World Resources Institute

Sustainable Enterprise Program
A program of the World Resources Inst

Molten Metal Technology (A) and (B)

Teaching Note

For more than a decade, WRI's Sustainable Enterprise Program (SEP) has harnessed the power of business to create profitable solutions to environment and development challenges. BELL, a project of SEP, is focused on working with managers and academics to make companies more competitive by approaching social and environmental challenges as unmet market needs that provide business growth opportunities through entrepreneurship, innovation, and organizational change.

USE OF THIS CASE

Key Lessons

The Molten Metal Technology (MMT) cases tell the story of a high-tech start-up in the hazardous and radioactive waste management field. Case A describes the company's meteoric rise from 1989 to 1995. Case B recounts the company's similarly meteoric fall from 1996 to 1997. A four-minute video, *Molten Metal Technology—Elemental Recycling: The Future of Environmental Technology*, is a good primer on the technology and the hype that surrounded it. It explains the catalytic extraction process (CEP) and includes commentaries by Maurice Strong, Vice President Al Gore, and others.

The case can be used in environmental business, competitive strategy, and entrepreneurship classes. In particular, the case demonstrates how a high-tech, start-up company failed at the crucial commercialization stage of its innovative technology. Students can discuss the necessary steps to getting such a start-up off the ground.

The environmental aspects of the case add political and regulatory factors to an already complex set of concerns including economic, market, and technology risks.

This case was prepared by Andrew Hoffman, Professor of Organizational Behavior, Julie Smith, MBA Student, and Steve Soukup, MBA Student, of Boston University as the basis for class discussion rather than to illustrate either effective or ineffective handling of an administrative situation.

In addition, these factors exposed the company to a great deal of media attention and investor euphoria. While this is both a benefit and a liability, MMT clearly paid a price for this attention. A key lesson is that the company must be run, first and foremost, on sound business principles. Environmental excitement can not divert attention from that track. The company might have been better off had it focused its early target, secured stable funding, and conserved that funding by operating in just one market area before moving to others.

Assignment Questions, Case A:

1) What was the overall business model for MMT: (a) from 1989 to 1995 and (b) for the future?
2) Are there any peculiarities about the hazardous waste market that make this start-up company different from other high-tech start-ups?
3) What were the toughest challenges and greatest uncertainties as the company was poised for commercialization at the end of 1995?
4) How well had MMT protected itself from these risks?
5) Looking to the future, if you were Bill Haney, what would you do? If you were Chris Nagel, what would you do?

Assignment Questions, Case B:

1) What went wrong?
2) Could it have been foreseen?
3) What lessons can be learned from this experience?

CASE SYNOPSIS AND CONTEXT

MMT was the product of a bright scientist from MIT (Christopher Nagel) and a savvy and successful businessman from Harvard (William Haney). The organization these two young entrepreneurs built was designed to draw in similarly energetic and talented individuals. The company had also been aggressive in its external relations with both government and industry. Haney, with the assistance of Washington lobbyist Peter Knight, had been successful in gaining the attention of government officials all the way to Vice President Gore. The company also successfully leveraged its relationships with industry giants such as Lockheed Martin, Rollins, Fluor Daniel, Westinghouse SEG, Hoescht Celanese, and DuPont to establish its three commercial start-ups: two in Oak Ridge, Tennessee (M4 Environmental LP/Commerce Park and MMT Tennessee/Bear Creek Road), and one in Bay City, Texas with Hoechst. These strategic elements created media attention and investor enthusiasm that drove the stock price up roughly 100% through the year 1995. That year, the company had just turned its first profit and everything seemed set for a bright future. But, as Case B shows, the company came crashing down. Early discussion among the students will probably center around three theories of what went wrong:

- The technology failed the company,
- The company was stretched too thin, devoting resources to three start-up plants simultaneously, and
- The company had overdeveloped investor expectations.

TEACHING STRATEGY

Case A

Instructors can begin with Case A and show the video to introduce the technology. Through the video, students can see the social benefits of the technology and the impressive credentials of the founders, particularly Bill Haney.

In discussing Case A, begin with the concerns students may have about the validity of the company and the threats it faces. Ask students whether they would invest in the company. Why or why not? This

usually exposes concerns over technology, market scope, investor capital, and the regulatory environment. Encourage students to identify which risk factors are specific to this company and which are inherent in any high-tech start-up? In this way students will be able to see the risks related to regulatory agencies and the environmental issue as either a threat (i.e., source of market uncertainty) or an opportunity (i.e., an entry barrier to other companies). Point out that waiting for certainty before investing can mean a missed opportunity with this company. This is a way to get students to think more critically about their decisions rather than just poking holes in the business proposal.

