requirements.

For more complex applications, such as GIS, Oracle recommends Oracle Spatial, an option to Oracle 10*g* Enterprise Edition. Oracle Spatial Option provides advanced spatial functionality, such as spatial functions (including area, buffer, and centroid calculations), advanced coordinate systems support, and linear referencing systems; topology; aggregate functions; network data models/operations; routing; as well as geocoding and support for gridded, TIN, and raster data sets. Oracle Spatial also supports direct interfaces with all major GIS systems, including those from ESRI, Autodesk, Intergraph, and MapInfo.

The focus of the new Oracle 10*g* Spatial features is to address the requirements of enterprise geospatial solutions customers by providing the following six capabilities:

- **Network data model.** A data model is provided to store network (graph) structure in Oracle Database 10*g*. It explicitly stores and maintains connectivity of link-node networks and provides network analysis capability such as shortest path and connectivity analysis. Applications requiring network solutions include transportation, transit, utilities, and life sciences (biochemical pathway analysis).

- **Routing.** For transportation applications, the network data model also supports a routing feature. Oracle introduces a scalable routing engine that provides driving distances, times, and directions between addresses (or locations that have been geocoded in advance). It is provided as a Java library that can be deployed in either Oracle Application Server or standalone Oracle Application Server Containers for J2EE (OC4J) environments. Other features include preference for either fastest or shortest routes, returning summary or detailed driving directions, and returning the time and distance along a street network from a single location to multiple destinations.

- **Topology data model.** Oracle Spatial includes a data model and schema that persistently store topology in Oracle Database. This is useful when there is a high degree of feature editing and a strong requirement for data integrity across maps and map layers. Another benefit is that topology-based queries typically perform faster for queries involving relationships such as adjacency, connectivity, and containment. Land management (cadastral) systems and spatial data providers benefit from these capabilities.

- **GeoRaster.** A new data type natively manages georeferenced raster imagery (e.g., satellite imagery, remotely sensed data, and gridded data) in Oracle Database 10*g*. Oracle Spatial's GeoRaster feature provides georeferencing of imagery; XML schema for metadata management; and basic operations such as pyramiding, tiling, cropping (subsetting), and interleaving. Applications in environmental management, defense/homeland security, energy exploration, and satellite image portals may benefit.

- **Spatial analytic functions.** New server-based spatial analysis capabilities include classification, binning, association, and spatial correlation — essential for business intelligence applications.

- **Geocoder.** Oracle Spatial features a geocoding engine that provides international address standardization, geocoding, and POI matching by querying geocoded data stored in Oracle Database. Its unparsed address support adds flexibility to customer applications. The Oracle Spatial geocoder is implemented as Java stored procedures inside the Oracle database server. A PL/SQL API for geocoding is provided.

Oracle has included a MapViewer component within Oracle Application Server. This software offers developers the option of rendering map data without having to develop or license their own map rendering engine. Oracle's MapViewer supports standard graphic formats such as JPEG, PNG, and SVG (Scalable Vector Graphics). MapViewer is also integrated with Oracle's JDeveloper Java development IDE. This Web Mapping Service (WMS)–compliant map server and visualization component is included at no cost with Oracle Application Server.

Oracle has an established user base within both the GIS and GET segments. The number of Oracle users that use spatial capabilities is hard to determine because those capabilities are blended with other Oracle features. However, in four separate surveys since 1999, IDC has found that Oracle holds about an 80–90% share of the overall geospatial database management market within medium-sized and large organizations.

Oracle sells geospatial technology through three primary channels: direct, integrators, and partners. Oracle's direct sales force has proven to be effective in large sales, particularly to government agencies. The vendor works with major systems integrators on a typical project-by-project basis. In addition, Oracle partners with GIS vendors such as ESRI, Autodesk, Intergraph, and MapInfo to provide complete GIS and geospatial solutions, particularly for geocentric workflows.

Oracle aggressively recruits third-party geospatial partners and aggressively keeps its partnering program open to all geospatial vendors.

Oracle's Strategic Impact on the SIM Industry

Oracle's spatial capabilities impact the geospatial industry in four specific ways:

- Lower cost for spatial integration. Because many of Oracle's spatial capabilities are a feature set within the vendor's technology stack, the cost of spatially enabling and operating information systems will be reduced significantly. Lower development costs will accelerate the uptake of spatial capabilities throughout broad IT communities.

- Oracle's SIM functionality is now available to its 200,000 client organizations and its developer community as an integral, no-cost feature set. This fact drives significant new opportunities for SIM and other technology vendors that want to spatially enable their own products. This is valuable in shortening the sales process for geospatial applications built by ISVs because there is no need to sell additional infrastructure over and above what potential customers already have in their datacenters.

- Oracle has tightly integrated spatial capabilities into its database and application server technology. This moves geospatial technology from being a specialty application to being a part of base-level information infrastructure. This integration simplifies the use of spatial data in business applications and removes much of the cost of using spatial data.

- Oracle's spatial feature set is now available to the Oracle, Java, and .NET developer communities. This means that developers can integrate spatial features directly into business and location-based applications at relatively low costs and with minimal training.

CASE STUDY: ORDNANCE SURVEY

With roots dating back to the eighteenth century, Ordnance Survey (OS) is well known to generations of British citizens for its comprehensive travel, historical, and planning maps. Today, the national mapping agency of the United Kingdom delivers much more than just maps.

