CEO - GPS Industry Assessment

Conducted for the Department of Commerce
by
The Institute for Defense Analyses

December 1998

L Kirk Lewis

Summary

The Interagency GPS Executive Board (IGEB) is deliberating the various aspects of proposed military and civilian modifications to the Global Positioning System. As with any modernization program considerable time and energy is being spent I determining the road maps to develop and employ these new capabilities. Key to the success of this modernization effort is GPS user community input. Understanding the needs of the user community at various milestones will assist the IGEB in determining what improvements are required and in quantifying the funding required to make GPS modernization a reality. With these goals in mind the Department of commerce asked the Institute for Defense Analyses (IDA) to conduct a limited survey of various users of the Global Positioning System to gain a better understanding of their thinking on the current GPS system and the impact of proposed future developments.

Key questions.

The purpose of this assessment was to gain knowledge derived from answers to the following questions:

How would your business (directly and indirectly) be affected by more robust GPS signal from space (2nd and 3rd civilian frequency/signals)?

"Without the increased robustness of additional frequencies and augmented systems such as differential and pseudolites, the technology will only be adopted sporadically for the basic transportation infrastructure. The nation will be faced with either restriction to economic growth or huge capital expenditures with substantial environmental impact. Efficiency gains in the 20% – 30% ranges for our fixed transportation infrastructure are reasonable assumptions. The national treasury is paid back by the taxes on the increase in economic activity" Charlie Trimble CEO US GPS Industry Council

What economic benefits would be accrued for your business if this new capability were available by 2005 versus 2012?

"Sooner is better from the standpoint of commercial development and leverage. The payoff for the country comes from the productivity and safety of life advantages of the applications, not from the direct sales of user equipment" Charlie Trimble

General Findings:

- **End the use of Selective Availability**
- **Future potential directly depends on how quickly that system is upgraded.**
- **Improved capability will provide major improvements in throughput / capacity / productivity and safety.**
- **Delay in modernization could reduce the potential of the system.**
- **Economic impact difficult to assess.**
- **Must insure the protection of GPS signal spectrum in international community**
- **If modifications are delayed the U.S. risks losing its preeminence in GPS**

SCOPE OF SURVEY AND DISCUSSION OF FINDINGS

Scope

Sample current users, developers, and associations

This assessment was conducted over a six-week period October 24 through December 3 1998. The assessment was not constructed to meet scientific methods or to be all-inclusive. It was conducted to afford decision-makers of the Department of Commerce an opportunity to get a snapshot of the current thinking of those participating in the assessment. Other studies and assessments ("GPS Market Projections and Trends…" DoC) provide a more in-depth understanding of the dynamics effecting the development and use of GPS. Data was gathered through telephonic discussions with CEO's and senior officials of 25 industries/associations, written responses, and information presented at Department of Commerce Executive Round Table discussion by key industry executives. Industries participating in these efforts included direct users of the GPS positioning and timing signals and producers of GPS equipment and services. (List is at appendix A)

General Findings

End the use of Selective Availability

There was a general consensus that the first agenda item for the Government is to end the use of Selective Availability (SA). Both individual and higher end users would see a marked increase in accuracy and therefore increased utility and opportunities for new applications with the ending of SA.

Future potential directly depends on how quickly that system is upgraded.

GPS has demonstrated its potential to become a truly global information utility. Its ability to fulfill this potential will to a great extent depend on how rapidly the current system is modernized and the level of increased signal power and number of signals needed to provide the positioning and timing data globally 100% of the time. As many users of the current system have learned their need for additional accuracy is addictive. Increased accuracy breeds new opportunities and applications. The current single frequency available for the civilian community and power of that signal is neither accurate nor robust enough for many of the envisioned applications. The timeline for current programmed modernization of the GPS system is so far in the future (from a business perspective more than 5 years) that it may not meet the needs of users. The demand for a common geospacial information is such that opportunities exist for other means to potentially provide this information, e.g. cellular telephones using TMD techniques, GPS/GLONASS receivers, etc. The extent that this will occur will in part be determined by the rate of the GPS modernization effort. As stated by the American Association of Railroads representative, "We continue deferred investing (at considerable expense) in GPS systems waiting for demonstrated government leadership in moving the modernization program forward." They do not want to commit the billions of dollars necessary to use GPS and its augmentations unless it fulfills levels of service that will meet their needs.

Improved capability will provide major improvements in throughput / capacity / productivity and safety.
New GPS capability will have significant impact on commerce in two major ways: It will greatly increase throughput/capacity/productivity of goods and services and significantly increase safety awareness thus reducing loss in equipment, time and manpower. Having a robust capability of knowing where things are in a four-dimensional global common geo-reference system will provide large economic benefits for users of this information utility. For example, agriculture will realize increased crop productivity through accurate placement of seed, fertilizer and speed of delivery to customers while reducing the hazards to the environment and experiencing greater safety through the use of the new capability of GPS. The fourth dimension GPS time will continue to play an ever-increasing basic component of the growing information infrastructure. Today we enjoy less than 100% availability of GPS signals and pay the price by limiting the use or using other systems to compensate for these shortcomings in a variety of ways depending on the GPS application. To a great extent additional signals and power will overcome these deficiencies and provide better use of current systems along with new opportunities not yet envisioned.

Delay in modernization could reduce the potential of the system.
The demand for geospacial information is out pacing the capability of the current GPS. Users are looking for other potential means of delivering the needed positioning and timing information. The longer the time until new capability is fielded the greater the potential for GPS to play a lesser role in this critical information service.

Economic impact difficult to assess.
Many of the today's applications were never envisioned at its inception. Differential GPS and Real Time Centimeter (RTK) accuracy were not predicted. Such capabilities have increased user productivity by a factor of more than two. GPS significantly lowers the operating costs of operations while greatly increasing their productivity. The economic impact of what the current systems provide has yet to be fully determined. What value is assigned to the critical role that GPS time provides to Internet operations, ATM banking and power distribution? It is relatively easy to calculate that by the year 2000 the GPS receiver industry could see $8 billion in sales and services. Respondents also pointed out that until the Government programs, GPS and the other augmentations are well developed and articulated to the users, it would be difficult to predict the amount of economic benefits in the year 2005 even more difficult to predict those in 2010. Yet all users: agriculture, aviation, automotive, banking, commercial space, construction, emergency medical response, mining, oil, surveying, transportation, telecommunications, and utilities see considerable economic benefits and potential.

Must insure the protection of GPS signal spectrum in international community
The World Radio Conference of 1997 brought to the attention of the user community the vulnerability of the use of the GPS spectrum to the building pressure of use of the L-band by other systems that could interfere with the GPS signal. Unless the GPS spectrum is protected it could have a significant impact on the full utilization of space based positioning and timing signals. This would translate directly to a negative economic situation.

