Chapter One: Introduction

1.1 Five Reasons Why AOC Markets Will Keep Growing

This report explores the commercial opportunities that exist for active optical cables (AOCs). It is the latest in the line of CIR reports on this topic which stretches back six years. Obviously, one reason why CIR has been covering this area of optical communications for so long is that the AOC market continues to grow and attract more market entries by a variety of firms.

In some ways it is a surprise that AOCs—a very simple product that has mostly sold into a niche market (IB)—can attract the kind of attention that it does. However, CIR continues to believe that we can expect a vibrant AOC market for years to come because of five key factors that we believe will shape and drive the AOC market going forward.

1.1.1 AOCs: Easy Fiber

The core reason why CIR believes that AOCs will do well in the coming decade is that they represent a low-cost entry point for data center managers wishing to take part of their center—or just a link or two—optical.

Active optical cabling is a black-box solution for creating a fiber-optic connection and consists of a complete fiber-optic data link (transceivers plus cable) that can be plugged into existing ports, enabling a very rapid introduction of optical connections. AOCs provide customers with access to all the undisputed advantages of fiber (high bandwidth, relatively thin, lightweight cable, security, etc.) in a plug-in format.

As far as CIR is aware, there is no other fiberization strategy currently available that has such a strong value proposition as AOCs. For several years now, AOCs have been deployed to optimize the existing infrastructure by providing higher data rates among servers, switches and storage facilities. CIR expects this general trend to continue, and anticipates that the trend will actually accelerate throughout the next decade. However, we also anticipate new trends that will create new opportunities going forward.

1.1.2 Breaking Out: The Rise and Rise of Ethernet AOCs

The all-round usefulness of AOCs provides an incentive to shift them from being a primarily IB product and into the Ethernet mainstream. Ethernet is orders of magnitude more deployed than IB links and any shift to optical Ethernet immediately creates a leap in the addressable market for AOCs.

Just a few years ago 40 GigE was a backbone technology, but now is deployed on servers, at least the biggest ones. At 40 GigE, fiber is an option that most data center managers will at least *consider it* for longer runs. But with 100 GigE, *optical* Ethernet has finally come into its own. *Now that 100 GigE has been mainstreamed on switches, there is a ready-made—and sizeable—market for Ethernet AOCs. Also, with Ethernet AOCs*

widely available and declining in price, there will be an incentive for many Ethernet-centric data centers to use them.

The rise of Ethernet AOCs is also creating several ways for AOC suppliers to compete effectively in the marketplace. The most obvious way is for firms to offer 100-GigE AOCs, a product that has yet to be widely sold by low-cost Asian suppliers. And in addition to AOCs that operate at the same data rate at both ends, there are also now "fan-out" AOCs that (say) can connect a 40-GigE switch port to four 10-GigE server ports.

While, Ethernet is where the volume is—and will continue to be—we also note that high-speed IB connections will increasingly become commonplace in the data center and HPC cluster. Another incentive to creating novel AOC products.

1.1.3 AOCs in the All-Optical Data Center: Up and Then Down

All-optical data centers have been around for decades, but as 100 GigE becomes mainstreamed, CIR believes it will increasingly be hard for network managers to resist the temptation to go "all optical." Although admittedly, years away, the adoption of 400 GigE will eventually make all-optical data centers ubiquitous. At least at the speculative level, this raises the question as to what happens to AOCs as fiber becomes ubiquitous, given that AOCs are a product whose existence is based on fiber being something that is still not widely deployed in the data center.

As CIR sees it, this is something of a "Catch 22." The all-optical data center could ultimately spell doom for AOCs, since such a center would seem to give the edge to field-installed fiber and standardized optical connectors. This is where all data centers are probably headed in the long run. However, there is still a long road to travel before all-optical data centers are really all that common. For one thing, while the very largest data centers (for supercomputing) already have a lot of fiber in them, most don't and fiber will be deployed in an uneven fashion; first entering rack-to-switch and inter-switch connections and taking some time before it reaches the server in most centers.

While many data centers may not need fiber optics for years to come, what we think will happen is that a growing buzz about the all-optical data center, will make data center managers consider optical data centers even those who might never have thought fiber optics before or at least not as intensely. This does not mean that many of these managers will rush to buy fiber links, but rather that they will be much more open to fiberization than they have ever been before.

