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Final Summary Report
GHRS SV/GTO Project

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Contract number NAS5-30433, known at Ball Aerospace as the GHRS SV/GTO project, supported our participation in the post-launch activities of the Goddard High Resolution Spectrograph aboard the Hubble Space Telescope. The period of performance was December, 1988 through December, 1998. The contract supported the involvement of Dr. Dennis Ebbets in the work of the GHRS Investigation Definition Team, and several other Ball people in the documentation and publication of results. Three main categories of tasks were covered by this contract; in-orbit calibration of the GHRS, guaranteed time observations, and education and public outreach. The nature and accomplishments of these tasks are described in the following paragraphs. This summary makes many references to publications in the scientific and technical literature. Appendix A is extracted from a complete bibliography, and lists those papers that are directly related to work performed under this GHRS contract.

The tasks related to the in-orbit calibration of the GHRS were by far the largest responsibility during the first six years of the project. During this period Dr. Ebbets was responsible for the definition of calibration requirements, design of experiments, preparation of observing proposals, tracking their implementation and execution, and coordinating the analysis and publication of the results. Prior to the launch of HST in 1990 the observing proposals were developed in cooperation with the scientists on the GHRS IDT, engineers at Ball Aerospace, the operations staff at the STScI, and project coordinators at GSFC. During the HST Science Verification period (1990 – 1991) Dr. Ebbets relocated to Maryland, and split time between NASA's Goddard Space Flight Center and the Space Telescope Science Institute. After the discovery of spherical aberration a large number of the original calibration plans were revised, and most of the proposals were rewritten. Throughout this period Ebbets was the primary liaison between the GHRS IDT, the SV management and the HST operations teams. The installation of COSTAR and the GHRS Redundancy Kit on the First Servicing Mission in December, 1993 led to a second intense round of calibration proposals, analyses and publications.

Throughout 1990 and 1991 Dr. Ebbets participated heavily in the analysis and publication of results of the SV program. He was particularly concerned with issues relating to resolution, scattered light and signal to noise ratio, the performance of the grating carrousel, the digicon detectors and the target acquisition flight software, and algorithms for data calibration and analysis. He coordinated and organized analyses from the entire GHRS team into 130 Systems Engineering Reports, which were maintained as reference material at Ball, the GHRS project office at Goddard, and at STScI. In February, 1992 we published the Final Report of the Science Verification Program, Appendix A, reference #66. The GHRS SV results were also communicated to the HST community in meetings, reviews and workshops, and were published in refereed journals and proceedings of various conferences. Papers # 48, 89, 96 and 111 are broad discussions of the performance of the GHRS. Papers # 42, 45, 47, 51, 64, 70, 75, 79 and 92 presented more detailed information about particular topics.

Dr. Ebbets' participation in the scientific program of the Guaranteed Time Observations had three main goals; completion of two GHRS Team Projects, collaboration with other IDT members with development of their observing proposals, and personal research interests. Dr. Ebbets was the lead scientist for two team projects, which investigated very weak interstellar absorption lines in the spectrum of Zeta Oph, and the photospheric spectrum of 10 Lac. The observing programs for both were executed successfully and produced data of exquisite quality. These spectra were analyzed with the assistance of students and post-docs at the University of Colorado, and were interpreted in consultation with the IDT scientists. Publications # 97 and 112 resulted from these projects. Personal interests included applications of high resolution and high signal to noise spectra, the massive star cluster R136, and the remarkable star Eta Carinae. In consultation with over a dozen collaborators observations were defined, proposals were prepared and implemented, data were analyzed and the results were communicated to the scientific community. The most productive of these collaborations were with Drs. Savage, Cardelli, Carpenter, Walborn and Davidson, as implied by the numerous references in Appendix A. Dr. Ebbets was an active participant in scientific workshops and symposia in the United States, England, Italy and Canada.

Dr. Ebbets believes strongly in the value of communicating to the general public the excitement of science and space research, and the role of NASA and HST in that mission. As such he has devoted a significant amount of time to educational and public outreach activities. The primary outlet has been speaking engagements with slide shows and general discussions to schools and adult groups. These engagements have averaged at least once a week throughput the period of the GTO contract. A list of speaking engagements completed since 1993 is attached as Appendix B. The majority of school talks have been to elementary schools in the Colorado front-range area. Middle schools and high schools are also included whenever opportunities arise. We have visited public and private classrooms, and several home school groups. Dr. Ebbets has also been a guest lecturer at the University of Colorado at Boulder, CU Denver, Colorado School of Mines, Colorado State University, University of Northern Colorado, Metropolitan State College, Northwest Missouri State University, Ball State University and the Rochester Institute of Technology. Adult groups have included service clubs such as Rotary, Optimists,

Kiwanis, Lions and Masons, professional societies of teachers, engineers, contractors and project managers, civic and patriotic clubs, church fellowship groups and retirees clubs. Every one of these engagements reaches an average of over thirty people, and many have had audiences in the hundreds. These presentations have always been well received, and the audiences always have reacted with enthusiasm and appreciation for NASA's HST program. There have been dozens of repeat invitations. Copies of a few of the many thank-you letters received over the years are attached to this report. In addition to visiting individual classrooms, Ebbets has also addressed associations dedicated to promoting science education and public understanding. Examples include Jefferson County Science Teachers, National Science Teachers Association, Colorado Space Grant Consortium, Colorado Space Education Initiative, the Challenger Center, the US Space Congress and the American Institute of Physics.