If modifications are delayed the U.S. risks losing its preeminence in GPS

"If the US government does not act quickly to continue to improve this global utility, GPS will probably not be the global standard for worldwide positioning/ navigation/timing in 2112." (Magellan)

"All of this analysis assumes that the US remains ahead of the international community in fielding advanced GPS, or GPS-like capability, setting the defacto standards. If enhanced GPS is not accelerated, then the US is at risk of loosing this advantage of position—in the marketplace, or with regard to national security." (Lockheed Martin Corporation)

"More importantly the US is currently preeminent in the GII [Global Information Infrastructure]. If this new capability were available by 2005 versus 2012, this would be a wise national investment helping to ensure and advance this continued preeminence."…….."We need the flexibility to capture opportunities as they arise. One-of-a-kind block change satellites with no flexibility can no longer be afforded. The ability to do this will ensure continued national preeminence in the GII." (Trimble Navigation)

Written Responses

Association of American Railroads
North America's Freight Railroads Online

Company: Association of American Railroads

Address:
50F St MW
Washington, DC 20001

EVP: Charles Dettmann

Business Sector: Railroads

1997 Gross Sales: AAR has no sales, but railroad freight revenues were in excess of $35 Billion

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How would your business (directly and indirectly) be affected by a more robust GPS signal from space (2nd and 3rd civilian frequency/signals)?

The addition of the 2nd and 3rd signals would improve the availability of the signals to the railroad industry. While these new frequencies do not improve the accuracy of the signal available for civilian use, there are several railroad applications requiring the use of GPS that will benefit from the additional frequencies.

The railroads currently use GPS for mapping and remote monitoring of forces on cars carrying automobiles. They are considering using GPS augmented by a differential correction for Positive Train Control (PTC). This application requires submeter accuracy in some instances. PTC will require a continuous GPS signal for all equipped trains, which operate over the national rail network. Analysis has shown that PTC rail capacity could be increased 20-25% on heavily traveled routes. The new frequencies would enhance the national availability of GPS for this application. Additionally with greater information about the exact location of trains and cars there would be a direct payback from a safety and accident avoidance perspective. Currently we believe that this initial amount would be in the $33M range. Our members currently face the dilemma of if and when to make the full investment in GPS based systems. Since billions are involved it is critical that we understand from the government when GPS will meet our needs. This is critical to preclude early commitment of funds before the capability is made available

What economic benefits would be accrued for your business if this new capability were available by 2005 versus 2012?

There is no readily apparent improvement from acceleration of the availability of the new frequencies. It is difficult to forecast the railroad uses' of GPS eight to 15 years in advance.

Association: Air Transport Association of America

Address:
1301 Pennsylvania Avenue, NW, Suite 1100,
Washington, DC 20004-1707

CEO: Carol Hallett

Business Sector: Airline Trade Association

1997 Gross Sales: ATA has no sales, but airline operating revenues were $109 Billion

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How would your business (directly and indirectly) be affected by a more robust GPS signal from space (2nd and 3rd civilian frequency/signals)?

Operation of airline aircraft could be significantly improved in both safety and efficiency. A second civilian GPS frequency will really become a necessity. The number of airline aircraft that will be operated for the benefit of public service will increase over the next few years to the point of air traffic gridlock. GPS will permit precision navigation that will permit better use of the airspace, and will facilitate the growth that is needed to serve public needs.

The second frequency would have to be in the aviation band of frequencies. It could provide increased protection against interference, intentional or unintentional. It could also permit ionospheric comparison on board the aircraft, with or without WAAS.

FAA's implementation of the Wide Area Augmentation System (WAAS) for GPS could be simplified and less expensive with a second frequency.

What economic benefits would be accrued for your business if this new capability were available by 2005 versus 2012?

A second civilian GPS frequency will provide some safety benefits, and safety benefits should be provided earlier rather than later.

No civilian use receivers that can accept a second GPS frequency will be available from the private sector until there is assurance that there will be a second frequency.

If there is going to be a second frequency, we need it as early as possible to permit aircraft operators and the air traffic control system providers time to plan for its use in the infrastructure.

CEO ROUNDTABLE ON GPS ISSUES

Company The Boeing Company

Address:
1200 Wilson Blvd.
Arlington, VA 22209

CEO/Contact: **Frank C. Weaver**
Director, Telecommunications Policy
(703) 465-3448

Business Sector: **Aerospace and Defense**

1997 Gross Sales: **$45.8 billion - which is comprised of:**
$26.9 billion – Commercial Aircraft
$18.1 billion – Information Space & Defense Systems
$ 0.7 billion – Other

How would your business (directly and indirectly) be affected by a more robust GPS signal from space (2nd and 3rd civilian frequency/signals)?

Even though The Boeing Company is the contractor of the Global Positioning System IIF, it is the primary users, the aviation industry and the military, that derive the greatest benefits. However, The Boeing Company is responsible for integrating GPS equipment on aircraft.

Availability of a 2nd and 3rd civilian frequency would enable airline operators to improve safety and to increase navigation accuracy thereby by reducing accidents resulting from controlled flight into terrain, mid-air collisions, landing, runway incursion, and other causes.

Also, greater efficiency can be obtained by flying more direct routes, thereby lowering fuel burn and reducing pollution and noise.

What economic benefits would be accrued for your business if this new capability were available by 2005 versus 2012?

An earlier availability of additional GPS civilian signals would enable capacity enhancements to meet the growing passenger demand for air travel. Worldwide air travel is projected to grow an average of 5% per year over the next 10 years. According to the Air Transport Association, trans-oceanic traffic growth is constrained due to spacing requirements between in-flight aircraft, because terrestrial navigation is not available over oceans.

Transition to a satellite-based Communications, Navigation, and Surveillance/Air Traffic Management (CNS/ATM) system that utilizes enhanced GPS civilian signals will be a vital part of the solution to the challenges of increasing air travel, increasing numbers of flights, and relieving airport congestion. Such a transition by the aviation industry has the potential to reduce the spacing requirements and to increase the capacity of the air traffic system while improving navigation accuracy.

Therefore, an earlier introduction could help to alleviate some of the potential congestion by introducing technological advancement into the infrastructure to sustain the forecasted growth.

Additional Comments:

Coordination of internationally adopted frequencies could lead to standardization of GPS receivers, and the economies of scale could lower the cost of manufacturing separate equipment to operate on various frequencies. Aviation safety can also be enhanced through standardization thereby allowing the adoption of an international system for navigation.

Company -- Boise Cascade Corporation

Address
1111 West Jefferson
Box 50
Boise, ID 83728-0001

CEO **George Harad**

Business **Sector Pulp & Paper, Building Products, Office Products, Forestry & Forest Products**

1997 Gross Sales ($) $5.494 billion

How would your business (directly and indirectly) be affected by a more robust GPS signal from space (2nd and 3rd civilian frequency/signals)?

