

INTEGRATED eLORAN/GPS RECEIVERS: AN OVERVIEW OF MARKETS AND COMMERCIALIZATION

Zachariah Conover
CrossRate Technology, LLC

Michael Leathem
CrossRate Technology, LLC

Abstract – *Over the past several years a significant amount of work has been done evaluating and enhancing the Loran system. These efforts have all but ensured the survival of Loran and the commitment of the United States to a robust radionavigation structure. The next step towards realizing the security and safety components of Loran is the production and adoption of eLoran and integrated eLoran/GPS receivers. This paper offers an overview of potential early adopters of the technology and offers comments on a path to commercialization.*

INTRODUCTION

Consumers, especially businesses, buy solutions to problems. In today's highly competitive business climate with narrowing profit margins and tight schedules, investment in technology must demonstrate real value to the consumer.

GPS technology has created a significant market because of the value that it demonstrates to the user. In various markets it is relied on for safety, security, cost savings, and in some cases, delivery of service. Due to the universal access to the system, the rapid development of technology, and the internet, GPS has developed a reputation for always working and always being correct. Now however, GPS applications are pushing the limits of the system and users and providers are realizing that GPS may not be the "be all, end all" solution. There may be a need, for some users, in some situations, for a backup system.

CrossRate Technology, LLC (CrossRate) received a grant from the Maine Technology Institute to research this potential market. Specifically, to determine if there are markets that are willing to embrace eLoran technology to solve their GPS reliability problem.

This paper is divided into two distinct sections. The first section discusses the market research efforts and the second offers broad comments on commercializing a product in these markets.

SECTION I: eLORAN MARKET RESEARCH

1.1 SCOPE OF WORK

The Transformative Knowledge Group led a market analysis effort for CrossRate, funded by a Maine Technology Institute Seed Grant.

The scope of work included:

- reviewing CrossRate's internal market research,
- identifying high potential market segments for further analysis,
- performing supplemental market research on these segments
 - including key decision making processes and factors as well as existing sales & distribution channels,
- analysis of the attractiveness of each high potential market segment,
- and, identification and profiling of top potential customers in these segments.

A collaborative approach to this effort, combining team-based, group analytic and planning work, with offline research in targeted areas, was used to maximize resources. This approach leveraged the knowledge and expertise of CrossRate and the expertise of the consultants. OnPoint Research was contracted to identify and obtain published research reports to provide additional detailed information on specific target market opportunities.

Due to the announced shut down of the Loran system in the mid-1990's and the transition to GPS the Loran market has gone relatively unanalyzed for almost a decade. Because of the lack of Loran activity and the transition to GPS over the past 20+ years the Loran market was approached as an "emerging" market. The one assumption established prior to conducting the research was that: the initial Loran target markets will be a subset of the GPS market.

It is important to note that this study did not seek to identify new markets but rather focused on potential adoption of the eLoran solution or an integrated eLoran/GPS solution in current GPS markets.

The majority of the market research is secondary market research supplemented, where possible, with primary market research.

Secondary market research exploits published sources like surveys, books magazines, annual reports, and 10-k's. Primary market research involves interaction with the customer. Non-reactive primary market research avoids influencing the customer's behavior and involves activities such as observations in real market situations. Reactive primary market research involves activities that may influence customer behavior such as surveys, interviews, and questionnaires.

1.2 GENERAL GPS MARKET SPACE

The GPS market is extremely broad. GPS technology is found in everything from dog collars to fighter jets. The existing civilian GPS market in the U.S., according to Ron Stearns of Frost and Sullivan, was projected to hit \$3.9B in 2002 and is projected to grow 12% annually through 2010. The GPS market is comprised of OEM sales to manufacturers and a variety of end product specialty markets, targeting various user groups. Stearns projects across the market, consumers account for 52% of sales, commercial customers account for 40%, and the military account for the remaining 8%.¹

While ABI Research predicts the GPS world market will exceed \$22B by 2008,² eLoran's target market will remain within North America, because the remainder of the world is not installing eLoran coverage at this time. However, the European Union, as concerned over GPS vulnerabilities as the U.S., may build an eLoran, or similar, system to provide coverage to Europe. Loran also exists in other parts of the world, particularly south east Asia, and it is possible that they will also employ an eLoran upgrade. Table 1, below, provides a cursory overview of the GPS market space.