Next, move on to how well Molten Metal Technology is positioned to handle these risks? This part of the discussion can focus on dual tracks: (a) gaining investors and (b) perfecting the technology to a commercial scale. (See the section below on "Entrepreneurial Analysis" for specifics about the company and its two founders.) Some students may feel that capital is secure because of the deep-pocket partnerships the company has cultivated; and, thus, the company has some leeway while developing its technology. Others may feel that the company is overhyped and that investor security is fragile. If another technology comes along that is better, MMT will lose out. It could, thus, be argued that time is of the essence in perfecting the technology. In both cases, many students find parallels to technological development in the pharmaceutical and biotechnology industries. However, unlike the development of a new drug, MMT has already perfected its technology in the laboratory (bench-scale).

Many students may assume that resizing an operation to a commercial scale is a simple matter. It is not. There are differences in both technical aspects and feed material. First, increasing the process scale is not simply a matter of increasing the size of the individual components. There are complex engineering equations and testing considerations that make the shift more difficult. Second, the feed material used in the laboratory is often of a higher purity and known concentration. Commercial material is often a more complex "soup," which means there could be problems in getting the process conditions to work properly.

Critical to this discussion are concerns for whether the two tracks (capital acquisition and technological development) are well coordinated. Are Haney and Nagel in sync with each other's efforts? How important is this coordination? What should be the central objective of this coordinated activity? In response to the latter question, discussion should focus on the paramount issue of getting at least one of the three plants up and running. This would gain legitimacy with investors, confidence with the MMT staff, and start the learning process for ramping up further operations. Some students may question whether the company should be involved in three plants at all or whether they are overextended and should be conserving resources for just one start-up. Similarly, this is a chance to draw out whether the company should focus on just radioactive or just hazardous waste, or both. Some may feel that the hazardous waste market is a dwindling, dead-end market. Others may look at the liquidity of the company and say that they would rather MMT spend money on new plants than hold on to the cash. The "Financial Analysis" section below can help with this discussion. The company's financial position is solid.

Finally, towards the end of the discussion of Case A, ask students again, who would invest and why? Point out those who may have changed their minds and remind everyone that investment for high returns requires risk. Is the risk with MMT justified? Using Exhibit 8 in Case A, ask students what they think of these projections and what assumptions may be behind them. Alex Brown is expecting the technology to go commercial in 1996. What if they don't? Can they afford any slippage? There are a couple of avenues to cover here. (1) What factors were critical to deciding whether slippage in the schedule is dangerous? This could include concerns about continued funding, the entry of a rival technology, and managing the expectations of investors. (2) If you were Bill Haney or Chris Nagel, would you like these projections? Some may like the positive press for increasing investor capital. Others may feel that the company has lost control of managing investor expectations. They may feel that Alex Brown has put them on a course that, if unrealized, could prove quite disastrous.

Then consider what steps the company should be making in anticipation of commercial operations and when. How and when should the company be making the shift from innovation-centered to profit-centered? What is involved in the shift? This is a critical point of the case. The company must time its shift carefully. It must staff up for commercial operations and marketing so that it can draw in customers as soon as the plants are ready. Inherently, however, this involves a risk. Shift too soon and there will be idle staff and unmet customer expectations. Shift too late and there will be idle plant capacity. How does a company know when to shift? Should MMT be shifting now? Finally, ask students about their predictions for the future of the company. Do they see a bright or an uncertain future? After students take a stand, move on to Case B.

Case B

In discussing Case B, look first at whether the company tried to make the transition to commercial operations too soon, committing all its resources with no contingency for a delay in commercial plant start-up? The "Financial Analysis" section below can help with this discussion. When the technology is delayed and partnerships start to fall apart, the company is hit with an unexpected contingency (the withdrawal of Department of Energy (DOE) funding) and collapses. In the end, the bottom line appears to be that they spread themselves too thin and did not conserve enough resources to ensure a good foothold into profitability. There was poor alignment between the company's political strategy (Bill Haney's realm) and product market strategy (Chris Nagel's realm). In their political strategy, they may have fallen for their own hype and tried to be all things to all people.

Other issues include:

- Was the company hamstrung by Bill Haney's need to respond to the Senate Subcommittee? He was the company's rainmaker. If he had not been distracted, could he have guided the company during this important period? If students fall back on the idea that political forces over which it had no control ruined the company, remind them that less than 10% of its funding actually came from the government.
- Was the company flawed regardless of whether Haney was distracted? Some will look to the organizational mission and rapidly expanding structure and say that the company was too fragile. Any kind of disruption was likely to knock it off course.
- Was there unethical behavior on the part of some of the company's executives and large investors? When Preston and others sold their shares, were they dooming the company to failure by withdrawing their financial support? How visible should such actions be? The shareholder suit accuses the officers of deception.

