London Business School

Edrich Instruments (A)

Abstract

When Martin McCabe was offered a job with Edrich Instruments in 1998, the company was at a crossroads. From its origins as a small academic research group specialising in optical instruments for astronomical observation, it had slowly developed into a supplier of test equipment for various semiconductor and data storage manufacturing markets. Now it was being offered the chance to enter into a deal worth $45 million to supply Luminos Technology, one of the world's largest telecom groups, with sophisticated monitoring equipment to be used in the roll-out of their fibre optic networks. The problem was that Edrich – used to making some 20-50 systems per month on a batch basis – would be required to mass produce 500 precision instruments per month. The Luminos order presented enormous opportunities, but with cash already in short supply, McCabe together with Edrich's founders, knew they would have a major challenge on their hands scaling up the company's manufacturing capabilities in such a short space of time. To deliver this change, Edrich Instruments had identified a need for a manufacturing manager and had contracted McCabe.

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Julian Lloyd prepared this case under the direction of Dr. Susanna Khavul, Assistant Professor of Entrepreneurship, London Business School, as the basis for class discussion rather than to illustrate either effective or ineffective handling of an administrative situation.

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Martin McCabe was facing what looked to be the offer of a lifetime – the chance to join an entrepreneurial high technology company poised for explosive growth. As he considered how he might help the company fulfil its potential, McCabe reviewed what he had found out about the company to date.

Early development

Edrich Instruments was founded in 1979 backed by three University of London academics – Paul Fisher (formerly a PhD student and full-time Research Assistant), Ken Graham (full-time Lecturer in Astronomy), and Tom Astor (Research Fellow).

The team's research focused on developing 'tunable optical filters'. These were familiar devices to astronomers who used them for a range of applications, including measuring the wavelength shifts of light, which in turn enabled them to map the motion of distant objects.

The optical filter was based on the Fabry-Perot Interferometer (FPI). This technique was invented in 1896 and involved two parallel, ultra-flat, coated glass sheets. As light passed through the glass, characteristic interference patterns would enable observers to detect minute changes in wavelength. However, to work properly, the glass plates had to be aligned at levels of precision better than a nanometer (a thousand-millionth of a metre).

Traditional FPIs were still too sensitive to environmental disturbance. They were almost impossible to use for the type of detailed astronomical observation work that Fisher and the team at Edrich were trying to undertake.

During their research, however, Edrich cracked the stability problem associated with environmental disturbance. Edrich inserted 'pzt' ceramic actuators between the glass sheets. Under voltage, these actuators would expand by minute amounts. This degree of expansion could be monitored and controlled by capacitance sensors that controlled the alignment to extraordinary levels of precision.

This stabilisation technique, combining capacitance position sensors and pzt actuators, would form the core of Edrich's products for the next 20 years.

Edrich's first product – the T-1100, launched in 1980 – found its key application among international observatories and space agencies. It enabled observers to make dramatic reductions in the amount of expensive 'telescope time' they needed in order to make their observations.

The tunable filter concept had only limited patentability, however, since Edrich had already released much of its research into the public domain by publishing various research papers.

The birth of nanopositioning

By 1985, Edrich had produced a number of one-off tunable filters for various clients and had even been invited to develop filters for equipment being used in the space shuttle. However, the Edrich team knew that serving these markets on a one-off basis would not provide a platform for future growth.

Edrich considered its technology strengths, and it soon became apparent that Edrich's 'nanopositioning' technology might have much wider applications outside of the space agencies market that Edrich had concentrated on so far.

The team's optimism was fuelled by discussions with various research laboratories in the field of semiconductor technology and data storage. Disk drive manufacturers, for example, were researching methods to measure the position of disk drive heads as they wrote to and read from hard and floppy disks. Semiconductor manufacturers were looking for a means of controlling the position of wafer chips in their wafer 'stepper' machines during manufacture.

Edrich did not have a clear view of how the semiconductor and data storage sectors might use the technology beyond these initial research applications. However, in the absence of clear market signals, Edrich sought to position itself closer to these sectors in the hope that a major application would develop.

Increasingly, Edrich would create prototypes in small volume for blue-chip clients who were developing niche applications. By spreading the net wide, Edrich hoped to lock into an application that would eventually deliver mass volume for its nanopositioning products. Fisher described this approach as 'kissing frogs' – one day, one of these nascent applications would turn out to be a prince.

Early manufacturing

Assembly and testing of its technically complex products was carried out by hand by skilled engineers trained in the complex mathematical and physical theory inherent in the design (most of the staff were skilled graduates who would take two to three years to become fully versed in the technology).

As part of its focus on technology strategy, Edrich decided to upgrade its manufacturing and design capabilities to better position itself to capture new orders. In November 1985, Edrich moved to a 1,400ft^2 facility based in an ex-print works in Sunbury, which was fitted out with a basic clean room, design facilities and precision manufacturing capability.

On the road to batch production

Between 1985 and 1987, Edrich got to grips with low-volume batch production rather than the production of one-offs. By 1987, it was producing around five nanopositioning systems a week for a range of semiconductor and data storage companies who needed the technology for their own research and development.

At these sorts of volumes, Edrich was keen to upgrade its technical capabilities, but lacked the financial strength to make the necessary investment. Accordingly, a deal was struck with 3i in which 3i acquired a 20 per cent equity stake for £250,000. Fisher knew that these were demanding terms, but also knew that without 3i's cash injection, new facilities would never be built.