¹ Hesseldahl, Arik (2003). GPS, The War And You [Electronic version]. *Forbes*, http://www.forbes.com/2003/03/025/cx_ah_0325gps_print.html

² Allied Business Intelligence Inc. (2004). *GPS World Markets: Opportunities for Equipment and IC Suppliers*, <http://www.abiresearch.com>

Table 1: BROAD GPS MARKET SPACE

GPS Market				
Industry	Positioning Timing Frequency	Redundancy Requirement	Market Potential	Customers/Users
Academia & Research	P/T/F	Medium	Variable	Assist in all types of research (sciences, medicine, humanities, etc.)
Agriculture	P	Low	Medium	Farmers monitor water runoff, chemical applications and runoff, planting seeds, harvesting crops
Automotive / Intelligent Vehicle Navigation	P	Medium	Large	Auto manufacturers, auto aftercare market, Roadside assistance
Avionics	P/T	High	Medium	Commercial and private aircraft
Banking & Financial Services	P/T	Medium	Small	Trading, Investment and Currency transactions, vaults, etc.
Consumer Electronics	P/T	Low	Large	Computers, clocks, etc
Consumer Recreational	P	Low	Large	Outdoorsmen; Fisherman, Campers, Hunters, Hikers, Kayakers, Golfers, Bicyclists, etc.
Maritime	P	High	Large	Commercial and private vessels
Military	P/T/F	High	Medium	Logistics, Planning, Operations, Equipment
Mining	P	Medium	Small	Guidance in open-pit mines
NASA	P/T/F	High	Small	Enormous use and potential for new applications
Public Safety	P/T	High	Medium	FEMA, Homeland Security, EMS, Resource Management
Rail System	P/T	High	Large	Trains
Surveying	P	Medium	Small	Land and Marine Surveying; NOAA, U.S. Geologic Survey, Oil industry, Mining industry, Mapping companies, Oceanography, Marine biology, etc.
Telecommunications	T/F	High	Large	Radio, television, film, cell phones (towers equipment, phones, service)
Tracking	P/T	Low	Large	Cell Phones, cars, etc.

1.3 TARGET MARKETS

The limitations and vulnerability of the Global Positioning System (GPS) are a concern for every GPS user. For some users, a lack of GPS information is not a critical problem and they may never even realize when they have lost GPS. However, there are many markets which rely on GPS information for personnel safety, security and operations that are very sensitive to a loss of GPS information. These are the markets that realize the importance of GPS and the vulnerability of the system and they are the markets that will adopt eLoran first.

It is these early adopters of eLoran technology in these select markets that will drive acceptance of the solution in the consumer markets. The following generic target market criteria were developed to provide a framework to sift through the broad GPS market to identify early adopters of eLoran in markets that are large enough to sustain growth.

- GPS information is critical to operations
 - Directly related to revenue or safety
- Large growing market

- Double digit growth
- Preferably already realizing the problem
 - Either vocalizing the problem or engineering a mitigation technique
- Limited receiver regulation or certification requirements
- Significant North American footprint

The result from overlaying these criteria on top of the GPS market is the identification of the following four target markets.

1.3.1 Commercial Mariners

Professional mariners earn their living on the ocean and have a deep understanding of the dangers inherent to the sea. While some may view mariner's "you always go out, you don't always come back" attitude with disdain, it is a way of life. The professional mariner does not roll over and go back to bed because it is cold and dreary, they get up and go to work. The lifestyle of the commercial mariner demands a reliable suite of electronics to help guide them. GPS receivers are not simply commonplace on commercial vessels they are a mainstay. Anecdotal evidence shows the need for a back up to GPS.

- In conversations with a water taxi operator on the Maine coast the vessels master said, "I am always losing GPS at the worst time and in the worst weather, a backup would be great."
- Fishermen on the West Coast are putting old Loran receivers back on their boats due to concern over GPS interference. Specifically, in California GPS was jammed for a month due to interference from a television antenna on a fishing boat.

Because of the real concerns voiced by mariners, their previous experience with the Loran system, and the severe consequences

from a loss of information, commercial mariners are predicted to be early adopters of integrated GPS/eLoran technology.