You could mention the model established by Ameritrade Holding Corporation, one of America's leading on-line brokerage firms (NASDAQ: AMTD). On March 10, 1999, the Omaha-based company announced that insiders wishing to sell stock would have to announce their intention in advance. According to J. Joe Ricketts, Chairman and Co-Chief Executive Officer:

> Our shareholders have placed their trust in us. I feel that instituting a policy that ensures they know in advance when insiders intend to sell stocks is simply the right thing to do. . . . Our officers and directors believe in the long-term growth prospects for our company. However, at times, for personal reasons such as estate planning and portfolio diversification, they may choose to sell stock when the window is open. While it's important for them to be able to do that, I also feel it's vital that all our shareholders are aware of their action.[1]

To draw out key lessons from the case, ask students whether any of these problems could have been foreseen. Some important discussion points can be:

- A company's strategy and structure must fit its context. From 1989 to 1995, the company was a high-tech start-up. It was focused on starting up at least one plant and maintaining funding until it did.
- A major part of a high-tech start-up company's strategy has to be managing expectations. The notion that the technology did not come out quickly enough is predicated on the idea that there was a particular time frame in which it should have come out. Both the technological development and investor expectations can be managed (to some degree) by the company's principals. There are few inherent timetables to such development except the expectations of investors.
- Strategy and structure are never static. The company must plan for the shift to commercialization (or any other stage) as the technology develops, the market shifts, and contingencies arise.
- The timing of the shift from entrepreneurial to commercial company is critical to its long-term success. MMT did not manage that shift well.
- It is possible to promote environmental issues (or any other social cause) and build a successful business. But business principles must come first. The company benefited from its social purpose in destroying toxic and/or radioactive waste by attracting media, political, and investor attention. But it failed in the end because it was not run well as a business.

According to Bud Arrowsmith, a former MMT executive, it was "business bungling, not the technology" that led to Molten Metal's downfall. In an interview in 1998, he emphasized that the company invested too many resources in a declining hazardous waste recycling market. "They expanded into a market that was going away."[2] Instead, the demand for nuclear waste processing was the real opportunity and that should have been the company's dominant if not singular focus. However, the product market strategy was too broadly focused before the technology had been proven. With such a disconnect, timing and reputation became crucial vulnerabilities. The company invested all its resources with no contingency for technological delays. The public relations hype that surrounded the company may have inflated investor expectations and created instability or uncertainty in the stock price. While the company's financial health may have permitted commercialization, the company's technology progress was easily side-lined by negative press from the DOE. Case B points out that the DOE contributed less than 10% of the company's overall capital. So, the DOE decision had less to do with a loss of money and more to do with shaking investor confidence. Despite the beginnings of commercialization as the plants started coming online, the company's demise came when partners and investors eventually got anxious and withdrew their support. An update at the end of this teaching note provides somewhat of a positive spin on the case. In November 1998, one of the Oak Ridge plants was sold and will continue to operate.

ANALYSIS

General Analysis

A central focus for discussion should be the vulnerabilities in the company. As a start-up firm, what were the risks facing the company? These can be divided into the technological, financial, competitive, and market risks. However, the impact of the regulatory and political risks should not be overlooked.

Technological risks. The bench-scale technology had been proven at the company's R&D facility in Fall River. Two key questions remained, however: could the technology be successfully ramped up in its commercial facilities in Tennessee and Texas and how long could the company wait for this to happen? What were the implications if there were delays in bringing these facilities online? Would the technology perform as expected and ensure an acceptable profit margin for the company?

Financial risks. The high cost of research and technology development coupled with the long period of market entry makes this a high financial risk. The length of time required for industry and regulatory acceptance of new technologies can be as long as 4 years. Then, the time between issuance of a government contract and complete remediation can be as long as 8 years. (Private clients moved more

quickly.) Because of the long period between technology development and full payment of services, the company had to finance operations with either private investment or loans. The latter was definitely less attractive given the uncertainty of the time frames involved. According to G. Mead Wyman, General Partner of Hambrecht & Quist Venture Partners, "a number of entrepreneurial firms with applicable cleanup technology have been stalled in the takeoff stage for periods ranging up to several years. The time required to penetrate the market must be conservatively estimated. Demonstration and proof of a technology's efficacy often is a major, time-consuming step in entrepreneurial business development."[3]

Market risks. The company decided to focus on three markets: (1) commercial low-level radioactive waste (LLRW), (2) government wastes, and (3) industrial and hazardous wastes. (See Exhibit 5 in Case A.) While each represented attractive markets, one might ask whether such a wide initial target market was prudent? Should the company have focused on one market to conserve funds, test the technology, and get its feet solidly on the ground? The government represented the largest market for environmental services, but the government moves slowly. On the other hand, government contracts require an understanding of the regulatory process (i.e., obtaining Best Demonstrated Available Technology (BDAT) status) to be successful. But MMT appeared to have developed that proficiency.