Appendix A
Scientific and Technical Publications Resulting from GHRS SV/GTO Contract

Dennis Ebbets, Ball Aerospace
Period of Performance 1988 through 1998
Complete as of February, 1999

42. Ebbets, D.C., Heap, S.R.and Lindler, D.J. 1988, "Photometric Characteristicsof Data from the Hubble Space Telescope Goddard High Resolution Spectrograph", in The Impact of Very High Signal to Noise Spectroscopy on Stellar Physics, IAU Symposium No. 132, ed. G. deStroebel and M. Spite, p.35.

43. Brandt, J.C., Ebbets, D.C., Carpenter, K.G. and Heap, S.R. 1988, "The Goddard High Resolution Spectrograph (GHRS) for the Hubble Space Telescope: Pre Launch Status", BAAS,

44. Ebbets, D.C. 1989, "The Slit Scattering Profile of the Echelle Modes of the Goddard High Resolution Spectrograph for the HST", BAAS, Vol. 20, p. 1004.

45. Ebbets, D.C., Christon, P. and Garner, H.W. 1989, "The Grating Carrousel Mechanism for the Goddard High Resolution Spectrograph for the HST", in Acquisition, Tracking and Pointing, SPIE, Vol. 1111, p. 58.

46. Ebbets, D.C., Becker, S.I. and Williams, B.D. 1989, "Target Acquisition Flight Software for the Goddard High Resolution Spectrograph for the HST", in Acquisition, Tracking and Pointing, SPIE, Vol. 1111, p. 317.

47. Cardelli, J.A., Ebbets, D.C., and Savage, B.D. 1990, "Scattered Light in the Echelle Modes of the Goddard High Resolution Spectrograph Aboard the Hubble Space Telescope: I. Analysis of Pre-Launch Calibration Data", Ap.J., 365, p.789.

48. Troeltzsch, J., Ebbets, D.C., Garner, H.G., Tuffli, A.L., Breyer, R., Kinsey, J., Peck, C., Lindler,D.J. and Feggans, J.K 1991, "In-flight performance of the Goddard High Resolution Spectrograph of the Hubble Space Telescope", in Space Astronomical Telescopes and Instruments, ed. P. Bely and J. Breckenridge, SPIE Vol. 1494, p.9.

49. Ebbets, D.C., Brandt, J.C. and Heap,S.R. 1991, "Status of the GHRS in May 1991" in The First Year of HST Observations, ed. A.Kinney and J.Blades, Space Telescope Science Institute, p.110.

50. Carpenter, K., Robinson, R., Ebbets, D.C., Brown, A. and Linsky, J. 1991, "GHRS Chromospheric Emission Line Spectra of the Red Giant Alpha Tau" in The First Year of HST Observations, ed. A.Kinney and J.Blades, Space Telescope Science Institute, p.212.

51. Beaver, E.A., Baity, W.A., Brandt, J.C., Ebbets, D.C., Garner, H.W., Heap, S.R., Lindler, D.J., Linsky, J.B., Lyons, R.W. and Rosenblatt, E.I. 1991, "Orbital Performance of the Goddard High Resolution Spectrograph Digicon Detectors on the Hubble Space Telescope", Proceedings of the 10th Symposium on Photoelectronic Image Devices, ed. B. Morgon, Institute of Physics Conference Series No. 121, p. 65.

52. Cardelli, J.A., Savage, B.D. and Ebbets, D.C. 1991, "Interstellar Gas Phase Abundance of Carbon, Oxygen, Nitrogen, Copper, Gallium, Germanium and Krypton Towards Zeta Ophiuchi", Ap.J., 383, p.L23.

53. Hutchings, J.B., Bruhweiler, F., Boggess, A., Heap, S.R., Ebbets, D.C., Beaver, E., Rosenblatt, E., Truong, K., Perez,M. and Westmacott,R. 1991, "First Results From the Goddard High Resolution Spectrograph: Ultraviolet Spectra of a Starburst Knot in NGC 1068", Ap.J., 377, pL25.

54. Heap, S.R., Altner,B., Ebbets, D.C., Hubeny, I., Hutchings, J.B., Kudritzski, R.P., Voels, S.A., Haser, S., Pauldarach,A., Puls, J. and Butler, K. 1991, "First Results From the Goddard High Resolution Spectrograph: Spectroscopic Determination of the Stellar Parameters of Melnick 42, an Of Star in the Large Magellanic Cloud", Ap.J., 377, pL29.

55. Wahlgren, G.M., Leckrone, D.S., Shore, S.N., Lindler, D.J., Gilliland, R.L. and Ebbets, D.C. 1991, "First Results From the Goddard High Resolution Spectrograph: A Demonstration of Spectral Resolution and Experiments with Deconvolution", Ap.J., 377, pL41.

56. Carpenter, K.G., Robinson, R.D., Wahlgren, G.M., Ake, T.B., Ebbets, D.C., Linsky, J.L., Brown, A. and Walter, F.M. 1991, "First Results From the Goddard High Resolution The Chromosphere of Alpha Tauri", Ap.J., 377, pL45.

57. Boggess,A., Bruhweiler, F.C., Grady, C.A., Ebbets, D.C., Kondo, Y., Trafton, L.M., Brandt, J.C. and Heap, S.R. 1991, "First Results From the Goddard High Resolution Spectrograph: Resolved Velocity and Density Structure in the Beta Pictoris Circumstellar Gas", Ap.J., 377, pL49.

58. Savage, B.D., Cardelli, J.A., Bruhweiler,F.C., Smith, A.M., Ebbets, D.C. and Sembach, K. 1991, "First Results From the Goddard High Resolution Spectrograph: Element Abundances as a Function of Velocity in the Neutral Gas Toward Xi Persei", Ap.J., 377, pL53.

