Case 3–2

BURLINGTON NORTHERN: THE ARES DECISION (A)

ARES will give Operations better control over its assets. We will schedule locomotives and cars more precisely, and get more efficiency and utilization of locomotives and tracks. ARES will also enable us to service our customers better by offering more reliable and predictable deliveries.

Joe Galassi, Executive Vice President, Operations

In July 1990, Burlington Northern's senior executives were deciding whether to invest in ARES (Advanced Railroad Electronics System), an automated railroad control system. ARES, expected to cost $350 million, would radically change how railroad operations were planned and controlled. The potential implications of this investment were so extensive that they affected virtually all parts of the BN organization. Nine years had passed since BN managers had begun to consider whether automated control technology could be applied to the railroad. Yet managers were still divided about whether the ARES project should be continued.

Company Background

Burlington Northern Railroad was formed in 1970 by the merger of four different railroads. In addition to a vast rail system, the merged company owned substantial natural resources including extensive land grant holdings containing minerals, timber, and oil and gas. In 1989, up to 800 trains per day ran on BN routes (see Exhibit 1) generating revenues of $4,606 million and net income of $242 million. Total assets equaled $6,146 million, and 1989 capital expenditures were $465 million (see Exhibit 2 for recent financial data).

BN's diverse operations and staffs were headquartered in three cities (see Exhibit 3

This case was prepared by Julie H. Hertenstein and Robert S. Kaplan.

Harvard Business School case 191–122.

EXHIBIT 1 Burlington Northern Route System

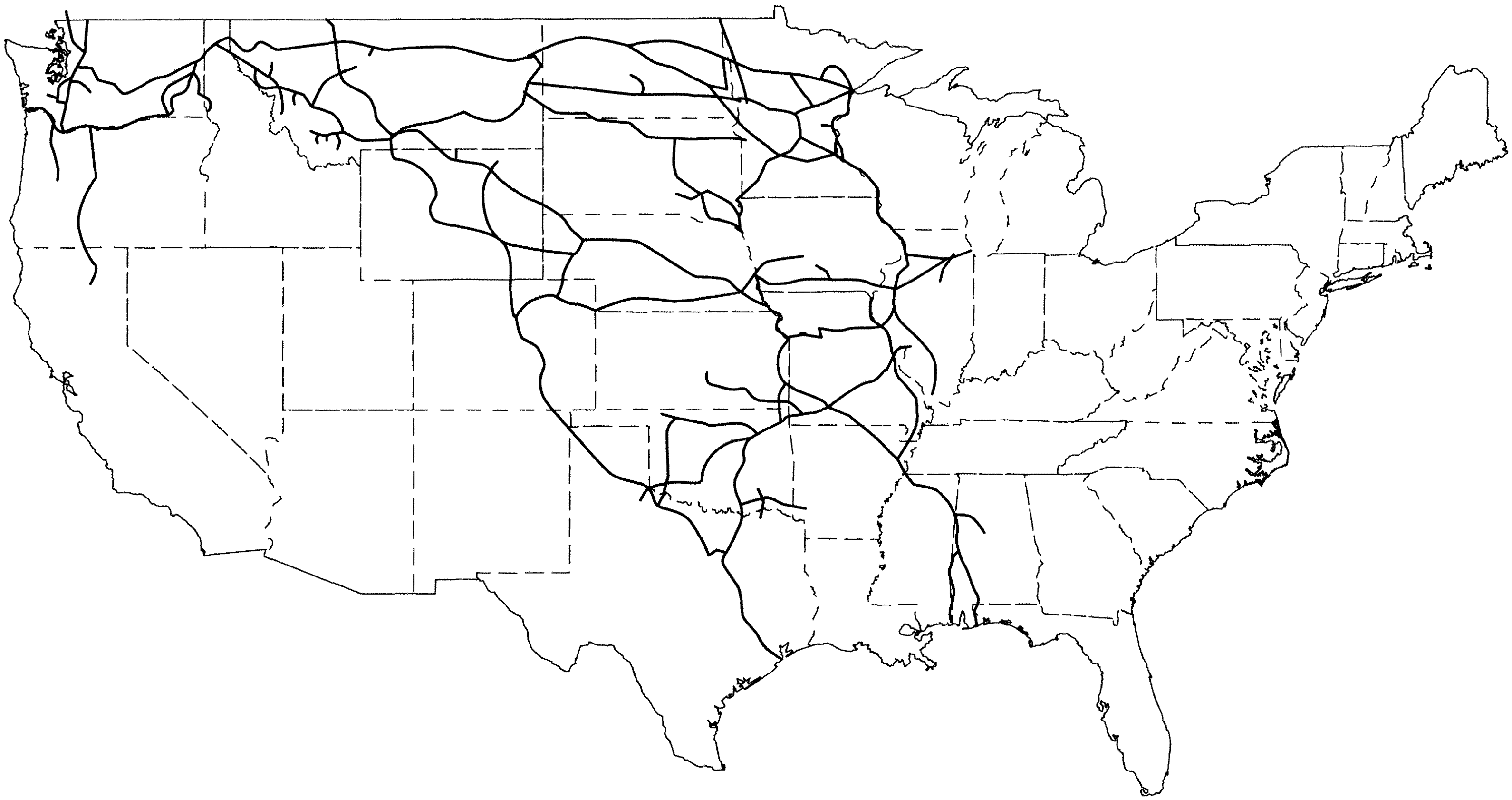


EXHIBIT 2 Recent Financial Data ($000)

December 31, Income Statements	*Year Ended* 1989	1988 Restated
Revenues:		
Railroad	$4,606,286	$4,541,001
Corporate and non-rail operations	–	158,516
Total revenues	**$4,606,286**	**$4,699,517**
Costs and expenses:		
Compensation and benefits	1,701,146	1,630,283
Fuel	327,606	288,477
Material	319,497	341,126
Equipment rents	343,436	320,900
Purchased services	524,845	531,555
Depreciation	309,206	350,948
Other	410,266	406,459
Corporate and non-rail operations	13,748	150,869
Total costs and expenses	**$3,949,750**	**$4,020,617**
Operating income	656,536	678,900
Interest expense on long-term debt	270,272	292,050
Litigation settlement	–	(175,000)
Other income (expense)—net	4,397	(32,655)
Income from continuing operations before income taxes	**390,661**	**179,195**
Provision for income taxes	147,670	80,493
Income from continuing operations	**$242,991**	**$98,702**
Income from discontinued operations net of income taxes	–	57,048
Net income	**$242,991**	**$155,750**

for an organization chart). The firm's CEO, COO, and corporate functions such as finance, strategic planning, marketing, and labor relations were located in Ft. Worth, Texas. The Operations Department, headquartered in Overland Park, Kansas, was the largest department in BN. It oversaw operating divisions comprising train dispatchers, operators, and their supervisors, and managed support functions such as research and development, engineering, and maintenance. Additional corporate staff functions, such as Information System Services, were located in St. Paul, Minnesota.

Products, Markets, Competitors, and the Effects of Deregulation

BN's revenues came from seven primary segments: coal, agricultural commodities, industrial products, intermodal, forest products, food and consumer products, and auto-

EXHIBIT 2 *(continued)* Balance Sheets ($000)

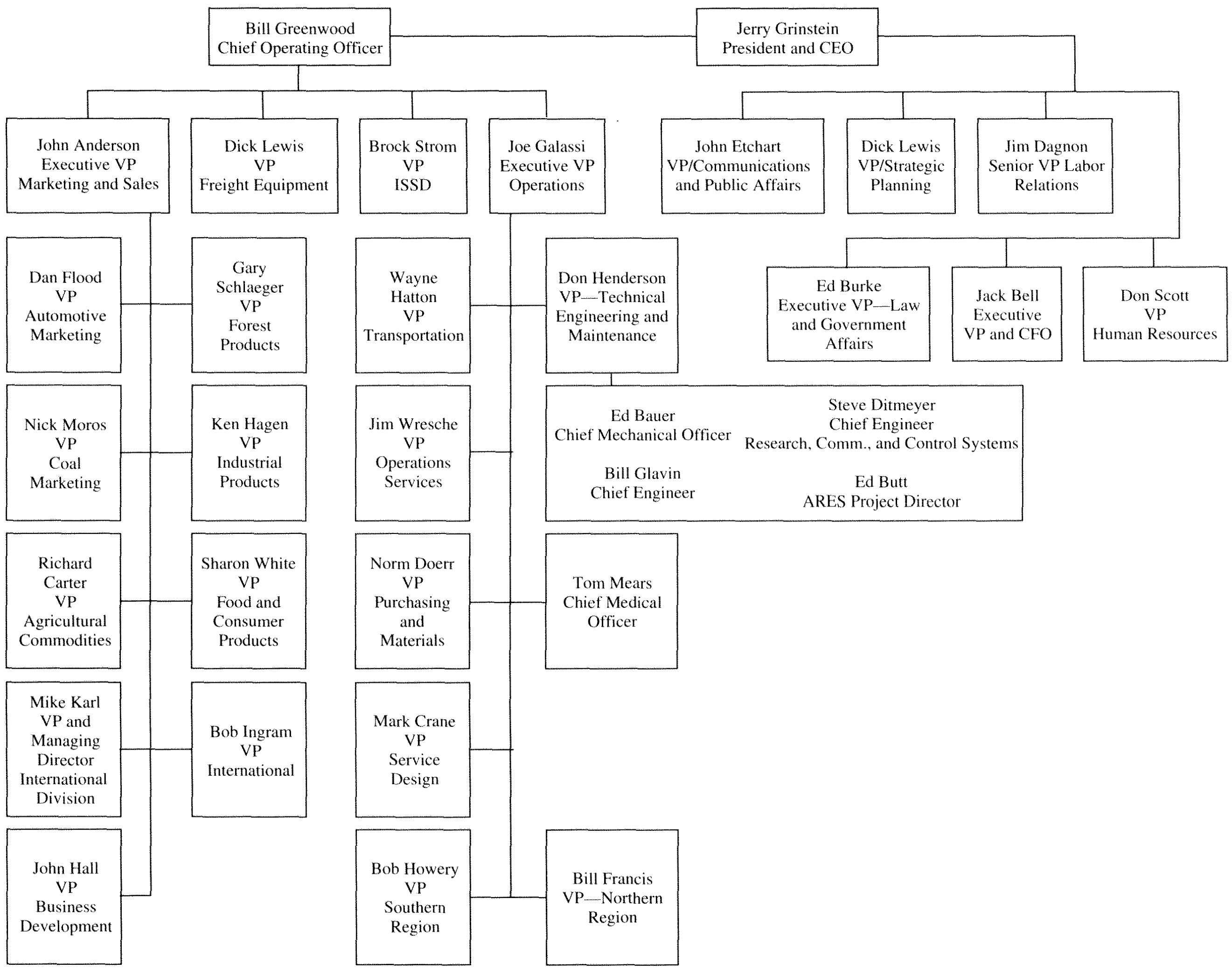
	Year Ended December 31, 1989	*1988 Restated*
Assets		
Current assets:		
Cash and cash equivalents	$82,627	$83,620
Accounts receivable—net	430,355	685,018
Material and supplies	133,286	157,954
Current portion of deferred income taxes	119,589	98,339
Other current assets	31,137	39,740
Total current assets	**$796,994**	**$1,064,671**
Property and equipment—net	5,154,532	5,078,262
Other assets	196,254	187,401
Total assets	**$6,147,780**	**$6,330,334**
Liabilities and Stockholders' Equity		
Total current liabilities	$1,287,966	$1,218,757
Long-term debt	2,219,619	2,722,625
Other liabilities	268,721	270,702
Deferred income taxes	1,277,715	1,186,124
Total liabilities	**$5,054,021**	**$5,398,208**
Preferred stock—redeemable	13,512	14,101
Common stockholders' equity:		
Common stock	967,528	992,405
Retained earnings (deficit)	131,544	(20,624)
	$1,009,072	**$971,781**
Cost of Treasury stock	(18,825)	(53,756)
Total common stockholders' equity	**$1,080,247**	**$918,025**
Total liabilities and stockholders' equity	**$6,147,780**	**$6,330,334**