The market was also fragmented with many small, mid-size, and large firms. For new entrants, the market was highly competitive with larger, established firms dominating the business and the smaller firms relying on subcontractor relationships for entry into the larger markets. Firms unable to establish industry ties were left to compete for very small projects. Again, MMT appeared to have poised itself well for this market by developing alliances with larger companies.

Competitive risks. Incineration, membrane separation (Commodore), biological degradation (Envirogen), and chemical treatment/solidification (Perma-Fix) were four different technological paths that this industry could pursue. Did CEP offer advantages over these other technologies? The ultimate success depended on the efficacy of a technology's cleanup performance, the cost, and the preferences of the regulatory environment.

Regulatory risks. The market was driven primarily by regulation, which had been changing steadily for the past 10 years. For example, a firm that invested heavily in perfecting cap-and-containment technologies in the early 1980s, effectively lost its market segment when Superfund Amendment and Reauthorization Act (SARA) amendments went into effect. A company heavily invested in incineration technologies in the late 1980s, probably watched its market segment dry up as the siting of commercial incinerator facilities became increasingly difficult. (See Exhibit 4 in Case A.) Was Rollins' desire to partner with MMT a hedge against a diminishing incineration market? Ask students whether this is the kind of market that they would want to be in. At this point, two issues can be raised. First, MMT's decision to forgo the Superfund market may have been one strategy for handling regulatory risk. But Carol Browner's failure to support the "combustion policy" represents how uncertain working within this regulatory regime can be. Could MMT have been better insulated from these risks?

Beyond establishing the market, government regulations were also an important consideration in the commercialization of innovative technologies. First, Superfund project managers looked for cleanups that would stand the test of engineering review, public scrutiny, and regulatory requirements. According to the Superfund Amendments, a remedial action had to be cost-effective and use permanent solutions and alternative treatment technologies to the maximum extent possible. Most of all, the technology had to work. This tended to foster a technology selection process that was risk-averse and, therefore, not favorable for innovative technologies. The failure of an innovative method at a hazardous waste cleanup site is much more serious than, for example, at a wastewater treatment plant. In addition to lost time and potential exposures to contaminants, a failure can increase costs, not only because the work has to be done over but because the cleanup could be complicated by the overall effects of the failed technology. [4]

Explicit technology preferences were also written into the regulations. For example, the Resource Conservation and Recovery Act (RCRA) Hazardous and Solid Waste Amendments of 1986 (HSWA) banned wastes from land disposal unless the waste met specified treatment standards set by EPA. Treatment standards were in three areas: concentration levels, specified technologies, and a total ban from land disposal. The concentration levels were based on BDAT for the waste. Innovative technologies, such as biological treatment, soil washing and solidification, in many cases, were not likely to achieve these levels.[5] In other cases, even if the technology did meet the concentration limit, it might not have been appropriate by definition, either due to a total ban limitation or the required use of another specified technology. For instance, at the time of the case, bioremediation was not listed among RCRA technologies. Again, MMT appeared to have understood these regulatory risks and actively sought BDAT status for its technology to treat particular waste streams.

Public opinion. Public opinion has long driven the hazardous waste market. Public response to the contamination at Love Canal prompted the creation of the controversial Superfund law forced the Department of Energy and Department of Defense to also begin to clean up their abandoned hazardous waste sites. In fact, environmental public opinion around the period of the case was quite high (as exemplified by *Time* magazine's use of the term "Endangered Planet of the Year"). Riley Dunlap described public opinion trends as follows:

> Environmental concern developed dramatically in the late 1960s and reached a peak with the first Earth Day in 1970. . . . Such concern declined considerably in the early 1970s and then more gradually over the rest of the decade, but remained substantial. . . . The 1980s saw a significant and steady increase in both public awareness of the seriousness of environmental problems and in support for environmental protection, with the result that by the twentieth anniversary of Earth Day in 1990, public concern for environmental quality reached unprecedented levels.[6]

By the end of 1995, a *Times Mirror/Roper* survey found that nearly three-quarters of Americans described themselves as environmentalists (21% active environmentalists, 51% sympathetic environmentalists, 22% neutral, and 3% unsympathetic). Sixty-nine percent also believed that environmental protection and economic development could go hand in hand.[7] Thus, support for Molten Metal Technology should have translated into shareholder interest.

But that support appeared to be fickle as evidenced by the public's opposition to incineration. (See Exhibit 4) People wanted toxic wastes cleaned up, but they didn't want any risk. Could this have played to MMT's advantage? Were shareholders and public opinion linked? Were they stable? The quote from the investor at the annual meeting in Case B shows just how much people believed in this company as being something beyond just a business. How much did the company push this kind of belief through public relations given the high visibility and apparent "win-win" possibilities it proposed? The company was clearly enjoying media attention. Was this completely objective analysis or was MMT good at commanding press attention? Students may notice that the article in *Environmental Science & Technology* at the opening of the case was written by Chris Nagel (and several other MMT employees).