The largest benefit to BCC would be the ability to have access to real time data correction, reduced time to create a fixed point, and 1-meter or better accuracy. If the additional channels will accomplish these goals, then it will reduce the time required for fieldwork and post processing of GPS data. This would reduce the turn around time on field projects and increase the number of uses in the field for GPS.

What economic benefits would be accrued for your business if this new capability were available by 2005 versus 2012?

Economic benefits to improved services at the same cost to be delivered in 2005 vs. 2012 based on both increase field productivity on existing work and increased number projects or GPS applications would range from 4 to 8 million dollars in.

Company: Caterpillar

Address
100 NE Adams Street
Peoria, IL 61629-5310

CEO Mr. Donald V. Fites
CEO & Chairman
Business Sector: Construction, Mining, Agriculture, and Environmental

1997 Gross Sales $18.9M

How would your business (directly and indirectly) be affected by a more robust GPS signal from space (2nd and 3rd civilian frequency/signals)?

Caterpillar has recently launched a new product that is usable only if dual GPS signals are available. This new product is our Computer Aided Earthmoving System (CAES). Briefly, this product provides earthmoving machine operators with real-time information describing the task they are performing. Traditionally this information has been provided to the operators by survey stakes, paper plans, and extensive supervision. The Caterpillar Computer Aided Earthmoving System provides this information by an innovative combination of high technology that includes data radios, on-board computers, graphic displays, and GPS. GPS is used to determine the real-time location of the earthmoving machine to within centimeters. Fast, accurate location of the machine is absolutely essential to the operation of CAES. Early customer results confirm that CAES can dramatically improve the accuracy and efficiency of a variety of earthmoving operations. A more robust GPS will ensure these customers that the benefits of CAES will continue uninterrupted. Furthermore, a more robust GPS will permit CAES to be used in applications where the current GPS has too limited satellite visibility because of terrestrial obstructions.

What economic benefits would be accrued for your business if this new capability were available by 2005 versus 2012?

The earlier availability will result in increased CAES sales and the resulting increased efficiency and savings for more Caterpillar customers.

Additional Comments:
Caterpillar feels that a Wide Area Augmentation System (WAAS) would be beneficial to current users of GPS and GPS based products like our CAES. Furthermore, we feel WAAS would increase the total number of GPS users by making higher accuracy GPS more easily obtainable.

Also, in their quest for a robust solution, many of our customers and potential customers are requesting that CAES use GLONASS as well as GPS. We believe a better solution for these customers is new GPS capability by 2005.

Company 

Ford Motor Company

Address
The American Road
Dearborn, Michigan 48121-1899

Business Sector: Automotive

Sales: $153.627B

How would your business (directly and indirectly) be affected by a more robust GPS signal from space (2nd and 3rd civilian frequency/signals)?

We are very enthusiastic about the emergence of a more robust GPS. The impacts on our business are several:

- Our operations are conducted under the principals of lean production and just-in-time delivery of components and subsystems. Our suppliers, and those of many other automakers, are required to maintain position information on each of their delivery vehicles so that, should a breakdown or unexpected traffic congestion occur, they can quickly inform our component and assembly plants of these delays and the forecasted new delivery time. A robust and effective GPS system is vital to this achievement.
- Ford Motor Company is the highest volume purveyor of on-board vehicle navigation systems in the United States through our Hertz subsidiary. These navigation systems use a combination of GPS and map-matching to accurately locate individual vehicles so the on-board computers can calculate routes and develop route guidance for drivers. Improvements in the GPS system will hopefully be of a nature that will improve the accuracy of the vehicle location data acquired by the on-board navigation systems.

A significant fraction of Ford Motor Company's research and development efforts is devoted to new products and processes that could improve the environment and traffic safety. One very interesting area is the possible linkage of global positioning data with digital road maps to give drivers warning of potentially dangerous situations on the road ahead, for example, warning of a sharp curve upcoming on an unfamiliar road at night. Currently available GPS location data are several orders of magnitude too crude to permit development of even a research prototype for evaluation of this concept. A robust and more accurate GPS system would allow us to undertake meaningful research in this area.

What economic benefits would be accrued for your business if this new capability were available by 2005 versus 2012?

With regard to the economic benefits that might accrue if this new capability was available by 2005 rather than 2012, please understand that we cannot quantify these benefits for competitive reasons. But even 2005 seems too long to wait. The interests we have in improved GPS, outlined above, have obvious and tangible value to our Company, but, more importantly, to our customers who would see price advantages (from lower manufacturing costs), greater utility (from better on-board navigation systems), and possible improvements in the environment and traffic safety (assuming successful fruition of potential future research programs that might be undertaken).

Association: United States GPS Industry Council

Address
1100 Connecticut Avenue, NW, Suite 520
Washington, DC 20036

CEO: Charles R. Trimble

Business Sector: GPS Industry

1997 Gross Sales ($): $500 Million Direct - $1.5 Billion Indirect

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How would your business (directly and indirectly) be affected by a more robust GPS signal from space (2nd and 3rd civilian frequency/signals)?

The information technology that GPS supports is the knowledge of position and time. It is this information technology that has commercial and "safety of life" value. Improving the robustness of GPS and therefore improving its ability to deliver this information is of key importance.

Information technology is key to increasing the efficiency and therefore the capacity of the nation's air, rail, roadway, and ports and harbors. Without the increased robustness of additional frequencies and augmented systems such as differential and pseudolites, the technology will only be adopted sporadically for the basic transportation infrastructure. The nation will be faced with either restriction to economic growth or huge capital expenditures with substantial environmental impact. Efficiency gains in the 20% – 30% range for our fixed transportation infrastructure are reasonable assumptions. The national treasury is paid back by the taxes on the increase in economic activity.

In terms of agriculture GPS technology is already increasing the efficiency of land use, starting to minimize the use of agricultural chemicals, and has the potential for promoting the widespread use of drip irrigation to conserve water. Increased efficiency in the use of our natural resources is the best way this nation can achieve continued growth with minimal environmental impact. Robust GPS is one of the important keys to achieving this efficiency.

What economic benefits would be accrued for your business if this new capability were available by 2005 versus 2012?

Sooner is better from the standpoint of commercial development and leverage. The payoff for the country comes from the productivity and safety of life advantages of the applications, not from the direct sales of user equipment.

Additional Comments

As important as GPS modernization is, without vigorous protection of the L1 frequency spectrum, modernization would be a hollow promise. It is vitally important that pseudolites at L1, and the 2nd and 3rd frequencies be announced as part of the GPS Modernization. We must secure the 1559 – 1567 frequency for GPS (GNSS). Note the probable French response to giving up sharing in the 1559-1567 band is to ask for segmentation of the lower 4 MHz (1559-1563). Our strongest defense for no segmentation of the band is split-spectrum pseudolites.