1.3.2 Military/First Responders

As the original designer of the GPS system, the military has fully integrated GPS throughout its operations and is now pushing the limitations of the GPS system. In the military, a loss of GPS information can very quickly result in people being hurt or killed. Following are specific examples that demonstrate that the military acknowledges the GPS vulnerability issue and is actively seeking a solution. For example:

- The Army had a Small Business Innovative Research (SBIR) grant to research the possibility of integrating GPS and Loran and possibly another system for use indoors.
- DARPA has two grant notices that have recently closed, both specifically targeting development of location services for use in GPS denied areas such as urban environments and underground.
- The Air Force, in conversations with the Coast Guard, has expressed interest in using Loran for redundant timing at its missile ranges.
- In a customer survey 100% of first responders indicated their willingness to purchase integrated GPS/eLoran receivers today.

Because of the full integration of GPS throughout the military, the severe consequences of a loss of GPS, and the ongoing work trying to solve the GPS problem, the military may also be an early adopter of integrated GPS/eLoran receivers.

1.3.3 Telecommunications

Telecommunications providers, as well as other distributed networks, have become

highly dependent upon precise timing information. Without precise time, these companies can not provide service to their customers. Currently the limitations of the GPS system are mitigated by using expensive oscillators to back up the timing provided by GPS. The integrated GPS/eLoran receiver will replace the expensive oscillator, providing a solution anywhere from 1/3 to 1/10 the current cost. The significant cost savings may make telecommunications companies early adopters of integrated GPS/eLoran receivers.

1.3.4 Fleet Management - Trucking/Rail

Hundreds of thousands of shipments travel by truck and rail every day. Over 800,000 of these shipments are hazardous material with 94% of these shipments traveling by truck.³ More and more of these shipments are being tracked, in transit, using GPS technology. The location information is used for security purposes and for just-in-time delivery programs. The more experience companies gain tracking their shipments, the more aware they become of the limitations in the system. For example:

- A major U.S. chemical company has admitted to losing rail shipments of hazardous material three to four times a year.
- A major U.S. chemical company has had problems of trucks carrying Hazmat being hijacked.
- Vehicle tracking companies are beginning to employ Assisted GPS to try and overcome the GPS availability problem.

³ Department of Transportation: The Office of Hazardous Materials Safety Research and Special Programs Administration (1998). *Hazardous Materials Shipments*. [Electronic version] <http://hazmat.dot.gov/pubs/hms/hmship.pdf>

- According to a C.J. Driscoll & Associates⁴ survey of fleet managers, 60% report being willing to pay for trailer monitoring equipment.

The concern over corporate liability and homeland security related to hazmat transportation may drive rapid acceptance of an integrated GPS/eLoran receiver in the hazardous material transportation market.

1.4 TARGET MARKET DATA

The following two tables provide summary detail on the four target markets. Table 2 provides detail on the individual markets today and table 3 provides projects overall market size moving forward based on the information in table 2

Table 2: SUMMARY TARGET MARKET DATA⁵

Market	Current GPS Market Size	Growth Rate	Average Unit Price
Maritime	750,000 Units Sold (2004)	14.7%	\$476
Military	32,200 Units Sold (2003)	12.0%	\$4,150
Timing	26,600 Units Sold (2003)	12.4%	\$7,400
Fleet Management	1,000,000 Users (2004)	15.4%	\$1,491

⁴ Driscoll, Clem & Sheldrick Mike (2004). *Trailer Monitoring Systems and Services Survey*. Retrieved Nov. 15, 2006 from http://www.cjdriscoll.com/Trailer_Monitoring_Study.htm

⁵ Frost & Sullivan (2004). *North American Global Positioning Systems Markets*.

