Part IV.

REFERENCE DOCUMENTS

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REFERENCE DOCUMENTS

Reference documents for the topics discussed in Part II, Chapters 1 through 11, are listed and annotated here. The references for each topic are arranged and numbered in their order of appearance in the appropriate chapter. Items listed include a broad representation of reports, memoranda, technical manuals, specifications, and design documents chosen to provide a thorough historical background for each subject area.

References for Chapter 1

NIKE-ZEUS System

1. NIKE-ZEUS Guided Missile System — System Study Report (U), Vol 1, Bell Laboratories, March 1, 1957. (SECRET-RD)

   Discusses the future air defense problem and the system requirements composed by such a threat. A description of the NIKE-ZEUS system appears in Part I. Part II treats, in more detail, the nature of the threat, the data-gathering facilities, the missile design and guidance, weapon capability, system integration and effectiveness, a proposed test and development program, and a resume of exploratory development.

2. NIKE-ZEUS Tactical Controls for Defense Against Ballistic Missile — Case 27495 (U), D. Gillette, Bell Laboratories TM, MM-58-4112-20, May 20, 1958. (SECRET)

   Discusses NIKE-ZEUS tactical controls for the anti-ICBM operation. The subsystems controlled are the Forward Acquisition Radar, the Local Acquisition Radar, the Local Defense Command, and a battery. The approach is to set up a model at a defense system and to cast the subsystems in their appropriate roles. The principles of organization and tactical control are then investigated.

3. NIKE-ZEUS Guided Missile System Ballistic Missile Defense (U), Bell Laboratories, April 1960. (CONFIDENTIAL)

   Describes the present (1960) NIKE-ZEUS System. Reflects system improvements that have been incorporated since issuance of the original system report in March 1957 (see Reference 1).

4. NIKE-ZEUS Guided Missile System Radars (U), Bell Laboratories, June 1960. (CONFIDENTIAL)

   Describes the NIKE-ZEUS radars and summarizes their physical and electrical characteristics.

5. A Tactical Philosophy for NIKE-ZEUS (U) — Case 27495-42, A. R. Eckler, Bell Laboratories TM, MM-62-4263-1, February 9, 1962. (CONFIDENTIAL)

   Describes tactical philosophy of the NIKE-ZEUS system, including engagement planning and engagement execution.

6. Dielectric Lenses — Case 27495-11, W. McMahon, W. A. Yager, and D. Edelson, Bell Laboratories TM, MM-58-112-16 and MM-58-111-11, February 21, 1958.

   A preliminary report on a study of materials and structures for dielectric lenses. Deals principally with spherical lenses of the Luneberg type. Loading low-density foams with small amounts of metal particles of the proper shape can provide media with all of the refractive indices required.

7. Target Detector for the NIKE-ZEUS Acquisition Radar — Case 27495-44 (U), G. L. Gamble, L. W. Jones, and W. F. Miller, Bell Laboratories TM, MM-58-4435-1, June 26, 1958. (CONFIDENTIAL)

   Describes the target detector for the NIKE-ZEUS acquisition radar. This detector provides averaged positional target information in digital form from analog signals received from the receivers of the acquisition radar.

8. The Proposed Design of the Track Initiator at the Local Acquisition Radar of the NIKE-ZEUS System — Case 27495-41 and 27495-44 (U), A. Ralston, Bell Laboratories TM, MM-58-4111-13, February 4, 1958. (CONFIDENTIAL)

   Discusses the design of the track initiator for resolved ICBM targets. Presents the logical design in its overall aspects, along with detailed discussion of the logical design of the various components. The reasons for using one mode of operation in preference to others are indicated.

9. NIKE-ZEUS DR — Operational Control of the High Level Transmitter — Case 27495-64, F. J. Schaefer, Bell Laboratories MFF, May 2, 1960.

   Describes the switching functions by which the power output of the Discrimination Radar High Level Transmitter may be controlled and directed. Also describes the proposed transmitter control layout for the DR Control Console.

10. Description of the Low Power Section of the NIKE-ZEUS DR Transmitter — Case 27495-64, R. E. Mahoney, Bell Laboratories MFF, February 27, 1961.

    Contains a condensed physical description of the low-power section of the Discrimination Radar Transmitter, along with a block diagram and description of the circuit operation.

11. NIKE-ZEUS DR — Off-Axis Accuracy — Case 27495-42 (U), W. L. Gaines and D. M. Vanden Akker, Bell Laboratories TM, MM-62-6434-4, October 4, 1962. (CONFIDENTIAL)

    Discusses the factors governing the accuracy of off-axis measurement of a radar system using phase monopulse.

12. NIKE-ZEUS TTR — Modes of Operation — Case 27495-42, W. L. Gaines, Bell Laboratories MFF, June 5, 1959.

    Lists and briefly describes the three principal modes of operation for the NIKE-ZEUS Target Track Radar (TTR). These differ from those of NIKE-AJAX and HERCULES Systems because of the extremely short warning before the NIKE-ZEUS TTR must be fully operational.

13. NIKE-ZEUS Target Track Radar Transmitter (U) — Case 27495-42, K. H. Haber, Bell Laboratories TM, MM-59-6436-13, October 1, 1959. (CONFIDENTIAL)

    Describes the TTR transmitter, including the chirp principle, the generation of receiver local oscillator signals, and the functioning of each transmitter portion.

14. Dynamic Analysis of a Three Gimbal Tracking Antenna — Case 27495, D. A. Conrad, Bell Laboratories TM, MM-57-114-39, September 23, 1957.

    Analyzes a three-gimbal tracking antenna. Reasons that, because of a third axis, the gimbal design is not wholly determined by directing the antenna at the target. A coupling of two or more motions of the axes fixes the system. The system's motion is described by an equation once the form's coupling is prescribed.

15. NIKE-ZEUS — Maximum Range of TTR — Case 27495-42 (U), W. L. Gaines, Bell Laboratories MFF, January 22, 1962. (CONFIDENTIAL)

    Calculates the maximum range of the TTR from the radar range equation.

16. NIKE-ZEUS MTR — Description and Test Results of the GS-59208 Transmitter — Case 27495-516 (U), D. B. Seamans, Bell Laboratories MFF, June 12, 1961. (CONFIDENTIAL)

    Outlines the design objectives and gives circuit description and typical performance data on this transmitter.

17. NIKE-ZEUS R&D Program Final Report (U), Vol 1 through 6, McDonnell-Douglas Astronautics Company, Report SM-49046, March 1966. (Vol 1 and 2 SECRET; Vol 3 through 6 CONFIDENTIAL)

Reviews the history of the development of the NIKE-ZEUS missile, and includes description and specifications for that missile.

18. NIKE-ZEUS Missile Guidance Section Seminar (U), Bell Laboratories, March 20-22, 1962. (CONFIDENTIAL)

Describes in detail the philosophy and operation of the Mod III guidance section for the NIKE-ZEUS missile.

19. NIKE-ZEUS Defense Center Data Processing System Study Report — Case 27495-44 (U), Bell Laboratories, April 13, 1962. (CONFIDENTIAL)

Summarizes a recent study of the tactical ZEUS Defense Center Data Processing System.

20. NIKE-ZEUS — The Target Data Consolidator Computer — Case 27495-44, L. L. Cochran and E. R. Weir, Bell Laboratories MFF, August 20, 1962.

Describes the Target Data Consolidator Computer and its functions, including data processing.

21. NIKE-ZEUS — Likelihood Ratios — Case 27495-42 (U), S. C. Reed, Bell Laboratories MFF, March 2, 1961. (CONFIDENTIAL)

Introduces the concept of likelihood ratios and explains their application to the decoy problem.

22. Card Changeable Nondestructive Readout Twistor Memory — Case 27495-42, J. Janik, Jr., Bell Laboratories TM, MM-58-4114-4 and MM-4431-2, March 10, 1958.

Describes the storage of information in the presence or absence of permanent magnets and the twistor. There is a continual search for a readily changeable yet nondestructive readout memory, one in which the information can be punched on a card and inserted into the array.

References for Chapter 2

NIKE-X System

1. Hardsite Defense (U), Bell Laboratories, July 14, 1964. (SECRET-RD)

   Discusses an early study which examined the system and component requirements for the active defense of hardened sites, concluding that effective levels of defense can be provided.

2. Active Defense of Strategic Missiles, Joint ARPA/Air Force Study, Vol 1-4, Bell Laboratories, August 25, 1966.

   Presents the results of a joint Army and Air Force study conducted by Bell Laboratories to determine the preliminary characteristics, effectiveness, costs, and schedules for the active defense of Minuteman, Titan II, and rebased advanced Minuteman forces.

3. NIKE-X Ballistic Missile Defense System — System Study Report (U), Vol 1 and 2, Bell Laboratories, October 1, 1963. (SECRET)

   Volume 1 discusses the threat and the requirements it imposes on a defense system, presents the general configuration of NIKE-X and its expected effectiveness against the threat, and gives fairly detailed descriptions of the subsystems which comprise NIKE-X. Volume 2 presents detailed technical material in support of critical design choices made in the course of the study.

4. Threat Analysis Study for the Secretary of Defense (U), Vol 1 and 2, NIKE-X Project Office, Bell Laboratories, and Stanford Research Institute, October 26, 1964. (SECRET-RD)

   Following a concise description of NIKE-X, the physical threat is described. A system operating plan is postulated, giving system responses against various aspects of the threat. Finally, deployment principles are discussed and quantative estimates are given for system effectiveness.

5. NIKE-X Weapon System — Tactical System Description (U), Bell Laboratories, January 15, 1966. (SECRET)

   Describes the NIKE-X System and its subsystems at the stage of development reached by 1966. The system by then included a VHF radar and the TACMAR option. The reference threats to which the system was being designed are given in some detail.

6. NIKE-X Defense Against Light Attacks, Report to the Secretary of Defense (U), NIKE-X Project Office, Bell Laboratories, and Stanford Research Institute, June 10, 1965. (SECRET-RD)

   Describes a NIKE-X System option that (1) provides a CONUS-wide defense against light attacks via a high altitude barrage defense with modified ZEUS missiles, (2) provides comparatively light (referenced to previous concepts) SPRINT terminal defense of high value population centers, and (3) provides for orderly growth to meet increasingly sophisticated attacks.

7. NIKE-X Deployment Study (DEPEX), Report to the Secretary of Defense (U), Office, Deputy Chief of Staff for Military Operations, Dept. of the Army, October 1, 1965. (SECRET-RD)

Describes a four-phase deployment concept for NIKE-X, initially optimized for area defense against a light attack from an Nth Country with particular emphasis on evolution of a ballistic missile threat from the CPR. Also provides for growth to meet massive and sophisticated attacks. Emphasis is on ZEUS barrage mode for area defense, but basically relies on relatively moderate (referenced to later concepts) deployment of system components.

8. System Study NIKE-X I-67 Defense Deployment (U), Vol 1 — System Description, Bell Laboratories, July 5, 1967. (SECRET-RD)

   Describes deployment and operational concept for countervalue (area) defense against CPR ICBM attack and for counterforce (Strategic Offensive Force) defense against USSR attack. Area defense was designed explicitly to deny damage by unsophisticated threats. Utilized PAR and SPARTAN as new system elements.

9. NIKE-X Studies for 1966 (X-66) (U), Vol 1-8, Office of Deputy Chief of Staff for Military Operations, Dept. of the Army, September 1, 1966. (SECRET-RD)

   Builds on previous studies with emphasis on more extensive range of attack situations. Reexamines previous studies. A very light area defense concept is postulated and tested ("Phase 0" of DEPEX), with emphasis on CPR.

10. Improved SPARTAN System Study Report (U), Bell Laboratories, April 1, 1968. (SECRET-RD)

    Summarizes system studies performed from July 1967 to March 1968 concerned with improving the SPARTAN missile in its area defense role.

11. NIKE-X Advanced Development, Hardsite Defense (U), Vol 1-5, Bell Laboratories, September 1968. (SECRET-RD)

    Reports on two system configurations: a fixed-radar and a movable-radar system to defend the existing Minuteman, rebased Minuteman force in harder silos, and a new ICBM force in hard-rock silos. The five volumes present the summary, threat and effectiveness, radar characteristics and design, radar operation and data processing, and interceptor supporting studies.

12. Hardsite Interceptor Study (U), Vol 1 - DAC-62407, Vol 2 - DAC-62408, McDonnell-Douglas Astronautics Corporation, November 1968. (SECRET-RD)

    Generated realistic interceptor designs for engaging ballistic and maneuvering threats in defense of hardsites including use of information from the ABMDA UPSTAGE experiment program.

13. NIKE-X — Discrimination Techniques for Hardsite Defense (U), N. Levine, (Bell Laboratories) and V. Lotsof (Cornell Aeronautical Laboratory), June 1, 1966. (SECRET-RD)

    Investigates the discriminants which might be effective against sharp, slender RVs and decoys from 100-kilofoot altitude down to 20-40 kilofeet.

14. Ballistic Missile Defense, Advanced Development Program, Advanced Data Processing, Vol 1, Bell Laboratories, September 30, 1969.

    The first of three annual reports; introduces the Parallel Element Processing Ensemble (PEPE) concept and details its architecture and software and initial simulations.

15. IEEE COMP CON '72 Digest:

    PEPE Computer Architecture, B. A. Crane, M. J. Gilmartin, J. H. Huttenhoff, P. T. Rux and R. R. Shively

    The PEPE Support Software System, D. E. Wilson

    Application of PEPE to Radar Data Processing, G. D. Bergland and C. F. Hunnicutt

    Parallel Processing of Ballistic Missile Defense Radar Data with PEPE, J. A. Cornell.

These papers present a brief overview of the characteristics, PHSD test implementation, and performance of PEPE in a general distribution publication. It was presented as an example of "Innovative Architecture," the theme of the Conference.

16. Ballistic Missile Defense, Advanced Development Program, Advanced Data Processing (U), Vol 2, Bell Laboratories, September 30, 1971. (SECRET)

    Presents an overview of the PEPE IC Model, details and results of PEPE application studies to Ballistic Missile Defense, ZOS, PHSD and Off-loading, and results of hardware implementation studies.

17. Ballistic Missile Defense, Advance Development Program, Advanced Data Processing (U), Vol 2, Bell Laboratories, September 30, 1969. (SECRET)

    Presents the results of studies of the Application of PEPE to SAFEGUARD, VIRADE, and to Coherent Waveform Processing.

18. Ballistic Missile Defense, Advanced Development Program, Advanced Data Processing, Vol 1, Parts 1 and 2, Bell Laboratories, September 30, 1970.

    This second annual report presents a detailed description of the Integrated Circuit (IC) PEPE model brassboard hardware and its support software and the PASS II evaluation studies.

19. Ballistic Missile Defense, Advanced Development Program, Advanced Data Processing (U), Vol 2, Bell Laboratories, September 30, 1970. (SECRET)

    Presents results of GPSS simulation studies of Ballistic Missile Data Processing and design alternatives and a study of the application of PEPE to SPRINT missile guidance.

20. Ballistic Missile Defense, Advanced Development Program, Vol 1, Advanced Data Processing, Bell Laboratories, September 30, 1971.

    The third annual and final report of PEPE studies at Bell Laboratories. Presents an overview of the PEPE system, hardware and software, and the principal final year studies and demonstrations, ZOS, PHSD, and offloading. Includes an introduction to proposed LSI implementation.

21. NIKE-X – Critical Review of BTL Optical Discrimination Program (U), Bell Laboratories, April 1, 1965. (SECRET)

    Reviews the accomplishments and future objectives of the optical/infrared measurement program and data analysis efforts. The sensor facilities and operational aspects of these data sources are defined.

22. NIKE-ZEUS Guided Missile System Test Planning Handbook (U), Bell Laboratories, July 1, 1963. (SECRET)

    Describes the early activities and target types available to the Reentry Measurement Program, prior to RMP-A. Sensor characteristics and data collection procedures are defined.

23. NIKE-X Re-entry Measurements Program Targets – Case 27703-1600 (U), R. Flex, Bell Laboratories MFF, May 19, 1966. (SECRET)

    Provides descriptions of both the RMP-A and RMP-B target vehicles. Preliminary instrumentation details and objectives are presented for the RMV-340 vehicle.

24. NIKE-X – Summary of Re-entry Measurements Tests to be Conducted at WSMR with NIKE-X Radars – Case 27703-1700 (U), J. N. Wright, Bell Laboratories MFF, December 15, 1964. (SECRET)

    Specifies the reentry test series planned for the WSMR and data objectives for the DR and TTR.

25. The NIKE-X Field Test Program Handbook (U), Bell Laboratories, November 1, 1964. (SECRET)

Presents the objectives of the Reentry Measurements Program and describes the targets associated with this program. Appendices provide tabulation of equipment (sensors) locations and a glossary.

26. NIKE-X — Description of Reentry Measurements Program (U), S. J. Buchsbaum, L. C. Hebel, Jr., C. W. Hoover, Jr., and R. E. Markle, Bell Laboratories, October 1, 1965. (SECRET)

    Reviews the NIKE-X discrimination program from its infancy in 1960 to 1965. Emphasis is placed upon the sleek-cone target class and those experimental measurements necessary for understanding the physics of reentry. The experimental program is explained in detail including those to be performed under RMP-B.

27. Radar Observations of Near Wake Velocities, RMAR 68-9 (U), J. R. Pignataro, Cornell Aeronautical Laboratory, Inc., Report UB-1376-S-149, August 1968. (SECRET)

    Describes a discrimination technique derived from radar observation of wakes of reentering objects.

28. NIKE-X Re-entry Measurements Program Non-RMV Targets — Case 27703-1600 (U), R. Flex, Bell Laboratories MFF, June 9, 1966. (SECRET)

    Presents parameters and characteristics for operational Reentry Vehicles, penetration aids systems, and research and development vehicles flown in the WTR and WSMR tests. Booster systems are defined.

29. NIKE-X Advanced Development, Analysis of Radar Data Obtained During the RMV-A Program (U), Bell Laboratories, May 1967. (SECRET)

    Reports overall results of RMV-A program and applicability to real-time discrimination.