Company John Deere

Address
909 River Dr.
Moline, IL 61265
309.765.7004

CEO: Hans W. Becherer

Business Sector Agriculture, Construction

1997 Gross Sales ($12.791 billion)

How would your business (directly and indirectly) be affected by a more robust GPS signal from space (2nd and 3rd civilian frequency/signals)?

John Deere strongly supports the availability of a 2nd and/or 3rd civil frequency. The primary benefit to Deere would be a more economical dual (or triple) frequency GPS receiver to support precise, real time positioning of agricultural and construction equipment through the use of advanced kinematic techniques. This improved positioning accuracy is important to our customers for precision farming operations (documenting yields and varying crop inputs such as seed and fertilizer) as well as vehicle navigation or guidance in agricultural and construction operations.

Precision Farming is a management tool for farmers that ties field activities and crop characteristics to precise field locations and captures and records (or reads and controls operations) information electronically. The key is to process the data into usable information to assist farmers in the decision-making process to increase their profit (increase yields and/or reduce farm input costs) and to improve environmental stewardship (apply only what is needed where it is needed).

Generally speaking most farm fields have areas where the yields are up to 50% above and below the field average. By documenting these yield differences and using this information along with crop history data (seed type, field operations, fertilizer and pesticide history) soil nutrient maps, weather history, etc.; farmers can begin to identify the causes and effects, and begin to vary his farm practices -- using more or different seed in different soil areas based on the soil fertility (production capacity), and likewise, only putting on chemicals where they are cost effective. Today many field practices are to put on a flat rate at the highest level required for any portion of the field. Sometimes a profit map will show a farmer that he put more $ in seed and inputs on an area that produced at a level below his costs.

Obviously the science here is learning the cause and effect to determine the best farming practices, but providing the farmer with the tools to document farming practices geo-spatially, and then to vary his farm practices and field inputs based on location are basic requirements.

It is difficult to quantify the economic benefits. However, the need for these capabilities is immediate, and may be developed in more costly and less effective manners without the proposed civilian frequencies. Development of new GPS user equipment and systems to exploit additional, new civil frequencies should certainly be accomplished by 2005.

Responses to the CEO GPS Assessment

Requested by the Institute for Defense Analyses
For Mr. Robert L. Mallet, Deputy Secretary of Commerce

Prepared by Douglas H. Reep, Ph.D., Director - Electronics Technology
Lockheed Martin Science and Engineering

Lockheed Martin Corporation

(All data are year-end 1997 unless otherwise noted)

Business Areas:	Aeronautics, Electronics, Energy & Environment, Information and Services, Space and Strategic Missiles, Global Telecommunications
Sales:	$28 billion
Sales by customer:	U.S. Department of Defense - 49% Commercial and civil government - 24% International - 21% NASA - 6%
Net earnings:	$1.3 billion
Backlog:	$47 billion
Stock ticker symbol:	LMT, on the New York Stock Exchange Ranked 32nd on the Fortune 500 list of largest industrial corporations
Employees:	Nearly 170,000 employees in the United States, and over 5,500 employees working internationally
Operations:	939 facilities in 457 cities and 45 states throughout the U.S.; Internationally, business locations in 56 nations and territories
Headquarters:	Lockheed Martin Corporation 6801 Rockledge Drive Bethesda, MD 20817 USA (301) 897-6000

How would your business directly or indirectly be affected by a more robust GPS signal from space (2nd and 3rd civilian frequency/signal)?

The definition process for the next generation robust GPS system is ongoing, but as a minimum, it is likely to include the addition of a second civilian frequency, decoupling of the civil codes from the Military codes, and an increase in satellite power.

The increase in power is significant to our business from a military perspective, because it, in conjunction with the addition of Anti-Jam technologies, will allow GPS to function much more reliably, in the expected Navigation Warfare environment. The more robust GPS signal is likely to foster more reliance on GPS, and result in more GPS-only based solutions being utilized, in cases where GPS could not be used alone previously. Critical applications, however, will still require a backup capability for military applications.

The decoupling of civilian GPS code from military GPS code is significant from a military perspective, because it allows our forces access to GPS, and the potential to deny access of GPS to our adversaries. This decoupling will open up NAVWAR Prevention opportunities for our business. Market size is presently being analyzed.

The addition of a second frequency primarily helps the civilian community achieve precise positioning, without the need for differential corrections. When Selective Availability is turned off, the largest component of position error will be the errors induced by the ionosphere and troposphere. With a second frequency, the ionosphere-induced errors may be corrected, much like they are limited in the military receivers today. The addition of the second frequency will ultimately reduce the cost associated with meter-level position, and should open up a wide range of commercial opportunities. Differential corrections will only be required when very precise navigation data is required.

Conceivably an improved signal could aid the aerospace industry in satellite attitude determination and navigation. Solid analysis is pending, and additional factors may be involved which could impact the desired direction for GPS enhancements. For example, there may be difficulty "looking down" from High Earth Orbit/ Geosynchronous Earth Orbit (HEO/GEO) satellites to the GPS satellite constellation, if the GPS constellation also "only sends its signals downward/earthward",

We assume that the accuracy of the enhanced GPS capability will be equivalent or better than the existing differential GPS accuracy, due to the more robust GPS signal from space (2nd and 3rd civilian frequency/signal), and that transmission equipment on ground (with associated ground surface survey required for differential GPS) will not be required with the enhanced GPS capability. This implies that the U.S. government must address the issues associated with the potential use of this new enhanced GPS capability by unfriendly civilian/military personnel or countries. If the new civilian GPS capability is indeed so accurate, and not subject to being turned off, one wonders why an enemy might not simply

use the new civilian GPS capability for their own military ends against us; and one wonders why the US wouldn't use it for its own military applications, as well. The advantage in the US having a separate military GPS capability will need to be carefully considered and managed.

All of this analysis assumes that the US remains ahead of the international community, in fielding advanced GPS, or GPS-like, capability, setting the defacto standards. If enhanced GPS is not accelerated, then the US is at risk of loosing this advantage of position – in the marketplace, and with regard to national security.

MILITARY SYSTEMS: Lockheed Martin's military contracting business will benefit from enhanced civilian GPS capability. As a cost savings initiative, the Department of Defense has requested contractors consider the use of Commercial Off the Shelf (COTS) systems, whenever it can be shown that there is no adverse impact on mission effectiveness. In this regard, we believe that an enhanced GPS signal would provide several venues for cost savings, in hardware, utilization, and employment. Some are directly attributable to cost savings and some are not, as discussed below.

