AATC Desert Storm

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NEWS RELEASE

BART

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February 23, 1994

FOR IMMEDIATE RELEASE

Clinton Awards BART High-Tech Defense 'Conversion' Money

The White House today announced the award of $19.5 million in Defense Conversion funds to an alliance of BART, Hughes Aircraft and Morrison Knudsen Corp. to develop an Advanced Automatic Train Control System (AATC). The new system will nearly double the current number of passengers BART can carry during the congested morning and evening commutes and eliminate the need for a second, multi-billion transbay tube.

Current train control technology and design limits operating headways to one train every 3 3/4 minutes. The new AATC technology will allow BART to operate trains at two-minute frequencies. This added capacity means that BART will be able to carry approximately 60,000 additional passengers during the morning and evening commute periods – from the current rate of 16 trains per hour to 30 trains per hour.

The 21st Century AATC system would convert the U.S. military's radio frequency position locating defense technology that was successfully used by U.S. forces during the Persian Gulf conflict to track equipment and troops, to pinpoint a speeding BART train to within 15 feet of its location – including inside the TransBay Tube.

Reducing the intervals would let BART have more trains in the TransBay Tube at the same time, thus increasing the system's capacity. Increasing the capacity of the existing system would obviate the need for a second TransBay Tube.

The new AATC system would also allow BART trains to use electricity more efficiently, thus reducing electricity consumption on the all-electric system. Accurate positioning of trains would also allow the trains to maintain higher average speeds.

(more)

"This technology is BART's future," said BART Board President Margaret K. Pryor. "This removes the existing major impediment to increasing BART's passenger-carrying capacity. Not only will BART be able to serve more people of the Bay Area -- and serve them with better, faster transit -- but we'll also save money on expanding the system; reduce air pollution and energy consumption; help to create thousands of new, good-paying jobs, and make California the hub of high-tech transit technology."

BART, Hughes Aircraft and Morrison Knudsen have already formed an alliance to convert the technology from military to civilian use and to apply it to transit. In addition to the specific benefit to BART, significant national and international markets exist for this technology.

Hughes and MK were selected by BART through a competitive process to design and demonstrate this equipment. With the receipt of these funds, BART can now proceed with the award of a contract to begin implementation of this work.

BART will help design and implement the system. Orange County-based Hughes will modify the military equipment, generate the control software and oversee system design and testing. Morrison Knudsen, the only manufacturer of rail cars in the United States, will integrate the technology into train cars and control stations. Morrison Knudsen is building 80 BART cars at a newly opened facility in Pittsburg in East Contra Costa County.

Hughes and Morrison Knudsen have already formed and invested in a joint venture company to pursue the market and to make the investments that will be required to develop business.

"Naturally I'm delighted to see the White House and the Clinton Administration recognize BART's standing as a natural conduit for military conversions to commercial applications," said BART General Manager Frank J. Wilson. "It shows, once again, that BART is on the cutting edge of transit not just in the United States, but throughout the world. It also shows the worth of BART's investment in R&D. BART was one of the first transit systems in the United States to set up its own in-house research and development department. And this investment has now paid off handsomely by attracting significant amounts of federal grants to leverage BART's relatively small investment."

(more)

BART, Hughes and Morrison Knudsen will match the federal grant in cash and in-kind contributions. The grant announced today covers the first two phases of the work. Phase I entails design and testing at BART's test track in Hayward. Phase II expands the program to include revenue-service testing on a portion of BART's main line system. Phase III, which would require another $32 million federal grant, entails revenue-system installation.

"The federal government's money will be recouped handsomely through sales to other transit systems in the United States and around the world," Wilson said. "BART will recoup its investment many times over through increased patronage and elimination of the need for a second, multi-billion TransBay Tube."

The funds are part of the President Clinton's "Technology Reinvestment Project," which is a cornerstone of his Defense Reinvestment Conversion Initiative. They are intended to link the best of America's defense and commercial industries in creating new "dual-use" technologies with both commercial and military applications, prepare defense engineers and workers for the manufacturing industries of the future, and help small defense firms make the transition to commercial markets.

The joint application by BART, Hughes, and Morrison Knudsen got a big boost from Rep. Ron Dellums, D-Berkeley, who chairs the House Armed Services Committee.

"Without his help, I don't know if BART would have been recognized," Pryor said. "He has taken the lead in Congress in helping convert military spending and technology to jobs- and wealth-producing civilian commercial uses."

The request also got help from Rep. Anna Eshoo, D-Atherton, a member of the House Subcommittee on Science and Technology, and from Senators Diane Feinstein and Barbara Boxer. All four have worked tirelessly in Washington to resurrect California's economy, devoting special attention to the relationship between high-tech transit, the environment, energy conservation and the conversion of military technology.

There currently are no U.S. suppliers of radio frequency-based advanced automatic train control signaling equipment for the transit industry. Converting the new technology from military to commercial transit use would put the United States — and particularly

California — on the cutting edge of 21st Century train control technology.

Analysts estimate a more than $1 billion market for the technology — ***in the United States alone.*** Within the next decade, the cities of New York, Philadelphia, Washington, D.C., Baltimore, Boston and Atlanta plan major investments in upgrades and extensions to systems that could use the AATC equipment.

Capturing just 50 percent of the U.S. transit market would sustain a business base of between $150 million and $300 million per year — most of it in California. In addition, modules developed for the AATC would be structured for "dual use" — to meet both civilian and military requirements. The business base would create and support thousands of good-paying, high-tech jobs in the state, from Silicon Valley to the hard-hit former defense industry center of Southern California.

Worldwide, the market is even greater as emerging industrial and electronics-driven nations build urban and rail systems to serve their growing industries. Both Japan and the industrialized nations of Europe are already working on advanced train detection and fixed-rail guidance systems akin to AATC.

Modeled after the successful Global Positioning Satellite defense technology, AATC entails placing radio transmitters and receivers alongside BART tracks and in the lead and tail cars of BART trains. Radios at the control stations communicate with the trains via radios installed at 1/3-mile to 1-mile intervals along the track.

Messages are sent and received between the vehicle and the trackside radios every 1/2 second, with each trackside radio calculating the time it takes for the signal to get from a vehicle radio to itself. The time is then directly converted to a distance between the trackside radio and the train and train reports are sent to the control stations where speed commands are selected and relayed back to the train. The position of a train traveling at 80 mph can then be pinpointed to within 15 feet.

Additionally, the new AATC will overlay BART's existing Automatic Train Control system, leaving the existing system to support precise monitoring and direct performance comparisons, and to act as a backup to ensure a safe, graceful transition to the 21st Century technology.

In making the announcement from the White House, President Clinton, joined by Secretary of Defense William Perry, said, "This marks another major step in our effort to protect our national security and promote our economic security in the post-Cold War world. We are investing in projects that will create the jobs of the future by exploring ideas, developing technologies, creating products and strengthening skills that will keep America strong, militarily and economically."

The BART/Hughes/Morrison Knudsen grant was one of only 212 technology conversion grants approved by the White House — ***out of nearly 3,000 applicants from across the country.***

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BART gets defense grant

$19.5 million to adapt military technology to double trains under bay

BY LEE GOMES
Mercury News Staff Writer

A series of Defense Department research grants announced Wednesday will spread $76 million among California-based organizations, including one that will help BART send twice as many trains under the San Francisco Bay as it does currently.

The Pentagon's Advanced Research Projects Agency gave a $19.5 million "Technology Reinvestment Project" grant to the Bay Area Rapid Transit District, Morrison Knudson Corp. and General Motors Corp.'s Hughes Aircraft Co. to use radio technology first developed for the military to pinpoint the location of a BART train to within 15 feet.

Using that information, BART said, its dispatchers will be able to safely send trains under the bay every two minutes, rather than at their current 3.45 minute intervals. Such a speed-up would eliminate the need for a second BART tunnel, the agency said.

The Pentagon's research funds were the last phase of a $600 million program intended, among other uses, to help defense companies commercialize some of the technology they had originally developed for military purposes. The program attracted 2,800 requests, of which only 212 were funded.

The administration has been mindful of California's economic situation in making the awards, and four of every 10 dollars from Wednesday's list went to state-based consortia, a general ratio that was also true in prior announcements.

The other California awards Wednesday included:

- $42 million to Lear Astronics Corp. of Santa Monica for an aircraft landing system that will improve visibility during bad weather.
- $18.4 million for Raytheon Co. in Goleta to research the use of "multichannel digital signal processors" as a way of expanding the capacity of radio frequencies.
- $15.8 million for Bell Atlantic Corp.'s Healthcare Systems operation in Greenbrae for research into ways medical data can be shared among hospitals or clinics.
- $12.2 million to Hughes Aircraft in Los Angeles for work on an automobile collision-prevention system.

One of the biggest awards went to International Business Machines Corp. — a $70.7 million grant to develop industrial software standards to promote the easy exchange of manufacturing design information.

SAN FRANCISCO CHRONICLE THURSDAY FEBRUARY 24, 1994

High technology could double number of trains at commute hour

By Jamie Beckett
Chronicle Staff Writer

Under a new federal grant awarded yesterday, the same technology that guided troop movements in the Persian Gulf war could someday allow BART to double its peak-hour capacity and carry thousands more riders daily.

An engineering team headed by BART will receive nearly $20 million to develop an automated control system that can pinpoint the location of each train and enable them to run closer together safely.

The BART project was one of 50 receiving a share of $190 million in federal money under a program that invests in military technologies with civilian applications.

The program focuses on areas like California where thousands of defense jobs have been lost since the end of the Cold War. Nearly half of yesterday's grants will go to California.

"Those who worked so hard to win the Cold War should not be unduly burdened by cutbacks in military expenditures," President Clinton said at a White House ceremony, which included Assembly Speaker Willie Brown, Senate President Pro Tem Bill Lockyer and other members of the California Legislature.

The BART control device is based on a digital battle communications system developed by Hughes Aircraft Co. and used by the Army to direct and track troops in the deserts of Kuwait and Iraq. The system, which uses radio waves, could allow BART computers to pinpoint trains to within 15 feet of their actual locations.

BART and most other transit operators currently rely on decades-old wire-based communications similar to a telephone. Because that technology is not exact, BART can now only spot a train within 1,000 feet of its actual position.

The new controls could reduce the intervals between trains from the current 3 minutes and 30 seconds to 80 seconds.

"This is the first major advance in controlling trains in decades," said Dan Reeder a spokesman for Hughes Aircraft, which is part of the BART team.

Hughes will modify the Army communications system for civilian use. Morrison Knudsen Corp., which builds train cars, will modify BART cars to accommodate the new system. The alliance will match the federal money with $19.5 million of its own funds. The new system is expected to cost about $60 million.

During the commute rush, BART operates 16 transbay trains an hour, and the only way currently to increase capacity would be to build a second Transbay Tube — at an estimated cost of $4 billion.

The new technology could expand that transbay capacity to 30 trains an hour, which translates into 60,000 additional passengers during the morning and evening commute hours, said Dorothy Dugger, executive manager of external affairs for BART. An average of 250,000 people now ride BART daily.

Transit operators in several other big cities, including New York, have already inquired about the new system, she said.

"This technology is BART's future," said BART board president Margaret Pryor.

Since the federal program began, the White House has allocated $662 million, with about 40 percent of the money going to California. In all, the government received 2,850 proposals requesting $8.5 billion.

Clinton singled out the BART project yesterday as an example of how military technology can be adopted for civilian use.

"California has been on the leading edge of military technology," Clinton said. "And converting this know-how for dual use in commercial applications will help our country move into the next century as the economic leader of the world."

Other Bay Area winners of the technology grants:

- ArrayComm Inc. in Santa Clara will receive $11.4 million to develop a prototype transmitter.
- The Electronic Power Research Institute in Palo Alto will receive $7.6 million to develop a more efficient electronic power converter.
- Loral Western Development Labs in San Jose will receive $2.8 million to develop a system for rapid transcription of hospital radiology reports.

Chronicle staff writer Marc Sandalow contributed to this report.

$20 Million Grant for New BART Control System

U.S. to fund transfer to BART of rail car tracking technology

By Meredith K. Wadman
WASHINGTON BUREAU

WASHINGTON — As California lawmakers downplayed the impact of a slash in federal money for base closures, President Clinton on Wednesday announced funding for a new Bay Area project he held up as a national model for converting military technology to peacetime use.

Approving California leaders — including a visiting delegation led by Assembly speaker Willie Brown — looked on at the White House while Clinton announced that the Pentagon will pay half the cost of a $39 million program that will develop a system to monitor BART rail cars based on Desert Storm tank-tracking technology.

The expected result, according to the president: Trains will be able to run closer together, almost doubling BART's capacity.

A BART spokesman said that once money has been found to install the system, the project would also eliminate the need for a second, multi-billion dollar, transbay tube.

The announcement came as Californians in Congress disputed the worries of a highly-placed administration official who last Thursday admitted that a $637 million, 57 percent slash in 1994 base closure funding could do long-term damage to the Bay Area.

Sen. Dianne Feinstein, who sits on the Senate Appropriations Committee, acknowledged that the base funding cut was "a little bit of a Pearl Harbor because some of us were not aware of it."

But she said Rep. Vic Fazio, D-Sacramento, who authored the amendment that contained the funding cut, had assured her that he "does not believe there will be any absence of money." What's more, Feinstein said, if there is, "between us we will see that any base left uncovered is in fact covered."

Fazio, for his part, lashed out at the administration official who last week called the cut potentially problematic. "There's no mistake, no need to go back and replace the money. It will all occur on schedule," Fazio said, adding that $2 billion currently in the base closing account will not even be entirely spent in 1994.

"The allegation by some unnamed official that we somehow have gutted that account was really a bureaucratic response of somebody who doesn't want to have to come back to Congress and ask for additional appropriations in the future," Fazio said. "Ultimately we'll have all the money he needs. We will have no problem appropriating it."

Wednesday's announcement of the grant for BART was the second-largest of 50 Clinton heralded as part of an administration program to convert military technology to civilian uses.

Clinton called the winning projects under the Technology Reinvestment Project "exciting, futuristic, far-sighted."

The winners agreed.

Military conversion grant for project, Clinton says technology for BART

THE OAKLAND TRIBUNE THURSDAY FEBRUARY 24, 1994

By Meredith K. Wadman
WASHINGTON BUREAU

IN THE NAVY'S WAKE
CONVERTING THE BASES

WASHINGTON — As California lawmakers downplayed the impact of a slash in federal money for base closures, President Clinton on Wednesday announced funding for a new Bay Area project he held up as a national model for converting military technology to peacetime use.

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The winners agreed.

"These days, this is equivalent to a new start," said Dan Reeder, a spokesman for Los Angeles-based Hughes Aircraft Co., which developed the tank-tracking technology and which will be a partner with BART and Morrison Knudsen Corp. (the maker of BART's cars) in the program.

"It's great," said Ron Rodriguez, a BART spokesman. "We're taking a highly sophisticated, track-proven technology and applying it to civilian commercial uses. This stuff works. Ask Saddam Hussein if it works."

The 29-month program will convert — but not install — the Hughes technology that allowed military commanders to track on screens the movements of humvees, helicopters, tanks and soldiers during Desert Storm.

Currently, wire technology is used to track BART rail cars. Replacing it with Hughes' radio and circuit integrated technology would enable BART to run trains 80 seconds apart, instead of the 3 minutes currently, through the crowded transbay tube.

In all, Clinton announced $190 million in grants — $86 million (45 percent) of which will go to projects led by California companies.

The companies fund about half of the costs of the projects, the federal government the other half. In the case of the BART project, the federal government will contribute about $19.5 million.

"This is a much needed boost for our state, and it could not have come at a better time," said Sen. Barbara Boxer, who attended the White House announcement.

$500 million in guarantees in aid package that includes BART system update

By Stewart M. Powell and David Eisenstadt
EXAMINER WASHINGTON BUREAU

WASHINGTON — BART and several Bay Area companies will receive more than $60 million in federal grants as part of a high-tech investment package announced by President Clinton.

At an elaborate White House ceremony Wednesday afternoon, Clinton also offered California $500 million in new loan guarantees to help state and local governments qualify for their share of the $10 billion in federal earthquake assistance.

California received 37 percent, or $222.4 million, of the $605 million for public-private projects that Clinton has authorized for conversion of military technology to domestic use. Matching private spending will roughly double the size of the spending.

The Technology Reinvestment Project grants will provide some relief for the state's hard-hit defense firms, said Anita Jones, director of defense research at the Pentagon.

"California workers can be heartened by this," Jones said. "We expect to see jobs come out of this."

In the Bay Area, BART in Oakland, ArrayComm in Santa Clara, the Electric Power Research Institute in Palo Alto and Loral Western Development Labs in San Jose were all slated to be beneficiaries of the new federal funds.

BART was awarded approximately $20 million to work with

Federal funds headed for state

Morrison Knudsen and Hughes Aircraft on a $39 million project, using technology developed in the Persian Gulf war to augment its automated train control system.

"We're delighted with the selection of BART and its partners," BART spokeswoman Dorothy Dugger said. "This technology is BART's future. It will enable us to double our capacity in peak hours."

The new technology, called Advanced Automatic Train Control System, could nearly double the number of passengers BART carries during commute hours. It would also eliminate the need for a second train tube running beneath the Bay.

The AATC system would use U.S. military radio technology which was applied by forces during Operation Desert Storm to track equipment and troops.

BART said the technology could pinpoint trains, even in the trans-Bay Tube, allowing for more trains in the tube at the same time.

BART estimates it will be able to carry about 60,000 more passengers during morning and evening commute hours and increase the number of trains running each hour from 16 to 30.

"This has the effect of building another trans-Bay tube for a fraction of the cost," said Dugger.

ArrayComm will use its $11.4 million grant to use technology derived from the Strategic Defense Initiative to create a commercial transmitter for wireless communications.

Electric Power Research Institute is expected to benefit from a $7.6 million grant to find cheaper ways to produce electricity in large amounts.

Other Bay Area companies selected included Greenbrae's Bell Atlantic Healthcare Systems Inc., slated to join in a $15.8 million medical information system, and Mountain View's Sun Microsystems Corp. and Spectrian Inc. They are expected to take part in an $18.4 million project to develop new digital electronics.

More work to be done

H. Lee Buchanan, director of the high-tech grants program at the Pentagon, cautioned that more work remained to be done before federal money began flowing to California.

"When you try to decide who is going to run this part or that part of a program, that's when the partnerships begin coming unglued," Buchanan said. "This is very much a work in progress."

Flanked by members of the cabinet, Congress and the California Legislature, Clinton also outlined how the new $500 million in loan guarantees would help state and local governments finance their 10 percent share of disaster relief over a 20-year period.

The loan guarantees will allow local jurisdictions to borrow money from banks at below-market interest rates. The guarantees were included in an emergency spending measure approved by Congress and signed by Clinton 11 days ago.

State officials had sought 100 percent federal funding of disaster relief, but Assembly Speaker Willie Brown said the $500 million in federal loan guarantees was $166 million more than requested by the state.

"At this stage of the game I think the federal government has met the level that the state government has indicated was the need," Brown said outside the White House. "Now as we unfold, clearly we will be back here asking for additional assistance if we think we merit it."

Zachary Coile of The Examiner staff and the States News Service contributed to this report.

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COMMENTS:

The Oakland Tribune
FRIEND OF THE PEOPLE IT SERVES
FRIDAY
FEBRUARY 10, 1995

GOP may ax BART project

By Meredith K. Wadman
WASHINGTON BUREAU

WASHINGTON — President Clinton summoned California lawmakers to the White House one year ago to watch him proudly unveil awards that are the centerpiece of his defense conversion program.

Key among them was a $19.5 million grant to help BART develop Army battlefield technology to track its trains, with the goal of doubling its capacity by 1998.

Clinton called the BART project "exciting, futuristic, farsighted" — a prime example of the virtues of converting military technologies to civilian uses.

But now the BART program is in deep trouble in the House, where Republicans on the Appropriations Committee are poised to kill the source of its funding: the 2-year-old Technology Reinvestment Project.

The TRP is a Pentagon fund that grants firms money, which they must match, to develop "dual-use technologies" — technologies with both military and civilian applica-

Please see BART, A-6

BART: Large federal grant hangs in balance

Continued from A-1

tions. The program has been a boon to California, which landed 28 percent of the grants in 1994, worth more than $100 million. The BART grant was the third-largest in the nation.

But the TRP has also become a key target of the Republican majority in the House, whose lawmakers argue that defense money should go to buy bombs and bullets, not a more efficient BART.

"TRP has become an administration slush fund for a New Age claptrap," said Rep. Robert Livingston, R-La., the Appropriations Committee chairman.

Today, his committee is all but certain to kill the TRP outright, slashing all $502 million of its 1995 funding as part of an effort to produce $3.2 billion extra for the Pentagon to spend in other areas in 1995.

That won't affect BART's $19.5 million, because it was landed in 1994. But the transit agency said Thursday that without an infusion of $32 million more in TRP money in 1996, it won't be able to move from development to application of the project.

"It would be very disappointing and, I think, a real shame if the program is killed," said Mike Healy, a BART spokesman. "Because it's really the first time they've been able to use the technology for defense conversion for a practical application to such things as ground transportation."

"Without funds, we can't do anything. We wouldn't be able to implement it," added Jean Nishinaga, the project manager. "The stakes are: fewer trains through the (Transbay) tube, more crowded trains, and higher congestion on the Bay Bridge."

BART is working on the project jointly with Hughes Aircraft and Morrison Knudsen Corp., which makes BART's cars.

The $19.5 million grant, which BART and its partners have matched, has been used to adapt Army communications radios that tracked the whereabouts of tanks and infantry in Desert Storm.

By being able to track cars' whereabouts to within 15 feet, BART should be able to run trains much closer together, increasing its capacity without needing to build more tracks.

Currently, the technology is being developed on a test track near Hayward.

In November, trials will move to operating cars between Lake Merritt Station and Fruitvale. But there the money ends.

If money can be found elsewhere, BART will in 1996 begin equipping cars to run through the Transbay tube and from West Oakland to Bayfair Station. Its goal: 30 trains per hour through the tube, instead of the current 16.

Those kinds of results are laudatory, according to the administration. Along with companies that are TRP beneficiaries, it has been fighting a losing battle to have the program spared.

"There has been some misunderstanding about the program, some thought that this is some kind of a relief program for industry. It is not. It is a program which funds very high priority, very high quality technology of value to defense," Defense Secretary William Perry said this week.

But even local Republicans remain unmoved.

"The issue is not whether BART should have access to technology enabling its trains to run more efficiently," added Rep. Bill Baker, R-Danville, a member of the surface transportation subcommittee of the House Transportation and Infrastructure Committee.

"The main feature of this debate is whether this project should be funded in the defense budget."

Others charge that the TRP has been used as a political goody for Democratic strongholds.

Program to Develop Joint Civilian-Defense Technologies May Die

By Bradley Graham and John Mintz
Washington Post Staff Writers

It was to have been the model program for maintaining the U.S. military's technological edge.

Instead of pursuing research and development separate from the rest of society, the Pentagon would enter into partnerships with private firms and universities around the country, putting up only part of the money to develop technologies that would have applications in both the military and commercial worlds.

But the program, called the Technology Reinvestment Project (TRP) and much heralded by the Clinton administration when launched two years ago, is now in danger of being eliminated by a Republican-led Congress critical of projects on which defense funds were spent.

A House Appropriations subcommittee has rescinded all of the $425 million budgeted for TRP in 1995, plus another $77 million not yet obligated from 1994. The full Appropriations Committee is due to affirm the rescission when it meets Friday.

Still hoping to salvage some part of the program, the White House plans to issue a report today outlining what it calls a new vision for developing militarily useful technologies and defending TRP as essential for breaking down barriers between the defense and commercial sectors.

"As a nation, we can no longer afford to maintain two distinct industrial bases," says the report, issued jointly by the National Security Council and National Economic Council. "We must move toward a single, cutting-edge national technology and industrial base that will serve military as well as commercial needs."

At issue is what expanded role the Pentagon should play in promoting industrial innovation. Administration officials contend the Pentagon has little choice but to team up with industry, because that is where much of the innovation is nowadays and because such teamwork can produce cost savings for the military. Republican critics say that with defense dollars as scarce as they are, the Pentagon cannot afford to divert resources from more traditional, military-oriented programs to pay for projects whose direct defense benefits may be difficult to measure immediately.

TRP was supposed to institutionalize a new approach to developing technologies of use to military and civilian sectors by mandating cost-sharing between the government and private entities. But the program, which began with legislation that had strong bipartisan support, faltered over perceptions the Clinton administration politicized it and selected projects that have had little defense utility. Now it has become a lightning rod for House GOP efforts to squeeze "non-defense" funds from the Pentagon budget.

"TRP has become an administration slush fund for a new age claptrap," said Rep. Bob Livingston (R-La.), chairman of the Appropriations Committee. "It's just not a top readiness concern, so it's expendable."

On the surface, at least, some TRP projects have been easy to ridicule. A few titles: "Holistic approach for preparing students to learn and lead in a new manufacturing paradigm" ($2.7 million for Arizona State University); "The realization coalition" ($8.6 million shared with engineering programs at five universities); "Diversity and cultural change—manufacturing" ($3.3 million for the University of Wisconsin).

Here are other TRP favorites Republicans like to hold up as examples of projects that would seem to have questionable links to national defense interests: $39 million to use an Army tracking system to help locate rapid transit trains in the San Francisco Bay area; $10.5 million to fund a team at the University of California's San Diego campus to explore new techniques for developing lightweight composite structures and applying them to build bridges; and $17.7 million for a coalition of firms to develop computer-aided earth-moving equipment.

Administration officials say each of these and every other TRP program has a clear military relevance, and each project was selected on its merit.

"There are significant misconceptions about what TRP is about," complained Gary Denman, who manages TRP as director of the Pentagon's Advanced Research Projects Agency.

One of the biggest misconceptions, he said, is that TRP is a defense conversion program.

"It is not about defense conversion," he said. "This program is about how we in the military are going to leverage the commercial base in this country. TRP has gotten this subject on the table as a key strategy for future defense capabilities. If this program dies, our military capabilities will be less and more expensive.

"The military must have access to commercial technologies because the whole world will," Denman went on. "If we don't apply them first, you can draw your own conclusions about what will happen."

TRP promotes both the "spin-off" and "spin-on" of defense technology. Spin-off means applying defense technologies to the commercial sector, the notion being that if a defense technology can find wider application, the cost to the Defense Department will be brought down. That is the idea, administration officials say, behind the train-locating, bridge-building and earthmoving equipment projects cited by GOP critics.

Spin-on refers to efforts to accelerate development of emerging commercial technologies, such as flat panel displays and high-density data storage, that are critical to the military.

Even some who accept the logic behind TRP's "dual-use" development strategy are skeptical that it will work: They question whether the Pentagon can stimulate or accelerate commercial applications of technology or whether it is better left to the market alone.

Administration officials say they would welcome the opportunity to debate these points on Capitol Hill, but complain there have been no hearings, just a House GOP rush to kill TRP in the first 100 days of the new Congress. The worry is that the death of TRP—the administration's largest and most visible dual-use program—will foreshadow decline of similar programs. "If the flagship is sunk, the rest of the fleet may follow," said Sen. Jeff Bingaman (D-N.M.), ranking minority member on the Armed Services subcommittee that oversees TRP.

A number of larger firms that have participated in TRP are rallying to its defense. A coalition of firms and trade associations, including DuPont, IBM, 3M, Westinghouse and Teledyne, has written a letter to House members extolling the program's potential.

"It's a double win for little money," said Mike Bowman, a vice president for DuPont, a firm that traditionally shuns federal research but is a member of a venture that is to receive $150 million in TRP funds over four years to develop jet engines made of longer-lasting, lightweight composite materials. "The government is a catalyst for partnerships that never would have happened."

BUDGET & PROJECT MANAGEMENT
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DATE: Februray 9, 1995

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FROM: Eugene Nishinaga

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NUMBER OF PAGES: 2 (including cover sheet)
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Niki Uchida at 510/287-4742

REMARKS:
Attached is a description of the benefits to the defense of the AATC project.

I am unable to get information from the FTA or ARPA regarding the status of the AATC grant. My contact in the FTA, Venkat Pindiprolu, tells me that our $19.5 million is fully obligated, probably from the FY94 budget but maybe even from the FY93 budget, and therefore is probably not in jeopardy. However, he said the only persons who would know for sure would be Dr. Gary Denman or Dr. H. Lee Buchanan in ARPA. Perhaps the best thing would be to have Congresswoman Pelosi contact them directly.

According to the article, the recission that is being considered by the Appropriation Committee tomorrow is only for the $425 million in the FY 95 program and the $77 million of unobligated FY 94 money. This would mean that our $19.5 million is not in danger because it is already obligated. Given this, it might be best for Congresswoman Pelosi to lay low rather than to draw attention to the project at this time.

If we are planning to take some action, one of the misconceptions that we should clarify is the notion that our project simply allows BART to "locate rapid transit trains." Our project is not to simply locate trains but to develop a control system that will result in a significant increase in the capacity of the system. This will allow BART to provide more service at a fraction of the cost of adding expensive trackage.