30. NIKE-X Advanced Development — Objectives and Description of the Re-entry Measurements Program Phase B (RMP-B) (U), L. C. Hebel, Jr., Bell Laboratories, June 30, 1967. (SECRET)

    Describes objectives and plans for RMP-B.

31. The Kwajalein Field Measurements Program Handbook (U), Bell Laboratories, May 1, 1968. (SECRET)

    Describes the KTS/NIKE sensor and associated activities in support of offense and defense system development with emphasis on gathering, reducing, and reporting radar data in support of the RMP.

32. The Kwajalein Field Measurements Program Handbook Supplement (U), Bell Laboratories, June 1, 1968. (SECRET)

    Provides material of special interest to test planning and scheduling personnel. This supplement also was used to convey corrections and additions to the above handbook.

33. NIKE-X Advanced Development, On-Board Experiments in RMP-B (U), Bell Laboratories, September 1968. (SECRET)

    Presents a detailed discussion of each experiment in the RMP-B on-board RMV-340 measurement series. The on-board measurements contributed knowledge of basic vehicle conditions during reentry and knowledge of near wake and boundary layer properties to aid in the interpretation of field measurements.

34. Ballistic Missile Defense Advanced Development Program, Bell Sphere Experiment (U), Bell Laboratories, July 1, 1971. (SECRET)

    Contains the information obtained from the Bell Sphere Experiments. The Reentry Vehicle chosen for experimental measurements of physical and chemical processes

was the sphere. These experiments provided measurements of precursor radiation; plasma sheathing; wake scattering, resulting from pure-air species, and wake enhancement and elimination, resulting from additions of electron donor atoms and attachment molecule; and on-board measurements of boundary layer and base electron densities.

35. MAR-I Multifunction Array Radar at White Sands, Test Planning Handbook (U), Vol 1 and 2, Bell Laboratories, October 1, 1964. (Vol 1 UNCLASSIFIED; Vol 2 SECRET)

Defines the testing program outlined for the MAR-I at White Sands. In addition, gives a brief description of the MAR-I functional capabilities. Vol 2 offers a detailed description of the MAR-I system and its subsystems. The descriptions contain tables and figures of the MAR-I radar parameters.

36. MAR-I, An Atlas of the Multifunction Array Radar at White Sands (U), Bell Laboratories, October 1964. (SECRET)

Deals exclusively with MAR-I at White Sands. The level of detail in the document is greater than any of the others listed herein. Gives detailed coverage of both system design and operation. This volume contains a profuse collection of functional schematics and line diagrams of consoles.

37. NIKE-X Weapon System — Kwajalein System Description (U), Bell Laboratories, November 30, 1965. (SECRET)

Presents complete description of the Kwajalein System, including MAR-II. Detailed radar design parameters are given as well as functional drawings, etc. Siting considerations for MAR-II are also shown.

38. MAR Design Manual (U), Bell Laboratories, June 1965. (SECRET)

Lists functional requirements and gives detailed functional schematics, equipment location drawings, etc. Document also gives a detailed description of each MAR subsystem.

39. TACMAR Reconfiguration to CAMAR (U) — Case 27703-1300, H. D. Hurlbut, Bell Laboratories MFF, June 17, 1968. (SECRET)

Briefly outlines the major design iterations of the MAR to TACMAR to TACMARK to CAMAR.

40. NIKE-X Advanced Development — CAMAR Program Plan (U), Bell Laboratories, September 15, 1968. (SECRET)

Presents the CAMAR program plan based upon preliminary study. Includes the objectives, brief description of program elements and schedules.

41. CAMAR Program Definition (U), Bell Laboratories, December 1, 1968. (SECRET)

Presents a more detailed description of the CAMAR Program and supersedes the earlier report (Reference 40).

42. CAMAR — First Quarterly Report (U), Bell Laboratories, April 1, 1969. (SECRET)

Summarizes progress for the period 31 December 1968 through 31 March 1969.

43. GUARDIAN — Second Quarterly Report, N. Levine, Bell Laboratories MFF, August 25, 1969.

This is the next quarterly report of progress on the GUARDIAN Program (formerly named the CAMAR Program) (see Reference 42).

References for Chapter 3

SENTINEL System

1. I-67 System Study — Case 27703-1600 (U), J. R. Logie, Jr., Bell Laboratories MFF, August 1, 1967. (SECRET)

   Gives the results of a study to define an ABM defense system to counter a minimal CPR countervalue threat or a USSR counterforce threat.

2. System Study, NIKE-X I-67 Defense Deployment (U), Vol 1 and 2, Bell Laboratories, Vol 1, July 5, 1967; Vol 2, October 6, 1967. (SECRET)

   Records the results of a study of the I-67 deployment of an Antiballistic Missile Defense system. Volume 1 contains a statement of the objectives of the defense, the characteristics of the subsystems, the deployment and organization, and the effectiveness against representative threats. Volume 2 contains the analyses and rationale leading to the selection of the systems described in Volume 1.

3. NIKE-X — CPR and USSR Threat for the January 1967 (I-67) Deployment (U) — Case 27703-1600, W. F. Bauer and R. B. Swerdlow, Bell Laboratories MFF, September 6, 1967. (SECRET)

   Describes in detail the "Design Threat" for the I-67 deployment plan, based on USSR and CPR offensive capability.

4. SENTINEL Siting Analysis — Boston (U) — Case 27703-1600, R. S. Rush, Bell Laboratories MFF, May 2, 1968. (SECRET)

   Evaluates the SENTINEL site options selected for locating a PAR and MSR in the Boston area.

5. Air Defense Capabilities of a SENTINEL Site (U), Case 27703-1600, Bell Laboratories, May 3, 1968. (SECRET)

   Describes the inherent air defense capabilities of a SENTINEL site.

6. Role of the Northernmost PAR in the I-67 Deployment (U) — Case 27703-1600, J. C. Hemmer, Bell Laboratories MFF, August 9, 1967. (SECRET)

   Presents results of a preliminary examination of the role of the northernmost Perimeter Acquisition Radar in the I-67 deployment.

7. SENTINEL — Perimeter Acquisition Radar Face Requirements — Case 27703-1600 (U), R. M. Hangley, Bell Laboratories MFF, January 9, 1968. (SECRET)

   Reports on a study that was conducted to determine the required number of faces per PAR in the SENTINEL deployment.

8. The Hardsite Defense Program — Case 27709-14 (U), R. S. McCarter, Bell Laboratories MFF, December 15, 1967. (SECRET)

   Describes the general problem of a Ballistic Missile Defense system and how the defense objectives, combined with a system design philosophy, shape the defense system within the bounds of the technologically possible.

9. Hardsite Defense — Case 27703-1600, R. Emerson Thomas, Bell Laboratories MFF, January 6, 1968.

   Discusses and considers the general question of different attacks and defenses for hardsite studies.

10. SENTINEL — MDC Man/Machine Interface Functional Requirements for Defense Oriented Functions (U) — Case 27703-1600, H. D. Todd, Bell Laboratories MFF, July 20, 1968. (CONFIDENTIAL)

    Presents the philosophy of man and the computer in the Missile Direction Center of the SENTINEL System.

11. Command and Control — Proposed Implementation of Nuclear Surety (U) — Case 27703-2110, L. R. Bowyer, Bell Laboratories MFF, October 16, 1963. (CONFIDENTIAL)

    Proposes a method of controlling nuclear surety in the SENTINEL System to ensure that defensive missiles are launched and detonated only when appropriately authorized.

12. SENTINEL System — Command and Control Program Design Report — Case 27703-1500 (U), T. L. Saxton, Bell Laboratories MFF, August 14, 1968. (CONFIDENTIAL)

    Describes the Defense Management Programs required for implementing a major portion of command and control functions in the SENTINEL System, and the software interfaces with other major blocks.

13. SENTINEL System — PAR Subsystem Command and Control Requirements — Case 27703-1940, R. F. Ricca, Bell Laboratories MFF, January 6, 1969.

    Defines the interface between the Support Operation Center and the Perimeter Acquisition Radar Subsystem. Describes tactical and support functions of the PAR Manager in the Command and Control concept for the SENTINEL System, radar test and maintenance philosophy, and manual operations of the Manager.

14. SENTINEL System — MSR Subsystem Command and Control Requirements — Case 27703-1400, G. T. Kresan, Bell Laboratories MFF, November 6, 1968.

    Defines the tactical and support functions of the Missile Site Radar Manager in the overall command and control of the SENTINEL System. Outlines the radar test and maintenance concept, defines the radar status levels, describes the manual tactical and support operations of the Radar Manager, and describes the hardware and software required to perform the test and maintenance functions.

15. The Optimum Availability of the NIKE-X Missile Site Radar and Data Processor for the I-67 Deployment (U) — Case 27703-1600, W. H. Mac Williams, Bell Laboratories TM, MM-67-4242-1, October 16, 1967. (SECRET)

    Presents an analytical framework for determining a "best value" of MSR and Data Processor availability, with respect to the dual-purpose I-67 deployment, and discusses the question of whether or not the cost of redundant circuits required to achieve a stated level of reliability is justified.

16. Approximate System Availability Models — Cases 27703-1600 and 36294-22, K. Grace, Jr., Bell Laboratories TM, MM-68-6223-8, October 25, 1968.

    Discusses the evaluation of the steady-state availability of complex systems with limited numbers of spares.

17. Approximate Spares Optimization in Complex Systems — Cases 27703-1600 and 36294-22, S. J. Amster, Bell Laboratories TM, MM-67-6223-8, September 25, 1967.

    Analyzes a spares optimization criterion and shows that it yields spares allocations very close (if not identical) to the optimal criterion where both are applicable and can be readily extended to more complex system configurations.

18. NIKE-X SPARTAN Warhead Effects Analysis (U) — Case 27703-1600, T. R. Lehnert, Bell Laboratories MFF, June 2, 1967. (SECRET)

    Considers effect of missile reliability, different defensive tactics, and target configurations.

19. Effects of Reduced Missile Reliability on SENTINEL Effectiveness (U) — Case 27703-1600, J. E. Keilin, Bell Laboratories MFF, January 23, 1969. (SECRET)

Presents an analysis of two types of missile failures: those which occur during the first portion of the flight and can be replaced by launching a substitute interceptor and those which occur so late in the flight that a substitute cannot be launched. Associates the total in-flight missile reliability with penetrator damage at two defended sites.

20. System Readiness Verification — Site and Multisite Exercises — Case 27703-1600, E. J. Bowers, Bell Laboratories MFF, January 29, 1969.

Describes the site configurations and the required simulation for each type of System Readiness Verification exercises. Proposes an operational doctrine to accommodate real and simulated intersite communications.

21. NIKE-X — Software Generation Breakdown — Its Principles and Practices — D.3. — Case 27703-1500, D. C. Thayer, Bell Laboratories MFF, March 28, 1968.

Describes the organization, content, use, and maintenance procedures for maintaining the SENTINEL Software Generation Breakdown.

22. Evaluation through System Simulation — A Preliminary View — Case 27703-1600, D. W. Abmayr and C. P. Neuman, Bell Laboratories MFF, April 22, 1968.

Proposes that the most profitable approach to system evaluation is through an overall system simulation, examines several simulation approaches, and identifies one as most promising.

23. NIKE-X SPRINT Urban Defense Firing Doctrine — Case 27703-1600 (U), J. W. Shaw, Bell Laboratories TM, MM-67-6422-7, August 25, 1967. (CONFIDENTIAL)

Describes the SPRINT Intercept Allocation Program which is being assembled to perform intercept simulations, study firing doctrine, determine how various tactical problems will be countered, and serve as a framework for any future tactical program.

24. Damage Analysis Tactics Evaluator (DATE) — Case 27703-1600, J. R. Evans and D. L. Murray, Bell Laboratories MFF, May 19, 1967.

Discusses an ABM defense system tactics study model which facilitates the study of defense tactics or firing doctrines and system performance.

25. Optimal Defensive Strategies Using Damage Assessment — Case 27703-1600, C. W. Spofford, Bell Laboratories TM, MM-67-4263-11, August 25, 1967.

Examines the advantages gained by the defense in assessing damage between waves of an offensive missile attack, and the effect of this assessment on the optimal offensive and defensive strategies.

26. SPRINT Firing Doctrine (U) — Case 27703-1600, J. W. Shaw, Bell Laboratories MFF, October 9, 1968. (SECRET-RD)

Presents the figures and notes used in a briefing given to the October 3, 1968 meeting of the SPRINT Vulnerability and Effects Working Group. Covers (1) fratricide and lethality, (2) how SPRINT is to be used, (3) SPRINT-SPRINT spacings, (4) use of SPARTAN and SPRINT in the same battle space, and (5) current estimates of miss distance.

27. Penetrations of the Defense Due to Battle Space Limitations and Leakage — Case 27703-1600 (U), J. E. Keilin, Bell Laboratories MFF, February 19, 1969. (CONFIDENTIAL)

Plots the probability of no penetrations and the expected number of penetrators for various values of arrival probability, defensive single-shot kill probability, number of successful arrivers required to guarantee penetration, and the number of attempted enemy launches.

28. SENTINEL - Missile Site Radar Performance Requirements (U) — Case 27703-1600, R. A. Dayem and R. A. Marth, Bell Laboratories MFF, January 15, 1968. (SECRET)

    Presents the performance requirements placed on the Missile Site Radar (MSR) hardware to ensure fulfillment of its role in the SENTINEL Defense System. Discusses the functions, threat, and environment appropriate to the MSR hardware.

29. SENTINEL — Perimenter Acquisition Radar Performance Requirements — Case 27703-1600 (U), R. S. Larkin and T. E. Lenigan, Bell Laboratories MFF, January 15, 1968. (SECRET)

    Presents the performance requirements placed on the Perimeter Acquisition Radar (PAR) hardware to ensure the fulfillment of its role in the SENTINEL Defense System. Discusses the functions, threat, and environment appropriate to the PAR.

30. Constraints on Attack Density Due to SPARTAN-Induced PAR Blackout (U) — Case 27703-1600, M. J. Spahn, Bell Laboratories MFF, October 19, 1967. (SECRET)

    Describes studies made to determine traffic limitations imposed upon the SENTINEL System by self-blackout under certain conditions.

31. NIKE-X SPRINT Kill Probability — Case 27703-1900 (U), J. M. Protzman, Bell Laboratories MFF, February 21, 1968. (SECRET)

    Describes the kill model adopted, the application of the kill model, and the values of kill probability which result.

32. Graphs of Kill Probability as a Function of Miss Distance for SPARTAN Exoatmospheric Intercepts (U) — Case 27703-1600, J. E. Keilin (UNIVAC), Bell Laboratories MFF, November 27, 1967. (SECRET)

    Develops probability equations to predict kill probability as a function of miss distance, in the light of more recent information, and charts the results.

33. SENTINEL System - Basis for the Development of the SENTINEL Data Processing System Hardware — DPS-2 — Case 27703-1500, T. H. Crowley, Bell Laboratories MFF, July 18, 1968.

    Describes the basis on which the development of SENTINEL Data Processing System hardware is proceeding.

34. NIKE-X — Functional Generation Breakdown for the I-67 Deployment — Cases 27703-1500 and -1600 (U), J. F. McDonald, G. W. McPheters, T. L. Saxton, and P. R. Sternfels, Bell Laboratories MFF, November 28, 1967. (SECRET)

    Outlines the structure (Functional Generation Breakdown) that will be used to specify the I-67 system software requirements. Identifies ten data processing functional configurations, and presents a functional generation breakdown for each.

35. SENTINEL Support Software Philosophy and Structure — Case 27703-1500, W. Hagerbaumer, R. Held, J. J. Kaplan, and J. G. Standley, Bell Laboratories MFF, January 15, 1969.

    Presents design concepts for the SENTINEL Support Software (as distinct from the R&D Support Software), and describes the interrelationships among various support facilities.

36. Programming System for NIKE-X, Language Processor Requirements Temporary Manual, Bell Laboratories, May 1, 1967.

    Considers the goals, capabilities, and restrictions of: real-time and non-real-time programs; the operating system (NEXOS); and the program development facility (NETSS).

37. NIKE-X - Meck Test Program — Case 27703-1600 (U), S. F. Knakkergaard, Bell Laboratories MFF, March 5, 1968. (SECRET)

    Outlines current plans for developing and testing the SENTINEL System capabilities at Meck. These plans reflect the impact of the deployment decision and recent changes in emphasis and schedules.

References for Chapter 4

SAFEGUARD System

1. SAFEGUARD System — Grand Forks IOC System Capability Definition (U) — Case 27950-1600, H. D. Hurlbut, Bell Laboratories MFF, July 8, 1974. (SECRET)

   Summarizes the principal SAFEGUARD System capabilities that will have been demonstrated at Grand Forks for Initial Operational Capability (IOC). In addition, discusses capabilities included in the system but not tested by IOC. Also gives a listing of capabilities once considered for SAFEGUARD but no longer part of the system.

2. SAFEGUARD System — GF ERD System Capability Description — Revision 1(U) — Case 27950-1600, J. M. Wuerz, Bell Laboratories MFF, June 18, 1973. (SECRET)

   Defines the SAFEGUARD System Capabilities which will be available at Grand Forks by the October 1974 Equipment Readiness Date (ERD). Capabilities are given in terms of (1) the threat scenario, (2) traffic levels, (3) available functions, and (4) confidence.

3. Terminating Pindown Defense Operations — Case 27950-1600 (U), K. A. Raschke, Bell Laboratories MFF, May 28, 1971. (SECRET)

   Emphasizes the basic purpose of the pindown defense mode, and explains its basic vulnerabilities. Notes the current procedure for ending counter-pindown engagement planning, and gives three alternatives to the present rules.

4. SAFEGUARD Firing Doctrine (U) — Case 27950-1600, K. A. Raschke, Bell Laboratories MFF, October 16, 1970. (SECRET)

   Provides an up-to-date comprehensive summary of firing doctrine for the Phase 2a SAFEGUARD deployment. The information is based primarily on the June 15, 1970 issue of the SAFEGUARD Data Processing System Performance Requirements.

