Section 1 Introduction

Ball's low risk technical approach combined with our corporate commitment to MTI and extensive development and integrated project team experience provides SNL/LANL with the best value for the MTI spacecraft bus subassembly.

We recognize the importance of MTI. The Multispectral Thermal Imager (MTI) project will demonstrate a technology that is of increasing importance to our national security. The spread of nuclear weapons in a multi-polar and regionally unstable world is a more proximate and dangerous threat to security than at any previous time. Add to that the proliferation of nuclear delivery systems, and the result is a compelling need to monitor nuclear proliferant activities. As illustrated in **Figure 1-1**, a space-based system can be used to monitor nuclear activities in areas where ground and air access is denied. Ball appreciates the opportunity to show how its more than 30 years of spacecraft experience can contribute to the Sandia National Laboratories/Los Alamos National Laboratory (SNL/LANL) team's demonstration of the feasibility of the MTI approach to satisfying this national security need.

1.1 Best Value for MTI

Ball delivers mission success. A successful MTI program needs a bus subassembly supplier who can work effectively as part of a team *and* bring to that team the experience and capability needed to solve problems efficiently and correctly. Ball brings:

Experience: For over 30 years Ball has been a supplier of high-quality space hardware. A continuous evolution of spacecraft from the Orbiting Solar Observatory series in the early 60's through the advanced GEOSAT Follow-On (GFO) satellite of today provides Ball's engineers with an unparalleled base of lessons learned that will be available for the MTI program.

Innovation: Small satellite systems such as MTI are the core of Ball's spacecraft business. Over the years we have successfully balanced advanced small spacecraft capabilities with risk and cost to achieve mission success.

Affordability: We have a demonstrated ability to deliver highly capable systems at a fraction of the cost of our competitors. For example, our GEOSAT Follow-On system will provide the U.S. Navy with an operational ocean altimetry mission at a mission cost of $60 million (spacecraft, payloads, launch vehicle, ground segment upgrades) that is comparable in performance and longer-lived than NASA's over $500 million TOPEX/POSEIDON mission.

Attitude: Because of our long history in the space instrument business, our spacecraft engineers have an unique *payload first* attitude. Advancing the state of the art for spacecraft subsystems is secondary to getting the mission accomplished. We understand the technical challenges of MTI as a mission and will work only toward accomplishing that mission.

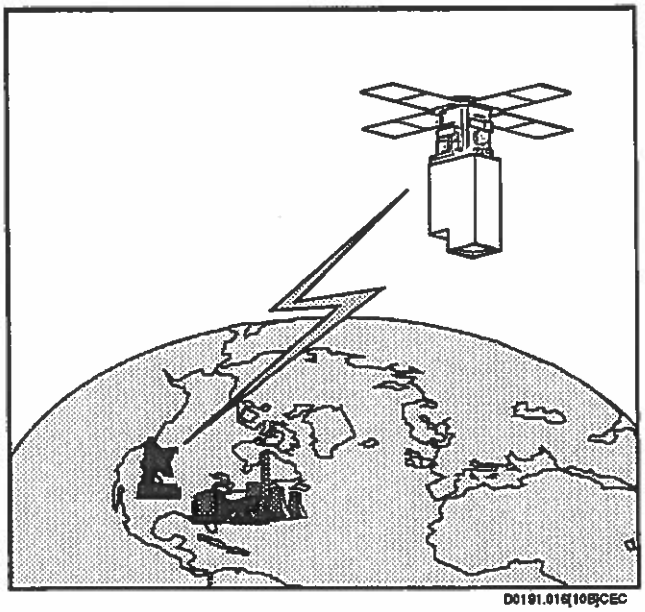

Figure 1-1 The MTI Mission—MTI will demonstrate the feasibility of monitoring nuclear proliferation activities from space.

Teamwork: In our science instrument, support services, and spacecraft businesses Ball frequently participates as a member of a team. As either a leader or a follower, we realize that open communications and teamwork are essential to keeping a team moving toward a common goal.