With the 3i deal secured in February 1988, Edrich moved out of its Sunbury premises into Blackwater Science Park. Here it was possible to set up a proper batch production facility with an in-house design CAD (Computer Aided Design) operation and a facility to lay out circuit boards in-house (which had previously been outsourced). In 1987 a Production Manager was brought in full time.

The roles of the founders remained fluid. The basic structure involved Paul Fisher occupying a CEO-type role and managing the Design, Operations, Sales and Marketing. Ken Graham acted as Chairman of the Board, while Tom Astor managed Electronics Development.

In practice, their roles often overlapped and from the beginning, 'constructive conflict' materialised over a range of issues, many of which remained unresolved. Graham and Fisher, in particular, were frequently competing for influence, Graham describing his role as acting as a 'brake' to Fisher's 'accelerator'.

Nonetheless, what was forming was a strong and committed corporate culture based around an impressive team of technical experts. Staff at all levels were deeply imbued with a sense of excitement at finding pioneering solutions to the technical challenges inherent in the sector Edrich was working in. Celebrations of the company's many technical achievements entered company folklore – staff worked hard and played hard. They also tended to stay, firmly believing – like the main Board members – that there were big opportunities ahead.

Telecoms joins the fray

By the late 1980s, Edrich began seeing potential in the telecoms market. Several companies were exploring the potential for large-scale roll-outs of high capacity fibre optic networks. Products that could monitor optical signals to a very high level of precision on fibre optic networks were likely to become increasingly central to these plans. A product Edrich sensed they would be well placed to provide.

Optical monitoring would be especially critical at the numerous fibre optic network hubs – where signals were being re-routed. Between these hubs, numerous amplification points would also need to be built – in which light signals would be decoded and re-transmitted to overcome the tendency of the light signal to fade after it had passed through multiple kilometres of glass fibre. Both applications required sophisticated light monitoring technology based around 'plug-in cards' that could be easily housed in standard racks.

Edrich soon found itself in an increasing number of conversations with telecoms companies about designing optical monitoring systems based on its tunable optical filter technology. Edrich's systems had always been compact, with no other company able to produce optical systems of comparable performance at such size.

In 1990, Edrich pressed home its advantage by trialling a microfilter – effectively a tunable optical filter 'on a card'. Once customised, the product offered optical monitoring in units that were much cheaper and smaller than existing test equipment.

Bell Labs and Luminos – one of the largest telecoms carriers in the US – immediately expressed interest in a prototype. They were all too well aware that fibre optics represented one of the most exciting opportunities facing the telecoms sector in decades. Previously confined to long distance networks, fibre was now being contemplated for all connections, including those in the local loop. Bandwidth also offered an explosion in voice and data services that had the potential to revolutionise the way customers used their telecoms services.

Although it was still early days for Luminos in terms of its fibre optic plans, it knew that identifying and working with equipment supplier partners would be key to its ability to deliver innovative solutions into this emerging market. Edrich, although a relatively small player, had mastered aspects of optical technology that could play an important role in Luminos's ambitions going forward, and Luminos was only too keen to evaluate how this technology might be utilised and adapted.

Return to space

At the same time, following discussions with Psilon, Edrich was making progress in its more traditional space business.

Psilon was owned by the French Espace aerospace group and was involved in the production of inter-satellite communications systems. In 1992 it signed a contract with Edrich for about £200,000 to supply nanopositioning equipment. There was a prospect that the Psilon technology would become a world standard for inter-satellite communication, which would have big implications for Edrich's business going forward.

Divisional reorganisation

Within Edrich, the debate began to rage about how best to organise itself to exploit these opportunities.

The structure that emerged in 1992 was a pragmatic compromise, with the company organising itself into four divisions on the following lines:

- T-1100 division. Focused on the manufacture and design of the T-1100 range targeted largely at the astronomy research sector. The nature of the sector meant that demand would always be for low-volume, customised 'one-off' orders.

- Nanopositioning division. Most of Edrich's growth had centred on its nanopositioning range, which had found profitable niche markets in the data storage and semiconductor manufacturing markets, and was now driving a batch production operation to service a range of clients.

- Space contracts. Although space contracts (such as the space shuttle and Star Wars contracts) tended to be short-lived, Edrich was excited by the prospects of the Psilon contract it had recently negotiated. As a result, it decided to create a separate division around the Psilon business. This reflected the fact that the technology was highly complex and required the use of Edrich's best designers and engineers. Chris Wexford was brought on as Project Manager to oversee the Psilon contract.

- Telecoms. Several telecoms companies showed interest in Edrich's microfilters and products were being supplied on a custom basis to Bell Labs and Luminos to enable them to work on their own prototype research and development. By 1992, as part of the divisional reorganisation, it was decided that the telecoms microfilters market offered sufficient promise that a separate telecoms division should be created. Ken Graham was put in charge of the division, but struggled to come to terms with managing the people or the product development process.

By 1994, with demand for relatively high volumes of microfilter products possible, Edrich felt that the telecoms business had the potential of scaling differently to the other businesses.

Accordingly, the decision was taken to separate Telecoms from the rest of Edrich's manufacturing and to set up dedicated manufacturing resources for the division, including a dedicated clean room and test equipment.

To provide better focus on the telecoms business, it was decided to put Chris Wexford in charge of the telecoms division, leaving Ken Graham with no role (see Exhibit 6) other than Chairman.