59. Cardelli, J.A., Savage, B.D., Bruhweiler, F.C., Smith, A.M, Ebbets, D.C., Sembach, K.R. and Sofia, U.J. 1991, "First Results From the Goddard High Resolution Spectrograph: Elemental Abundances in the Diffuse Clouds Toward Xi Persei", Ap.J., 377, pL57.

60. Smith, A.M., Bruhweiler, F.C., Lambert, D.L., Savage, B.D., Cardelli, J.A., Ebbets, D.C., Lyu, C.H., and Sheffer, Y. 1991, "First Results From the Goddard High Resolution Spectrograph: C I, S I, and CO Toward Xi Persei and the Physical Conditions in Diffuse Clouds", Ap.J., 377, pL61.

61. Walborn, N.R., Ebbets, D.C., Parker, J.W., Nichols-Bohlin, J., and White, R.L. 1992, "Ultraviolet and Optical Spectral Morphology of Melnick 42 and Radcliffe 136a in 30 Doradus", Ap.J., 393, p.L13.

62. Ebbets,D., Walborn,N., White,R., Davidson,K., Malumuth,E., 1992, "Imaging of eta Carinae with the HST planetary camera", BAAS, 24, 686E .

63. Cardelli,J.A., Mathis,J.S., Savage,B.D., Ebbets,D.C., 1992, "Abundance of interstellar carbon toward zeta Ophiuchi", BAAS, 24, 1129C.

64. Gilliland, R.L., Morris, S.L., Weymann,R., Ebbets, D.C., and Lindler, D.J. 1992, "Resolution and Noise Properties of the Goddard High Resolution Spectrograph", P.A.S.P., 104, p.367.

65. Walborn, N.R., Ebbets, D.C., Malumuth, E. and White, R.L. 1992, "HST Images of Eta Carinae", in Non-iostropic and Variable Outflows from Stars", ed. Space Telescope Science Institute, p361.

66. Ebbets, D.C. 1992, "Final Report: Goddard High Resolution Spectrograph Science Verification Program for the Hubble Space Telescope", Ball Aerospace Systems Group.

67. Heap, S.R., Ebbets, D.C. and Malumuth, E. 1992, "The Starburst Cluster R136a",

68. Soderblom, D.R., Boggett, W., Hulbert,S., Skapik, J., Walter, L., Ebbets, D.C., Garner, H.W., Brandt, J.C. and Heap, S.R. 1993, "The Goddard High Resolution Spectrograph after the Servicing Mission", BAAS, 182, p2807.

69. Brandt, J.C. .... Ebbets, D.C. .... et al. 1993, "Observations of 3C273 with the Goddard High Resolution Spectrograph on the Hubble Space Telescope", A.J., 105, p. 831.

70. Ebbets, D.C. 1993, "Instrumental Artifacts, Stray and Scattered Light in the Goddard High Resolution SPectrograph", in Space Astronomical Telescopes and Instruments II, ed P.Bely and J. Breckinridge, SPIE Vol. 1945, p.308.

71. Ebbets,D., Malumuth,E., Davidson,K., White,R., Walborn,N., 1993, "Proper Motions of the N Condensations of Eta Carinae", Massive Stars and Their Lives in the Interstellar Medium, Conf. Proc., p263.

72. Ebbets, D.C., Cardelli, J.A. and Savage, B.D. 1993, "Calibration and Removal of Stray and Scattered Light in the Goddard High Resolution Spectrograph", Proceedings of the Ninth Workshop on the Vacuum Ultraviolet Calibration of Space Experiments, High Altitude Observatory, Boulder.

73. Linsky,J.L., Diplas,A., Andrulis,C., Brown,A., Savage,B., Ebbets,D., 1993, "Deuterium in the Line of Sight Towards Procyon and its Cosmological Significance", BAAS, 182, 0806L

74. (STIS related)

75. Cardelli, J.A. and Ebbets, D.C. 1993, "Attaining High Signal to Noise Data with the Goddard High Resolution Spectrograph", in Calibrating Hubble Space Telescope, ed. J.Blades and S. Osmer, Space Telescope Science Institute.

76. Ebbets, D.C., White, R.L., Walborn, N.R., Davidson,K. and Malumuth, E. 1993, "Imaging of Eta Carinae with the HST Planetary Camera", in Science With the Hubble Space Telescope, ed. P. Benvenuti and E. Schreier, ESO Conference and Workshop Proceedings No. 44, European Southern Observatory, p. 395.

77. Heap, S.R., Ebbets, D.C. and Malumuth, E. 1993, "The Nature of R136a", in Science With the Hubble Space Telescope, ed. P. Benvenuti and E. Schreier, ESO Conference and Workshop Proceedings No. 44, European Southern Observatory, p. 347.

78. Ebbets, D.C., Garner, H.W., White, R.L., Davidson,K., Malumuth, E. and Walborn, N.R. 1993, " New HST Images of Eta Carinae and its Surrounding Nebulosity", in Circumstellar Media in the Late Stages of Stellar Evolution, 34th Herstmonceux Conference, ed., Cambridge University Press

79. Cardelli, J.A., Ebbets, D.C., and Savage, B.D. 1993, "Scattered Light in the Echelle Modes of the Goddard High Resolution Spectrograph Aboard the Hubble Space Telescope: II. Analysis of In-flight Spectroscopic Observations", Ap.J., 413, p.401.

80. Cardelli, J.A., Mathis, J.S., Ebbets, D.C. and Savage, B.D. 1993, "Abundance of Interstellar Carbon Towards Zeta Ophiuchi", Ap.J., 402, p.L17.