Improvements in navigation capabilities generally have far reaching impacts based on their broad applicability and long term utility. Platform and missile/weapon effectiveness, situation awareness, and speed of response, are all examples of areas affected by improvements in navigation, especially improvements of an order of magnitude or greater. Increases in platform navigation accuracy can improve reliability, maintainability, and life cycle costs while simultaneously positively affecting ability to maintain schedules (as in landing in bad weather when a divert might otherwise be necessary). Improved navigation may also minimize the effects of weather/light in arriving at a defined point, in a timely manner. In other words the platform can more reliably be counted on to be "On Time - On Target." The military utility of this improvement is hard to quantify, but nevertheless the capability has been hotly pursued over the last 50 years.

For weapons, precision has been proven as a significant force multiplier. It directly impacts the following areas: force structure, mix, ability to reliably service targets in close proximity to civilian or other politically charged facilities/areas, extending weapon launch ranges (resulting in survivability benefits), allowing very tight mission planning constraints with respect to time (enhances weapons effects), and minimizes navigation infrastructure required to facilitate extensive air operations.

Reliance on GPS greatly reduces the cost of inertial navigation systems. In combination with improved GPS, a relatively inexpensive (e.g., Micro-Electro-Mechanical System, MEMS-based) Inertial Measurement Unit (IMU) can achieve the accuracy necessary for most applications that formerly required $100,000 to $1,000,000 inertial systems. It might be that evolution of the newly emerging MEMS technology is "almost perfectly timed" to take advantage of GPS technology, opening yet additional markets.

There are both direct and indirect cost benefits associated with the improvements in these capabilities. The very accurate timing functionality associated with GPS also contributes

significantly to the ability to synchronize situation awareness (Link 16, CEC, JCTN) and anti-jam capabilities (Frequency hoppers like Have Quick II). Military planning is also accelerated, by reducing the rework associated with updating positions as new and more accurate data is provided. Visibility into airlift and sealift is improved as well as the on time delivery rate and availability of alternate airfields (not requiring the infrastructure associated with today's navigation aids).

The control and exploitation of navigation and time are key elements of Information Warfare; an area that is developing rapidly and that contains numerous unknowns with respect to future direction and impact. Signal strength and location of the host air / space vehicle will allow full utilization of the advantages of a commercial signal that remains current with a global network and tracking system. The Global Air Traffic system will be a key benefactor of an improved GPS signal that will provide the military commander with near-real time status of deploying, enroute, and redeployment of airlift assets enabling "just in time munitions."

What is known is that capabilities tied to accurate and affordable navigation and time will be key contributors to that future. Assessing the cost benefit of navigation and time improvements is a very complex challenge, with a very large number of sub-effects and impacts.

COMMERCIAL / CIVILIAN SYSTEMS: A positive business impact is expected provided that a "more robust" GPS signal means more signal strength, more signal sources, more accuracy, and more reliability, including anti-jam/anti-spoof capability. This positive impact could be realized from increased aircraft sales (U.S. and foreign) based on compatibility with Foreign Air Traffic Control Systems, increased volume of safe airspace and simplified ground control, to accommodate more aircraft. Additionally, reduced navigation subsystem and cockpit subsystem crew workload could be realized.

A more robust civilian GPS signal may preclude the need for additional supporting/backup navigation systems. This may reduce costs of new commercial flight and ground support systems and associated costs to our customers. This could be a significant saving, providing added safety to accomplish the following:

- Significantly increase the number of commercial airports that can be used for precision GPS approach to landing in marginal IFR weather by commercial airlines with passengers, i.e., airports that do not have a Category II or III rated instrument Landing System (ILS).

- Significantly increases the number of airports that can be used for emergency landings by military, commercial, and general aviation airplanes in marginal IFR weather.

- Improved aircraft position accuracy can be used to increase ATC traffic capability by reducing separation between properly equipped aircraft.

- Enhanced military aircraft rendezvous capability in marginal weather, i.e., refueling, etc.

GPS is being planned also as a major element of geolocation, for commercial communication applications. Although current plans are to implement capabilities without improvements in the current system, it is clear that multi-channel improvement and increased availability will improve certain mission goals, as well as increase the secondary services provided by such systems, such as 911 services to cellar phones.

What economic benefits would be accrued for your business if this capability were available by 2005 versus 2012?

For example, economic benefits, from earlier implementation, could be realized in the form of aircraft sales resulting from safer, high density (1nm vs. 5nm separation) airspace and improved ground control (Category III @O/O visibility). We are currently near the edge of exceeding the 6000 simultaneous controlled flights limit in the continental U.S. using today's navigation technologies.

Additional savings could be realized from the reduction in avionics equipment life cycle and improved Military Restricted Airspace Flight Controls, including reduced hazard and reaction times for civil/military safe flight during periods of Military Air Support and National Emergency Mobilization.

The economic benefit for Lockheed Martin comes from providing unique GPS solutions that we might not have been able to provide solely based on GPS, because of inaccuracies in the commercial GPS world, or because of susceptibility to interference in the Military world. Economic benefit will also be obtained by providing solutions that allow us to prevent our adversaries access to the GPS, and by providing the technology to protect GPS for use by our military forces.

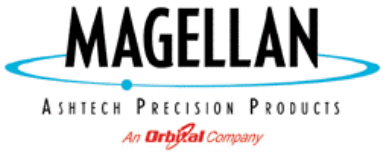
Lockheed Martin is, generally, a developer of systems. Most economic benefits will be accrued by the customers and end-users of the systems we develop, usually military, but sometimes commercial. However, new market opportunities may emerge for Lockheed Martin. For example, improved navigation in the air transport industry could lead to a transformation of air traffic control to "air traffic management," with a shift from consolidated control at regional centers to distributed control from the aircraft themselves. This change in operations concept could create new opportunities for Lockheed Martin, by way of new air traffic automation and airline operations automation. An associated financial benefit for airlines and other pilots, of enhanced GPS, is that aircraft can fly direct rather than on VOR radials (thereby saving fuel and time enroute).

Additional Comments and Information

The assessment commissioned by the Department of Commerce and being compiled by the IDA is aimed at commercial business areas that are significantly influenced by the use of GPS. Lockheed Martin has traditionally served the Department of Defense and Department of Energy, as its most significant customers. Moving to the future, commercial business will be increasingly important. Lockheed Martin announced in August the formation of a new enterprise, Global Telecommunications, to concentrate and extend the Corporation's role in the expanding telecommunications services marketplace.

Although, not segregated from other business factors and separately accounted, enhanced GPS capability should provide additional, significant market opportunities for Lockheed Martin.