Coping with volume

Volume orders for telecoms equipment were beginning to come in. In 1996, first Atlantia and then AurTel – two large telecoms equipment suppliers who, like Luminos, were interested in the potential for creating fibre optic networks – placed orders for network monitoring equipment based on Edrich's tunable filter products. Each order was for 100 'microfilters on a card'.

As Edrich got to grips with fulfilling these orders, it was faced with a range of challenges as it attempted to shift from batch production to low-volume manufacture.

- A key issue was that, while the cards themselves could be mass produced, assembly of the optical parts on the microfilter cards was almost impossible to automate. Rigorous specialist testing was required at each stage of the assembly process and where even minor product variability was detected, components would have to be disassembled, re-tested and then re-assembled before moving on to the next manufacturing stage.

- It was also clear during testing that the design of the microfilter equipment made it virtually impossible to completely eradicate minute variability in performance. From necessity, wires physically intruded into the actuator, sensor and interferometer components. This meant that the overall microfilter products could not be completely protected from temperature and humidity fluctuations, both of which affected the accuracy of the microfilters' light readings (see Exhibit 4).

- To monitor the issue and to ensure product performance and quality, Edrich devised a wide range of tests at each stage of the 15-stage manufacturing process. The testing cycle meant that a single product passing all 15 tests without problems could be manufactured in 12 hours. Where a product failed one of the tests, it would be returned to the previous assembly stage where the relevant component would be re-assembled. The tests established that the variability could not be completely eradicated, but kept it at a sufficiently low level to make no difference to the applications that AurTel and Atlantia would be using (see Exhibit 5).

- A further issue was that sales and operational data were not properly integrated into manufacturing processes, reducing the ability of manufacturing operations to schedule their capacity and component requirements to handle future orders. Part lists were held on a central Access database, but this functioned poorly and most departments preferred to keep their own lists of parts on locally produced Excel spreadsheets. This produced a range of databases that never properly tallied.

- Edrich's manufacturing activities were also complicated by the fact that between the three founders – Paul Fisher, Ken Graham and Tom Astor – clear demarcation of responsibility had never been finalised. To a great extent this was viewed positively and reflected Edrich's fluid, 'entrepreneurial' feel, but it had also become a source of tension and conflict and complicated the manufacturing process where ownership of a product and responsibility for its ongoing quality were rarely clearly established.

- Edrich had tended to adapt its products as it built them, meaning that each product it assembled would tend to differ in small ways from its predecessor. This tended to reflect its research and development rather than production culture; Edrich largely encouraged this approach, aware that, to date, customers had been looking for innovative solutions to resolve particular problems. As a result, the company did not have formal change control mechanisms in place to monitor and control output specifications.

Lost in space

During 1997, the Psilon order, which had proved highly lucrative, finally came to an end. Psilon had failed to establish itself as a communications standard and it was clear that after Edrich had fulfilled the Psilon contract there would be no more space contracts coming through.

As a result, revenues for the second half of 1997-98 would be significantly lower than the first half. As a result, Edrich knew that it would be increasingly reliant on building its telecoms business as a future engine of growth.

A prince?

In November 1997, Luminos Technology approached Edrich to discuss an order that promised to transform the company's fortunes.

Luminos sat down to discuss an order worth $45 million a year, which would require Edrich to supply nearly 500 microfilter network monitors per month. Luminos would incorporate the microfilters into prototype network hardware that it was designing and looking to sell to a range of telecoms companies that were considering a major roll-out of fibre optic networks in the US. It looked like the kissing frogs strategy had finally found a prince.

Fisher and Graham knew that this was 'the big one'. The stock markets and telecoms industry were abuzz with the potential being offered by fibre optics as the 'Information Revolution' got under way (see Exhibit 6). There was equal interest shown in component suppliers in the industries as analysts realised that an entire sector could soon become dependent on the capabilities of leading optic players like SDL and JDS Uniphase. With Luminos – one of the world's largest telecoms equipment suppliers – approaching Edrich for a major order of its unique microfilters, Edrich could see that it was in the right place at the right time.

Edrich worked flat out with Luminos to iron out the terms of the contract. These were largely agreed by July 1998. The contract specifications were detailed and involved product performance that Edrich had not needed to meet before. For example, the Luminos order would require lower levels of sensitivity to humidity and temperature variation than Edrich had been able to achieve on the AurTel and Atlantia orders. Edrich was confident that over time it could achieve this specification target as it fine-tuned the product design in preparation for volume manufacture.

In some cases, the contract required conformance to international standards that were not finalised. In other cases, it was left open to interpretation whether conformance would be required to each specification taken in isolation or to specifications taken in combination. The latter would be much more problematic for Edrich. It would take months of testing to evaluate how performance varied under different combinations of environmental fluctuations – such as temperature, humidity, pressure and vibration – all being varied simultaneously. The results would, however, be largely academic since no fibre optic application actually required performance of this precision.

Fisher was prepared to tolerate this level of uncertainty because he knew that, ultimately, Luminos had nowhere else to go (see Exhibit 6). No other manufacturer was even close to being able to develop microfilter equipment comparable to Edrich's and it was, therefore, in Luminos' interest to partner Edrich through the learning curve. Nor did Luminos have any incentive to prolong the manufacturing and testing process in order to produce microfilter performance far in excess of anything Luminos's own customers would ever need.