AATC
BENEFITS TO DEFENSE

35 TO 50% Reduction in Cost of the Enhanced Position Location Reporting System (EPLRS) Hardware

The AATC project will reduce the cost of the EPLRS hardware for defense applications. This will result from:

1. Targetted cost reduction design efforts
2. Introduction of Commercial Off the Shelf components
3. Application of commercial manufacturing processes
4. Economy of scale resulting from increased customer base

Enhancement of the Basic EPLRS Capability

The AATC will enhance the basic capabilities of the EPLRS system by developing hardware and software applicable to both defense and commercial applicatoins. Specific enhancement include:

1. A new processor board which replaces the original 8 bit processor with a more powerful 32 bit processor
2. The ability to use higher level programming languages which will greatly reduce software development time
3. Improvements in the communciation network management capability

Preservation of the Technical and Manufacturing Base

The AATC will preserve the technology base in this country for military purposes by maintaining high paid technical/manufacturing jobs that will otherwise be eliminated through defense cuts

Bay Area Rapid Transit District
Research and Development Division
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DATE: January 24, 1995

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NUMBER OF PAGES: 5 (including cover sheet)
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REMARKS:

Per our discussion yesterday, I am attaching some materials describing our involvement with Sandia National Lab. As described in the attached EDD, we are planning to sign a Cooperative Research and Development Agreement (CRADA) with Sandia National Lab in early February which will kick off our formal relationship with Sandia in technology development areas. Prior to this, however, BART and Sandia have already been working together in an informal manner to examine several technology related problems. The second attachment describes some of the things that have been pursued. As you can see there are some exciting possibilities that I think may be of interest to others.

I am going to try to get Dick White to visit Sandia, possibly at the time of the signing of the CRADA. This might be a good time to publicize our activities with Sandia.

Gene

AATC Safety Assessment -- Because AATC is a revolutionary method of train control, it presents some different safety considerations than the traditional train control systems. Sandia will provide an independent safety assessment of AATC, in support of BART's safety analysis activities. This involvement provides the benefits of a perspective and safety methodology which has evolved from Sandia's extensive experience in studying the safety of high consequence systems such as nuclear weapons and their delivery systems, and nuclear reactors.

Station Cars -- Sandia has assisted in BART's electric vehicle Station Car project by developing a method for calculating the economics of station car operations. There is considerable uncertainty about the various cost elements, and the analysis is useful to indicate which cost elements are most critical and which are negligible.

Graffiti-Etched Glass -- In a more traditional transfer of technology, Sandia is investigating whether their "Sol-gel" liquid glass technology might be able to help BART solve our problem with graffiti-etched glass.

Security -- Sandia has the lead role within the Department of Energy for security (which includes the security of nuclear weapons). Part of this responsibility includes the need to continually evaluate the state-of-the-art in security technologies. Sandia's Director of the Center for Security Systems has had several conversations with BART. Topics have included:

bullet-proofing of temporary police stations,
passenger station design to reduce opportunities for adversaries,
and ticket security technologies.

Evaluation and Test Planning -- One of Sandia's strengths is their expertise in the processes of evaluating, testing, and developing new technologies or new applications for technologies. They are helping us define what tests and demonstrations should be performed to transition a new technology from a concept to the point where we are confident of its maturity and qualifications for revenue service.

Traction Power Program -- One of our major objectives is to reduce BART's traction power costs -- both capital and operating costs. We have commenced an integrated program which includes:
simulation of our traction power and train control systems,
technology to improve our substations and our power transmission,
methods to reduce power and energy requirements,
quantification of our regenerative braking,
and evaluation of energy storage technologies.

Computer Simulation of Traction Power -- Sandia has developed a simulation of BART's electrical system and we intend to merge that model with our train control model. It will be our primary means of evaluating the effects of changes on our traction power needs.

Energy Storage -- Sandia has done considerable work on evaluating the potential benefits of energy storage, including supporting our study of Superconducting Magnetic Energy Storage. The results so far indicate that there are more cost-effective ways to eliminate voltage sag and it is difficult to justify the economics of energy storage systems, except for possibly a few select locations.

Reliability and Maintenance -- In addition to our work on Traction Power, we are working on ways to improve BART's reliability and maintenance. Sandia excels at data acquisition, processing, and analysis, and they have done substantial work on applications of artificial intelligence and pattern recognition. We are looking at ways to apply those skills to improve BART's ability to diagnose faults in equipment. An initial goal is to reduce the number of repeater incidents. A longer term goal is to predict faults before they occur.

Axle Defect Study -- Sandia completed a study of our axle defects. Preliminary reports (which were subsequently found to be misleading) showed an alarming increase in the percentage of inspected axles with defects. Sandia performed detailed fatigue calculations, reviewed the results of metallographic inspections of the axles, and recalculated the axle defect statistics. In a parallel effort, Sandia identified a method for inspecting the axles without de-trucking the car should study indicate the need for periodic inspection. The results of Sandia's study showed no indication that BART has any problem with axle fatigue. No fatigue cracks have ever been seen on BART's axles, the defects (which are invariably found to be manufacturing defects and inclusions) are not increasing in size or number, and the axles are well beyond the service life at which a fatigue problem would have become obvious.

Advanced Automatic Train Control -- AATC is BART R&D's largest single project. In addition to allowing trains to operate at closer headways than in presently possible, AATC has the potential to provide many other benefits such as reducing the instantaneous power load on any given substation. Development of such capability may significantly reduce future capital costs to upgrade BART's traction power system. Sandia and BART are in the process of defining what an appropriate role would be for Sandia in developing these capabilities.

January 24, 1995

Summary of BART/Sandia Activities

Bill Rorke, a Senior Member of the Technical Staff of Sandia National Laboratories has been on assignment to BART since the beginning of calendar year 1994. He splits his time between an office located in BART's Research and Development offices and his office at Sandia where he coordinates the efforts of the many other Sandians who can help us structure the important technical questions and identify promising avenues of solution. Sandia has sponsored these activities without receiving any funding from BART.

This relationship evolved from comments Frank Wilson made when he spoke at Sandia's Upper Management Seminar in August 1993. Regarding technology transfer from the national laboratories to interested business sectors, he stated that he and his staff didn't know what capabilities exist in the various laboratories and the people in those laboratories don't understand transit problems from an operator's perspective. John Crawford, Vice President of Sandia's California site, subsequently authorized the personnel exchange with BART to close that gap. John's interest is to capitalize on Sandia's California location by partnering with local industry stakeholders in the development of program and results that have national impact.

The relationship between BART and Sandia is in the process of being formalized with a Cooperative Research and Development Agreement (CRADA). The CRADA describes the nature of the work being done, emphasizes the partnership between Sandia and BART in solving problems, and provides all the administrative, liability issues, and legal structure necessary including protection of intellectual property rights, etc. CRADAs can be dissolved at short notice on the request of either party.

Presently the CRADA is getting its final approvals at Sandia and the Department of Energy (who have jurisdiction over Sandia). After those approvals have been obtained, the CRADA will be sent to BART for approval.

The remainder of this memo describes some of the main activities that have been completed, are presently in progress, or are being considered for future work.

Noise Reduction -- The first project undertaken between BART and Sandia has been directed at reducing car noise. This project has been underway for a year and will be completed by October of 1995. So far Sandia has conducted several tests of our cars, both on the Test Track and in revenue service. They have produced a detailed acoustical mapping of our cars and characterized the noise from the primary sources. They have shown a simple way to reduce interior noise on noisy cars by more than 10 dB by isolating the motor reactors. Future activities will focus on reducing the noise from other sources, perhaps including active noise cancellation techniques.

BART

EXECUTIVE DECISION DOCUMENT

GENERAL MANAGER APPROVAL:	GENERAL MANAGER ACTION REQ'D: Sign CRADA
DATE:	BOARD INITIATED ITEM [ ]

SIGNING OF COOPERATIVE RESEARCH AND DEVELOPMENT AGREEMENT WITH SANDIA NATIONAL LABORATORY

PURPOSE:
To obtain the General Manager's approval and signature on a Cooperative Research and Development Agreement (CRADA) between the San Francisco Bay Area Rapid Transit District (BART) and the Sandia National Laboratory (Sandia).

DISCUSSION:
BART's Research and Development staff is actively pursuing the infusion of new technologies into transit to support the District's future operating requirements. As part of this activity, a CRADA has been developed with Sandia for the purpose of collaborating on projects that introduce advanced technology solutions to address technical problems of interest to mass transit at a national level. The purpose of this CRADA is to establish a cooperative relationship with Sandia. Work performed under the CRADA will draw upon the technology base developed in the national laboratories for other purposes and adapt applicable technologies to the transit environment. Sandia, under its operating contract to the Federal Department of Energy, has acquired a broad range of R&D expertise that may be applicable to the transit industry. This agreement is intended to facilitate the investigation of national mass transit problems through the combined talents of BART and Sandia.

BART and Sandia have identified several areas of potential collaboration and have selected one project to develop specific working relationships. This project will study noise reduction techniques for mass transit systems and will result in one or more demonstrations of technology solutions on BART property. The development of other collaborative opportunities will be based on experience gained in this project.

The CRADA has been approved as to form by the Office of the General Counsel.

FISCAL IMPACT:
BART's fiscal contribution to the project will be entirely in-kind. Engineering and other staff labor and use of BART vehicles and test track constitute BART's contribution. The total Sandia contribution for the noise reduction study will be $340,000.

ALTERNATIVE:
Not to sign the CRADA and to not pursue joint technology development with Sandia.

RECOMMENDATION:
On the basis of analysis by staff, it is recommended that the General Manager sign the Cooperative Research and Development Agreement with Sandia National Laboratory.

ROUT-ING NO.	PERSON	DUE DATE	INITIAL	DATE
1.	E. NISHINAGA			
2.	J. PURCELL			
3.	J. DUNN			
4.				
5.				
6.				
7.				
8.				
9.				
10.				

PROPOSAL AFFECTS (CHECK ALL THAT APPLY)

_ OPERATING BUDGET	_ OPERATIONS
_ CAPITAL BUDGET	_ MAINTENANCE
_ CAPITAL PROGRAMS	_ ENGINEERING
_ GOVERNMENT RELATIONS	_ PUBLIC INFO
_ LABOR RELATIONS	_ PROCUREMENT
_ AFFIRMATIVE ACTION	_ STAFFING
_ SAFETY	_ CONSULTANTS
_ LEGAL	_ OTHER

COORDINATION TO COMPLETE ACTION ("X" IF APPROVALS REQUIRED)

[X] AGM OPERATIONS	[ ] SAFETY AND INVESTIGATIONS	[X] GENERAL COUNSEL
[ ] AGM DEVELOPMENT	[ ] EXTERNAL AFFAIRS	[ ] CONTROLLER TREASURER
[ ] AGM ADMINISTRATION	[X] BUDGET & PROJECT MANAGEMENT	[ ] DISTRICT SECRETARY

PREPARED BY E. Nishinaga

INITIALS ______ DATE Jan. 23, 1995

FORM NO 1163 (Rev 1. 3-23-93)

94-021

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February 23, 1994

FOR IMMEDIATE RELEASE

Clinton Awards BART High-Tech Defense 'Conversion' Money

The White House today announced the award of $19.5 million in Defense Conversion funds to an alliance of BART, Hughes Aircraft and Morrison Knudsen Corp. to develop an Advanced Automatic Train Control System (AATC). The new system will nearly double the current number of passengers BART can carry during the congested morning and evening commutes and eliminate the need for a second, multi-billion transbay tube.

Current train control technology and design limits operating headways to one train every 3 3/4 minutes. The new AATC technology will allow BART to operate trains at two-minute frequencies. This added capacity means that BART will be able to carry approximately 60,000 additional passengers during the morning and evening commute periods — from the current rate of 16 trains per hour to 30 trains per hour.

The 21st Century AATC system would convert the U.S. military's radio frequency position locating defense technology that was successfully used by U.S. forces during the Persian Gulf conflict to track equipment and troops, to pinpoint a speeding BART train to within 15 feet of its location — including inside the TransBay Tube.

Reducing the intervals would let BART have more trains in the TransBay Tube at the same time, thus increasing the system's capacity. Increasing the capacity of the existing system would obviate the need for a second TransBay Tube.

The new AATC system would also allow BART trains to use electricity more efficiently, thus reducing electricity consumption on the all-electric system. Accurate positioning of trains would also allow the trains to maintain higher average speeds.

(more)

"This technology is BART's future," said BART Board President Margaret K. Pryor. "This removes the existing major impediment to increasing BART's passenger-carrying capacity. Not only will BART be able to serve more people of the Bay Area – and serve them with better, faster transit – but we'll also save money on expanding the system; reduce air pollution and energy consumption; help to create thousands of new, good-paying jobs, and make California the hub of high-tech transit technology."

BART, Hughes Aircraft and Morrison Knudsen have already formed an alliance to convert the technology from military to civilian use and to apply it to transit. In addition to the specific benefit to BART, significant national and international markets exist for this technology.

Hughes and MK were selected by BART through a competitive process to design and demonstrate this equipment. With the receipt of these funds, BART can now proceed with the award of a contract to begin implementation of this work.

BART will help design and implement the system. Orange County-based Hughes will modify the military equipment, generate the control software and oversee system design and testing. Morrison Knudsen, the only manufacturer of rail cars in the United States, will integrate the technology into train cars and control stations. Morrison Knudsen is building 80 BART cars at a newly opened facility in Pittsburg in East Contra Costa County.

Hughes and Morrison Knudsen have already formed and invested in a joint venture company to pursue the market and to make the investments that will be required to develop business.

"Naturally I'm delighted to see the White House and the Clinton Administration recognize BART's standing as a natural conduit for military conversions to commercial applications," said BART General Manager Frank J. Wilson. "It shows, once again, that BART is on the cutting edge of transit not just in the United States, but throughout the world. It also shows the worth of BART's investment in R&D. BART was one of the first transit systems in the United States to set up its own in-house research and development department. And this investment has now paid off handsomely by attracting significant amounts of federal grants to leverage BART's relatively small investment."

(more)

BART, Hughes and Morrison Knudsen will match the federal grant in cash and in-kind contributions. The grant announced today covers the first two phases of the work. Phase I entails design and testing at BART's test track in Hayward. Phase II expands the program to include revenue-service testing on a portion of BART's main line system. Phase III, which would require another $32 million federal grant, entails revenue-system installation.

"The federal government's money will be recouped handsomely through sales to other transit systems in the United States and around the world," Wilson said. "BART will recoup its investment many times over through increased patronage and elimination of the need for a second, multi-billion TransBay Tube."

The funds are part of the President Clinton's "Technology Reinvestment Project," which is a cornerstone of his Defense Reinvestment Conversion Initiative. They are intended to link the best of America's defense and commercial industries in creating new "dual-use" technologies with both commercial and military applications, prepare defense engineers and workers for the manufacturing industries of the future, and help small defense firms make the transition to commercial markets.

The joint application by BART, Hughes, and Morrison Knudsen got a big boost from Rep. Ron Dellums, D-Berkeley, who chairs the House Armed Services Committee.

"Without his help, I don't know if BART would have been recognized," Pryor said. "He has taken the lead in Congress in helping convert military spending and technology to jobs- and wealth-producing civilian commercial uses."

The request also got help from Rep. Anna Eshoo, D-Atherton, a member of the House Subcommittee on Science and Technology, and from Senators Diane Feinstein and Barbara Boxer. All four have worked tirelessly in Washington to resurrect California's economy, devoting special attention to the relationship between high-tech transit, the environment, energy conservation and the conversion of military technology.

There currently are no U.S. suppliers of radio frequency-based advanced automatic train control signaling equipment for the transit industry. Converting the new technology from military to commercial transit use would put the United States — and particularly

(more)

California – on the cutting edge of 21st Century train control technology.

Analysts estimate a more than $1 billion market for the technology – ***in the United States alone.*** Within the next decade, the cities of New York, Philadelphia, Washington, D.C., Baltimore, Boston and Atlanta plan major investments in upgrades and extensions to systems that could use the AATC equipment.

Capturing just 50 percent of the U.S. transit market would sustain a business base of between $150 million and $300 million per year – most of it in California. In addition, modules developed for the AATC would be structured for "dual use" – to meet both civilian and military requirements. The business base would create and support thousands of good-paying, high-tech jobs in the state, from Silicon Valley to the hard-hit former defense industry center of Southern California.

Worldwide, the market is even greater as emerging industrial and electronics-driven nations build urban and rail systems to serve their growing industries. Both Japan and the industrialized nations of Europe are already working on advanced train detection and fixed-rail guidance systems akin to AATC.

Modeled after the successful Global Positioning Satellite defense technology, AATC entails placing radio transmitters and receivers alongside BART tracks and in the lead and tail cars of BART trains. Radios at the control stations communicate with the trains via radios installed at 1/3-mile to 1-mile intervals along the track.

Messages are sent and received between the vehicle and the trackside radios every 1/2 second, with each trackside radio calculating the time it takes for the signal to get from a vehicle radio to itself. The time is then directly converted to a distance between the trackside radio and the train and train reports are sent to the control stations where speed commands are selected and relayed back to the train. The position of a train traveling at 80 mph can then be pinpointed to within 15 feet.

Additionally, the new AATC will overlay BART's existing Automatic Train Control system, leaving the existing system to support precise monitoring and direct performance comparisons, and to act as a backup to ensure a safe, graceful transition to the 21st Century technology.

In making the announcement from the White House, President Clinton, joined by Secretary of Defense William Perry, said, "This marks another major step in our effort to protect our national security and promote our economic security in the post-Cold War world. We are investing in projects that will create the jobs of the future by exploring ideas, developing technologies, creating products and strengthening skills that will keep America strong, militarily and economically."

The BART/Hughes/Morrison Knudsen grant was one of only 212 technology conversion grants approved by the White House – ***out of nearly 3,000 applicants from across the country.***

-- 30 --

BART PROPOSES USING DEFENSE TECHNOLOGY TO RUN TRAINS

By Frank J. Wilson, BART General Manager

BART has developed a unique partnership with Morrison Knudsen and the Hughes Aircraft Company (HMK) to develop the next generation of train control system, once again providing leadership in developing transportation technology. We have finally found a way to allow the BART system to double its capacity and save $10 billion dollars in construction costs. Utilizing Star Wars technology tested in Desert Storm, BART and HMK are seeking funds to develop an Advanced Automatic Train Control System (AATCS) using the U.S. Army's Enhanced Position Location Reporting System technology.

The Enhanced Position Location Reporting System allows U.S. Army troops and their commanders to know their exact locations at all times, with an accuracy of 15 feet. An earlier version of the system, called the Position Location Reporting System, was actually demonstrated by the U.S. Marines during Desert Storm excercises in the Middle East in 1991. The AATCS will provide BART's central operations with the exact locations of all trains, including those operating at high speeds.

Current train control technology provides accuracies of about 2,000 feet. Therefore trains are kept apart at great distances for an interval between trains of two and one-half minutes to maintain safe standards. The Advanced Automatic Train Control System will allow

BART to cut the intervals down to one minute with the same safety margins.

In addition to doubling capacity, the AATCS will provide several other improvements to BART's operations. It will permit BART to install the new equipment without any disruption of service. It will render 100 to 1,000 times increase in the reliability of the existing train control system. The AATCS would provide new capabilities to monitor and communicate train health. The system will allow for up to ten percent power savings through better train control.

The development of the AATCS technology can give U.S. business the ability to capture a major portion of the $150 to $300 million domestic train control market and it would create more than 2,000 new jobs. It will provide U.S. business with access to foreign markets with potential sales far exceeding that of the United States.

BART, in partnership with Hughes Aircraft and Morrison-Knudsen has applied for Federal Defense Conversion funds to help get a pilot program underway. Hughes Aircraft and Morrison-Knudson have formed a partnership called HMK to provide advanced technology train control products based on the EPLRS.

Morrison-Knudsen is a $2 billion corporation and a well recognized leader in the transit industry. They have developed and delivered microprocessor based, vehicle-borne control equipment (satellites??) which will be integrated into the train product line. Their facility in

Pittsburg, California has been building the next generation of BART cars and has an excellent understanding of BART's needs. They will ensure the assignment of AATCS program personnel who are knowledgeable with transit control systems.

Hughes Aircraft Company is a $12.3 billion company and is the largest private employer in California. They are a leader in the design, production and support of high technology electronic systems for military, commercial, and scientific use. Hughes will assign program personnel to the development of the AATCS who are familiar with EPLRS technology and equipment.

The application of the military technology to BART will be completed in increments to satisfy all the public safety issues involved. The program is structured to validate the system design principles and the train tracking capability prior to activation of the system. BART and HMK are committed to a multidisciplinary, concurrent approach to the development of the AATCS. This is critical to ensure that all technical requirements are met on schedule and that the resulting product is easily manufactured and installed.

BART, as the sponsoring agency will operate as the manager of the AATCS development project. We are a progressive transit agency with a proven track record as a leader in the transportation technology. Nearly 20 years ago we introduced the original Automated Train Control System (ATCS). As an active participant in the development of the next stage of train control systems, BART will provide critical speed-code-selection logic for the AATCS, guidance on compatibility with their existing ATCS system, necessary modifications to the vehicle ATC system and installation of AATCS equipment. Once again, BART proves that it has the organizational strength and resources to provide the transit industry with state of the art technology.

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NUMBER OF PAGES: 3 (including cover sheet)

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Niki Uchida at 510/287-4742

REMARKS:

re: AATC FACT SHEET, 2/23/94

AATC FACT SHEET
2/23/94

PROJECT DESCRIPTION:

The AATC project will develop a new advanced train control system that will enable BART to nearly double its current passenger-carrying capacity. The new system will adapt a military Enhanced Position Location Reporting System (EPLRS) developed by the Hughes Aircraft Company to be used in a battlefield environment.

PROJECT TEAM:

The project will be undertaken by a team composed of BART, Hughes Aircraft Company, and the Morrison Knudsen Corp.

Hughes and Morrison Knudsen have formed a independent entity called HMK to implement the project.

SYSTEM CAPABILITY:

Headway Reduction

	Design Headway	Operating Headway
Existing system	150 seconds	225 seconds (3 and 3/4 minutes)
AATC system	80 seconds	120 seconds (2 minutes)

Train Position Resolution

Existing system	From +/- 350 to 1000 feet
AATC system	+/- 15 feet

Train Command Update Rate

Existing system	Only as trains cross block boundaries
AATC system	Every 0.5 seconds

PROJECT PHASES, FEDERAL FUNDING AND DURATIONS:

Phase 1

12 month duration
Test track demonstration
$7.3 million

Phase 2

17 month duration
Limited revenue track test
$12.2 million

Phase 3 (Not included in current grant award)

12 months
A and M Line implementation and demonstration
$32 million

BENEFITS TO BART:

Improved Headways

Train headways would be reduced allowing more trains to be operated through the Transbay Tube.

Current system allows 16 trains per hour.

AATC would allow 30 trains per hour

Less energy consumption

Tighter tracking will support innovative braking profiles which will improve the energy efficiency of the system. Preliminary analysis indicate that an improvement of as much as 12% might be possible.

Shorter trip times

Tighter tracking will support control algorithms which will result in shorter trip times. Preliminary analysis indicates a 4% improvement.

Greater system reliability

The mean time between disruptive events due to control equipment failure will increase from once every few days to once every 3 years.

Easy upgradability

The technology will enable BART to upgrade system performance with no disruption of revenue operation during installation.

BACKGROUNDER

PROGRAM OBJECTIVES

The program objectives are to demonstrate the feasibility and benefits of applying exisitng military communications, command and control and association position location technologies to automatic train control. The program will focus on the spin-off transitioning of existing Enhanced Position Location reporting System equipment and technology to immediate use in the transit market place, thus establishing dual-use of military technology.

Application of advanded technology to areas such as train control, which have seen no innovation in over a decade, offers better use of the existing infrastructure. Advanced automatic train control development would be expensive and risky if supporting trechnologies had not already been developed.

With the Enhanced Posidtion Location Reporting System, the position of a given force element is ascertained when it rtransmits a mesage which is received by three separate force elements. The precise time (known by all system radios) is used to accurately measure the travel time from the transmitting radio to the receiving radio. With ~~Which~~ three such time of arrival measurements, the position of a transmitting unit can be precisely determined.

The paramount requirement is to continuously track locations of all trains. Train location is determined more accurately using position location reporting system-type technology in the advanced automated train control application since their paths are fixed relative to the infrastructure. In effect, train locations are one-dimensional rather than three-dimensional as on the battlefield. As a result, they can be determined within a few feet using trains and trackside units equipped with Enhanced Position Location Reporting System radios.

Most rail transit systems use fized block train control systems that incorporate large operational train spacings thereby precluding full utilization of the infrastructure. Moving block systems, such as the advanced automated train control system, permit reducitons of train spacing to improve capacity and safety margins. The advanced automated train control system goes one step further in offering flexibility and systemperformance unmatched by tother moving block approaches. Transit agencies are demanding customers: safety is paramount, cost control is critical, system performance must be relaible and equipment must be maintained over its life.

-END-

BACKGROUNDER

ENHANCED POSITION LOCATION REPORTING SYSTEM

The Enhanced Position Location Reporting System (EPLRS) is a computer-controlled, digital communications network used by U.S. Army troops and commanders on the battlefield. EPLRS compact user units can be carried on troops' backs, mounted in vehicles such as trucks or tanks, and installed in helicopters to provide direct user-to-user data communications, identification and position and navigation services to Army units in the air and on the ground.

Developed and built by Hughes Aircraft Company under contract to the U.S. Army Communications Electronics Command at Ft. Monmouth, N.J., EPLRS furnishes secure and jam-resistant data communications and introduces important new capabilities in the support of modern computerized, tactical command and control systems.

EPLRS communications support the five mission areas of the U.S. Army in the tactical battlefield: maneuver control, air defense, fire support, intelligence/electronic warfare and combat service support. EPLRS supplies links to command and control data systems established in each mission area.

The system is composed of hundreds of EPLRS user units and a net control station. The user units, or radios, are a little larger than a standard Army voice radio. The units are 14 inches by 10 inches by five inches and weigh about 20 pounds.

Hughes is currently under production for the EPLRS system to the U.S. Army. The system was field tested in early 1993 by the U.S. Army 24th Infantry Division, mechanized, during joint training exercises with the Kuwaiti Army.

-END-

9/93

$20 Million Grant for New BART Control System

SAN FRANCISCO CHRONICLE THURSDAY FEBRUARY 24, 1994

igh technology could double number of trains at commute hour

By Jamie Beckett
Chronicle Staff Writer

Under a new federal grant awarded yesterday, the same technology that guided troop movements in the Persian Gulf war could someday allow BART to double its peak-hour capacity and carry thousands more riders daily.

An engineering team headed by BART will receive nearly $20 million to develop an automated control system that can pinpoint the location of each train and enable them to run closer together safely.

The BART project was one of 50 receiving a share of $190 million in federal money under a program that invests in military technologies with civilian applications.

The program focuses on areas like California where thousands of defense jobs have been lost since the end of the Cold War. Nearly half of yesterday's grants will go to California.

"Those who worked so hard to win the Cold War should not be unduly burdened by cutbacks in military expenditures," President Clinton said at a White House ceremony, which included Assembly Speaker Willie Brown, Senate President Pro Tem Bill Lockyer and other members of the California Legislature.

The BART control device is based on a digital battle communications system developed by Hughes Aircraft Co. and used by the Army to direct and track troops in the deserts of Kuwait and Iraq. The system, which uses radio waves, could allow BART computers to pinpoint trains to within 15 feet of their actual locations.

BART and most other transit operators currently rely on decades-old wire-based communications similar to a telephone. Because that technology is not exact, BART can now only spot a train within 1,000 feet of its actual position.

The new controls could reduce the intervals between trains from the current 3 minutes and 30 seconds to 80 seconds.

"This is the first major advance in controlling trains in decades," said Dan Reeder a spokesman for Hughes Aircraft, which is part of the BART team.

Hughes will modify the Army communications system for civilian use. Morrison Knudsen Corp., which builds train cars, will modify BART cars to accommodate the new system. The alliance will match the federal money with $19.5 million of its own funds. The new system is expected to cost about $60 million.

During the commute rush, BART operates 16 transbay trains an hour, and the only way currently to increase capacity would be to build a second Transbay Tube — at an estimated cost of $4 billion.

The new technology could expand that transbay capacity to 30 trains an hour, which translates into 60,000 additional passengers during the morning and evening commute hours, said Dorothy Dugger, executive manager of external affairs for BART. An average of 250,000 people now ride BART daily.

Transit operators in several other big cities, including New York, have already inquired about the new system, she said.

"This technology is BART's future," said BART board president Margaret Pryor.

Since the federal program began, the White House has allocated $662 million, with about 40 percent of the money going to California. In all, the government received 2,850 proposals requesting $8.5 billion.

Clinton singled out the BART project yesterday as an example of how military technology can be adopted for civilian use.

"California has been on the leading edge of military technology," Clinton said. "And converting this know-how for dual use in commercial applications will help our country move into the next century as the economic leader of the world."

Other Bay Area winners of the technology grants:

- ArrayComm Inc. in Santa Clara will receive $11.4 million to develop a prototype transmitter.
- The Electronic Power Research Institute in Palo Alto will receive $7.6 million to develop a more efficient electronic power converter.
- Loral Western Development Labs in San Jose will receive $2.8 million to develop a system for rapid transcription of hospital radiology reports.

Chronicle staff writer Marc Sandalow contributed to this report.

F nd ng for BART tech nology

THE OAKLAND TRIBUNE THURSDAY FEBRUARY 24, 1994

Military conversion grant for project, Clinton says

By Meredith K. Wadman
WASHINGTON BUREAU

WASHINGTON — As California lawmakers downplayed the impact of a slash in federal money for base closures, President Clinton on Wednesday announced funding for a new Bay Area project he held up as a national model for converting military technology to peacetime use.

Approving California leaders — including a visiting delegation led by Assembly speaker Willie Brown —looked on at the White House while Clinton announced that the Pentagon will pay half the cost of a $39 million program that will develop a system to monitor BART rail cars based on Desert Storm tank-tracking technology.

The expected result, according to the president: Trains will be able to run closer together, almost doubling BART's capacity.

A BART spokesman said that once money has been found to install the system, the project would also eliminate the need for a second, multi-billion dollar, transbay tube.

The announcement came as Californians in Congress disputed the worries of a highly-placed administration official who last Thursday admitted that a $637 million, 57 percent slash in 1994 base closure funding could do long-term damage to the Bay Area.