Commitment: As a company, we have made a long term commitment to New Mexico. We have an established Albuquerque office for support services work and are eager to expand our presence, demonstrate our capabilities, and enhance our reputation in this growing area.

We our excited about the opportunity to participate in the MTI project. We believe our proposal demonstrates that Ball provides the best value for MTI.

1.2 Low-Risk Technical Approach

Ball proposes a low-risk approach to the spacecraft bus subassembly that makes maximum use of existing designs, high heritage components, and lessons learned from actual hardware programs. Overall mission risk will be reduced by MTI having access to the broad base of technical resources available at Ball.

Low Risk: Ball builds quality, high technology satellites. The experience and lessons learned from small satellite programs such as DARPASAT, Brilliant Pebbles, LOSAT, and GEOSAT Follow-On will be used to reduce risk on MTI. **Figure 1-2** illustrates how Ball's MTI design concept uses existing designs and off-the-shelf components to keep this part of the MTI project low risk. The components and vendors we have selected, have proven reliable on previous programs. The majority, such as Eagle-Picher, Ithaco, Adcole, and Spectrolab have either just completed fixed price contracts or are performing on one now with Ball. We know the vendors and their hardware, and have recently reviewed and approved their designs and their production and quality procedures. The selection of existing designs and off-the-shelf components together with engineers who have gained their experience building hardware will keep technical, cost, and schedule risk low.

Unique Breadth of Technical Expertise: Ball has thousands of man-years of spacecraft, electro-optical payload, and mission operations experience in our 839-person aerospace division. The engineers who solved jitter and pointing challenges on the Relay Mirror Experiment (RME) or built the corrective optics for the Hubble Space Telescope are available for trades and "what if" analyses, as are the people who packaged DARPASAT and performed launch vehicle trades for GFO.

1.3 Experience and Performance

Ball has over 30 years of experience in developing high quality spacecraft and electro-optical payloads for NASA/DOD/DOE, commercial, and international customers. Our recent success in developing and launching a small, high technology satellite for ARPA (DARPASAT) and in providing the corrective optics for the Hubble Space Telescope (installed in December 1993) shows that Ball remains on the cutting edge of small satellite and imaging satellite technology. **Figure 1-3** shows a representative sample of Ball's successful and on-going programs. We currently are working on contracts for two follow-on instruments for the Hubble Space Telescope, and both Radarsat and GFO have options that are likely to be exercised. Our on-going programs provide a stable environment that enables us to retain our key technical people and ensure that the support proposed will remain available throughout the MTI project.

1.4 A Team Player

Ball has an outstanding record filling a variety of roles on integrated project teams. For the initial flight tests for Brilliant Pebbles components and technologies, we were fully integrated into a team led by Lawrence Livermore National Laboratory (LLNL). On Radarsat, we delivered a spacecraft bus assembly to Spar Aerospace Ltd. (SPAR) of Canada for payload and solar array integration and we continue to provide task support; on our current effort with INTA (the Spanish National Space Agency), we initially colocated system engineers at INTA to assist them in the design of a small satellite and are now providing a variety of components and task order engineering support; on the current GFO program, we are responsible for delivering a fully operational satellite on orbit. As a company that has experience as a team member and a team leader, we appreciate both our potential role on

Navigation and Timing

Component	Vendor	Heritage
GPS Receiver	Motorola	MSTI 2

Structure

Component	Vendor	Heritage
Al Honeycomb Deck and Panels	Ball	DARPASAT
Mechanisms	Starsys	APEX
Cornerposts	Ball	DARPASAT, RME, Radarsat