However, Edrich did have an incentive to climb the learning curve quickly. The pricing schedule in the contract specified that during the first half of 1999, each channel monitor would sell for $20,000. From August 1999, the unit price would fall to $8,500 (by which time, volumes were projected to run at 150 per month). In 2000, Luminos would buy all units for $7,500 each, regardless of volume.

With the contract terms agreed, it was decided that production should begin in early 1999, ramping up to a full production rate of 500 per month by June 2000.

To achieve this it was clear that a major investment (estimated at £1.2 million) would need to be made to install the necessary specialist manufacturing equipment, (analysers, power equipment, manufacturing chambers, temperature and humidity control equipment and testing equipment). Additionally, the Luminos order would require the installation of a new clean room costing around £400,000.

To help fund this – and to help offset the mounting losses that Edrich had experienced since the Psilon business had fallen away – in May 1998 Edrich arranged a £2.4 million bank loan facility. Ian Forsyth, Finance Director, armed with the latest company financials (see Exhibits 1 and 2), also began discussions with various venture capital houses – including 3i – about securing a further £2 million cash injection in exchange for a 9 per cent equity stake.

With the long lead time for key components (particularly the specially coated glass ordered from Luxembourg), Edrich would need to place orders with suppliers during the third quarter of 1998 in order to be in a position to start volume manufacture in the first quarter of 1999. It was estimated that with components costing $6,000 per unit, preliminary orders worth $500,0000 would be required to cover the first three months of manufacturing.

Edrich also looked to recruit a Manufacturing Manager – Martin McCabe – to oversee the Luminos order. McCabe had a strong background in running large-scale manufacturing systems within the defence sector. Edrich was attracted by his experience of complex electronic and optical systems and by the experience he could bring to bear in effecting a rapid transition from batch to scale manufacture, (see Exhibit 5 for the organisational structure.)

Edrich offered McCabe the position in August. McCabe needed to decide quickly whether Erich's proposed rapid dash for scale was achievable. He could see that the timescales were extremely tight and that there were considerable risks involved. Over the next six to nine months, Edrich would need to transform its operation from one used to producing 20-30 systems per month to a full-scale production capability of 500 per month.

A major recruitment drive would be required to house the clean room, with 32 new manufacturing engineers and 15 operators. Many of these would need to be in place by the end of the year before production started.

Offsetting these risks was the fact that Luminos – one of the largest manufacturers of telecoms equipment in the world – would be partnering Edrich. There were bound to be manufacturing teething problems, but with Luminos having every incentive to help Edrich climb the learning curve, early production problems were likely to be surmountable during the company's transition.

To McCabe, the urgency of the transition represented an exciting challenge and a far cry from the organised product and manufacturing development that had been the norm in his previous roles. He had one week left to decide whether he would accept the position – would the Luminos deal fulfil Edrich's longstanding strategy of becoming a volume manufacturer in a high growth sector, or would the burdens of scaling up at this speed prove intolerable?

Exhibit 1: Management accounts – Profit and loss to 31 March 1997-98 and 1998-99

£s	Year to 31 March 1998					Year to 31 March 1999				
	1997			1998		1998			1999	
	Q2	Q3	Q4	Q1	Total	Q2	Q3	Q4 F	Q1 F	Total
Turnover										
Nano	972,000	1,004,400	885,000	930,000	3,791,400	780,000	966,000	900,339	921,150	3,567,489
Telecoms	84,000	66,150	75,000	105,000	33,0150	120,000	150,000	165,000	180,000	615,000
Optical systems (T-1100 and space contracts)	1,110,000	1,026,000	210,000	252,031	2,598,031	198,000	255,000	258,000	222,000	933,000
Total	2,166,000	2,096,550	1,170,000	1,287,031	6,719,581	1,098,000	1,371,000	1,323,339	1,323,150	5,115,489
Cost of sales										
Materials	595,650	576,551	321,750	286,800	1,780,751	315,000	330,000	360,000	363,866	1,368,866
Salaries	205,770	199,172	111,150	122,268	638,360	120,000	108,000	126,000	125,699	479,699
Duty	36,822	35,641	19,890	21,880	114,233	0	0	0	0	0
Expenses	158,118	153,048	85,410	93,953	490,529	102,000	108,000	96,000	108,000	414,000
Total	996,360	964,413	538,200	524,901	3,023,874	537,000	546,000	582,000	597,566	2,262,566
Contribution	1,169,640	1,132,137	631,800	762,130	3,695,707	561,000	825,000	741,339	725,585	2,852,924
Works overhead	237,000	186,000	168,000	165,000	756,000	174,000	189,000	360,000	409,210	1,132,210
Gross profit	932,640	946,137	463,800	597,130	2,939,707	387,000	636,000	381,339	316,374	1,720,713
Overhead										
Engineering	234,000	261,000	285,000	306,000	1,086,000	333,000	337,800	342,000	357,000	1,369,800
Sales & marketing	207,000	232,200	276,000	297,000	1,012,200	285,000	307,200	315,000	324,000	1,231,200
G & A	241,200	246,000	237,000	244,800	969,000	252,000	246,000	252,000	258,000	1,008,000
Total	682,200	739,200	798,000	847,800	3,067,200	870,000	891,000	909,000	939,000	3,609,000
Operating profit	250,440	206,937	-334,200	-250,670	-127,493	-483,000	-255,000	-527,661	-622,626	-1,888,287