Capital Expenditures ($000,000)

	Year Ended December 31, 1989	*1988 Restated*
Roadway	$297	$305
Equipment	154	155
Other	14	14
Total	**$465**	**$474**

Source: 1989 Annual Report.

EXHIBIT 3 Burlington Northern Organization Chart



Source: Company documents.

motive products (Exhibit 4 contains segment information).

Coal was BN's largest source of revenue, representing about one-third of total revenue. Over 90 percent of the coal carried by BN originated in the Powder River Basin of Montana and Wyoming. BN had invested heavily in the 1970s to build lines to serve the Powder River Basin. If the U.S. government enacted the anticipated acid rain legislation, demand for the Powder River Basin's low-sulfur coal was expected to increase

EXHIBIT 4 Burlington Northern's Seven Business Segments

		Revenue (in millions)		*Revenue Ton Miles (in millions)*		*Revenue per Revenue Ton Mile (in cents)*	
Segment	*Description*	*1989*	*1988*	*1989*	*1988*	*1989*	*1988*
Coal	90% originates in Powder River Basin	$1,504	$1,500	111,087	107,202	1.35	1.40
Agricultural	Primarily grain; also food and other products	718	743	37,443	38,167	1.92	1.95
Industrial Products	44 major commodities, including chemicals and allied products, primary metal products	682	626	26,511	23,289	2.57	2.69
Intermodal	Highway trailers and marine containers moved on specially designed flatcars or double stack cars	649	615	21,505	20,222	3.02	3.04
Forest Products	Lumber and wood products; pulp paper and allied products	480	490	18,956	18,593	2.53	2.64
Food and Consumer	Food and parts for various finished products industries	413	403	15,202	14,436	2.72	2.79
Automotive	Shipment of finished automobiles; evenly divided between domestic and import traffic originating principally from Pacific Northwest ports	154	145	1,823	1,649	8.45	8.79

Source: 1989 Annual Report.

substantially. Managers also believed that Powder River coal had promising export potential to Japan and other Pacific Rim nations from the west coast ports served by BN.

Coal was carried in unit trains or "sets" (108 cars, each holding 102 tons of coal, powered by 3 to 6 engines). Virtually all of the unit coal traffic was under long-term contract with fewer than two dozen customers. To insure good asset utilization, cycle time was important. A reduction in the average cycle time reduced the number of sets required to carry a given amount of coal, and hence, reduced the capital investment in coal cars, most of which were owned by customers. Thus, unit coal trains never stopped, and the coal business was almost totally predictable. Although sensitive to cycle time, the coal business was not sensitive to arrival time precision as coal could be dumped on the ground without waiting for special unloading facilities or warehouse space. Even electric utilities, however, were becoming aware of just-in-time delivery benefits.

BN's major competition in coal was other railroads, especially the Union Pacific (UP). UP had made substantial investments in heavy-duty double track and in new technology, fuel-efficient engines for carrying coal. BN management believed UP had excess capacity whereas BN, with its single track lines, was running close to capacity on its coal lines.

Agricultural commodities, primarily grain, was BN's second largest segment. Strategically located to serve the Midwest and Great Plains grain-producing regions, BN was the number one hauler of spring wheat, and the number two hauler of corn. Although grain and coal were both bulk commodity businesses with little competition from trucks, the grain business differed substantially from coal. Demand for grain deliveries was more random since the time of harvest varied from year to year, and export demand for grain also fluctuated with the highly variable market price of grain. Grain traders dealt for the best prices, and long-term arrangements were uncommon. BN managers expected that with the change in economic policies in Eastern Europe (and possibly the Soviet Union), the standard of living in these countries would rise, leading to an increased demand for grain. With its ability to serve both the grain-producing regions and West Coast and Gulf ports, BN expected this segment of its business to grow significantly in future years.

During the late 1980s, BN changed the marketing of grain transportation through its Certificates of Transportation (COT) program. Under this program, BN sold contracts containing commitments to move carloads of grain within a three-day interval, six months in the future. The COT was helping to eliminate some of the randomness in grain shipments and pricing. BN, though, now had to have cars available reliably for the contracted shipment, or else incur a large penalty for failure to perform. The COT program had been a successful innovation, but it put a premium on BN to coordinate and plan its grain operations.

John Anderson, executive vice president for Marketing and Sales, believed that BN's five other commodity businesses had many similarities:

> Although the customers differ, these five businesses all have significant flat or boxcar movements. They have random movement and demand, and are strongly service sensitive. Customers make tradeoffs between price and quality and these businesses all put us into severe competition with trucks.
>
> Think of a continuum of commodities. At one end of the continuum are commodities that should go by train such as coal or grain. These commodities are heavy and low cost, have low time sensitivity, and come in large

lots. At the other end are commodities that should go by truck, such as strawberries, electronics, and garments. These are light and high cost, have extremely high time sensitivity, and come in small lots. In between these two extremes are many commodities where trucks and trains compete vigorously on price and service.

Historically, trucks had taken over the transportation of more and more of the contested commodities. At the end of World War II, about 70 percent of intercity freight had been shipped by rail. In the post–WW II era, rail's share of intercity shipments was lost, primarily to trucking, and especially in the service-sensitive segments. Ed Butt, ARES project director, highlighted the reasons for trucking's inroads:

> Trucks charge as much as two to three times what it would cost for rail service. But trucks go door-to-door, and people will pay for that level of service.

Recent trends in manufacturing, such as just-in-time production systems and cycle time reduction, were making trucking's service time advantages even more valuable. Railroads were using their intermodal trailer/container-on-flatcar service to offer door-to-door delivery but still could not offer the reliability of delivery that trucks could obtain on a highway system where drivers could often make up for unexpected delays. As Butt explained:

> We may have peaked at 75% on-time delivery for our general merchandise, and 80% for intermodal. But 75–80% is not good enough for just-in-time service. Trucks achieve a 90–95% rate and we need to get into that range to attract the just-in-time customers, who are enormously sensitive to consistent, reliable deliveries.

Effects of Deregulation

The deregulation of both the trucking and railroad industries in 1980 had changed both the railroads' and the truckers' competitive environment. The Motor Carrier Act of 1980 gave truckers much greater freedom in setting rates and entering markets. The Staggers Rail Act of 1980 gave railroads similar freedom in setting their own rates; it also included provisions allowing railroads to own other forms of transportation.

Following deregulation, BN modernized its railroad operations. Richard Bressler, the chairman in 1980, established a research and development department in Operations and hired Steve Ditmeyer to head the group. Numerous new technologies and innovations were considered and, where appropriate, were applied to railroad operations. During the 1980s, railroad productivity increased dramatically: the number of employees declined by 50 percent while revenue ton miles increased by over two-thirds.

But trucking rates fell significantly after deregulation, putting pressure on the railroads' chief advantage: the low-cost transportation of freight. In 1990, additional regulatory changes permitting trucks to be longer and heavier were under consideration. These changes would enable trucks to further reduce their costs. However, Dick Lewis, vice president of Strategic Planning, recognized:

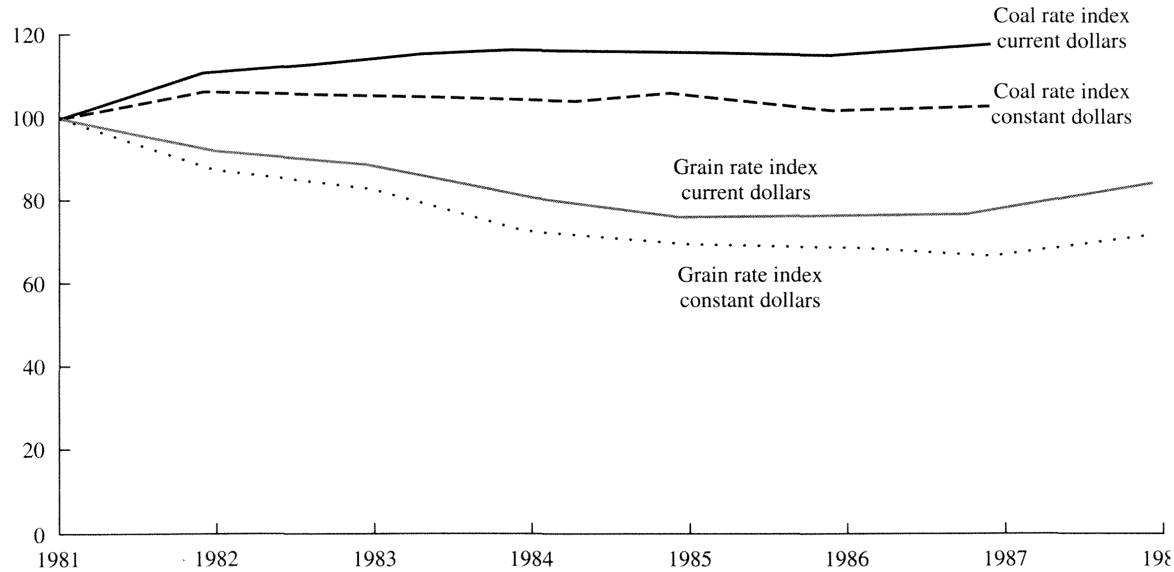
> In our recent analysis we've been surprised to find that railroads and not trucks are some of our major competition. Since deregulation, intra-railroad competition is increasing and driving down prices at a fearsome rate. [See Exhibit 5.] Trucks have carved off their own segments fairly solidly. Railroads want to compete in these segments, but they don't, and trucks are pretty secure in them.