5. The SAFEGUARD Response to an Attack of Less-Than-Massive Magnitude (U) — Case 27703-1600, K. A. Raschke, Bell Laboratories MFF, July 31, 1970. (SECRET)

   Describes the SAFEGUARD response to an attack that is of less than massive magnitude (accidental launch defense mode). Considers system operation, Interceptor Response procedures, and features investigated but not incorporated.

6. The Response of the SAFEGUARD System to an SLBM Pindown Attack (U) — Case 27703-1600, K. A. Raschke, Bell Laboratories MFF, July 24, 1970. (SECRET)

   Examines the present pindown concept and SLBM threat, and the characteristics and capabilities of the SAFEGUARD response. Considers possible modifications and improvements in system response.

7. An Operational Description of the Functions of the Elements of the SAFEGUARD System During Each of the Defense Modes — Case 27703-1600 (U), J. R. Logie, Jr., Bell Laboratories MFF, February 24, 1970. (SECRET)

   Documents the functions required at the PAR and MSR for the defense modes of system operation.

8. SAFEGUARD System — Operational Concept — Case 27703-1600 (U), J. R. Logie, Jr., Bell Laboratories MFF, May 19, 1969. (SECRET)

   A design concept paper intended to establish a basis for writing a consistent set of Data Processing System Performance Requirements (DPSPRs). The concept covers the defense objectives, command and control configuration, and SPARTAN, SPRINT, PAR, and MSR operation.

9. SAFEGUARD Attack Assessment — A Preliminary Analysis of PAR Capability (U) — Case 27950-1600, R. S. Rush, Bell Laboratories MFF, June 5, 1973. (SECRET)

   Documents an analysis undertaken to evaluate Perimeter Acquisition Radar capability for attack assessment and early warning.

10. Terminal Defense Degradation from Low Altitude Offensive Blackout — Case 27950-1600 (U), L. Behrendt, Bell Laboratories MFF, July 12, 1972. (SECRET)

    Delineates nuclear "blackout" effects in a terminal defense area for various sizes of penetrator weapons.

11. SAFEGUARD Attack Assessment — A Preliminary Analysis of MSR Capability (U) — Case 27950-1600, R. S. Rush, Bell Laboratories MFF, May 14, 1973. (SECRET)

    Documents an analysis to support an evaluation of the Grand Forks Missile Site Radar capability to characterize certain attack patterns.

12. Interceptor Capability in Command Guidance Systems — Case 27950-1600, C. Imagna, Bell Laboratories MFF, October 20, 1970.

    Presents an improved solution to the command guidance system problem of choosing the best point on the capability surface of the guidance loop and computing the steering command which will move the interceptor to this point at intercept time.

13. SAFEGUARD System — The Rational Supporting the MSR Track Performance Requirements (U) — Case 27950-1600, A. W. Besse, Bell Laboratories MFF, December 4, 1970. (SECRET)

    Explains why the particular system configurations and design values were chosen for the Target Tracking portion of the MSR Weapons Process section of the Data Processing System Performance Requirements, and provides supporting documentation. Begins with a brief description of overall system operation.

14. SAFEGUARD — Tactical Wake Track Design — Case 27950-1600, J. E. Marowitz, Bell Laboratories MFF, February 28, 1974.

    Describes the DG-5 Wake Track design. Gives a general description of the overall design philosophy and the implementation of the design by the track function.

15. SAFEGUARD System — Performance of Tactical Kill Assessment (U) — Case 27950-1600, G. C. Smith, Bell Laboratories MFF, April 14, 1973. (SECRET)

    Discusses SPRINT kill probability under various engagement assessments.

16. SAFEGUARD System — Data Processing Performance Requirements Missile Site Data Processor (U), Part 1, G-437953, Case 27950-2110, Bell Laboratories, Revision December 1, 1969. (SECRET)

    This document was superseded by Reference 39, Part 1.

17. SAFEGUARD System — Data Processing Performance Requirements Missile Site Data Processor (U), Part 2, G-437953, Case 27950-2110, Bell Laboratories, Revision October 15, 1969. (SECRET)

    This document was superseded by Reference 39, Part 2.

18. SAFEGUARD System — Data Processing System Performance Requirements PAR Data Processor (U), G-437954, Case 27950-2110, Bell Laboratories, September 15, 1969. (SECRET)

    This document was superseded by Reference 38.

19. SAFEGUARD System — CLC Throughput Study — Status Report — Case 27950-1500, D. B. Knudsen, Bell Laboratories MFF, January 9, 1974.

Reports on the characterization of the CLC-2 hardware. The CLC-2 is a large, high speed, multiprocessor, general purpose computer which performs data processing for the SAFEGUARD System. Presents data on Program Store queueing and throughput of a 10-processor, 10-Program Store system.

20. SAFEGUARD System — CLC Throughput Study — Case 27950-1500, D. C. Ruberg, Bell Laboratories MFF, October 4, 1972.

Gives a preliminary report on the Central Logic and Control 2 throughput work being conducted at Madison, N.J.

21. SAFEGUARD — Meck Test System — IOC Characterization, Maximum Data Throughput Tests — Case 27950-1500, D. L. Fritzsche, Bell Laboratories MFF, February 24, 1971.

Deals with purpose and goals of IOC (Input/Output Controller). Describes measurement of Indirect Command execution times, and maximum data rate to and from each peripheral device; measurement of maximum IOC data throughput; simulation of worst-case M-2 Input/Output activity for evaluation of IOC capability margins.

22. SAFEGUARD System — Basic Deployment — MSR Data Processor Sizing — Case 27950-1600 (U), R. T. Herbst, Bell Laboratories MFF, October 8, 1971. (SECRET)

Provides the basis for the recommendation that the MSR DPS sizing for the basic SAFEGUARD deployment be 10 Processor Units, 12 Program Stores, and 14 Variable Stores, and that the basic deployment, 2 PARS and 4 MSRs, preserve the option to install more than 10 Processors at each MSR site.

23. SAFEGUARD System — Study of EMP Effects on Intrasite Data Communications (U) — Case 27950-2110, P. W. Grabow, Bell Laboratories MFF, June 22, 1972. (SECRET-RD)

Presents applicable Electromagnetic Pulse (EMP) waveforms and spectra for surface, air, and high-altitude bursts. Estimates the effects of these bursts on intrasite data transmission using Lenkurt 46C repeaters with Anaconda cable. Indicates that SPRINT-type air bursts will not produce data errors, whereas surface bursts within a Minuteman field and high-altitude bursts at any distance should be assumed to cause errors in intrasite communication.

24. Functional Description of the SAFEGUARD Data Transmission Subsystem — Case 27950-1100, D. K. Dixon and T. F. Turnmire, Bell Laboratories MFF, July 23, 1971.

Presents complete functional descriptions of the DTC and DTCA.

25. SAFEGUARD System — Tactical Communications Criteria (U), 11,425,721 Revision H, Bell Laboratories, May 31, 1974. (SECRET)

Presents tactical communication requirements including those for survivability, traffic loads, data rates, transmission disturbances, and circuit delay.

26. Procedures and Tolerances in SAFEGUARD Time-Keeping — Case 27950-1500, G. L. Gamble, Bell Laboratories MFF, February 15, 1972.

Presents a detailed description of the major time procedures to be performed at the master time site and at the slave time sites at start-up and on a continuing basis.

27. SAFEGUARD System — System Design Requirements for Displays and Controls (U), Vol 1, 11268704, Bell Laboratories, SDRSDCV1@SD##XXXX, June 30, 1974. (SECRET)

Contains a complete functional description of the tactical manual actions available at IOC at the BMDC, MDC, and PAR, and information relating to each console position.

28. SAFEGUARD System — MSR Radar Monitor Console Displays and Interfaces (Revision 1) — Case 27950-1400, G. T. Kresan and R. H. Thieme, Bell Laboratories MFF, December 5, 1973.

    Describes all Radar Monitor Console indicators, controls, and interfaces. Incorporates recent functional changes and reflects all Engineering Change Proposals that are outstanding for this console.

29. SAFEGUARD System — Command and Control Subsystem — Description of the Missile Monitor and Test Console and TTY — Case 27950-2110, J. J. Cappiello, Bell Laboratories MFF, December 15, 1970.

    Presents a description of the Missile Monitor and Test Console and its functions. Includes status and control signal information related to both remote and local missiles and associated equipment.

30. SAFEGUARD System — Data Management Console and Teletypewriter — Man/Machine Description — Case 27950-2110, I. A. Kronish, Bell Laboratories MFF, October 11, 1974.

    Presents a description of the tasks performed at the Data Management work position.

31. SAFEGUARD System — Command and Control Display Subsystem — Functional Description of the Data Processing Officer Console Position — Case 27950-1500, S. R. Peck, Bell Laboratories MFF, September 26, 1972.

    Presents a consolidation of the relevant material concerning the Data Processing Officer (DPO) console position. This material has been combined into a single, coordinated design specification. Also documents the current design philosophy for this operating position, including rationale, currently designed capabilities, and future expected capabilities.

32. User Oriented Description of the Maintenance and Diagnostic Processor Operating System, Version 1 (MDP/OS-1) — Case 27950-1100, R. A. Buccigrossi, K. J. Henderson, and J. R. Shutt, Bell Laboratories MFF, April 29, 1971.

    Presents a description of the Maintenance and Diagnostic Processor Operating System, Version 1 (MDP/OS-1), with its associated file on development programs.

33. SPRINT Remote Launch — Equipment Status, Control, Readiness Verification, Diagnosis and Maintenance — Case 27703-1000, D. P. Worrall, Bell Laboratories MFF, October 21, 1969.

    Proposes a maintenance concept for the electronic equipment being developed by Bell Laboratories to support remote launchings of SPRINT missiles. General testing, fault detection, status reporting, fault isolation, repair, and verification are considered. The hardware under consideration includes the Remote Launch Data Controller (RLDCT) and the Monitor and Control Multiplexer Local (MCML) located in the Missile Site Control Building (MSCB).

34. SAFEGUARD System — Description of a Logic Simulation Program to Aid in the Development of M&D Programs — Case 27950-1500, H. L. Benoy III and M. P. Smith, Bell Laboratories MFF, January 10, 1974.

    Describes the use and operation of the Maintenance and Diagnostic Logic Simulator (MDLSIM), a set of programs used to aid in developing maintenance and diagnostic test programs by simulating logic circuits found in the SAFEGUARD data processing system.

35. SAFEGUARD — Data Processing System — Maintenance and Diagnostic Processor Controller Functional Description, Case 27950-1500, J. A. Meyer and F. B. Torres, Bell Laboratories MFF, October 25, 1971.

    Presents detailed information on the Maintenance and Diagnostic Processor Controller, an interface and control unit designed by Bell Laboratories for use with the modified CDC-1700 computer. Provides a general physical description of the hardware and details for each part of the hardware.

36. SAFEGUARD System Software Development Plan (U), Vol 1 and 2, G486643, Bell Laboratories, July 1, 1971. Vol 1 (UNCLASSIFIED), Vol 2 (SECRET)

Describes the various activities and events proposed as a means of building the Data Processing System software required for the deployment of the Phase I SAFEGUARD System, and indicates the relationships between the various events. The plan reflects the principal assumptions, activities, and issues that are fundamental to the development and deployment of the SAFEGUARD Data Processing System software.

37. SAFEGUARD — IBM Support Computer System Utilization and Performance Guidelines — Case 27950-1500, E. S. Swanson, Bell Laboratories MFF, January 20, 1972.

Specifies guidelines for the practical solution of problems pertaining to the detection of bottlenecks in the support computer configurations, helps evaluate hardware/software changes before and after the changes are made, and helps provide the best computing service possible given the type of load presented to the computer.

38. SAFEGUARD System — Data Processing System Performance Requirements, PAR Weapons Process (PW1) PAR System Exerciser Process (EPX) (U), 11277025, L. C. Johnson, Bell Laboratories, SRDPARWP@PR##XXXX, June 15, 1970, Revised March 28, 1975. (SECRET)

Contains the Data Processing System Performance Requirements (DPSPRs) for the Perimeter Acquisition Radar (PAR) to be used as a basis for developing the PAR Weapons Process (PW1) and the PAR System Exerciser Process (EPX).

39. SAFEGUARD System — Data Processing System Performance Requirements, MSR Weapons Process (MW1) MSR System Exerciser Process (EMX) (U), 11277024 - Parts 1 and 2, L. C. Johnson, Bell Laboratories, SRDMSRWP@PR##XXXX, June 15, 1970, Revised April 7, 1975. (SECRET)

Contains the Data Processing System Performance Requirements (DPSPRs) for the Missile Direction Center (MDC) to be used as a basis for developing the MSR Weapons Process (MW1) and the MSR System Exerciser Process (EMX).

40. SAFEGUARD System — Data Processing System Performance Requirements, Ballistic Missile Defense Center (BW-1) (U), 11277026, L. C. Johnson, Bell Laboratories, SRDBMDCW@PR##XXXX, November 30, 1970, Revised March 15, 1975. (SECRET)

Contains the Data Processing System Performance Requirements (DPSPRs) for the Ballistic Missile Defense Center (BMDC) to be used as a basis for developing the BMDC Weapons Process (BW1).

41. SAFEGUARD System — CLC Resource Configuration and Initialization by the CLC Control Facility — Case 27950-1500, P. T. Guarneri, Bell Laboratories MFF, November 6, 1972.

Identifies the functions performed by the CLC Control Facility (CTL) which result in configuration and/or initialization of CLC resources, and defines the state of these resources when CTL transfers execution control to either the Basic or the Tactical Operating System.

42. SAFEGUARD System — Tactical Operating System (TOS) Functional Specification — COXTOSFN@FN01XXXX, S. A. Svach, Bell Laboratories, March 12, 1970, Revised January 4, 1971.

Discusses the functions performed by the TOS modules, their relationship to each other, and the relationship of TOS to other SAFEGUARD Data Processing System facilities.

43. Error Handling by the Tactical Operating System (TOS) — Case 27950-1500, J. G. Standley, Bell Laboratories MFF, March 31, 1972.

Explains the general philosophy and the detailed methods that TOS will use to handle and report error conditions. The general error handling philosophy, the TOS structure and division of responsibility for error processing, and the TOS mechanisms for error reporting are detailed.

44. CENTRAN: A Case History in Extensible Language Design, Case 27950-1500, B. N. Dickman, Bell Laboratories TM, TM-74-6623-3, April 1, 1974.

    Presents the design history of CENTRAN to describe how and why the computer language was designed and how it was implemented.

45. SAFEGUARD System — SAFEGUARD Tactical Computer Simulator (STACS) User Manual (U), IBM Corporation, FTXUSERM@UM##XXXX, Revised December 11, 1972.

    Describes the use of the SAFEGUARD Tactical Computer Simulator (STACS) program, with primary emphasis on the new STACS Control language. Encompasses STACS capabilities through Version C. STACS provides facilities for unit/task level testing of CLC-2 programs in a non-real-time environment.

46. SAFEGUARD — Configuration Management Operating System Manual for Operations and Maintenance, SAF-2009, Issue 1, Western Electric, September 1974.

    Gives the detailed structure and procedures for controlling SAFEGUARD hardware and software.

47. SAFEGUARD System — Software Configuration Management Plan, Bell Laboratories, DCCMGMNT@SM02XXXX, Revision 2, August 2, 1974.

    Outlines the general policies and procedures to be followed for controlling SAFEGUARD software to meet the contractual configuration management requirements.

48. SAFEGUARD — Tactical System — Patch Utility Program User Manual for PUP R4/A4 — Case 27950-1500, T. J. Buckley, Bell Laboratories MFF, March 27, 1974.

    Provides information on the use of the SAFEGUARD Patch Utility Program (PUP). This program provides a self-documented storage and maintenance capability for changes or modifications to the bound object code generated during software development at the tactical SAFEGUARD sites (including TSCS).

49. A Method to Add Configuration Identification Information to CLC Software — Case 27950-1500, R. A. Grubic, Bell Laboratories MFF, February 15, 1974.

    Describes a method that will allow Central Logic and Control (CLC) support software to maintain configuration identification information on disc. The method will aid in maintaining the credibility of SAFEGUARD Software by minimizing confusion in the disc patching of tactical software.

50. Execution Preparation Facility (XPF) — User Manual, IBM Corporation, FEXXPFUS@UM13XXXX, February 3, 1975.

    Describes the capabilities, operation, and procedures for using the Execution Preparation Facility. This software facility prepares a collection of programs and data sets for real-time or non-real-time execution on the Central Logic and Control (CLC2) computer or under the SAFEGUARD Tactical Computer Simulator (STACS).

51. SAFEGUARD Tactical System — Proposal for Implementation of a System Logging Function in the Tactical Operating System (TOS) Environment — Case 27950-1500, P. V. Guidi, Bell Laboratories MFF, August 19, 1970.

    Proposes a unified method for logging and recording critical system information based on current Tactical Operating System (TOS) Tape Manager, Error Control, and DEBUG Histogramming design.

52. The Breakpoint Timer — A Proposed Hardware Facility to Aid in Software Development at the TSCS — Case 27703-1500, T. L. Warner, Bell Laboratories MFF, February 17, 1970.

    Describes capabilities required of a proposed new Breakpoint Timer to permit on-line analysis of process tests.

53. SAFEGUARD System — Concepts and Facilities of the CLC Monitor — Case 27950-1500, T. L. Warner, Bell Laboratories MFF, May 25, 1973.

Presents the functions available through the Central Logic and Control Monitor, and provides initial information concerning the user's interface with this subsystem. The CLC Monitor is an independent subsystem which interfaces with the CLC to gather data for debugging, tuning, and evaluation of both software and hardware.

54. SAFEGUARD System — PAR-EPX QUICK LOOK Data Analysis Tool — Case 27950-1500, D. W. Sullivan, Bell Laboratories MFF, April 2, 1974.

Describes a subroutine, QUICK LOOK, which can provide an assessment of the overall functional performance of the PAR Weapons Process during the termination sequence of an exercise.