For additional perspectives on win-win scenarios, see two articles by Porter and van der Linde's in the *Harvard Business Review* and *Journal of Economic Perspectives*.[8] Palmer, Oates and Portney offer a different point of view[9] as do Walley and Whitehead.[10] Finally, for an integration of the two perspectives, see the *American Behavioral Scientist* article by Hoffman, et al.[11]

Political risks. Peter Knight, an independent lobbyist in Washington, had been Vice President Gore's campaign manager. This association would prove a critical benefit and liability for MMT. Haney and Knight were able to secure $33 million in DOE funding for the new technology. But in 1997, a Senate subcommittee would cast a shadow of impropriety over the company, drawing connections between the Knight/Gore Connection and the DOE funding. Although the charges were eventually dismissed, the public relations impact was damaging. Was this just bad luck, or should MMT have been a little more careful in how it managed its government relations? How critical was it that Haney was never brought as a witness before the subcommittee? Would it have been better had he been able to state his case?

Entrepreneurial Analysis

This case is an excellent example of a new venture that has both a political strategy and a product market strategy. The political strategy takes place in the legislative arena, relying on bargaining, agendas, power, etc.,[12] whereas the product market strategy takes place in the market arena, relying on competitive dynamics, technology strategy, and market position. Where were the overlaps? Where were the differences? The discussion can center on the question for Case A of what students would do if they were Nagel or Haney. Or, it can focus on questions from Case B of whether one is more at fault than the other. Initial analyses might suggest that Nagel and the technology caused the failure of MMT. However, more critical analysis should also consider whether the political and the product market strategies were misaligned. Could it have been that Haney (and Knight) built expectations beyond what could reasonably be expected from the technology? Did Haney not have a good idea of the risks inherent in technological development? Did Haney make a critical mistake in not coordinating with Nagel?

Issues of strategic commitment[13] can also be introduced and discussed. Companies can sometimes make strategic investments that set them in a particular direction and "lock them in" to a particular strategy (along the lines of path dependence). So, why was the company so committed to the direction of relying on government contracting to gain its success? Why couldn't it shift?

Staffing was another issue. The entrepreneurial company was growing rapidly and scrambling to find the right kinds of people for their culture and to fill needed capabilities. They also wanted to create a working environment in which they would grow and prosper. While there is limited information on the culture of the company, one should discuss the challenges of building an entrepreneurial company as rapidly as this one was built. An important point is that entrepreneurial firms are always lacking some capabilities. The art of leadership is knowing which ones you cannot do without. This is particularly true when resources are limited. It would appear that staffing costs became a problem for the company. (See the Financial Analysis section below.) Related to staffing is the divided attention of Bill Haney in dealing with the Senate subcommittee hearings. Can an entrepreneurial company survive when one of its leaders is so preoccupied?

Another point is the theory of social capital in entrepreneurial endeavors.[14] Students can discuss the degree to which the reputations and connections enjoyed by the founders permitted this business to grow quickly. This was critical.

Finally, what were the personal risks? The entrepreneurs (Nagel and Haney) had tremendous personal risk. One could imagine that Haney and Nagel suffered personally, financially, emotionally, socially, and perhaps even in terms of their families. This suffering could have taken place both during the start-up and after the fall. Also, what about the risks of the company's managers and executives? They joined the company and bought into Haney and Nagel's vision (and also bought into the company's stock option plan). What were their personal risks? And, what were their professional responsibilities? Were there ethical issues related to John Preston, company directors, and other employees selling $2.6 million worth of MMT stock in August and September of 1996? Did they contribute to the company's demise? Do the shareholders who are suing the company have a case? Was it unethical to save their own investment in

the company when other shareholders (such as the investor in the 1997 annual meeting) were sticking it out through thick and thin? These are key issues in any entrepreneurial business venture.

Financial Analysis

The ratio analyses in Exhibits TN-1 and TN-2 can be given to students with Case A and Case B, respectively, or you may choose to hold them back and have students develop them on their own.

Ask students why, after things looked so good in 1995, did the situation sour so rapidly in 1996? Was there evidence that this would happen? Was there something obviously wrong? The financial data are interesting in that the "usual suspects" (such as poor liquidity and high D/E ratios) really don't seem to be the cause of the problem. In short, there was no solid evidence, although others may find something in hindsight to indicate impending problems.

Consider the following:

- **Liquidity.** The quick and current ratios were declining, but both were pretty healthy in 1995. Accounts receivable collections were improving.
- **Operations.** Sales per employee doubled between 1994 and 1995, which makes things look pretty good. Total assets to equity were up, indicating good use of assets.
- **Financing.** Times-interest-earned turned positive in 1995, indicating good ability to service debt. Debt to equity dropped slightly.