Although Ordnance Survey is a government agency, it is funded entirely through revenue generated from licensing fees for its data and services. As a result, it must manage costs in the same way as any other commercial organization, be responsive to the public's needs, and continually seek new sources of revenue. To meet its £150 million annual revenue requirements, OS has had to adopt an entrepreneurial approach to its business. The agency's innovations are changing the foundations of national mapping in Britain and worldwide.

Here's what OS is doing: In the past four years, OS has made a step change from producing digital maps to providing comprehensive geographic information for a wide range of commercial and government applications. The foundation of Ordnance Survey's new business is a program it calls Master Map, which is an information system that acquires and maintains comprehensive geospatial and georeferenced data across the United Kingdom.

Master Map's organizing principle is a convention with an unusual name: the "Topographic Object Identifier" or TOID. A TOID is a unique, persistent identifier for geographic objects as small as two centimeters. This means that every building, road segment, and railroad track — or any other geographic feature — in Britain can be uniquely identified and have an essentially unlimited amount of data associated with it. For example, a building may be associated with records about the owners, taxes paid, historical use, current and past valuations, construction materials, hazardous materials present, or anything else.

The TOID convention also provides a persistent point for data interchange between Ordnance Survey and its customers. For example, a city may update Ordnance Survey's data about city roads as the city maintains those roads. OS can then update its Master Map database so that the rest of Britain has current data about that city's roads.

Master Map is proving to be a success. However, it poses serious information processing challenges. Ordnance Survey must manage multiterabyte data streams with precision and accuracy on a 24 x 7 basis. It must also exchange data with

thousands of British businesses and consumers daily while managing varying license terms for each user and collecting fees that vary for each use.

OS started working toward the Master Map system about five years ago. It consolidated about 40 different databases that were running different products into an Oracle enterprise database. The resulting data resource is a 2TB unified logical data set.

To manage this data set, Ordnance Survey uses the spatial features of Oracle Database, which require no customization to enable third-party applications to display location data, including regional revenue and customer demographics. Oracle Locator, a standard Oracle Database feature, displays physical assets such as roads, bridges, gas lines, and telephone and electric networks for a wide variety of uses that range from charting traditional maps to producing business intelligence and managing assets. In addition, Ordnance Survey uses the Oracle Spatial Option to Oracle Database Enterprise Edition along with third-party GIS software tools for geospatial data entry, edits, analyses, and data manipulation.

How does Oracle handle OS requirements? According to Ed Parsons, OS CTO:

> We needed a database with high accessibility, availability, performance, and reliability. Because we couldn't compromise on any of these criteria, we chose Oracle. Before Oracle, we had to generate much more software in-house and customize up to 80% of the third-party products we use. Now customization is down to potentially 20%, saving us time and money. In addition, managing a spatial database on Oracle is like managing any other Oracle database as far as my team is concerned.

In short, Oracle handles the load of a real-time, national-level geospatial information system well.

CHALLENGES/OPPORTUNITIES

Oracle's primary opportunity centers around establishing the leadership position in spatially enabled IT infrastructure. If Oracle can maintain this position, its spatial technology will become deeply established within large enterprise systems and across a wide range of spatially enabled business applications. Additionally, Oracle is positioned to gain the attention of the following two key constituencies:

- **Systems integrators.** Systems integrators need a direct way to integrate spatial technology into their customers' systems. Oracle's 10*g* platform provides known enterprise integration capabilities. Since spatial capabilities are included in the 10*g* package, integrators are likely to use Oracle when they need cross-enterprise spatial integration.

- **Developers.** The demand for enterprise spatial integration opens interesting new opportunities for both geospatial specialists and enterprise developers. As users demand spatial capabilities within enterprise applications, Oracle provides a safe, standards-based option for both groups.

IDC sees four challenges for Oracle as it moves deeper into spatial markets:

- Like any pioneer, Oracle is moving into uncharted territory. It will have to find and solve the tough problems associated with spatial integration while building customers' confidence in its capabilities.

- Some of Oracle's new territory overlaps with that of some established GIS vendors. Oracle needs to maintain a cooperative relationship with those vendors while competing in some situations. While this cooperate/compete relationship is increasingly common across all of IT, it will still be challenging.

- Oracle has established a position as a provider of spatial integration platforms. Eventually, it will have to pay for its success through increased competition from other IT infrastructure players. Both IBM and Microsoft are adding spatial capabilities to their own integration platforms. Eventually, Oracle will have to differentiate itself from these IT infrastructure competitors.

- Spatial capabilities are becoming more common among enterprise applications such as business intelligence, ERP, CRM, and supply chain management. As this migration continues, enterprise software vendors such as SAP, Siebel, and Business Objects will need to differentiate their offerings from Oracle's. These companies may elect to develop their own spatial capabilities or license them from established geospatial vendors.

CONCLUSION

Oracle has made an unambiguous commitment to spatial technology across its technology stack. Coupled with Oracle's well-established customer base and deep expertise in enterprise integration, the company's spatial capabilities are having a profound, positive effect on the SIM industry. Perhaps more importantly, Oracle is helping to open new markets for spatial technology.

IDC believes that Oracle's success will continue and that Oracle will accelerate the adoption of spatial technology within enterprise systems. Oracle, along with a wide range of allied vendors and their customers, will see commercial success and more capable information systems because of Oracle's commitment to spatial technology.