Exhibit 2: Balance sheet

Balance sheet To 31 March	1997	£ 1998
Fixed assets		
Tangible assets	770,969	780,895
Investments	214,010	200,000
Total fixed assets	984,979	980,895
Current assets		
Stock and WIP	481,202	581,621
Trade debtors	345,600	458,015
Bank and deposits	497,203	99,229
Other current assets	702,070	669,051
Total current assets	2,026,075	1,807,916
Current liabilities		
Trade creditors	-252,730	-453,441
Short term loans	-427,010	-326,142
Other current liabilities	-772,990	-549,375
Total current liabilities	1,452,730	-1,328,958
Net current assets/liabilities	573,345	478,958
Total assets less current liabilities	1,558,324	1,459,853
Long term liabilities		
Long term debt		-13,754
Other long term liabilities	-199,209	-149,759
Total long term liabilities	-199,209	-163,513
Total assets less liabilities	1,359,115	1,296,340
Shareholders funds		
Issued capital	3,498	3,498
Total reserves	1,355,617	1,292,842
Share premium account	83,859	83,859
Revaluation reserves	199,750	199,750
Profit/(loss) account	882,008	754,515
Other reserves	190,000	254,718
Total shareholders funds	1,359,115	1,296,340

Exhibit 3: Forecast production schedule 1998 and 1999

	1998			1999								
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
Production volume (microfilter units)												
AurTel	32	23	20	20	20	20	20	20	20	20	20	20
Atlantia	3	5	2	10	20	30	25	25	20	20	20	20
Luminos				10	10	20	40	70	100	130	150	150
Total	35	28	22	40	50	70	85	115	140	170	190	190
Materials – purchase commitments (£k)												
AurTel			20	20	20	20	20	20	20	20	20	20
Atlantia			54	54	54	54	54	54	54	54	54	54
Luminos			90	158	225	338	338	338	338	338	338	338

Exhibit 4: AurTel prototype test stage results – October 1997

During early 1997, Edrich had been asked to produce a microfilter for AurTel with a view that 20 units would be manufactured per month from January 1999. Edrich estimated the cumulative lead time of manufacture at five weeks, during which time each product would have to pass through 20 different assembly stages. Failure at any stage would require the unit to be partially disassembled and re-tested. Each unit contained around £1,000 of materials. During trial manufacturing (April-September 1997), Edrich were aiming to produce ten units per month, but production problems resulted in average output levels of four per month. The main problems revolved around components failing to conform to specification standards at various test levels.

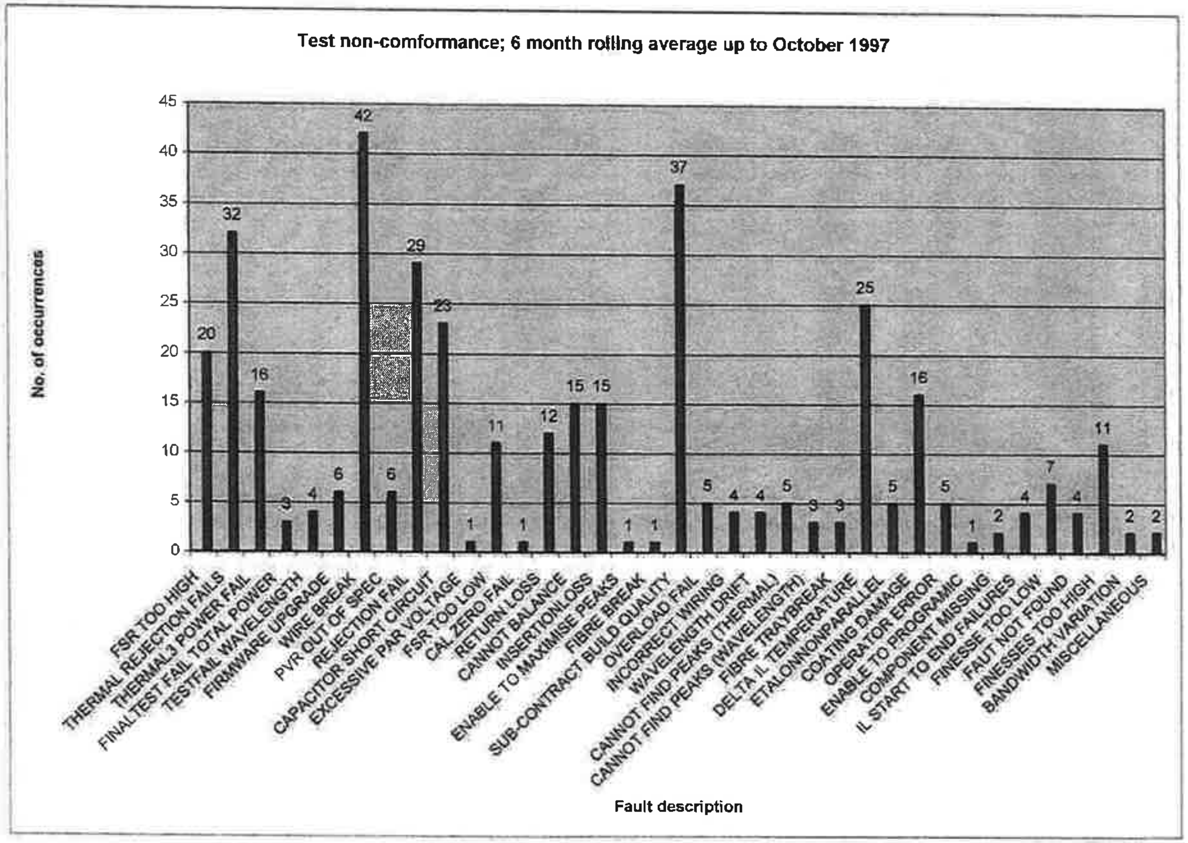
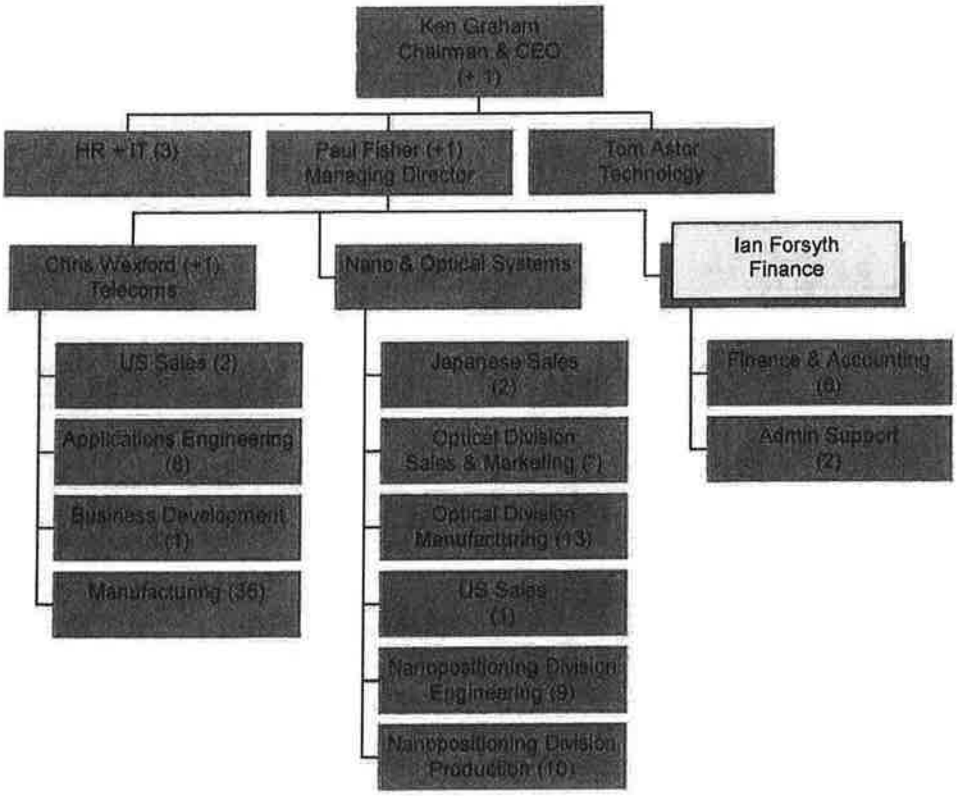