Existing Operations

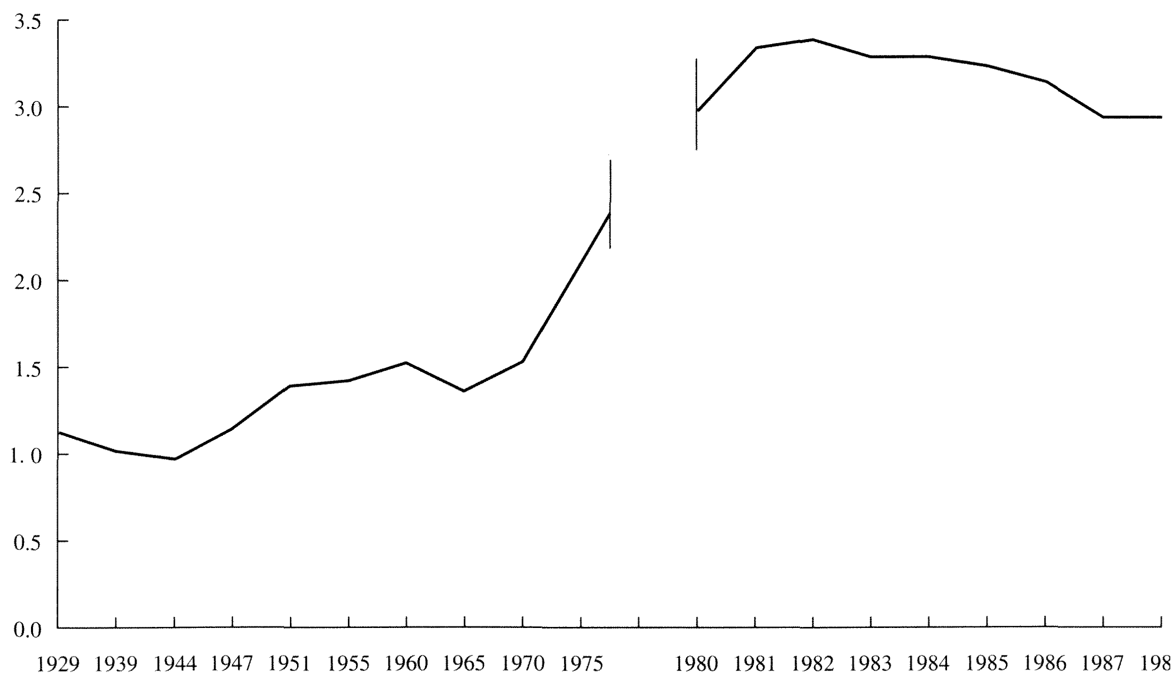
In 1990 each day up to 800 trains traveled approximately 200,000 train-miles on the 23,356 miles of track on BN routes. The 5,000 junctions created 25 million possible

EXHIBIT 5 Railroad Rates and Ton-Mile Revenue

Grain and Coal Rate Index
Current and Constant Dollars



Ton-Mile Revenue
Current Dollars



Source: Association of American Railroads.

distinct routings, or origin-destination pairs, for the cars that comprised BN trains. Meets and passes—two trains "meeting" on a single track with one of them directed off to a siding so that the other can "pass"—were carefully managed by the railroad's dispatchers. BN managers believed that thousands of meets and passes occurred each day, but were unsure about the precise number; some believed the actual number was as high as 10,000 per day.

A train running off schedule could potentially affect many other trains due to the limited number of tracks—often only one—and sidings in any area. Thus, controlling train operations meant controlling an extensive, complex network of dynamic, interdependent train and car movements.

Trains were controlled by dispatchers, each responsible for a distinct territory. Dispatchers still utilized technology developed around 1920 and little changed since then. A dispatcher was responsible for the 20 or 30 trains operating on his shift in his territory. Operations personnel, however, estimated that a good dispatcher could really only focus on and expedite five to seven trains. The remainder were inevitably treated with less attention and lower priority. At present, dispatcher priority went to scheduling competitive segments like intermodal and merchandise traffic; unit trains carrying coal and grain were not scheduled. Dispatchers had little basis for trading off delaying an intermodal train versus reducing the cycle time for a coal train.

Dispatchers saw information only about their own territories, and not others. Thus, if a delayed train entered a dispatcher's territory, he would be unaware that enough slack existed further down the line to make up all the lost time, and that he should not jeopardize the schedules of his other trains by trying to catch the delayed train up to its schedule. Typically, trains were directed to run as fast as they could and then halted to wait at sidings.

Dispatchers also scheduled maintenance-of-way (MOW) crews. MOW crews would travel to a section of track that needed maintenance and repair. But the crews were not allowed to initiate work on the track until the dispatcher was confident that no train would run down the track during the crew's work period. At present, train arrivals at MOW work sites could be predicted within a 30- to 45-minute window, but for safety reasons, the work crews were cleared off the track much sooner than the beginning of this window.

Dispatchers spent considerable time establishing communications with trains and MOW vehicles. Dispatchers had to search various radio frequencies to establish contact with trains; MOW vehicles often reported long waits until they were able to get through to the dispatcher for permission to get onto the track. In fact, on some occasions, the MOW crew traveled to the maintenance site but were unable to get through to the dispatcher before the maintenance window closed and another train was scheduled to arrive, hence wasting the trip.

Current information about railroad operations was difficult to obtain. For example, to know how much fuel was available, an engineer had to stop the train, get out, and look at the gauge on the tank at the back of the locomotive. Trains refueled nearly every time they passed a fueling station, even if the added fuel was not necessary for the next part of the trip. Further, despite daily maintenance checks of critical components such as brakes, lights, and bells, and scheduled periodic maintenance every 92 days, the only evidence of a locomotive performing poorly came from reports filed by the crew about observable failures or breakdowns. Except for the newest locomotives, no gauges or recording systems monitored conditions that could foreshadow failures such as oil pressure or temperature changes.

Information about the location of cars and trains was also subject to delay and error. Conductors were given instructions about which cars to set out and pick up at each location. Following completion of a set-out or pick-up, the conductor made a written notation. When the train arrived at the next terminal (conceivably hours later), the paper was given to a clerk who entered the data via keyboard to update management data files. Arrivals of trains at stations were recorded by clerks who, if busy, might not observe the actual arrival, thus recording a 12:00 train as 12:15, and then entering this fact at 1:00 to the management data files.

Some executives were exploring the application of modern management science philosophy to improve railroad scheduling. According to Mark Cane, vice president, Service Design:

> There are many potentially useful operations research and artificial intelligence techniques that are not yet being used by the railroad. Decision support technology has made a quantum leap forward, and we are trying to take advantage of it.

Dick Lewis illustrated the contrast between the BN and another highly scheduled transportation company:

> A benchmark company in this area is UPS. UPS has 1,200 industrial engineers working for them; BN has only half a dozen.

One view, integrated network management, was being discussed among BN's senior managers. Under this approach, scientifically designed schedules would be generated, broken down into standards for each task, plus the appropriate education and incentives would be provided for local operations personnel to cause them to run the railroad to schedule. One operating manager voiced the concerns of many about this approach to railroad train scheduling:

> BN has talked a lot about running a scheduled railroad. However, the real challenge is how to manage the unscheduled, for example, a broken air hose or a broken rail. The problem is that problems do not happen on schedule.

By mid-1990, BN's service design organization had begun to institute a reporting system called the service measurement system. Bands of acceptable performance were established for scheduled trains and compared with actual results. On-time scheduled performance measures became part of the bonus incentive system for non-union operating personnel. Following the institution of the reporting scheme, service showed definite and steady improvement. The percentage of scheduled cars arriving within targeted performance bands jumped from 25 percent in January 1990 to 58 percent in June. This suggested to BN managers that service performance could be improved simply by better collection and reporting of performance measures.

Strategic View of Operations

In late 1989, BN executives undertook a major strategic review to help shape the future. Gerald Grinstein, the chief executive officer of BN, focused the review on answering questions like, "What kind of railroad should we be?" Executives formed eight teams to examine in depth the following areas: operating strategies, customer behavior, information technology, labor, business economics, organizational performance, industry restructuring, and competitive analysis.

Dick Lewis explained the conclusions reached by this strategic directions project:

> This company, and the railroad industry, face two major challenges: service and capital in-

tensity. We must improve our ability to deliver service. We must reform and reconstitute our service offerings, especially in highly service-sensitive segments. Since World War II, railroads have retrenched from service-sensitive segments. For example, they have stopped carrying passengers and less-than-carload shipments.

If we improve service, the first opportunity created is to increase volume, at the expense of other rail carriers. The second opportunity is to raise prices, but this is more questionable. To be able to raise price requires a *radical* service change, not a marginal one. The change must be radical enough to be perceived by a customer who says, "Wow! That's different!" For example, in our chemical business we recently made such a change. We reduced the average delivery time by more than half, and we also reduced the variability of the delivery time. The shipper found he could get rid of 100 rail cars. That had a measurable value significant enough for the customer to perceive the service improvement. We have subsequently been able to structure an agreement with the shipper to provide financial incentives to BN to further improve the service.

The other side of this equation is that BN must improve utilization of assets. We have high capital intensity, poor utilization of rolling stock, and low asset turnover ratios. Actually, BN is good for the industry, but the industry itself has very poor ratios. Not only are the ratios poor, but the capital requirements for the 1990s are daunting. Just the traditional investments in locomotives, freight cars, and track replacements are daunting. If we can improve utilization of these assets, then we can reduce the capital investment required during the 1990s.