Company: Magellan



Address
471 El Camino Real
Santa Clara, CA 95050-4300

CEO: Jonathan W. Ladd, Vice president of Surveying and Mapping Systems representing Magellan for Charles Boesenberg (president and CEO)

Business Sector: GPS Manufacturing

Sales: $153M

How would your business (directly and indirectly) be affected by a more robust GPS signal from space (2nd and 3rd civilian frequency/signals)?

The business impact of a more robust GPS signal could be very significant for Magellan. We already manufacture and sell two frequency products that form the backbone of our precision products business (about 50% of our gross revenue). The use of "codeless" dual frequency receivers is growing today due to the performance advantages achievable using both L1 and L2 frequencies. Dual-frequency products support robust, high productivity, high accuracy positioning solutions for applications including; surveying, mapping, machine control, dredging, mining, aviation (LAAS), and photogrammetry. C/A on L2 will improve accuracy and signal availability because more signal strength translates into better under tree canopy tracking, faster "time to centimeter" position/navigation solutions and faster signal acquisition and reacquisition.

A third protected civil signal will further improve accuracy and "robustness" of use/performance/integrity for precision products which support many "safety of life" applications. Additional frequencies will also expand the number of applications for GPS and, therefore, the overall market for these products. However, first we must assure that the current (as well as any future) spectrum is protected. In current GPS band transmissions from MSS transceivers (satellite telephones) jam the fundamental GPS navigation signal. We call upon US government agencies to take the necessary steps to keep the current GPS frequencies protected from those who wish to share the same spectrum. However, Magellan supports the addition of (non-interfering) pseudolite (navigation) signals at L1 and L2 as an augmentation to current GPS capabilities.

What economic benefits would be accrued for your business if this new capability were available by 2005 versus 2012?

If made available by 2005, we will take modernized GPS capability into account in our R&D/fiscal planning/allocation of NRE dollars to fund next generation multi-frequency products. The year 2012 is too far out to make any long term R&D/funding plans. A lot can happen in 12 years, including current GPS capabilities becoming outdated and eclipsed

by other, potentially industry launched and maintained, positioning and navigation satellite systems. If the US government does not act quickly to continue to improve this global utility, GPS will probably not be the global standard for worldwide positioning/navigation/timing in 2012.

Please realize that GPS modernization and spectrum allocation (more protected frequencies) are time critical, global market issues. Uncertainty of GPS support and stability (through modernization) is effecting our relationships with global partners/customers today. The current GPS spectrum infringement by MSS issue has raised strong concern by many large players interested in integrating GPS into safety of life infrastructure. Also, the fact that the US is pulling back funding from WAAS further erodes international confidence in US commitment to improving and expanding GPS in nonmilitary sectors. These factors help other international interests make the cases for competing systems.

Please take immediate steps to insure that GPS continues to be the recognized global standard. This can only be accomplished through a commitment to continuous improvement through modernization.

Additional Comments and Information

- Our government should announce commitment of a modernization/improvement plan for GPS and, as an immediate first step, turn off SA. This will act as a strong initial signal to the international community that the US is committed to improving GPS for civilian users.
- Announce support for GPS constellation expansion through the "Open Architecture" concept being discussed at the IRT, CGSIC and other forums.
- High level US government policy statements regarding support and expected timing for WAAS and NDGPS augmentation.
- GPS and GLONASS used together are a formidable technology/product combination today giving very high levels of position integrity especially for safety of life applications like avionics. The US government should support dual use of GPS and GLONASS as part of an overall GNSS infrastructure strategy.

Company: Motorola

Address
8201 E McDowell Rd
Scottsdale, AZ 85252

CEO: Christopher B. Galvin

Business Sector: Terrestrial & Space

- **Currently, the terrestrial markets include high volume semiconductor, automotive and timing markets.**

- **In addition Low Earth Orbiting satellite market.**

1997 Gross Sales ($28.7B): Commercial GPS

Terrestrial: Automotive GPS Systems, OEM Board level products, GPS Semiconductors (Total Sales Dollars unavailable)

Space: The Space Market is estimated at $50B+ with 75% in Government and 25% in the Commercial Segment, which is growing at 10-12% per year. By year 2001, the Space Market is estimated to be $75B+ with 50% in Government and 50% in Commercial. The value of GPS to the space industry is to provide better navigation and location control. The GPS capability helps to insure a safe launch and safe operation. Motorola is prime on the commercial Iridium LEO constellation ($6B+) and the commercial Teledesic LEO constellation ($15B+). Teledesic and all future commercial constellations that Motorola primes will have GPS Receivers to provide the robust timing, navigation; tracking and control functions that are needed to insure safe operation.

How would your business (directly and indirectly) be affected by a more robust GPS signal from space (2nd and 3rd civilian frequency/signals)?

The technical benefits of the 2nd frequency (assumed at I.2) would be:

- Ionospheric correction would provide improved navigation performance.

- Kinematic positioning would allow for sub-meter capability for LEO satellites.

- Attitude determination would benefit from nearly instant integer ambiguity resolution.

a) The timing market would also have improved accuracy.

b) There would be a need in some cases for more complex hardware/software designs.

c) May in some cases remove the need for differential measurement where higher accuracy was needed.

The use of a third civilian frequency is unclear at this time. We have not seen any definitive frequency/power/chipping/rate/etc. to base a comment.

What economic benefits would be accrued for your business if this new capability were available by 2005 versus 2012?

Assuming that additional satellite constellations will be launched after the year 2005, the savings in hardware not needed in Space or on the ground could be greater than $40M. In addition, the new hardware design(s) and individual satellite applications may have benefits greater than $10M. The real value is in the greater protection and safe operation of a $75B industry assets.

Since currently planned constellations such as Teledesic and INX are currently being designed with launch dates prior to 2005, no savings will likely accrue on the near-term constellations, but future endeavors will benefit from these improvements. Any improvements that could be implemented by software upgrades could result in immediate savings. Improvements requiring hardware upgrades would take a greater time to implement and turn into an economic benefit to the corporation.

We have not fully thought out the long-term benefit of the GPS Modernization Program as the 2012 date of implementation is beyond most of our strategic planning. If given more time, Motorola could provide more definitive benefits of moving the date of implementation to the 2005 time frame.

Company: Trimble Navigation Ltd.

Address
645 North Mary Ave
Sunnyvale, CA 94088

Business Sector: GPS manufacturing

Chairman: Robert Cooper

1997 Gross Sales: $250 million

How would your business (directly and indirectly) be affected by a more robust GPS signal from space (2nd and 3rd civilian frequency/signals)?

GPS significantly lowers the operating costs of many of our customers while greatly increasing their productivity. These customers are vital to the national economy: agriculture, aviation, automotive, banking, commercial space, construction, emergency medical response, mining, oil, surveying, transportation, telecommunications, and utilities. The predictable continuous availability of GPS to customer operations is becoming a critical dependency. The addition of a second and third civil frequency helps to ensure the robustness of GPS and significantly decreases critical infrastructure and national industrial base vulnerability, particularly in an increasingly complex international spectrum environment.