The company's revenue stream growth, assisted by decreased R&D and SG&A in 1995 suggest an interesting accounting problem. According to "generally accepted accounting principles," R&D is to be expensed, not capitalized. However, if a company is expensing it through cost of goods sold (or, "cost of revenue," as MMT calls it), some of it could end up in inventory (i.e., capitalized). It is not likely that auditors would like this approach. However, since there's no inventory on the balance sheet, the issue is moot (i.e., they in effect have expensed off all the R&D). The important issue is that one cannot tell how much R&D there really is because a portion is being run through Cost of Goods Sold (COGS). What we don't know because of their accounting is whether there were REAL decreases in R&D or just perceived ones.

In the end, it is questionable whether "customer funding" justifies the mixed classification of these two types of expenses. Generally, SG&A is a period expense and should not be included in COGS, even if the customer "funds" it—any more than a sales commission (which a customer also "funds") should be included in COGS. However, without more knowledge about the specific expense elements, it's hard to say with certainty. Maybe if R&D is project-specific and for a particular customer, one could justify calling it part of COGS.

With the mixed classification, a component analysis of the income statement now becomes misleading. We no longer know exactly how much R&D or SG&A is occurring. So much for Alex Brown & Sons analysis, and kudos to Fidelity! A question for Alex Brown's analysis is "who made the net income forecasts and what did they have in mind?" How did they develop the projections in Exhibit 8 in Case A? Are they believable? What kinds of assumptions went into them?

MMT appears to have increased R&D and SG&A staff in preparation for some big sales that never materialized. A very important question here is one of managing growth—finding the right balance between having personnel in place to handle the increase in demand but not so many people that you'll be caught short if forecasts don't materialize. In this regard, one might ask what "full commercialization" means in this context.

What happened in 1996? The company took on a lot of debt, but that's deceptively simple because the problems associated with that (higher interest payments, drain on cash for principal) would come in 1997 and beyond, not in 1996.The company's liquidity, sales-to-employee ratio, and sales-to-assets are all dropping. So, there are some worrisome signs.

The big problem, however, appears to be that operations got a bit out of control in 1996. A component analysis of the income statement shows that the cost of sales (MMT's term is "cost of revenue") stayed about the same at 80% (versus 79% in 1995), while R&D increased to 41% of sales (from 25% in 1995) and SG&A increased to 29% of sales (from 7% in 1995). Two questions emerge at this point. Are these real or perceived increases as discussed earlier? And, if real, are these increases bad? Not if it was part of a plan to beef up sales and R&D because there is a sense that 1997 will produce some new products and the following years will see growing sales. It has been 6 years since opening up shop, however, so one must ask whether there is a business or not.

Case B suggests that the staff increase was to prepare for contracts that didn't materialize because of the delay in the technology. Next, the company failed to downsize quickly enough to recover. The key lesson here is how to manage technological risk when there are only a few customers and no firm contracts. How devastating was the loss of the DOE contract? Were expectations and the company's success too dependent on that? Companies should know that they can't count on continued government contracts—multi-year contracts, yes; but annual contracts out of annual appropriations, no. Make sure that students understand the revenue implications of technological delays and DOE funding in Case A.

It appears that the fatal stroke for MMT was using long-term debt to finance operating losses. Sometimes it can't be avoided if survival is at stake, but it is a very drastic measure. Case B doesn't provide many specifics about the nature of SG&A and R&D expenses, but if there were real increases in preparation for commercialization, they should have been cut immediately. The management dilemma comes when one hesitates to make cuts because of the hope that there will be revenue around the next corner. But, managers end up continuing to turn corners never initiating layoffs. MMT had to produce cash flow or the lenders would begin to exert some pressure. What they did in 1996 as a result of those higher R&D and SG&A expenses was crucial. If they had put some products and sales potential in place, the future probably would have looked pretty good. If not, . . .

Update (through November 1998)

December 3, 1997. Molten Metal Technology, Inc. and four of its affiliates filed for Chapter 11 in the U.S. Bankruptcy Court, District of Massachusetts. The company retained the Blackstone Group to review a range of strategic alternatives, including obtaining financing, developing strategic partnerships or the possible sale of all or a portion of the company's assets.

December 4, 1997. The National Association of Securities Dealers announced that common shares of Molten Metal Technology, Inc. would be traded under the Symbol MLTNQ.

December 23, 1997. Molten Metal Technology, Inc. announced that it had secured $7.7 million in short-term financing. The loan, due January 30, 1998, was secured by a lien on basically all of the company's assets. Though no commitment was made, the lender expressed an interest in providing a $20 million medium-term loan.

January 30, 1998. For the month of December 1997, Molten Metal Technology, Inc. reported a net loss of $5.057 million on net revenue of $4.1 million.