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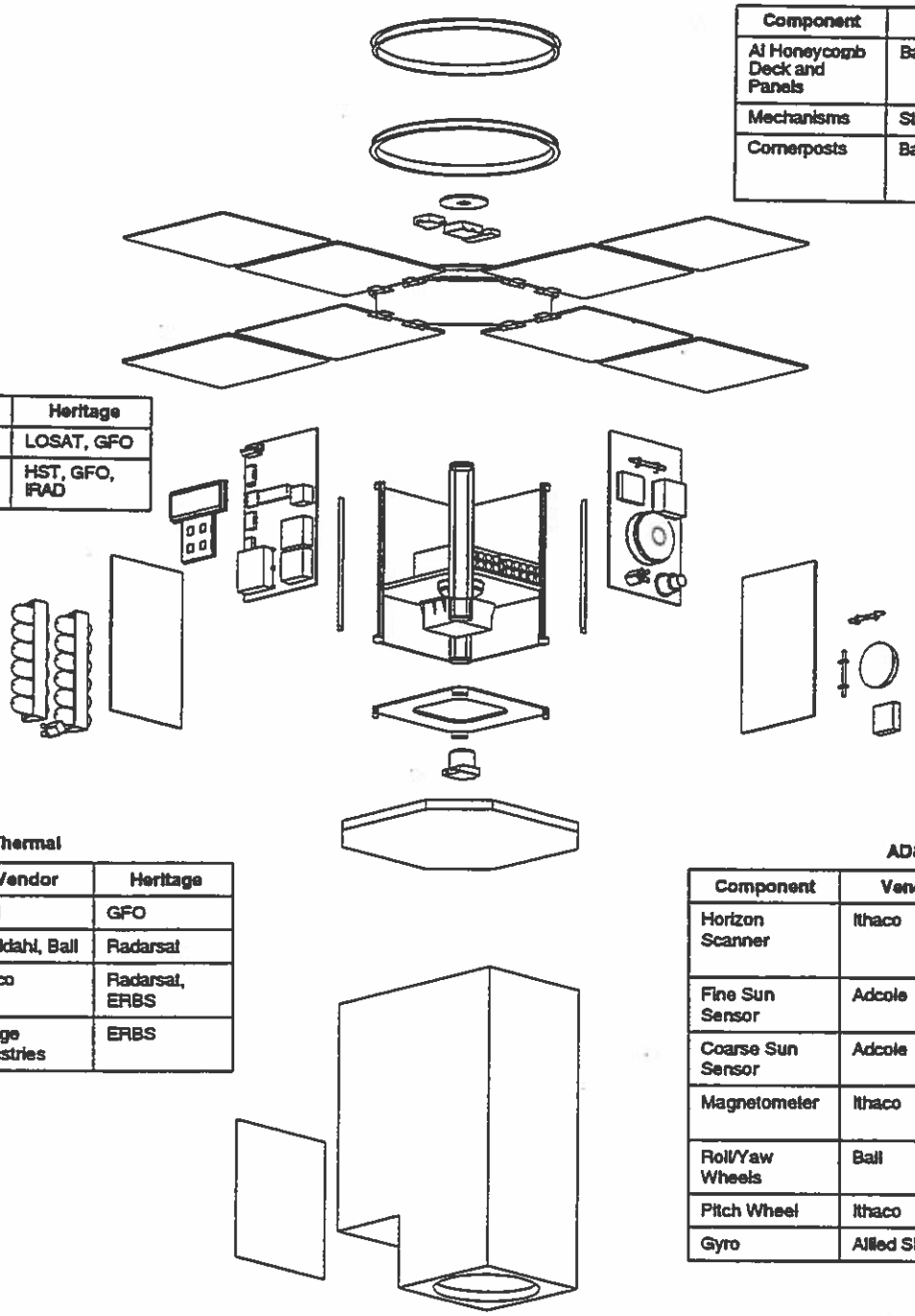
Power

Component	Vendor	Heritage
Solar Cells	ASEC	LOSAT, GFO
Battery NiH_2 Cells Packaging	Eagle Picher, Ball	HST, GFO, IRAD



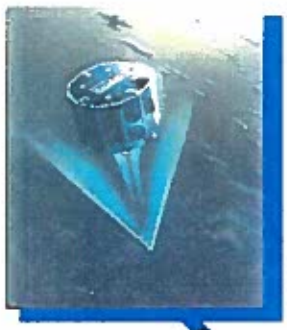
Thermal

Component	Vendor	Heritage
Finishes	ITRI	GFO
Blankets	Sheldahl, Ball	Radarsat
Heaters	Minco	Radarsat, ERBS
Beta Cloth	Dodge Industries	ERBS