Exhibit 5: Organisation chart

Etalon Instruments Organisation Chart



Appendix 6: Fibre optics in the news – *Red Herring* article

Fiber optics takes the spotlight
By Vanessa Richardson
September 3, 1999

Now it's official: fiber optics is white-hot. Cisco Systems announced last week it was buying two privately held networking companies that specialize in fiber-optic systems – Cerent and Monterey Systems – for a combined $7.4 billion. The $6.9 billion laid out for Cerent was the most ever paid for a tech startup.

"Cisco put the seal of approval on the fiber-optics industry and the valuations that the individual companies are getting," says Kevin Slocum, analyst for the SoundView Technology Group. That particularly applies to the component makers, companies that sell the nuts and bolts – or, in this case, the lasers and multiplexors – to companies (like Cisco) that design the network systems, which then in turn sell the systems to phone and data carriers to install on their networks.

Last Thursday, the Cisco announcement sent the prices of the three major component makers soaring. They've since fallen a bit – JDS Uniphase, the No. 1 parts maker, closed Wednesday at $110; smaller supplier SDL closed at $81.19; and E-Tek Dynamics, after dropping lower, closed back up at $60.75 – and offer the opportunity to buy into the infrastructure.

Not that they're bargains at these prices, though. Based on estimated year 2000 earnings, JDS Uniphase trades at a price/earnings ratio of 100, E-Tek at 96, and SDL at 75. Because of that, some analysts have downgraded their ratings from Strong Buy to Buy or Hold since the Cisco deal went through, based on pricey valuations.

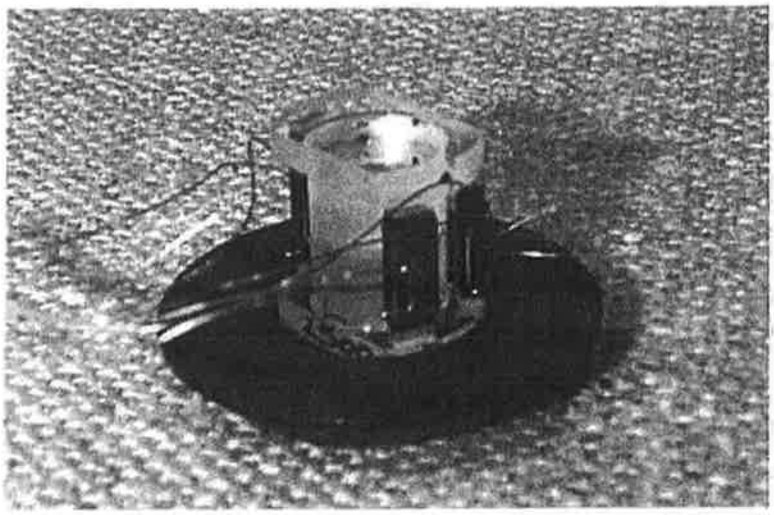
Other analysts and fund managers think the nuts-and-bolts makers are still worth the price. "Luminos, AurTel – all the system suppliers get their basic equipment from just a handful of companies," says SG Cowen Securities analyst Jim Kedersha. "In short, they need these guys. They can't go anywhere else."