More specifically, some of them may insist on finding data center solutions that are "fiber ready" in some way. Some of these decision makers will opt for reconstructing their data centers—or even their entire enterprise network. But others will create a kind of "pseudo-optical data center" made up, wholly or partly, of AOCs. In any case, AOCs fit very nicely into the idea of making new data center products "fiber ready."

The bottom line is that CIR thinks the rise of the all-optical data center will encourage the use of AOCs at first. There will be a certain group of users who will deploy lots of AOCs

to create the pseudo-optical data centers referred to above. But as all-optical data centers become the norm, field-installed fiber will increasingly become common, and at the expense of the AOC market.

As the all-optical data center becomes pervasive, the AOC market may go into decline, but it will be many years before this negative trend really makes its impact felt. On the other hand, some suppliers that CIR has talked with think that AOCs will have a role to play, even in the most optical of data centers, but for very short-reach connections. It is really too early to be sure of such things.

1.1.4 Enter the Dragon: The Growing Role of Chinese Firms in the AOC Business

Perhaps the single most noticeable trend in the AOC market in the past year is the arrival of the Chinese suppliers in the mid-level of this market. Some Chinese players have been involved in the AOC market since its inception, but have competed traditionally in this space mostly with low-end AOC products; low-end, both in the sense that the product is not costly and in the sense that they are likely to be low performance or even low quality.

All this has changed over past year or so. What we are seeing now is more and more Chinese firms playing in the AOC market with *relatively* sophisticated products, although for the most part, these firms have yet to show that they can offer viable 100-Gbps AOC products. What we *are* seeing though—and for the first time—are Chinese firms that are making their technology, and not their cost, a competitive advantage in the AOC space.

As a result of this trend, we are covering quite a few more Chinese suppliers in this year's CIR AOC report. This is an important development, but shouldn't be too much of a surprise. Chinese industrial policy now focuses on the domestic development of world-class technology. The intended market for this technology are Chinese users themselves. However, we don't doubt that Chinese manufacturers will also be actively exporting their technology, too.

None of this is to say that AOCs are a focus of Chinese national industrial policy, which does indeed specifically target some technologies; LEDs, for example. However, it seems reasonably certain that the general thinking about the promotion of advanced technology embodied in Chinese policy will affect the AOC market and lift the sails of Chinese AOC companies. CIR thus feels that in our 2015 AOC report we will be covering even more Chinese companies and at a greater depth.

We also note that this kind of product roadmap—from low-cost/low-performance to world class has been an economic development pattern in Asia since the 1950s. In the next few years the rise of the Chinese AOC suppliers will be of growing importance to established AOC firms in the U.S., Korea, Japan and Europe. One long-term scenario is that Chinese suppliers may be able to become dominant players in the AOC space, but that day still seems some way off.

1.1.5 Branding, Technology and the Commoditization Factor

Some of the analysis above suggests that the addressable markets for AOCs are about to take a great leap forward in terms of volume. This encouraging news must be balanced against the fact that it is in the nature of AOCs to commoditize quickly—they are, after all, little more than standardized connectors with even more standardized cable between them. While—as we have noted above—Chinese AOC firms are becoming more sophisticated, there can be little doubt that they continue to compete on price to some extent; again a boost to commoditized AOCs.

Given all this, the AOC firms will need to find strategies to deal with commoditization. We think that there are really two of these strategies, although they may be mixed and matched in different ways:

- One possibility is to emphasize superior technology. This is not that easy to do for such a relatively simple product as an AOC, but there are ways. The one firm that claims some success using such a strategy is Luxtera whose AOC line was acquired three years ago by Molex. Using CW lasers and a silicon photonics approach, the Molex/Luxtera AOCs are very different to any other AOCs on the market and our understanding is that a few customers specifically choose these AOCs because of their technology.

  So far, no other AOC maker has gone as far as Molex/Luxtera in making its products distinct in the marketplace through the deployment of novel technology. However, others have made technology part of their AOC marketing story by using their semi-proprietary optical engine technology and stressing the performance or other features of the optical engine when selling AOCs. Generally, we expect technology innovations in AOCs in the future to be derived from the latest developments in photonics, optoelectronics and packaging.