55. Proposal for SAFEGUARD Data Reduction System, Case 27703-1500, P. A. Highland, Bell Laboratories MFF, May 12, 1969.

Outlines the functional requirements for a fully developed data reduction system, gives examples from typical design areas, and proposes a software structure within which to develop the capability. Discusses the proposed reduction system in terms of its flexibility to handle user-developed routines, stage-by-stage development of capability, machine adaptability, and data reduction run structuring.

56. SAFEGUARD System — System Integration and Evaluation Test Plan (U), G-741752, Bell Laboratories, July 1974. (SECRET)

Contains the Weapons System Contractor's plan for integrating the major components of the SAFEGUARD System. The test plan encompasses basic integration tests, system-level integration testing, and Operational System Readiness Verification (OSRV).

57. SAFEGUARD System — System Test Specification Grand Forks Minuteman Defense Mode System Test (SYS/M3) (U) (80/015), M. J. Suralik, Bell Laboratories, SIBGMM03@SP##XXXX, March 15, 1974, Revised May 12, 1975. (SECRET)

Contains the system test specification for testing the Perimeter Acquisition Radar (PAR), the Missile Defense Center (MDC), and the Ballistic Missile Defense Center (BMDC) operating in a netted mode and in the Minuteman defense mode.

58. SAFEGUARD System — System Test Specification Grand Forks Accidental Launch Defense Mode MSR and PAR Test (U) (80/0610), M. J. Suralik, Bell Laboratories, SIBGAL01@SP##XXXX, March 15, 1974, Revised July 31, 1974. (SECRET)

Contains the system test specification for testing the Perimeter Acquisition Radar and the Missile Defense Center operating in a netted mode and in the Accidental Launch defense mode.

59. SAFEGUARD System — System Test Specification Grand Forks Pindown Defense Mode/Minuteman Defense Mode System Test (U) (80/035), J. F. Dorsch, Bell Laboratories, SIBGPM02@SP##XXXX, May 1, 1973, Revised May 13, 1975. (SECRET)

Contains the system test specification for testing the Perimeter Acquisition Radar, the Missile Defense Center, and the Ballistic Missile Defense Center operating in a netted mode and in the Pindown defense mode followed by a switch to the Minuteman defense mode.

60. SAFEGUARD System — System Test Specification Grand Forks Accidental Launch Defense Mode/Minuteman Defense Mode System Test (GF SYS/AM3) (U) (80/025), M. J. Suralik and R. R. Desiardins, Bell Laboratories, SIBGAM02@SP##XXXX, 11277144, March 15, 1974, Revised May 9, 1975. (SECRET)

Contains the system test specification for testing the Perimeter Acquisition Radar, the Missile Defense Center, and the Ballistic Missile Defense Center operating in a netted mode and in the Accidental Launch defense mode followed by a switch to the Minuteman defense mode.

61. SAFEGUARD System — System Test Specification Grand Forks Autonomous Missile Site Radar (MSR) Minuteman Defense Mode Test (U) (53/0560), J. F. Dorsch, Bell Laboratories, SIBGMA01SP##XXXX, 11277141, November 1, 1974, Revised December 16, 1974. (SECRET)

Contains the system test specification for testing the Grand Forks configured Missile Site Radar (MSR) site operating autonomously in the Minuteman defense mode.

62. SAFEGUARD System — Grand Forks Effectiveness Sensitivity to MSR and PAR Site Availability/Reliability Product (U) — Case 27950-1600, D. C. Swanay, Bell Laboratories MFF, February 1, 1973. (SECRET)

Presents updated calculations of SAFEGUARD System effectiveness sensitivity to MSR and PAR site Availability/Reliability (A/R) product. These calculations include the impace of SALT deployment limitations and reflect current system firing doctrine. The calculations were made in support of a recommendation on a deferred maintenance manning concept proposed for Grand Forks.

63. Evaluation of System A/R — Case 36294-11, K. Grace, Jr., Bell Laboratories MFF, November 8, 1971.

Presents an evaluation of System Availability/Reliability through a series of formulas and a block diagram. The aim of System A/R is to make possible the successful completion of a mission of duration T, based on the probability that the system is operational through the duration of the mission.

64. Simulation Model for System Availability — Case 27703-1600, T. A. Solomita, Jr. and K. Grace, Jr., Bell Laboratories TM, MM-69-8223-5, October 23, 1969.

Describes a SIMSCRIPT simulation model for determining the availability of a complex system by simulating the failure of on-line and spare units, and location, removal, repair, and replacement of failed units. Includes flowcharts and descriptions of the event routines and subroutines, and an example to illustrate the detailed output gathered from a sample run.

65. SAFEGUARD System — Post-IOC Operation and Maintenance Study Programs (Mini-CTM) — Case 27950-1500, D. R. Vogel, Bell Laboratories MFF, October 1, 1974. (UNCLASSIFIED)

Presents a plan for the evaluation of post-IOC operation and maintenance.

66. SAFEGUARD — BMDC System Status Displays — Functional Design Requirements — Case 27950-1500, D. R. West, Bell Laboratories MFF, October 27, 1971.

Defines the tactical display functional requirements for the Ballistic Missile Defense Center System Status Displays. Discusses display-panel locations, indicators, and functions.

67. SAFEGUARD System for Control of Nuclear Employment Authority (U) — Case 27950-2110, N. Ehrlich, Bell Laboratories MFF, May 31, 1973. (SECRET)

Describes the system for transmitting and receiving Nuclear Employment Authority (NEA) messages for SAFEGUARD. Includes the controls, displays, and system operation required for both the tactical and test modes.

68. SAFEGUARD System — MSR and PAR Equipment Readiness Center and PAR Equipment Readiness Officer — Man/Machine Description — Case 27950-2110, I. A. Kronish, Bell Laboratories MFF, November 30, 1972.

Presents descriptions of the most recent design configurations of the MSR and PAR Equipment Readiness Centers and the PAR Equipment Readiness Officer work position. This material replaces three sections of the Man/Machine Interface Description.

69. SAFEGUARD System — MSR Equipment Readiness Officer — Man/Machine Description Section 3.4.1 — Case 27950-2110, T. B. Henry, Bell Laboratories MFF, January 11, 1973.

Describes the Equipment Readiness Officer (ERO) position in the Missile Direction Center. Presents a detailed console description for the System Maintenance console (ERO's console), the functions of the cathode-ray tube and teletypewriter facilities, and specific tasks performed by the ERO. (The primary function of the ERO, on-line maintenance, is referred to elsewhere as the Site Maintenance Coordination Function.)

70. SAFEGUARD System — DPS Real Time Exercisers — Case 27950-1500, G. D. Kepley, Bell Laboratories MFF, January 27, 1970.

Defines the type of real-time exercisers required for the Data Processing Subsystem, and indicates their detection capabilities, as proposed implementation, and an error response philosophy.

71. SAFEGUARD System — Installation Test Program (ITP) Descriptions — Case 27950-1500, L. Lesser, Bell Laboratories MFF, August 11, 1972.

Contains a description of all Installation Test Programs for the Madison Tactical Software Control Site (TSCS) to aid operating and maintenance engineers in problem solving.

72. SAFEGUARD — A System Analysis of Tactical Mode Debugging Tools — Case 27950-1500, L. J. Gawron, Bell Laboratories MFF, April 1, 1974.

Presents an analysis of a number of tactical mode debugging tools and proposes a package of several such tools for implementation within the Tactical Operating System. The analysis involved a survey of test personnel at all three SAFEGUARD sites (MSR, PAR, and BMDC), as well as at the TSCS, to determine which debugging tools would be most useful.

References for Chapter 5

SAFEGUARD System Evaluation

1. SAFEGUARD System — Data Processing System Performance Requirements, MSR Weapons Process (MW1) MSR System Exerciser Process (EMX) (U), 11277024-Parts 1 and 2, Bell Laboratories, SRDMSRWP@PR##XXXX, June 15, 1970, Revised May 20, 1975 (Part 1), April 7, 1975 (Part 2). (SECRET-RD)

   Contains the Data Processing System Performance Requirements (DPSPRs) for the Missile Direction Center (MDC) SPARTAN/SPRINT site in the single-site deployment of the SAFEGUARD System, consisting of the Grand Forks Perimeter Acquisition Radar (PAR), Grand Forks Missile Site Radar (MSR), and Ballistic Missile Defense Center (BMDC) in Cheyenne Mountain.

2. SAFEGUARD System — Data Processing System Performance Requirements, PAR Weapons Process (PW1) PAR System Exerciser Process (EPX) (U), 11277025, Bell Laboratories SRDPARWP@PR##XXXX, June 15, 1970, Revised May 20, 1975. (SECRET)

   Contains the DPSPRs for the PAR Data Processor in the single-site deployment of the SAFEGUARD System, consisting of the PAR, the MSR, and the BMDC.

3. TACSAF Users Guide (U), J. Golub, General Research Corporation, Internal Memorandum DIM #332, November 15, 1974. (SECRET)

   Describes the SAFEGUARD Simulation, its capabilities and limitations, and the options available to the user.

4. MSRSIM Users Guide, Internal Memorandum DIM #333, John T. Fyfe, General Research Corporation, November 13, 1974.

   Describes the MSR Simulation, its capabilities and limitations, and the options available to the user.

5. Intercept Subsystem Evaluation Phase I (U), Vol I-II, McDonnell-Douglas Astronautics Company, Report No. MDC G1246, November 1969. (SECRET-RD)

   Contains an evaluation of SPRINT intercept capability; an analytical determination of miss distance and applicable regions of the field of fire; and an evaluation of the effects of warhead and RF shadowing on kill probability, and the utility of intercept-point bias and drag-bias guidance techniques.

6. Intercept Subsystem Evaluation Phase II (U), Vol I-II, McDonnell-Douglas Astronautics Company, Report No. MDC G1379, August 1970. (SECRET-RD)

   Describes the development of the non-real-time version of the SPRINT Engagement Simulation (SES) and Monte Carlo simulation of 80 intercept points over the field of fire to verify analytic results.

7. Intercept Subsystem Evaluation — Phase III (U), Vol I-II, McDonnell-Douglas Astronautics Company, Report No. MDC G1952, July 1971. (SECRET-RD)

   Describes the determination of guidance-critical intercepts for specifying Meck Test Program requirements, the evaluation of the effect of reduced missile and target-track rates on intercept effectiveness, the evaluation of the real-time target-prediction algorithm, and the development of linear-intercept effects models for system simulation.

8. Intercept Subsystem Evaluation, Phase IV (U), McDonnell-Douglas Astronautics Company, Report No. MDC G3719, August 1972. (SECRET)

Contains the effects of target wake on SPRINT intercept effectiveness, the investigation of exoatmospheric RV tumble on beta history during early reentry, and the initial evaluation of real-time guidance algorithms.

9. Intercept Subsystem Evaluation, Phase V (U), Vol I and II, McDonnell-Douglas Astronautics Company, Report No. MDC G4774, July 1973. (SECRET)

Contains the evaluation of the real-time guidance algorithms and their effectiveness in the waking-target environment, and the effect of target misidentification on intercept capability.

10. Intercept Subsystem Evaluation, Phase VI (U), McDonnell-Douglas Astronautics Company, Report No. MDC G5347, March 1974. (SECRET)

Contains the characterization of miss distance and intercept-point (IP) motion over the SPRINT field of fire, the determination of the linear region applicable to the tactical design, and the updating of the miss distance and IP motion models for the system simulation.

11. SPRINT Intercept Subsystem Validation — Final Summary Report (U), Vol I-II, McDonnell-Douglas Astronautics Company, Report No. MDC G5355, March 1974. (SECRET)

Describes the program of SPRINT intercept tests conducted at Meck to validate the SPRINT Intercept Simulation (SIS). Also indicates the overall approach to simulation validation, the reasons for selecting the particular tests, and the test results.

12. SPARTAN Intercept Subsystem Validation and Characterization — Final Summary Report (U), McDonnell-Douglas Astronautics Company, Report No. MDC G5336, March 1974. (SECRET)

Describes the program of SPARTAN intercept tests conducted at Meck to validate the SPARTAN Intercept Simulation (SPASIM). Also indicates the overall approach to simulation validation, the reasons for selecting the particular tests, and the test results.

13. SENTINEL System — System Development Plan, Vol IV — System Evaluation Program (U), Bell Laboratories, Report 69R019, March 1969. (SECRET)

Presents the results of early evaluation studies on PAR performance, specifically the probability of detection and performance of the nonuniform track scheme. Describes the initial simulations developed for system evaluation, including a SPARTAN footprint generator. Also contains the initial set of test requirements developed for the Meck Test Program.

14. SAFEGUARD System — System Development Plan, Vol 3 Parts I-III — System Evaluation Program (U), Bell Laboratories, March 1970. (SECRET-RD)

Presents the system evaluation results for 1969. Includes the MSR and PAR performance studies, the SPRINT and SPARTAN capability studies, and the performance of the battle-planning functions in the nuclear environment. Part III is devoted to simulation development and modeling for SAFSIM, MSRSIM, and the SPRINT and SPARTAN Intercept Simulations.

15. SAFEGUARD System — System Development Plan, Vol 3, Books 1-3 — System Evaluation Program (U), Bell Laboratories, March 1971. (SECRET-RD)

Presents the system evaluation results for 1970. Major activities included threat-evaluation system effectiveness versus offensive strategies and MSR/MSDP traffic-capacity studies. Also contains additional modeling information for SAFSIM and MSRSIM, updated test requirements and data analysis plans for the Meck Test Program, and results of the initial tests at Meck.

16. SAFEGUARD System — System Development Plan, Vol 3, Books I-III — System Evaluation Program (U), Bell Laboratories, March 1972. (SECRET-RD)

Presents the system evaluation results for 1971. Major activities included MSR/MSDP and PAR/PARDP traffic-capacity and overload-response studies, the environmental effects on SPRINT intercept capability, and initial studies of MSR track in the cluttered environment. Also includes Meck Test Program results and evaluation test plans for TSCS and the tactical site.

17. SAFEGUARD System — System Development Plan, Vol 3 — System Evaluation Program (U), Summary Report and Appendices (4 books), Bell Laboratories, March 1973. (SECRET-RD)

Presents the system evaluation results for 1972. Includes evaluation of MSR track in the cluttered environment (wake and tank breakup), PAR track of unresolved targets, SPRINT effective field of fire, SPARTAN effectiveness, traffic-capacity and overload studies, and system false alarm rates. Also includes Meck Test Program results and simulation development.

18. SAFEGUARD System — System Development Plan, Vol 3 — System Evaluation Program, Part 1, MSR Functional Performance (U), Bell Laboratories, January 1975. (SECRET)

Summarizes MSR/MSDP performance in the functional areas of surveillance, track, target selection, and SPRINT and SPARTAN intercept performance. Includes coast cluster track, wake track, tank breakup, and nuclear effects.

19. SAFEGUARD System — Analysis of Controlled Test Requirements (U), Bell Laboratories, May 1, 1970. (SECRET)

Contains a detailed discussion of the importance of maintaining control over the extraneous debris that normally accompanies target complexes so that data-gathering objectives can be more easily satisfied.

20. SAFEGUARD System — Revised Natural Breakup Model for Titan II Tank (U), Bell Laboratories, Report 73R126, September 1973. (SECRET)

Describes a natural breakup model for a Titan II tank for use by SAFEGUARD designers to evaluate the impact of this environment on system performance.

21. SAFEGUARD System — Tank Breakup — The Phenomenology of Contiguous Clutter (Titan II) (U), Bell Laboratories, Report 73R130, September 1973. (SECRET)

Reviews aspects of the Titan II tank breakup phenomenon relevant to understanding the contiguous-clutter effect.

22. SAFEGUARD System — Wake Track Functional Evaluation Report — Missions in the R19 Test Period (U), Calspan Corporation, Report No. UB-2946-S-35, January 1974. (SECRET)

Analyzes the performance of the wake-track algorithms during five Meck tracking missions. Includes results using targets on both radial and offset trajectories, performance of wake-track entrance and exit tests, and measurement accuracies (biases and measurement variance).

23. SAFEGUARD System — Track Through Tank Breakup Functional Evaluation Report (U), Calspan Corporation, Report No. UB-2946-S-52, October 1974. (SECRET)

Analyzes the performance of the track-through-tank-breakup algorithms during six Meck tracking missions. Two problems noted during analysis of early missions were investigated; solutions were found, implemented, and checked out on later missions.

24. SAFEGUARD System — Modeling of Radar Signal Returns From Wake Based on MSR M2/R17-R19 Data (U), Calspan Corporation, Report No. UB-2946-S-43, March 1974. (SECRET)

Documents wake models derived from individual pulse profiles (digital video recorder data) of wakes recorded by the Meck MSR. Presents a detailed description of the rigorous statistical techniques used to derive the models. The models described were incorporated in MSRSIM.

25. SAFEGUARD System — Wake Track Functional Evaluation Report — Missions in the R19E and R20 Test Periods (U), Calspan Corporation, Report No. UB-2946-S-48, September 1974. (SECRET)

Analyzes the performance of the wake-track algorithms during six Meck tracking missions in the R19E-R20 time frame. Extends the analysis to include targets on fly-by trajectories. Includes an evaluation of changes made in the wake-track algorithms.

26. SAFEGUARD System — Meck Test Requirements for SAFEGUARD System Evaluation (U), Bell Laboratories, June 1, 1968, Revised May 1, 1972. (SECRET)

Details requirements for all tests conducted at Meck to evaluate the system, including radar function test requirements and SPRINT and SPARTAN interceptor test requirements. Also details the data to be obtained on each of these tests.

27. SAFEGUARD System — Meck Test System Compared with the System to be Deployed Case 27950-1500, L. Bernstein, Bell Laboratories MFF, October 19, 1971.

Contains a broad description of hardware and software differences between the Meck and Grand Forks SAFEGUARD installations.

28. SAFEGUARD System — SPARTAN Intercept Function — M2/Tactical Differences Case 27950-1600, E. D. Ballard, Jr., Bell Laboratories MFF, March 9, 1973.