The ARES Project: The Origins

Steve Ditmeyer, chief engineer-Research, Communications, and Control Systems, reached deep into his desk and withdrew a slip of paper with a handwritten note: "Any application to locomotives?" BN's chairman Bressler had written that note in 1981 shortly after Ditmeyer had joined the company, and attached the note to an article on new aircraft instrumentation that promised lowered costs by improving fuel and other operating efficiencies. The note and article eventually filtered down to numerous railroad staffs.

In 1982, BN's R&D department contacted the Collins Air Transport Division of Rockwell International to learn whether aircraft technology could be applied to the rail industry. The two companies agreed to work together to identify workable solutions. By the end of 1983 they discovered that the technology existed to integrate control, communications, and information. An electronics unit, placed in each locomotive, could receive signals from the Department of Defense's Global Positioning System (GPS) satellites, and calculate the train's position to within ±100 feet, a significant improvement over the existing ±10–15 mile resolution from existing systems. By calculating its location every second, the train's speed could also be estimated accurately. A communications network could then be developed to carry information back and forth between the train and a control center.

The R&D department managed the early stages of the ARES project, with oversight by the R&D Steering Committee comprised of senior officers of Transportation, Engineering, Mechanical, Operations Services, Marketing, and Information Systems. The Board of Directors in July 1985 viewed a demonstration of the proposed technology installed on two locomotives. In August 1985 BN's senior executives agreed to fund a prototype system: equipping 17 locomotives on BN's Minnesota Iron Range, putting the data segment in place in the Iron Range, and building those elements of the control segment that would permit BN to communicate with and control the locomotives from the

Minneapolis control center. The Iron Range was chosen because it was a closed-loop segment of BN's network with a variety of train control systems, and was served only by a limited set of equipment.

By 1986 the ARES project had grown too large to be carried out by the small R&D staff, and Don Henderson was chosen to oversee the formation of a separate ARES team to manage the project's development. Henderson ensured that team members represented various operations departments that would potentially be affected by ARES: dispatching, mechanical, maintenance-of-way, control systems and communications, freight car management, and information system services. The team members worked with their respective departments and with others such as general managers and operating vice presidents to ensure a system that met operational needs and worked in the railroad environment. Operations managers saw ARES as a means to accomplish key goals of service improvements, operating efficiencies, and improved capital utilization. Operations incorporated ARES into the strategic plans it prepared and presented to corporate.

The ARES prototype was installed on the Iron Range in 1987. The ARES team, BN field personnel, and system developer Rockwell spent the next several years testing, evaluating, and improving the ARES system.

Under Henderson's guidance, the ARES concept evolved to a full command, control, communications, and information system that would enable BN to gain additional control over its operations. ARES, using high-speed computing, digital communications, and state-of-the-art electronics, could generate efficient traffic plans, convert those plans into movement instructions for individual trains and MOW units, and display those instructions to engine crews. By knowing the position and speed of trains and other equipment on the tracks, ARES could automatically detect deviations from plan or potential problems and communicate these exceptions to control center dispatchers. Dispatchers could determine the corrective action required and use ARES to send and confirm new movement instructions to trains. In many ways, ARES could be considered analogous to the Air Traffic Control system that controlled the aviation industry. ARES eventually came to consist of three segments: Control, Data, and Vehicle.

The Control segment received information on train position and speed to produce schedules and to check that vehicles followed proper operating procedures. It warned dispatchers of violations to limits of authority and speed, and produced authorities and checked them for conflict. The Control segment also helped to schedule the MOW crews to get much higher utilization of MOW equipment and labor time. The Control segment displayed for dispatchers the activity in their territories, and supplied information about crews and work orders for any train.

The Data segment communicated data back and forth between the Control segment and locomotives, MOW vehicles, and track monitoring and control equipment. It made use of BN's existing microwave and VHF radio network.

The Vehicle segment on board each locomotive or MOW vehicle included a display (CRT) to provide information from the Control segment, a keypad to communicate back to the dispatcher, an on-board computer to monitor various aspects of locomotive performance, and a throttle-brake interface that the dispatcher or the on-board computer could activate to stop the train if the crew became disabled, if the train violated its movement authorities, or communication was lost with the ARES system. This segment included a receiver for satellite signals to calculate train position and speed which were then communicated to the Control segment.

The Vehicle segment incorporated an Energy Management System that received information on track profile and conditions, speed limits, power, and car weight to determine a recommended train speed that met service requirements, while minimizing fuel consumption and providing good train-handling characteristics.

The Vehicle segment also included the Locomotive Analysis and Reporting System (LARS). LARS used a number of sensors and discrete signals to monitor the health and efficiency of locomotives and provide early warning signals about potential failures. LARS was expected to permit problematic locomotives to be pulled out of service for maintenance before they failed unexpectedly in a remote region and to provide a database that maintenance people could analyze to prevent future malfunctions.

The ARES Project: Current Status

By 1989, BN had spent approximately $15 million, cumulatively, on the ARES project. BN managers estimated that Rockwell had spent three times this amount. "Concept validation" had been accomplished through the Iron Range test which had proven that the technology could locate trains under real operating conditions, and could communicate back and forth between the control center and the locomotive. Rolling stock hardware had been tested for robustness and reliability. The Iron Range prototype system was demonstrated not only to numerous groups of BN executives and operating personnel but also to customers, representatives of other railroads, and numerous industry and governmental groups. By late 1989, testing of the prototype was completed. (See Exhibit 6 for a summary of the development process and Exhibit 7 for details of further development required for full implementation.)

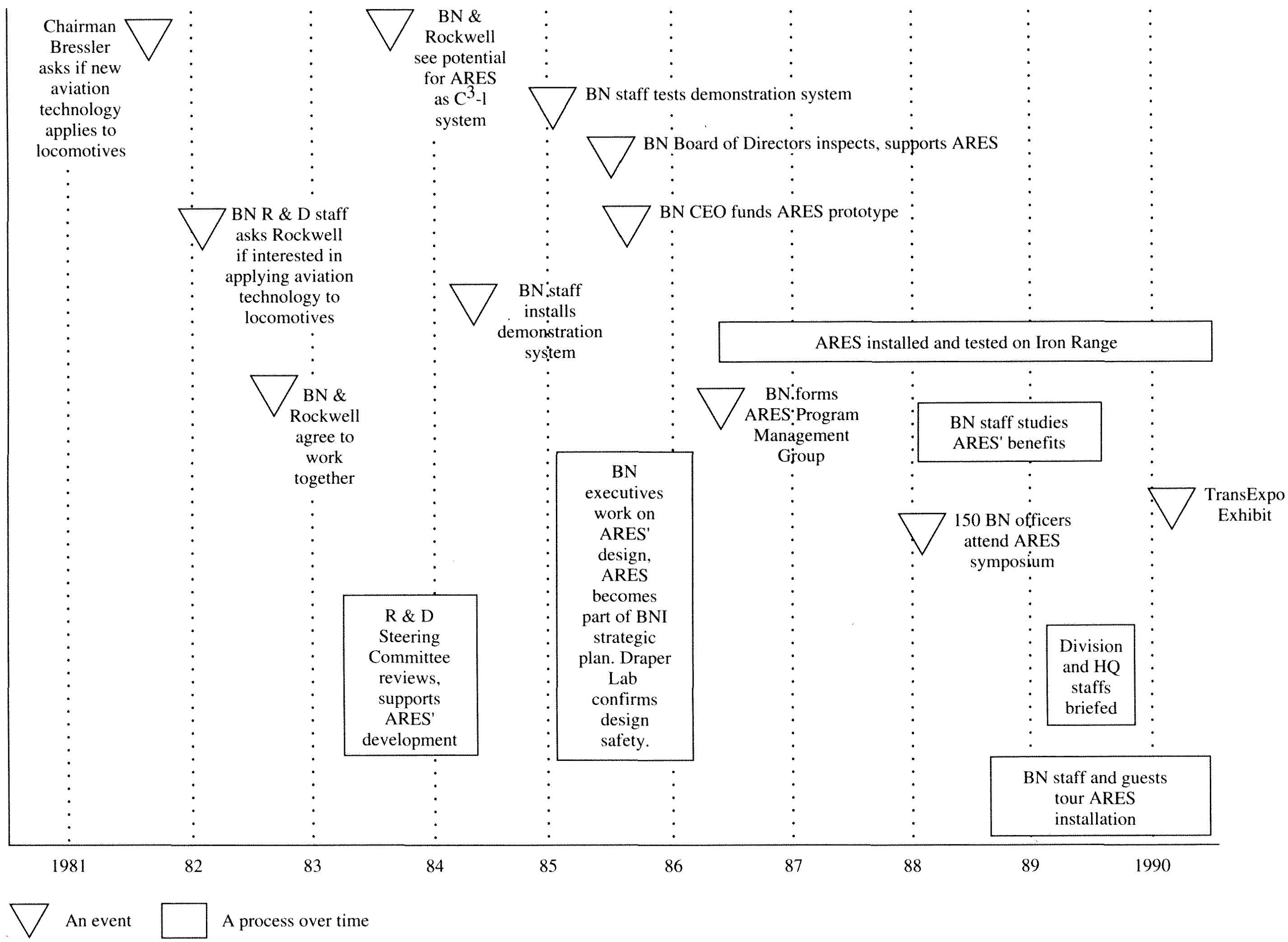
The ARES team had seen enough from the Iron Range testing to believe that it would enable BN to provide better service, improve asset utilization, and reduce costs. The ARES project that senior executives were evaluating and deciding whether to authorize in 1990 was an integrated command, control, communication, and information (C^3-I) system for controlling train movements with, according to the ARES staff, "unprecedented safety, precision, and efficiency." According to a document prepared by R&D and project staff members:

> ARES will allow BN to run a scheduled railroad with smaller staffs and more modest [capital] investments than current signaling systems. It will maintain accurate, timely information about train consists and locations. The results will be improved service, with higher revenue potential, and cost reductions. Another important benefit will be the elimination of train accidents caused by violations of movement authority.

The ARES team now requested authorization for the expenditures needed to complete the development of the full operational system and to roll out implementation throughout the railroad. The ARES team, and its sponsors Don Henderson, vice president—Technology, Engineering and Maintenance, and Joe Galassi, executive vice president—Operations, faced several important considerations as they prepared to present this investment for authorization.

First, corporate management was significantly changed from the management that had authorized earlier phases. Four CEOs, including the current executive, Gerald Grinstein, had held office since the 1981 inception of the project. None of the vice presidents who were on the R&D steering committee in 1982 and 1983 was still with

EXHIBIT 6 BN Personnel Involvement in ARES' Design and Implementation



Source: Company documents.