AD&C

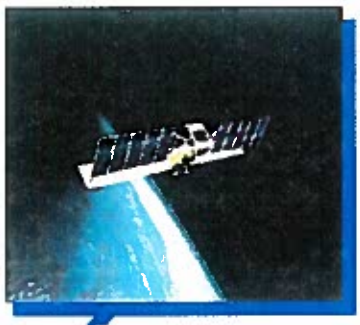
Component	Vendor	Heritage
Horizon Scanner	Ithaco	GFO, Classified Program
Fine Sun Sensor	Adcole	Radarsat
Coarse Sun Sensor	Adcole	GFO
Magnetometer	Ithaco	DARPASAT, GFO
Roll/Yaw Wheels	Ball	Clementine, GFO
Pitch Wheel	Ithaco	P91-1
Gyro	Allied Signal	Iridium

Figure 1-2 Ball's MTI Design Concept—Ball will use existing designs and high heritage components for the MTI spacecraft subassembly.



Relay Mirror Experiment
- Unprecedented point and track accuracy
- Pitch/roll maneuvers
- Jitter control
- Total mission
- SPIE Technology Achievement Award 1991

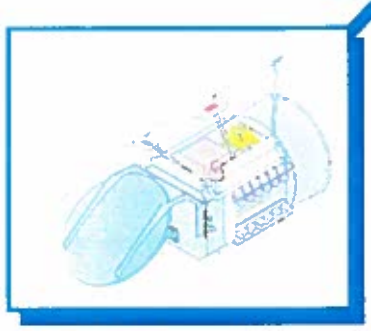
YSB
- Gimballed telescope for SNL
- SNL/Ball team
- Third flight unit being refurbished



Radarsat
- Fixed price contract
- Bus delivered to SPAR for payload integration
- Task contracts
- 1995 launch

DARPASAT
- Taurus launch (March 1994)
- MTI size satellite
- Baseline MTI structure and mechanisms
- Sunline spinner

Corrective Optics for Hubble Space Telescope
- Complex optical payloads
- Total team environment
- Unsurpassed performance



GEOSAT Follow-On
- Small high technology satellite
- AD&C components and algorithms for MTI
- High reliability (8-year mission)
- Radiation tolerance
- MTI battery and cells
- Three axis stabilized
- 1996 launch

LOSAT
- Skunk works program
- Multispectral payload
- Track maneuvers
- 165-lb satellite

Brilliant Pebbles
- LLNL/Ball team
- Track maneuvers
- Integrated electro-optical payloads
- Hardware in loop testing

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Figure 1-3 Examples of Ball's Applicable Experience—Ball brings extensive experience, in both spacecraft and space instruments to the MTI team.

MTI as well as the need to follow the lead of the mission integrator. Ball will provide quality hardware and engineering support without attempting to infringe on the mission integrator's role or grab the spotlight when the mission succeeds. Ball's experience as a team player is demonstrated in letters from recent customers presented in **Figure 1-4**.

1.5 Committed to MTI

Ball is fully committed to helping SNL/LANL demonstrate the potential of MTI.

Business focus on small satellites. Ball has pioneered the push to highly capable small satellites like MTI. Since 1988, we have invested 100 percent of our spacecraft IR&D funds toward developing small satellites and supporting technologies.

Long-term commitment to New Mexico. We believe New Mexico is an important and growing center of space excellence and are committed to increasing Ball's presence. We already have more than 50 people working full time in Albuquerque and we have over 10 years of continuous on-site support of SNL programs.

Commitment to working with national laboratories. Ball fully understands how working with national laboratories maintains our competitive edge, and we are committed to establishing long-term relationships with national centers of excellence. Our small satellite programs greatly benefited from our association with LLNL on Brilliant Pebbles. The technology transfer from APL and JPL on the GFO program gives us significant advantages in competing for future environmental remote sensing missions. For a mid-size aerospace company like Ball to effectively compete in today's market, close working relationships with national laboratories are a must. Ball is willing to share our experience and expertise in return for the opportunity to work with SNL/LANL.