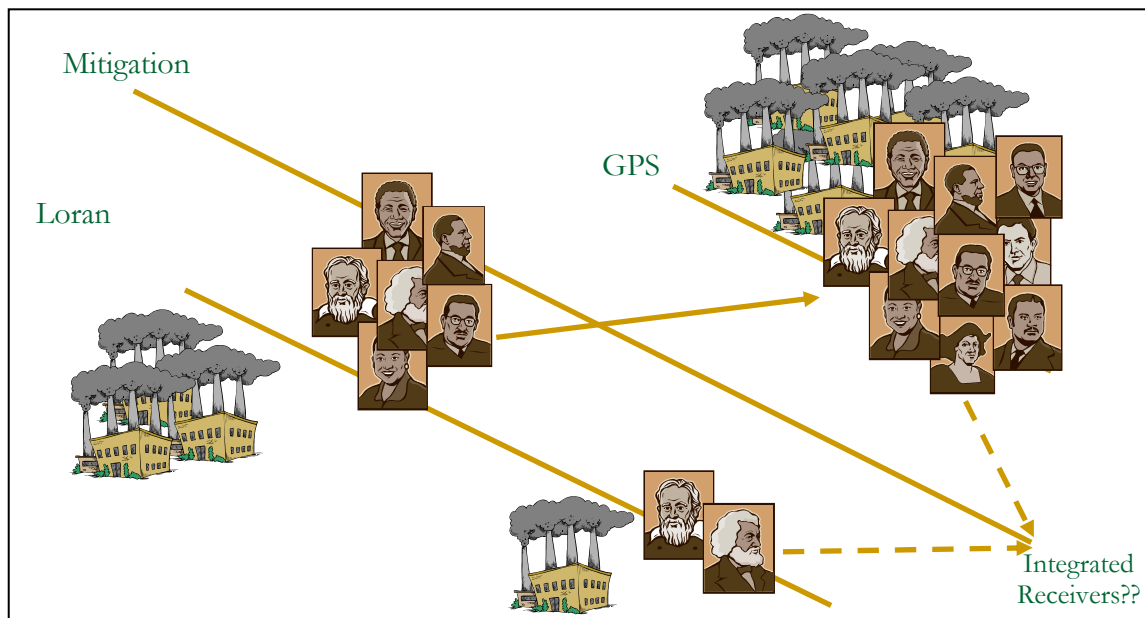
Market Segment	Current Market Size	Market Potential (Projected 2010)
Maritime	\$250M (2004)	\$432 M
Fleet Management	\$445M (2003)	\$861 M
Military	\$167M (2005)	\$225 M
Timing (Telcom)	\$250M (2005)	\$445 M
Total Market	\$1.112 B	\$1.963 B

The market research suggests that the next set of markets to emerge will be:

- The antenna size and the normalization of customer accuracy requirements will be the driving factors behind market adoption.

2.1 DEFINING THE OPPORTUNITY

It is the historical movement of customers and the adoption of new technology, as depicted in figure 1, that has created a void, or opportunity, in the market space. In the figure the people represent the customer while the buildings represent industry. The mitigation line represents the employment of mitigating technologies by the customers. Understanding how companies adapted from Loran to GPS and how new companies emerged to compete may provide insight to young companies seeking to establish themselves in the market place. For companies timing will be everything. Too early and the company will shrivel before the market arrives, too late and the company will give up valuable market share to its competitors.



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GPS companies have been very successful over the past decade focusing their marketing efforts on user applications and absolute accuracy. The issue of reliability has largely been side stepped by simply avoiding GPS hostile environments. This has been a successful strategy for many years and will continue to be successful in the majority of markets because GPS is a great system. But consumers (individual and business) are beginning to realize their significant reliance on the data for standard business operations and safety. As users realize radionavigation information is a critical link in the value chain, the dominant selling point can be shifted from absolute accuracy to reliability.

While many, especially those in the Loran community, already realize the vulnerability issues surrounding GPS and the robust nature of an integrated solution it is important to remember that to the customer this is shocking news. This will require the market to educate the customer on the issues they are facing and the solutions that are available.

While the marketing parameters may be changed, the customer is always a moving target. Even if the discussion is shifted to reliability the customer requirements will continue to develop. Figure 2, below, generically shows how customers that begin with similar requirements will evolve at different rates creating disparate market segments.