Sen. Dianne Feinstein, who sits on the Senate Appropriations Committee, acknowledged that the base funding cut was "a little bit of a Pearl Harbor because some of us were not aware of it."

But she said Rep. Vic Fazio, D-Sacramento, who authored the amendment that contained the funding cut, had assured her that he "does not believe there will be any absence of money."

What's more, Feinstein said, if there is, "between us we will see that any base left uncovered is in fact covered."

Fazio, for his part, lashed out at the administration official who last week called the cut potentially "problematic."

"There's no mistake, no need to go back and replace the money. It will all occur, on schedule," Fazio said, adding that $2 billion currently in the base closing account will not even be entirely spent in 1994.

"The allegation by some unnamed official that we somehow have gutted that account was really a bureaucratic response of somebody who doesn't want to have to come back to Congress and ask for additional appropriations in the future," Fazio said. "Ultimately we'll have all the money he needs. We will have no problem appropriating it."

Wednesday's announcement of the grant for BART was the second-largest of 50 Clinton heralded as part of an administration program to convert military technology to civilian uses.

Clinton called the winning projects under the Technology Reinvestment Project "exciting, futuristic, far-sighted."

The winners agreed.

"These days, this is equivalent to a new start," said Dan Reeder, a spokesman for Los Angeles-based Hughes Aircraft Co., which developed the tank-tracking technology and which will be a partner with BART and Morrison Knudsen Corp. (the maker of BART's cars) in the program.

"It's great," said Ron Rodriguez, a BART spokesman. "We're taking a highly sophisticated, track-proven technology and applying it to civilian commercial uses. This stuff works. Ask Saddam Hussein if it works."

The 29-month program will convert — but not install — the Hughes technology that allowed military commanders to track on screens the movements of humvees, helicopters, tanks and soldiers during Desert Storm.

Currently, wire technology is used to track BART rail cars. Replacing it with Hughes' radio and circuit integrated technology would enable BART to run trains 80 seconds apart, instead of the 3 minutes currently, through the crowded transbay tube.

In all, Clinton announced $190 million in grants — $86 million (45 percent) of which will go to projects led by California companies.

The companies fund about half of the costs of the projects, the federal government the other half. In the case of the BART project, the federal government will contribute about $19.5 million.

"This is a much needed boost for our state, and it could not have come at a better time," said Sen. Barbara Boxer, who attended the White House announcement.

TRI-VALLEY HERALD THURSDAY FEBRUARY 24, 1994

U.S. to fund transfer to BART of rail car tracking technology

By Meredith K. Wadman
WASHINGTON BUREAU

WASHINGTON — As California lawmakers downplayed the impact of a slash in federal money for base closures, President Clinton on Wednesday announced funding for a new Bay Area project he held up as a national model for converting military technology to peacetime use.

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BART gets defense grant

$19.5 million to adapt military technology to double trains under bay

BY LEE GOMES
Mercury News Staff Writer

A series of Defense Department research grants announced Wednesday will spread $76 million among California-based organizations, including one that will help BART send twice as many trains under the San Francisco Bay as it does currently.

The Pentagon's Advanced Research Projects Agency gave a $19.5 million "Technology Reinvestment Project" grant to the Bay Area Rapid Transit District, Morrison Knudson Corp. and General Motors Corp.'s Hughes Aircraft Co. to use radio technology first developed for the military to pinpoint the location of a BART train to within 15 feet.

Using that information, BART said, its dispatchers will be able to safely send trains under the bay every two minutes, rather than at their current 3.45 minute intervals. Such a speed-up would eliminate the need for a second BART tunnel, the agency said.

The Pentagon's research funds were the last phase of a $600 million program intended, among other uses, to help defense companies commercialize some of the technology they had originally developed for military purposes. The program attracted 2,800 requests, of which only 212 were funded.

The administration has been mindful of California's economic situation in making the awards, and four of every 10 dollars from Wednesday's list went to state-based consortia, a general ratio that was also true in prior announcements.

The other California awards Wednesday included:

- $42 million to Lear Astronics Corp. of Santa Monica for an aircraft landing system that will improve visibility during bad weather.
- $18.4 million for Raytheon Co. in Goleta to research the use of "multichannel digital signal processors" as a way of expanding the capacity of radio frequencies.
- $15.8 million for Bell Atlantic Corp.'s Healthcare Systems operation in Greenbrae for research into ways medical data can be shared among hospitals or clinics.
- $12.2 million to Hughes Aircraft in Los Angeles for work on an automobile collision-prevention system.

One of the biggest awards went to International Business Machines Corp. — a $70.7 million grant to develop industrial software standards to promote the easy exchange of manufacturing design information.

CONTRA COSTA TIMES
ALSO: VALLEY TIMES
THURSDAY
FEBRUARY 24, 1994

CALIFORNIA

IN BRIEF

Alameda County

BART, 2 firms to get grant to build trains

OAKLAND — BART and two companies will receive a $19.5 billion "defense conversion" grant to build trains that could carry nearly double the number of passengers during commute hours, transit officials announced.

BART officials said the White House announced the award Wednesday.

The Oakland-based transit company will work with Hughes Aircraft and Morrison Knudsen to develop an Advance Automatic Train Control System that could greatly increase the capacity of BART's lines, officials said.

That could eliminate the need for a second tube across the Bay, saving "multibillion" dollars, BART officials said.

Capacity would increase because the automatic control system would allow the trains to run closer together. Trains now can only pass every 3¾ minutes, officials said. The new technology would allow BART to run trains every 2 minutes and carry about 60,000 more passengers during the heavy morning and evening commute, BART officials said.

The reason the project is getting defense conversion dollars is that it would involve using a military radio technology to run the trains.

The project would convert the U.S. military's radio frequency position-locating defense technology to pinpoint speeding BART trains to within 15 feet of their position, even inside of the Transbay Tube, officials said. The technology was used successfully by U.S. forces during the Persian Gulf War to track equipment and troops.

$500 million in guarantees in aid package that includes BART system update

By Stewart M. Powell and David Eisenstadt
EXAMINER WASHINGTON BUREAU

WASHINGTON — BART and several Bay Area companies will receive more than $60 million in federal grants as part of a high-tech investment package announced by President Clinton.

At an elaborate White House ceremony Wednesday afternoon, Clinton also offered California $500 million in new loan guarantees to help state and local governments qualify for their share of the $10 billion in federal earthquake assistance.

California received 37 percent, or $222.4 million, of the $605 million for public-private projects that Clinton has authorized for conversion of military technology to domestic use. Matching private spending will roughly double the size of the spending.

The Technology Reinvestment Project grants will provide some relief for the state's hard-hit defense firms, said Anita Jones, director of defense research at the Pentagon.

"California workers can be heartened by this," Jones said. "We expect to see jobs come out of this."

In the Bay Area, BART in Oakland, ArrayComm in Santa Clara, the Electric Power Research Institute in Palo Alto and Loral Western Development Labs in San Jose were all slated to be beneficiaries of the new federal funds.

BART was awarded approximately $20 million to work with

Federal funds headed for state

Morrison Knudsen and Hughes Aircraft on a $39 million project, using technology developed in the Persian Gulf war to augment its automated train control system.

"We're delighted with the selection of BART and its partners," BART spokeswoman Dorothy Dugger said. "This technology is BART's future. It will enable us to double our capacity in peak hours."

The new technology, called Advanced Automatic Train Control System, could nearly double the number of passengers BART carries during commute hours. It would also eliminate the need for a second train tube running beneath the Bay.

The AATC system would use U.S. military radio technology which was applied by forces during Operation Desert Storm to track equipment and troops.

BART said the technology could pinpoint trains, even in the trans-Bay Tube, allowing for more trains in the tube at the same time.

BART estimates it will be able to carry about 60,000 more passengers during morning and evening commute hours and increase the number of trains running each hour from 16 to 30.

"This has the effect of building another trans-Bay tube for a fraction of the cost," said Dugger.

ArrayComm will use its $11.4 million grant to use technology derived from the Strategic Defense Initiative to create a commercial transmitter for wireless communications.

Electric Power Research Institute is expected to benefit from a $7.6 million grant to find cheaper ways to produce electricity in large amounts.

Other Bay Area companies selected included Greenbrae's Bell Atlantic Healthcare Systems Inc., slated to join in a $15.8 million medical information system, and Mountain View's Sun Microsystems Corp. and Spectrian Inc. They are expected to take part in an $18.4 million project to develop new digital electronics.

More work to be done

H. Lee Buchanan, director of the high-tech grants program at the Pentagon, cautioned that more work remained to be done before federal money began flowing to California.

"When you try to decide who is going to run this part or that part of a program, that's when the partnerships begin coming unglued," Buchanan said. "This is very much a work in progress."

Flanked by members of the cabinet, Congress and the California Legislature, Clinton also outlined how the new $500 million in loan guarantees would help state and local governments finance their 10 percent share of disaster relief over a 20-year period.

The loan guarantees will allow local jurisdictions to borrow money from banks at below-market interest rates. The guarantees were included in an emergency spending measure approved by Congress and signed by Clinton 11 days ago.

State officials had sought 100 percent federal funding of disaster relief, but Assembly Speaker Willie Brown said the $500 million in federal loan guarantees was $166 million more than requested by the state.

"At this stage of the game I think the federal government has met the level that the state government has indicated was the need," Brown said outside the White House. "Now as we unfold, clearly we will be back here asking for additional assistance if we think we merit it."

Zachary Coile of The Examiner staff and the States News Service contributed to this report.

'Peace dividend' to benefit BART

The Clinton administration Wednesday awarded another $190 million to companies, schools and local governments nationwide to develop commercial products from military technology, completing a yearlong series of grants in a program to ease the burden of defense budget cuts on industry by promoting "dual use" technologies. One grant went to a project using military communications technology developed by Hughes Aircraft division of General Motors Corp. to locate all trains in the BART system even in tunnels. Some 212 proposals involving 1,631 organizations have been selected to date and the $605 million awarded so far will be at least matched by selected participants, the Pentagon said.

EDITORIALS

Clear Tracks Ahead for BART

AT LAST BART may be able to carry the number of passengers promised when the transbay tube went into service nearly 20 years ago. A federal grant of close to $20 million will help replace an obsolete train control system with battlefield technology tested in the Persian Gulf.

When the rapid transit system was under construction, residents of the Bay Area were told that trains would run at 90-second intervals during the peak hours. But the promise could not be kept. Instead, the state Public Utilities Commission ordered BART to maintain 15-minute headways in order to make sure that trains speeding beneath the bay didn't crash into each other.

That meant BART could provide rush-hour patrons with only four trains an hour in each direction. Even today, the shortest time between trains is 3 minutes 30 seconds. The new system may cut intervals 80 seconds.

THE NEW GRANT is part of a government-sponsored program to use military technology for civilian development. It will be matched by funds from private contractors and public sources to construct a $60 million radio-based signal system developed by Hughes Aircraft Co. to pinpoint train locations within 15 feet.

BART has endured many difficulties, but after enjoying a welcome period of competent management, it appears to be on the verge of reaching its potential.

BART

BART Marketing,
Media & Public Affairs
800 Madison Street
Oakland, CA 94607

MARKETING, MEDIA & PUBLIC AFFAIRS

DATE: 02-25-94 TIME: 12:30

FAXing 9 Pages (including cover sheet)

TO: DAN REEDER

COMPANY: HUGHES AIRCRAFT

FAX NO: (714) 732-0674

FROM: MIKE HEALY

COMPANY: BAY AREA RAPID TRANSIT (BART)

PHONE NO: (510) 464-7110

COMMENTS: ATTACHED ARE THE CLIPS PER DISCUSSION

Mike Healy

BAY AREA

IN BRIEF

Alameda County

BART, 2 firms to get grant to build trains

OAKLAND — BART and two companies will receive a $19.5 billion "defense conversion" grant to build trains that could carry nearly double the number of passengers during commute hours, transit officials announced.

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San Mateo County

Clerk gets last laugh on would-be robber

SOUTH SAN FRANCISCO — An armed man gave up on a sandwich shop robbery, apparently in frustration after the clerk thought it was a joke, police said Wednesday.

Police said a man in his mid-30s entered the Subway Sandwich shop at closing time Tuesday and de-

San Francisco

Phony bomb threat clears federal building

SAN FRANCISCO — Authorities evacuated a federal building after a telephoned bomb threat Wednesday morning, but let employees return to work after authorities determined that the threat was a hoax.

The FBI got a half-dozen calls between 3:45 and 4:21 a.m., apparently from the same man, saying the building on Golden Gate Avenue would be blown up, said bureau

spokesman Ric
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cials said they
A bomb sq
building and
parked outsid
found no explos
The caller
group affiliati
made no deman
FBI had no rec
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ternal Revenue
other federal ag

BART

BAY AREA RAPID TRANSIT DISTRICT
800 Madison Street - Lake Merritt Station
P.O. Box 12688
Oakland, CA 94604-2688
Telephone (510) 464-6000

July 19, 1993

Technology Reinvestment Project
3701 N. Fairfax Drive
Arlington, VA 22203-1714

Re: Proposal for Technology Reinvestment Project (TRP) Funding of the Advanced Automatic Train Control Development Project

Gentlemen:

As the designated Sponsoring Agency, the San Francisco Bay Area Rapid Transit District (BART) submits herewith a proposal for TRP funding of the Advanced Automatic Train Control Development Project, representing an alliance of BART and HMK, a Contract Joint Venture of the Surface Systems Business Unit of the Hughes Aircraft Company, located in Fullerton, California and the Rail Systems Group of the Morrison Knudsen Corporation, located in Boise, Idaho. The proposal is for consideration under the Regional Technology Alliance Assistance Program.

Enclosed please find 12 copies each of the Technical Proposal and Cost Proposal.

Should you require any additional information, please contact me at your earliest convenience.

Sincerely,

Frank J. Wilson
General Manager

Enclosures

HMK

By ______________ Dated July 20, 1993
L.K. Brajkovich
Group Vice President, Sensors and Communications Systems Division
Hughes Aircraft Company

By ______________ Dated July 19, 1993
F.E. Templeton
Vice President, Rail Systems Group
Morrison Knudsen Corporation

TRP Cover Sheet 1: Proposal

Technical [X] Cost [ ]

FOR TRP USE ONLY. DO NOT WRITE IN THIS SPACE

1a. Proposal Title:
Advanced Automatic Train Control (AATC) System

1b. Activity:	1c. Program:	1d. Technology Focus Area and Specific Topic:
Dual-Use Development	Regional Technology Alliance Assistance Program	Vehicle Technology - Sensors and Electronics for Vehicle Systems

2. Point of Contact	4. Names, Organizations, and % Time Commitment of Key Personnel
2a. Name and Mailing Address of Contact: Frank J. Wilson, BART/HMK Alliance, 800 Madison St., Oakland, CA 94604-2688	4a. Eugene I. Nishinaga, BART/50% 4b. John A. Evans, BART/100% 4c. Marvin D. Swensen, Hughes/50% 4d. James A. Kivett, Hughes/80% 4e. Dr. Fred E. Templeton, Morrison Knudsen Corp./30%
2b. Telephone Number: 510-464-6060	5. Names of Key Organizations Participating
2c. Fax Number (if any): 510-464-6009	5a. San Francisco Bay Area Rapid Transit (BART) District, Frank J. Wilson, General Manager
2d. E-Mail Address (if any):	5c. Hughes Aircraft Company, L.K. Brajkovich, Group V.P.
2e. Type of Business (SIC Code or other description):	5e. Morrison Knudsen Corporation, F.E. Templeton, V.P.
3. Federal Government Cost	6. Matching Funds over Base Period
3a. Base Cost and Duration (months): $19,575,000/29 months	6a. Cash ($): $11,951,000
3b. First Option Cost and Duration (months): $32,207,000/24 months	6b. In-Kind Contributions ($): $7,624,000
3c. Second Options Cost Duration (months): $0/12 months	6c. Types of In-Kind Contributions: Asset Rental/Technology Royalties
3d. Base Period Match Percent Represented by TRP Funds: 50%	6d. Total Matching Funds ($): $19,575,000
7. Does This Proposal Involve Participation by Foreign-Owned Organizations? YES [ ] NO [X]	8. Identify (if any) any Federal Agency or Entity that was Instrumental in Formulating the Proposal Idea, Team, or Approach: Federal Transit Administration (FTA)

ABSTRACT

A BART/HMK (Hughes Aircraft Company, Morrison Knudsen) team proposes to develop an Advanced Automated Train Control system by conversion of existing defense command, control and communications technology. This team brings together a progressive transit agency, the pre-eminent American defense electronics supplier, and the only remaining American rail car manufacturer to address a rail transit market long remiss in incorporating advanced electronics. Investment in the Enhanced Position Location Reporting System, which supplies the primary technologies for this conversion, exceeds 250 million dollars. This prior investment offers a significant hurdle to competitors interested in bringing similar technology to the market.
The system offers revolutionary improvements in rail transit performance and brings sufficient flexibility to support a variety of future upgrades. Its scope is sufficient to encompass a global market. During the past year, BART and HMK have performed feasibility tests with success beyond expectations. Because the product's potential market exceeds $200 million annually, BART/HMK is now proposing that ARPA participate in its development to partially defray the remaining investment. The development is split into a two-phased baseline program and two options for equipping a portion of BART's revenue track as a testbed and for demonstrations to other transit authorities.

TRP Cover Sheet 2: Proposal Participants

(Use as many copies as necessary to list all participants. Include entities listed on Cover Sheet 1)

Proposal Title:
Advanced Automatic Train Control (AATC) System

a. Name and Address of Participant 1 of 3 San Francisco Bay Area Rapid Transit (BART) District 800 Madison St. Oakland, CA 94604-2688 Check if: (Small Business [ ]) (HBCU/MI [ ]) (Foreign-owned [ ]) (Small Disadvantaged Business (SDB) [ ])	d. Point of Contact, Organization, and Address Eugene I. Nishinaga San Francisco Bay Area Rapid Transit (BART) District 800 Madison St. Oakland, CA 94604-2688 e. E-Mail Address (if any):
b. Telephone Number: 510-869-2415 c. Fax Number (if any): 510-287-4760	f. Type of Business (SIC code or other description) Public Transit Operator
a. Name and Address of Participant 2 of 3 Hughes Aircraft Company (HMK) 1901 W. Malvern. Fullerton, CA 92634 Check if: (Small Business [ ]) (HBCU/MI [ ]) (Foreign-owned [ ]) (Small Disadvantaged Business (SDB) [ ])	d. Point of Contact, Organization, and Address Marvin D. Swensen Hughes Aircraft Company (HMK) 1901 W. Malvern. Bldg. 676 M/S DD245 Fullerton, CA 92634 e. E-Mail Address (if any):
b. Telephone Number: 714-441-9713 c. Fax Number (if any): 714-441-9660	f. Type of Business (SIC code or other description) 3669 Communication Equipment
a. Name and Address of Participant 3 of 3 Morrison Knudsen Corporation (HMK) 720 Park Blvd. Boise, Idaho 83729 Check if: (Small Business [ ]) (HBCU/MI [ ]) (Foreign-owned [ ]) (Small Disadvantaged Business (SDB) [ ])	d. Point of Contact, Organization, and Address Dr. Fred E. Templeton Morrison Knudsen Corporation (HMK) 2603 Eastover Terrace Boise, Idaho 83706 e. E-Mail Address (if any):
b. Telephone Number: 208-386-6374 c. Fax Number (if any): 208-386-7510	f. Type of Business (SIC code or other description) 3734 Rail Road Equipment
a. Name and Address of Participant ____ of ____ Check if: (Small Business [ ]) (HBCU/MI [ ]) (Foreign-owned [ ]) (Small Disadvantaged Business (SDB) [ ])	d. Point of Contact, Organization, and Address e. E-Mail Address (if any):
b. Telephone Number: c. Fax Number (if any):	f. Type of Business (SIC code or other description)

Introduction

This proposal is for a Technology Development Project to demonstrate a prototype revolutionary advanced train control system on the Bay Area Rapid Transit (BART) System. BART, internationally recognized as a progressive transit system, is the sponsoring agency under the Regional Technology Alliance Assistance Program. The proposal addresses the Information Infrastructure focus area, specifically emphasizing communications network architecture and wireless communications which improve the performance and safety of vehicles moving along a fixed guideway.

This project will achieve three national priorities.

(1) maximize the performance of in-place rail systems throughout the country at the lowest cost

(2) minimize the cost of future mission-critical procurements by the Department of Defense

(3) position the U.S. as the worldwide manufacturing leader in a revitalized market for capital-intensive transportation systems.

Many transit agencies in the US and around the world will reach the limit of their existing passenger carrying capacity within the next decade. Introducing a major advance in train control technology offers a means of utilizing transit capacity which is not available with conventional control systems.

The project pioneers an Advanced Automatic Train Control (AATC) system which integrates proven military technology with newly developed commercial products to serve an important non-military market. The acceptance by the transit industry of military developed, battlefield proven vehicle tracking technology will lead to the ultimate replacement of train detection technology in use since the 1880s.

Competing advanced train control technologies are being actively pursued in Europe and Japan. Commitment of resources now, to support the transfer of military technology to the transit marketplace, will position the United States at the forefront of the worldwide train control industry.

Program Objectives

BART and the Hughes/Morrison Knudsen (HMK) joint venture have identified Hughes Enhanced Position Location Reporting System (EPLRS) radio based military communications technology as the basis for formulating an AATC system that will revolutionize the performance of current transit systems. This technology will provide a safe and highly cost effective solution to the problem of limited transit system capacity. Accordingly, BART and HMK have been working to adapt EPLRS technology to this application.

This effort involves the development of the most advanced train control system in the world with the objectives to:

- Double the passenger carrying capacity of existing rail systems
- Offer unprecedented safety, reliability and ease of retrofit to existing transit systems
- Demonstrate great flexibility, adaptability and expandability to fit varying transit requirements

This system will be applicable in widespread rapid transit applications in light rail, high speed rail and MAGLEV systems and will be implemented at half the cost of conventional technologies.

This project will also undertake to:

Provide the proof of performance required by the transit industry

The primary responsibility of any transit agency is to transport members of the public in complete safety. With this overriding duty, no agency, either within the U.S. or overseas, will install a new generation of equipment unless safe operation of the transit system can be demonstrated. One of the goals of this project is to remove any doubts held by the industry and regulatory bodies as to the safety of AATC vehicle tracking technology.

Meet BART's critical headway needs

Headway is a measure of the time interval between trains. To meet increasing ridership demands, headway improvements are needed by BART on their existing system. This innovative 21st century train detection and control system will reduce the interval between trains for safe operation to as little as 80 seconds, with the ability to go to 60 seconds in the future. This AATC allows more trains to operate over existing track, eliminating the need to construct far more costly additional infrastructure.

Maximize dual uses for military and commercial markets through common hardware

The AATC system relies upon the proven position tracking capability of EPLRS and adapts it to a commercial transit application. Continued development in the commercial arena will directly benefit the military market.

It is also intended to demonstrate that the AATC system will permit much tighter control and coordination of train movements than is now possible. This allows the power consumption of trains over time to be equalized by coordinating their acceleration and deceleration. Correspondingly, the need to construct new power substations can also be minimized.

Because of the public safety issues involved, a carefully planned incremental approach must be adopted. The program is structured to validate the system design principles and the train tracking capability prior to activation of the AATC system for full train control.

The demonstration system will be implemented across an operating track network sufficiently complex to prove that the technology will provide the sustained levels of safe, reliable, enhanced performance as required by the transit industry.

Benefits To BART, San Francisco Bay Area, and the U.S.

Since present day transit signaling and communication costs are driven by the construction and maintenance of cable along the track, a radio based approach has major advantages. Successful development and demonstration of this technology is expected to have far-reaching ramifications for the economy of California and the United States. It will benefit the economy by re-establishing the United States as a world leader in train control technology and open up other applications for commercial, safety proven, reliable position tracking technology.

There is potential to:

- Capture a 50% share of a $150 to 300 million domestic train control market
- Provide U.S. access to a foreign market with sales potential far exceeding that of the U.S.
- Maintain up to 1800 high quality manufacturing jobs

National defense will be supported by providing dual uses for hardware to maintain jobs, improve efficiency and preserve military readiness. Design improvements for transit use will benefit defense applications.

It will be possible to support national goals of reducing pollution, traffic congestion, and energy consumption. Furthermore, the project will promote needed expansion of the domestic transit industry.

In addition, there are important benefits to BART and the San Francisco Bay Area:

- A near doubling of BART system capacity by 1996 – needed to support the increased service levels which will arise following completion of the Dublin-Pleasanton extension during 1996
- Installation without disruption of service
- 100 to 1000 times the reliability of the existing train control system
- New capabilities to monitor and communicate train health
- Up to 10% power savings through improved train control

- Opportunities for disadvantaged business enterprises to share in up to $2M of fabrication and construction

For these reasons, this proposal is being submitted under the Regional Technology Alliance Assistance Program.

The need for new power substations and a second transbay tube that would otherwise be required at considerable capital cost can be eliminated. Demonstration of an AATC system within the next three years is needed to prove that increased service levels can be achieved in support of traffic demands through the transbay tube as the additional Dublin-Pleasanton line is brought into operation during 1996. To meet this objective, it is critical that work commence early in the fall of 1993.

Technical Approach

The geographical layout of the BART system provides an ideal demonstration site for the AATC system. The Transbay Tube, where four train lines merge into one, presents a bottleneck that cannot be relieved without major capital expenditures. The AATC will overlay the in-place Automatic Train Control (ATC) system. This approach leaves the existing system in place as a backup that ensures a safe, graceful transition, and supports precise monitoring and direct performance comparisons.

The position of BART trains will be measured by a radio network and reported to equipment located at existing control stations. Spread spectrum EPLRS radios will be placed on the lead and tail cars of trains. Radios at the control stations communicate with the trains via radios installed at 1/3 mile to 1 mile intervals alongside the track.

Messages are sent and received between the vehicle and the trackside radios. Each trackside radio calculates the time it takes for the signal to get from a vehicle radio to itself. This time can be directly converted to a distance between the trackside radio and the vehicle. Train position reports are sent to the control stations, via a unique, patented (pending) wireless communications network, where speed commands are selected and relayed back to the train.

Train position can be determined very accurately (within ±15 ft) since there are two radios on each train and each radio is within range of at least three trackside radios. This structure gives a highly reliable, fault tolerant performance which, when combined with the interference immunity of EPLRS, provides a highly robust train control system.

The system provides for the transfer of trains between the newly instrumented AATC track segments and those controlled by the existing ATC without loss of automatic control.

Station and vehicle interface modules will be developed to interface with existing hardware. The train interface modules will use state-of-the-art Local Operational Network (LON) integrated circuit technology for vital and ultra-reliable communications and control between different cars in a train.

Criteria For Success

Preliminary feasibility and parameter measurement demonstrations have already been performed by the alliance partners. Analysis and field evaluation have confirmed the technical and business feasibility of this technology. Similarly, the system design requirements have already been defined in a system specification developed by BART with inputs from HMK.

An initial demonstrations system, where a multiplicity of features will be demonstrated and studied, will be in operation in late-1995. It will illustrate the potential for:

- System capacity increases
- Reliability and maintainability
- Operator acceptance
- Train Scheduling improvements
- Energy conservation

During the early phases of the program, the AATC system will operate in a monitor mode.

Monitor mode consists of locating trains and generating, but not issuing, speed commands. These speed commands will be verified for accuracy. Once sufficient data and confidence is acquired, the system will be placed into control mode. The system performance demonstration will be conducted to confirm that the established success criteria listed below have been achieved or exceeded:

• Crush headway	90 seconds
• MTBSSD	26,000 hours
• MTBH	10^9 hours
• Tracking capacity	20 consists per control zone
• Minimum position report rate	0.5 seconds for each consist
• Position accuracy	±15 feet for 100 mph at 99.9%

Program Organization And Management

BART has joined with HMK to form an alliance to demonstrate the feasibility of transitioning EPLRS equipment and technology into the transit marketplace. Members of the BART and HMK executive staffs will provide program oversight. A detailed program plan will be established, and adherence to this plan will be monitored along with technical and financial status.

Execution of the program plan will be accomplished with the participation of all members of the alliance. BART will participate in the design and implementation process to ensure that the integrity of the existing ATC system is maintained, that the newly installed AATC system is compatible with the existing ATC system, and that the overall BART system can easily transition between ATC control and AATC control. Hughes will accomplish the required modifications to the military equipment, generate the control software and oversee system design and test. Morrison Knudsen will integrate, on the car and in the control station, those elements of the AATC system that interact with the existing ATC equipment. The partners are able to provide comprehensive laboratory, integration, manufacturing, test track, and revenue track facilities to effectively conduct this program.

The overall regional technology alliance assistance program comprises a 29-month base program, and two options. The first option is 24 months in duration and a second extends 12 months beyond the first option. The base program develops the system concept and system design as well as the design of the critical system functions. The options implement a feasibility demonstration AATC system on the revenue track.

Commitment To Productization

A demonstration of the AATC is essential due to the industry requirements for service proven products. Initiation of this TRP program will enable demonstration of the viability of the military-based AATC product within three years. Marketplace analysis conducted by the transit industry demonstrates over a $1 billion market in the U.S. alone. With production capabilities for identical EPLRS modules already established, the successful conclusion of this program will result in a manufacturable product and validated proof-of-production capabilities for each new element of the AATC system. This combination of a large marketplace with demonstrated manufacturability enables commercial sustainability.

Once viability is demonstrated, Hughes and Morrison Knudsen are committed to producing the AATC equipment. Hughes and Morrison Knudsen have already formed (and invested in) a joint venture company for pursuing this marketplace and making the investments required to develop the resulting business. Without Defense Conversion Funding support, the funding needed to validate the AATC technology development program is not available. The BART sponsor and both industrial participants can make the commitment to proceed only if the required amounts of Federal funding are provided.