Ball has shown commitment to working with SNL/LANL by successfully completing the Department of Energy's Foreign Ownership, Control, or Influence (FOCI) review.

Our best people. We have chosen outstanding, experienced people who have proven themselves in team environments. We will assign the people SNL wants and needs as the program evolves.

1.6 Mandatory Requirements

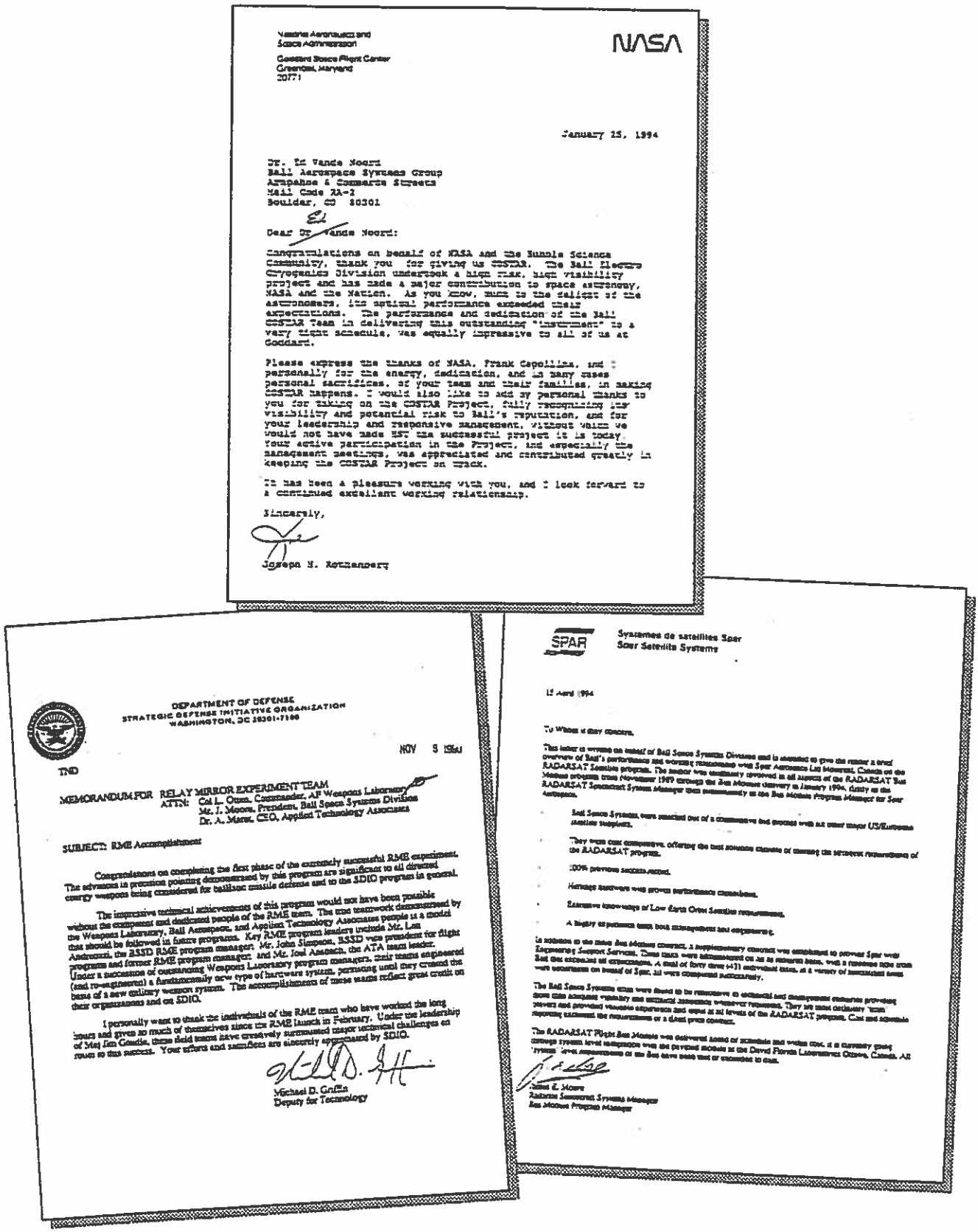
Ball exceeds all mandatory requirements for participation in MTI.