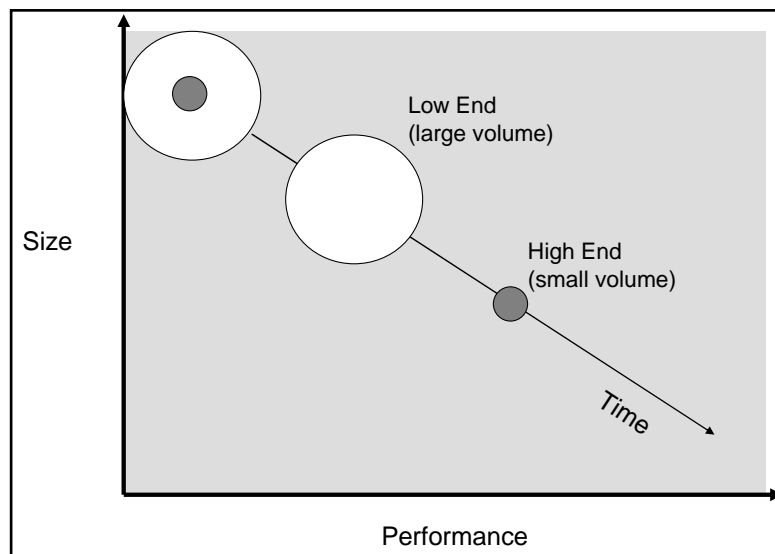


Figure 2: SHIFTING USER REQUIREMENTS AND SEPARATION OF USER SEGMENTS

At first blush it may appear that the same receiver can meet the needs of customers in all markets. Minor modifications and the same receiver is good everywhere; the perfect “make once, sell many times” company. While from an engineering perspective this is true the marketing and customer support side must point out that each of the different potential markets have very different market entry paths and very

different sales cycles. Taking the time to differentiate the customer base and determine the customer requirements will provide companies with a distinct advantage. It will be important not only to understand the lower end of the customer requirements but the upper end as well. Integrated solutions will be targeted at a select group of demanding customers that will demand their individual requirements

are met. Figure 3, below, demonstrates the relationship between “product value” and “price.” Notice the maximum and minimum “product value” that is acceptable to the

customer. Also notice the “product perception range”, this is the movement of the same product due to customer reaction and marketing efforts.

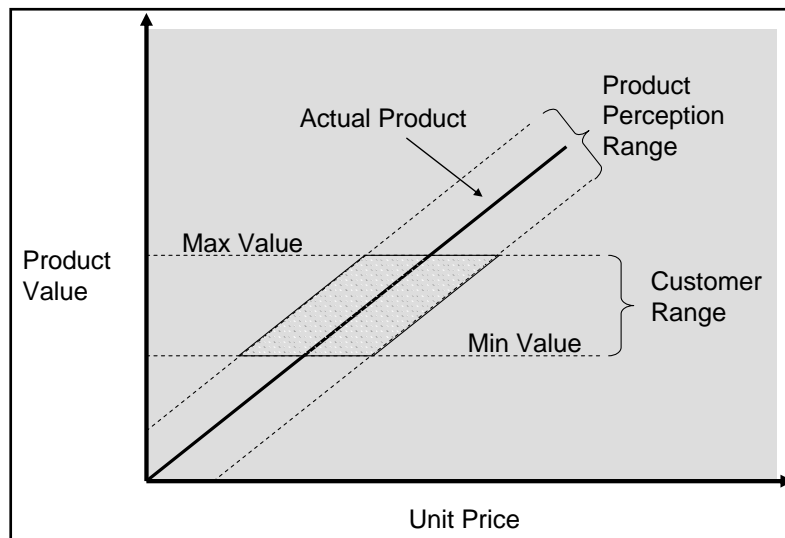


Figure 3: PRODUCT VALUE TO UNIT PRICE COMPARISON

Within the selected markets consumers can be broken into three broad groups depending on their response to finding out GPS doesn't work everywhere. The three types are depicted in figure 4 below. Like a stop light the customer's responses provide a clear “go/no go” plan for the marketing team. While from an engineering perspective some customers that fall in the “bad” zone may

appear to be a perfect match for the technology it is important to recognize that timing is everything. With limited marketing budgets it is important for companies to successfully target and attack the low hanging fruit (the “good” zone) before working up to the difficult “bad” zone customers.

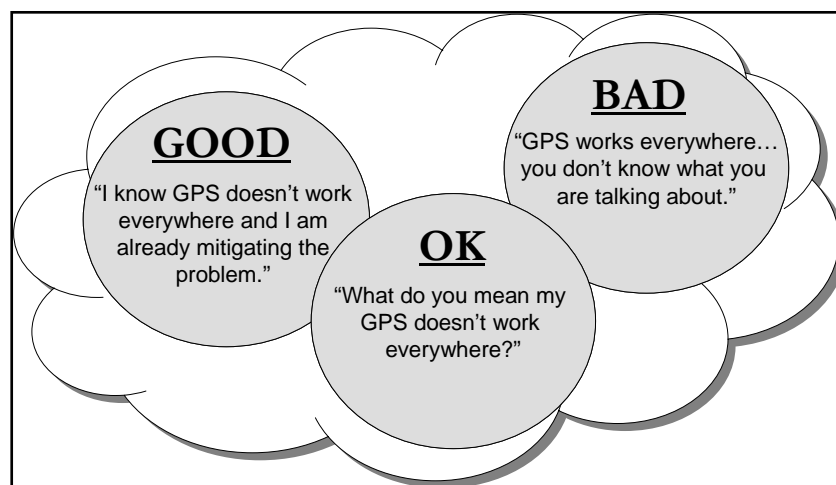


Figure 4: DIFFERENTIATION OF CUSTOMERS WITHIN A MARKET SEGMENT

2.2 COMMODITIZATION

Because the markets are distinct and the requirements vary between market segments the integrated receiver community has the opportunity to avoid commoditizing the solution. By refocusing the customer on reliability and the value of the solution the price point can be held reasonable for a significant length of time.