81. Shore, S.N., Altner,B., Bolton,C.T., Cardelli, J.A. and Ebbets,D.C. 1993, "Goddard High Resolution Spectrograph Observations of Narrow Discrete Stellar Wind Absorption Features in the Ultraviolet Spectrum of the O7.5III Star Xi Persei" Ap.J., 411, 864.

82. Howarth, I.D., Bolton, C.T., Crowe, R.A., Ebbets, D.C., Fieldus, M.S., Fullerton, A.W., Gies, D.R., McDavid, D., Prinja, R.K., Reid, A.H., Shore, S.N. and Smith, K.C. 1993, "Time Series Observations of O Stars - III: IUE and HST Spectroscopy of Zeta Ophiuchi, and Implications for the 'Photospheric Connection'", Ap.J., 417, 338.

83. Carpenter,K., Robinson,R., Judge,P., Ebbets,D., Brandt,J., 1993, "On the Weakness of C I and O I Resonance Line Emission from the Chromosphere of alpha Ori.", BAAS, 183, 1504C

84. Cardelli,J.A., Ebbets,D.C., 1993, "Discovery of Interstellar Lead and Thallium", BAAS, 183, 4410C.

85. Ebbets, D.C., Garner, H.W., Heap, S.R., Maran, S.P., Malumuth, E.M., Robinson, R.D., Lindler, D.J., and Hutchings, J.B. 1994, "In-Orbit Performance of the COSTAR/GHRS Side 1 Based on Observations of R136a", BAAS, 184, 3105.

86. Carpenter,K.G., Robinson,R.D., Judge,P.G., Ebbets,D.C., Brandt,J.C., 1994, "GHRS Observations and Analysis of the 0 I and C I Resonance Lines in the UV Spectrum of alpha Ori (M2 Iab)", csss....8...56C

87. Malumuth, E.M., Ebbets, D.C., Heap, S.R., Maran and Hutchings, J.B. 1994, "UV Imaging of R136 with the GHRS and the WFPC2", BAAS, 184, 3104.

88. Heap,S.R., Ebbets,D.C., Malumuth,E.M., Maran,S.P., DeKoter,A., Hubeny,I., 1994, "GHRS Spectroscopy of individual stars in R136a", ApJ, 435L,39H.

89. Brandt, J.C. .... Ebbets, D.C. .... et al. 1994, "The Goddard High Resolution Spectrograph: Instrument, Goals and Science Results", PASP, 106, 890.

90. (STIS related)

91. Ebbets,D., 1995, "Capabilities of GHRS Side 1", Calibrating HST Conf. Proc., p164.

92. Ebbets,D., 1995, "Equivalent Width Uncertainties in GHRS and STIS Spectra", Calibrating HST Conf. Proc., p207.

93. (STIS related)

94. Davidson,K., Ebbets,D., Weigelt,G., Humphreys,R., Hajian,A., Walborn,N., Rosa,M., 1995, "HST/FOS spectroscopy of ETA Carinae: the star itself, and ejecta within 0.3 arcsec", AJ, 109, 1784D.

95. Brandt,J.C., Heap,S.R., ... Ebbets,D.C., et al, 1995, "An Atlas of Alpha Orionis Obtained with the Goddard High Resolution Spectrograph on the Hubble Space Telescope", AJ, 109, 2706B

96. Heap,S.R., Brandt,J.C., ... Ebbets,D.C., et al. 1995, "The Goddard High Resolution Spectrograph: In-Orbit Performance", PASP, 107, 871H

97. Brandt,J.C., Heap,S.R., ... Ebbets,D.C. et al., 1996, "High Signal-to-Noise Ratio Observations of Weak Interstellar Absorption Lines Towards Zeta Ophiuchi With the Goddard High-Resolution Spectrograph Aboard the Hubble Space Telescope", AJ, 112, 1128B

98. (STIS related)

99. Ebbets,D., Morse,J., Davidson,K.,Walborn,N., 1997, "New HST Results on Eta Carinae and the Inner Nebula", Luminous Blue Variables conf. 249E.

100. Davidson,K., Ebbets,D., Johansson,S., Morse,J., Hamann,F., 1997, "HST/GHRS Observations of the Compact Slow Ejecta of ETA Carinae", AJ, 113, 335D

101. Morse,J., Davidson,K., Ebbets,D., 1997, "Multi-band WFPC2 Imaging of Eta Carinae", BAAS, 190, 0704M

102. Brandt,J.C., Heap,S.R., Ebbets,D.C., Snow,M., 1997, "Introduction to the GHRS Ultraviolet Spectral Atlas of 10 Lacertae", BAAS, 190, 2501B

103. (STIS related)

104. (STIS related)

105. Brandt,J.C., Heap,S.R., ... Ebbets,D.C. et al., 1997, "Observations of 3C273 with the Goddard High Resolution Spectrograph on the Hubble Space Telescope. II.", AJ,114,554.

106. Ebbets,D.C., Walborn,N.R., Parker,J.Wm, 1997, "Ultraviolet Spectral Morphology of the Stellar Core of eta Carinae", ApJ, 161, 489L.

107. Davidson,K., Zethson,T., Johansson,S., Ishibashi,K., Ebbets,D. 1997, "Strange velocities in the equatorial ejecta of Eta Carinae", BAAS, 191, 3406.

108. (NGST related)

109. Ebbets,D.C., 1998, "Panel Discussion on the Future of UV Spectroscopy in Space", The Scientific Impact of the Goddard High Resolution Spectrograph.