Hughes, in its military programs, has a recognized competency in the system integration, multidisciplinary planning and implementation needed for success in AATC. The company has many years experience of managing complex, large scale projects to develop communication systems. Morrison Knudsen has extensive experience with transit products, train cars, electronics design, manufacturing, support, and customer requirements. BART has a record of successfully implementing and operating novel, state-of-the-art transit and ATC systems, and has a nationally recognized technical staff. This team is extremely well qualified to successfully convert this technology application into a successful program and then into a commercially sustainable business. The significant participation of each of these parties in this program and product area reflects a commitment to make this endeavor successful. The probability of success, given this background and this approach, is unusually high.

Pervasive Impact And Benefits

Currently there are no U.S. suppliers of advanced automatic train control signaling equipment for the transit industry. The market place is ripe for revolutionary approaches and technologies since the current state-of-the-art equipment is based on decades old technology. Introduction of the next generation AATC system should cause explosive growth in this marketplace. Within the next decade, New York, Philadelphia, Washington, D.C., Baltimore, Boston, Atlanta, and Los Angeles plan major investments in upgrades and extensions to systems which this AATC approach is directly applicable. It is estimated that capturing a small fraction of the market would sustain a business base of approximately $50 to $100 million per year. Capturing a 50% market share would result in a sustained industrial base of $150 to $300 million per year. The worldwide market not included in these figures, is larger than the domestic market.

Since all components are manufactured domestically, AATC production translates to a large number of high quality jobs. A spectrum of job types will be created and/or sustained. The high technology military industrial base required for EPLRS (including both large electronics system suppliers such as Hughes and a great number of smaller electronics suppliers) can be maintained to service both the military and the transit marketplaces. New installation, manufacturing, and support jobs will be established within each city upgrading its transit system. These will help support diverse, minority, and small business bases.

The market is projected to extend about twenty years into the future and a train control system typically has a service life of twenty years. Jobs created to manufacture, install, service and maintain AATC equipment will be sustained over this extended period.

Modules developed for AATC will be structured for dual use — to meet military and transit requirements. Commercial approaches developed for new or modified modules in the AATC system will provide lower cost production processes for subsequent military buys. Once the AATC market is established, improvements in product capabilities will occur. Such additional AATC capabilities will bring synergistic improvements to the military products. Conversely, improvements in military products should provide advanced capabilities to transit industry products.

Direct application of the military EPLRS equipment and technology to the transit industry is a high leverage spin-off transitioning of military technology that targets existing needs. Military communication systems, specifically designed to circumvent system failures, are ideally suited to meet the stringent reliability/ safety demands of the automatic train operation functions.

Proof of the AATC system capability will launch U.S. industry into a major market with a world class product. The opportunity exists for a defense conversion investment into a project carrying a high likelihood of success and offering a substantial return for the nation's investment.

1. Need for the AATC System

The requirement to provide significantly increased passenger capacity while retaining the ability to utilize existing rail transit infrastructure is uniquely satisfied by the Advanced Automatic Train Control system.

The growth of urban areas around the world provides transit agencies with the challenge of increasing passenger volume. This increase in passenger demand is propelling transit agencies towards the limits of their existing capacity which is imposed more by the technology of the supporting signalling and control systems than by the inherent limitations of the existing transit infrastructure.

There are three principal means by which capacity can be increased as depicted in the table below.

Also, the need for effective rail transit continues to grow as governments worldwide try to get people out of single passenger cars. Furthermore, increased rail transit results in related energy savings, improvements in safety, and reduced impact on the environment. Compared to automobile travel, rail travel is much safer on the basis of either passenger miles travelled or fatal injuries per hour. From an environmental standpoint, rail is far less polluting than automobiles which are the primary producers of those effluents that the EPA has targeted for reduction. Examples abound which do little to encourage anyone to quit driving. Tokyo employs pushers to literally cram people onto rail cars.

Typically, the physical rail infrastructure permits increased utilization but the corresponding support systems are outdated. No rail transit support system is quite so antiquated as train control. Existing automatic train control systems derive primarily from the invention in 1872 of the track circuit which, however, was not placed in service anywhere until 1911. To date many transit authorities have not incorporated track circuits and still operate under manual control. Improved train control has more potential to exploit the existing rail infrastructure in a cost effective way, while enhancing safety than any other subsystem.

Technology for addressing automatic train control is now available, having been developed for military applications. Vast expenditures associated with these military developments have precluded their independent emergence on the commercial side because individual suppliers could not afford the investment. The opportunity to convert these defense technologies for the rail transit application is at hand; TRP support could enable an American vendor to become dominant in a global market.

HOW TO INCREASE USE OF EXISTING TRANSIT INFRASTRUCTURE
Advancement of train control technology will maximize exploitation of the currently unusable capacity of existing transit infrastructure.

Method	Ramification
Construct additional tracks on existing routes	Can only be achieved at significant construction cost.
Operate longer trains at existing frequency	Requires modification to existing stations, again a major construction cost
Operate trains at increased frequency	Can only be achieved by installing upgraded signalling and control systems. This can be satisfied by AATC systems at dramatically lower cost than for the other alternatives

2. Military Position Location Technology Meets AATC Needs

Battle proven EPLRS offers an opportunity to convert defense technologies to develop a revolutionary transit product with global sales potential in the area of train control.

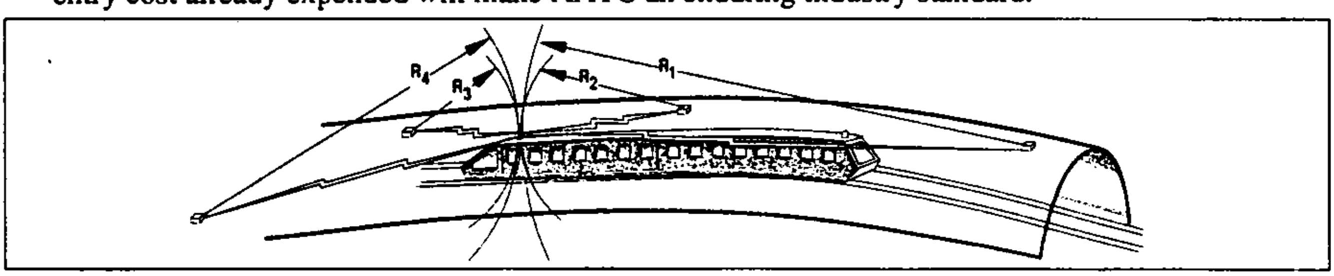
The program objectives are to demonstrate the feasibility and benefits of applying existing military communications, command and control and associated position location technologies to automatic train control (ATC). The feasibility demonstration will employ military hardware and software to implement an Advanced Automatic Train Control (AATC) system for use in the transit industry. This demonstration will establish and measure performance improvements, added capabilities, and flexibility provided through the application of this dual-use technology. Of critical importance will be the demonstration of safety and reliability operations.

The program will focus on the spin-off transitioning of existing Enhanced Position Location Reporting System (EPLRS) equipment and technology to immediate use in the transit market place, thus establishing dual-use of EPLRS technology and major portions of the hardware. In the technology development focus areas, this program focuses on application of this military technology in the area of Information Infrastructure. The sub areas of communication network architecture and wireless communications are targeted. As a side issue, the vehicle systems and vehicle integration sub areas of the vehicle technology focus area is also targeted.

Application of advanced technology to areas such as train control, which have seen no innovation in over a decade, offers better use of the existing infrastructure. AATC development would be expensive and risky if supporting technologies had not already been developed. EPLRS determines the position of properly equipped battlefield assets (tanks, artillery, helicopters, etc.), on or above the battlefield in a 3-D reference plane to within a few meters. The position of a given force element is ascertained when it transmits a message which is received by three separate force elements. The precise time (known by all EPLRS radios) is used to accurately measure the travel time from the transmitting radio to the receiving radio. With three such Time of Arrival (TOA) measurements, the position of a transmitting unit can be determined. EPLRS also provides secure, reliable, jam-resistant communications and communications network management. These capabilities were thoroughly verified in Desert Storm.

The EPLRS capabilities are also exploited in the AATC system. The paramount requirement is to continuously track locations of all trains. Train location is determined more accurately using EPLRS-type systems in the AATC application since their paths are fixed relative to the infrastructure. In effect, train locations are one-dimensional rather than three-dimensional as on the battlefield. As a result, they can be determined within a few feet using trains and trackside units equipped with EPLRS-type radios. Since these units transmit command and status information, and this information is relayed along the radio network, all major functions of EPLRS are fully utilized in the AATC application.

Most rail transit systems use fixed block train control systems that incorporate large operational train spacings thereby precluding full utilization of the infrastructure. Moving block systems, such as the AATC system, permit reductions of train spacing to improve capacity and safety margins. The AATC system goes one step further in offering flexibility and system performance unmatched by other moving block approaches. Transit agencies are demanding customers: safety is paramount, cost control is critical, system performance must be reliable, and equipment must be maintained over its life. Its improved performance, low price, and the vast entry cost already expended will make AATC an enduring industry standard.



Train Position Determination. Radio communication between wayside radio sets and vehicle radio sets provides ranging measurements.

3. BART Application of the AATC System

The proposed AATC system is designed to meet basic transit system requirements while providing software and firmware paths to allow upgrades for future desired capabilities.

The AATC system proposed by the BART/HMK team is designed to meet all of the functional requirements necessary for safe and reliable transit operation. Margins in both system performance and implementation permit subsequent upgrades with enhanced or additional capabilities. Primary functional requirements appear in the table.

For BART, the AATC system will improve system passenger carrying efficiency by reducing normal headway between trains from the current 225 seconds to a goal of 135 seconds. With more accurate and timely train positions, BART's existing fixed block control algorithms can be altered to achieve this headway. Future headway requirements of 80 seconds and ultimately 60 seconds must utilize new moving block control algorithms requiring more accurate and timely position updates. Stated train tracking subsystem requirements support current and future system headway requirements. The position update rate affects the communications network structure which must provide an independent measurement on each and every train (up to 20 per control zone) every 0.5 second. It also affects the processor loading of the control station computer because measurement data for all trains in a control zone must be converted into train positions and filtered appropriately.

The mean time between hazard (MTBH) of 10^9 hours for the entire automated system relates directly to passenger safety and assumes critical importance. First, the position location function cannot unknowingly generate inaccurate train positions. Second, selection and delivery of incorrect speed commands from the control station to trains must be exceedingly rare. Hence, verification and recovery algorithms must trap all potential erroneous occurrences. A trackside wireless communications architecture has been developed which provides a data link having an extremely low message error rate, message acknowledgement and foreward error correction. Additionally, hardware, firmware, and software supporting ranging, reporting, and position calculations must prevent any possibility of algorithmically determining a false train position and/or speed command acknowledgment.

The 26,000-hour requirement for System Service Reliability, coupled with the mean repair times, equates to having a portion of the BART system operating in a degraded service mode no more than once in three years. This requirement forces the system architecture to employ a certain degree of redundancy. MTBF requirements for AATC hardware components serve as a lower limit on MTBF specifically intended to limit maintenance actions on the equipment.

AATC FUNCTIONAL REQUIREMENTS

AATC Parameter	Requirement
Crush Headway	150 seconds in 1993; 90 seconds in 1995; 80 seconds in 1997
• Tracking Capacity	• 20 trains per control zone
• Minimum Position Update	• 0.5 seconds for each train
• Position Location Accuracy	• ±15 feet for < 100 mph at 99.9%
System Service reliability	26,000 hours (1 failure in 4 years)
• MTBF: Onboard Equipment	• 3,000 hours for each vehicle
Trackside Equipment	• 5,000 hours for each locations
Station Equipment	• 2,000 hours for each station
• Repair Times (initial fault to repair):	
Onboard Equipment	• 6 hours median
Station Equipment	• 6 hours median
Trackside Equipment	• 12 hours median
MTBH	10^9 hours (1 hazard in 100,000 years)

4. AATC System Concept

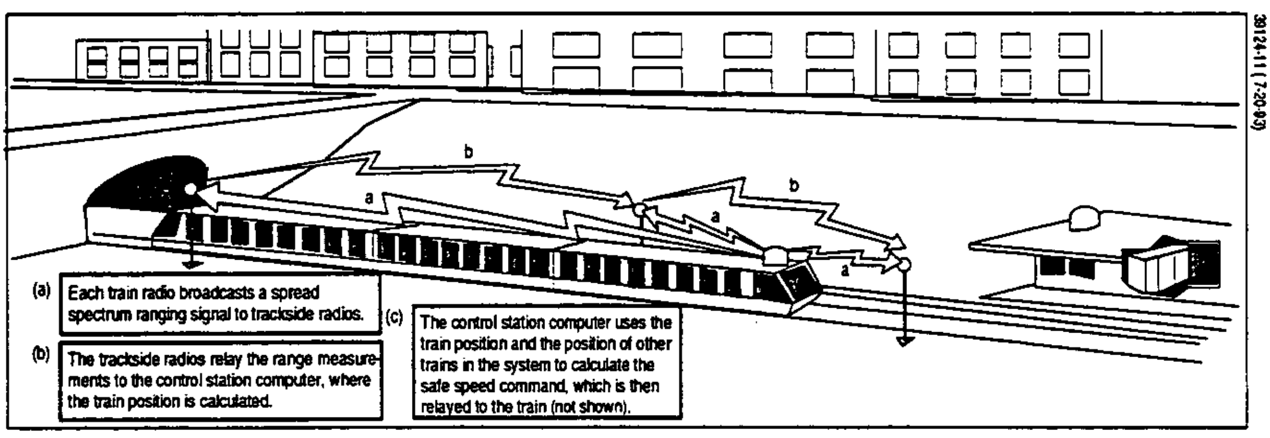
Advanced U.S. Army technology in the AATC system will create a train control system providing improved performance for a fractional cost of existing lower capability systems.

By incorporating EPLRS technology into the AATC System, the train transit industry will acquire a new standard for (1) tracking train positions, (2) selecting of safe speed codes, and (3) communicating of the speed codes from the station to the train. This new system architecture advances the state of the art by utilizing defense-derived spread spectrum radios for locating trains as well as communicating vital information between the trains and the controlling station.

To implement position location, each consist carries two spread-spectrum radio sets (RSs); one in the lead car and another in the rear. This permits independent location of both the front and rear of the train, critical parameters in selection of the safe speed command. Identical RSs are also positioned along the trackside so that, anywhere along the track, each vehicle RS is within radio frequency (RF) line of sight (LOS) of at least two trackside RSs. This placement also allows each trackside RS to communicate with at least two RSs uptrack, and two RSs downtrack, to ensure reliable relaying of data to and from the control station. Each control station will be outfitted with two RSs, one at each end. All radio sets in the AATC system operate in a time synchronous mode, i.e., they have exactly the same time of day.

As the train travels along the track, its RSs listen for spread spectrum signals from the trackside RSs . When the train RSs receive the spread spectrum signal, they make a time of arrival (TOA) measurement on it during the receive process. The train RS then transmits at a scheduled time a signal containing its TOA measurements addressed to (and received by) two trackside RSs within the train's RF LOS ((a) in the figure). These trackside RSs then take TOA measurements on the received signals and convert paired TOA measurements into ranges from themselves to the train RS. This process is performed many times a second to filter out any anomalous ranges. Smoothed range data is then relayed down the track by the trackside RSs to the control station computer ((b) in figure), using a bus architecture. The bus supports two-way data transfers every 33 msec, can support at least 20 trains for each control station, and can provide full support as long as there are no back-to-back radio failures. Using these multiple ranges, and with the trackside RS positions precisely known, the station's AATC control computer then computes the train's position. This entire process is performed every half second for every train in the system to maintain the precise status of the position of all trains.

The station's AATC control computer then uses this position information, in combination with the train status, track data, and interlocking status for gates and switches, to select the safe speed codes for all of the trains operating within its control zone. The safe speed code is then transmitted to the train by relaying the command from the stations radio back up the track, using the reverse of the relay path taken by the range data ((c) in figure).



Advanced Automatic Train Control. The entire process is performed each 0.5 second for every train in the system.

5. Previous Radio Set Ranging Feasibility Demonstrations

Previous demonstrations conducted on BART property validated key design parameters and proved that RF ranging is a feasible location technology for the AATC application.

Two sets of demonstrations using BART facilities in the past year have validated the BART/HMK approach. The first set, in August 1992 at 400 MHz, established the capabilities of RF ranging using an existing military system (EPLRS). The results showed that single path ranging of the demonstration equipment could consistently resolve to ± 1 count (its lowest resolution, ±12 feet) and that ranging worked in the tunnels, although range was limited due to frequency (as expected). Standard EPLRS units were used.

The second set was conducted at the objective frequency, 2.4 GHz, in February 1993 to determine performance for: propagation in the tunnels, location using simple algorithms, effective wayside spacing, and communication integrity. These demonstrations used the same military-based system, with the addition of a frequency converter, antenna and special firmware and software. An external breadboard up/down converter was used to change the EPLRS 400 MHz frequency to 2.4 GHz. The 2.4 GHz frequency was selected for the objective system to ensure reliable communications in the tunnels. A breadboard horn antenna specifically designed for operation on trains and in tunnels was used as part of the test.

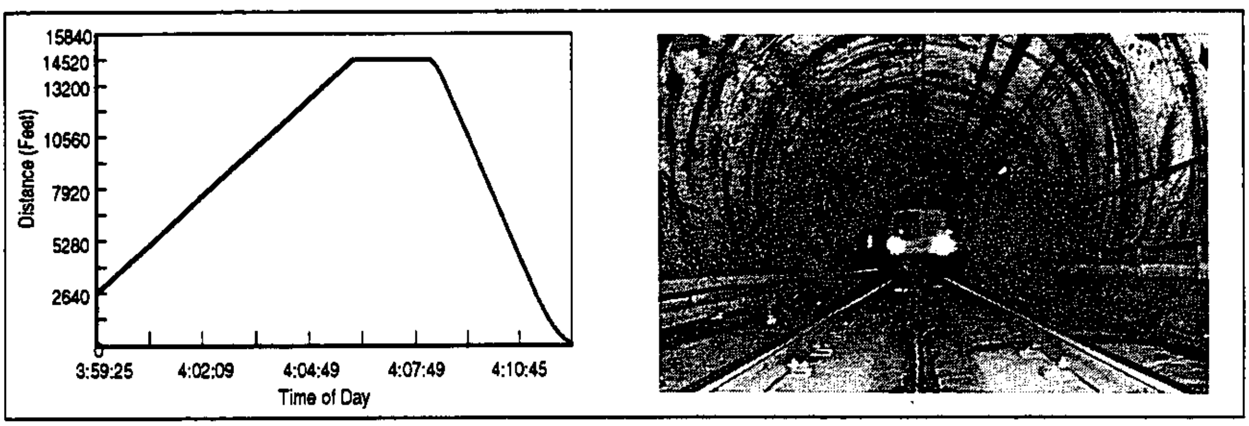
A radio set was installed on a train and three trackside units were installed along the test track and inside the tunnels. The train was stopped at various locations along the track and ranging measurements made to the trackside units. A simple software algorithm used these ranging measurements to estimate civil location. Civil location estimates for all measurements at a given location were averaged to form a position estimate and compared with the actual train locations. The actual train location was determined by noting the civil location marks on the track and counting ties and sidings from that position. The actual measurements were:

- Test Track +15, -7 feet
- Steep Bend Tunnel +25, -16 feet

The objective system will have positioning errors less than 25% of the demonstration measurements due to improved ranging resolution (±3 feet), position algorithms, and filtering.

Communication integrity was demonstrated by sending 765 messages (80 bits each) per minute and recording the number of messages properly received. These measurements were made from various locations along the track and were collected for a minimum of 10 minutes at each location. Communication integrity measured at all locations exceeded 99% under all conditions. A representative result from the demonstrations appears in the figure.

Dynamic demonstrations were also conducted and compared against a dynamic tracker that used wheel rotation to determine distance traveled. Results from both measurement and communications integrity demonstrations established confidence for ultimately achieving specified position accuracy and message error rates.



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Range Demonstration in Berkeley Tunnel, Up and Back, 2.7 Miles. The feasibility of the AATC concept was demonstrated under worst-case conditions by actual testing in the Berkeley tunnel.

1. Overview of System Architecture

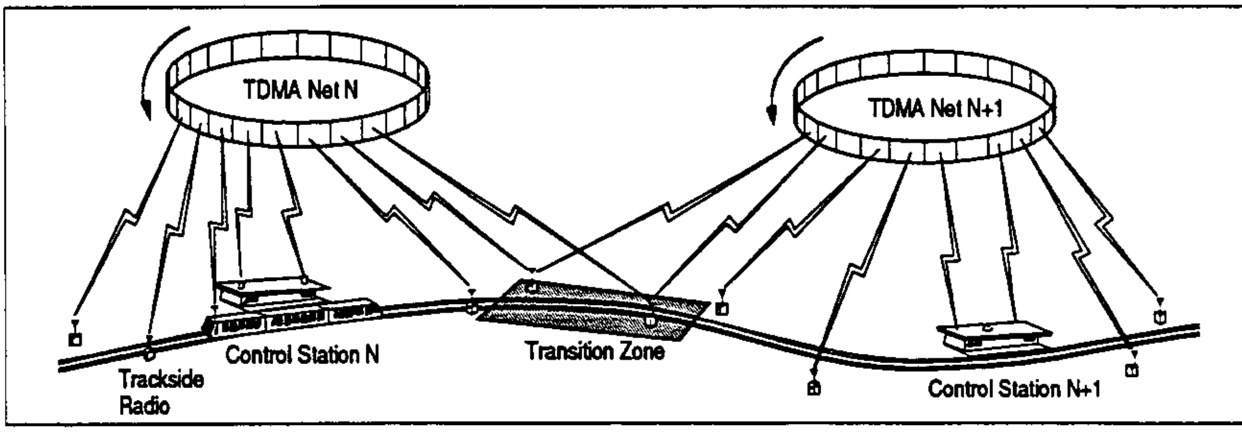
Incorporating proven U.S. Army wireless communications technology into the AATC system architecture provides next generation train control and communications to the transit industry. This architecture supports all of BART's current and long-term train control needs, and can be applied to all large transit systems.

The BART/HMK team's proposed system architecture was derived from the existing position/location and communications capabilities developed on the ARMY EPLRS program, and from the needs of BART to reduce unnecessarily large distances between trains while increasing the safety margins. The system architecture was developed to minimize disruption to existing revenue operations of any transit authority, as only a wireless system can do. The architecture has distributed control, dividing the system into multiple control zones, with each independently insuring system safety within its own zone. A transition zone is established between control zones, with both control stations sharing responsibility for safety.

Each control zone consists of a single control station, dedicated wayside radio sets (WRSs), and two or three WRSs residing inside the transition zone between each pair of adjoining control stations. The WRSs are placed in fixed, surveyed positions alongside the track. Each WRS has direct RF connectivity with the two WRSs in each direction adjacent to it along the track, and acts as a relay node to transfer messages (including measurements and commands) along the track in either direction.

The system provides for all radio sets (RSs) in each control zone to be integrated into a single time-synchronized Time Division Multiple Access (TDMA) communications network. This network provides multiple radio access to a communications channel by dividing time into small, repeating slots which can be allocated to a radio to support any required communications functions. The AATC TDMA architecture will have a basic frame rate of 0.5 second, meaning that the functional allocation of time slots will repeat every 0.5 second in a periodic fashion. All of the control zones, although having independent TDMA networks, will be in complete time synchronization so that trains moving from one control zone to another maintain only one time base. Radio sets that reside in the transition zone between the area of responsibility of two control stations will participate in the networks of both of the control zones.

In order to perform the position location function, each VRS is assigned transmit time slots. The WRSs are scheduled to listen on those timeslots and perform a time of arrival (TOA) measurement on the received signal. These TOA measurements are paired with TOA measurements reported by the VRSs to form range measurements which are forwarded to the control station, then used to determine the train position on the track, and finally correlated with filtered versions of the expected train position based on its speed and last position.



AATC System Architecture. This architecture comprises distinct TDMA networks which can replace or overlay existing control zones for maximum compatibility and evolutionary growth. The improved capability can be applied to all large transit systems.

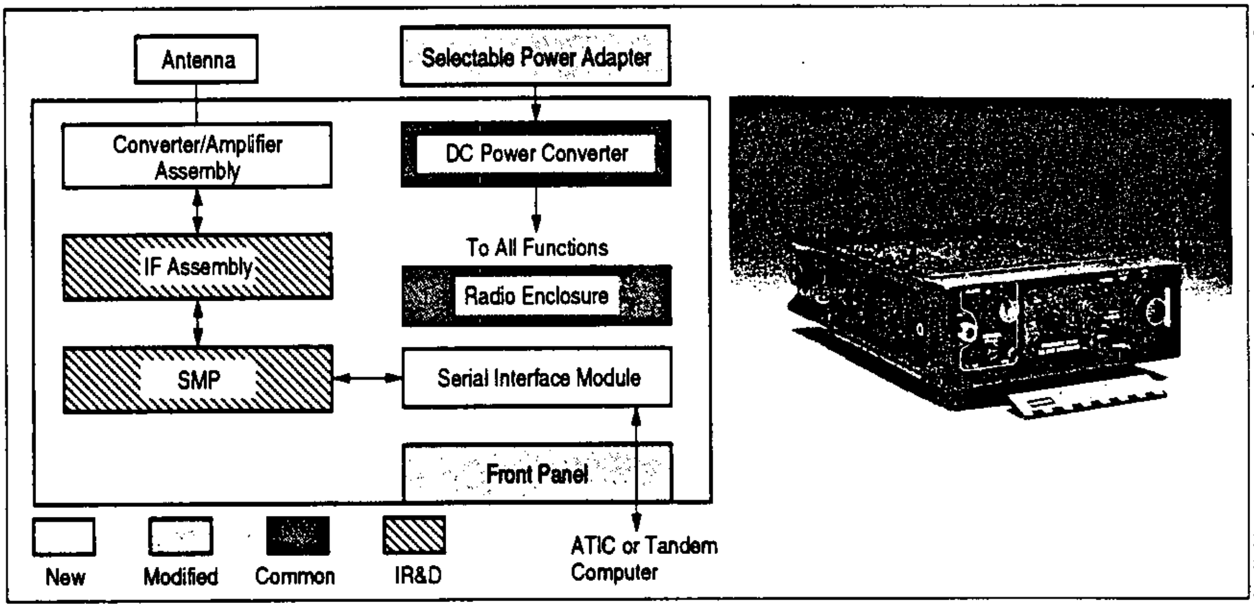
2. Dual Use of Existing Military Hardware and Firmware

The AATC radio set is a derivative of the rugged, battle-proven EPLRS radio set which is modularly constructed to facilitate its adaptation to new uses such as AATC.

The AATC radio set hardware (see figure) meets typical transit environmental conditions and satisfies AATC hardware construction requirements by its compliance to rigorous military standards. Its modular construction approach provides for rapid diagnosis and replacement of faulty hardware modules. Hardware functions are implemented via five individual modules housed within a single enclosure. Of these six items, the IF Assembly (IFA), the Signal Message Processor (SMP), the DC Power Converter (DCPC), and the enclosure were previously developed for EPLRS. The main enclosure, including the module interfacing interfacing circuitry, is unchanged. The enclosure's front panel will be modified to remove unused EPLRS connectors, switches, and functions. The remaining two modules, the Serial Interface Module (SIM) and Converter/Amplifier Assembly (CAA) will be developed specifically for the AATC application. In addition, the Selectable Power Adaptor from EPLRS will be only slightly modified to support 220 volt AC operation. Also, the firmware, which is contained within the SMP and controls the radio set functions, contains common code modules.

The Converter/Amplifier Assembly (CAA) provides frequency conversion, transmitting power amplification, and low noise receive amplification of the 2.4 GHz AATC RF waveform. The CAA converts the 420-450 MHz waveform from the IFA to the 2.4 GHz band using a stable, synthesized 2,005 MHz oscillator, which is phase locked to the internal reference of the IFA. The SMP controls selection of the CAA's transmit and receive functions. The Serial Interface Module (SIM) provides the serial data interface to the AATC equipment, as well as providing Cyclic Redundancy Check code generating/checking services for the SP function for over-the-air messages. The serial data interface is firmware programmable to provide interfacing to the various equipments.

Although the signal message processor (SMP) is currently in production for EPLRS, Hughes is embarking on IR&D (Independent Research and Development) to upgrade a VHSIC version of the SMP. This new version of the SMP will be used as part of the AATC configured EPLRS units. Likewise, Hughes will develop on IR&D a higher performance IF amplifier (IFA) to replace the IFA in the current EPLRS configuration. Both units will be part of the AATC units used during the demonstration.



RS Functional Block Diagram. The modular design with extensive re-use of existing modules produces a low-risk implementation.

3. Description of the Vehicle Subsystem

The vehicle subsystem incorporates an AATC interface to the existing train control subsystem and a battle-proven state-of-the-art wireless radio for train communications, control and position/location.