February 3, 1998. In order to complete due-diligence in connection with a possible $20 million loan, Molten Metal Technology Inc.'s lender agreed to extend the term of the $7.7 million short-term loan for one week. The due date for the loan was now February 13, 1998. Morgens Waterfall Vintiadis Co. acted as agent in the financing agreement.

February 6, 1998. Molten Metal Technology, Inc. employed Continental Plants Corporation as auctioneer/broker for the company's assets.

February 11, 1998. The NASDAQ National Stock Market delisted the Molten Metal's securities effective with the close of business on February 10, 1998.

February 25, 1998. For the month of January 1998, Molten Metal Technology reported a net loss of $3.8 million on net revenues of $1.8 million.

March 9, 1998. The U.S. Bankruptcy Court approved Molten Metal Technology's request for a $20 million loan facility from affiliates of Morgens Waterfall Vintiadis Co. The company would use the financing to repay $7.7 million in short-term financing received from Morgens Waterfall in December 1997. Repayment of the approved funds was due at the end of 1999.

March 20, 1998. For the month of February 1998, Molten Metal Technology reported a net loss of $3.1 million on net revenues of $2.069 million.

March 24, 1998. Price Waterhouse LLP informed Molten Metal Technology, Inc. that it would not stand for reelection as the company's accountants, and terminated its relationship with the company.

April 12, 1998. Molten Metal Technology, Inc. asked the U.S. Bankruptcy Court for authorization to employ Bass, Berry, Sims, PLC of Nashville, Tennessee, as special Tennessee tax counsel. The firm would aid the company in resolving a controversy with the Tennessee Department of Revenue over a sales and use of a tax assessment of approximately $7.2 million.

May 1, 1998. For the month of March 1998, Molten Metal Technology, Inc. reported a net loss of $2.6 million on net revenues of $2.6 million.

May 29, 1998. For the month of April 1998, Molten Metal Technology, Inc. reported a net loss of $1.3 million on net revenue of $4.5 million.

June 26, 1998. For the month of May 1998, Molten Metal Technology reported a net loss of $2.5 million on net revenues of $3.2 million.

July 8, 1998. The U.S. Bankruptcy Court approved Molten Metal Technology, Inc.'s request to reject the lease at its Bay City, Texas, CEP facility.

July 24, 1998. For the month of June 1998, Molten Metal Technology, Inc. reported a net loss of $3.8 million on net revenues of $1.4 million. Molten Metal Technology, Inc. and Morgens, Waterfall, Vintiadis Co.—lending agent—amended their $20 million debtor-in-possession agreement by modifying EBITDA and throughput covenants through December, 1999.

August 17, 1998. The Tennessee Department of Environment and Conservation ordered MMT to appoint an independent radiological safety specialist for its Q-CEP facilities or be shut down and pay a $100,000 fine. The order followed a July investigation by TDEC into a series of allegations of improper posting of radioactive materials.

September 18, 1998. Bankruptcy trustee Stephen Gray sought the Court's permission to approve an agreement between the debtors, the trustee, and the lenders, which called for an asset sale carve-out for the benefit of the lenders. All lenders also agreed to provide additional advances and consented to Molten Metal Technology, Inc.'s use of their cash collateral.

September 29, 1998. The U.S. Bankruptcy Court granted Molten Metal Technology Inc. approval for its amended debtor-in-possession financing agreement, allowing the company to continue operations while trustee Stephen Gray pursued possible sales transactions.

November 16, 1998. The Allied Technology Group (ATG) of California bought MMT's Bear Creek Road plant (formerly MMT Tennessee) in Oak Ridge, Tennessee, for about $9 million. ATG hired most of the MMT employees working at the facility. MMT's Commerce Park plant in Oak Ridge (formerly M4 Environmental) had not yet attracted a buyer and was in the process of being closed. The $60 million treatment plant in Bay City, Texas—built but never operated—remained up for bid.