The Choice Is Clear
Fiber-optic technology has been around since the late 1980s, primarily in long-distance telephone system backbones. It has become a hot item now for both phone and corporate networks because of growing demand for bigger bandwidth. And fiber has great headroom. The laser light that carries data through fiber-optic glass can be split into different colors, or wavelengths, each of which carries a discrete data channel. Better yet, transmission facilities for new wavelengths can be retrofitted onto existing plants that connect to fiber already in the ground, which makes it the easiest way to increase bandwidth.

Wall Street estimates for annual growth in the use of fiber optics settle around 30 to 40 percent. In its acquisition announcement, Cisco estimates that the market will hit $17 billion in 2002. Currently, fiber optics is most widely used for long-haul telecommunications (e.g., phone calls from Los Angeles to New York) and for overseas cable laid underwater, but it has found a new use in metropolitan areas for cable TV and corporate intranets – AT&T, for example, is using fiber optics for cable transmission.

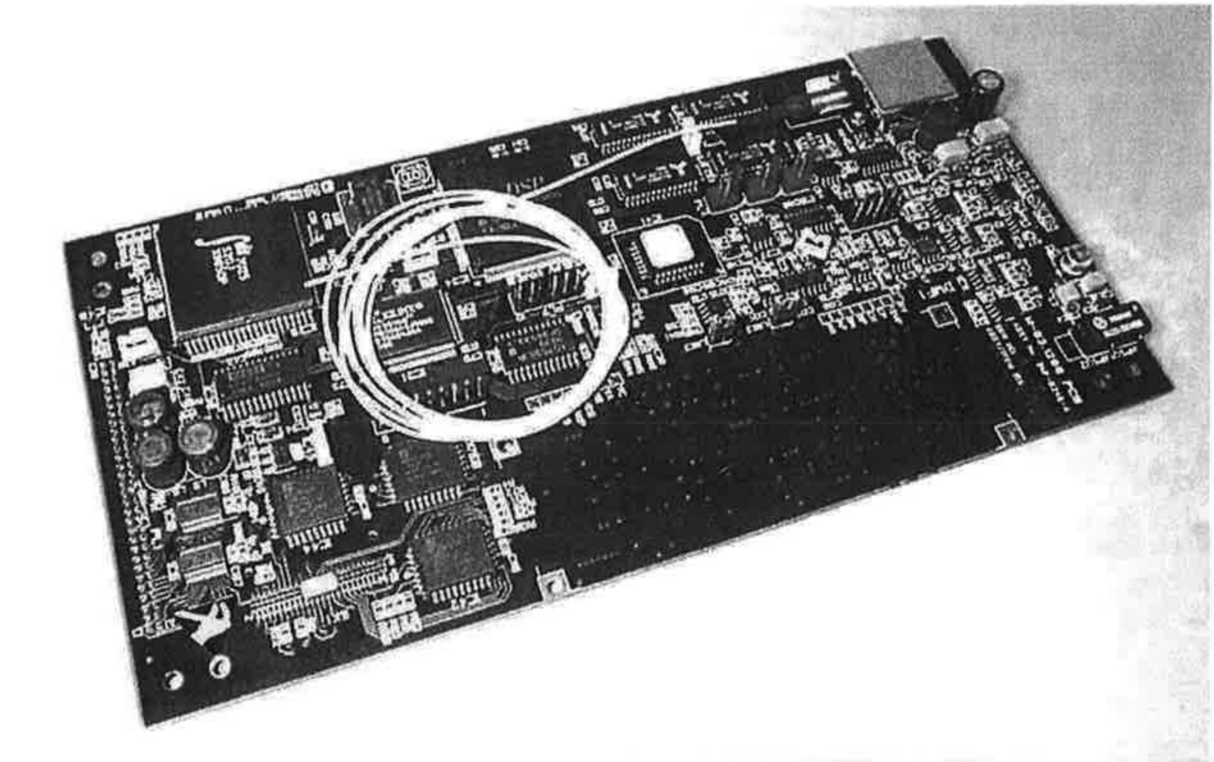
For all these uses, component makers supply the lasers, the chips, the amplifiers, and various other gadgets needed to send the light skipping down the wire. "If you buy into the fact that Moore's Law applies to fiber optics and that demand is doubling every six months, these companies are worth buying into," says Philip Fine, a portfolio manager for Loomis Sayles & Company, which holds JDS Uniphase and SDL in its Aggressive Growth fund and private investments. "Cisco is the best large-cap play on infrastructure, but components stocks are another way to profit from it."

