

Chapter One: Introduction

1.1 Will the AOC Market Continue to Grow?

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 that stretches back seven years. Obviously, one reason why CIR has been covering this area of optical communications for so long is that the AOC market has continued to grow and attract more market entries by a variety of firms.

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However, since our previous report in 2014 we think that there has been a definite softening in the activity for the worldwide AOC market. Not only have there been fewer product introductions in the AOC space—not many at all actually—but some firms seemed to have dropped out of this space altogether. In some cases, AOC products that were announced a year or so back never seem to have made it to product catalogs.

In many ways this should be no surprise; the surprise should have been that AOCs ever made the splash that they did a couple of years back. AOCs are a very simple product that has mostly sold into a niche market (IB). CIR believes that the current lower level of product introductions is a sign that the supply of AOCs and the excitement about AOCs as a business have somewhat overshot the real world. It is not a sign that AOCs are not a decent business opportunity.

We still expect the AOC market to be quite healthy for years to come although there may be some consolidation of this industry sector; it is unclear that the world needs 30 plus AOC manufacturers.

1.1.1 The Core Value Proposition for AOCs Still Remains Strong

The core reason why CIR believes that the AOC market will continue to do well in the coming decade is that they represent a low-cost entry point (arguably *the* low-cost entry point) for data center managers wishing to take part of their center—or just a link or two—optical. It seems inevitable that there will be a growing number of such managers.

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 we see the shakeout that is apparently going on in the AOC space as an adjustment to the realities, not a flaw in the basic AOC business model

1.1.2 Breaking Out: Beyond IB, but Slowly.

The all-round usefulness of AOCs has always provided an impetus for the AOC market to shift them from being a primarily IB product and into the Ethernet mainstream and beyond. In particular, Ethernet is orders of magnitude more deployed than IB links and any shift to optical Ethernet immediately creates a leap in the size of the addressable market for AOCs.

The environment for using Ethernet AOCs has become very favorable, now that 100 GigE is mainstream on switches in even medium-sized data centers. But we note that again Ethernet AOCs have not taken off as fast as some hoped a year or two back. This may be read as something of a cautionary tale for those AOC firms that are pushing forward with “consumer AOCs” (USB and HDMI).

In any case, 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 for creating novel AOC products.

1.1.3 Will the All-Optical Data Center Kill the AOC Market?

All-optical data centers have been around for decades, but as 100 GigE becomes mainstreamed, CIR believes it will be increasingly hard for network managers to resist the temptation to go “all optical.” 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.

However, CIR believes that this should not worry AOC manufacturers and indeed will not be a factor that they are concerned with for many years to come. Most data centers don't have much fiber in them 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. *In other words, there is still a big addressable market for AOCs and the way that fiber is likely to be introduced into the data center is very conducive to the use of AOCs.*

Although admittedly years away, the adoption of 400 GigE will eventually make all-optical data centers ubiquitous. Before then, however, 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 begin to consider using more optical data centers – especially those using AOCs – in the data center.

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."

1.1.4 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.

AOC firms will need to find strategies to deal with commoditization. As a practical matter, CIR believes that there are really two of these strategies, although they may be mixed and matched in different ways.

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. For example, 400 Gbps AOCs will depend more on innovations in 400 Gbps interface technology than on AOC-specific developments.

Branding: 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 to be 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 valuable 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 communications and high-performance computer spaces.

1.3 Objectives of this Report

The goal of this report is to explore the issues that we have mentioned above and show how these will lead to new opportunities for suppliers of AOCs for the data center over the next nine 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, beginning in 2014, CIR has covered 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 nine-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 since CIR began publishing these reports. But this year has been different; the number has fallen a little suggesting a trend towards consolidation, a trend which shouldn't be a surprise to anyone.

1.4 Scope of this Report

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 for many years to come.
- There is also some discussion of 400 Gbps AOCs, since many see this as an opportunity—although one that will not appear until late in the forecasting period considered in this report.

As we have already noted, this report is focused on the data center and related markets such as enterprise networks. We also examine all the big themes in data centers. These include clouds, SDN, and virtualization. These are no longer new trends, but continue to infiltrate themselves into the data center and have significant impacts on how fiber in general—and AOCs in particular—are deployed.

Obviously, there is no attempt to discuss these matters in detail, we are concerned here only with the ways that these 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.

CIR has 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. The analysis presented here is also based in part on interviews with different players in this space ranging from key suppliers and users of AOCs in the U.S. and throughout the world.

A discussion of the forecasting methodology is included in Chapter Four of this report; this chapter being dedicated to delivering CIR's nine-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. As far as possible we have focused on changes that have occurred since CIR's latest report on AOCs.

Chapter Three of this report provides profiles of 24 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. Note that there are a few other companies—Corning is one—that are focusing on AOCs for consumer applications. This is the focus of Volume II of this report.

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