Notes

1. Ameritrade Holding Company (1999) "Ameritrade Holding Announces New Policy Governing Sales of Stocks by Insiders: Shareholders to be Informed in Advance of Stock Sales," Press Release, March 10 (Omaha, Nebraska).
2. L. Brass (1998) "ATG buys portion of Molten Metal Technology," *The Oak Ridger On-line,* December 30.
3. _____ (1990) "Industrial waste management," *TechLaw Update,* Third Quarter, p. 1.
4. A. Hoffman (1992) *The Hazardous Waste Remediation Market: Innovative Technological Development, and the Market Entry of the Construction Industry,* CCRE Working Paper No. 92-1 (Cambridge, MA.: MIT Department of Civil and Environmental Engineering).
5. U.S. Environmental Protection Agency (EPA) (1990) *A Management Review of the Superfund Program* (Washington DC: U.S. Government Printing Office), pp. 4-7.
6. R. Dunlap (1991) "Trends in public opinion toward environmental issues: 1965-1990," *Society and Natural Resources,* 4: 285–312.
7. Times Mirror (1995) *The Environmental Two Step: Looking Back, Moving Forward* (Washington DC: Times Mirror Magazines).
8. M. Porter and C. van der Linde (1995) "Green and competitive: Ending the stalemate," *Harvard Business Review,* September-October: 120–134; M. Porter and C. van der Linde (1995) "Toward a new conception of the environment-competitiveness relationship," *Journal of Economic Perspectives,* 9(4): 97–118.
9. K. Palmer, W. Oates, and P. Portney (1995) Tightening environmental standards: The benefit-cost or the no-cost paradigm?" *Journal of Economic Perspectives,* 9(4): 119-132.
10. N. Walley and B. Whitehead (1994) "It's not easy being green," *Harvard Business Review,* May-June: 46–51.
11. A. Hoffman, J. Gillespie, D. Moore, K. Wade-Benzoni, L. Thompson and M. Bazerman (1999) "A mixed-motive perspective on the economics versus environment debate," *American Behavioral Scientist,* 42(8): 1254–1276.
12. G. Allison (1971) *Essence of Decision* (Boston: Harper Collins).
13. P. Ghemawat (1991) *Commitment—the Dynamic of Strategy* (New York, NY: Free Press).
14. P. Bordieu (1983) "Forms of capital," in J. Richardson, ed., *Handbook of Theory and Research for the Sociology of Education* (New York, NY: Greenwood Press), pp. 241–258; and M. Dollinger (1995) *Entrepreneurship: Strategies and Resources* (Boston: Irwin).

Exhibit TN-1: MMT Ratio Analysis: 1994 & 1995

	Fiscal Year Ending	
	12/31/95	**12/31/94**
Quick ratio	5.31	11.53
Current ratio	6.38	11.75
Sales/cash	0.51	0.14
SG&A/sales	0.07	0.50
Receivables turnover	23.04	7.43
Receivables days sales	15.63	48.46
Net sales/working capital	0.49	0.15
Net sales/plant & equipment	1.27	0.79
Net sales/current assets	0.42	0.14
Net sales/total assets	0.29	0.11
Net sales/employees	155,568	76,590
Total liability/total assets	0.28	0.25
Total liability/common equity	0.40	0.33
Times interest earned	1.24	-18.75
Current debt/equity	0.00	0.00
Long term debt/equity	0.21	0.23
Total debt/equity	0.21	0.23
Total assets/equity	1.40	1.33
Pretax Income/net sales	0.01	-1.01
Pretax income/total assets	0.00	-0.11
Pretax income/invested capital	0.00	-0.12
Pretax income/common equity	0.00	-0.14
Net income/net sales	0.01	-1.01
Net income/total assets	0.00	-0.11
Net income/invested capital	0.00	-0.12
Net income/common equity	0.00	-0.14
R&D/sales	0.25	1.00
R&D/net income	30.97	-0.99
R&D/employees	38,684	79,688

Source: Disclosure Incorporated (1998), *Molten Metal Technology: Company Analysis.*

Exhibit TN-2: MMT Ratio Analysis: 1994, 1995 & 1996

	Fiscal Year Ending		
	12/31/96	**12/31/95**	**12/31/94**
Quick ratio	3.69	5.31	11.53
Current ratio	4.05	6.38	11.75
Sales/cash	0.49	0.51	0.14
SG&A/sales	0.29	0.07	0.50
Receivables turnover	24.68	23.04	7.43
Receivables days sales	14.59	15.63	48.46
Net sales/working capital	0.58	0.49	0.15
Net sales/plant & equipment	0.61	1.27	0.79
Net sales/current assets	0.44	0.42	0.14
Net sales/total assets	0.23	0.29	0.11
Net sales/employees	132,040	155,568	76,590
Total liability/total assets	0.75	0.28	0.25
Total liability/common equity	2.98	0.40	0.33
Times interest earned	-8.38	1.24	-18.75
Current debt/equity	0.03	0.00	0.00
Long term debt/equity	2.40	0.21	0.23
Total debt/equity	2.43	0.21	0.23
Total assets/equity	3.98	1.40	1.33
Pretax income/net sales	-0.96	0.01	-1.01
Pretax income/total assets	-0.22	0.00	-0.11
Pretax income/invested capital	-0.26	0.00	-0.12
Pretax income/common equity	-0.89	0.00	-0.14
Net income/net sales	-0.96	0.01	-1.01
Net income/total assets	-0.22	0.00	-0.11
Net income/invested capital	-0.26	0.00	-0.12
Net income/common equity	-0.89	0.00	-0.14
R&D/sales	0.41	0.25	1.00
R&D/net income	-0.43	30.97	-0.99
R&D/employees	54,435	38,684	79,688

Source: Disclosure Incorporated (1998), *Molten Metal Technology: Company Analysis.*