Contains a description of the differences in implementing the SPARTAN intercept function at the Meck and Grand Forks SAFEGUARD installations.

29. SAFEGUARD — Comparison of Tactical and M2 System Data Gathering Algorithms - Case 27950-1600 (U), M. E. Jacobs and R. A. Steigerwalt, Bell Laboratories MFF, January 3, 1973. (SECRET)

Contains a description of the differences between the Meck and Grand Forks implementation of the data-gathering algorithm.

30. SAFEGUARD System — Differences Between the Tactical and Meck Versions of the SPRINT Intercept Function — Case 27950-1600, W. P. Chapman, Bell Laboratories MFF, April 19, 1973.

Contains a description of differences between Meck and Grand Forks implementation of the SPRINT intercept function.

31. SAFEGUARD System — System Development Plan, Vol 1 — Meck Island System Description (U), Bell Laboratories, Revised April 1973. (SECRET)

Contains information concerning the SAFEGUARD System research and development equipment installed in the Kwajalein Atoll, including a comprehensive description of the subsystem and range instrumentation.

32. SAFEGUARD System — Summary of MSR Data Analysis — M1 Test Period (U), Cornell Aeronautical Laboratory, Report No. UB-2946-S-11, March 1972. (SECRET)

Summarizes the analysis of MSR performance based on data gathered during the M-1 test period at Meck. Includes data handling, bias analysis, single-pulse range and angle accuracy, analysis of track-filter performance, amplitude measurement accuracy, and RCS measurement analysis.

33. SAFEGUARD System — M-2 System Functional Requirements and Description (U), Bell Laboratories, August 1, 1972. Revised August 1, 1973. (SECRET)

Compiles the M-2 revision level R20 of the Meck software and includes a broad description of functional capabilities required for R20 and prior revision levels.

34. SAFEGUARD System — Meck System Test Program (U), Bell Laboratories, June 1, 1970, Revised February 28, 1974. (SECRET)

Contains information concerning the Meck Island research and development test program in support of the overall SAFEGUARD System evaluation program, including mission descriptions for all planned system tests.

35. SAFEGUARD System — Target Support Plan (U), Bell Laboratories, June 15, 1970, Revised January 15, 1974. (SECRET)

Contains information on the ICBM and IRBM targets used at Meck, such as procurement cycle, design requirements, description of Reentry Vehicles (RVs), auxiliary objects, target delivery systems, and broad target-related mission results.

36. SAFEGUARD System — Summary of Documentation Available for Meck System Evaluation Tests, S. F. Knakkergaard, Bell Laboratories MFF, May 16, 1975.

Contains a mission-by-mission tabulation of major premission and post-mission reports for the M-1 and M-2 periods. The following reports are included in the tabulation:

Mission Test Specification defines the mission objectives and requirements, and includes range instrumentation priority assignments.

Mission Test Plan restates mission objectives and requirements, and specifies operational details for conducting a mission.

Final Mission Test Report provides final critique on data qualification and presents data in a large number of plots. Data analysis is not included.

Target Data Summary summarizes the results of MSR data relating to the target delivery system performance.

Mission Data Summary Memorandum presents MSR data in a series of plots to be used as a tool for mission analysis and function evaluation.

Preliminary Mission Test Specification was used prior to 1972 to present an early representation of mission objectives and requirements.

Mission Data Analysis Summary Report summarizes results of primary analysis of MSR performance.

This memorandum also lists documents related to miss distance measurement data.

37. SAFEGUARD System — Summary of Meck MSR Measurement Performance Analysis (U), D. R. Johnson and R. A. VanSlooten, Calspan Corporation, Report No. UB-2946-S-42, February 1, 1974. (SECRET)

Summarizes MSR measurement performance. Includes analysis of results on frequency-dependent range biases (TRM-87), T3/T1 range biases (TRM-113), amplitude-dependent angle biases (TRM-113), target-track/missile-track biases (TRM-112), off-axis angle accuracy (TRM-98), and face-to-face biases (TRM-95).

38. SAFEGUARD System — Independent Miss Distance Measurement in the Meck Test Program (U), Bell Laboratories, Report 71R074-10, June 1971. (SECRET)

Discusses the various method considered for measuring miss distance on SPRINT and SPARTAN live-target intercept missions. Provides the rationale and justification for the recommended measurement technique.

39. SAFEGUARD System — System Integration and Evaluation Test Plan (U), Bell Laboratories, July 1973. (SECRET)

Contains a detailed description of the system test and evaluation program originally planned for SAFEGUARD. Describes the philosophy and approach taken in developing the program and the rationale for each of the test scenarios.

40. SAFEGUARD System — System Integration and Evaluation Test Plan Revision (U), Bell Laboratories, G-741752, Revised July 1974. (SECRET)

    Provides the same information as for the original program plan but for a test program that was reduced in scope. This was the program conducted for the SAFEGUARD System.

41. TACSAF Analysis of the M1/M3 (DPM) Scenario (U), General Research Corporation, Internal Memorandum DIM #324, July 26, 1974. (SECRET)

    Documents the results obtained with the system simulation for one of the five System Technical Verification Test (STVT) scenarios. (Also see References 42 through 45.) This scenario tested the Grand Forks configured MSR site operating autonomously in the Minuteman Defense Mode. The results of testing under all five scenarios provided the basis for the performance criteria contained in the test specifications. The scenario is described and the nominal system response to the scenario is provided. Variations in functional performance (i.e., detection altitudes, RV call altitudes, etc.) observed in a series of Monte Carlo runs are indicated. Variations in total system response due to relatively low probability occurrences are described and the probability of observing that particular response is estimated.

42. TACSAF Analysis of the SYS/A3 Scenario (U), General Research Corporation, Internal Memorandum DIM #321, May 17, 1974. (SECRET)

    Documents the results obtained with the system simulation for the netted PAR, MSR, and BMDC operating in the Accidental Launch Defense Mode.

43. TACSAF Analysis of the SYS/M3 Scenario (U), General Research Corporation, Internal Memorandum DIM #325, August 8, 1974. (SECRET)

    Documents the results obtained with the system simulation for the netted PAR, MSR, and BMDC operating in the Minuteman Defense Mode.

44. TACSAF Analysis of the SYS/AM3 Scenario (U), General Research Corporation, Internal Memorandum DIM #327, September 30, 1974. (SECRET)

    Documents the results obtained with the system simulation for the netted PAR, MSR, and BMDC operating in the Accidental Launch Defense Mode followed by a switch to the Minuteman Defense Mode.

45. TACSAF Analysis of the SYS/PM3 Scenario (U), General Research Corporation, Internal Memorandum DIM #326, September 10, 1974. (SECRET)

    Documents the results obtained with the system simulation for the netted PAR, MSR, and BMDC operating in the Pindown Defense Mode followed by a switch to the Minuteman Defense Mode.

46. SAFEGUARD System — System Test Specification, Grand Forks Autonomous MSR Minuteman Defense Mode Test (DPM)(U), (5410100) 11277146, J. F. Dorsch, Bell Laboratories, SIBGMA02@SP##XXXX, March 15, 1974, Revised June 10, 1974. (SECRET)

    Contains the System Test Specification (STS) for testing the Grand Forks configured MSR site operating autonomously in the Minuteman Defense Mode. Provides a detailed description of the scenario, together with the particular performance criteria applicable to the test. Includes the performance bounds and the procedures to be used for verifying the system performance. (Also see References 47 through 50.)

47. SAFEGUARD System — System Test Specification, Grand Forks Accidental Launch Defense Mode System Test (U), (80/010) 11277142, M. J. Suralik, Bell Laboratories, SIBGAL02@SP##XXXX, February 11, 1974, Revised April 15, 1975. (SECRET)

    Contains the STS for the netted PAR, MSR, and BMDC operating in the Accidental Launch Defense Mode.

48. SAFEGUARD System — System Test Specification, Grand Forks Minuteman Defense Mode System Test (SYS/M3) (U) (80/015), M. J. Suralik, Bell Laboratories, SIBGMM03@SP##XXXX, March 15, 1974, Revised October 30, 1974. (SECRET)

    Contains the STS for the netted PAR, MSR, and BMDC operating in the Minuteman Defense Mode.

49. SAFEGUARD System — System Test Specification, Grand Forks Accidental Launch Defense Mode/Minuteman Defense Mode System Test (GF SYS/AM3) (U), (80/025) 11277144, M. J. Suralik, Bell Laboratories, SIBGAM02@SP##XXXX, March 15, 1974, Revised December 15, 1974. (SECRET)

    Contains the STS for the netted PAR, MSR, and BMDC operating in the Accidental Launch Defense Mode followed by a switch to the Minuteman Defense Mode.

50. SAFEGUARD System — System Test Specification, Grand Forks Pindown Defense Mode/Minuteman Defense Mode System Test (U), (80/035) 11277145, J. F. Dorsch, Bell Laboratories, SIBGPM02@SP##XXXX, May 1, 1973, Revised August 23, 1974. (SECRET)

    Contains the STS for the netted PAR, MSR, and BMDC operating in the Pindown Defense Mode followed by a switch to the Minuteman Defense Mode.

References for Chapter 6

Nuclear Vulnerability and Hardening

1. SAFEGUARD System Special Environmental Criteria, 11425709 (U), Revision B, Bell Laboratories, February 5, 1973. (SECRET-RD)

   Specifies the nuclear environments for SAFEGUARD ground equipment.

2. SAFEGUARD System — SPRINT In-Flight Nuclear Requirements, 11327052 (U), Revision A, Bell Laboratories, October 16, 1974. (SECRET-RD-CNWDI)

   Specifies the nuclear environments for the SPRINT missile in flight.

3. SAFEGUARD System — SPARTAN In-Flight Nuclear Environments, 11327051 (U), Revision A, Bell Laboratories, October 16, 1974. (SECRET-RD-CNWDI)

   Specifies the nuclear environments for the SPARTAN missile in flight.

4. Effects of EMP on Bell System Long Haul Transmission Facilities, I. G. Durand, D. V. Batorsky, L. Coffey, R. L. Johnson, G. F. Raupp, and P. M. Simonelli, Bell Laboratories, April 30, 1974.

   Summarizes results of the SAFCA EMP Program in which Bell Laboratories and AT&T Long Lines evaluated the effects of EMP on SAFEGUARD communications circuits.

5. SAFEGUARD System — Missile Site Radar (MSR) Subsystem Hardware Assessment Report (U), Final Issue, Bell Laboratories, May 1, 1975. (SECRET)

   Reports results of MSR nuclear hardness assessment.

6. SAFEGUARD System — Perimeter Acquisition Radar (PAR) Subsystem Hardness Assessment Report (U), Final Issue, Bell Laboratories, January 15, 1975. (CONFIDENTIAL)

   Reports results of PAR nuclear hardness assessment.

7. SAFEGUARD System — Data Processing System (DPS) Hardness Assessment Report (U), Final Issue, Bell Laboratories, May 1, 1975. (CONFIDENTIAL)

   Reports results of DPS nuclear hardness assessment.

8. SAFEGUARD System — Common Equipment Hardness Assessment Report (U), Final Issue, Bell Laboratories, May 1, 1975. (CONFIDENTIAL)

   Reports results of nuclear hardness assessment of equipment common to more than one SAFEGUARD subsystem.

9. SAFEGUARD System — Summary Hardness Assessment Report: Electromagnetic Pulse and Miscellaneous Nuclear Effects (U), Bell Laboratories, May 1, 1975. (SECRET)

   Reports results of EMP hardness assessment for SAFEGUARD ground-based facilities. Also reviews criteria development and summarizes subsystem hardness assessments for aerial dust, crater ejecta impacts, debris, and blast/ground motion-induced building rotations.

10. SAFEGUARD System — SPRINT Missile Subsystem Final Hardness Assessment Report (U), Bell Laboratories, January 15, 1975. (SECRET)

    Reports results of SPRINT Subsystem nuclear hardness assessment.

11. SAFEGUARD System — SPARTAN Missile Subsystem Final Hardness Assessment Report (U), Bell Laboratories, February 15, 1975. (SECRET)

    Reports results of SPARTAN Subsystem nuclear hardness assessment.

12. SAFEGUARD System — Lessons Learned in the SAFEGUARD Nuclear Vulnerability and Hardening Program, Bell Laboratories, June 1, 1975.

    Points out lessons learned — both managerial and technical — by Bell Laboratories and its subcontractors during the SAFEGUARD Nuclear Vulnerability and Hardening Program.

References for Chapter 7

Missile Site Radar

1. The Missile Site Radar (U), R. C. Newhouse; and Technical Characteristics of the Missile Site Radar (U), P. L. Hammann, — Case 27703-1400, Bell Laboratories, May 19, 1964. (SECRET)

   Transcript of presentations on the Missile Site Radar (MSR) as conceived at the time of presentation, May 19, 1964. Summarizes the initial MSR system concept and details of the technical characteristics of the initial MSR design.

2. Work Statement for Development of the Missile Site Radar, GA-8532 Revision E, Bell Laboratories Report, May 6, 1964, Revised October 1, 1968. (SECRET)

   Establishes requirements for the work to be done in connection with the development of the prototype MSR installed at Meck Island. This work statement was a part of Bell Laboratories Contract 600630 with the Raytheon Company.

3. NIKE-X Redundancy Analysis — Case 27703-1600 (U), M. T. Fine, Bell Laboratories MFF, December 21, 1966. (CONFIDENTIAL)

   Presents the results of a study which shows the effect of NIKE-X subsystem availability and reliability on subsystem cost, considering redundancy. For purposes of this study, the missile site module, which includes the Missile Site Radar (MSR) and the Missile Site Data Processor (MSDP), was selected.

4. SAFEGUARD System — Final Report of MSR Hardware Tests at Meck Island — Case 27703-1710 (U), G. A. Ripsom, Bell Laboratories MFF, August 30, 1969. (SECRET)

   Covers MSR testing at Meck from the initial start date of February 1, to August 1, 1968 to the requirements of the GA-8532 Work Statement, Revision E, dated October 1, 1968.

5. NIKE-X Weapon System, Missile Site Radar Description (U), Bell Laboratories, April 1, 1967. (SECRET)

   Provides a brief description of the functions and characteristics of the MSR and its major subsystems. Covers operating frequencies; waveforms transmitted and received; digital, transmitter, receiver, and antenna major assemblies. Primarily describes the Meck prototype MSR and has not been updated to the tactical design.

6. Work Statement Specification for the Development (Phase IV) of the Tactical Missile Site Radar (MSR) SAFEGUARD System (U), GA-8601 Revision C, Bell Laboratories, May 24, 1968, Revised November 1, 1972. (SECRET)

   Establishes the design objectives for the MSR and defines the work to be performed in adapting the prototype design, as defined in GA-8532, for use in the tactical SAFEGUARD System. This work statement was a part of Bell Laboratories Contract 601873 with the Raytheon Company.

7. IMSR Hardware Development and Installation Schedules — Case 27703-1400, P. L. Hammann, Bell Laboratories MFF, January 28, 1970.

   Summarizes the development and installation schedule and incremental hardware cost for the IMSR radar modification.

8. SAFEGUARD System — Tactical System Interface Missile Site Radar Operational Description (U), G-634441, Bell Laboratories, January 1, 1971. (SECRET)

   Contains information on the general characteristics of the radar and on how each subsystem performs.

9. SAFEGUARD System — MSR Hardness Status — Report of Hardness Review at Raytheon, October 7-8, 1969 — Cases 27703-2130 and 27703-1400, P. B. Grimado and L. A. Peralta, Bell Laboratories MFF, December 4, 1969.

   Comments on the October 1969 review of the program to harden the Missile Site Radar equipment against shock and vibration (principally nuclear).

10. SAFEGUARD System — Missile Site Radar (MSR) Subsystem Hardness Assessment Report (U), Bell Laboratories, Final Issue October 15, 1974. (SECRET)

    Final summary Hardness Assessment report for the Missile Site Radar, including exposed and housed equipment.

11. Crater Ejecta Threat to Faces of SAFEGUARD MSR Building — Case 27950-2130 (U), J. M. Jacisin, Bell Laboratories MFF, June 25, 1973. (SECRET)

    Assesses the severity of the crater ejecta environment on the element faces of the SAFEGUARD Missile Site Radar building for a specified peak overpressure.

12. SAFEGUARD System — Review of MSR Antenna Service Vehicle — Case 27950-2110, H. W. Lubow and J. G. Trautman, Bell Laboratories MFF, July 19, 1973.

    Documents the results of a review of the MSR Antenna Service Vehicle held at Bell Laboratories, Whippany, N.J., including such aspects as safety, human factors, and corrosion control.

13. NIKE-X MSR — Antenna Performance with Large Numbers of Failed Elements — Case 27703-1400, T. H. Feiertag, Bell Laboratories MFF, May 6, 1966.

    Discusses curves of root-mean-square (rms) sidelobe degradation, gain loss, and rms steering error for the MSR when 0 to 50 percent of the front radiating elements are made inoperative.

14. SAFEGUARD — The System Impact of MSR Q-Channel Blanking Performance (U) — Case 27950-1600, W. F. Boyer, Bell Laboratories MFF, April 15, 1974. (SECRET)

    Documents a study conducted to determine the system performance implications of the current estimate of Q-channel blanking performance. Concludes that this current Q-channel performance does not significantly degrade the overall system and recommends a revision of the MSR Performance Design Specification.

15. NIKE-X — MSR Q-Channel Performance — Case 27703-1400 (U), S. B. Windes, Bell Laboratories MFF, July 8, 1966. (SECRET)

    Defines the MSR Q (broadbeam receiving) channel and investigates its effectiveness in helping to prevent sidelobe tracking with and without a clutter fence.

16. SAFEGUARD System MSR — Q-Channel Evaluation — Case 27950-1400, P. D. Hansell, Bell Laboratories MFF, December 13, 1973.

    Outlines a procedure for determining MSR Q-channel receiver parameters using only the receiver. The purpose of this procedure is to measure the effect of these parameters on Q-channel blanking performance and to define a range of values for which performance meets or exceeds specified values.