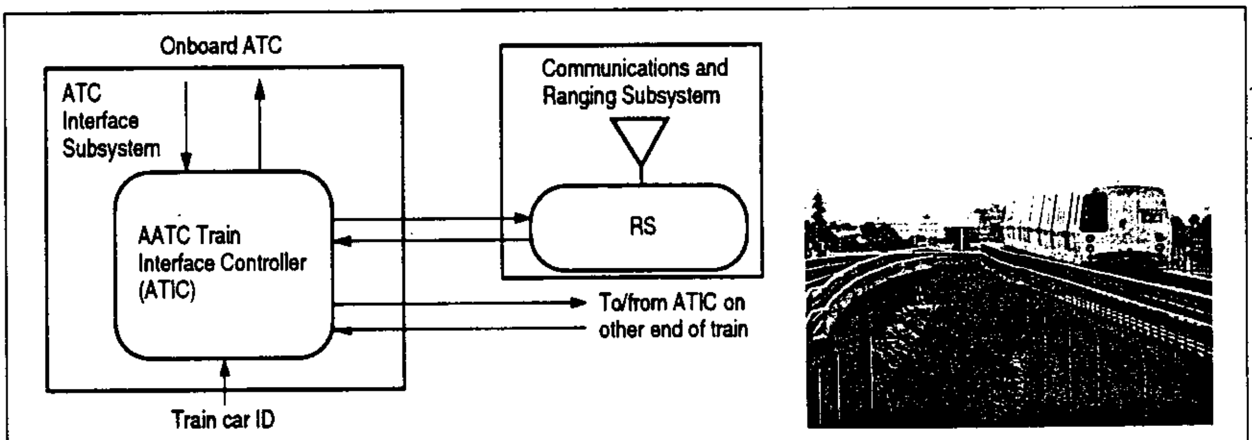
The BART/HMK team's proposed vehicle subsystem architecture utilizes wireless communication technology developed for the U.S. Army. This architecture is fully redundant in the control and reporting structure, providing uninterrupted service for any individual component failures. The vehicle subsystem provides excess capabilities to allow future growth for the AATC system, as well as to easily accommodate the needs of other transit systems. A flexible message structure is utilized to allow message structure changes and additions to be easily incorporated.

A train has two identically equipped control cars, one at each end of the train. This allows the train to move in either direction. Each train vehicle has an AATC Train Interface Controller (ATIC) and a Radio Set (RS) as shown in the figure. The RS provides the main communications and position-tracking capability for the train vehicle in the AATC system. Speed commands are received via wayside RSs (WRSs) at least every 0.5 second and are sent to the ATC via the ATIC. The ATC will send back ATC status, track signal information, and the received speed command acknowledgment. The ATIC takes the ATC information and sends it back to the control station via the RS network.

ATIC – The ATIC also sends all received information to the ATIC on the other end of the train. This allows either RS to fail without loss of functionality. To ensure uniqueness of AATC equipment onboard train cars and trains, the train car identification (ID) is hardwired into the ATIC. The ATIC and its local RS use that ID to uniquely identify their reports.

Trainline Communications – Data communications on existing trainlines was also successfully demonstrated on a ten-car train at BART in March 1993. Equipment similar to that included for the AATC system, was installed in the lead and rear cars. Over three million bytes of data were transmitted with no errors, loss of data, and no effects on the existing trainline functions.

Vehicle RS – Train vehicle RSs send TOA information to the wayside RSs. The wayside RSs take this information and the TOA measurements made on a train and send range information to the control station for position determination. This same communications path is then utilized to transmit data and/or commands to the train.



Train Vehicle Hardware. The AATC train vehicle hardware is identical at both lead and tail, which allows the train to move in either direction without any operator intervention for the AATC hardware.

4. Description of the Trackside and Station Subsystems

The trackside and station subsystems utilize a robust wireless networking architecture to reliably communicate between the control stations and the trains. This wireless networking architecture can be utilized for any transit application.

The trackside and station subsystems utilize the U.S. Army derived radio set as the vehicle subsystem. The radio set provides the reliable and robust communication and position/location between the trains and the control stations. The radio sets also provide very accurate ranging data for position location. The AATC control station architecture utilizes existing ATC control signals and precise range information from trains to calculate precise train positions and send out speed commands accordingly, thereby reducing operational headway between trains. This headway reduction is controlled automatically and safely by the control station.

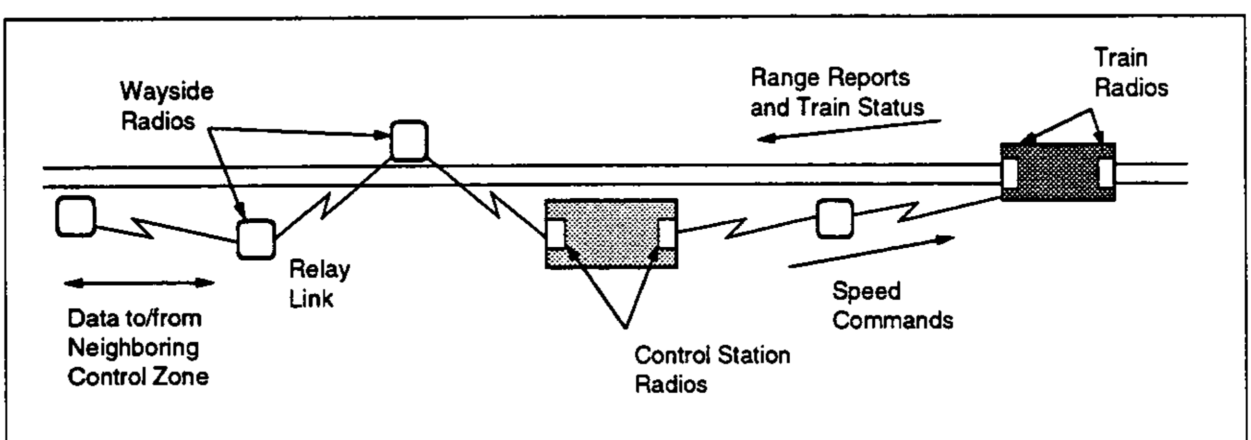
Station Computer – The station computer provides position calculations, speed code selection and network management. It is a fault-tolerant, off-the-shelf, triple-redundant computer system with voting logic to select a two-out-of-three output in case of failure. It receives all station ATC information from the ASIC via three independent RS-232 interfaces (see figure). The station computer receives all vehicle-borne and trackside-borne information via two redundant RSs. The station computer sends train position information and all failure information to central control via an ethernet interface.

ASIC – The AATC Station Interface Controller (ASIC) is the interfacing unit between the station computer and station ATC hardware. The ASIC has three redundant, independent data-collection systems, so any single failure will be detected and isolated by the station computer.

Station RSs – The two RSs are the main communications component of the station, providing all trackside and vehicle communications with the station. Each RS has an independent RS-422 interface with the station computer and will be physically on the trackside, adjacent to the station.

GPS – Each control zone contains a GPS receiver, an off-the-shelf unit used to provide a common time synchronization, so that RSs in different control zones can quickly communicate upon system startup. The GPS communicates with the RS via an RS-422 interface. The GPS(s) will be physically located just above the RS on the trackside.

Trackside RS – Each trackside installation contains an RS which will be mounted differently depending upon the track configuration (at grade, above grade, in tunnels, and type of tunnel). The RS is the main communications component of the system and allows information to be exchanged from the station, along the trackside, to the vehicle, and back. The RS will always include a common receiver/transmitter, a common selectable power adapter and an antenna. The specific type of antenna will vary depending upon the track configuration.



Network Data Flow. Relay paths will be formed to trackside and train radios beyond the line of sight of control station.

1. Compatibility with the BART ATC System

All three subsystems (vehicle, trackside, and station) of the AATC system have been designed to operate with no changes to the existing ATC hardware and only minor changes to onboard ATC software.

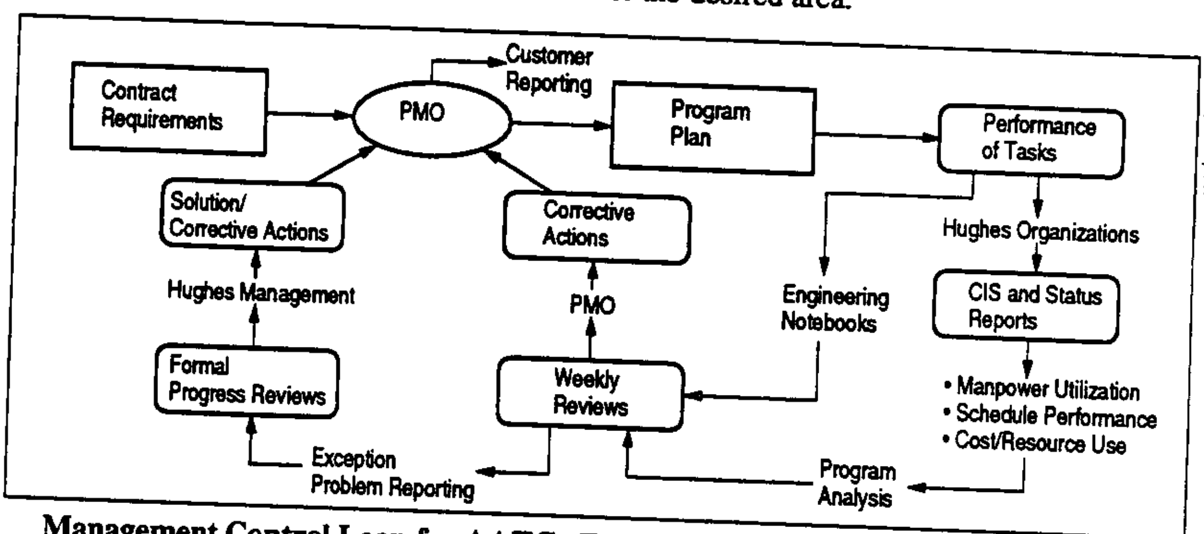
HMK recognizes that BART and other transit authorities have significant investments in ATC systems which must be preserved to the maximum extent. To reduce overall program cost and risk, the AATC design overlays the existing block signalling system emphasizing compatibility with in-place equipment. All electrical connections are made to standard interfaces, and none require deletions or rerouting of wiring. Inputs to AATC are made either to high-impedance circuitry or through optical isolation devices. Outputs from AATC are limited to onboard commands which are connected by triple-redundant logic to an existing standard interface on the ATCs.

All AATC onboard components (train interface controller, vehicle radio sets, and antennas) fit into available spaces. The AATC equipment imposes light electrical loads on existing power buses. Furthermore, the AATC system does not require hardware modifications to the on-board ATC. Only a minimal change to ATC software will be needed in order for the existing ATC system to accept the delivery of AATC commands. Likewise, to report train status and transmit other data from the onboard ATC equipment to the AATC equipment, software changes will be required, but these, too, are minimal and non-interfering. Existing ATC protocols (header, trailer, and cyclic redundancy) are supported at all levels of AATC communications.

The AATC system requires redundant communications pathways through the full length of the consist. The proposed system applies a spread-spectrum signalling technology to selected train lines, which neither interferes with the existing application of those lines nor experiences interference from those existing applications.

Trackside and station installations require no modifications to existing tracks, interlockings, or signals, nor the laying of wires in conduits or any between-the-rails construction. Thus there will be no interference with day-to-day train operations.

Phase 2 of the BART program implements the AATC system on the Lake Merrit and Fruitvale control zones as well as the transition zones associated with them. Based on data collected during earlier feasibility demonstrations on BART revenue tracks, HMK has analyzed drawings provided by BART which depict the above boundaries and determined that 19 radio sets will enable satisfactory control of trains over the desired area.



Management Control Loop for AATC. Feedback mechanisms at all levels escalate problems to the level necessary to gain resolution.

2. Overlaying AATC onto the BART System

In an operational sense the current BART ATC system and the proposed AATC system are functionally equivalent. As a result, AATC overlays the BART system without disruption. Once in place, train control can be automatically transferred between the two systems.

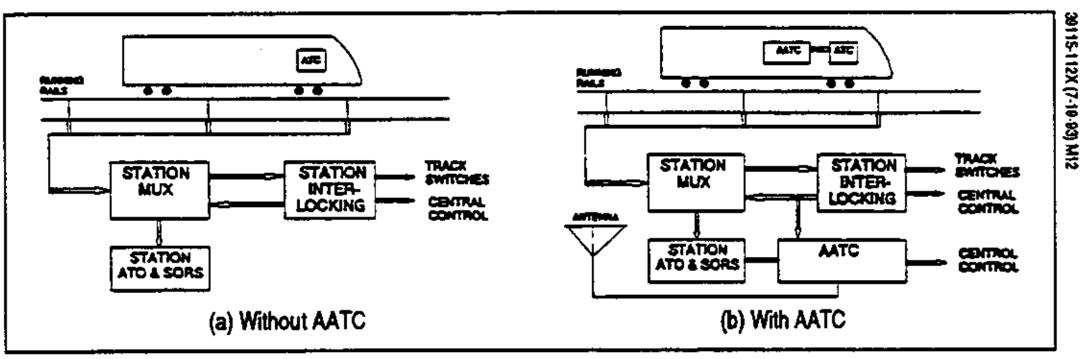
The ATC and AATC systems accomplish three basic functions: 1) train position location, 2) safe-speed code selection based on train location, and 3) transmission and execution of the selected speed by the train. In ATC, train position is determined by physically shunting the signal transmitted through a track segment ("track block"). The station multiplexer equipment determines the presence and position of a train within a "track block." Train location (to within a "block" boundary) and the distance between blocks occupied by trains ahead and behind a safe speed-code is selected. The ATC control station then sends the safe speed-code command through the track circuit. Each train receives its unique speed-code command via the onboard ATC subsystem which is executed by the propulsion subsystem. The AATC system determines train position by measuring the time of arrival (TOA) of RF communication between the wayside and train radios. Train location is communicated to the control station and used to select the safe speed-code to be transmitted to the train(s).

The speed-code commands are communicated to the train through the trackside EPLRS network. The speed-code command received by the EPLRS radio on board transfers the speed command through the AATC subsystem to the ATC subsystem. The ATC subsystem commands the propulsion system as before.

The design goal of maintaining established operational procedures, even during the different phases of AATC deployment, can be met by the AATC system. When the AATC system is overlayed control zones can operate under the original fixed block control system, while others operate under AATC control. It is possible for a train to be placed into the BART system in either type of control zone. When the train is in a non-AATC controlled zone the ATC subsystem will revert to the fixed block control system.

The station control zone TDMA networks are all in steady state synchronous operation, with the entire BART system under AATC control. A new train can be added to the system from any possible point. When the VRSs are powered on, they immediately search for a TDMA network, and enter the network if one is present. Entering the network causes the control station computer to provide reporting assignments to each of the train's VRSs. This entire process takes only seconds. When fully implemented AATC will provide an indication to the operator that the train is under AATC control.

As a train transitions from one type of control zone to another, a smooth transfer of control occurs completely transparent, and without operator action. AATC VRSs continuously search for active AATC control zone's and automatically enter the TDMA network. AATC speed commands are transferred to the train's ATC computer, as the AATC control zone is entered and automatically transfers the train's control over to the AATC system. The reverse process then occurs as the train exits the AATC control zone.



Overlay Plan. AATC overlays the BART system with very little disruption.

3. System Installation and Integration

The HMK system elements to be installed will have been tested and qualified for cut-in/cut-over to the BART system prior to installation. Discrete, well defined installation and test tasks of proven effectiveness will minimize impact on existing BART operations.

Compared to current approaches, the use of RF communications in the BART/HMK AATC approach significantly reduces installation cost and time. Minimal construction is required to install the trackside radio network, and no contact with tracks or connections to track signalling equipment are needed except through the ASIC at each station.. This allows non-intrusive overlay and installation of the AATC system without disrupting or interfering with the existing BART ATC system. It also avoids any negative impact to revenue operations.

Demonstrations will be performed on the test track prior to any implementation on any revenue track. Additionally, training and certification of all installation and test personnel will be accomplished prior to any Phase 2 revenue track activity. The proposed approach focuses on "time-defined" cut-in/cut-over tasks, with proven task instructions. The instructions will encompass tools, test equipment and verification procedures to validate and certify satisfactory task completion at cut-in, prior to cut-over. For trackside installations, electrical connection to source power is the only active cut-in/cut-over task required. The table lists the verifications and test equipment for cutting-in/cutting-over wayside equipments.

The retrofit for existing BART vehicles, which can be accomplished in a matter of hours using step-by-step procedures, will be overlapped with current maintenance cycles. This will reduce most of the impact to the train car installation, since the interface controller, radio set and antenna can be easily installed in a matter of minutes once the car has been prepped.

In the control stations, installations are limited to backroom environments and thus will not interfere with passenger services or train operations. Critical station activity is the installation of the Tandem computer and the connection of the interlocking signals to the interface controller. Complete facility preparation will have been performed, and the facilities will be inspected and verified for compliance and readiness prior to installation of any system hardware. All cut-in/cut-over procedures will be proven and certified prior to cut-in/cut-over.

Wayside Cut-In/Cut-Over Tasks	Test Equipment Requirements	Inspection Requirements
Station:		
Trackside:		
Secure and Red Tag Power	None	X
Connect Prepared Power Leads	None	
Cold Check for Opens	Multimeter	
Cold Check for Grounds	Multimeter	
Perform Resistance Check	Multimeter	
Inspect Installation	None	X

Wayside Cut-In/Cut-Over Tasks. Simple cut-in/cut-over tasks only require use of common test equipment to verify installation.

1. The Need to Demonstrate

Transit authorities and regulatory agencies will only accept a new technology after extensive demonstration.

The train location and tracking technology being introduced to transit by the AATC project promises to revolutionize the transit industry. This introduction is being attempted in an industry which, for a variety of reasons, has resisted technological innovations, perhaps more than in any other industry. The primary reason for transit's resistance of technological innovation is the need for safety. The transit industry is one in which the safety of the patrons is held in the highest regard, resulting in a great reluctance to try technologies that are not tried and proven.

Two major considerations drive this conservatism. First of all, the density of patrons on a transit system far exceed other forms of transportation. An accident involving a typical 10 car train on the BART system, for example, would endanger the lives of well over 1,000 people, far more than would be involved in the crash of a major airliner. Secondly, because transit competes with the automobile for patrons, any perception of a less than impeccable safety record drives people to the more convenient automobile. As a result, transit has always resisted technological innovations to safety critical train control equipment. This resistance is well documented in the procurement specifications of almost every major train control equipment procurement which require years of demonstrated revenue operation before any system is considered for purchase.

The situation described above results in a classic case of Catch 22. Transit will not try new technologies until they are demonstrated but transit will also not allow new technologies to be demonstrated because they are unproven. This very problem has prevented transit from benefiting from the many technical innovations available to other industries. The AATC project will attempt to overcome this obstacle with the uniquely qualified team of Hughes, Morrison-Knudsen, and BART.

Successful introduction of the AATC technology requires a carefully planned and implemented program plan. Rushing the process (cutting critical steps) can result in an undesirable conclusion not of benefit to anyone. Accordingly, the HMK/BART team has devised a program that enables the team to proceed carefully, with significant up front demonstrations in environments that pose no risk to the public. Final demonstration, however, will require operation of the system in a full revenue environment to gain acceptance by the transit industry.

Given the above considerations, the program proposed in this application spans four years and is comprised of the phases shown in the table.

DEMONSTRATION IN THE AATC PROGRAM

Phase	Demonstration
Baseline TRP Program	
Phase 1 (12 months)	Proof of concept demonstration at BART's Hayward test track
Phase 2 (17 months)	Initial system demonstration with equipment installed on a limited section of BART's revenue track
Options	
Phase 3 (24 months, beginning six months after Phase 2)	Installation and pre-revenue demonstrations on enough of BART's revenue track to establish operational performance
Phase 4 (12 months)	Revenue demonstration to gain acceptance of AATC by transit industry

2. System Performance Verification - Base TRP Project

The HMK/BART team proposes an orderly, two phase system performance verification program. Utmost care will be taken to assure that the verification process will be carried out in an environment that can have no impact to the safe and proper operation of the BART system.

The base demonstration program will be carried out in two steps. Phase 1 of the program utilize BART's test track where all activities can be carried out with no effect on revenue operation. Phase 2 will occur after the completion of all Phase 1 demonstrations and will take place on BART's revenue track.

During the base program, no demonstrations can be performed which involves the control of trains on revenue track during revenue hours. The control of trains during revenue hours will be impossible because only trains equipped with AATC radio sets can be tracked by the AATC. As a result all verification which requires the control of trains on revenue track will be conducted during non-revenue hours of the BART system when only AATC equipped trains will be operating.

Phase 1 Verification Program – BART owns and operates a 2.5 mile test track located in Hayward, California. All track on the test track is at grade. The test track is physically identical to BART's revenue track and includes a structure in which is housed train control equipment that is identical to that which controls trains on the rest of BART's system. This test track will be the site for all Phase 1 demonstrations.

Prior to functional demonstrations on the test track, systematic on-site integration will be conducted to build confidence in the system. It will begin with unit verification on each individual item after physical installation. Front and rear train communication will then be verified. Demonstration of the ATC operation will then verify that no hazard can result from operation of the AATC equipment. The station and wayside elements will then be integrated to form a network which can be evaluated for proper communications integrity.

During the functional demonstrations on the test track all AATC functions that can be verified with only one station will be verified. Phase 1 demonstrations measure key performance parameters to verify system feasibility and to refine the design with emphasis on safe, reliable operation. Key performance features to be verified include train tracking, speed command selection and communication, fault tolerance, and the systems ability to recover after hardware failures.

Phase 2 Verification Program – The Phase 2 verification program will develop hardware to be installed in two revenue stations and on 10 BART cars. The purpose of the Phase 2 verification program will be twofold. First, all functions that were not verifiable during the Phase 1 demonstration will be demonstrated. Primarily these functions are those that require the interaction between two control stations. Also, as all test track demonstrations were performed above ground, train tracking integrity in tunnel environments will be verified during this phase. The second primary objective of the Phase 2 verification program will be to collect train tracking performance data over an extended period of time to begin developing a statistical basis for assessing the integrity and consistency of the train location algorithms. This verification data will be collected during revenue hours using revenue trains. All AATC equipped trains involved in the demonstration, however, will not be under the control of the AATC but will be tracked by the AATC throughout the duration of this demonstration. About 1,000 trips through the AATC equipped area will be logged during this verification phase.

3. Revenue Demonstration - TRP Project Options

A revenue demonstration is key to AATC's final acceptance throughout the transit world.

Demonstration of the new technology in a passenger-carrying, revenue environment is key to its successful introduction to the transit industry. As discussed earlier, transit has traditionally demanded demonstration before acceptance. This project option, if scaled appropriately, will provide this demonstration. To be effectual, however, the demonstration must be in a passenger-carrying, revenue environment.

The AATC system design requires all trains in the system to be equipped with AATC train radio sets before any trains can be controlled by speed commands generated by the AATC system. To prove the performance and benefits of the AATC system, especially to BART's peer properties, a high traffic density segment of track must be equipped with AATC radios. The HMK/BART team proposes to install equipment from Bayfair station to Daly City station, the highest traffic density section of the BART system. This section of track will be used to demonstrate that the capacity of existing infrastructure can be doubled.

Phase 3, Pre-Revenue Demonstrations – Demonstrations during this phase will be an extension of the data collection activity started during Phase 2 demonstrations. More train cars will be equipped and extensive amounts of data will be collected as equipped trains under the control of the existing ATC equipment are tracked by the AATC system. Due to the safety critical nature of the train tracking function, both BART and the California Public Utility Commission will closely scrutinize the volumes of data that will be collected during this period to convincingly verify that the system will, under no circumstances, fail to properly track every train in the system. This data collection will continue throughout the period when the equipment is being installed on all BART cars and in all stations in the demonstration area. Under no circumstances will trains be controlled by the AATC during this period.

Phase 4, Revenue Demonstration – The importance of this final demonstration phase cannot be overemphasized. During this phase, trains will, for the first time, be operated under the control of the AATC technology during revenue hours. The demonstration will last for 12 months, long enough to expose the system to the rigors of day to day operations. It is to this demonstration that the world will look to pass judgment on the advanced technology being introduced. Issues such as, can the train be safely controlled, or can two trains be operated at the targeted headway will already have been answered during previous demonstration phases. This phase will be a demonstration to answer questions such as:

1) Can the technology stand up to the challenges of day to day operations and the multitude of situations that will occur?
2) Will the technology be accepted by those operating the system?
3) Can such systems be maintained cost-effectively by transit maintainers?
4) Will the public react positively to the increased performance afforded by the new technology?

Such questions can only be convincingly addressed by an extended demonstration phase in a true revenue environment which exposes the system to the heavy demands of a growing and healthy transit system. These in-depth verifications will convince even the worst transit skeptics that AATC meets their needs cost effectively.

1. Creation of Regional Alliance for Project Execution and Management

The regional technology alliance of BART, Hughes Aircraft and Morrison-Knudsen is well qualified to spin off this technology to a successful program and then to a commercially sustainable business. The significant investment and participation of these parties into this product area reflects their commitment to make this endeavor succeed.

The San Francisco Bay Area Rapid Transit (BART) District is a progressive transit authority and a pioneer in many areas of transportation technology including introduction of the original ATC system nearly twenty years ago. BART will supply facilities to allow verification of the AATC system and will actively participate in the AATC development providing both management and engineering. As a public entity BART will serve as the "sponsoring agency." BART is an integral part of the development team, providing critical speed-code-selection logic for the AATC system, guidance on compatibility with the ATC system (vehicle and station), necessary modifications to the vehicle ATC system, and installation of AATC equipment (revenue and test tracks).

HMK is a joint venture formed by Hughes Aircraft Company and Morrison Knudsen to provide advanced technology train control products based on integrated, cooperative ranging and communications. Each company supplies technology, product, facilities, personnel, equipment, tools, and/or transit domain contributions sufficient to the development based on extensive experience and proven state-of-the-art equipment. Hughes and Morrison Knudsen are also "eligible firms and proposers," being U.S. owned and operated firms.

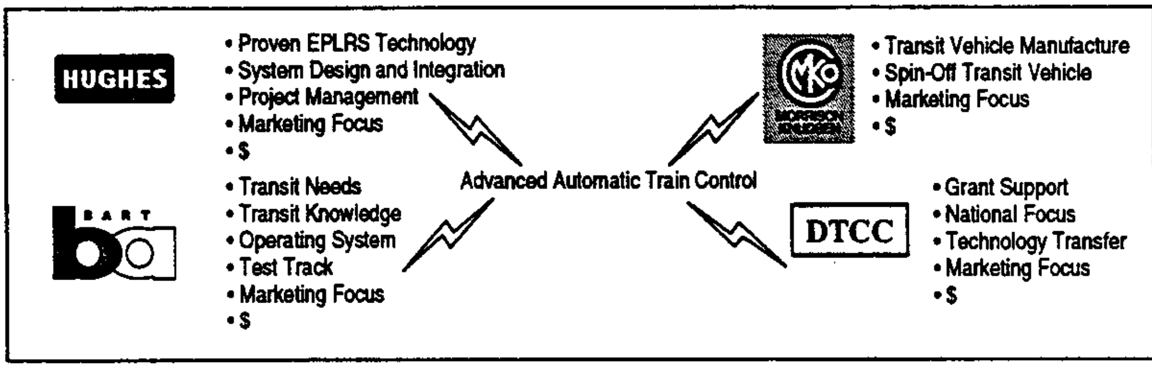
Hughes, a $12.3 billion company and the largest private employer in California, is a leader in the design, production, and support of high technology electronic systems for military, commercial, and scientific use. Hughes will ensure the assignment of AATCS program personnel who are knowledgeable with EPLRS technology and equipment.

Morrison Knudsen, a $2 billion corporation and a recognized leader in the transit industry, has developed and delivered microprocessor based vehicle-borne control equipment which will be integrated into the train product line. With facilities in Pittsburg, CA, MK supplies BART cars and has an understanding of the District's needs. MK will ensure the assignment of AATCS program personnel who are knowledgeable with transit control systems.

BART and HMK are committed to a multidisciplinary, concurrent approach to the development of the AATC system. This is critical to ensure that all technical requirements are met on schedule with the result being an easily manufactured/installed product.

BART, as the sponsoring agency, will operate under a management plan. HMK will provide the technical lead for the alliance and associate program management. A suitable organizational structure in compliance with TRP requirements will be created for implementing the plan.

Each participating teammate will establish detailed plans and schedules consistent with the master program plan and shows interrelationships of major program tasks. The plan is monitored against the milestone schedule and budget associated with each task. Not a part of the Alliance but an important adjunct to it will be small disadvantaged and minority owned businesses in the Bay area that will be utilized to support the conduct of the AATC TRP program.



TRP Regional Alliance. BART is serving as the sponsoring agency.

2. Control of Technical Performance, Cost and Schedule

To manage their programs, Hughes and MK have established tools and techniques as shown in the figure with a goal of achieving uniform reporting while retaining flexibility for controlling projects with varying requirements.

Master Program Plan – The master program plan translates system requirements into major tasks, each associated with a cost, schedule, and expected output. The plan is monitored against the milestone schedule and the budget associated with each task. When deviations from the plan occur, solutions must be generated, reports made to management, and corrective action taken. Each team supporting the program establishes detailed plans and schedules for their major tasks consistent with the master program plan. Detailed planning occurs within the framework of the master schedule which also shows interrelationships of program tasks.

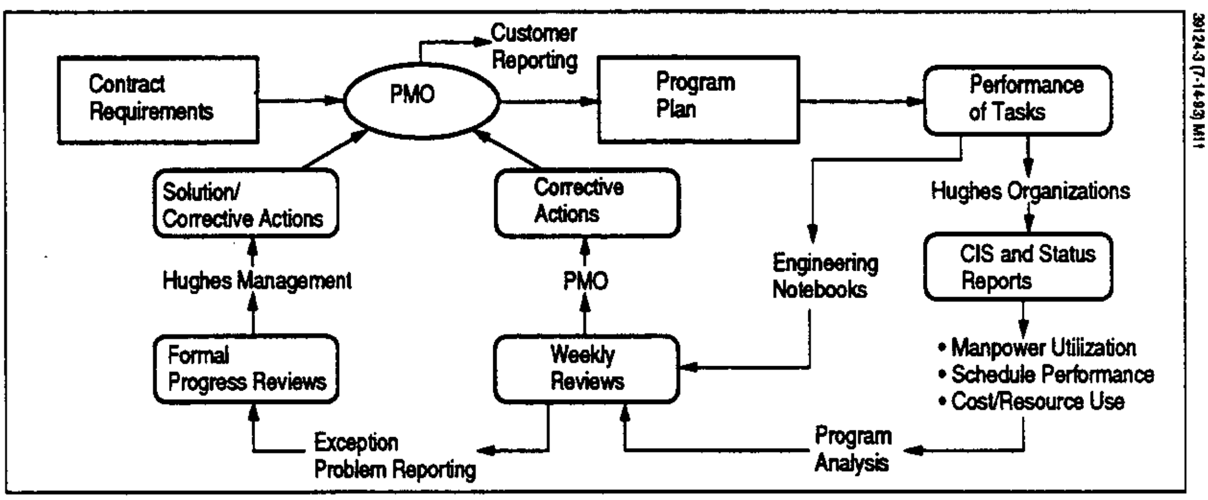
Coordination Meetings – For development programs, the program manager holds weekly meetings for coordination and communication of all aspects of the program. Both HMK and BART will participate in these meetings. To review overall progress and critical items, the HMK program manager also reports weekly to division management and monthly to higher management. Special problems are reported at the required level as they occur.