Demonstrated Company Experience: Ball has successfully completed a number of satellite projects comparable in scope and complexity to MTI. For evaluation purposes, Ball submits the Relay Mirror Experiment (RME) as the satisfactorily completed satellite project that fulfills the mandatory requirement of "at least one satellite project that was comparable in scope and technical complexity to MTI."

As illustrated in **Figure 1-5**, the RME spacecraft, orbiting at 450 km, carried a sensitive optical payload with low jitter requirements that redirected a laser beam propagated from Earth back to a 3-m target scoring board on Earth. RME "achieved relay beam pointing accuracy which was 16 times beyond the technical requirement, thereby establishing new standards for acquisition, tracking, and pointing (ATP) systems."[1] The pitch and pointing maneuvers required for MTI are similar to the maneuvers required of the RME spacecraft. RME was sponsored by SDIO with Phillips Laboratory heading a team that had Ball as the prime contractor.

Proven Project Manager: Ball proposes Ron Young as the MTI project manager. He is currently employed at Ball as the project manager for Radarsat. Radarsat is a major spacecraft bus assembly, which Ball recently delivered to SPAR. SPAR is integrating the bus with a synthetic aperture radar payload and solar arrays, and performing all system-level tests. The Radarsat bus was developed under a fixed-price contract with system engineering and support services provided under a parallel task order contract. We are currently providing integration and test support under the task order contract. We are also developing the Radarsat mission control facility under contract to MacDonald Detweiler of Canada.

[1] Relay Mirror Experiment/Wideband Angular Vibration Experiment, Vol. I, Phillips Laboratory, Directorate of Lasers and Imaging, Kirtland AFB, NM, January 1992.



National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland
20771

NASA

January 25, 1994

Dr. Ed Vande Noord
Ball Aerospace Systems Group
Arapahoe & Commerce Streets
Mail Code AA-2
Boulder, CO 80301

Dear Dr. Vande Noord:

Congratulations on behalf of NASA and the Hubble Science Community, thank you for giving us COSTAR. The Ball Electro Cryogenics Division undertook a high risk, high visibility project and has made a major contribution to space astronomy, NASA and the Nation. As you know, much to the fallout of the astronomers, its optical performance exceeded their expectations. The performance and dedication of the Ball COSTAR Team in delivering this outstanding "instrument" to a very tight schedule, was equally impressive to all of us at Goddard.

Please express the thanks of NASA, Frank Cepollina, and I personally for the energy, dedication, and in many cases personal sacrifices, of your team and their families, in making COSTAR happens. I would also like to add my personal thanks to you for taking on the COSTAR Project, fully recognizing its visibility and potential risk to Ball's reputation, and for your leadership and responsive management, without which we would not have made HST the successful project it is today. Your active participation in the Project, and especially the management meetings, was appreciated and contributed greatly in keeping the COSTAR Project on track.

It has been a pleasure working with you, and I look forward to a continued excellent working relationship.

Sincerely,

Joseph H. Rothenberg

DEPARTMENT OF DEFENSE
STRATEGIC DEFENSE INITIATIVE ORGANIZATION
WASHINGTON, DC 20301-7100

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TND

MEMORANDUM FOR RELAY MIRROR EXPERIMENT TEAM
ATTN: Col L. Otten, Commander, AF Weapons Laboratory
Mr. J. Moore, President, Ball Space Systems Division
Dr. A. Marx, CEO, Applied Technology Associates

SUBJECT: RME Accomplishment

Congratulations on completing the first phase of the extremely successful RME experiment. The advances in precision pointing demonstrated by this program are significant to all directed energy weapons being considered for ballistic missile defense and to the SDIO program in general.