110. (STIS related)

111. Robinson,R.D., Ake,T.B., Ebbets,D.C. et al., 1998, "The Goddard High Resolution Spectrograph: Post-COSTAR Characteristics", PASP, 110, 68.

112. Brandt,J.C., Heap,S.R., Ebbets,D.C. et al., 1998, "An Ultraviolet Spectral Atlas of 10 Lacertae Obtained with the Goddard High Resolution Spectrograph on the Hubble Space Telescope", AJ, 116, 941.

113. Morse,J.A., DavidsonK., Bally,J., Ebbets,D.C., Balick,B., Frank,A.; 1998, "Hubble Space Telescope Wide Field Planetary Camera 2 Observations of eta Carinae", AJ, 116, 2443.

114. (NGST related)

115. Brandt,J.C., Heap,S.R., ... Ebbets,D.C. et al., 1999, "Echelle Spectroscopy of Interstellar Absorption toward mu Columbae with the Goddard High Resolution Spectrograph", AJ, 117, 400.

Appendix B
HST & astronomy related Public Presentations

Talks to schools and student's groups

Date	Audience
Jan. 14 1993	Martin Park Elementary School, Boulder
Jan.20, 1993	Bear Creek Elementary School, Boulder
Feb. 02, 1993	Mapleton Hill Elementary School, Boulder
Feb. 10, 1993	Southern Hills Middle School, Boulder (science fair)
Feb. 17, 1993	Douglas Elementary School, Boulder (science fair)
Mar. 29, 1993	Skinner Middle School, Denver
Apr. 8,9, 1993	East Grand Middle School, Granby, visits to Ball
May 10, 1993	Heatherwood Elementary School, Boulder (2 talks)
May 12,13	East Grand Middle School, Granby (7 talks)
Sept. 27, 1993	University of Colorado, Boulder (Careers Week)
Oct. 19, 1993	Eisenhower Elementary School, Boulder
Jan. 17, 1994	Viento Girl Scouts, Boulder
Jan. 24, 1994	Viento Girl Scouts, Boulder
Feb. 07, 1994	Spangler Elementary School, Longmont
Feb. 08, 1994	Mesa Elementary School, Boulder
Feb. 09, 1994	Boulder Country Day School, Boulder
Feb. 14, 1994	Spangler Elementary School, Longmont
Feb. 15, 1994	Martin Park Elementary School, Boulder
Feb, 28, 1994	Spangler Elementary School, Longmont
Mar. 11, 1994	University of Colorado, Denver
Mar. 12, 1994	Boulder Valley School District Science Fair
April 05, 1994	Colorado School of Mines, Golden
April 20, 1994	Metro State College, Denver
May, 05, 1994	hosted Chris Taam as shadow student at Ball
May 18, 1994	Boulder Day School
June 21, 1994	Ball State University, Muncie, IN
July 19, 1994	Frontiers of Science Institute, visiting Ball
Sept. 07, 1994	Horizon High School, Brighton (2 HST talks)
Sept. 23, 1994	Centaurus High School, Lafayette
Oct. 03, 1994	Bear Creek Elementary School, Boulder
Oct. 4,5, 1994	Douglas County school (2 groups of 75 students each visited Ball)
Oct. 26, 1994	Simla High School stdents, visiting Ball
Oct. 31, 1994	Bear Creek E.S. shadow students at Ball
Nov. 01, 1994	Mesa Elementary School, Boulder
Nov. 10, 1994	Colo. School of Mines, Golden, IEEE
Nov. 14, 1994	CU Boulder, Astronomy 2000
Nov. 22, 1994	New Vista High School, Boulder

Nov. 28, 1994	CU Boulder, IEEE
Nov. 28, 1994	Andrea Schweitzer visit from Madison
Dec. 06, 1994	Spangler E.S. Longmont
Dec. 15, 1994	Casey Middle School, Boulder (visit to Ball)
Feb. 14, 1995	Bear Creek Elementary School, Boulder
Feb. 15, 1995	Southern Hills Middle School, Boulder (science fair judge)
Mar. 09, 1995	Platte Middle School, Boulder
Mar. 13, 1995	Platte Middle School, Boulder
Apr. 05, 1995	Longmont Middle School shadow student visit to Ball
Apr. 24, 1995	Thompson Elementary School
May 1, 1995	Platte Middle School
May 9, 1995	Red Rocks Elementary School, Morrison
May 22, 1995	Centaurus High School, Lafayette
July 11, 1995	Frontiers of Science @ Ball
July 13, 1995	American Indian Science & Engineering Society
July 14, 1885	CU Foreign students
Sept 22, 1995	Horizon High School, Adams County
Nov 2, 1995	Casey Middle School Boulder
Nov 20, 1995	Graduate Astronomy Class (Gary Thomas CU)
Dec 8, 1995	International English Students (CU)
Jan 19, 1996	Ryan Elementary School, Lafayette
Jan 24, 1996	Red Rocks Elementary School, Morrison
Mar 6, 1996	Spangler Elementary School, Longmont
Mar 8, 1996	Boulder Christian School
Mar 14, 1996	Eisenhower Elementary School, Boulder
March 20, 1996	Kohl Elementary School, Broomfield
Apr 17, 1996	CEC
May 24, 1996	Boulder High School
July 10, 1996	Frontiers of Science @ Ball
Nov 6, 1996	Horizon High School, Adams County
Nov 9, 1996	North West Missouri State University
Jan 7, 1997	Kohl Elementary School (science fair talk)
Jan 29, 1997	Kohl Elementary School, TAG
Feb 26, 1997	Loveland Middle School
Feb 28, 1997	Maple Grove Elementary School (Lakewood)
Mar 10, 1997	Colorado Springs school visit to Ball
Apr 22, 1997	CSU students visit to Ball
Apr 25, 1997	Casey Middle School, Boulder
May 19, 1997	Berthoud High School
July 14, 1997	Ball State University
July 17, 1997	Frontiers of Science @ Ball
Nov. 4, 1997	Eisenhower elementary school
Nov. 7, 1997	Horizon HS