17. SAFEGUARD System — MSR - Prototype and Tactical Phase Shifter Diode Reliability — Case 27950-1400, M. R. Dungan, Bell Laboratories MFF, March 18, 1971.

    Records a presentation covering prototype (Meck) diode failures and rates, accelerated aging test and effectiveness, evaluation of the tactical diode reliability, and predicted tactical system phase shifter failure rates.

18. A High Power, S-band, Reciprocal, PIN Diode Phase Shifter — Case 27703-1400, G. C. Di Piazza and R. J. Gutmann, Bell Laboratories TM, MM-65-6468-1, August 21, 1965.

    Describes design details of diode phase shifter built for initial MSR design. Present MSR phase shifter design was based on work reported here, extrapolated to the higher power requirements of the prototype and tactical systems.

19. Diode Specification for High Power Microwave Phase Shifters and Switches — Cases 27703-1950 and 27703-1800, A. Zacharias, Bell Laboratories TM, MM-67-2652-5, March 9, 1967.

    Explores the interaction between circuit parameters and diode parameters in high-power microwave phase shifters and switches, and presents a design procedure for producing a shifter or switch that is optimum for a given application.

20. NIKE-X MSR — Relation Between Phase Shifter Bit Size Error and Antenna Performance — Case 27703-1400, S. B. Windes, Bell Laboratories MFF, September 21, 1966.

    Documents a computer-aided study to determine how MSR antenna performance would be affected by uncertainties in determining the average size of the phase shifter control bits.

21. NIKE-X MSR Antenna Performance vs. Number of Phase Shifter Bits — Case 27703-1400, R. J. Tromley, Bell Laboratories MFF, April 22, 1966. (CONFIDENTIAL)

    Summarizes calculated MSR antenna performance as a function of the number of phase shifter bits. The data include effects of antenna random errors which result from manufacturing tolerances, reflections, and calibration inaccuracy.

22. NIKE-X MSR — Proposed Methods of Antenna Per-Element Phase Alignment — Case 27703-1400 (U), P. T. Sproul, Bell Laboratories MFF, March 20, 1964. (CONFIDENTIAL)

    Describes the phase shifter bit measurement system and estimates accuracy of measurement. Discusses implementation for fault location use.

23. SAFEGUARD — MSR — Use of RF Absorber on Small Array Adapter Ring — Case 27703-1400 (U), S. B. Windes, Bell Laboratories MFF, January 15, 1970. (CONFIDENTIAL)

    Presents reasons for recommending that absorber material be added to the adapter

ring around the Missile Site Radar array. Signal-to-clutter ratios that meet system requirements are among the objectives of this recommendation.

24. SAFEGUARD System — MSR Antenna Retrofit for Absorbing Spill-over Energy — Case 27703-1400, D. L. Chandler, Bell Laboratories MFF, June 9, 1970.

    Describes the methods of retrofit possible when adding an absorber to attenuate the feedhorn spillover energy on the RF chamber front-end adapter of the Missile Site Radar.

25. SAFEGUARD System — MSR Array Surveys — Case 27950-1400, D. L. Chandler, Bell Laboratories MFF, August 24, 1971.

    Presents detailed optical methods for determining the effective pointing direction and clocking angle of each tactical MSR array. Includes a method to relate these parameters to system coordinates. The optical techniques apply equally to Meck and tactical arrays.

26. SAFEGUARD System — Missile Site Radar Monopulse Comparator Alignment — Case 27950-1400, E. O. Martin, Bell Laboratories MFF, January 3, 1974.

    Details a simple and effective technique for monopulse comparator alignment on the Meck Missile Site Radar. This technique was used successfully at the Grand Forks MSR.

27. SAFEGUARD System — MSR — Tactical RF Receiver Compression Performance — Case 27950-1400, E. W. Potter, Jr., Bell Laboratories MFF, September 29, 1971.

    Briefly describes the main difference between the tactical MSR RF receiver and the prototype designs. Includes a block diagram description of the tactical RF receiver and plots of the compression curves and input/output measurement curves for the double conversion mixer, the UHF Mixer/IF amplifier, and the three-stage parametric amplifier stages of the tactical design.

28. SAFEGUARD — Dispersed Pulse Amplitude Measurement and Adaptive Thresholding for the Tactical MSR (Summary) (U) — Case 27950-1400, P. D. Hansell and K. M. Hueter, Bell Laboratories MFF, June 27, 1972. (CONFIDENTIAL)

    Discusses design concept of dispersed pulse measurement, which will provide improved tracking of waking targets and improved AGC operation.

29. NIKE-X Missile Site Radar — Low Level Transmitter Configuration, J. H. Pruden, Bell Laboratories MFF, March 8, 1965.

    Describes the planned MSR low-level transmitter configuration and its connections to other MSR equipment, and describes a suggested revision. Compares the two configurations and presents objections and a possible compromise to the revision.

30. Missile Site Radar (MSR) Command, Control, and Interface Computer (CCIC) — Functional Description (MSR 4.1-11), Raytheon Company, Revision 1, July 31, 1969.

    Describes how various digital radar-controlled transform computers generated orders as timing pulses for analog radar equipment and how replies based on these orders are generated for processing by the computer.

31. SAFEGUARD System — MSR Transmitter — Summary of VA-144 Performance — Case 27950-1400, P. T. Sproul, Bell Laboratories MFF, December 27, 1974.

    Summarizes performance of the VA-144 klystrons at Meck and at Grand Forks. Includes discussion of problems encountered and solutions achieved. Also considers life experience at Meck versus design goal.

32. VA-144 ESM RB-9 Program, Vol I-VIII, Varian Associates.

    Documents all work performed in final development of the VA-144 klystrons for tactical MSR transmitter. Includes copies of key technical memoranda.

33. Waveguide Breakdown Effects at High Average Power and Long Pulse Length, A.S. Acampora and P. T. Sproul, BSTJ, Vol 51, No. 9, November 1972.

Discusses waveguide breakdown due to particulate matter in the presence of long pulses and high average power and develops an analytical solution to predict breakdown performance. Confirming experimental results are presented.

34. SAFEGUARD System — MSR — Feedhorn and Waveguide Arc Logic — Case 27950-1400, J. H. Pruden, Bell Laboratories MFF, August 3, 1971.

Reviews logic associated with recent findings concerning the mechanisms of waveguide and feedhorn arcing in the MSR to ascertain that the corrective and protective actions taken in the high level transmitter are optimum to maintain MSR operation.

35. SAFEGUARD System — MSR Grand Forks Collector Pressure Increase Problem Summary — Case 27950-1400, P. T. Sproul, Bell Laboratories MFF, March 20, 1975.

Summarizes the effort to identify the source of a pressure drop increase in the klystron cooling channel. The problem was encountered only at the Grand Forks installation. Includes the results of the study and corrective action.

36. NIKE-X Missile Site Radar Interface with in Input/Output Controller of the Data Processing System — Case 27703-1400, J. O. Hardy, Bell Laboratories MFF, December 13, 1965.

Documents information on the interface between the Input/Output Controller of the NIKE-X Data Processing System and the Missiles Site Radar Command, Control, and Interface Computer.

37. SAFEGUARD System — Tactical System Interface — Missile Site Radar/Data Processor (U), Digital Data Format Specifications, G-438801, Bell Laboratories, KMFTSIMD@FS##XXXX, October 1, 1969, Revised February 3, 1975. (SECRET)

Contains information on the various instructions and interfaces, with the parameter contained in the interface words identified as to value and limits.

38. SAFEGUARD System — MSR/MSDP Interfaces, Vol II — Hardware/Software Interactions (U), Books 1 and 2, G-741636, Bell Laboratories, June 1, 1973. (SECRET)

Contains information on the data paths selected in the MSR based on the transmit and receive instructions and what information is generated as radar replies.

39. SAFEGUARD System — MSR/MSDP Interfaces, Vol I — Timing and Control (U), Part 1, G-741636, Bell Laboratories, August 31, 1973. (CONFIDENTIAL)

Contains information necessary to determine what timing operations occur within the Missile Site Radar as a result of a radar transmit or receive instructions in all modes of operation.

40. Missile Site Radar (MSR) Beam Steering Computer (BSC) Functional Description, (BAA 4.2-11), Raytheon Company, September 15, 1967.

Describes the process of converting $\sin\alpha$ and $\sin\beta$ steering angles to phase differences between adjacent radiating elements.

41. Digital Control Group Concept Document, Vol I-IV, L. Shear, Raytheon Company, BR-7579, November 1973.

Contains information on the design concepts and descriptions of the various digital controllers that interface with the analog sections of the MSR.

42. SAFEGUARD System — MSR Radar Monitor Console Displays and Interfaces — Case 27950-1400, G. T. Kresan and R. H. Thieme, Bell Laboratories MFF, December 21, 1971.

Describes all Radar Monitor Console (RMC) indicators, controls, and interfaces.

43. NIKE-X MSR — Outline of Required Internal Radar Tests — Case 27703-1400, R. A. Reed, Bell Laboratories MFF, January 20, 1966.

    Outlines those MSR tests requiring more than one subsystem and varying degrees of control by the MSDP. Establishes overall requirements for these tests.

44. SAFEGUARD System — Study of MSR Digital Control Group (DCG) Diagnostic Test for Fault Location — Case 27950-1400, L. R. Hamilton, Bell Laboratories MFF, December 9, 1971.

    Describes the results of a study of the controller located in the control rack to determine the feasibility of using the test outputs for fault isolation and maintenance purposes in the DCG.

45. System Development Plan, Vol 3 — System Evaluation Program, Part 1 — MSR Functional Performance (U), Bell Laboratories, January 1975. (SECRET)

    Contains all significant evaluation results for the tactical MSR and Missile Systems. Includes the Calspan analyses of sphere and satellite tracking data showing range and angle tracking accuracies.

46. SAFEGUARD Performance/Design Specification Missile Site Radar (U), 11327054 Revision B, Bell Laboratories, October 16, 1974. (SECRET)

    Specifies the performance and design characteristics of the MSR to establish a production base. This specification is the highest generation document covering the MSR.

47. MSR Stateside Antenna Subsystem Test Report (U), Raytheon Company, BR-4644, August 1, 1968, with Errata Sheet, December 23, 1968. (SECRET)

    Pertains to measurements of a full-scale MSR antenna array on a pattern measurement range.

    Part 1 — Data summary by performance areas, specifications, and design objectives.

    Part 2 — Appendix A: Antenna Patterns

    Part 3 — Appendix B: Contour Plots

48. SAFEGUARD System Reliability Program Review, April 5 and 6, 1972, Minutes, Bell Laboratories, April 1972. (SECRET)

    A review and update of the current A/R values for the SAFEGUARD System and its major equipment based on currently available data reflecting the Phase I deployment concept.

49. NIKE-X — MSR Antenna — Characteristics of EMP Considered as Threat to MSR — Case 27703-1400 (U), T. H. Feiertag, Bell Laboratories MFF, September 29, 1966. (SECRET)

    Calculates the spectrum and energy content of a typical Electromagnetic Pulse (EMP) caused by a nuclear detonation to determine its effect on the MSR antenna front element and phase shifter.

50. NIKE-X — MSR Antenna — EMP Threat to MSR Antenna — Case 27703-1400 (U), S. E. Windes, Bell Laboratories MFF, August 25, 1967. (SECRET)

    Updates a previous memorandum by T. H. Feiertag, dated 9/29/66, entitled, "Characteristics of EMP Considered as a Threat to MSR."

References for Chapter 8

Perimeter Acquisition Radar

1. PAR Phase IA Report (U), General Electric Company, EHM-11043, March 1, 1967. (SECRET)

   Summarizes the initial definition phase of the Perimeter Acquisition Radar (PAR) development. Includes detailed requirements and configuration for the PAR.

2. PAR Phase II Definite Plans (U), Revision A, Vol I-X, General Electric Company, EHM-1134/75, Revised May 1968. (Vol I-V, VII, and IX — SECRET; Vol VI, VIII, and X — UNCLASSIFIED).

Volume I	Executive Summary
Volume II	Technical Development Plan
Volume III	Specifications, Books 1-10
Volume IV	Program Operations Plan
Volume V	Manufacturing Plan
Volume VI	Site Activation Plan
Volume VII	Test Plan
Volume VIII	Configuration Management Plan
Volume IX	Reliability and Quality Assurance Plan
Volume X	Engineering Support Plans

   Summarizes the development of the PAR, including the design, development, and manufacture of the PAR equipment.

12. SAFEGUARD System — Technical Requirements for Facilities Construction, Vol 1 and 3, Issue 2, Rev 2C, J. G. Matthews, Bell Laboratories, November 16, 1972.

    Volume 1 General, Drawing Nos. 11277040, 11277041, and 11277042, Issue 2, Rev 2C.

    Volume 3 PAR Building, Drawing Nos. 11277048, 11277049, 11277040.

    Contains detailed drawings of the PAR facilities to be constructed in North Dakota (PAR-1) and Montana (PAR-2).

14. SAFEGUARD System — PAR-1 R&D Test Plan, Revision A, Bell Laboratories, August 2, 1972.

    Defines the test program to verify system performance for the PAR installation at Grand Forks, North Dakota.

15. SAFEGUARD System — Special Environmental Criteria, Bell Laboratories, 11425709 Revision B, August 18, 1971. (SECRET)

    Defines the environmental criteria the radar equipment had to meet to withstand nuclear effects.

16. Analysis of the Beam Steering Errors Arising from Antenna Element Displacements of a Phased Array Radar, D. J. Enright, Bell Laboratories TM, TM-75-6512-1, April 10, 1975.

    Analyzes beam steering errors caused by mechanical displacements of the antenna elements.

17. SAFEGUARD System — PAR — PAR Spectrum Signature Summary Report (U) — Case 27950-1940, V. D. Vanacore, Bell Laboratories MFF, March 26, 1975. (SECRET)

    Summarizes the characterization of the PAR spectrum signature, including electromagnetic compatibility.

18. SAFEGUARD Performance/Design Specification Perimeter Acquisition Radar (U), BMDMP 4.04.A, 11327060, Revision B, Bell Laboratories, November 21, 1969, Revised October 16, 1974. (SECRET)

    Contains the radar subsystem performance requirements for the PAR.

19. SAFEGUARD System — Perimeter Acquisition Radar (PAR) Subsystem Hardness Assessment Report (U), Case 27950-2130, Bell Laboratories, Final Issue, January 15, 1975. (CONFIDENTIAL)

    Summarizes the program to evaluate the ability of the hardware to withstand the nuclear shock and vibration requirements.

20. SAFEGUARD System — An Analysis of the Effect of Thermal Noise on the PAR Angle Tracking Precision (U) — Case 27950-1940, D. J. Enright, Bell Laboratories MFF, December 18, 1972. (SECRET)

    Analyzes the effect of thermal noise on the PAR angle tracking precision, including expected PAR performance.

21. SAFEGUARD System — PAR External Receive Pattern Measurements Program — Final Report (U), A. T. Vitenas, Bell Laboratories MFF, July 26, 1974. (SECRET)

    Describes a program to measure the antenna receive pattern. Includes an analysis of the measurement results.

22. NIKE-X PAR Trade-off and Study Report (U),
35. Volume I-XIV, General Electric Company, July 1, 1967. (SECRET)

Volume I	Cost Optimization Study
Volume II	Transmitter Study
Volume III	Antenna and RF Component Study
Volume IV	Signal Processing Synthesis
Volume V	Monitoring Study
Volume VI	Environment and Propagation Studies
Volume VII	Radiation Control Study
Volume VIII	Specifications — Tube
Volume IX	Specifications — Solid State
Volume X	Surveillance Performance Studies
Volume XI	Noise Measurement and Threshold Determination Studies
Volume XII	Parametric Studies
Volume XIII	Availability vs Cost Analysis
Volume XIV	Cost and Schedule Study

    Discusses the results of a study concerning system design problems, schedules, cost, and trade-offs for a PAR program evolving from the NIKE-X system. Includes the rationale for component selection and specifications for equipment to be used in the PAR.

36. Analysis of Auroral Data from Prince Albert Radar Laboratory, Final Report, W. E. Jaye, W. G. Chestnut, and B. Craig, Stanford Research Institute, SRI Project 7465, September 1969.

    Summarizes the results of a study conducted at Prince Albert Radar Laboratory in Canada to investigate auroral effects at UHF.

37. SAFEGUARD System — Description of the Hardness Verification Program for the PAR Ground Plane and Antenna Elements — Case 27950-2130, L. Y. Cooper, Bell Laboratories MFF, January 20, 1971.

    Describes a program to evaluate the PAR facility and equipment for hardening against nuclear shock and vibration, thermal stress, dust, and debris to ensure that PAR integrity could be maintained during an attack.

38. PAR Sensor Subsystem — Availability and Reliability Summary (U), General Electric Company, October 24, 1973. (CONFIDENTIAL)

    Discusses the availability and reliability of components in the PAR.

References for Chapter 9

SPRINT Missile Subsystem

1. SAFEGUARD System — SPRINT Warhead Section Tests — Case 27950-1000, D. B. Seamans, Bell Laboratories MFF, October 28, 1971.

   Summarizes the results of SPRINT Warhead Section tests to date, including results of both the preflight ground testing of the FTQs (Flight Test Qualification Units) as well as flight tests.

2. SAFEGUARD SPRINT Interceptor Response — Intercept Deadzone (U) — Case 27703-1500, S. C. Nordberg, Bell Laboratories MFF, March 26, 1970. (CONFIDENTIAL)

   Describes a method developed to determine the upper and lower limits of the missile capability deadzone along the trajectory of a particular object. Assumes that missile capability bias is available, and shows how a two-iteration process is used to compensate for approximations of missile and target flight. Accuracy of the method is well within the limits required by SPRINT Interceptor Response for intercept planning.

3. SAFEGUARD Performance/Design Specification SPRINT Subsystem (U), 11327045 Rev. A, Bell Laboratories, December 31, 1969, Revised December 18, 1974. (SECRET)

4. SPRINT Phase III Development Program Summary, Martin Marietta Corporation, OR-3650-1, February 1973. (SECRET)

   Accents the highlights of the development program.