Cost Information System (CIS) – Hughes' CIS is a uniform system for documenting and tracking the delegation of work, and for recording and reporting actual and planned cost. It allows the program manager to maintain close control over program expenditures and to ensure that planned costs and tasks are on schedule.

Design Reviews – Design reviews, a principal means for controlling a technical design, are a useful tool for the program manager to monitor overall design progress and quality. Attendance at these reviews includes both management and technical representatives from HMK and BART. ARPA representatives will be invited also. Results of each design review are documented and distributed into engineering notebooks to team members to keep them aware of the decisions, results, and any planning or design revisions required.

Informal Meetings – Besides the formal means of communication described above, the program manager engages in numerous informal meetings with working personnel. These meetings provide the best means of imparting objectives and ensuring that project goals are being realized. They also provide feedback to the manager on critical design decisions.

Engineering Notebooks – All design personnel maintain Engineering Notebooks to record the results of their work. These notebooks include analyses, design concepts, block diagrams, specifications, and breadboard test data. This material allows engineering and management to track and critique the design as it evolves. It is available for review by BART and ARPA.



Management Control Loop for AATC. Feedback mechanisms at all levels escalate problems to the level necessary to gain resolution.

1. Dual-Use of EPLRS Technology/Equipment Benefits for U.S. Economy and National Security

The dual-use of EPLRS technology and equipment launches a new U.S. firm capable of competing (potentially dominating) in the transit signaling and communications industry which is almost exclusively serviced by foreign owned companies. Capturing a portion of this market will ensure the capability to design and produce military type communications, position location, positive identification, and related covert RF equipment that will maintain a dual-use capability.

The type of signaling and communications equipment presently being provided to the transit industry is based on decades old technology and currently there are no U.S. owned firms that provide such equipment. Through the use of technology reinvestment project funds, a new U.S. firm can be launched to compete and potentially dominate this global market segment. Reinvesting state-of-the-art military technology and equipment will allow the U.S. to leap-frog the emerging state-of-the-art transit signaling technology and equipment offered by the foreign competition. The capabilities provided by the EPLRS based transit signaling and communications equipment are orders of magnitude greater than that afforded by emerging systems, but at a fraction of the cost. Such performance and cost advantage will not only put the U.S. industry into the transit signaling and communications systems business but immediately propel the U.S. industry into a leading position in this world-wide market. It is estimated that the near term addressable market is about $0.5 billion a year and the competitiveness of the EPLRS based system could potentially capture at least half of this market.

The EPLRS based transit signaling and communications system address the much needed capability for a "moving block" signaling system. As the transit systems are upgraded many are being forced to a "moving block" concept to increase the capacity and utilization of their existing transit systems in order to meet the demands of increased ridership. New transit systems desire to obtain the maximum of efficiency due to budget constraints. The application of EPLRS to this problem will allow the U.S. industry to dominate in delivering the next generation transit signaling/communications equipment and systems. Constituting such a market position will also establish the EPLRS system as the industry standard for the next generation transit signaling systems. Establishing such a position within the transit and aligned industries would ensure economic growth in this segment of the U.S. industrial base and potentially generate overall $1 billion of revenue annually.

Entrenching EPLRS technology and equipment into the transit signaling business will not only maintain the capability to produce EPLRS communication systems for the Army, Navy, and Marines, but also allow for reductions in cost for future equipment buys by the military. In addition, improvements made in the EPLRS transit product could allow for improved capabilities to be provided in the military product as well but at a reduced cost to the government. Producing several hundreds to thousands of transit units on the same production line as EPLRS in a dual-use mode that benefits the military relative to national security since the production capability is maintained without the military having to procure any equipment. In addition the capability is maintained to produce aligned RF military type of equipment for positive situational awareness (which minimizes casualties from friendly fire) and other cooperative/covert/anti-jam RF equipment.

In addition to maintaining a production capability, transitioning the EPLRS technology into the transit industry will also maintain a viable engineering labor force capable of designing the sophisticated RF communications equipment and systems required for military applications. Those engineers who designed and support the current EPLRS system have experience in the analysis, design, and development of secure, anti-jam, covert, and cooperative communications and radar systems and equipment. It is important to maintain such an experience base for future national security and defense needs.

2. Creation of a New Dual-Use Commercial Product Boosts U.S. Competitiveness

The creation of a new dual-use product has highly leveraged cost effectiveness in bolstering the U.S. economy if the product is commercially viable. This cost effectiveness is amplified if the product has broad market segment application and/or allied products can be derived from the application of the new product.

The transit industry signaling market segment is an excellent business entry point for this new dual-use EPLRS based product. There are several related industry segments that could benefit from the same stringent type of communications necessitated by the fail safe demands of the transit industry. Signaling and control functions associated with the commuter rail and freight rail along with buses and the air craft market segments are potentially aligned market segments for this type of new product. The need for military type communications will foster a whole new set of commercial product lines.

All told the EPLRS based transit signaling and communications equipment and systems represent an exciting new product line that should open a whole new world market for U.S. industry. These new products derived from the transitioning dual-use military communication technology should have a significant economic impact. In the transit industry alone, there is some $200 million of imported transit signaling products yearly. The potential exists to export some $300 million of EPLRS based transit signaling products annually providing a $0.5 billion swing in U.S. imports/exports. Once initiated into the commercial market arena the EPLRS type of technology should certainly experience a proliferation into other market segments and applications. This type of proliferation is usually exponential resulting in added economic benefit to the U.S that should provide an export potential in the range of $1 billion.

Dual use of EPLRS is viable in the transit industry which represents a class of potential users of extremely reliable, jam resistant, and secure communications equipment and systems traditionally only provided to the military. This industry, which demands fail-safe operations, must ensure that train operations are provided through equipment that functions with the highest integrity possible. The delivery of train control commands must be timely and accurate. Due to the potential problems of communications interference, EMI, fading, and tampering, the transit industry until now has not embarked upon the use of RF communications as a means of accomplishing train control and operations. Communications in the tactical military environment are only satisfied if the communications equipment and systems provide anti-interference (anti-jam), EMI rejection, security and are able to operate in severe signal to noise environments. Therefore, the application of military style communications systems and equipment to the transit and allied industries is of immense value.

The transit industry also represents a class of potential users that can benefit from military capabilities associated with position location and positive and/or cooperative identification. GPS is of course a good example of dual-use technology and has great application in the transportation market segments. However, there are situations where GPS is not well suited nor applicable, such as in tunnels or where the position update rate is high. In these cases, the position location technology provided by the military EPLRS communications system fills the void.

A very important intrinsic part of EPLRS that is directly applicable to train operations control is the attribute of these systems to quickly determine equipment and communications data failures and take corrective action. These systems and their potential transportation industry counterparts are self-healing relative to the communications network and data providing fail-safe operations. These systems are highly redundant both in terms of equipment and data integrity and are well suited for meeting the high demands of the transportation industry.

3. Creation of Long-Term, High Quality Jobs

The cuts in the defense budget have and will continue to cause a reduction in the trained work force required to implement highly sophisticated military RF equipment. This impact could be mitigated to some extent through the dual-use of EPLRS. Commercializing and proliferating the use of such equipment will ensure that a highly trained work force is maintained and kept abreast of the state-of-the-art knowledge.

The recent cuts in defense expenditures have seen a comparable reduction in the defense industry work force. A similar downturn in defense expenditures occurred in the early 1970's. During that earlier downturn many highly skilled engineers and technicians were lost forever from the defense industry work force. When a subsequent upturn in defense expenditures occurred, a demand for highly qualified engineers and technicians went unmet. It took several years to obtain an adequately trained work force that could meet the needs of the defense industry. So as to not repeat the mistakes made during the early 70's, it seems prudent, to the extent possible, to maintain a viable, highly trained work force capable of meeting the needs of the defense industry and to ensure the national security. To train or retrain such a work force in the future would be more costly and time consuming than that required in the 1970's due to the ever escalating rate of technology change and cost to maintain parity with technical knowledge. On the other hand, it is presently impossible to maintain a standing highly trained work force just for the purpose of meeting the needs of future eventualities.

The challenge then is to maintain a highly trained work force that will be capable of meeting the future needs of the defense industry and at the same time is contributing to the economic strength of the country. The spin-off transitioning of EPLRS for dual-use in the transit and related industries meets this challenge. The new products for the transit and allied industries require highly trained engineers and technicians to design, produce and support these products. As the products proliferate, these and additional highly trained workers will be required to design products that are more and more sophisticated thus allowing the work force to continually advance their technical knowledge and skill. The types of skills maintained and enhanced through the proliferation of commercial EPLRS kind of equipment will allow future analysis, design and production of highly sophisticated communications, radar, position location, and positive identification equipment for the military. It is in the national interest to have such a trained work force to rapidly respond to future defense build up crises.

In addition to maintaining high quality jobs, the dual-use of EPLRS technology, equipment, and systems will also potentially foster the creation of a large number of high quality jobs. It is estimated that the number of jobs that could be created by capturing only a fraction of the transit industry signaling market is in the range of 400 to 1800 jobs. Capturing a larger portion of the market or expanding into related market areas could potentially more than double these numbers.

HMK fully support the Small Disadvantaged Business (SDB) and Disadvantaged Business Enterprise (DBE) programs with the federal and local governments. Although a SDB/DBE qualifying firm is not a participant in the alliance, there are specific goals for awarding a percentage of the subcontracted effort to qualifying firms in accordance with the BART competitive procurement. HMK has been actively recruiting firms in the Bay Area to support this project through solicitations for quotes and personal visits. In addition, Hughes Aircraft Company has entered into a formal mentor-protégé relationship with a federally qualified 8(a) firm for manufacturing services.

In addition to maintaining and expanding the number of high quality jobs related to the primary product, there would also be a maintenance and expansion of capabilities associated with sub-tiered suppliers that can and would be exploited for other uses i.e., different communications media such as satellite, or even radars. These capabilities would, in their own right, foster creation of high quality jobs.

4. Program Impact on Environment, Safety and Performance

Implementation of AATC reduces the cost of building new transit infrastructures and doubles the ridership capacity over existing transit lines. These benefits potentially result in an attractive alternative to travel by automobile. Any reduction in automotive traffic has a positive impact on the environment and improves transportation safety. Sponsoring the development of the HMK train control system will have a significant effect on the local environment in San Francisco and safe regional mobility over the term of the project.

Automobiles, because of their large numbers, are the primary producers of EPA criteria pollutants--those effluents targeted for reduction. Therefore, the objective is to limit the use of automobiles by offering more efficient alternatives; achieving this goal is particularly important in California, the most environmentally sensitive state in the United States.

In order to lure automobile drivers out of their vehicles, a need exists to establish new transit infrastructure and increase the capacity of existing transit systems. The problem with establishing new infrastructure is the prohibitive cost. Although the AATC system will not ameliorate the cost-prohibitive nature of putting in new transit systems, it does significantly reduce the cost of the train control subsystem. AATC reduces by about two-thirds these costs, which are in the range of $3-5 million per mile. AATC can more than double the passenger carrying capacity of existing lines. As a result of reducing the cost of building new transit infrastructure, there will be greater potential to build more transit lines in congested cities like Los Angeles where few transit alternatives exist. As a result of more than doubling the capacity over existing transit lines more passengers will be willing and able to use transit as an alternative to automotive transportation. Implementation of AATC has the potential of significantly reducing environmental pollutants associated with the automobile mode of transportation.

The AATC system at BART will demonstrate a system that nearly doubles throughput on existing infrastructure. Constructing additional lanes for automobiles would be far more expensive since the only alternative would be add bridge capacity or build a tunnel for automobiles--a solution that would be required to alleviate BART's congestion through the transbay tube if AATC were not employed. A solution that builds new infrastructure is cost, however adding more highway capacity is the wrong solution when considering the United States' goals of improving air quality in the major urban areas, reducing dependence on foreign sources of energy and improving the use and performance of rapid transit systems.

Improved safety is another benefit achieved by sponsoring the development of the AATC system. The AATC system will offer very high safety performance with a projected mean time between hazard of 10^9 hours. When compared to automobile travel, train travel is typically much safer on a passenger mile travel basis or on the basis of fatal injuries per hour. It is curious that rail transit has resisted automation which typically improves safety by avoiding human error. The improvement to rail safety induced by AATC should be similar to safety improvements brought about by automation in air transit years ago.

Benefits to the United States will be significant if the HMK system becomes successful. Other cities struggling with situations comparable to San Francisco. For example, New York City has air quality problems and is constrained by the geographic boundaries (East River, the Hudson river and New York harbor). New York has many more alternatives available to motorists in that there are several tunnels and bridges under/across the rivers. Once the capacity of the present railway tunnels is reached, however, more motorists will be induced to drive personal automobiles instead of using transit. Meeting BART's future demand for passenger capacity will keep people using transit and driving less. This in turn has substantial impact on energy conservation and the quality of the environment. This supports the United States' goals of reducing dependence on foreign petroleum imports.

1. Market Viability

The market for the Advanced Automatic Train Control (AATC) system is projected to grow in the medium term with a window of opportunity for a new supplier three to five years from now. HMK has developed a business plan responsive to the opportunities available for which the TRP project is the first step.

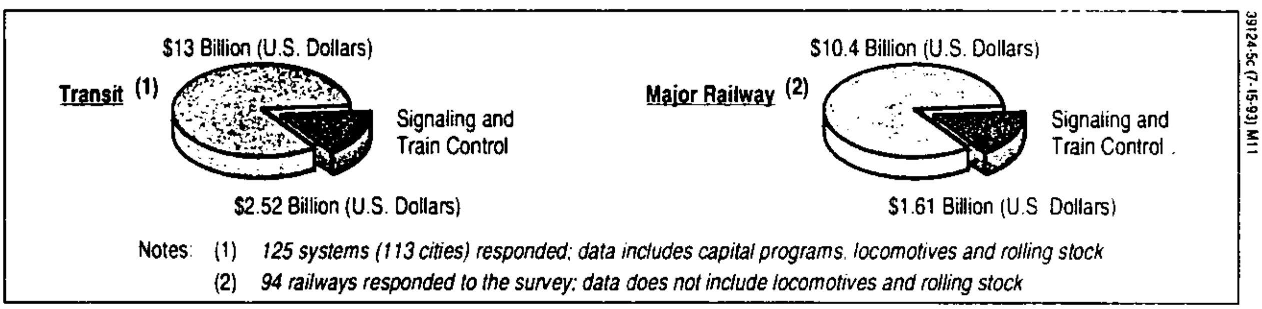
Because of its inherent ease of installation, comparative lower cost and flexibility to meet future demand, the AATC development program offers greater potential in the long term than competitive and existing systems to satisfy customers in passenger transit, freight rail transport, intercity passenger rail, high speed rail, and MAGLEV.

As shown in the figure, the existing train control market is substantial. Based on a survey published in **The International Railway Journal: World Railway Investment**, the 1993 international signaling and train control market in transit is at least U.S. $2.5 billion, or nearly 20% of total expenditures of those surveyed. Furthermore, the survey of major railways indicates 15% of allocated expenditures are earmarked for signaling capital programs. The survey represents a large data set as 125 transit systems in 113 cities and 94 railways throughout the world responded.

The future train control market is a multi-billion dollar market worldwide. In the U.S., transit agencies allocate significant portions of capital improvements to train control. Likewise, major freight carriers spend considerable money on advanced communications technology and signal maintenance. The primary difference between the transit market and the freight railroad market is one of demand. Passenger transportation is characterized by high service levels meaning high train frequency requirements while freight transportation is characterized by less frequent, long trains that operate within one 1.5 to 2 mile train block. In the medium-term, high speed rail will open another business area for the AATC system, while in the long-term, magnetic levitation technology and the U.S. Class I freight railroads represent a large customer base (see table).

POTENTIAL CUSTOMERS FOR THE AATCS TECHNOLOGY

Time Frame	Asia	North America	Europe
Near Term 1994-1998	Hong Kong Japan Rail	NYCTA, New York City TTC, Toronto	London Paris Metro Deutsche Bundesbahn, Germany
Medium Term 1999-2003	Bangkok, Thailand	SEPTA Amtrak, NE Corridor NJ Path Long Island Railroad WMATA, Washington MARTA, Atlanta	Deutsche Bundesbahn, Germany TGV France British Rail Southern Region
Long Term 2004 and Beyond	Singapore Seoul, Korea Taipei, R.O.C.	Santa Fe Railroad CSX Union Pacific Los Angeles-Las Vegas MAGLEV	Continuing System Development



1993 Train Control Market. The International Railway Journal: World Railway Investment in 1993.

2. Business Plan and Growth Projections

TRP funding will enable HMK to successfully demonstrate and prove the workability of the AATC system by 1996. At that time, the market will be growing rapidly allowing HMK to proceed with its business entry strategy by providing a sustainable commercial venture.

A successful new product launch must be planned comprehensively to be successful. HMK and BART offer a unique team to accomplish the final step in the plan to complete this product development. Since the transit industry is cautious in adopting technology that is unproven in service operation, the TRP project presents the only opportunity to develop industry confidence in the product prior to offering the AATC system as a fully operational system. BART's pursuit of advanced train control technology, through attending conferences, and soliciting proposals from prospective suppliers, has confirmed that the capabilities and technology of the AATC system will be unique.

HMK has developed a detailed business strategy for achieving success in this market. The first step is to establish the confidence of the industry through a successful TRP project and sale of a full demonstration system to BART. In order to accomplish this, HMK has devoted a very experienced management team to this project, with some of the best rail and communications technology project management expertise available in the United States. BART is equally committed to this technology, and possesses some of the best technical expertise in the transit industry to bring to bear on such a challenging program.

A detailed communications plan is necessary to develop confidence in the performance of the AATC system. During the TRP project, HMK plans to disseminate at regular intervals information concerning the progress of the demonstration program. Several sources include the American Public Transit Agency, the American Association of Railroads, IEEE, etc. HMK and BART intend to host site visits by representatives of other transit properties, Federal officials or private sector corporations interested in the program. Site visits at BART are currently commonplace, so BART is experienced in managing the process effectively. By implementing a detailed communications plan HMK will achieve the objective of making the industry comfortable with the technology through awareness of its performance. When the proposed TRP project is completed in 1996, a viable, competitive commercial product will exist that many customers will consider in their strategic planning for the next century.

The business strategy developed by the HMK accomplishes several objectives:

- Partnership with BART initiates entry into a challenging industry and provides credible demonstration partner with whom to complete development
- TRP project supports challenging entry by providing funding and visibility that is essential for HMK to instill confidence to BART's peer properties (transit authorities)
- HMK management plan during demonstration addresses promotion of system within industry through site visits, articles, technical presentations and BART's experience
- U.S. Industry gets fully demonstrated train control system that can enter and potentially dominate the world market.
- Future market growth supports notion that a sustained commercial enterprise can be created around this core technology
- Project growth scenarios predict <u>addressable</u> market of $1 billion annually beginning in 1996. The capturable revenue flow from this market should involve sustainable 400 to 1800 jobs in the high-technology sector through the year 2005 (the product cycle).
- Transit industry receives the next generation train control system capable of doubling throughput on existing infrastructure and reaping numerous environmental benefits.

3. Commitment to Productization Dependent on Successful Demonstration

Provided TRP funds are awarded for this project, HMK is committed to carrying through product development until a commercially viable product is available to transportation industry customers.

HMK has demonstrated a significant commitment to providing the AATC system as a commercial product for the transportation industry. In fact, during 1992 and 1993 HMK conducted preliminary demonstrations of various AATC system components at BART to gather data on radio range, position resolution and multipath wave propagation along with trainline communications. Although the market growth for this technology is favorable, suppliers of transportation equipment must prove in-service operation of systems to convince customers that the technology is valuable and is reliable.

The transit industry – the primary market driver in the near term—historically makes commitments to new technology cautiously. The public transit industry in the U.S. is heavily subsidized to meet operating expenses, and it does not have substantial funding available for capital programs. As publicly funded agencies, transit operators are frequently "in the news" for many activities – initiatives with both favorable results and, unfortunately, embarrassing outcomes as well. Therefore, investments made in any system are planned to minimize risk. This industry characteristic forces the suppliers of high cost transportation equipment into a challenging position. Experience with products becomes a more important market driver than technological innovation because experience yields higher levels of technological maturity and less uncertainty in system performance. It is not uncommon for a proven system design for a high cost/high value-added capital purchase to enjoy a long product cycle—possibly lasting ten years or more before significant re-engineering.

The HMK system is not a commercially viable product until the first customer purchases the system. The first customer will not purchase the system at its current development level because the system is unproven and it would be irresponsible in the public sector to take such high risks, if other options are available. Likewise, HMK cannot feasibly run a favorable demonstration that instills confidence in the industry without an industry partner that will testify to other industry members that the system operates effectively. BART is the ideal partner/participant in this program because BART has a substantial demand for the technology and is/has been the technological innovator in the industry. If HMK were to fund development of the program internally and arrange verifications on test tracks, the system development costs would be insurmountable and the confidence level in the system would still not be sufficient to drive the market to the HMK technology. Technology reinvestment project funds effectively reduce the hurdle to enter the business, accept the risks, demonstrate the system comprehensively and complete product development.

The proposed TRP project provides the opportunity to transfer a military technology for use in the commercial sector. The military industries are heading for a no-growth cycle, if not an industry consolidation. If this project is successful, HMK will be ready to enter the train control market and will re-engineer the system to meet the transit industries requirements. Indeed, some of that re-engineering may occur during the demonstration work at BART.

BART, as sponsoring agent in this project, will be the first customer of the HMK AATC system in 1996 - three years from now. HMK will be then be in position to offer the product to other customers and will then be able to cite service operation data to facilitate product sales. HMK would maintain the dual-use capabilities of the base system (EPLRS), but innovations in the transportation application would be transferable to the military application. By 1996, HMK will be able to begin to bid competitively for numerous profitable signaling projects that are commercially sustainable through the end of the century and beyond. What is most important is that sponsorship of this program by TRP would preserve the technical expertise and manufacturing capability in the Unites States military-industrial complex and improve productivity in the transportation sector through increased capital asset utilization.

1. Overview of Multi-Year Project

BART/HMK has a master work schedule that capitalizes on a tight-knit team familiar, from prior efforts, with the requirements and technologies needed for the AATC Program.

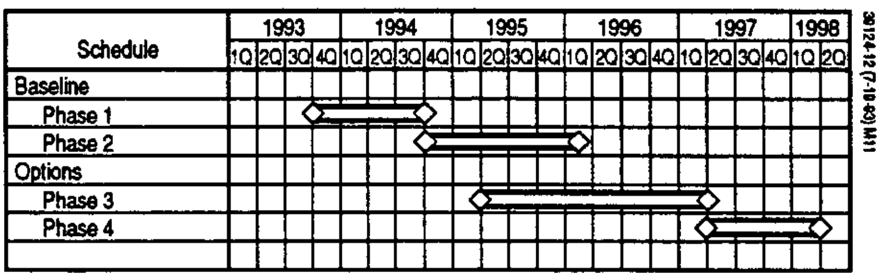
In approaching the AATC Program, BART and HMK are drawing on the same personnel who worked on AATC design and demonstration activities during the past year and have thus learned valuable lessons through firsthand experience. Consequently the proposed AATC overview schedule shown in the figure is aggressive, capitalizing on design and test efforts completed in the past year. It offers a two-phased baseline program with demonstrations concluding each phase. It also offers two options.

Phase 1 of the baseline program extends over twelve months, beginning with preparation of team Work Authorization Documents during the first two weeks to establish the work to be performed by each of the program's partners. During the first ten months, design modifications (hardware, software and firmware) will be completed, radio sets and controllers fabricated and tested, and subsystems (tracksides, stations, and vehicles) assembled and tested. Phase 1 concludes with installation and demonstration of these subsystems at BART's test track. Regular technical interchanges and data reporting provide ARPA visibility into program progress.

Phase 2 of the baseline program commences upon successful completion of the Phase 1 demonstration and lasts for seventeen months. Upgrades of Phase 2 equipment will begin immediately so that all radio set and controller fabrication can be completed in ten months. During a subsequent period of five months, these units will be tested and combined along with TANDEM computers and trainline communicators into trackside, vehicle and station subsystems. Preparations for installation at the Fruitvale and Lake Merritt stations will begin six months into Phase 2 and will conclude with the complete installation of tested subsystems fifteen months from Notice to Proceed. The demonstration will begin as soon as the Fruitvale installation is complete and will continue for at least two months to permit sufficient data gathering.

One option to the baseline program (Phase 3) will provide AATC equipment to build out enough of BART's M-line and A-line (eight additional stations) to demonstrate a 90 second headway through the TransBay Tube. In addition, the rest of BART's fleet of contract cars will also be equipped. This demo system will be available to potential customers from transit authorities worldwide.

The other option (Phase 4) will extend for twelve months beyond completion of Phase 3. During this phase, BART will gather data on the performance of the AATC system as it operates along the revenue track. The extended verifications in this phase will win this system acceptance with other transit authorities and regulatory bodies.



BART Master Schedule

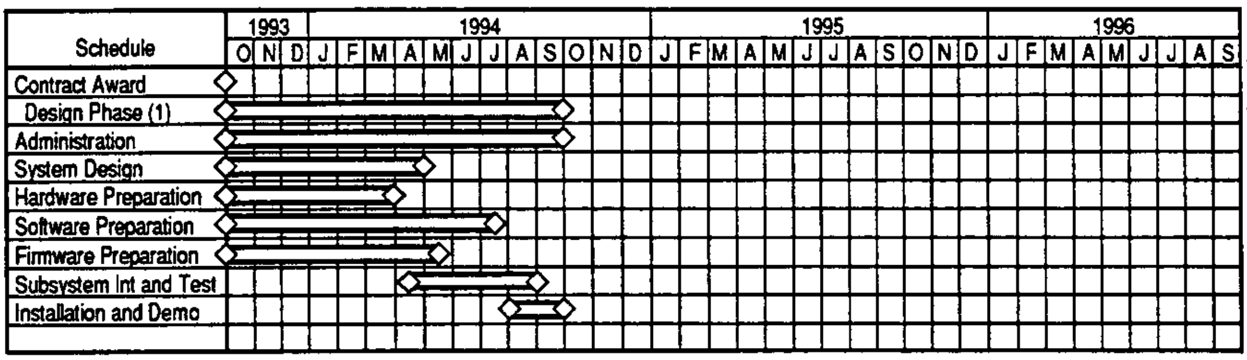
2. Phase 1 Schedule and Critical Milestones

The experience from prior demonstrations at BART, and the availability of existing EPLRS equipment designs are keys to successful execution of the Phase 1 demonstration.

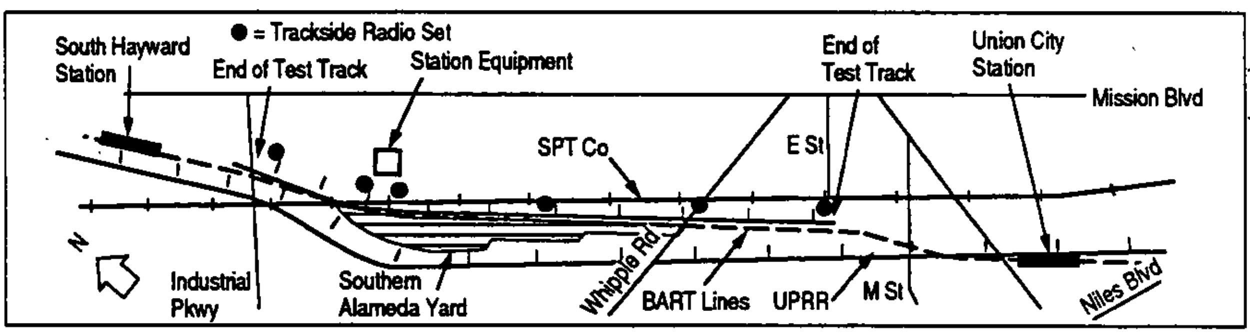
After initial demonstrations at 400 MHz in August 1992, two questions were raised about the proposed radio network design. First, can the equipment achieve needed performance levels when operating at 2.4 GHz. The first question was answered positively when the February 1993 demonstrations (at the tunnel test track), yielded better results than expected. Second, is the equipment mature enough? The second question was answered positively as the February demonstration units provided design criteria for subsequent modifications. While the demonstrations showed that 400 or 900 MHz are not suitable operating frequencies in BART's tunnels, 2.4 GHz is.

HMK has been preparing for Phase 1 since completion of these demonstrations. Most of the thirteen radio sets needed for Phase 1 will be borrowed from existing stocks of EPLRS Units. The converter/amplifier module and antenna proven during the February demonstrations will be upgraded. A new serial interface module which replaces an expensive cryptographic module, is being designed. Design of the controllers will be done by Morrison Knudsen simultaneously with Hughes' modification of radios, based on a similar locomotive controller. Control station software and radio set firmware developed on EPLRS are tailored for the AATC application. Both will use a series of incremental releases to support radio and subsystem integration and test.