Jan. 23, 1998	Twin Peaks Charter School, Longmont
Feb. 4, 1998	Southern Hills Middle School
March 16, 1998	Kohl ES, Broomfield
March 17, 1998	Southern Hills Middle School
March 31, 1998	Metro State College,Denver
March 31, 1998	Heart School, Denver
April 23, 1998	Take your kids to work day, Ball
May 12, 1998	Mt. Zion Luthern School, Boulder
July 27, 1998	Frontiers of Science
Sept. 23, 1998	Horizon High School
October 1, 1998	Casey Middle School
October 13, 1998	CU Astronomy Class (Gary Thomas)
October 21, 1998	CU Careers Day Panel Discussion
Dec. 14, 1998	Fairview High School

Talks to adult service clubs, professional organizations etc.

Date	Audience
Jan. 19, 1993	Boulder Optimists
Feb. 25, 1993	Broomfield Rotary
Mar. 31, 1993	CNN Interview, Al Hinman
Apr. 12, 1993	Ball Teacher's Symposium
Apr. 16, 1993	Av. Week Interview, Jim Asker
May 12, 1993	Teledyne Corporation Board of Directors
July 07, 1993	Boulder Lions Club
Sep. 6-8, 1993	"Explore" Symposium, Beaver Creek
Nov. 01, 1993	Boulder Kiwanis
Nov. 04, 1993	Gates Rubber Co. Engineering Society
Nov. 18, 1993	Coal Creek Rotary
Dec. 10, 1993	NIST physicists lunch meeting
Dec. 16, 1993	Society of Automotive Engineers, Phoenix
Jan. 20, 1994	Boulder Central Optimists
Feb. 09, 1994	Project Management Institute, Denver
Feb. 17, 1994	ZONTA Women's Professional Club, Boulder
Feb. 25, 1994	ATT Engineer's Week, Westminster
Mar. 02, 1994	Boulder Lions Club
Mar. 16, 1994	ΔΚΓ, Thornton
Mar. 29, 1994	Colorado Society of Automotive Engineers, Boulder
Mar. 31, 1994	Boulder Central Optimists
April 28, 1994	American Chemical Society, Laramie, WY
May 04, 1994	Niwot Kiwanis
May 10, 1994	Longmont Rotary
May 14, 1994	Explore Symposium Preview, Beaver Creek
June 21, 1994	Ball Corporation HQ employees, Muncie
June 21, 1994	Muncie (IN) Rotary
June 23, 1994	Longmont Optimists
July 08, 1994	University Hills Rotary, Denver
July 16, 1994	Professional Colorado Contractors Council, Vail
Aug. 27, 1994	Generations Symposium, Vail
Sept. 08, 1994	Gates Rubber Co. Engineering Club
Sept. 15, 1994	AIAA Rocky Mountain Region chapter
Sept. 19,20	Explore Symposium, Beaver Creek (5 talks in 2 days)
Sept. 26, 1994	Smoky Hill Rotary Club, Aurora
Oct. 14, 1994	Boulder Rotary Club
Nov. 15, 1994	Northglen/Thorton Rotary Club
Nov. 17, 1994	Boulder Central Optimists
Nov. 29, 1994	CEC, Ball & Meade Johnson executives

Feb. 09, 1995	Colorado Professional Engineers
Mar. 15, 1995	Niwot Kiwanis
Mar. 22-25	National Science Teachers Association Convention
May 30, 1995	Colorado Professional Engineers
July 24, 1995	Ball Corporation Directors
Sept 5, 1995	Boulder Optimists
Sept 8,, 1995	Colorado Space Grant Consortium
Sept 15, 1995	1st Presbyterian Church, Boulder
Oct 12, 1995	CU Foundation
Dec 4, 1995	DAR Littleton
Dec 5, 1995	Denver Lions
Dec 12, 1995	Society of Manufacturing Engineers
Jan 26, 1996	Colorado Space Education Initiative, Colorado Springs
Jan 30, 1996	Boulder Valley Rotary
Feb 8, 1996	ZONTA, Boulder
Mar 1, 1996	Ball Aerospace Payday Seminar
Apr 26, 1996	CU Foundation
May 2, 1996	Boulder Optimists
May 10, 1996	Welshire Presb. Church, Denver
June 16, 1996	St. Andrews Presb. Church, Boulder
June 19, 1996	Jefferson Kiwanis
July 11, 1996	Colorado School of Mines (retired faculty)
July 19, 1996	Challenger Center (visitors to Ball)
Aug 20, 1996	Rotary (visitors to Ball)
Sept 14, 1996	CU Foundation
Sept 26, 1996	Professional Colorado Contractors Council
Oct 3, 1996	Explore, Beaver Creek
Oct 23, 1996	CEC
Oct 29, 1996	Golden Kiwanis
Oct 31, 1996	Longmont Rotary
Nov 15, 1996	Loveland DAR
Dec 6, 1996	Stearns Rogers engineers club
Dec 11, 1996	National Sojourners
Jan 14, 1997	Loveland Rotary Club
Jan 16, 1997	Loveland Presb. Church (seniors fellowship)
Jan 20, 1997	AIAA (@CEC)
Mar 22, 1997	Denver Astronomical Society
Apr 3, 1997	US Space Command (visitors to Ball)
Apr 4, 1997	Colorado Space Grant Consortium (@CSU)
Apr 11, 1997	GYRO Club of Denver
Apr 18, 1997	CU Foundation
Apr 29, 1997	US Space Congress, Cocoa Beach
May 2, 1997	American Institute of Physics, College Park
May 6, 1997	Ball HST 2002 reception