By focusing on product differentiation rather than price differentiation the integrated receiver industry can evolve into a stable industry with a vibrant R&D effort.

2.3 COMPETITION – TECHNOLOGIES

As companies choose their markets and develop their products they must keep in mind the competing technologies. The following is a list of technologies which may compete for the eLoran market space.

- *Triangulation:* Several startup companies are exploring the possibility of using existing radio waves to triangulate position in GPS challenging environments. Examples include using television station transmissions (www.rosun.com), Bluetooth® sub stations, cellular phone towers, and mesh networks to determine position.
- *Radar Mapping:* For aviation applications downward looking radar is combined with accurate terrain maps to determine location.
- *Inertial Navigation:* A handful of companies, including Rockwell Collins, are attempting to make inertial navigation a cost effective solution for individual consumers. Also, developments in MEMS inertial devices coupled with GPS may compete in this space as well.

- *Assisted GPS:* A few fleet management companies have begun offering Assisted GPS services to their clients. Assisted GPS involves two way communications with the user to provide “hints” on what GPS satellites to look for and the data manipulation is done at a “home” site away from the user.

While these competing technologies all solve part of the GPS vulnerability problem none of them solve all aspects of the issue. eLoran is the only alternative that can provide users position, time, and frequency information. In addition to this, many of these solutions are not separate from GPS. If the GPS system is lost these “backup” systems will be lost as well. With the discussion focused on reliability eLoran will compete effectively in this technology area.

SECTION III: SUMMARY AND CONCLUSION

3.1 SUMMARY

The CrossRate market research, funded by MTI, clearly demonstrates that there are market segments in which an eLoran solution to the GPS reliability problem may be embraced. From the broad GPS market four target markets were identified as potential early adopters of the eLoran technology. These target markets are:

- Commercial Maritime
- Military/First Responders
- Telecommunications
- Fleet Management – Trucking/Rail

Together these four markets represents over \$1B in potential today and applying industry growth rates these markets represent \$2B in potential in 2010. In customer surveys and conversations individuals have indicated a willingness to purchase the solution today

while large corporate customers require a long-term government commitment to the Loran system.

The varying purchasing patterns and market dynamics of the four target markets suggest that multiple companies will emerge to solve the unique customer issues. A single company will have difficulty bridging the numerous and varied issues of this customer base. The current dynamics within the GPS industry supports this conclusion.

3.2 CONCLUSION

The last decade has been a trying time for the entire Loran industry. The silver lining to the industry is that the research and talent has come together and has been working toward a common goal, save the system, for many years. This has resulted in some of the most significant improvements the system has ever seen.

The markets are poised and ready to accept the eLoran solution. Customer education will be required and the eLoran industry will need to work to shift focus from absolute accuracy to reliability but the opportunity is here. With a positive government decision the most significant risk factor in the market will be removed and customers will be ready to listen. Industry will respond with a product offering.

BIOGRAPHIES

Zachariah S. Conover is the co-founder and President/CEO of CrossRate Technology, LLC a Portland, ME based company focused on developing integrated eLoran/GPS receiver technology. Prior to founding CrossRate he served as an officer in the U.S. Coast Guard with tours at the Loran Support Unit and as a Deck Watch Officer onboard USCGA STEADFAST in Astoria, OR. He received his Bachelor of Science degree in Electrical Engineering from the U.S. Coast Guard Academy and his Master of Business Administration from Drexel University with honors.

Michael R. Leathem is co-founder and Vice President of Engineering for CrossRate Technology. Prior to his work with CrossRate, he worked for Micron Technology in Product Engineering and National Semiconductor in Process Integration. He received his Master of Science in Microelectronics Manufacturing Engineering from Rochester Institute of Technology in 2002, and his Bachelor of Science in Electrical Engineering from Syracuse University in 1999.

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