EXHIBIT 7 Development Required to Implement ARES as of Early 1990

Scheduling Programs—Train scheduling programs comprised two modules: the Strategic Traffic Planner (STP) and the Tactical Traffic (or Meet and Pass) Planner. The STP viewed railroad operations globally, for example, determining optimal schedules for the entire railroad system. It could determine whether a late train should be caught up in the current dispatcher's territory, or a subsequent one with more slack. BN had contracted to have STP specifications written, but no computer programs had been written.

The Meet and Pass Planner functioned at a local level. STP schedules were passed to the Meet and Pass Planner. Treating STP schedulers as constraints, the Meet and Pass Planner produced a meet and pass schedule for a dispatcher's shift; the dispatcher revised this schedule, if necessary, and authorized it. Authorized meets and passes were communicated through ARES to the trains as operating instructions, which the engineers carried out. Prototype Meet and Pass Planner computer programs had been written; ARES staff members had tested their functionality and had used them in simulation to evaluate ARES benefits. However, the Meet and Pass Planner had not been tested in the Iron Range nor had it actually controlled trains. ARES staff had identified prototype bugs requiring resolution; they were also concerned whether the meet and pass planning algorithms were the most efficient.

Energy Management System—The ARES staff considered Rockwell's original Energy Management System prototype unacceptable; it was not used to provide control input to trains in the Iron Range. Rockwell was reworking the Energy Management System, but it was not yet complete nor ready for testing.

Locomotive Analysis and Reporting System (LARS)—The data-gathering aspect of LARS had been tested in the Iron Range. However, BN had little experience analyzing these data. They could not evaluate the nature and magnitude of potential savings, due in part to the Iron Range's unique closed-loop where locomotives passed a maintenance station daily instead of every several days as on other portions of the railroad.

Existing Iron Range Software—The software used in Iron Range tests was considered prototype software. While it was designed as efficiently as possible, the prototype testing had revealed that greater efficiencies were possible. The production software would further have to be designed to gain greater efficiencies when regulatory restrictions were lifted in the future. Thus, the Iron Range prototype software required redesign before it could be implemented as efficient production software.

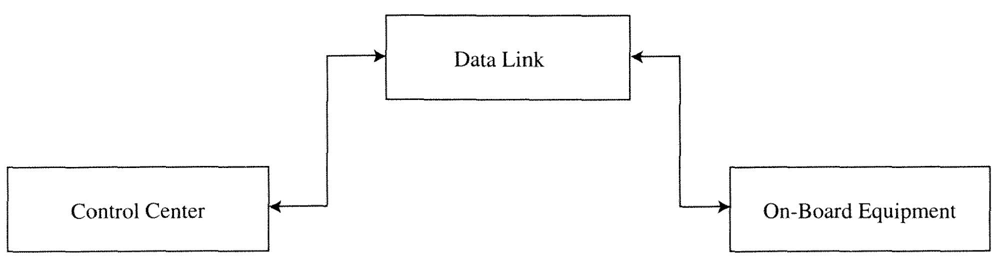
the railroad. Of the board members who saw the ARES demonstration in July 1985, only one, the current chairman, remained. Thus, although ARES had undergone a lengthy development process within BN, many who must now support and authorize it were unfamiliar with the choices that had guided its development.

Second, there was a question of whether to propose a full-blown implementation of the ARES project or just an initial phase or two. Presenting the full-blown project would inform top management of the potential range of ARES features and would give them the bottom line for fully installing ARES for the entire railroad: about $350 million. (See Exhibit 8 for cost breakdown.) Even for a company of the size of BN, this investment was a large amount. And ARES was a complex project, different from typical

EXHIBIT 8 ARES Cost Breakdown

Major Cost Categories	*Cost*	*Comments*
Control Center	≅$ 80 million	Software development is a major component of this cost.
Data Link (Wayside Communications)	≅$ 80 million	BN planned to replace much of its existing pole line communication network with an ARES-compatible data link regardless of the decision on ARES. However, this conversion had barely begun.
On-Board Equipment	≅$200 million	Roughly $100,000 per road locomotive; less for switch locomotives and MOW vehicles. Of this, LARS = $16,000/ locomotive with total costs (including software development) expected to be less than $35 million. Although not expected to exceed LARS, Energy Management System costs had not been estimated in detail.

LARS and the Energy Management System were generally considered modules separable from the rest of ARES. Beyond these two, however, it was difficult to identify ARES modules that could be implemented independently. For example, sending a movement authority to a train required the control segment to check conflicts with other vehicles' authorities, the data link to communicate the authority to the train, and the on-board equipment to enable the engineer to receive and confirm the authority. Thus, each of these three segments had to be implemented for ARES to operate in any given region. Although not every locomotive had to be equipped, as fewer locomotives in a region were equipped the overall system became less effective since ARES could no longer confirm the location of—and spacing between—all trains. Limiting ARES to a geographic region within BN reduced Data Link and On-Board equipment costs commensurate with track and vehicle reductions, and reduced Control Center costs somewhat.



railroad investments in modern locomotives, cars, track, and ties. According to Henderson:

> We may not do the entire railroad; early implementation at least would inevitably be limited to specific geographic areas. Further, we may or may not implement all of the ARES features; the LARS system and the energy management system are clearly very separable pieces.

Galassi explained the rationale for proposing the entire project:

> We figured that top management would want to have a picture of the total project, rather than being fed a piece at a time for incremental decisions and wondering where the end of the line was.

Finally, there was the issue of how to communicate the ARES benefits and credibly measure their value. Some of the benefits that the ARES team had identified were either difficult to measure because the values were unknown—how much more would a customer be willing to pay for a 1 percent improvement in service?—or because the railroad did not record and track certain data—how much time was lost by trains waiting for meets and passes? The team firmly believed that if they implemented this innovative technology, they would experience benefits they had not yet even anticipated.

To help measure the variety of benefits from a full-blown implementation of ARES, the team economist, Michael Smith, contracted with a half-dozen outside consultants, each of whom focused on a specific area such as measurement of market elasticity, measurement of LARS effects, measurement of meet/pass efficiency, and improved safety. (See Exhibit 9 for a summary of each benefit study.) Some benefits could be measured only partially in financial terms; for example, improved safety would reduce damaged equipment and freight by perhaps $20 million per year, although its value in human and political terms was even more significant. According to Steve Ditmeyer:

> ARES reduces the probability of a collision by two orders of magnitude because, in contrast with our existing railroad control system where one failure or a mistake by one person can cause an accident, with ARES no single person or piece of equipment can cause an accident; two must fail simultaneously.

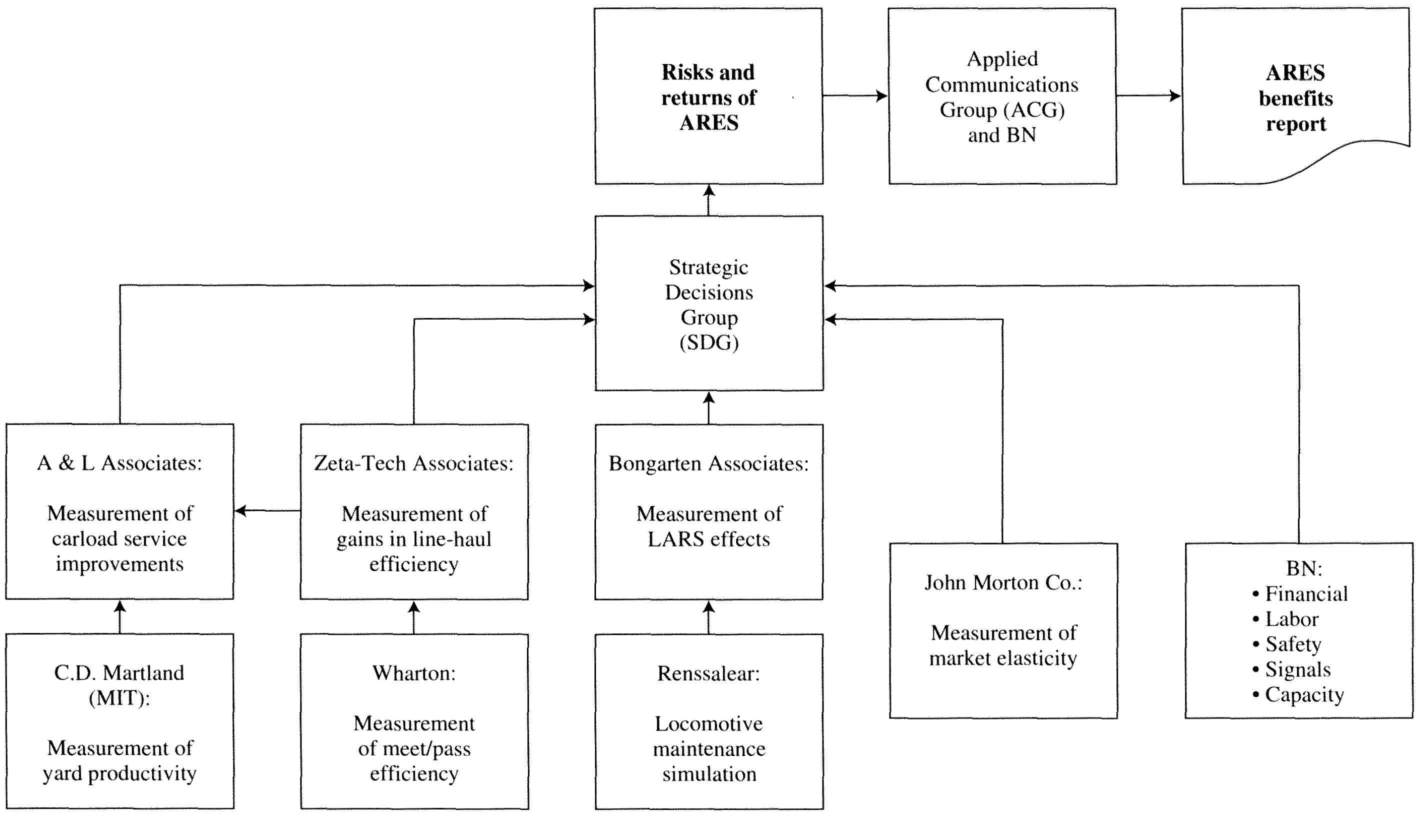
The Strategic Decisions Group (SDG) was hired to help the ARES team integrate the results of the individual consulting studies with other BN data into a single, coherent analysis of benefits. The analysis was conducted using three strategic scenarios supplied by BN's planning and evaluation department: base, focused, and expansion. Using probability distributions of key uncertainties supplied by BN managers, a set of computer models were built to calculate the probability distributions of the net present value of ARES under each of the strategic scenarios.[2] Exhibit 11 illustrates a representative annual and cumulative after-tax cash flow for the ARES project. The SDG report concluded:

> The potential benefit of ARES is large but highly uncertain. Using the best information currently available, we estimated the gross benefit in the range of $400 million to $900 million, with an expected present value of about $600 million. This benefit should be weighed against a cost of approximately $220 million (present value). The benefits depend greatly on implementation success: The system design must be sound, a strong implementation plan must be developed, and functional groups across the BN system must be committed to using it to full advantage.