June 2, 1997	interview with Les Echo (French business newspaper)
June 9, 1997	Boulder Kiwanis
July 14, 1997	Ball Corp HQ, Muncie
July 15, 1997	Muncie Rotary
July 24, 1997	Manville retirees
Aug 13, 1997	Niwot Kiwanis
Sept. 16, 1997	Boulder Optimists
Sept. 18, 1997	Metro State College
Sept. 20 1997	Pueblo Masonic Temple
Sept. 23, 1997	Explore Symposium, Beaver Creek CO
Sept. 26, 1997	CU Foundation
Oct. 14, 1997	Gates Rubber Co. Retirees
Oct. 15, 1997	Labatts Brewery
Oct. 20, 1997	OSA NCAR Boulder
Oct. 21, 1997	IEEE Warner Robins, GA
Nov. 7, 1997	Ball payday seminar COS
Nov. 19, 1997	National Tooling Association, Denver
Nov. 21, 1997	CO Science Teachers @ Ball
Dec. 4, 1997	N. CO Astronomical Society
Dec. 11, 1997	Denver Botanical Gardens
Feb 3 1998	Sigma XI, University of Colorado
Feb. 5, 1998	Instrument Society of America, Denver
March 10, 1998	MIT Alumni @ Ball
April 17, 1998	CU Foundation
April 29, 1998	VIVA group, Denver
May 21, 1998	AESF Castle Rock
June 3, 1998	Niwot Kiwanis
June 4, 1998	Broomfield Rotary
June 19, 1998	CU class @ Ball (Laura Tedder)
July 16, 1998	Boulder Optimists
August 19, 1998	Boulder Rotary
August 26, 1998	BVSD teachers visiting Ball
Sept. 25, 1998	CU Foundation Seminar
October 5-9, 1998	Explore, Beaver Creek
Nov. 5, 1998	Northern Colorado Astonomical Society
Nov. 11, 1998	Boulder Optimists
Nov. 11, 1998	Denver Museum of Natural History

March 7, 1997
2255 Creighton Dr.
Golden, CO 80401

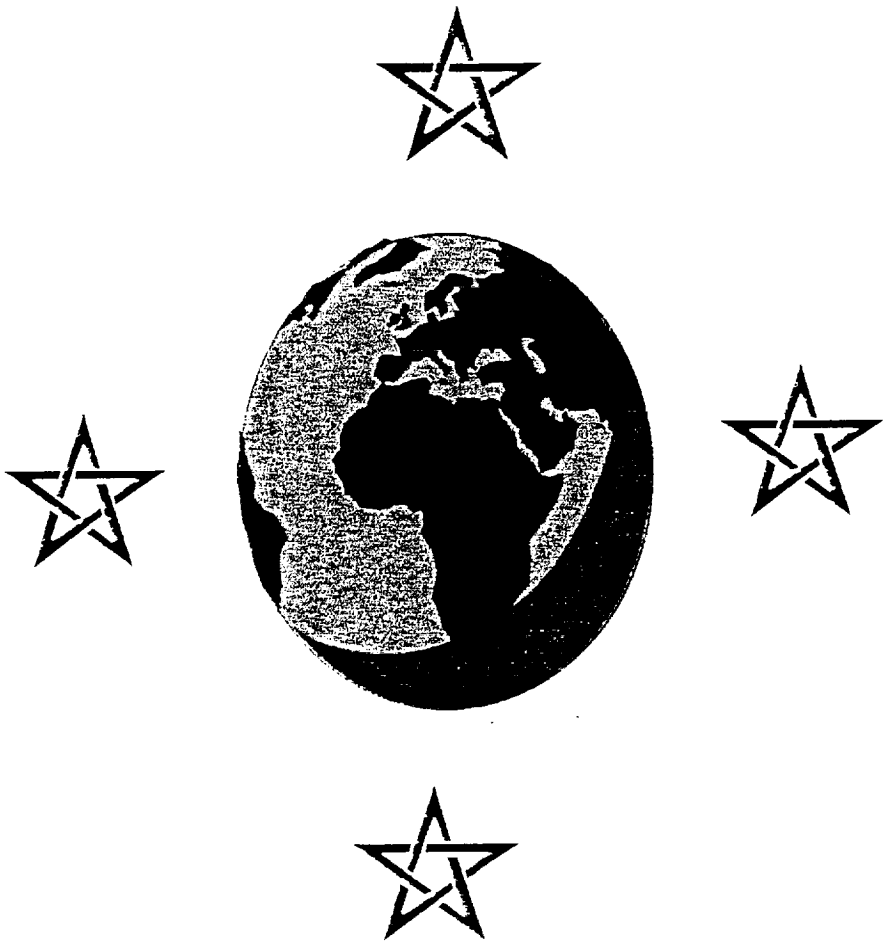
Dear Dr. Ebbetts,

How are you?

I really enjoyed your presentation. It was great! I never thought the Hubble Telescope could be so great. I learned a lot and, am trying to learn more. Space is very interesting and you are very lucky to have such a wonderful job.

Thankyou very much for coming.