The impressive technical achievements of this program would not have been possible without the competent and dedicated people of the RME team. The true teamwork demonstrated by the Weapons Laboratory, Ball Aerospace, and Applied Technology Associates people is a model that should be followed in future programs. Key RME program leaders include Mr. Lee Andreozzi, the BSSD RME program manager; Mr. John Simpson, BSSD vice president for flight programs and former RME program manager; and Mr. Joel Aasarch, the ATA team leader. Under a succession of outstanding Weapons Laboratory program managers, their teams engineered (and re-engineered) a fundamentally new type of hardware system, persisting until they created the basis of a new military weapon system. The accomplishments of these teams reflect great credit on their organizations and on SDIO.

I personally want to thank the individuals of the RME team who have worked the long hours and given so much of themselves since the RME launch in February. Under the leadership of Maj Jim Gaudie, these field teams have creatively surmounted major technical challenges en route to this success. Your efforts and sacrifices are sincerely appreciated by SDIO.

Michael D. Griffin
Deputy for Technology

SPAR

Systèmes de satellites Spar
Spar Satellite Systems

15 April 1994

To Whom it may concern,

This letter is written on behalf of Ball Space Systems Division and is intended to give the reader a brief overview of Ball's performance and working relationship with Spar Aerospace Ltd Montreal, Canada on the RADARSAT Satellite program. The author was continually involved in all aspects of the RADARSAT Ball Mission program from November 1989 through the Ball Mission delivery in January 1994, firstly as the RADARSAT Spacecraft System Manager then subsequently as the Ball Mission Program Manager for Spar Aerospace.

- Ball Space Systems were selected out of a competitive bid process with all other major US/European satellite suppliers.
- They were cost competitive, offering the best economic chassis or meeting the stringent requirements of the RADARSAT program.
- 100% previous success record.
- Heritage hardware was proven performance characteristics.
- Extensive knowledge of Low Earth Orbit Satellite requirements.
- A highly experienced team, both management and engineering.

In addition to the Ball Aerospace contract, a supplementary contract was established to provide Spar with Engineering Support Services. These tasks were administered on an as required basis, with a response time from Ball that exceeded all expectations. A total of forty three (+43) individual tasks, at a variety of associated levels were undertaken on behalf of Spar. All were completed successfully.

The Ball Space Systems team were found to be responsive to economic and management concerns providing those with adequate visibility and technical information whenever requested. They are most definitely "team players" and provided valuable experience and input at all levels of the RADARSAT program. Cost and schedule reporting exceeded the requirements of a fixed price contract.

The RADARSAT Flight Star Mission was delivered ahead of schedule and within cost. It is currently going through system level integration with the payload module at the David Florida Laboratories Ottawa, Canada. All [illegible] level requirements of the Star have been met or exceeded to date.

Robert E. Moore
Radarsat Spacecraft Systems Manager
Star Mission Program Manager

Figure 1-4 Ball is a Team Player—Our team play and technical expertise is well documented.

