BELLCOMM, INC.
1100 Seventeenth Street, N.W. Washington, D.C. 20036

SUBJECT: Trip Report - Seventh Intersociety Reliability and Maintainability Conference, San Francisco, California, July 15-17, 1968 - Case 610

DATE: July 30, 1968

FROM: D. J. Belz

ABSTRACT

The Seventh Reliability and Maintainability Conference, sponsored by ASME, SAE, and AIAA, was held on July 15-17, 1968. Brief summaries of two papers and a complete list of all papers in the conference proceedings are provided.

(NASA-CR-97649) TRIP REPORT - SEVENTH INTERSOCIETY RELIABILITY AND MAINTAINABILITY CONFERENCE (Bellcomm, Inc.) 10 p

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MEMORANDUM FOR FILE

The Seventh Reliability and Maintainability Conference, sponsored by ASME, SAE, and AIAA, was held in San Francisco on July 15-17, 1968. Sixty-four technical papers were presented in fourteen sessions held during the three day meeting. A complete list of papers published in the proceedings of the conference is attached; copies of any of these papers may be obtained from the writer. Two papers of particular interest are summarized in the remainder of this memorandum.

1. Testing for Spacecraft Reliability - A Management Overview, by A. M. Smith and W. R. Waltz, General Electric Company, Philadelphia.

The records of ground and flight test failures or defects from five unmanned spacecraft programs were analyzed. Each of the five programs, which were not named, produced relatively complex spacecraft having active 3-axis stabilization and a "significant content" of electromechanical equipment as opposed to passive or spin stabilized spacecraft having predominantly electronic equipment. Defects analyzed in this study included only those which in the authors' judgment were of a catastrophic or significantly degrading nature, or were of sufficient severity to have warranted corrective action in the program; a total of 1500 defects from the five programs were analyzed.

Each defect was considered in order to determine the level of assembly that was necessary for the defect to manifest itself. Of the failures experienced in flight, 39% were considered capable of detection at the component level, 13% at the subsystem level, 37% at the system level, and 11% at the "less than component" level. Thus, 50% of the flight defects could not have been detected in ground tests conducted below the subsystem level of assembly.

In each of the five programs, 36% to 65% of defects present at entry into system acceptance tests were such that they should have been detected by the prior component acceptance tests; 17% to 68% of all defects present at entry into system acceptance tests should have been detected during the prior qualification test program.

For one of the spacecraft programs considered, 51% of in-flight "anomalies" were attributed to faulty design, 26% to inadequate manufacturing procedures, and 23% to defective parts or materials. Of the in-flight anomalies attributed to faulty design, 75% could not have been detected below the system/subsystem level of assembly in ground testing.

The utility of environmental testing (thermal/vacuum and vibration) was also considered. Of all flight defects observed, 40% were judged to be "environmentally sensitive". In one multi-vehicle program, vibration tests on flight systems were performed at the beginning, middle, and end of the program with intermediate flight systems not vibration tested. Thermal/vacuum tests were performed on flight systems only in the latter phase of the program. Vibration testing was estimated to have reduced the number of vibration-sensitive defects occurring in flight by 72%. Thermal/vacuum testing was estimated to have reduced the number of temperature-sensitive defects occurring in-flight by 50%.

2. Long Life Design Features of the Nimbus II Meteorological Observatory, by S. Charp, General Electric Company, Philadelphia.

The Nimbus II spacecraft was launched into a nearly polar orbit in May 1966. Although its design life was six months it has continued to function for approximately four times that duration. The successful achievement of this operational lifetime was attributed to several factors:

a) The spacecraft and its related ground systems were conceived, analyzed, planned, and conceptually integrated before extensive detailed design effort occurred.

b) Conservatively high estimates of environmental stresses to be encountered by the spacecraft were embodied in environmental specifications and in designs.

c) Engineering designs were supplemented with a "test, evaluate, redesign, retest" or "test, fix, test" program.

d) A capability was provided to override preprogrammed orbital operations with ground commands.

e) A Design Change Control Board met "almost daily" to review and act upon proposed changes. General improvements in designs were not normally accepted as reasons for a change; rather, changes were authorized to correct design errors or to resolve manufacturing and materials problems.

f) Harnessing and cabling were fabricated in a three-dimensional jig to avoid the hazard of weakened leads and connector joints which might result from the stresses of installing a planar-assembled harness in the spacecraft.

g) A full-scale thermal model simulating all internal heat sources and distribution paths was employed in the iterative design process leading to the final configuration of thermal blankets, reflective heat shields, automatic louvers, and passive paint coatings. Temperatures within ±5°C of nominal are experienced in-flight; this compares with a design goal of ±10°C.

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D. J. Belz

Attachment

Technical Papers Presented at the Seventh Reliability and Maintainability Conference, July 15-17, 1968

1. B. H. Caldwell, "An Engineering Approach to Long Life Complex Space Systems"
2. F. E. Senator et al, "Earth Orbital Space Station Effectiveness - Reliability, Safety and Maintainability"
3. S. Charp, "Long Life Design Features of the Nimbus II Meteorological Observatory"
4. H. P. Nicely and C. B. Mayer, "Design Tools for the Optimization of Redundancy for a Planetary Vehicle"
5. A. Murphy, "Maintenance on the Moon"
6. C. M. Ryerson, "Survey of Reliability Prediction Techniques"
7. G. B. Cohen, "Survey of Reliability and Maintainability Demonstration Techniques"
8. R. W. Stoffel, "System Analysis via Probability Diagrams"
9. L. R. Webster, "Reliability - 110 Years of Increasing Complexity and Value"
10. A. J. Kullas and W. Bishop, "The Role of Reliability and Quality Assurance in Managing Advanced Systems"
11. M. N. Olsen and W. H. Shaw, "The Role of Reliability and Quality Assurance in Program Management"
12. J. J. Tamsen, "Reliability Estimation and Demonstration of Gas Turbine and Rocket Propulsion Systems"
13. C. D. Galloway et al, "Implications of Reliability Models and Indices Used in Utility Power Generation System Planning"
14. W. R. Lans and R. M. Ohlenkamp, "Availability Assessment of Nuclear Plants"
15. J. L. Sauter, "Programming is Also a Reliability Problem"
16. G. H. St. Onge, "Power System Reliability in Petroleum and Petrochemical Plants"
17. H. Von Schertel, "Safety, Reliability and Maintainability of Supramar Commercial Hydrofoil Boats"