Appendix 7: Product and workshop photos

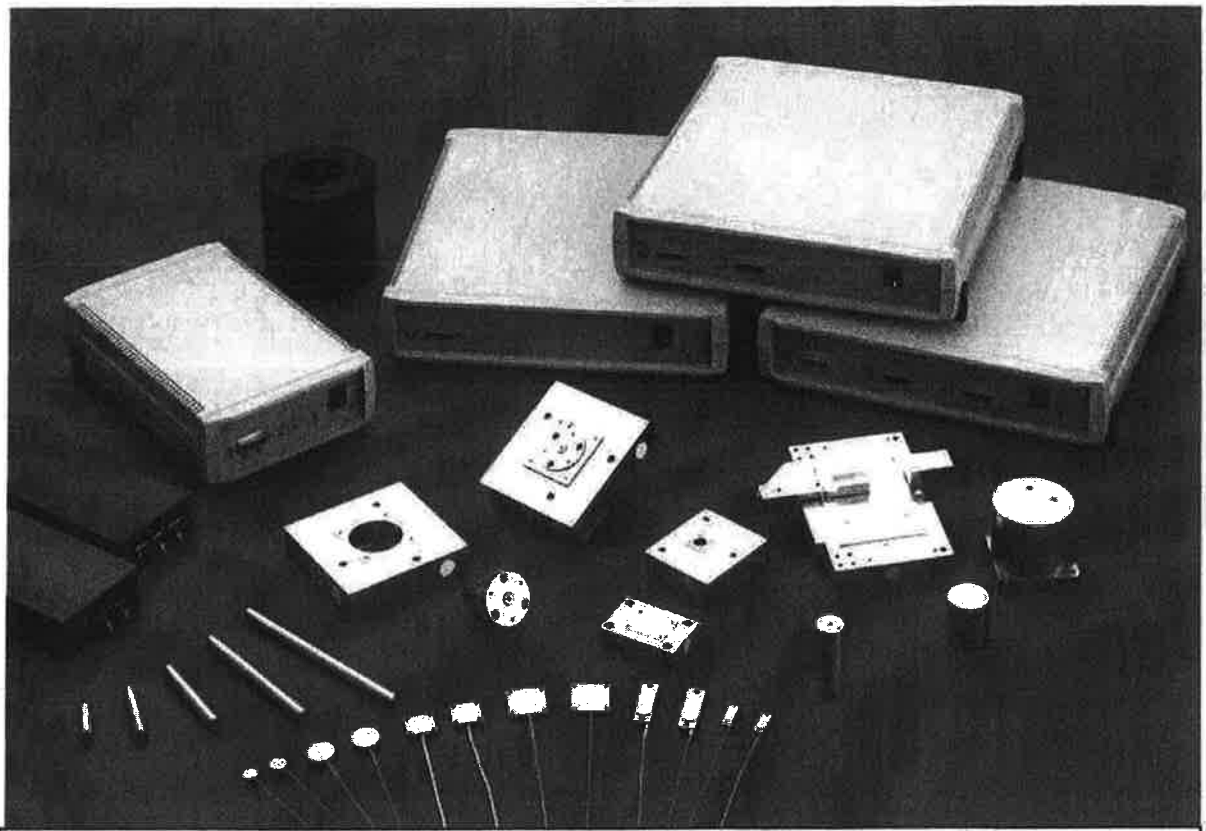


Internal optics of an Edrich MicroFilter

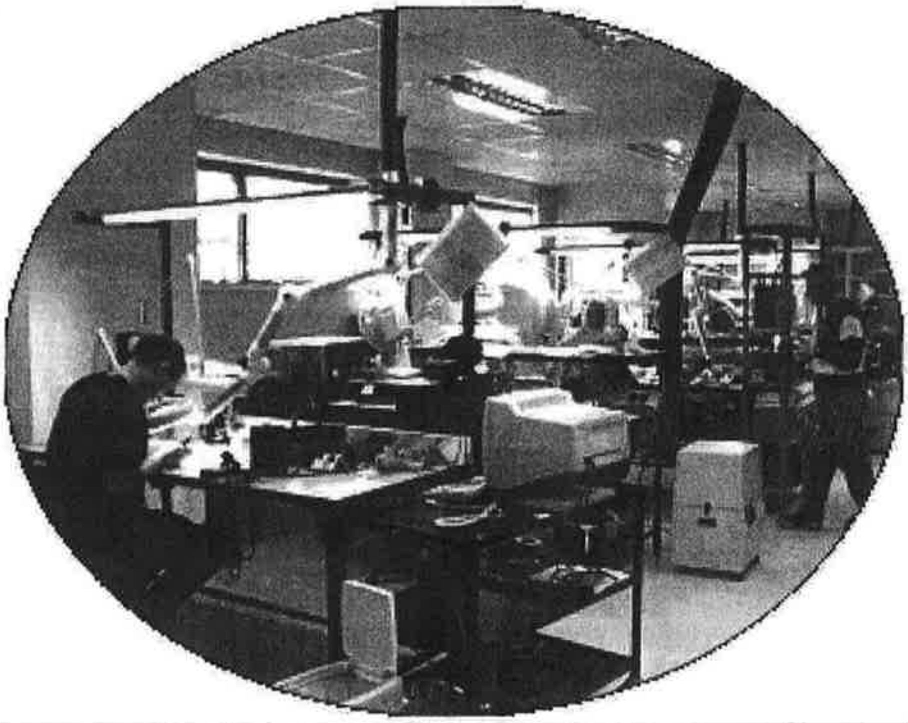
Fully configured Edrich T-1100



MicroFilter with control electronics



Examples of the Edrich Nanopositioning range



The Edrich workshop and test centre at Woodwalton