After integration, each subsystem will be installed at BART's test track. Phase 1 station equipment will be installed in the test track control room, as existing power and cooling there are adequate. Wayside radio sets will be installed at the six locations shown below to obtain complete coverage. HMK will install radio set antennas on vehicles, with the vehicle radio set and ATIC placed on the floor of the car using temporary cables to supply power and interfaces to the 3-ATP units and trainlines. System verification and final demonstration will then occur.



AATC Baseline Phase 1 Schedule



Location of Trackside Radio Sets Along Test Track. The six radio sets will be pre-assembled at Hughes for delivery to the sites.

3. Phase 2 Schedule and Critical Milestones

The proposed Phase 2 schedule builds upon the accomplishments of Phase 1 to demonstrate the AATC system over the most challenging portion of BART's system.

BART has opted in Phase 2 to install equipment in a subset of the control zones. The zones selected, Fruitvale and Lake Merritt, cover all track configurations encountered at BART - aerial, grade and tunnel. Lake Merritt offers a variety of divergences, convergences and transition zones with more challenge than other portions of the M- and A-lines. Thus, the Phase 2 demonstrations offer an accurate indication of AATC success systemwide, as desired by BART.

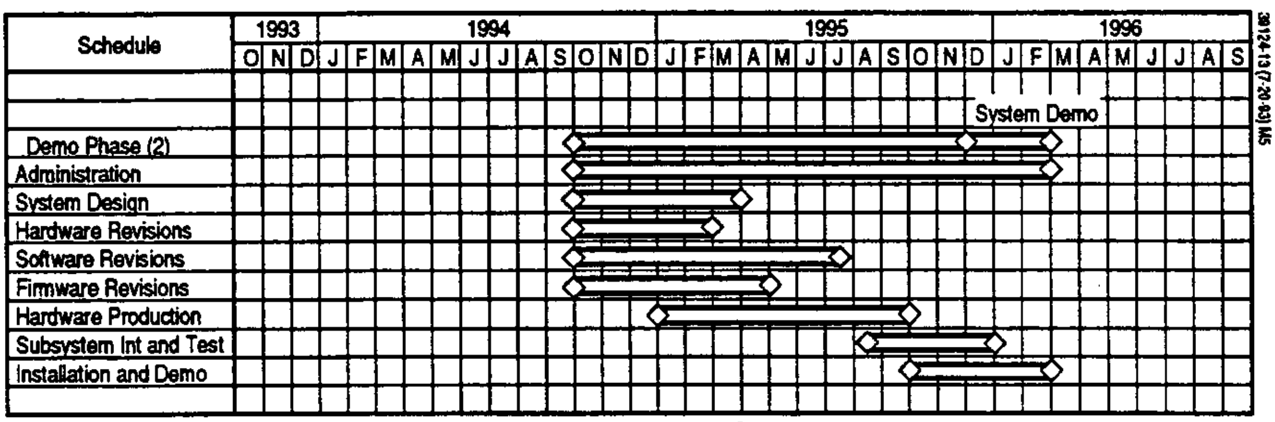
A substantial number of radio sets (40) and controllers (12) will be built in a short time to support installation along this section of the BART system. Long lead parts will be ordered upon initiation of Phase 2. Certain components of the radio sets and the enclosures will be borrowed from existing stocks and replaced later. This permits an initial five radio sets to be built and tested within one year and a total of forty in fourteen months (see figure).

Both software and firmware will be upgraded as preplanned in Phase 2. All firmware changes will be available for insertion in Phase 1 radio sets and controllers. These changes will be verified in the first Phase 2 fabricated units. Software upgrades will be available to support tests of the first suite of control station equipment. Both schedules, software and firmware, accommodate incremental releases to support Phase 2 test schedules.

As they emerge from fabrication and test, hardware items will be integrated into trackside, vehicle and station subsystems. Trackside subsystems, essentially radio sets with mounts and antennas, will be integrated at Hughes. Radio sets, the station controllers from Morrison Knudsen and two purchased TANDEM computers will be configured into two station subsystems at Hughes. Radio sets and antennas will be delivered from Hughes and vehicle controllers produced at Morrison Knudsen to support vehicle subsystem integration at BART.

To support rapid installation of Phase 2 equipment, preparations begin before subsystems are available. Site surveys at Fruitvale and Lake Merritt stations take place, including possible demonstrations with Phase 1 equipment, five months prior to installation. Based on these site surveys, layouts with locations for wayside radios and station subsystems are drawn up. Preparations of the chosen sites, particularly in tunnels, will begin prior to installation because of the restricted hours available for installation. All equipment installed in Phase 2 is deliverable.

Station installation will also include some site preparation but, except for radio set placement, it will occur as an integral part of the installation itself, since work hours are not severely restricted in these areas. The Fruitvale control zone should be running first, permitting limited, but valuable, demonstrations to start. The Lake Merritt control zone will follow a month later, permitting system demonstrations like those involving handoffs. Vehicle preparations also begin prior to subsystem availability so that the ten cars designated by BART can be accommodated during their maintenance cycles as convenient for BART. Demonstrations of elements of the Phase 2 subsystems will occur at the test track prior to any activity on the revenue tracks.



AATC Baseline Phase 2 Schedule

4. Statement of Work

For both phases of the program, BART and HMK have formed teams to address the major tasks supporting AATC system design, development, integration, installation, demonstration and test.

For the baseline program (Phases 1 and 2) the following major tasks will be accomplished by the corresponding teams in accordance with the schedule provided in Topic 3.1.

Systems Design – BART/HMK shall architect and specify AATC system, subsystems and equipment designs. BART/HMK shall perform related analyses and modelling.

Hardware – BART/HMK shall design, develop, fabricate and test radio sets and controllers for use in AATC subsystems.

Firmware – BART/HMK shall design, code, integrate and test radio set firmware and controller firmware.

Software – BART/HMK shall design, code, integrate and test control station software.

Systems Integration and Test – BART/HMK shall integrate hardware (developed and purchased) into vehicle, station and trackside subsystems and shall test these subsystems.

Installation – BART/HMK shall install AATC subsystems to support demonstration.

Demonstration – BART/HMK shall plan, conduct and report on the demonstration of the AATC system at the BART test track.

Hardware Implementation – BART/HMK shall produce radio sets and controllers and procure other items necessary to support the demonstration at Fruitvale and Lake Merritt stations.

BART/HMK shall manage, coordinate and report to ARPA upon the Phase 1 program and provide technical guidance and support (safety, reliability, quality, configuration and data) to the participating teams.

Phase 1 deliverables include quarterly status reports, a final technical report and the demonstration. Phase 2 deliverables include quarterly status reports, a final technical report, the demonstration and subsystems installed in the 2 control zones and on the 10 rail cars. Preliminary and Final Design Reviews shall be held at Hughes' or BART facilities.

For the options, the following major tasks will be accomplished in accordance with the schedule provided in Topic 3.1.

Hardware Implementation

- Vehicle Equipment – BART/HMK shall implement radio sets (256) and controllers (256) for the rail cars.
- Trackside Equipment – BART/HMK shall produce radio sets (96) for the trackside units.
- Station Equipment – BART/HMK shall produce and procure control station equipment (8).

Integration/Demonstration

- Zone Acceptance – BART/HMK shall demonstrate and buy off control zones (8) from HMK.
- Test Equipment – BART/HMK shall design and develop test equipment for AATC.
- Engineering Support – BART/HMK shall provide engineering support to assist with fabrication problems and system demonstration after zone acceptance.

Installation

- Planning – BART/HMK shall plan for vehicle, station and trackside installations.
- Vehicle Equipment – BART/HMK shall install the vehicle equipment in BART rail cars.
- Trackside Equipment – BART/HMK shall install trackside equipment along the tracksides.
- Station Equipment – BART/HMK shall install station equipment in the control stations.

District Expenses – BART effort shall include design and integration/demonstration support, installation and operation of the BART system during Installation and demonstration test.

Administration – BART/HMK shall manage, coordinate and report to ARPA on the options and provide technical support to the teams.

Deliverables in the option include equipment for 256 vehicles, 96 trackside units and 8 stations, test equipment spares and technical interchanges.

5. Critical Milestones of Optional Phases 3 and 4

Two options to the baseline AATC system build upon accomplishments of Phases 1 and 2 to complete enough of BART's M-line and A-line for revenue operation.

Once AATC system operation is proven, an opportunity exists to produce additional units on the same assembly-line to meet BART's headway reduction needs. The first option (Phase 3) provides AATC coverage for BART's A and M lines and 256 rail cars.

At the completion of Phase 3, BART would be the first revenue user of the AATC system. This phase will provide 8 additional AATC-equipped control stations and 256 AATC-equipped rail cars so that all trains are AATC capable allowing BART to keep the AATC functional 24 hours a day and to capitalize on the benefits of the system.

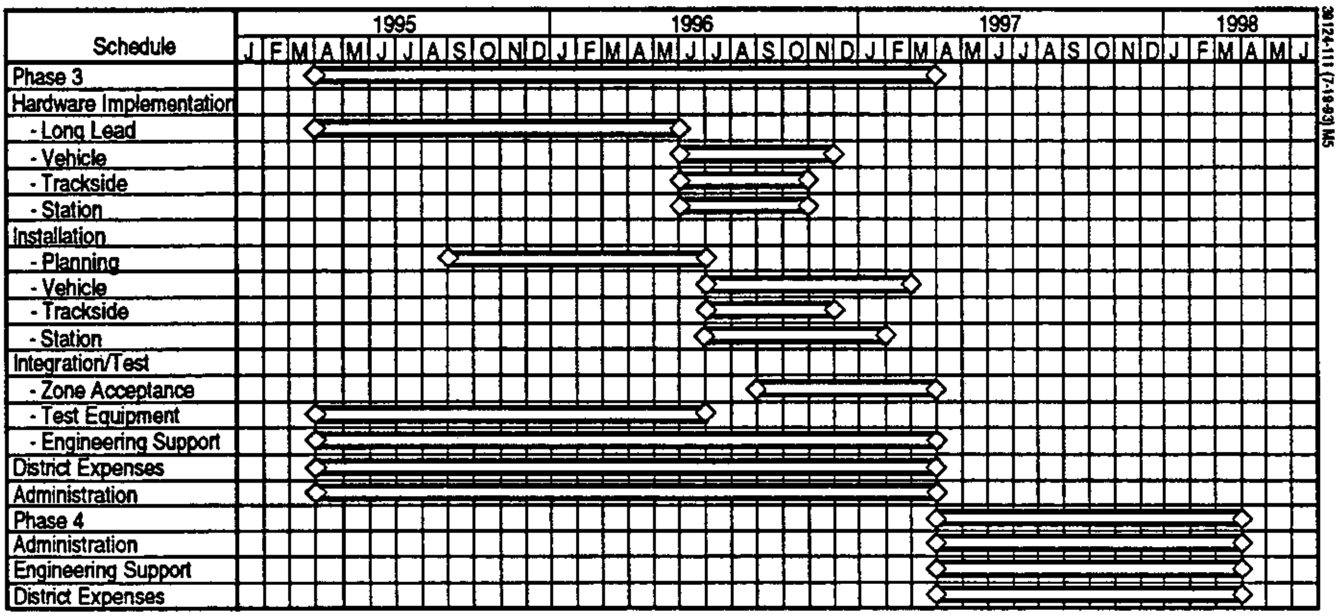
Phase 3 entails fabrication of radio sets and controllers at a modest rate of 70 per month. To accommodate radio set and controller fabrication, long-lead parts are ordered six months after the start of Phase 2. This approach permit radios sets and controllers to start rolling off the line fourteen months into Phase 3 and to reach peak rate three months later. This is a reasonable fabrication rate to obtain the 410 radio sets and 266 controllers required.

To minimize the impact on BART's operations, vehicle installation will occur at five sites (Pittsburg, CA and the four maintenance yards) in assembly line fashion with a rate peaking at 2 cars per day. Cars can be shuttled to and from the installation site at night. To speed up installations, components will be kitted and prepwork (bracket and cable installation) done during routine car maintenance.

For trackside equipment, site surveys will also be accomplished for the eight control zones so that selected sites may be prepared early. This approach facilitates installations in work areas available only for limited periods. Planned trackside installations during a five-month period average one per weeknight. Two station subsystems are installed each month.

Regular reviews (preliminary and final design reviews, first article configuration item, and safety certification), and data reporting allow good visibility into program progress. System supportability now assumes a major role, as BART begins to maintain AATC equipment.

The second option, Phase 4, gives BART an opportunity to run the installed AATC system long enough for the industry to gain confidence in it. Sufficient data will be logged during this period to gain additional confidence and track record regarding all aspects of equipment performance. During this option, supportability of the system will also be verified.



BART AATC Options Schedule

Para #	Requirement Title	Page#*
A.1.1.1.a	Technical quality and merit.	2.a-3, 2.b-1, -3, -4; 2.f-1
A.1.1.1.a	Comparison and contrast with others to assure non-duplication.	2.g-2
A.1.1.1.b	Feasibility consistent with proposed cost.	2.a-5, 2.c-1, CP 3
A.1.1.1.b	Knowledge and appreciation for areas of technical risk.	2.a-5, 2.c-1, 2.c-2
A.1.1.2.a	Clarity of technical objectives	2.a-3, 2.a-4
A.1.1.2.a	Quality and coherence of the technical plan	2.b-1, -3, -4; 2.c-1, -2, -3; 3-1, -2, -3, -4
A.1.1.2.a	Project plans based on well-defined objectives, milestones and deliverables.	2.d-1, -2, -3; 3-1, -2,-3, -4
A.1.1.2.b	Quality and appropriateness of the technical staff assigned.	2.e-1, 3-1
A.1.1.2.c	Management plan addresses the need for facilities, equipment, design and manufacturing tools and other technical, financial and administrative resources to accomplish objectives	2.e-1
A.1.1.2.d	Protection of intellectual property by the participants.	2.e-2
A.1.1.3.a.i	Compelling Benefits - Creation of new firms and of long-term, high quality jobs.	2.f-1, -2, -3; 2.g-1, -2
A.1.1.3.a.ii	Compelling Benefits - Viability in a commercial market for a technology developed for defense purposes.	2.f-1, -2, -3; 2.g-1, -2
A.1.1.3.b	Health, safety and environmental hazards reduction.	2.f-4
A.1.1.3.c	Apply critical technology research and development to advance the national security interests of the U.S.	2.f-1
A.1.1.4.a	Commercially sustained within 5 years, without Federal funding.	2.g-3
A.1.1.4.a	Need for Federal funding to initiate activity.	2.g-3
A.1.1.4.b	Effectiveness of the participants in similar kinds of activities.	2.a-5, 2.e-1
A.1.1.4.c	System-integration and multidisciplinary planning.	2.d-2, -3, 2.e-2
A.1.1.4.d	Structure of the activity-Participants possess necessary skills and offer the appropriate financial involvement for achieving subsequent productization.	2.e-1, -2
A.1.1.4.d	Participation of Federal, State, local, private, and nonprofit entities and institutions of higher education.	2.e-1, -2
B.3	Regional technology alliance has one or more eligible firms that conduct business in the region of the U.S.	2.e-1, -2
B.3	Regional technology alliance has a sponsoring agency, an agency of a local government.	2.e-1, -2
B.3	Sponsoring agency of an alliance shall operate under a management plan.	2.e-2
B.3	50% maximum DoD funding for 6 years maximum.	CP 5
B.3	Sponsoring organizations will meet financial requirements.	CP 8, 9, 10
B.3	Sponsoring organizations will provide management assistance.	2.e-1, -2
B.3	No construction or renovation of facilities.	CP 3
B.3	Use or license the results (<half of the participants) fully funded by non-Federal Governments.	2.e-2

* Page numbers are for Technical Proposal unless indicated with a CP (for Cost Proposal page number).

TRP Cover Sheet 1: Proposal   Technical [ ]   Cost [X]

FOR TRP USE ONLY. DO NOT WRITE IN THIS SPACE

1a. Proposal Title:
Advanced Automatic Train Control (AATC) System

1b. Activity:	1c. Program:	1d. Technology Focus Area and Specific Topic:
Dual-Use Development	Regional Technology Alliance Assistance Program	Vehicle Technology - Sensors and Electronics for Vehicle Systems

2. Point of Contact	4. Names, Organizations, and % Time Commitment of Key Personnel
2a. Name and Mailing Address of Contact: Frank J. Wilson BART/HMK Alliance 800 Madison St. Oakland, CA 94604-2688	4a. Eugene I. Nishinaga, BART/50% 4b. John A. Evans, BART/100% 4c. Marvin D. Swensen, Hughes/50% 4d. James A. Kivett, Hughes/80% 4e. Dr. Fred E. Templeton, Morrison Knudsen Corp./30%
2b. Telephone Number: 510-464-6060	5. Names of Key Organizations Participating
2c. Fax Number (if any): 510-464-6009	5a. San Francisco Bay Area Rapid Transit (BART) District, Frank J. Wilson, General Manager [signature]
2d. E-Mail Address (if any):	5c. Hughes Aircraft Company, L.K. Brajkovich, Group V.P. [signature]
2e. Type of Business (SIC Code or other description):	5e. Morrison Knudsen Corporation, F.E. Templeton, V.P. [signature]
3. Federal Government Cost	6. Matching Funds over Base Period
3a. Base Cost and Duration (months): $19,575,000/29 months	6a. Cash ($): $11,951,000
3b. First Option Cost and Duration (months): $32,207,000/24 months	6b. In-Kind Contributions ($): $7,624,000
3c. Second Options Cost Duration (months): $0/12 months	6c. Types of In-Kind Contributions: Asset Rental/Technology Royalties
3d. Base Period Match Percent Represented by TRP Funds: 50%	6d. Total Matching Funds ($): $19,575,000
7. Does This Proposal Involve Participation by Foreign-Owned Organizations? YES [ ] NO [X]	8. Identify (if any) any Federal Agency or Entity that was Instrumental in Formulating the Proposal Idea, Team, or Approach: Federal Transit Administration (FTA)

ABSTRACT

A BART/HMK (Hughes Aircraft Company, Morrison Knudsen) team proposes to develop an Advanced Automated Train Control system by conversion of existing defense command, control and communications technology. This team brings together a progressive transit agency, the pre-eminent American defense electronics supplier, and the only remaining American rail car manufacturer to address a rail transit market long remiss in incorporating advanced electronics. Investment in the Enhanced Position Location Reporting System, which supplies the primary technologies for this conversion, exceeds 250 million dollars. This prior investment offers a significant hurdle to competitors interested in bringing similar technology to the market.
The system offers revolutionary improvements in rail transit performance and brings sufficient flexibility to support a variety of future upgrades. Its scope is sufficient to encompass a global market. During the past year, BART and HMK have performed feasibility tests with success beyond expectations. Because the product's potential market exceeds $200 million annually, BART/HMK is now proposing that ARPA participate in its development to partially defray the remaining investment. The development is split into a two-phased baseline program and two options for equipping a portion of BART's revenue track as a testbed and for demonstrations to other transit authorities.

5/14/93

TRP Cover Sheet 2: Proposal Participants

(Use as many copies as necessary to list all participants. Include entities listed on Cover Sheet 1)

Proposal Title:
Advanced Automatic Train Control (AATC) System

a. Name and Address of Participant 1 of 3

San Francisco Bay Area Rapid Transit
(BART) District
800 Madison St.
Oakland, CA 94604-2688

Check if: (Small Business ☐) (HBCU/MI ☐) (Foreign-owned ☐)

(Small Disadvantaged Business (SDB) ☐)

b. Telephone Number: 510-869-2415

c. Fax Number (if any): 510-287-4760

d. Point of Contact, Organization, and Address

Eugene I. Nishinaga
San Francisco Bay Area Rapid Transit
(BART) District
800 Madison St.
Oakland, CA 94604-2688

e. E-Mail Address (if any):

f. Type of Business (SIC code or other description)
Public Transit Operator

---

a. Name and Address of Participant 2 of 3

Hughes Aircraft Company (HMK)
1901 W. Malvern.
Fullerton, CA 92634

Check if: (Small Business ☐) (HBCU/MI ☐) (Foreign-owned ☐)

(Small Disadvantaged Business (SDB) ☐)

b. Telephone Number: 714-441-9713

c. Fax Number (if any): 714-441-9660

d. Point of Contact, Organization, and Address

Marvin D. Swensen
Hughes Aircraft Company (HMK)
1901 W. Malvern.
Bldg. 676 M/S DD245
Fullerton, CA 92634

e. E-Mail Address (if any):

f. Type of Business (SIC code or other description)
3669 Communication Equipment

---

a. Name and Address of Participant 3 of 3

Morrison Knudsen Corporation (HMK)
720 Park Blvd.
Boise, Idaho 83729

Check if: (Small Business ☐) (HBCU/MI ☐) (Foreign-owned ☐)

(Small Disadvantaged Business (SDB) ☐)

b. Telephone Number: 208-386-6374

c. Fax Number (if any): 208-386-7510

d. Point of Contact, Organization, and Address

Dr. Fred E. Templeton
Morrison Knudsen Corporation (HMK)
2603 Eastover Terrace
Boise, Idaho 83706

e. E-Mail Address (if any):

f. Type of Business (SIC code or other description)
3734 Rail Road Equipment

---

a. Name and Address of Participant ____ of ____

Check if: (Small Business ☐) (HBCU/MI ☐) (Foreign-owned ☐)

(Small Disadvantaged Business (SDB) ☐)

b. Telephone Number:

c. Fax Number (if any):

d. Point of Contact, Organization, and Address

e. E-Mail Address (if any):

f. Type of Business (SIC code or other description)

Proposal for

ADVANCED AUTOMATED TRAIN CONTROL SYSTEM (AATCS)

VOLUME 2: COST/FUNDING PROPOSAL

Friday, July 23, 1993

Submitted to:

Technology Reinvestment Project
3701 North Fairfax Drive
Arlington, VA 22203-1714

Prepared by:

Bay Area Rapid Transit District (BART)
800 Madison Street - Lake Merritt Station
P.O. Box 12688
Oakland, Ca. 94604-2688

and

Hughes - Morrison Knudsen (HMK)
P.O. Box 3310
Fullerton, California 92634-3310

In Response to:
Advanced Research Projects Agency Solicitation No. SOL93-29

STATE OF CALIFORNIA-BUSINESS, TRANSPORTATION AND HOUSING AGENCY PETE WILSON, Governor

DEPARTMENT OF TRANSPORTATION
OFFICE OF THE DIRECTOR
1120 N STREET
P. O. BOX 942873
SACRAMENTO, CALIFORNIA 94273-0001
(916) 654-5267
FAX (916) 654-6608
TDD (916) 654-4014

July 16, 1993

LETTER OF ENDORSEMENT
CALIFORNIA DEPARTMENT OF TRANSPORTATION
FOR THE
TECHNOLOGY REINVESTMENT PROJECT

I am pleased to inform the federal Technology Reinvestment Project (TRP) Evaluation Committee that the partnership headed by Bay Area Rapid Transit (BART) has been selected to receive the endorsement of the California Department of Transportation (Caltrans).

The partnership's proposal went through a competitive review in which it was determined that the proposed activity meets the necessary criteria of Caltrans' Defense Conversion Program to merit the endorsement. These criteria include the extent to which the proposal meets the selection criteria of the TRP, as well as criteria more directly related to the needs of California transportation. These items include, and are not limited to, an understanding of Caltrans' areas of interest in advanced transportation systems and the proposal's immediate and long-range potential for California job creation, retention, and/or business attraction.

Caltrans looks forward to the decision of the TRP Evaluation Committee.

Sincerely,

JAMES W. VAN LOBEN SELS
Director

Introduction

The cost volume contained herein contains the cost estimates and matching amounts that form the basis for a negotiated funding agreement between the Defense Technology Conversion Council (DTCC)/Advanced Research Projects Agency (ARPA) and a Regional Technology Alliance composed of the sponsoring agency (Bay Area Rapid Transit District) and the industrial partner (HMK - a joint venture between Hughes Aircraft Company and Morrison Knudsen Corporation).

The cost estimates contained is this volume were developed in accordance with standard estimating practices used by the respective entities and were based on detailed specifications and a statement of work developed between the participants over the last 12 months. Tasks were broken down into their constituent parts, assigned to multi-disciplinary teams, and estimated based on engineering judgment and similarity to development on the military programs from which the technology was derived (PLRS and EPLRS programs). The estimates were then reviewed by the other teams on the program and management. The manufacturing costs were derived from quotes, similarity of parts, and realization rates experienced on the PLRS/EPLRS manufacturing lines.

In addition to "in-kind" contributions there are other contributions by the industrial partner and sponsor that are listed as non-matched contributions. These convey the value of existing proprietary technology and account for some transactions which will benefit the alliance, but not be incorporated into the cost accounting for the project. These should be considered favorably during the evaluations as they add value to the proposed effort and would, if applied as a matching contribution, reduce the effective matching rate requested. In accordance with the requirements of the TRP, there are no facilities renovation or construction included in the costs or matching funds for this effort.

Although a Disadvantaged Business Enterprise (DBE) is not a participant of the Alliance, a portion of the subcontracted effort is being set aside for DBE participation under the terms of the competitive procurement issued by BART. Efforts have been on-going over the last several months to identify certified DBE's to support this specific program. Many of the DBE companies selected will be certified by the Regional Transit Authority in San Francisco.

The funding requirements for this effort are divided into a Base period of performance of 29 months representing the Phase 1 and Phase 2 activities described in the Technical Volume and an Option for the Phase 3 activities. In addition, the phase 4 activity of BART evaluation, as described in the technical proposal, is planned to be conducted at no additional cost to the Government. The in-kind cost to BART is estimated at $113M.

SECTION 1 – TOTAL PROPOSED COSTS $(000)

BASE PERIOD – PHASE 1 + PHASE 2 (29 months)

	HMK		BART		
SOW Tasks	Price	In-Kind	Cost	In-Kind	ARPA COSTS
System Engineering	2,207	900	2,043	0	5,150
Hardware Engineering	3,307	900	497	150	4,854
Firmware Engineering	2,783	0	128	0	2,911
Software Engineering	3,900	0	433	0	4,333
Hardware Implementation	9,282	0	0	113	9,395
System Test	2,191	0	323	3,740	6,254
Installation	749	0	127	1,821	2,697
Administration	2,968	0	588	0	3,556
TOTALS:	27,387	1,800	4,139	5,824	**39,151**

OPTION 1 – PHASE 3 (24 months)

	HMK		BART		
SOW Tasks	Price	In-Kind	Cost	In-Kind	ARPA COSTS
System Engineering	0	0	198	0	198
Hardware Engineering	0	0	236	0	236
Firmware Engineering	0	0	0	0	0
Software Engineering	0	0	132	0	132
Hardware Implementation	25,635	0	0	0	25,635
System Test	428	0	118	20,490	21,036
Installation & System Support	3,512	0	2,013	9,975	15,500
Administration	1,548	0	129	0	1,677
TOTALS:	31,123	0	2,826	30,465	**64,414**

SECTION 2 - COST TO GOVERNMENT $(000)

BASE PERIOD - PHASE 1 + PHASE 2 (29 months)

The Alliance is requesting a 50% match for the Total Proposed Costs as shown above.

Total Proposed Price **$39,151** * .5 = **$19,575**. *Effective Rate = 48%

The requested payment schedule is quarterly payments at the beginning of each quarter for both the base program and the option. The quarterly amounts requested are indicated below. Program notice to proceed is assumed to be October 1993.

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	5th Qtr	6th Qtr
Period	10/93-12/93	1/94-3/94	4/94-6/94	7/94-9/94	10/94-12/94	1/95-3/95
TRP Funds	2936	1958	1958	1958	2936	1957

	7th Qtr	8th Qtr	9th Qtr	10th Qtr		
Period	4/95-6/95	7/95-9/95	10/95-12/95	1/95-3/95		
TRP Funds	1957	1957	979	979		

OPTION 1 - PHASE 3 (24 months)

The Alliance is requesting a 50% match for the Total Proposed Costs as shown above.

Total Proposed Price **$64,414** * .5 = **$32,207**. *Effective Rate = 48%

The requested payment schedule is quarterly payments at the beginning of each quarter for both the base program and the option. The quarterly amounts requested are indicated below. Program notice to proceed is assumed to be April 1995.

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	5th Qtr	6th Qtr
Period	4/95-6/95	7/95-9/95	10/95-12/95	1/96-3/96	4/96-6/96	7/96-9/96
TRP Funds	6441	3221	3221	3221	6441	4831

	7th Qtr	8th Qtr				
Period	10/96-12/96	1/97-3/97				
TRP Funds	3221	1610				

* As discussed in the introduction, there are proprietary technologies that are being contributed without claiming them as matching funds. If they were included the effective matching rate would be 48% . The value as derived in the following section is $4.8 M applied to the total estimated cost for all three phases - $103,565.

SECTION 3 - FUND MATCHING $(000)

BASE PERIOD - PHASE 1 + PHASE 2 (29 months)

HMK Funding	$ 8,151*
HMK In-Kind	$ 1,800
BART Funding	$ 3,800
BART In-Kind	$ 5,824
Total Match	$19,575

OPTION 1 - PHASE 3 (24 months)

HMK Funding	$ 0
BART Funding	$ 1,742
BART In-Kind	$30,465
Total Match	$32,207

*Includes $2.0M of independent research and development (IR&D) involving system architecture and performance, hardware, and component development supportive of the AATC product and associated system.

SECTION 3 - FUND MATCHING (cont.)
MATCHING IN-KIND CONTRIBUTIONS - BART $(000)

BASE PERIOD $5,824

Description	Value	Method to determine value
Transit Car Rental	4,025	Rental fee per car times number of cars in use for the demonstration.
Track Rentals	550	Rental fee per station per 8 hour shift times the number of stations.
Power Costs	184	Kilowatts per car mile times number of car miles times cost per kilowatt
Maintenance	584	Maintenance cost per mile times number of car miles accumulated during demonstration.
Non-Labor	218	Non-labor expense factor per car mile times number of car miles.
Computer Lease	263	BART lease of one TANDEM computer to the project at 5% per month of cost.