18. H. Hjorstvang and J. Van Overeen, "Reliability and Maintainability Provisions for a Rapid Transit Interurban System"

19. E. T. Ireton, "Evolutionary Growth of Helicopter Maintainability, Reliability and Safety"

20. E. C. Frost and A. B. Stacey, "Reliability and Maintainability Considerations for the Next Generation Subsonic Transport"

21. J. A. Levisky and C. W. Rogers, "Aging Characteristics Identified by Instrumental Analytical Methods"

22. J. L. Myers and E. L. Moon, "Service Life Prediction Program for the Minuteman LGM30 Propulsion System"

23. I. Doshay and D. B. Shube, "Advanced Missile Models and Methods for Availability Prediction"

24. A. M. Smith and W. R. Waltz, "Testing for Spacecraft Reliability - A Management Overview"

25. N. E. Tipton, "Measuring and Optimizing Dormant Weapon System Availability"

26. D. H. Heaton, "The Specification Approach to System Engineering Management"

27. W. D. Smith, "Incentive Contracting - Its Impact on System Engineering and Reliability"

28. J. F. Medford and W. V. Sterling, "Purchasing and Contracting Problems in the System Effectiveness Field for Weapon System Development (Incentives)"

29. F. L. Hale and W. B. Dalrymple, "Management of Systems Effectiveness Aspects of Saturn V Contracting and Procurement"

30. I. Bazovsky, "Appraisal of Guaranteed MTBF Warranty Programs"

31. P. J. Christianson et al, "Design Factors Affecting Reliability and Performance of Molded Solid Electrolyte Tantalum Capacitors"

32. T. Da Silva and A. Carlini, "Integrated Circuits: A Microelectronic Marvel but a Mechanical Control Nightmare"

33. C. H. Stuart, "Interconnecting Reliability"

34. J. K. Morris, "Eliminate Power Transitor Second Breakdown Failures"

35. K. Inaba and R. Matson, "Measurement of Human Errors with Existing Data"

36. P. F. Muller, "Potential Damage Evaluation - A Method for Determining the Potential for Human-Caused Damage in Operating Systems"

37. L. V. Rigsby and A. D. Swain, "Effects of Assembly Error on Product Acceptance and Reliability"

38. R. E. Olson and P. J. Stack, "Systems Safety - Concept and Management Application"

39. J. L. Simpson and T. J. Lebel, "Development and Application of System Safety Criteria"

40. L. A. Adkins and M. C. Thatro, "Reliability Requirements for Safe All Weather Landings"

41. C. O. Miller, "Hazard Analysis and Identification in System Safety Engineering"

42. A. M. Breipohl and W. C. Mc Cormick, "Bayesian Estimation of Time-Varying Reliability"

43. W. J. Mc Farland, "Uses of Bayes Theorem in its Discrete Formulation for Reliability Estimation Purposes"

44. J. J. Deely and W. J. Zimmer, "Some Comparisons of Bayesian and Classical Confidence Intervals in the Exponential Case"

45. J. E. Olsson, "Implementation of a Bayesian Reliability Measurement Program"

46. D. V. Mastran, "A Bayesian Approach for Assessing the Reliability of Air Force Re-entry Systems"

47. D. G. Gregor, "Logistics Resource Analysis"

48. F. S. Nowlan, "Spare Engine Management - An Example of Current Airline Practice in Logistics Planning and Management"

49. M. K. Kennedy, "A 'Closed Loop' Logistics Study in Combat Environment - Project 'Pacer Sort'"

50. M. M. Holland, "A Technique of Availability Prediction for Advanced Support Program Development"

51. R. R. Carson and J. S. Whiteside, "On Developing Optimum Integrated Logistic Support Procedural Models"

52. G. K. Davenport, "Systems Availability"

53. T. M. Fisher, "Automotive Safety Engineering"

54. W. L. Mc Intire and M. F. Lingren, "Design Reliability of Aircraft Reduction Gears"

55. J. W. Rice, "How Quality Assurance Contributes to the Reliability of Western Electric's Bell Telephones"

56. M. Kaplan, "Consumption is the Sole End and Purpose of All Production - How Are We Doing?"

57. C. E. Ingram et al, "Designing for Reliability Based on Probabilistic Modeling Using Remote Access Computer Systems"

58. M. J. Bratt et al, "Probabilistic Strength Mapping - Reliability vs Life Prediction Tool"

59. E. R. Forrester and V. H. Thevenow, "Designing for Expected Fatigue Life"

60. D. Kececioglu and E. B. Haugen, "A Unified Look at Design Safety Factors, Safety Margins and Measures of Reliability"

61. J. H. Anderson and W. P. Cox, "Aging Effects in Au-Al and Al-Al Bonds used in Microelectronics"

62. W. W. Dunn, "An Insulation Materials Design to Achieve a High Reliability Medium-Weight Wire"

63. J. R. Koch, "Experience Derived Guidelines for Effective Failure Analysis"

64. A. J. Giguerre et al, "Improving the Contribution of Material and Process Technology to Program Reliability"

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