- The second way to deal with commoditization in the AOC space will be to make use of branding strategies. What we have in mind here would be similar to what 3Com used to do with its Ethernet interfaces. That is, while there were many less expensive Ethernet interfaces that could be purchased, there was a tendency to buy 3Com since it appeared be to a symbol of quality and reliability. As with AOCs, these PC interfaces while fairly commoditized, were also situated within strategic parts of the network, computer room or data center. But while we think this kind of branding will inevitably be used in the AOC space, it is far from clear how well this strategy will do in the long run.

1.2 Intended Audience for this Report

CIR's annual report on AOC market opportunities is now widely regarded as the most authoritative market forecast and technology assessment in the AOC space and is read by business development and marketing executives in cabling, component and equipment firms throughout the world.

CIR anticipates that this report will be a high-value resource for marketing and business development managers at components and cable firms that are currently supplying AOCs or plan to do so in the future. We also believe that the report will be of use to data center and enterprise networking managers as well as investors in the data-com space.

1.3 Objectives of this Report

The goal of this report is to explore the five issues that we have explored above and show how these will lead to new opportunities for suppliers of AOCs for the data center over the next ten years. In previous CIR reports on AOCs we also covered how AOCs have potential for sales into non-AOC markets including consumer electronics, personal computing and digital signage. However, in 2014, CIR is covering these "non-traditional" markets for AOCs in a separate volume.

In addition to identifying the near-term and long-term opportunities that will emerge for AOCs in the data center as the result of important economic and technological trends, this report also quantifies these opportunities. This quantification is presented in the form of granular ten-year forecasts of the AOC market that are presented later in this report. The forecasts include appropriate breakouts by data rate, standards/MSA, cable type, reach, wavelength and form factor.

This report is primarily about business strategy rather than technology. And as such we have included a fairly lengthy Chapter consisting of profiles of leading AOC suppliers. In this Chapter we have discussed and analyzed the strategies of these firms. The number of firms that are included in this space has grown every year that CIR has been publishing this report and they are now quite a diverse group including some of the worlds biggest suppliers of cabling and telecom components. On the supply side, this report also provide CIR's take on the rise of Chinese suppliers and other new entrants into the AOC space.

1.4 Scope of this Report

As mentioned above, this year CIR has decided to split our report into two volumes. In this volume we analyze and forecast the opportunities for AOCs in their traditional data center and HPC markets, which is where AOCs began life as "InfiniBand extenders," but now embrace all the other major local area networking protocols. In Volume II, we analyze AOC opportunities in markets where AOC insiders believe they will generate significant revenues over the next decade: personal computing, consumer electronics and digital signage.

More specifically, coverage in this report is of the full range of AOCs that are now used in the data center. This includes the full range of speeds, but we have focused on 40 Gbps and 100 Gbps cabling in this report, since we believe that this is where a lot of opportunities are going to be focused. We also look at how AOCs may be adapted to the many different MSAs, cable type and connector types that they can utilize.

However, as we have already noted, this report is focused on the data center and related markets such as enterprise networks. With this in mind we have not discussed the relatively few AOCs—and their suppliers—that are specifically targeted towards the HDMI and other video applications.

Finally, the report examines all the big themes in data centers. These include clouds, SDN, and virtualization. Obviously, there is no attempt to discuss these in a broad sense, we are concerned here only with the ways that these data center trends impact the current and future data center markets for AOCs.

1.5 Methodology

The methodology used to compile this report is similar to that used in other reports published by CIR. The analysis presented here is based on data and views collected from interviews with many different players in this space ranging from key suppliers and users of AOCs in the U.S. and throughout the world. These interviews were conducted over the phone and in person.

CIR also collected and analyzed data from third party sources including (1) corporate Web sites, financials and presentations, as well as (2) reputable trade and technical publications, including papers delivered at conferences.

A discussion of the forecasting methodology is included in Chapter Four of this report; this chapter being dedicated to delivering CIR's ten-year forecasts of AOCs in the data center.

1.6 Plan of this Report

Chapter Two of this report discusses the data center and related enterprise networks as addressable markets for AOCs. It covers how the latest trends in the data center are likely to impact the AOC market and where the opportunities will emerge as a result.

Chapter Three of this report provides profiles of more than 30 companies that offer AOCs. The focus of these profiles is on an analysis on the latest products and market strategies that are emerging from the firms covered.

Finally, Chapter Four provides ten-year market projections of the AOC market based on our view of addressable markets and penetration rates.