5. Phase III Development Plan SPRINT Subsystem (U), Vol I-IV, Martin Marietta Corporation, OR-3650-2, July 1974.

   Volume I — System Description and Overall Development Plan. Gives an overall description of SPRINT, including major changes that have occurred. (SECRET)

   Volume II — Engineering Development and Test Programs. Gives a complete description of the development and testing of major assemblies. Included are some problems encountered and their resolutions. (SECRET-RD)

   Volume III — Support Activities. Gives a description of support activities such as programming, quality, reliability, procurement and documentation. (CONFIDENTIAL)

   Volume IV — Flight Test Program. Includes a listing of the flight test program with significant milestones highlighted. (SECRET)

6. SAFEGUARD System — Missile Subsystem Interface Description (U), Bell Laboratories, January 1, 1974. (SECRET)

   Combines remote launch design requirements with all hardware and software interfaces, except Guidance, which is covered below (Reference 7).

7. SPRINT I Missile Subsystem Interface Specification – Guidance Software with SPRINT I Missile Hardware (U), 11268700, Bell Laboratories, November 27, 1973. (SECRET)

8. SPRINT – S-Band Attenuation Measurements on SPRINT 1st and 2nd Stage Motors (U) – Case 27703-1000, E. P. Chowaniec and L. L. LeBlanc, Bell Laboratories MFF, February 3, 1965. (CONFIDENTIAL)

   Presents results, methods, and correlation for RF attenuation measurements performed on SPRINT first- and second-stage motors at the Allegheny Ballistics Laboratory. These measurements were part of the SPRINT communications program designed to achieve the first slant-look measurements at S-band through full-scale flame plumes.

9. SAFEGUARD SPRINT/SPARTAN Component Parts, First Source Status Program (G741194) – Cases 27703-1000 and 27703-1010, J. Brown, Bell Laboratories MFF, April 28, 1969.

   Discusses the program written to list the SPRINT/SPARTAN Component part "first source" information. Lists the functions of the program and indicates the key-punching formats.

10. SAFEGUARD System – First Stage Ballistic Trajectories for Remote Launch of the SPRINT Missile – Case 27703-1000, R. H. Whiting, Bell Laboratories MFF, May 12, 1969.

    Derives the algorithm and justifies the assumptions used to calculate trajectories for SPRINT after first-stage burnout with delayed second-stage ignition.

11. SAFEGUARD System – SPRINT Missile Subsystem – Final Hardness Assessment Report (U), Bell Laboratories, January 15, 1975. (SECRET-RD)

12. A Reliability Model for the SPRINT Missile – Case 27703-1600 (U), S. Dier, Bell Laboratories MFF, June 30, 1967. (SECRET)

    Generates and makes available probabilistic data and analysis pertinent to the development of a reliability model of the SPRINT missile.

13. SAFEGUARD Performance/Design Specification – SPRINT Control Equipment (Remote) (U), 11327050 Rev. A, Bell Laboratories, May 26, 1970, Revised October 16, 1974. (SECRET)

14. SPRINT Interceptor Response – Location of SPRINT Missile Blackout – Case 27950-1500 (U), R. L. Buchwalter, Bell Laboratories MFF, December 10, 1970. (CONFIDENTIAL)

    Describes an analytical method for locating blackout along the SPRINT trajectory. The method considers the characteristics of the SPRINT trajectory, the blackout volume, and the times of formation and dissipation of the fireball.

15. Final Report – Aging and Deterioration Test Program – First and Second Stage Rocket Motors, Martin Marietta Corporation, Document No. TRP 10301481-008, June 27, 1975. (UNCLASSIFIED)

    Presents the results of tests on SPRINT missile motors aged in a configuration and environment simulating the tactical in-cell conditions. Discusses motor design, propellant, test configuration, and test procedures.

16. SAFEGUARD Performance/Design Specification – SPRINT Launch Equipment (U), 11327047 Rev. A, Bell Laboratories, October 16, 1974. (SECRET)

17. SPRINT Test Control and Monitoring Unit (MGS Testing), S. Gross, Bell Laboratories TM, MM-67-6223-3, May 17, 1967.

    Describes the operation and circuit structure of the SPRINT Test Control and Monitoring Unit, which is being used for automatic, long-term reliability testing of the SPRINT Missile Guidance Set.

18. Shock Testing of SPRINT Missile Guidance Sets and Safety and Arming Devices in Simulated Flight Environments — Cases 27703-1000 and 25601, A. F. Stormont, Bell Laboratories MFF, March 20, 1969.

    Reviews test criteria; describes test apparatus, instrumentation and data analysis methods; and compares flight-produced and laboratory-simulated shock environments in the guidance, control, and warhead compartments of the SPRINT missile.

19. SAFEGUARD System — SPRINT Burst Delay Timer Effectiveness Study (U) — Case 27703-1600, M. J. DeFazio, Bell Laboratories MFF, June 23, 1969. (SECRET-RD)

    Describes a study made to determine the conditions, if any, under which a SPRINT Burst Delay Timer would be useful for enhancing the effectiveness of the SAFEGUARD System. Includes consideration of SPRINT self-blackout and effects of ionizing radiation.

20. Accleration and Acoustic Testing of SPRINT/SPARTAN Cables and Antennas — Cases 27703-1000, 27703-1010 and 37994-2, R. T. Wood, Jr., Bell Laboratories MFF, September 8, 1969.

    Records results of acoustic noise and acceleration tests made on SPRINT/SPARTAN cables 11276263, 11275280, and 11275152.

21. SAFEGUARD System — SPRINT — Effects of Launch Station Verticality and Azimuth Errors on the Pitchover Error Budget (U) — Case 27950-1000, E. F. Engelbert, Bell Laboratories MFF, February 14, 1972. (CONFIDENTIAL)

    Make a determination as to the extent of station verticality and azimuth errors on the overall pitchover error budget for the SPRINT missile system.

22. Recommendations for Harnessing Techniques for SPRINT — Cases 37992-1 and 27703-1810, G. J. DeVries, Bell Laboratories MFF, July 29, 1968.

    Discusses a lecture-demonstration on the preparation of wiring harnesses for the SPRINT missile. Shows the advantages of different processing techniques, including the use of flat wireboards, master template breakouts, precut wires, and preterminated shields.

23. SPRINT MBGE Test Set Encoder Section — Case 36294-22, L. Rosa, Bell Laboratories MFF, May 22, 1964.

    Reports results of Bell Laboratories reliability analysis of the memory system contained in the encoder section of the SPRINT Missile-Borne Guidance Equipment test set. Mean time between replacements figures for the memory system, the encoder less the memory, and the encoder with the memory are included.

24. Calibration of SPRINT Autopilot Accelerometer (U) — Case 27703-1810, H. J. Luer and R. G. McCoy, Bell Laboratories MFF, July 20, 1964. (CONFIDENTIAL)

    Describes statistical analysis undertaken in setting performance parameter limits for the SPRINT autopilot accelerometer. Discusses nature of SPRINT missile error budget and the application of the Central Limit Theorem in the statistical approach to the calibration of the autopilot accelerometer. Tabulates maximum errors allowable in accelerometer calibration.

25. SPRINT/SPARTAN — Reliability Study of MGS R&D Field Experience — Case 36294-22, W. J. Akstulewicz, Bell Laboratories MFF, September 29, 1969.

    Documents a reliability study of Missile Guidance Sets under research and development field conditions. The study considered (1) units in ground test programs, (2) those sets designated for flight tests, and (3) sets in storage.

26. SPRINT Missile Guidance Set, Reliability Evaluation Results — Case 36294-22, Richard G. Smith III, Bell Laboratories MFF, September 11, 1970.

    Describes implementation of the test program defined in SPRINT Guidance Set Reliability Evaluation Specification G485090 and documents the test results.

27. SPRINT — Launch Preparation Equipment — Case 36294-22, T. L. Tanner, Bell Laboratories MFF, March 26, 1971.

Reviews the reliability predictions for the integrated-circuit version of the SPRINT Launch Sequencer (IC LSEQ), which replaces the discrete LSEQ in the Launch Preparation Equipment for the tactical SPRINT system.

28. SENTINEL System — Explosive Quantity — Safety Distances for SPARTAN and SPRINT Missiles — Case 27703-2110, C. G. Reinschmidt, Bell Laboratories MFF, September 4, 1968.

Documents a reduction in the distances required between quantities of SPRINT and SPARTAN missiles and the nearest inhabited building. The revised safety classification should permit easier handling and controlling of missile sections during checkout.

29. SAFEGUARD System — SPRINT EED No-fire Characteristics — Case 27950-1000, J. A. Freund, Bell Laboratories MFF, June 25, 1971.

Describes tests of SPRINT missile Electro-Explosive Devices (EEDs) to determine input power levels induced in the devices by several types of electromagnetic fields.

30. SAFEGUARD System — Missile Subsystem Safety Interlocks — Case 27950-1000, D. P. Worrall, Bell Laboratories MFF, February 4, 1974.

Reviews the utilization of safety interlocks and Safety Interlock Override in the missile subsystems and the remote launch equipment.

31. NIKE-X — Acquisition of a SPRINT Missile in the Toss-and-Catch Mode — Case 27703-1600 (U), W. P. Chapman, Jr., Bell Laboratories MFF, February 28, 1967. (CONFIDENTIAL)

Reviews the problem of establishing track on a SPRINT missile after it is launched from a site several miles from the tracking radar.

32. SAFEGUARD System — SPRINT PACA Safety Margins (U) — Case 27950-1000, J. A. Freund, Bell Laboratories MFF, July 20, 1972. (SECRET)

Analyzes safety margins for various electromagnetic radiation environments during transportation of the SPRINT missile Propulsion and Control Assembly (PACA).

33. SENTINEL System — SPRINT — Proposed UTL Testing Program — Case 27703-1000, J. R. DeTizio, Bell Laboratories MFF, March 18, 1969.

Proposes a test program for the two SPRINT/SPARTAN Universal Transporter Loader (UTL) prototypes. The test program is composed of (1) Design Development Testing, (2) Acceptance Testing, (3) Design Verification Testing, and (4) Qualification Testing.

34. NIKE-X — Factor of Safety, Proof Testing and Recertification Testing — Case 27703-1600, C. G. Reinschmidt, Bell Laboratories MFF, June 29, 1967.

Clarifies the use of safety factors in the design of NIKE-X equipment and the requirements for proof testing and recertification of handling equipment before use.

35. SAFEGUARD Performance/Design Specification — SPRINT Air Vehicle (U), 11327046 Rev. A, Bell Laboratories, January 7, 1970, Revised December 18, 1974. (SECRET)

36. SENTINEL System — Flame Propagation Tests on Hydraulic Fluids — Case 27703-2110, J. A. Wojciak, Bell Laboratories MFF, January 23, 1969.

Describes procedures and results of flame propagation tests performed on five hydraulic fluids. Based on results of these tests, recommends the use of fire resistant fluids in new hydraulic system designs rather than the currently used petroleum based fluids or enclosure of hydraulic lines to eliminate the possibility of spraying oil from a ruptured line.

37. Environmental Requirements for the SPRINT Subsystem (U), Specification MO-141H, Martin Marietta Corporation, September 15, 1971. (SECRET)

38. SAFEGUARD System — SPRINT — Autopilot Timer Error Study — Case 27950-1000, R. C. McCrea, Bell Laboratories MFF, August 19, 1970.

    Presents the results of a study into the effects of early "time-out" of the timing circuit on SPRINT initial pitchover angle.

39. "Space Phase Lag" and SPRINT Steering Order Resolving Schemes (U) — Case 27703-1000, G. J. Ryva and J. C. Hsu, Bell Laboratories TM, MM-65-4264-6 and 65-4232-11, May 20, 1965. (CONFIDENTIAL)

    Seeks to clarify the deleterious effects of SPRINT "space phase lag" (the continual error between the spacial orientations of the commanded and achieved lateral accelerations when the missile rolls). Compares the three-resolver scheme currently used for SPRINT to the more common one-resolver scheme regarding effectiveness in reducing space phase lag.

40. Preliminary Study of Blackout Effects on SPRINT Miss Distance (U) — Case 27703-1600, F. J. Hinger, Bell Laboratories MFF, July 5, 1967. (SECRET)

    Presents the results of a preliminary study of the effects of blackout on SPRINT guidance. The results were obtained by Monte Carlo methods applied to a two-dimensional simulation of a SPRINT guidance package.

41. Simulation of SPRINT Launch Eject High-Frequency High-Level Shock Environments — Cases 25601 and 27703-1000, P. Johansen, Bell Laboratories MFF, June 28, 1967.

    Summarizes alternative methods available for simulating the SPRINT Missile-Borne Guidance Equipment and Autopilot shock environments, and presents results of a laboratory evaluation of a ballistic pendulum method.

42. SPRINT Launch and Test Planning Feasibility Study of SPRINT Launch Recovery System, D. Lomax, Bell Laboratories MFF, September 9, 1964.

    Presents a Martin Company mathematical simulation of the loading dynamics of the Shock Recovery System used for SPRINT launch eject tests, summarizing the analytical method used.

43. Deriving Body Attitude from SPRINT Flight Data — Case 27703-1000, B. D. Jensen, Bell Laboratories TM, MM-66-6481-3, December 15, 1966.

    Shows how the complete dynamic history of a missile flight can be determined if the acceleration vector is given in both the missile and battery coordinate systems and the angular rate about one of the missile axes is known.

44. An Investigation of Staging Transients on SPRINT WSMR Flights 7 and 8 — Case 27703-1000 (U), W. P. Wesley, Bell Laboratories MFF, July 5, 1967. (SECRET)

    Presents the result of an investigation to determine the nature and origin of previously unexpected forces acting on the SPRINT missile during separation from the first stage. The Simulated Analog Missile, a full 3-dimensional analog simulation of the SPRINT missile which contains a detailed program of the missile functions and nominal missile aerodynamics, was used in the investigation.

References for Chapter 10

SPARTAN Missile Subsystem

1. SAFEGUARD Performance/Design Specifications, Bell Laboratories.

   SPARTAN Subsystem, 11327041 Rev A, December 18, 1974. (SECRET)

   SPARTAN Air Vehicle, 11327042 Rev A, December 18, 1974. (SECRET)

   SPARTAN Launch Equipment, 11327043, August 12, 1970. (SECRET)

   SPARTAN Ground Support Equipment, 11327047, December 1974.

   Provide performance requirements and design specifications. Also establish a base for tactical production drawings and associated test and logistics support requirements.

2. SAFEGUARD System — SPARTAN Subsystem — Development Plan (U), Vol I—III, McDonnell-Douglas Astronautics Company, January 31, 1966, Revised August 1972. (SECRET)

   Summarizes the design and planning effort. Descriptions of the role of SPARTAN in the SAFEGUARD System, missile configuration, site facilities, and program schedules (including yearly milestone and flight test schedules) are presented. Also included are program plans and schedules for engineering, ground testing, flight testing, manufacturing, quality control, reliability, logistics, procurement, documentation, facilities, and field site operation.

3. SAFEGUARD/SPARTAN Fault Tree Analysis, McDonnell-Douglas Astronautics Company, MDC G5183, June 1974.

   Presents a quantitative assessment of inadvertent missile launch. Identifies components whose failure would result in a critical event, indicates probability of occurrence, and shows critical paths and associated failure probabilities.

4. SAFEGUARD System — SPARTAN Missile Subsystem Final Hardness Assessment Report (U), Bell Laboratories, February 15, 1975. (SECRET)

   Final issue in the series of SPARTAN missile subsystem hardness assessment reports. Contains results of each program and lists all pertinent documentation.

5. SPARTAN Missile Rain Erosion Test — Case 27950-1000, N. R. Lampert, Bell Laboratories MFF, October 8, 1970.

   Describes the results of recalibrating the pressure instruments used in high-speed rainfield tests of a SPARTAN missile nose cone.

6. SAFEGUARD System — SPARTAN Response to Guidance Orders (U) — Case 27950-1010, J. B. McCauley, Bell Laboratories MFF, January 26, 1972. (CONFIDENTIAL)

   Explains briefly the nature of the SPARTAN missile response to a guidance command during second-stage flight.

7. SENTINEL-SPARTAN Explosive Separation System Development and Test Results, McDonnell-Douglas Astronautics Company, DAC 58769A, September 1968.

   Describes the development, design, and testing of the interim design explosive separation system for the SPARTAN missile.

8. Implementation of Loss of RF Destruct for SPRINT and SPARTAN — Cases 27703-100 and 27703-1010, J. L. Henry, Bell Laboratories MFF, October 15, 1969.

   Proposes a means of interfacing the Missile Guidance Set/Warhead Adaption Kit missing messages which trigger missile safe destruct.

9. SAFEGUARD System — SPARTAN — SPARTAN Third-Stage Orientation Accuracy (U) — Case 27950-1010, J. B. McCauley, Bell Laboratories MFF, May 10, 1972. (SECRET)

   Explains the nature and extent of aerodynamic effects on the centerline orientation of the SPARTAN third-stage vehicle during the final flight phase before intercept.

10. Qualification Testing of the SPARTAN Safety and Arming Device (SAD) — Case 27950-1000, J. Lowe, Bell Laboratories MFF, April 2, 1971.

    Describes tests and results of qualification testing of the SPARTAN II safety and arming device. Shock response spectrum graphs for the 2500 g, 0.067-millisecond qualification test are shown.

11. NIKE-X/ZEUS: Analysis of Space Phase Lag with a Four-Gimbal Stable Platform (U) — Case 27703-1010, E. J. Schuler, Bell Laboratories MFF, March 25, 1966. (CONFIDENTIAL)

    Analyzes Space Phase Lag (spatial orientation between the commanded and achieved lateral acceleration vectors of a missile in flight), considering only the effect of missile roll. Investigates use of a stable four-gimbal platform for the ZEUS missile.

12. NIKE-X/ZEUS — Documentation of Missile Acceleration and Attitude Error Analysis Programs for Steering Control Systems — Case 27703-1010, J. W. Levengood, Bell Laboratories MFF, December 15, 1966.