The ARES team concluded that the primary known benefits of ARES (see Exhibit 12) were to be measured in reduced expenditures on fuel, equipment, labor, and trackside equipment; damage prevention; and enhanced revenues. The largest component, revenue enhancements, however, had the most uncertain estimates (see Exhibit 13).

[2]The cumulative probability distributions of the net present value of ARES benefits under each of the strategic scenarios are shown in Exhibit 10.

EXHIBIT 9 Consultant's Studies of ARES Benefits Source



Source: Company documents.

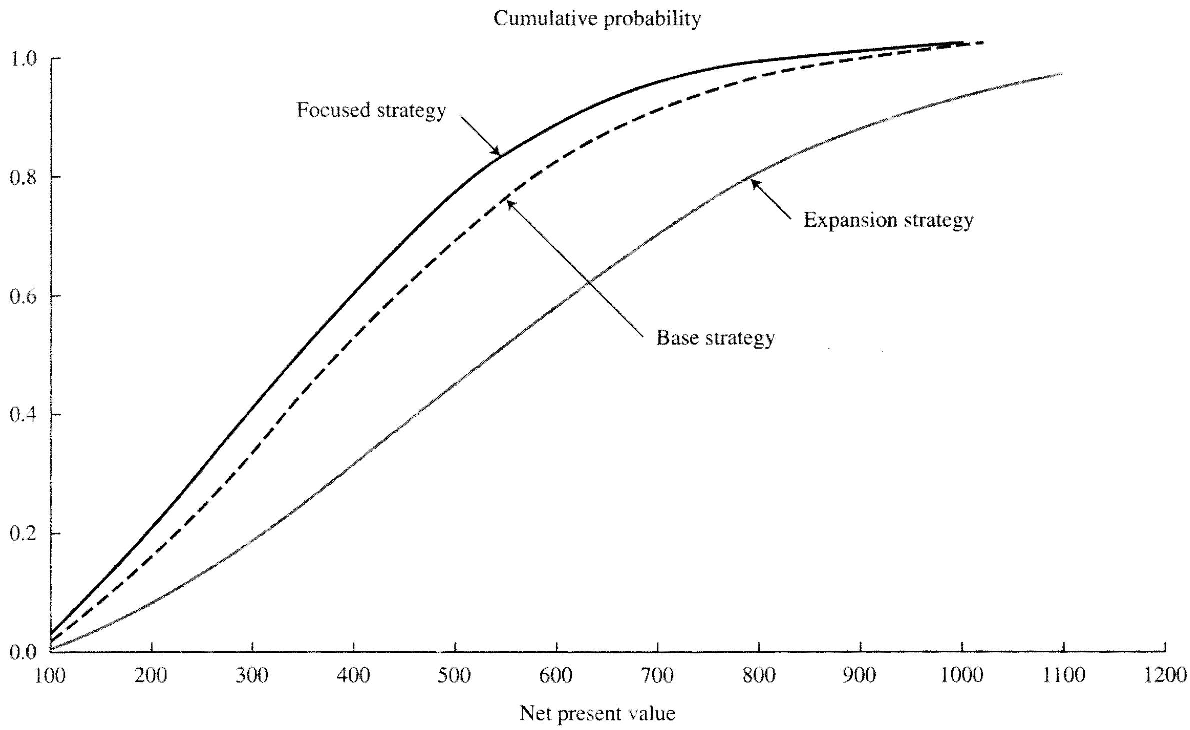
EXHIBIT 9 *(continued)*

Consultant	*Purpose*	*Approach*	*Results*
A & L Associates	Measure effect of ARES improvements in terminal and line-haul performance on carload service.	Service improvements were modeled for a representative BN section using the Service Planning Model with inputs on existing conditions and expected changes in performance supplied by C.D. Martland, Wharton, and Zeta-Tech.	Reductions in line-haul times and increased terminal performance will decrease total trip times by 7–8% even if scheduled connections and blocking strategies are unchanged.
John Morton Company	Measure the increase in traffic expected with an increase in the level of service offered customers in given market/commodity areas.	Questionnaires were distributed to decision makers who routinely select modes/carriers for shipping commodities in or across BN territories. A demand elasticity model was constructed using conjoint analysis. The model was calibrated, tested, and sensitivity analyses were conducted to generate demand elasticities for each service attribute.	Perceived performance differences between truck and rail are most dramatic with respect to transit time, reliability, equipment usability, and level of effort. Improving reliability offers greatest leverage for increasing BN's revenues. A 1% improvement in reliability, if, and only if, fully implemented and perceived in the marketplace could yield a 5% increase in revenues; a 5% improvement in reliability could yield a 20% increase in prices.
Bongarten Associates	Evaluate the Locomotive Analysis and Reporting System (LARS).	A simulation using actual BN data on train information, trouble reports, and repairs tested LARS in four modes: (1) inspection of units committed to shops; (2) examining component status during on-road failures; (3) using prospective diagnostics to schedule additional repairs when the locomotive is already committed to the shop; (4) using prospective diagnostics to bring the unit into the shop before a failure occurs.	The two LARS modes which offer the greatest promise are modes 2 and 3; mode 3 offers higher savings but requires development of a prospective diagnostics system. Savings of 3% to 5% were calculated in five areas: departure delay, on-line delay, time off-line, maintenance man-hours, and reduced severity of repair due to early detection.

EXHIBIT 9 *(concluded)* Consultant's Studies of ARES Benefits

Consultant	*Purpose*	*Approach*	*Results*
Charles Stark Draper Laboratory	Analyze how safe ARES would be, compared to BN's existing train control systems.	Modeling using Markov analysis.	The probability of a train control system-related accident would be reduced by a factor of 100 when ARES is in place. The primary reason for this improvement is that ARES' integrated system architecture provides highly reliable checks and balances that limit the impact and propagation of human errors.
Zeta-Tech Associates	Measure gains in line-haul efficiency from Energy Management System (EMS) module and Meet/Pass Planning module.	Recorded actual operating data on 846 trains (55 were selected for detailed analysis) from 16 "lanes" chosen to represent BN's full range of operating conditions, control systems, traffic volumes, and mixes. Modeled actual operation to establish baseline fuel consumption and running time; then modeled fuel consumption and running time using (1) EMS module and (2) Meet/Pass Planner.	EMS module produced only 2% net fuel savings and large increases in running times for some trains. Z-T argued this was due to software flaws in algorithm and priorities. Meet/Pass Planner reduced running time for all 846 trains by an average of 21%. For the 55 selected trains, travel time decreased 17% and fuel consumption decreased 2.5%. Reliability increased; the travel time standard deviation also decreased.
Wharton	Measure Meet/Pass efficiency and feasibility.	Modeled fuel consumption and running time using various Meet/Pass dispatching algorithms on selected study trains in the 16 lanes evaluated.	ARES can produce meet/pass plans consistent with operating policies which yield travel time and fuel savings in 30 seconds or less; a pacing algorithm produces further fuel savings.
C.D. Martland (MIT)	Measurement of yard productivity.	Collected detailed data from several BN yards. Modeled effect of improved reliability of train operations on (1) yard efficiency through improved interface between line-haul, terminal operations, and crew assignments, and enhanced capabilities for communications with and supervision of crews; (2) on yard processing times; and (3) on train connection reliability.	Train performance was variable enough to allow considerable room for increased reliability, reducing average yard times about one hour. Modest improvements in terminal efficiency and train connection performance could be achieved through better utilization of terminal crews. Overall ARES could reduce average yard time .5 to 2 hours at major terminals and reduce missed connections by 15 to 17%.

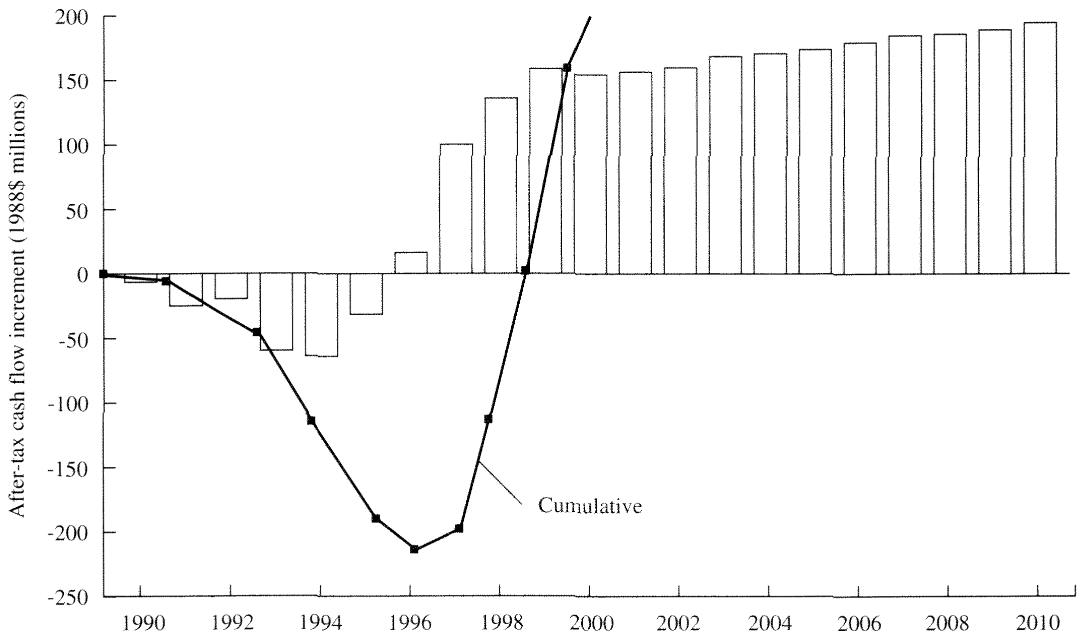
EXHIBIT 10 Cumulative Probability Distributions of ARES Benefits under Three Scenarios



Base (status quo) strategy mean = $406 million
Focused strategy mean = $360 million
Expansion strategy mean = $576 million

Source: Company documents.