Sincerely,
Jimmy Hensley
from Judy Truits class



Boulder Valley
Public Schools

6500 Arapahoe, P.O. Box 9011
Boulder, Colorado 80301
(303) 447-1010

Kohl Elementary School
1000 W. 10th Avenue
Broomfield, Colorado 80020
(303) 466-5944
Fax: (303) 466-8915

Robert E. Rea
Principal

Richard M. Schermerhorn
Assistant Principal

January 28, 1997

Dr. Dennis Ebbets
2242 Holyoke Drive
Boulder, CO 80303

Dear Dennis,

On behalf of the students, staff and parents of Kohl Elementary School it is my pleasure to express our sincere thank you for your highly enlightening presentation on January 7. I have received numerous comments and remarks from students about your exciting program. The five staff members of our Science Fair Committee have encouraged me to have you come back for a staff inservice sometime.

Please feel free to stop by school during our Science Fair on Friday, February 7, or Monday, February 10. I think you would be pleased to see the scope and scientific detail of our projects.

Again, our thanks and appreciation!

Sincerely,

Bob Rea
Principal

cc: David Agular
Ball Corporation

Colorado State University

Department of
Atmospheric Science
Fort Collins, Colorado 80523-1371
(970) 491-8360
FAX: (970) 491-8449

May 5, 1997

Ms. Janet Bachio
Mr. Bob Barry
Dr. Dennis Ebbets
Mr. Jim Snow
Mr. Elroy Briggs
c/o Dr. Ed Vande Noord
Ball Aerospace & Technologies Corp.
P.O. Box 1235
Broomfield, Colorado 80038-1235

Dear Friends,

Thank you for taking the time to explain the process of satellite development as well as the history of satellite and instrument development at Ball Aerospace. The tour gave the 20 members of our graduate class, "Observing the Atmosphere and Earth from Satellite" a semester's worth of information in less than two hours.

Sincerely yours,

Tom

Thomas H. Vonder Haar
University Distinguished Professor
of Atmospheric Science

THV/aes

BREGA & WINTERS P.C. ATTORNEYS AT LAW

April 14, 1997

Ronald S. Loser
Director

866-9426

Dennis Ebbets
Ball Aerospace
P. O. Box 1062
Mail Stop AR 1
Boulder, CO 80306

Re: GYRO Club

Dear Dennis:

Thank you so much for your fascinating presentation last Friday. You held everyone spellbound. I hope you can do it again next year and update us on the results of the new equipment.

Good luck to all of your scientific endeavors and I'll hold a good thought for your daughter's astronaut ambition. It was interesting to learn about you and your family.

Very truly yours,

Ronald S. Loser

RSL/jao

DENVER
James W. Bain
Stuart N. Bennett
Charles F. Brega
Robert R. Dormer
Peter A. Gergely
Wesley B. Howard
Robert C. Kaufman
Yvonne M. Kreye
S. Scott Lasher
Ronald S. Loser
Jack R. Luellen *
Brian A. Magoon
Loren L. Mail
Jay John Schnell

COUNSEL
Jay W. Enyart

OF COUNSEL
Mark Spitalnik

*Admitted in California only

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THE
DENVER ASTRONOMICAL SOCIETY
CHAMBERLIN OBSERVATORY
2930 East Warren Avenue
Denver, Colorado 80208
(303) 871 - 5172
http://www.du.edu/~pryan/das.html

March 25, 1997

Dr. Dennis Ebbets
Ball Aerospace Corporation
P.O. Box 1062, mail stop AR-1
Boulder, Colorado 80306

Dear Dr. Ebbets,

It is always a distinct pleasure to have a guest speaker who is, not only knowledgeable, but enthusiastic about their topic. It reflects a passion for the work they're doing in the way the interest is conveyed.

As I'm sure you're aware, so many times, scientific speakers can be overly "cerebral" in their presentations, which has the effect of losing audience interest. May I say, on behalf of those present at the DAS banquet, that your delivery and enthusiasm were both very highly charged.

I don't believe there is an astronomical person, amateur or professional, who does not follow the goings-on of the HST with great interest and expectation. To learn intimate details about this marvelous machine was, indeed, a treat, and we can only hope that the future will yield more new and fascinating information. I trust you will visit us again to keep us updated. That will be an event to which we will all look very much forward.

Many thanks again,

Steve Solon
President, The Denver Astronomical Society

p.s. - Please forgive the misspelling of your last name. Our treasurer was misinformed as to the correct spelling prior to the issuing of the check.

Dear Dennis,

The members of the Gates Retirees Club wish to thank you for your presentation at their recent meeting.

Much has been shown on TV as well as written about the "Hubble" telescope; the slides and your talk brought the members up close and showed how parts can be replaced to extend the life of this important enterprise. It is money well spent and will benefit everyone.

Again, our thanks to you.

Sincerely,

Ruth Bauer
Secretary

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Boulder, CO 80301

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13. ABSTRACT *(Maximum 200 words)*

Contract number NAS5-30433, known at Ball Aerospace as the GHRS SV/GTO project, supported our participation in the post-launch activities of the Goddard High Resolution Spectrograph aboard the Hubble Space Telescope. The period of performance was December 1988 through December 1998. The contract supported the involvement of Dr Dennis Ebbets in the work of the GHRS Investigation Definition Team, and several of the Ball people in the documentation and publication of results. Three main categories of tasks were covered by this contract; in-orbit calibration of the GHRS, guaranteed time observations, and education and public outreach. The nature and accomplishments of these tasks are described in the report. This summary makes many references to publications in the scientific and technical literature. Appendix A is extracted from a complete bibliography, and lists those papers that are directly related to work performed under this GHRS contract.

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