OPTION 1 PERIOD $30,465

Description	Value	Method to determine value
Transit Car Rental	16,658	Rental fee per car times number of cars in use for the demonstration.
Track Rentals	3,150	Rental fee per station per 8 hour shift times the number of stations.
Power Costs	1,810	Kilowatts per car mile times number of car miles times cost per kilowatt
Maintenance	6,446	Maintenance cost per mile times number of car miles accumulated during demonstration.
Non-Labor	2,400	Non-labor expense factor per car mile times number of car miles.

MATCHING IN-KIND CONTRIBUTIONS - HUGHES

• The Advanced Automatic Train Control System is built on a foundation of technical data rights owned by Hughes Aircraft Company and Morrison-Knudsen. These data rights are contained in proprietary data, patents issued, and patents pending. The technologies include spread spectrum processing techniques, train control architecture, communications networking, and specific products and processes used in the manufacture of the equipment to be provided. The investments made by the respective corporations in developing these proprietary data exceed $10 M, however, the valuation of technology rights are typically prorated at a royalty fee of 6% of the price of the equipment produced. The price of the equipment and corresponding royalties claimed are as follows:

Vehicle Equipment $62 K * 266 vehicles * 6% royalty = $ 990 K
Wayside Equipment $53 K * 136 waysides * 6% royalty = $ 432 K
Station Equipment $365 K * 10 stations * 6% royalty = $ 219 K
(Note: Excludes 120K non-proprietary computers per station)

• Hughes Aircraft Company is providing data rights for its Situation Awareness Software Program to the US Army Communications Electronics Command (CECOM) in exchange for the loan of the EPLRS equipment needed during Phase 1.
Valuation - $ 200 K (joint CECOM/GMHE valuation)

Total In-Kind Valuation of Proprietary Technology = $1841 K

SECTION 3 - FUND MATCHING (cont.)

Sources of cash for matching funds

The source of cash for HMK is ultimately from operating profits of the joint venture and/or the respective joint venture partners (Hughes Aircraft Company and Morrison Knudsen Corp.). The balance sheets for both companies (attached) also reflect sufficient cash reserves. In addition G.M. Hughes Electronics maintains banking relationships with the following banks:

BANK OF AMERICA
555 SOUTH FLOWER ST.
LOS ANGELES, CA 90071
CONTACT: MR. DAVID THOMAS
(213) 228-3627

CITIBANK
725 SOUTH FIGUEROA ST.
LOS ANGELES, CA. 90017
CONTACT: MS. DEBRA TRONSON
(213 239-1424

Morrison Knudsen maintains a banking relationship with the following banks:

KEY BANK OF IDAHO
702 WEST IDAHO ST.
BOISE, IDAHO 83701
CONTACT: MR. JACK B. HEMENWAY
(208)334-7260

CONTINENTAL BANK
231 SOUTH LA SALLE ST.
CHICAGO, ILLINOIS 60697
CONTACT: MS. LYNN W. STETSON
(312)828-6757

BANK OF AMERICA
555 CALIFORNIA ST.
SAN FRANCISCO, CA. 94104
CONTACT: MS. ADELINA TORUNIAN
(415) 622-5120

The above mentioned banking institutions can provide reference as to the financial resources and credit-worthiness of the parties.

CONSOLIDATED BALANCE SHEET

ASSETS	December 31,	
(Dollars in Millions Except Per Share Amount)	1992	1991
Current Assets		
Cash and cash equivalents (Note 1)	$ 702.7	$ 348.3
Accounts and notes receivable		
Trade receivables (less allowances)	795.3	705.0
General Motors and affiliates (Note 2)	207.6	375.6
Contracts in process, less advances and progress payments of $4,026.4 and $2,500.9	2,456.4	2,283.1
Inventories (less allowances) (Note 1)	1,199.6	1,033.8
Prepaid expenses, including deferred income taxes of $87.2 in 1992	185.2	88.0
Total Current Assets	5,546.8	4,835.8
Net Equipment on Operating Leases (less accumulated depreciation of $94.6 and $192.9)	582.7	466.4
Property—Net (Note 9)	2,866.9	2,943.1
Intangible Assets (Note 1)	3,620.8	3,766.9
Investments and Other Assets, including deferred income taxes of $142.4 in 1992—principally at cost (less allowances)	1,403.3	920.6
Total Assets	$14,020.5	$12,930.8

LIABILITIES AND STOCKHOLDER'S EQUITY		
Current Liabilities		
Accounts payable		
Outside	$ 718.0	$ 548.4
General Motors and affiliates (Note 2)	89.6	106.7
Advances on contracts	585.7	493.2
Notes and loans payable (Note 10)	267.2	703.2
United States, foreign, and other income taxes, including deferred amounts of $7.7 and $100.2 (Note 7)	79.7	226.7
Accrued liabilities (Note 11)	2,114.2	1,206.8
Total Current Liabilities	3,854.4	3,285.0
Long-Term Debt and Capitalized Leases (Note 10)	711.0	147.1
Postretirement Benefits Other Than Pensions (Note 5)	1,352.3	—
Other Liabilities, Deferred Income Taxes, and Deferred Credits	1,287.8	1,280.5
Stockholder's Equity (Note 12)		
Capital stock (outstanding, 1,000 shares, $0.10 par value) and additional paid-in capital	6,314.7	6,365.9
Net income retained for use in the business	628.4	1,961.8
Subtotal	6,943.1	8,327.7
Minimum pension liability adjustment	(104.3)	(101.8)
Accumulated foreign currency translation adjustments	(23.8)	(7.7)
Total Stockholder's Equity	6,815.0	8,218.2
Total Liabilities and Stockholder's Equity	$14,020.5	$12,930.8

Certain amounts for 1991 have been reclassified to conform with 1992 classifications.
Reference should be made to the Notes to Consolidated Financial Statements.

CONSOLIDATED BALANCE SHEET

(Thousands of dollars except share data)

December 31,	1992	1991(a)
ASSETS		
Current assets		
Cash and cash equivalents	$ 134,011	$ 138,946
Short-term investments, at cost that approximates market	43,681	119,144
Accounts receivable including retentions of $44,871 and $41,493	160,196	135,253
Refundable federal income taxes	18,365	—
Inventories	78,856	57,086
Costs and earnings in excess of billings on uncompleted contracts	127,254	120,624
Investments in construction joint ventures	68,904	57,516
Deferred income taxes	36,135	22,156
Other	14,010	7,475
Total current assets	681,412	658,200
Investments and other assets		
Marketable securities, at cost, market $69,998 and $63,929	60,902	57,231
Investments in and receivables from unconsolidated affiliates	38,567	45,291
Investments in gold mining joint ventures	31,238	31,706
Other investments and assets	98,298	82,242
Total investments and other assets	229,005	216,470
Property and equipment, at cost		
Land and mineral rights	20,755	12,595
Buildings and improvements	133,100	109,690
Machinery and equipment	46,708	49,764
Construction equipment	219,591	194,900
Total property and equipment	420,154	366,949
Less accumulated depreciation	(226,147)	(189,842)
Property and equipment — net	194,007	177,107
Total assets	$1,104,424	$1,051,777

(a) Restated to include the financial position of businesses acquired in December 1992 accounted for as poolings-of-interests.
(b) Share data have been restated to reflect the two-for-one stock split in May 1992.
The accompanying notes are an integral part of the financial statements.

SECTION 3 - FUND MATCHING (cont.)

NON-MATCHED CONTRIBUTIONS

Hughes Aircraft Company and Morrison-Knudsen have previously invested resources (cash and talented personnel) and intend to invest additional resources in various development and test activities related to the technology development proposed herein. These are not used for the ARPA match therefore ensuring that the matched amounts included above are of the highest quality. The respective corporations believe it is not in the best interest of all parties to negotiate over the perceived value of these contributions to the program for the purposes of the match, therefore, our valuation is provided for ARPA's use in evaluating the proposal on it's other merits if it so pleases.

• A redesign of the existing Radio Frequency Assembly (RFA) was undertaken by Hughes Aircraft Company to generate a new design using modern technology components and assembly techniques to replace the earlier design developed for the PLRS/EPLRS programs. This design transition from old to new technology involves replacing discrete amplifier and attenuator designs with monolithic microwave integrated circuit (MMIC) amplifiers and voltage variable attenuators, and discrete digital circuitry and phase locked loop circuit designs with application specific integrated circuits (ASICs). These changes and the transition from multiple circuit boards to a single circuit board and from through hole mounting components to surface mounting components results in a 50% reduction in the number of components, an increase of 40% in the reliability of the unit, and an estimated reduction in the cost to produce and maintain the unit by more than 30%. The RFA provides modulation (conversion from digital format to analog format) for transmission, and demodulation (conversion from analog format to digital format) for reception. The unit also provides up conversion of the analog signal to the desired RF frequency for transmission, and down conversion of the received RF signal for processing by the demodulator.
Valuation - $ 0.5M

• The development of a VHSIC Signal Message Processor (SMP) has been undertaken by Hughes Aircraft Company to generate a new design using VHSIC technology that allows increased throughput performance, lower unit production cost, reduced weight and power consumption, and increased reliability. This is achieved by replacing the separate custom microcircuits for Timing/Control, Hamming Error Correction, and Data Tracking/Correlation with a single Signal Processor chip, replacing the 10 chip analog hybrids and discrete components used for preamble correlation with a digital Single Chip Correlator, and replacing two configurable gate arrays and two RAM chips with a single Dual Channel I/O chip.
Valuation - $ 3.3 M

• Hughes Aircraft Company and Morrison-Knudsen together and separately have diligently developed the system concept and architecture design for supporting the rail transportation requirements over the last 12 months and have submitted it for technical evaluation to BART. Several technical interchanges were held to refine and iterate the design which forms the basis of this effort. Several approaches are unique for which patent applications have been submitted.
Valuation - $ 0.5 M

SECTION 3 - FUND MATCHING (cont.)

• Hughes Aircraft Company and Morrison-Knudsen together and separately have conducted several demonstrations of the application of specific technology approaches to the requirements of rail transportation on the BART test track and on revenue track during non-operational hours. These evaluations provided valuable information regarding RF transmission in tunnels at the specific operating frequencies to be used, analysis of location algorithms, data to support the accuracy requirements for train control under varying conditions and track configurations, and interfacing techniques with the existing train control lines.

Valuation - $ 0.5 M

TERMS AND CONDITIONS

1. As stipulated in TRP documentation and understood by the Alliance, it is hoped that the information provided herein will be sufficient to merit further discussions during which we can obtain a better mutual understanding of both our submittal and the means by which the Government executes an agreement to pursue this effort. It is hoped that at the conclusion of those discussions that an agreement will be reached that will specifically identify the technical approach and the financial obligations of the parties.

2. The Alliance may terminate this agreement at the conclusion of any phase after written notice and consultation upon a reasonable determination by BART or HMK that the project will not produce the planned results commensurate with the expenditure and/or the availability of resources. With regard to costs incurred in a case of termination, the Government and the Alliance will negotiate in good faith an equitable adjustment for work accomplished towards the Payable Goals at the time of termination.

BART
BAY AREA RAPID TRANSIT DISTRICT
800 Madison Street - Lake Merritt Station
P.O. Box 12688
Oakland, CA 94604-2688
Telephone (510) 464-6000

BUDGET & PROJECT MANAGEMENT
212 - 9TH STREET - 2nd FLOOR
OAKLAND, CA 94607
FAX (510) 287-4760

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COMPANY: ____________

TELEPHONE: ____________

FAX: 2103

FROM: ____________

TELEPHONE: ____________

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Name: Mike DePallo

Company/Organization: BART

Fax Phone Number: 1-510-287-4760

From: Bob Schmidt

Date: 9-13-93

Number of Pages including Cover Page: 5

SPECIAL INSTRUCTIONS:

We are doing a project for the California Energy Commission relating to defense conversion proposals, and we would like to submit this to the San Jose Mercury FOR AN OP ED. Sen. Alfred Alquist will be the author. Do you have any problems, comments, suggestions? Please call me at (916) 442-1196. Thank you.

Client Name/Code:

If there are any problems receiving this transmittal, please call (916) 444-2671

Technology developed to deliver intense, pulsed electrical power to military weapons systems may soon mean smoother rides for BART passengers traveling under San Francisco Bay.

The prospect of giving a significant peacetime purpose to a military technology also illustrates the opportunity California has to resume its role as an industrial leader in the western world.

The Westinghouse Marine Division in Sunnyvale, working with PG&E, the Electric Power Research Institute (EPRI), and BART, has obtained the endorsement of the California Energy Commission on a joint proposal seeking a portion of $472 million the Federal Government has made available for defense conversion projects.

The federal program, as a writer for the New York Times recently put it, is designed to "turn swords into infrastructure."

Westinghouse's proposal is among more than 30 from California firms that have received Letters of Support from the Energy Commission and are now being considered by the Federal Technology Reinvestment Project (TRP). Many rely on the skills, technology, facilities and equipment accumulated while helping make the United States the most potent military power in history.

And all have in common contributing significantly to California's quest for cleaner air by reducing reliance on the traditional, gasoline-powered internal combustion engine.

The Energy Commission has also endorsed a TRP application by the Solar Engineering Applications (SEA) Corporation, also in Sunnyvale. SEA's POWERGRID 1000 project, developed in concert with Sandia National Laboratories in Albuquerque, N.M.; the U.S. Department of Energy, and the California Energy Commission will "provide renewable, non-polluting electricity to the bulk power market at a lower cost than conventional power generation," Energy Commission Chairman Charles Imbrecht told the TRP review committee.

SEA's photovoltaic concentrator technology will provide power at $1 per watt, half the current cost, Imbrecht said.

The motivation for the federal Technology Reinvestment Project is not new. For decades, supporters of the space program have insisted there would be everyday commercial applications of the program's research, and in fact there are many products now available to consumers that have their origin in the Apollo, Gemini, and space shuttle projects.

Now it is time to find practical commercial uses for the military technology for which, happily, there appears to be a diminishing national need.

Westinghouse's Sunnyvale facility has been the prime contractor designing and supplying U.S. Navy ship propulsion and power-generation systems, and pulsed-power launching systems for the Navy's Trident and Cruise Missiles, the Air Force's MX Missile, and other modern weapons. Elsewhere, the firm has also been asked to develop high-quality electric power free from harmonics, voltage dips, and unexpected interruptions, for use with electronic warfare systems, including high-power radar and microwave systems.

That combined expertise prompted Westinghouse to seek a solution to a growing problem on the Bay Area Rapid Transit system.

As BART passengers regularly making the three and one-half mile trip under San Francisco Bay may know, there are occasional periods of jerky motion near the middle of the tube. Because of the relatively long distance between the power substations at each end of the tube, the train voltage may drop to undesirable levels under certain conditions, particularly during rush hours when traffic load requires trains to run more frequently.

Westinghouse, in its application for TRP funds, says it can use the knowledge and products developed working on military projects to solve the problem. BART, PG&E, EPRI, the California Department of Transportation, and the California Energy Commission, agree that Westinghouse Sunnyvale can do what it says, and are helping to sponsor and endorse the project. But more funds are needed, and that's where the TRP comes in.

The Westinghouse/BART proposal, and other proposals by such powerhouse California firms as Lockheed, Hughes, Aerojet, General Dynamics, Southern California Edison, Northrop, TRW, Southern California Gas, and AlliedSignal, are now in Washington, accompanied by Letters of Support from the Energy Commission.

The emphasis on energy efficiency and diversity should make them highly attractive, but hard work by the large California congressional delegation is needed to make sure the state's firms get a fair share of the money the Federal Government has earmarked for defense conversion projects.

Government and business leaders in California have been talking for years about the need for a public-private partnership to strengthen our economy. The state's economy, battered by the recession and the downsizing of military operations, certainly needs strengthening.

It needs, now, what a true public-private partnership can

BART/EPLRS Project
News Release Draft No. 1
Dan Reeder
Hughes: Tel.: (714) 732-4631
Mike Healy: Tel.: (510) 464-7110

MILITARY TECHNOLOGY CAN IMPROVE NATION'S MASS TRANSIT SYSTEM CAPACITY

WASHINGTON, D.C., Sept. 9 -- The use of an existing military battlefield communications system can double the passenger capacity of the nation's urban mass transit systems and save tens of billions of dollars in new construction costs according to Frank J. Wilson, General Manager of the San Francisco Bay Area Rapid Transit (BART) system.

The successful application of this newly-available technology will nationally revolutionize the expansion capabilities of rail rapid transit system such as BART, but greatly improve the reliability of the nation's mass transit systems according to Wilson.

BART, which celebrates its 21st year of service this year, is a 71.5-mile regional train network serving three counties; Alameda, Contra Costa, and San Francisco, and parts of northern San Mateo County. The transit district is currently constructing extensions which will add about 34 miles of new track to the system.

"We are hoping to be the first mass transit system in the nation to use military technology to increase our passenger capacity," said Wilson. "We've applied for Federal Technology Reinvestment Program funds to help us get a pilot program underway.

"If we are successful in getting the funding, we can complete our demonstration and implementation phases. We plan to implement a feasibility demonstration of an advanced automated train control system on the revenue track by the mid 1990s."

Once BART is successful, Wilson predicts other mass transit systems across the nation, such as those in New York, Washington, Boston, Chicago, Atlanta, Los Angeles and other cities could benefit from the breakthrough technology.

"If we tried to double the passenger capacity of BART through conventional methods by constructing new lines, tunnels and stations, it would probably cost us $10 billion today. If we can use this highly cost efficient technology in other regional systems, we could save the nation more than $50 billion in new construction costs."

BART and its two contractors, California-based Hughes Aircraft Company and Idaho-based Morrison Knudsen, are seeking about $50 million in Technology Reinvestment Program funds. BART expects to put up a matching amount to complete the project.

The new technology will allow BART to nearly double its capacity by 1996. The extra capacity is needed to support the increased service levels which will arise following completion of the Dublin-Pleasanton extension ~~during 1996.~~ w/ partial in late 1995.

Wilson said other benefits include the ability to install the new equipment without disruption of service; a 100 to 1,000 times increase in the reliability of the existing train control system; new capabilities to monitor and communicate train health; up to 10 per cent power savings through improved train control; the ability for U.S. companies to capture a major portion of a $150 to $300 million domestic train control market; provide U.S. access to foreign markets with potential sales far exceeding that of the U.S.; and maintaining or creating more than 2,000 jobs.

The BART advanced automated train control system will use the U.S. Army's Enhanced Position Location Reporting System, which is produced by Hughes. Hughes has formed a joint venture with Idaho-based Morrison Knudsen, one of the nation's largest manufacturers of train cars, to work with BART on the project. The joint venture is called HMK.

The Enhanced Position Location Reporting System allows U.S. Army troops and their commanders to know their exact locations at all times, with an accuracy of 15 feet. An earlier version of the system, called the Position Location Reporting System, was used by the U.S. Marines during Desert Storm.

For BART, the system will provide exact locations of all trains, including those operating at high speeds. Because current train control technology provides accuracies of about 2,000 feet, trains are kept apart at great distances for safety reasons.

"By knowing more precisely where all the trains are located in the system at all times, we will be able to shorten the intervals or headway between the trains while actually improving reliability and safety," said Wilson. "That will allow us to get more trains into BART stations during rush hour periods and our passengers to their destinations more quickly than before."

Current technology allows for an interval between trains of two and one-half minutes while maintaining safe standards. This will ultimately be cut to one minute with the same safety margins by using the Hughes technology.

The application of the military technology to BART will be completed in increments to satisfy all the public safety issues involved. The program is structured to validate the system design principles and the train tracking capability prior to activation of the advanced automated train control system.

The demonstration system will be implemented across an operating track network sufficiently complex to prove that the technology will provide the sustained levels of safe, reliable, enhanced performance as required by the transit industry.

Hughes will provide BART with the same Enhanced Position Location Reporting System radios it has been supplying the U.S. Army for several years. Minor modifications to the radios will be required to allow them to perform at maximum capability in the BART tunnels.

"The harsh environment of mass transit tunnels is not a whole lot different from that of a battlefield," said Marv Swensen, one of several Hughes scientists and engineers working on the project. "Since our radios are already built to military specifications, we can take the radios right off our existing factory line and make minor modifications to meet the BART requirements."

Earlier this year, Hughes engineers completed a technology demonstration project where the technical concept was proven. Equipment was installed on trains each night and tests were conducted during the early morning hours when it would not affect the system's service.

"We are ready to start implementing this technology," said Swensen. "Our tests have proved to us it is going to work, so it is just a matter of moving ahead with the rest of the system design and begin operating the technology on longer stretches of BART's system."

-END-

9/93

FAX COVER PAGE

HUGHES

To: Michael Healy Date: 9-3-93

Fax Phone: Pages to Follow: 7

Addressee's Phone:

From: Dan Reeder
Manager
Public Relations Department
Hughes Aircraft Company
Systems Sector &
Aerospace and Defense Sector Surface Systems
PO Box 3310
Fullerton, Calif. 92634

(714) 732-4631 office
(714) 732-0674 fax

Michael,

Here is a slightly revised news release w/ four of the primary backgrounders.

Best regards,

Dan Reeder

BART/EPLRS project
News Release Draft No. 2
Dan Reeder
Hughes
(714) 732-4631

MILITARY TECHNOLOGY CAN IMPROVE NATION'S MASS TRASIT SYSTEM CAPACITY

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Under the project, Hughes will modify the military radios, produce the control software and oversee the system design and test. Morrison Knudsen will integrate the equipment into the cars, control station and existing automated train control equipment.

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-END-

9/93

BACKGROUNDER

ADVANCED AUTOMATED TRAIN CONTROL SYSTEM CONCEPT

By incorporating the Enhanced Position Location Reporting System technology into the Advanced Automated Train Control system, the train transit industry will acquire a new standard for tracking train positions, selecting of safe speed codes and communicating of the speed codes from the station to the train. This new system architecture advances the state of the art by utilizing defense-derived spread spectrum radios for locating trains as well as communicating vital information between the trains and controlling station.

Typically, the physical rail infrastructure permits increased utilization but the corresponding support systems are outdated. No rail transit support system is quite so antiquated as train control. Existing automatic train control systems derive primarily from the invention in 1872 of the track circuit which, however, was not placed in service anywhere until 1911. To date many transit authorities have not incorporated track circuits and still operate under manual control. Improved train control has more potential to exploit the existing rail infrastructure in a cost effective way while enhancing safety than any other subsystem.

To implement position location, each train will carry two radios, with one in the lead car and one in the rear car. This permits independent location of both the front and rear of the train, critical parameters in selection of safe speed control. Identical radios are positioned alongside the track and in the control stations. They communicate via line-of-sight and all the radios in the system operate with synchronized clocks.

As the train travels along the track, the radios communicate with each other and make time of arrival measurements of the signals. This process is performed many times a second to filter out any anomalous ranges. Smoothed range data is then relayed down the track by the trackside radios to a control station computer. Using the multiple ranges received, the station's advanced automated train control computer then computes the train's position. This process is performed every half second for every train in the system to maintain the precise status of the position of all trains.

The station's advanced automated train control computer then uses this position information, in combination with the train status, track data and interlocking status for gates and switches, to select the safe speed codes for all trains operating within its control zone. The safe speed code is then transmitted to the train by relaying the command from the stations radio back up the track.

-END-

9/93

BACKGROUNDER

ENHANCED POSITION LOCATION REPORTING SYSTEM

The Enhanced Position Location Reporting System (EPLRS) is a computer-controlled, digital communications network used by U.S. Army troops and commanders on the battlefield. EPLRS compact user units can be carried on troops' backs, mounted in vehicles such as trucks or tanks, and installed in helicopters to provide direct user-to-user data communications, identification and position and navigation services to Army units in the air and on the ground.

Developed and built by Hughes Aircraft Company under contract to the U.S. Army Communications Electronics Command at Ft. Monmouth, N.J., EPLRS furnishes secure and jam-resistant data communications and introduces important new capabilities in the support of modern computerized, tactical command and control systems.

EPLRS communications support the five mission areas of the U.S. Army in the tactical battlefield: maneuver control, air defense, fire support, intelligence/electronic warfare and combat service support. EPLRS supplies links to command and control data systems established in each mission area.

The system is composed of hundreds of EPLRS user units and a net control station. The user units, or radios, are a little larger than a standard Army voice radio. The units are 14 inches by 10 inches by five inches and weigh about 20 pounds.

Hughes is currently under production for the EPLRS system to the U.S. Army. The system was field tested in early 1993 by the U.S. Army 24th Infantry Division, mechanized, during joint training exercises with the Kuwaiti Army.

-END-

9/93

BACKGROUNDER

PROGRAM OBJECTIVES

The program objectives are to demonstrate the feasibility and benefits of applying exisitng military communications, command and control and association position location technologies to automatic train control. The program will focus on the spin-off transitioning of existing Enhanced Position Location reporting System equipment and technology to immediate use in the transit market place, thus establishing dual-use of military technology.

Application of advanded technology to areas such as train control, which have seen no innovation in over a decade, offers better use of the existing infrastructure. Advanced automatic train control development would be expensive and risky if supporting trechnologies had not already been developed.

With the Enhanced Posiotion Location Reporting System, the position of a given force element is ascertained when it rtransmits a mesage which is received by three separate force elements. The precise time (known by all system radios) is used to accurately measure the travel time from the transmitting radio to the receiving radio. Which three such time of arrival measurements, the position of a transmitting unit can be determined.

The paramount requirement is to continuously track locations of all trains. Train location is determined more accurately using position location reporting system-type technology in the advanced automated train control application since their paths are fixed relative to the infrastructure. In effect, train locations are one-dimensional rather than three-dimensional as on the battlefield. As a result, they can be determined within a few feet using trains and trackside units equipped with Enhanced Position Location Reporting System radios.

Most rail transit systems use fized block train control systems that incorporate large operational train spacings thereby precluding full utilization of the infrastructure. Moving block systems, such as the advanced automated train control system, permit reducitons of train spacing to improve capacity and safety margins. The advanced automated train control system goes one step further in offering flexibility and systemperformance unmatched by toher moving block approaches. Transit agencies are demanding customers: safety is paramount, cost control is critical, system performance must be relaible and equipment must be maintained over its life.

-END-

BACKGROUNDER

DUAL USE OF MILITARY HARDWARE

The advanced automated train control radio set hardware meets typical transit environmental conditions and satisfies advanced automated train control hardware construction requirements by its compliance to rigorous military standards. Its modular construction approach provides rapid diagnosis and replacement of faulty hardware modules.

Hardware functions are implemented via five individual modules housed within a single enclosure. Of these six items, the intermediate frequency assembly, the signal message processor, the DC power converter and the enclosure were previously developed for the Enhanced Position Location Reporting System. The main enclosure, including the module interfacing circuitry, is unchanged. The enclosure's front panel will be modified to remove unused connectors, switches and functions. The remaining two modules, the serial interface module and the converter/amplifier assembly will be developed specifically for the trains application. In addition, the selectable power adapter will be only slightly modified to support 220 volt AC operation.

The converter/amplifier assembly provides frequency conversion, transmitting power amplification and low noise receive amplification of the 2.4GHz advanced automatic train control radio frequency waveform. The serial interface module provides the serial data interface to the advanced automatic train control equipment. The serial data interface is firmware programmable to provide interfacing to the various equipment.

Although the signal message processor is currently in production for the Enhanced Position Location Reporting System, Hughes is embarking on an internal research and development project to upgrade a VHSIC (very high speed integrated circuit) version of the processor. The new version of the signal message processor will be used as part of the train system configured Hughes radios. Hughes also will develop internal research and development a higher performance intermediate frequency amplifier to replace the intermediate frequency assembly in the current radio configurations. Both new items will be part of the advanced automated train control units used during the demonstration.

-END-

9/93

31 projects

Dorothy Robin

Possibly in Two weeks

Ken Kopper

MEMO *from*

DOROTHY W. DUGGER

12/1

Mike Healy -

I've not seen your perf. ~~appraisals~~ appraisals for your direct reports. They were due to Personnel Mon. Nov 30. I have to sign off on them.

I'll show you mine if you'll show me yours.

by cob Fri - pls

DWD

Defense Conv.
Can be used to
support infrastructure
within 3 years.

<u>Hyatt</u>
Crystal City

APTA JMK

~~[illegible]~~ (Thur)

Speaker

Mark Swenson

Manager of New Business Dev.

FTH - Seed Money

PHONE MEMO

TO Mike	DATE 9/7	TIME 1:08	~~AM~~ PM
FROM David Shea	AREA CODE NO. (703) 284-4245		
OF Hughes Aircraft	EXT.		

MESSAGE

SIGNED

PHONED ☐	CALL BACK ☑	RETURNED CALL ☐	WANTS TO SEE YOU ☐	WILL CALL AGAIN ☐	WAS IN ☐	URGENT ☐

MEMO *from*

MIKE HEALY

50 Color 8X10's

~~Ø~~2 shots:

Ground Station: 9:00

10:30 a

BART Train.

100 press kits'

100 Shea

David ~~Shea~~.

703-

284-4245

20th Fl

Hughes Advertising

11 Wilson Blvd.

Arlington VA

22209

-3978

~~BH~~ RT Application is currently under review.

Mark Thompson – 202-658-6355

Hughes

base project R+D

19 Mil ~~[illegible]~~

30 + Mil

Tom Epstein – White House Liaison
from Brown

Conversion of TRP funds.

Conversion Vs. Technology Use.

APTA – + TRB

100 Press Kits

834-9410

ARPA — First Year ~ Future awards

$450 Mil available

Regional Tech alliance

Hughes — One of firms

Public Private Partnerships

Project Selection

Comm

Defense

NASA

Transportation

Judith Bernell — Pena's office DOT

Jeff

Tim Beltz — Military Asst to Sec. DOT

(Coast Guard)

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Fed. Ex