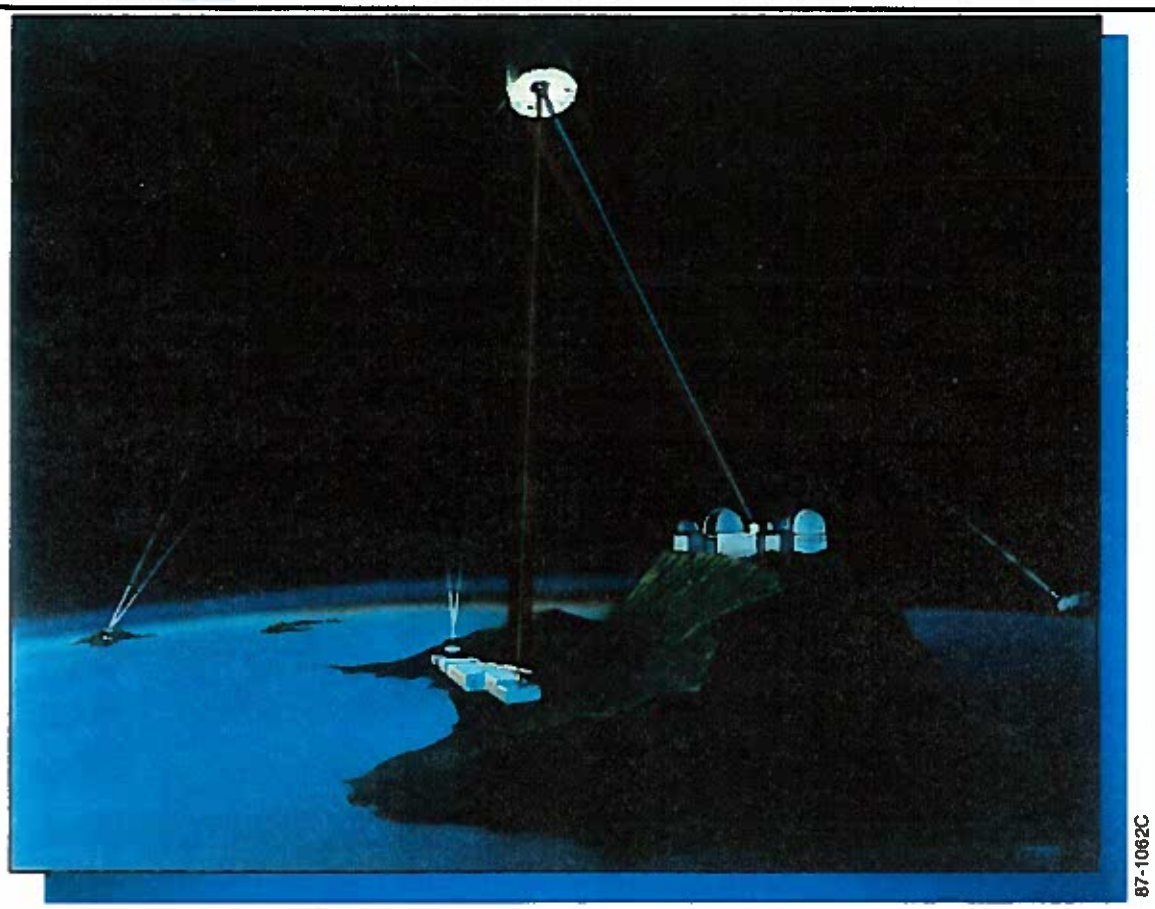

Figure 1-5 Satisfaction of Prior Development Requirements—The Relay Mirror Experiment was a satellite project of the comparable scope and technical complexity as MTI.

Experienced System Engineers: Ball proposes two highly experienced system engineers for the Phase 1 labor contract. Harold Montoya, who has 14 years of experience, is currently employed at Ball as the Radarsat system support contract manager. In this position, he is providing technical coordination for on-going system studies, training, and test support. Prior to this assignment, he was the electrical design manager and system engineer for the Radarsat program. His system engineering duties included requirements flowdown and end-item specification development.

As the launch interface engineer for RME, he was responsible for all payload documentation required by the launch vehicle contractor and the range. He also coordinated all integration activities at the launch site. Prior to that assignment, he managed the RME thermal subsystem design, analysis, and integration effort.

Jeff Dierks, who has 15 years experience, is a current Ball employee just completing an assignment as the system engineer responsible for all DARPASAT integration, test, and launch activities. (DARPASAT was successfully launched on a Taurus on March 13, 1994.) His previous assignment at Ball consisted of system engineering tasks on RME including developing the spacecraft bus specification and the interface control documents between the spacecraft bus and payload. Prior to joining Ball in 1986, he developed state-of-the-art space structure designs at Harris.

1.7 Conclusion

Ball is the credible choice for MTI. We are large enough to have a broad base of experience, expertise, and financial stability, and yet small enough to provide high management visibility, and streamlined management to MTI. We have demonstrated our ability to deliver mission success both as a team leader and as a team player. Ball is highly motivated to establish working relationships with SNL/LANL and will commit the necessary resources to make MTI a success.