GPS is becoming increasingly important to the National Information Infrastructure (NII), including the Internet, electronic banking, stock transactions, and the power grid.

The Presidential Decision Directive (NSTC-6) on GPS and the Defense Authorization Act—FY98 (PL 105-66) provide for the "continuous availability of GPS". A second and third civilian frequency will ensure that this united national mandate will be carried out in the national interest.

What economic benefits would be accrued for your business if this new capability were available by 2005 versus 2012?

GPS is becoming an international utility and a critical element of the Global Information Infrastructure (GII). Many of the today's applications were never envisioned at its inception. Differential GPS and Real Time Centimeter (RTK) accuracy were not predicted. Such capabilities have increased user productivity by a factor of 2 and higher. In addition, the GPS industry is estimated to be near $8 billion by the year 2000.

It is no easier now to envision future applications and benefits. More importantly, the U. S. is currently preeminent in the GII. If this new capability were available by 2005 versus 2012, this would be a wise national investment in helping to ensure and advance this continued preeminence.

Additional Comments:

The Europeans are talking about an advanced technology system beyond the GPS system capability today. The U.S. needs to update the GPS system architecture and satellite design with the capability to change the digital processing in our spacecraft to take advantage of new receiver algorithms to continually advance the capability of the user segment in the future. Currently, at the end of the satellites' lifetime, we are using twenty-year-old technology. We need to upgrade the space segment on a regular basis rather than provide a static capability for 20 years. We need to find ways to provide this capability to reconfigure the GPS satellites from the ground command. We are using a similar capability on the spacecraft that we are sending into deep space. Instead of looking to the past to determine our future in GPS, we need a vision that integrates space into the Global Information Infrastructure. Our current space-based GPS model is ten years out of synch with the two-year change cycle of the GII. With a flexible satellite reconfiguring capability, the dividend on space investment is achieved earlier and is sustained longer. The investment cost in the asset itself becomes a small fraction of the long term dividend to the national interest.

We need the flexibility to capture opportunities as they arise. One-of-a-kind block change satellites with no flexibility can no longer be afforded. The ability to do this will ensure continued national preeminence in the GII. If this capability is already available to NASA, the U.S. needs to figure out how to migrate this concept to our commercial and military interests in GPS.

Telephonic Responses

Company: Atlantic Container Line

Address:
50 Dogwood Road
South Plainfield, NJ 7801
Chris Dubina
Business Sector: Worldwide containerized shipping

Comments:
Turn off Selected Availability now and we will see an increase in throughput. A more Robust signal will enable greater throughput of cargo at many of the world ports. With less than 1-meter accuracy we see the possibility to increase the throughput rate as much as 10-15% at these currently restrictive ports. We need this capability as soon as we can get it whatever the source.

Company: Thunder Basin Coal Co.

Address
PO Box 406
Wright, WY 82732

Business Sector: Open Pit Coal Mining

Comments:
Todate, Thunder Basin Coal Company has only used GPS to assist in survey operations. Should a more accurate and stronger signals be available the potential for greater use of GPS services in our mining operations would be significant. From tracking of equipment and material to the better scheduling and movement of rail cars would provide immediate payback and greatly improve operations. Currently Thunder Basin Coal Co is producing 45 million tons of coal a year. Each year we drill 170 miles of blast holes where we use 150 million pounds of explosives to blast both the coal and the overburden. Electric shovels load the coal into 240-ton trucks where it is carried to crushers to reduce it to two inches in size. A conveyor then carries the coal more than two miles to storage and loading facilities. Two entirely separate crushing and streams can operate to ensure timely delivery to customers. Three state-of-the-art high-speed precision load-out facilities at Black Thunder allow as many as 1540 rail cars in 24-hour period.

The sooner that we see a “real” increase in GPS capability the later we can take advantage it.

Company: BankAmerica Corp

Address
555 California Street
San Francisco, CA 94104

Business Sector: Banking, Financial Management

Comments:
Use of GPS time is critical to high speed banking networks. Additional frequencies and capabilities will greatly simplify the current time backup systems that consist of LORAN and other complex avenues to have near GPS time accuracy. The cost impact is more of providing continuous data communications between an ever-expanding network of banking locations. This expansion is not only geographical but includes a continuing increase in the volume of data transmissions. Earlier GPS capabilities will greatly facilitate better service**.**

Company: Cyprus Amax Minerals

Address
9100E. Mineral Circle
Englewood CO 80112

Business Sector: Copper, molybdenum, and coal mining
Comments
Considerable savings can occur with a greater 3 dimensional capability in many mining operations. This will include considerable savings by reducing the time required to establish a common georeference grid in: initial mineral discovery and documentation; GPS controlled mining equipment operations and better tracking of movement of materials and equipment. Additional signals will go a long way to increase the number of satellites viewed from deep open pits. Additional augmentation will still be required but we envision that it will be less than today. The sooner we can realize these savings the better.

Company: Farmland Industries

Address
3315 N. Farmland Trafficway
Kansas City, MO 64116

Business Sector: Agriculture

Comments:
The potential for full use of GPS will not be fully utilized until more agriculture users become familiar with the capability and its potential for better crop management. Additionally for those using the service the overwhelming number of agriculture users have expressed the need for a more robust system with reliability approaching 100% and accuracy's less than 2-3 inches. With capabilities such as this the entire agriculture business would be positively impacted. Efficiencies in production distribution and safety will be realized.

Company: Federal Express

Address
2005 Corporate Ave.
Memphis, TN 38132

Business Sector: Air/Ground Shipping

Comments:
We are using GPS in a variety of ways from aircraft and trucking navigation to limited parcel and equipment tracking. The potential for GPS use is extensive, however, we have delayed decisions on its use until we better understand not only what GPS and its augmentations will provide but how the government will implement WAAS and NDGPS. Because our demand for information is insatiable we are looking at any technologies that will increase the efficiency of our operations now. It is possible that using TMD and other technologies that we will not fully commit to GPS. How soon this new capability is made available will greatly determine which course we seek in the future.

Company: GROWMARK Inc.

Address
1701 Towanda Ave
Bloomington IL, 71701

Business Sector: Advanced crop production and livestock feeding systems

Comments:
We at GROWMARK see great potential for a greater GPS capability. Due to the weakness of the current signal we have not implemented its use to the extent needed. To some degree we are waiting for this capability to mature before proceeding. The sooner that this capability is available the sooner we can take advantage of the service.