EXHIBIT 11 ARES Projected Annual and Cumulative After-Tax Cash Flow



Source: Company documents.

EXHIBIT 12 Primary ARES Benefits

ARES offers many benefits which enable BN to reach its goals of safe and profitable rail operations. Following is a summary of those benefits.

- Increased rail operations safety results from constant monitoring of wayside signal and detector equipment, train movement, and locomotive health.
- Greater operating efficiency and improved customer service come from operating trains to schedule and handling trains that deviate from schedule, the results of improved traffic planning.
- Improved safety and increased customer service come from real-time position, speed, and ETAs for all trains computed continuously and automatically provided to MOW crews and other BN users through existing BN computer systems.
- Improved dispatcher productivity results from automating routine dispatching activities such as threat monitoring, warrant generation, traffic planning, and train sheet documentation.
- Higher effective line capacity is provided by accurate vehicle position information and automatic train movement authorization.
- Improved MOW productivity results from improved traffic planning.
- Improved business management is possible with accurate, current information about the status and performance of operations and equipment.

Key Points

- The study examined benefits in the following areas and estimates the present value of those benefits:

• Fuel	$ 52 million
• Equipment	$ 81 million
• Labor	$190 million
• Trackside equipment and damage prevention	$ 96 million
• Enhanced revenues	$199 million
Total	$618 million

- To account for uncertainty in these estimates, the study calculated ranges of values for them and probabilities of achieving values within the ranges.

- The factors with the largest potential for delivering benefits are also the most uncertain:

  - ARES' ability to improve transit time and
  - The amount customers are willing to pay for better service.

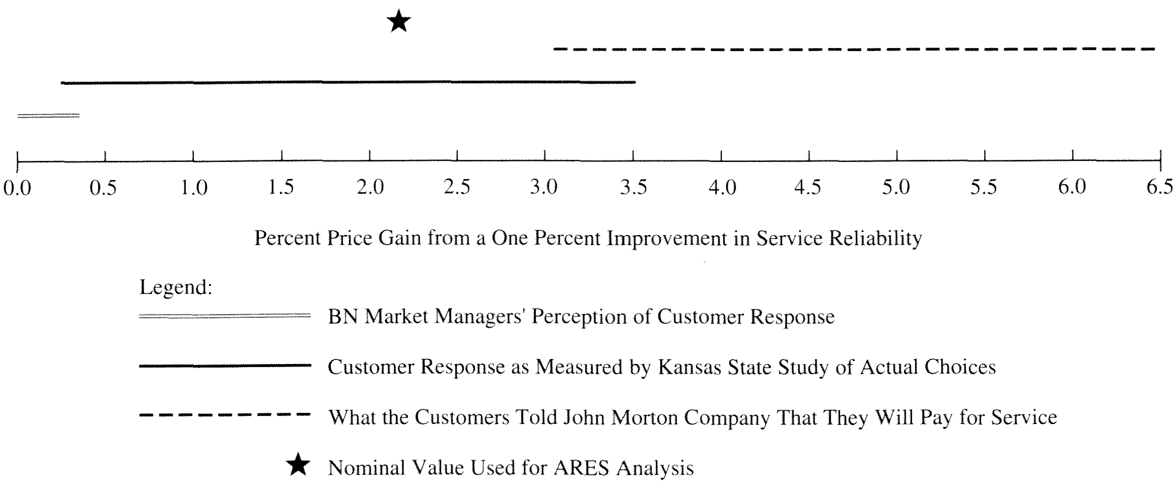
- Accounting for ranges and probabilities, ARES will make the following mean contribution to net present value for each corporate strategy:

• Focused strategy	$360 million
• Base strategy	$406 million
• Expansion strategy	$576 million

- The probability of ARES earning less than 9% real after-tax rate of return is extremely small.

Source: Company documents.

EXHIBIT 13 Price Gain versus Increased Service Reliability



Source: Company documents.

Case 3–3

BURLINGTON NORTHERN: THE ARES DECISION (B)

ARES seems to be a technology in search of a problem. The projected benefits from ARES have been derived from a bottom-up approach, not from a top level strategic planning process.

Dick Lewis, Vice President of Strategic Planning

ARES has the aura of an R&D-driven project. It was never subjected to the company's long-term resource allocation financing process or to a ranking among strategic priorities.

Jack Bell, Chief Financial Officer

Ed Butt, ARES project director, and Don Henderson, vice president, Technology, Engineering and Maintenance, had presented ARES benefits to senior executives.[1] While the executives found the benefits "fairly convincing," according to CEO Grinstein, they still had questions, "Do we need those benefits? Will there be a return on the $350

This case was prepared by Julie H. Hertenstein and Robert S. Kaplan.

Harvard Business School case 191–123.

[1]The ARES project was described in "Burlington Northern: The ARES Decision (A)," HBS Case No. 191–122.

million? Is there a cheaper way to get them?" Senior executives had a nagging feeling that BN might be able to obtain 80 percent of the benefits for only 20 percent of the costs. Jack Bell articulated these concerns:

> ARES is a very large, complex project. It has many bells and whistles. We need to figure out what is the most important aspect of the project. If it is meet and pass planning, then we should assess the most cost effective way of doing meet and pass planning. "Unbundling," however, is not the favorite activity of project teams, especially late in the development process.

Managers were also worried that the ARES team had become overcommitted to their project and had lost their objectivity for analysis. Some referred to ARES team members as "zealots." It seemed that whenever senior managers identified a problem, ARES was offered as the solution; this confused some executives about exactly what ARES benefits were.

Executives also did not fully believe all aspects of the ARES benefits analysis, particularly the service-price elasticities. The marketing department considered the estimates overstated (see Exhibit 1), and wondered why its people had not been more involved in developing this analysis beyond providing suggestions on market research firms, research sites and questionnaire content.

Others worried about the magnitude of the investment itself. A $350 million investment was not the largest BN had made, especially considering that the investment would be made over a several year period. However, some were concerned that the actual investment would turn out to be much larger. According to Bill Greenwood, chief operating officer:

> Many things may be incomplete in the ARES system. Therefore, I don't know if the $350 million represents a bottom line price tag, or if the actual cost to design, program, implement and debug ARES will be a considerably larger number. The technology—vehicle identification, radio and satellite communication, and locomotive monitoring—is almost the least of our concerns. The technology alone does not deliver the benefits. We need to change our underlying business processes which are not only large in number, but intensely interrelated. And the roles and responsibilities of many of our operating positions must be redesigned in order to achieve the objectives and benefits of ARES. This kind of planning process was not undertaken in the piloting of ARES, but it will be vital to successful, widespread adoption.

The significance of the required organizational changes concerned other managers as well. Observers noted that this investment would catapult the organization from the Iron Age into the Electronic Age. According to Dick Lewis:

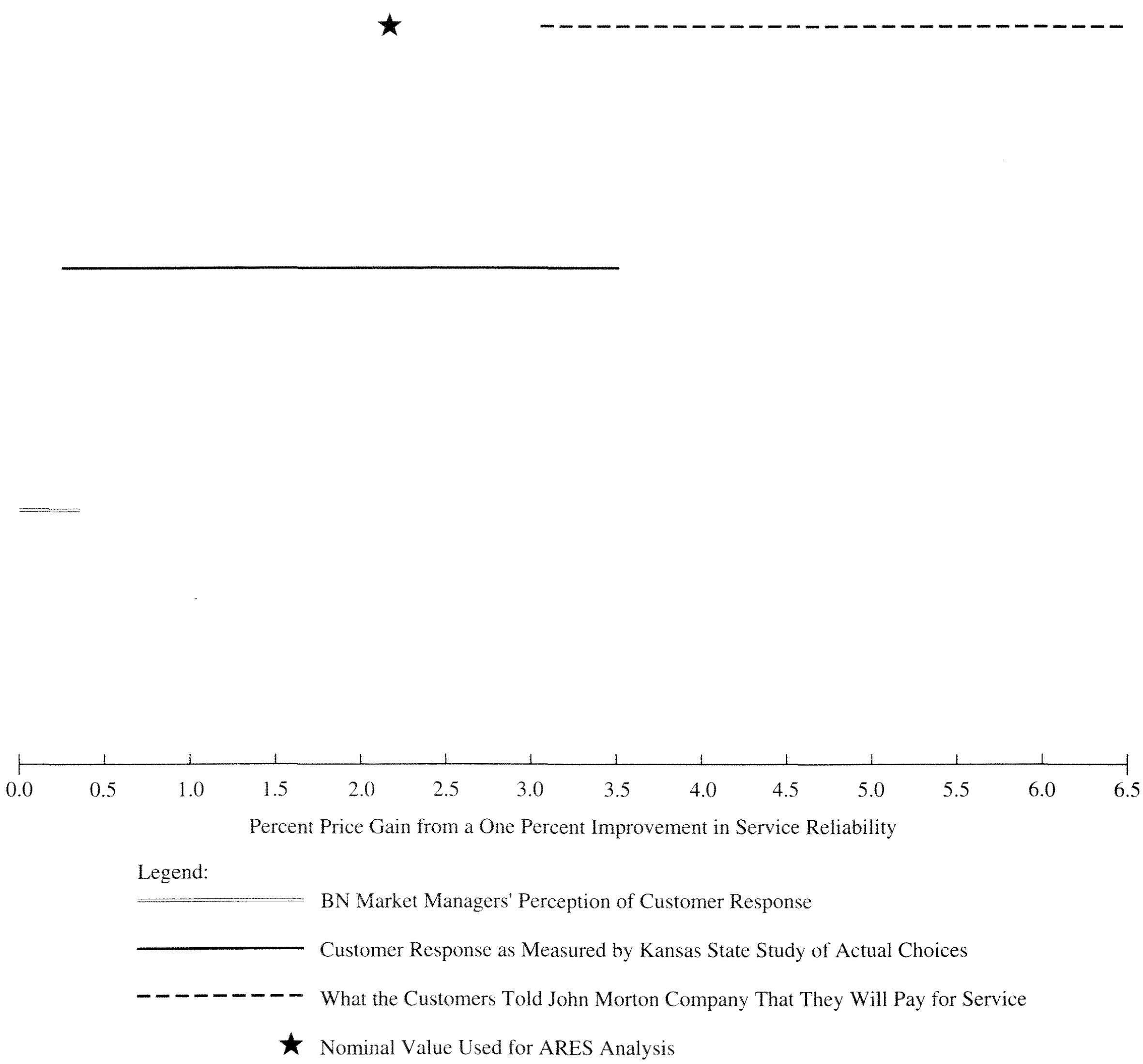
> We wanted to increase our confidence in how the railroad's traditional, hierarchical organization with its deeply rooted, hundred-year-old history would handle the major organization changes that would be necessary.