    Documents two digital computer programs for analyzing SPARTAN missile acceleration and attitude errors caused by gain and null errors in the SPARTAN steering control systems.

13. Explanation of the Stable Platform Flip Maneuver and the Laboratory Simulation of this Maneuver — Case 27703-1810, F. M. Stepniak, Bell Laboratories MFF, August 1, 1966.

    Explains the execution of a "Flip" maneuver by the all-attitude, four-gimbal SPARTAN stable platform as required for maintaining proper reference under certain conditions of SPARTAN flight.

14. SAFEGUARD System — Thermal Stress Analysis of SPARTAN Launch Area Antenna Window — Case 27703-1810, J. R. Mc Kay, Bell Laboratories MFF, July 13, 1970.

    Analyzes thermal stress during nuclear blast to which the SPARTAN launch area antenna window may be subjected and concludes that the window is unlikely to fail.

15. SAFEGUARD System — SPRINT/SPARTAN Tactical Electromagnetic Radiation (EMR) Environment — Cases 27950-1000 and 1010 (U), J. A. Freund, Bell Laboratories MFF, July 18, 1972. (SECRET)

    Documents the basis for calculating the tactical EMR environments produced by the Missile Site and Perimeter Acquisition Radars (MSR and PAR). A worst-case environment is defined for the SPRINT and SPARTAN missiles during flight, their launch stations, the universal missile building, the warhead facility, and the remote SPRINT launch site.

16. SAFEGUARD System — EMR Induced Inadvertent Launch Analysis for the SPRINT and SPARTAN Missiles (U) — Cases 27950-1000 and 1010, J. A. Freund, Bell Laboratories MFF, July 20, 1972. (SECRET)

    Gives safety margins for electromagnetic radiation induced inadvertent launch of SPRINT and SPARTAN missiles for in-cell configurations of closed cell, open cell, and maintenance mode.

17. SAFEGUARD System — SPARTAN Launch Cell Thermal Analysis — Case 27858-1010, W. R. Sieling, Bell Laboratories MFF, October 19, 1973.

    Discusses the possibility of SPARTAN motor autoignition if the SPARTAN auxiliary power unit gas generator should fire inadvertently. Predicts the worst case of temperature environment within the SPARTAN launch cell.

18. SAFEGUARD System — SPARTAN — Results of the MDAC Analysis to Determine the Lock-out Requirements for the Axial Isolation System — Case 27950-1010, C. S. DeSilets, Bell Laboratories MFF, November 30, 1970.

    Discusses the McDonnell-Douglas analysis of the dynamics of launching the SPARTAN missile supported by an unlocked axial isolation system.

19. SAFEGUARD System — SPARTAN — Response of the Axial Isolation System to Earthquake Induced Ground Motions — Case 27950-1010, C. S. DeSilets, Bell Laboratories MFF, April 7, 1971.

    Presents an analysis of the responses of damped structures to earthquakes. This analysis was initiated because of the concern that the axial isolation system, being designed to keep the vertical acceleration of the SPARTAN missile supported on its launch rail below 1 g during nuclear ground shock conditions, may not be able to maintain the structural integrity of the missile during earthquake-induced loading conditions.

20. SAFEGUARD System — SPARTAN — Reevaluation of Environmental Criteria and Stress Requirements for Equipment in the SPARTAN Launch Station Deflector Region — Case 27950-1010, G. N. Zacsek and W. R. Sieling, Bell Laboratories MFF, June 16, 1971.

    Presents an analysis to determine the dynamic temperature history of a surface on which SPARTAN missile exhaust gases impinge, e.g., the deflector plate and junction boxes in the cell. The analysis was initiated in response to data which indicate that temperatures in the tactical design launch station will be considerably higher than those found in the old shallow-depth cell.

21. SAFEGUARD System — SPARTAN Launch Cell Preparation Equipment Vault (LPEV) — LPEV Nuclear Ground Shock Environment Requirements — Cases 27950-2130 and 27950-1010, J. F. Stevenson and C. S. DeSilets, Bell Laboratories MFF, September 29, 1970.

    Outlines procedures used in establishing requirements for nuclear ground shock environmental testing. Records data on shock spectra envelopes and acceleration-time histories that are consistent with the shock spectra, to be used for mathematical analysis purposes, as well as aiding in establishing future test criteria for LPEV equipment.

22. SAFEGUARD System — SPRINT/SPARTAN EMR Vulnerability in Abnormal MSR/PAR Environments (U) — Cases 27950-1000 and -1010, J. A. Freund, Bell Laboratories MFF, August 3, 1973. (SECRET)

    Provides data in answer to the Nuclear Weapon System Safety Committee proposal to inhibit MSR and PAR radiation when the cover of a launch cell containing a missile with a war reserve warhead is open for entry.

23. SAFEGUARD System — SPRINT/SPARTAN EMR Vulnerability in Abnormal MSR/PAR Environments (U) — Cases 27950-1000 and -1010, J. A. Freund, Bell Laboratories MFF, October 10, 1973. (SECRET)

    Presents data to show that the SPRINT and SPARTAN missile subsystems are safe under conditions of MSR or PAR RF Inhibit Mask control failure. Proposes, therefore, deletion of Rule 9 of the Nuclear Weapons Systems Safety committee, which would prohibit MSR and PAR radiation when the cover of a launch cell containing a missile with a war reserve warhead section is open.

24. SPARTAN — Reliability Study of the Burst Delay Timer — Case 36294-22, W. J. Akstulewicz, Bell Laboratories MFF, May 28, 1969.

    Presents results of a reliability study performed on the SPARTAN burst delay timer design.

25. Qualification Tests of the SPARTAN Burst Delay Timer — Case 27703-1010, J. L. Henry, Bell Laboratories MFF, June 13, 1969.

    Describes the procedures and results of qualification tests (operation under extremes of temperature, random and sinusoidal vibration, shock, acceleration, pressure, and acoustic energy) performed on the SPARTAN burst delay timer.

26. SAFEGUARD System — Evaluation of SPARTAN Auxiliary Heating/Cooling and Ventilating Unit — Case 27950-1010, G. N. Zacsek, C. S. DeSilets, and D. F. O'Sullivan, Bell Laboratories MFF, April 21, 1972.

    Reviews the capability of a trailer-mounted air conditioning unit that is being assembled by the Army to ventilate a SPARTAN cell while personnel are in the cell performing maintenance operations. Examines the compatibility of this unit with the launch station's environmental control system and its capability to maintain the station's temperature and humidity requirements in accordance with the facility criteria.

27. Potential Adhesives For Use On Model 115 ZEUS-NIKE-X Nozzle, McDonnell-Douglas Astronautics Company, Report No. SM 49189, April 27, 1966.

    Determines mechanical and physical properties of adhesives for bonding nozzle liners to steel shells; includes methods for evaluation and selection of an adhesive system.

28. Three-Motor Transportation and Handling Environmental (THE) Test Program Test Results, McDonnell-Douglas Astronautics Company, Interim Report Vol I and II, MDC G3876, December 1972, and Final Report, MDC G4662, July 1973.

    Details the test plan and results of the program which evaluated the capability of the SPARTAN motors to survive the ground handling environments.

29. MGS Power Discrete Circuit Operation — Case 27703-1010, L. G. Johansson, Bell Laboratories MFF, October 2, 1967.

    Presents worst-case output data and describes the operation of the Missile Guidance Set (MGS) power discrete circuit under end-of-life condition. Discusses and evaluates the effects of radiation on either a triggered or untriggered circuit.

30. Relocation of SPARTAN Strakes and Effect Upon Antenna Gain (U), Bell Laboratories Report, September 25, 1965. (SECRET-RD)

    Presents the results of an antenna pattern measurement program conducted as a result of a requirement to relocate the aft antenna strakes of the SPARTAN missile.

31. Design and Reliability Considerations for Integrated Circuit Operational Amplifiers Used in SPRINT/SPARTAN Launch Preparation Equipments — Cases 27703-1000 and 27703-1010. F. J. Zgebura, Bell Laboratories MFF, May 7, 1970.

    Describes the electrical and reliability differences that exist between the two basic forms of integrated circuit operational amplifiers proposed for use in the SPRINT /SPARTAN Launch Preparation Equipment.

32. SPARTAN Hydraulic Control System Review: June 6, 1968 — Case 27703-1010, E. J. Schuler, Bell Laboratories MFF, June 26, 1968.

    Presents a review of problems and design changes in the hydraulic control system of the SPARTAN missile.

33. SPARTAN HPU Vibration Signature Analysis — Theoretical Background — Data Handling Techniques — Application and Empirical Refinement, AiResearch Manufacturing Company, Report 72-8442, September 1972.

Describes the development of the exceedance curve method of vibration signature analysis used for acceptance testing of SPARTAN hydraulic power units.

34. SAFEGUARD System — SPARTAN — The Problems of Condensation on the Inner Surfaces of the SPARTAN Launch Cell Covers — Case 27950-1010, W. R. Sieling, Bell Laboratories MFF, August 13, 1970.

Investigates likelihood of condensation forming on the inner surface of the SPARTAN launch cell covers and estimates insulation requirements necessary to prevent condensation under worst-case conditions.

35. SAFEGUARD System — SPARTAN — SPARTAN Launch Cell Cover Insulation (U) — Case 27950-21, Filing Case 27950-1010, W. R. Sieling, Bell Laboratories MFF, November 24, 1970. (CONFIDENTIAL)

Considers the possibility of completely removing the silicone rubber insulation from the outer surface of the SPARTAN launch cell covers.

36. SAFEGUARD System — SPARTAN — Effect of Decelerator Configuration on Cell Cover Reaction Forces — Case 27858-1010, E. J. Schuler, Bell Laboratories MFF, December 31, 1973.

Documents a study of the forces and material strengths pertinent to an investigation of the cracking of a cell cover frame which occurred during the SPARTAN M2-34 launch when the cover was operated in the fast mode.

37. SAFEGUARD System — SPRINT/SPARTAN Status of EMR Evaluation Program — Cases 27950-1000 and 1010, J. A. Freund and R. P. Massey, Bell Laboratories MFF, May 3, 1974.

Summarizes the status of the Electromagnetic Radiation (EMR) Test and Analysis Programs for the SPRINT and SPARTAN subsystems. These programs have combined the efforts of Bell Laboratories, their subcontractors, and government agencies. Not all aspects of this EMR evaluation had been completed at this time. This memorandum provides recommendations regarding the remaining work on a task-by-task basis.

38. SAFEGUARD/SPARTAN Missile Subsystem Effectiveness Engineering Mathematical Model (U), McDonnell-Douglas Astronautics Company, DAC 61926, June 1971. (CONFIDENTIAL)

Presents the quantitative assessment of SPARTAN missile subsystem reliability and availability, including R&D flight reliability history and missile reliability growth.

39. SAFEGUARD System — SPARTAN — Design Deficiencies of the Nuclear Ground Shock Isolated Launch Rail Uncovered During the Dynamic Test at Illeginni — Case 27950-1010, C. S. DeSilets, Bell Laboratories MFF, June 29, 1972.

Reviews the design deficiencies in the SPARTAN axially isolated launch rail that were uncovered during the dynamic test performed on a SPARTAN missile and launch rail installed in Launch Station 31 at Illeginni. Describes subsequent redesign effort required.

40. SAFEGUARD System — Meck System Test Program (U), Bell Laboratories, Report 4S040R92B, June 1, 1970, Revised February 28, 1974. (SECRET)

Presents requirements and plans for SAFEGUARD System prototype testing at the system level at the Kwajalein Missile Range.

41. SAFEGUARD System, Progress Report (U), Bell Laboratories, January 1975. (SECRET)

This report, one of a series prepared for the Army by Bell Laboratories, contains a summary of the test program at Meck.

42. SAFEGUARD/SPARTAN Missile Subsystem Effectiveness Engineering Mathematical Model Methodology, McDonnell-Douglas Astronautics Company, SM 52285C, August 1971.

Contains the analytical methodology used to describe the SPARTAN missile subsystem effectiveness. The probabilistic theory and techniques used to analyze reliability and availability are presented.

43. SAFEGUARD System — Review of SPARTAN Flights Conducted in the Meck System Test Program (U) — Case 27950-1010, H. G. Idell and J. A. Piccininni, Bell Laboratories MFF, July 30, 1975. (SECRET)

Describes the results of SPARTAN missile flights launched during the tests at Meck Island.

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Data Processing System

1. SAFEGUARD System — Data Processing System (DPS) — Tactical Software Control Site — MSR DPS and PAR DPS Configurations — System Description, Engineering Support Data Manual DPST-01, Western Electric, May 31, 1973.

   Provides comprehensive coverage of theory, operation, and on-line maintenance.

2. DPS-2 Hardware Change Requests — Case 27703-1500, A. F. McPherson, Bell Laboratories MFF, March 1, 1968.

   Lists and discusses all changes from DPS-1 (NIKE-X) to DPS-2 (SENTINEL/SAFEGUARD) for all elements of the DPS, with recommendations as to whether they should be included in the DPS-2 design.

3. SAFEGUARD System — Systems Programmer's Guide to the SAFEGUARD CLC, Vol 2, Bell Laboratories, SYSPROG-CLMV2, Revision 6, June 1, 1974.

   Complete and detailed description of the CLC and all its component parts. Contains comprehensive listings of word structure and organization.

4. Patent No. 3, 641, 505 — Multiprocessor Computer Adapted for Partitioning into a Plurality of Independently Operating Systems, issued to W. M. Artz, K. R. Cornelius, J. W. Olson, G. R. Signor, and F. E. Slojkowski, February 8, 1972.

   Patent granted on the multiprocessor computer organization as used in SAFEGUARD, with capability for partitioning into independent systems.

5. SENTINEL — Results of Availability Study of Central Logic and Control (CLC) of Missile Site Data Processor — Case 27950-2110 (U), R. F. Morra, Bell Laboratories MFF, February 27, 1969. (SECRET)

   Results of a study showing that with a partitionable system, required availability can be achieved by using an on-line spare (n + 1 rack) philosophy rather than more extensive redundant systems.

6. SENTINEL System — Logic Design Manual, G489909, Bell Laboratories, July 1968.

   Contains logic design rules for use in designing the SENTINEL logic to meet system operational speed and reliability.

7. SAFEGUARD System — Data Processing System (Tactical Software Control Site) — Central Logic and Control Digital Data Processor — Operation and On-Line Maintenance, Engineering Support Data Manual CLCT 1-11, Western Electric, June 30, 1972.

   Comprehensive coverage of theory, operation and on-line maintenance.

8. SENTINEL Processor — System Design Specification, L. L. Cochran, Sperry Rand — Univac Document U-101956, April 4, 1968.

   The basic specification to which Univac worked in the design of the processor unit.

9. A Proof of the Validity of the Proposed Very High Speed Multiply Algorithm for the NIKE-X Computer, M. R. Steffen, Sperry Rand-Univac, Document U-100652, January 14, 1966.

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10. Structure and Sequences of the NIKE-X Processor Program Control Section — Logic Studies, L. F. Delaney, Sperry Rand-Univac, Document U-100380, November 11, 1964, Revised October 26, 1965.

    Describes the theory, structure and operational sequences of the program control section for the processor.

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    Describes the operand control unit for the processor, including instructions, memory speeds and interfaces characteristics.

12. SAFEGUARD System — Data Processing System (Tactical Software Control Site) — Central Logic and Control Program Storage — Operation and On-Line Maintenance, Engineering Support Data Manual CLCT 2-11, Western Electric, February 29, 1972.

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13. SAFEGUARD System — Data Processing System — Variable Store and Fixed Program Store Core Memory System — Operation and On-Line Maintenance, Vol I, Engineering Support Data Manual CLCT 23-11, Lockheed Electronics Company, February 4, 1970.

    Comprehensive coverage of theory, operation and on-line maintenance.

14. SAFEGUARD System — Functional Description of the Program Store Interface Switching Unit — Case 27950-1100, R. W. Stout, Bell Laboratories MFF, May 16, 1972.

    Theory and operation of the interface switching unit that connects a program store rack to other parts of the CLC.

15. SAFEGUARD System — Description of Changes Required to Decrease Data Access Time in VS, PS, and T&S Racks — Case 27950-1100, C. S. Hughes II, Bell Laboratories MFF, June 24, 1971.

    A description of ISU changes which take advantage of a speed-up in data access time of the 500 ns Lockheed core memory.

16. SAFEGUARD System — Data Processing System (Tactical Software Control Site) — Central Logic and Control Variable Storage — Operation and On-Line Maintenance, Engineering Support Data Manual CLCT 3-11, Western Electric, January 31, 1972.

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    Theory and operation of the interface switching unit that connects a variable store rack to other parts of the CLC.

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19. Initiation and Termination of I/O on the SENTINEL Input/Output Controller — Case 27703-1500, J. G. Standley, Bell Laboratories MFF, May 22, 1968.

    Comprehensive description for programmers of how to initiate and terminate input/output operations.

20. SENTINEL System — Input/Output Controller Command Word Repertoire — Case 27703-1500, J. E. Cullom and R. B. Plunkett II, Bell Laboratories MFF, December 1, 1968.

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    Interface timing specification which must be met by any of 16 peripheral devices outside the CLC.

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24. NIKE-X Proposal for a Timing Generator/Status Unit Which Interconnects to the CLC Via an Interface Switching Unit — Case 27703-1500, J. W. Olson, Bell Laboratories MFF, April 6, 1967.

    The first written description of the timing generator and status unit to be used in the CLC.

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26. SAFEGUARD System — Description of the Timing, Status, and Store Transfer Group Interface Switching Units — Case 27703-2140, J. W. Hooker, Bell Laboratories MFF, June 18, 1969.

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27. SAFEGUARD System — Data Processing System — Precision Frequency and Time Generator (PF&TG) — Operation and On-Line Maintenance, Engineering Support Data Manual PFTT-11, Western Electric, August 15, 1970.

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    Comprehensive coverage of theory, operation and on-line maintenance. Includes a list of instruction manuals for the commercial or modified commercial equipment.

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