Company: MCI Worldcom Inc

Address
PO Box 406
Wright, WY 82732

Business Sector: Communications

Comments:
GPS modernization is critical to telecommunications and high-speed data transfer application. Those additional signals from space will increase the robustness of the GPS timing service. As the GPS time moves to pico-second timing our industry will see significant increase in throughput capacity of current and future data links. Additionally, as the new capability becomes available we will no longer need to rely on the LORAN timing signal for backup as we do currently. It is difficult at this time to determine the impact of fielding this capability in 2005 versus 2012. Our business plans extend our vision for around 5 years and these dates are too far in the future for us to understand the impact.

Company: OnStar

Address
888 West Big Beaver Suite 200
Troy, MI 48084

Business Sector: Navigation, communication and emergency services

Comments:
GPS plays a significant role in our future business plans. The success of the OnStar system since its introduction in 1997 on Cadillac cars has led to now being offered on 24 GM models. The demand is rapidly growing for an integrated navigation system with communications capability and services including emergency repair, theft and better positional awareness. The current GPS capability barely meets the requirements and needs of this demand. The long-term success will be to a great extent determined by how rapidly the Government can improve GPS and all of its augmentation systems. The need to do this is now! We can ill afford to wait as suggested in the questions posed. We are committed to the government Intelligent Transportation System (ITS) and are working to strengthen this program when we can. Our philosophy is well summarized below by one of our Vice Presidents.

"As a manufacturer, I'm not willing to cede the market for navigation and other advanced ITS systems to the Japanese – or to any other competitor. And, more importantly, as a citizen I want the U.S. to maintain ITS leadership (Ken Baker GM Vice President and General Manager Micro-Turbine Generator Business Unit, Global R&D Council)

Without GPS modernization soon we will not be able to achieve this.

Appendix

Department of Commerce Round Table Discussants: December 3, 1998

Gerald D. Conover	**Manager, External Technology Liaison**	**Ford Motor Company**
Chuck Dettmann	**Sr. Executive VP**	**Association of American Railroads**
Henry Ott	**Sr. Government Liaison Space Service**	**Motorola**
Robert Cooper	**Chairman of the Board**	**Trimble Ltd.**
Charles Trimble	**President**	**GPS Industry Council**
Douglas H. Reep	**Director Electronics Technology**	**Lockheed Martin Science and Engineering**
Jonathan W. Ladd	**VP**	**Magellan**
Bill Sear	**Sr. VP**	**Airline Transport Association**
Frank Weaver	**Director Telecommunications Policy**	**The Boeing Company**

Industry Associations Contacted

Participated in the DOC round Table and provided written input

Provided Writtten and/or Telephonic input

Chose not to provide information

Industry/ Technology Area	Company	President/CEO	Address	Telephone
GPS	US GPS Industry Council	Charles Trimble	645 North Mary Avenue Post Office Box 3642 Sunnyvale, CA 94088	408-481-2209
	Trimble Navigation Ltd.	Robert Cooper	645 North Mary Avenue Post Office Box 3642 Sunnyvale, CA 94088	408-481-7501 301-982-5222
	Magellan	Charles Boesenberg Jonathan W. Ladd	1170 Keifer Rd Sunnyvale, CA 94086	408-524-1630 408-524-1492
Aviation	Airline Transport ˝ Associ	Bill Sears	1301 Pennsylvania Ave NW Washington, DC 2004	202-626-4007
Space Systems	The Boeing Company	Phillip M. Condit/	7755 E. Marginal Way South Seattle, WA 98108	206-655-2121
	Lockheed Martin	William Ballhaus	6801 Rockledge Dr. Behtesda, MD 20817	301-897-6000
Communications	Motorola	Robert Galvin? Dr. Rose Gibson	8201 E McDowell Rd MD H2250 Scotsdalle, AZ 20006	602-441-8232
	MCI Worldcom	Jack Wimmer	1801 Penn. Ave., NW Washington, DC 20006	972-729-5371
Automotive	OnStar/ General Motors	Chet Huber	888 W Big Beaver Troy, Mi 48084	248-269-1395
	Ford Motor Company	Martin B. Zimmerman	American Road Dearborn, MI 48121	313-337-3244
	Chrysler	Bernard Robertson	1000 Chrysler Drive Auburn Hills, MI 48326	248-576-8037
Shipping/Ground/Air	UPS	James P. Kelly	55 Glenlake Pkwy, NE Atlanta, GA 30328	404-828-6000
	Federal Express	David Zanca	2005 Corporate Ave. Memphis, TN 38132	901-369-3600 901-224-7508
Shipping/Maritime	Atlantic Container Line	Chris Dubina	50 Cragwood Road South Plainfield, NJ 70802	908-668-5418 908-668-5477+H24
Trucking	Yellow	A. Maurice Myers Vicki Schuter	10990 Roe Avenue Overland Park, KS 66211	913-696-6100 913-344-3599
	Landstar System	Jeffrey C. Crowe	4160 Woodcock Drive Jacksonville, FL 32207	904-390-1234
Agriculture	John Deere	Hans W. Becherer Chuck Studek	1 John Deere Place Moline, IL 61265	309-765-8000 309-765-7021
	Farmland Industries	Harry D. Cleberg Jerry Leeper	3315 N. Farmland Trafficway˝	816-459-6440
	GrowMARK INC	Steve Barwick	1701 Towanda Ave Bloomington, IL 71701	309-557-6395

Railway	Burlington Northern/˝ San	Mat Rose COO	2650 Lou Menk Drive Fort Worth, TX 76131	817-333-2000 817-352-6100
	CSX Transportation	Ron Conway VP Ops Doug Crew	500 Water Street Jacksonville, FL 32202	904-359-7699
	American Association of R	Cahrles Dettmann	50 F St MW Washington, DC 20001	202-639-2190
Mining/Construction	Caterpillar	Doug Crew	100 N.E. Adams St. Peoria, IL 61629	309-675-1000
	Cyprus Amax Minerals	Phil Wolf	9100 E. Mineral Circle Englewood, CO 80112	303-643-5000 303-643-5221
	Case Equipment	Jean-Pierre Rosso	700 State Street Racine, WI 53404	414-636-6011
	Thunder Basin Coal Co	Terry Walsh	PO Box 406 Wright, WY 82732	307-464-2327
Oil	Mobil Corp	Lucio A. Noto/ Anthony Corso	3225 Gallows Rd. Fairfax, VA 22037	703-846-4802
Power	Virginia Power	Norman Askew Larry Birvin	PO Box 6666 Richmond, VA 23261	804-771-3193 804-771-3553
Timber	Boise Cascade	George J. Harad Guy Hurlbutt	1111 W. Jefferson Street Boise, ID 83702	208-384-7703
Banking	BankAmerica Corp.	Daniel Riley ex VP Global Payments	555 California Street San Francisco, CA 94104	415-622-3383