Financial Operations and Restructuring

Even if ARES were justified, did BN have adequate funds to undertake it? During the late 1970s railroad industry financial performance had been generally poor. The industry was capital intensive, return on assets was low, and some railroads had been forced into bankruptcy.

Concurrently, concerns developed among some of BN's most senior managers that the firm was not doing enough to exploit its extensive land grant and natural resource holdings. They also believed that BN's stock price did not adequately reflect the value of its railroad operations and its natural resource holdings. This belief was made more tangible when T. Boone Pickens started to

EXHIBIT 1 Price Gain versus Increased Service Reliability



purchase Burlington Northern shares in 1987. BN management decided to restructure the company. Burlington Resources Inc. (BR) was created in May 1988 as a holding company for BN's natural resource operations. In July 1988, BR completed an initial public offering of its stock and in December, BN distributed its shares of BR common stock to BN's common stock holders, thus spinning BR off from BN and leaving BN with one principal subsidiary: Burlington Northern Railroad Company. To effect this spin-off, BN issued large amounts of debt, leaving the firm with a debt-to-total-capital ratio of 76 percent, a level considered high for the industry.

In his 1988 letter to shareholders, CEO Gerald Grinstein stated:

> We must manage the substantial debt load remaining after the spin-off of Burlington Resources Inc. This will require a clear strategic focus so that we can maximize the cash flows available for capital improvements while reducing the outstanding debt.

Jack Bell soon noticed the investment community's enthusiasm for debt repayment.

> Following the recapitalization, the investment community estimated BN's earnings per share at $3.20 and its share price at $22, a 7× P/E multiple. We queried analysts about why the multiple was so low and they told us about their concern with the level of debt for a company in a cyclical industry. To convince the investment community that BN had a viable program to pay down the debt and still invest in the railroad, we announced an accelerated debt repayment program that would repay more than the amount required in the debt covenants. Subsequently, we supported this program with progress reports of BN's cash flows and debt paydown in 1989 ($500 million as of year end) and a projection of 1990 cash flows (excluding net income). [See Exhibit 2.] BN's stock price rose significantly in the months following this report.

BN planned to continue to accelerate paydown. Grinstein's 1989 letter to shareholders said:

> One of our top priorities has been to improve our financial structure. We have undertaken a major improvement program and made significant first-year progress, retiring over $500 million in debt [debt-to-total-capital ratio: 68%]. . . . Our goal is to achieve a total debt level of 50% of total capitalization by 1994, paying down debt at an average rate of $200 million per year.

To emphasize the urgency of debt repayment, BN instituted a bonus plan in 1989 for all 3,000 of its salaried employees. The average percent bonus in any year depended on the company's earnings per share, net income, and debt paid down. Individual performance could make individual bonuses somewhat higher or lower than average. Salaried employees below the level of vice president were divided into three groups whose bonuses could range up to 10 percent, 20 percent, or 40 percent of their annual salary, respectively. Bonuses for employees at or above vice president level were administered separately.

In an era of accelerated debt paydown, funds for investment were tight, and there were many competing demands for available funds. Normal aging of equipment would require heavy expenditures to replace locomotives, freight cars, and track. Recently acquired concrete ties had already demonstrated benefits beyond those originally projected, leading to proposals to make further investments in them as well. The growth in export potential caused some BN managers to consider whether additional railroad acquisitions with good access to West Coast ports should be sought. Brock Strom, vice president, Information System Services, believed that the new strategies resulting from the firm's strategic review would require additional MIS investments to support them. The strategies were still emerging so no specific demands were defined, though his "unsubstantiated guess" was that $100–200 million would be required. Jim Dagnon, senior vice president—Labor Relations, suggested that if the current round of labor negotiations produced an agreement that train crew sizes could be reduced, an investment of $100–200 million to "buy out" the excess crew would have an 18-month payback.

Technology Concerns

Apart from financial considerations, some managers were concerned that BN was considering adopting an automated train control

EXHIBIT 2 1989 Cash Flow ($ in millions)

	Sources of Cash	
Net income		$ 243
Depreciation		310
Deferred taxes		69
Lease financing		100
Cash balance drawdown		1
Accounts receivable sale		250
Working capital change		124
Asset sales net		19
Total		$1,116
	Uses of Cash	
Capital expenditures		$ 473
Dividends		109
Debt service		505
Required		112
Optional		393
ETSI		25
Other		4
Total		$1,116

1990 Cash Flow Planning Assumptions

	Sources of Cash		
Net income		$?	
Depreciation		350	
Deferred taxes		30	
Lease financing		100	
Cash balance drawdown		40	
Other		50	
Total		$570	+ Net income
	Uses of Cash		
Capital expenditures		$537	
Dividends		92	
Required debt service		115	
ETSI		25	
Other		1	
Total		$770	+ Discretionary debt paydown

Source: Company documents

technology that differed from the Advanced Train Control System (ATCS) being developed by members of the Association of American Railroads (AAR). ATCS controlled trains; ARES controlled the entire railroad operation. By 1990, when BN had already tested the ARES prototype, the AAR was still developing specifications for ATCS. Some believed that the ARES system was as many as five years ahead of ATCS in development. Other comparisons between the two systems are shown in Exhibit 3.

Other managers pondered whether BN should be first in the industry with an automated train control technology. According to Joe Galassi:

> If the investment is unique for some period and represents a competitive advantage, then BN should be the first mover and get the additional business. However, if the technology does not offer a big marketplace advantage, then it is not best to be first. If other competitors implement it first, BN has the advantage of watching them and avoiding their mistakes.

Many believed that the development of the control center represented another notable risk. Software development was a key element of the $80 million control center cost. Much of the complex set of control center software had yet to be developed and integrated although some algorithms had already been tested. Forecasts of development costs, or of development time, might be exceeded. Brock Strom suggested that some prior computer applications had not always gone exactly as planned. For example, the computerized track warrant system that one division got from the Canadian Pacific Railroad was supposed to take one

EXHIBIT 3 ATCS and ARES Comparisons

Differences	*ATCS*	*ARES*
Accuracy (feet)	+100	+100
On-board equipment (per unit)	\$20,000–\$80,000	\$20,000–\$80,000
Wayside communications	UHF Radio \$146 million	VHF Radio \$78 million
Equipment maintenance	5%+[a]	5%
On-board signaling	Yes	Yes
Train control	Yes	Yes
On-line locomotive condition	Yes	Yes
Set-out and pick-up instructions to train crews and confirmation from them	Yes	Yes
Full safety benefits	No[b]	Yes
Positioning system	Transponders between rails; plus dead-reckoning on locomotives	GPS satellites; plus dead-reckoning on locomotives

[a]Add \$0–\$2,000/locomotive/year
[b]ATCS cannot effectively monitor the location of maintenance-of-way vehicles due to the substantial time they spend between widely spaced transponders.

year to implement; it actually took four. However, the remaining ARES software resembled existing software applications such as the FAA's air traffic control system. According to Brock Strom:

> The technology risks are not that significant. The hardware technologies have been used in other industries; therefore, the issue is not developing a brand new technology but transitioning an existing technology to the railroad. ARES is a major software development effort with all the normal problems, but the programming effort is quite feasible and should be able to be implemented.

Gerald Grinstein believed:

> For the industry to succeed, it will inevitably have to get into some kind of new technology. I don't want BN to be the sole ARES advocate. I've invited other railroads to come and observe the prototype system in the Iron Range. If BN goes with ARES, it will probably drive the rest of the industry this way. The others have to stay competitive, and ATCS is not realistically available now, so ARES is the only operating solution at the current time.
>
> The ARES decision is caught up in another process, shaping BN's future. Major questions to be answered are, "What kind of railroad should we be?" If we deliver a much greater, more reliable level of service, can we profit from that?

Joe Galassi stated:

> There are really two reasons to do ARES. The first is better service. The second is that we will be better able to control assets by scheduling locomotives and cars more precisely and getting better productivity out of the assets. However, the real heart of the matter is service to the customer.

Mark Cane, vice president, Service Design, concurred:

> ARES could bring higher reliability to the railroad. It could improve the mechanical quality of the railroad, through fewer engine breakdowns. It could improve reliability in terms of consistent arrival time through dispatching and schedule discipline. It could also increase the capacity of the physical plant by tightening the spacing between trains, thus allowing more trains to travel on the existing track. If ARES cost $50 million, we might have already begun it, but $350 million is a problem in light of competing demands for capital.

Jim Dagnon also found that ARES offered significant advantages from his perspective:

> The union leadership has toured the ARES prototype facilities. They loved it. The work force is as ready to adopt ARES as any work force I've ever seen. A significant aspect of ARES for all labor is safety; safety is extremely important and they see ARES as increasing safety. They see ARES as making their job easier and more important, especially the engineers. Conductors are a little less enthusiastic; it may reduce their job responsibilities. Ultimately, ARES has the potential to schedule the crews' work; this would lead to a higher quality of life compared with today's unscheduled, on-call environment in which crews don't know whether or when they will be called to work.

As BN's executives pondered whether or not to proceed with ARES, they still were not fully comfortable with whether the assessment of ARES benefits was realistic or optimistic. They also struggled with whether the benefits, or many of them, could be attained at a lower cost: Were technologies cheaper than the one prototyped with Rockwell available to support the ARES project? Could the benefits be unbundled? For example, the recent experience with the service measurement system suggested to some executives that improved discipline and reporting could enhance service without the large capital investment required by ARES. Yet, in contrast to JIT experiences which had taught manufacturing firms to fix their manufacturing processes before automating them, at BN, without automation—that is, ARES—managers lacked information on operations needed to fix the process. Could BN have the cake without the icing?

Before proceeding with a decision, BN's senior executives decided to conduct an outside audit of the ARES proposal. SRI International (formerly Stanford Research Institute) was engaged to audit the benefits analysis, to investigate the possibility of unbundling the benefits, and to study whether alternative, less expensive technologies were feasible.