Appendix 6

BALLISTIC SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND

FLETCHER COMMITTEE

Folder Three of Three Folders

This folder contains Fletcher Committee Report on Minuteman Flexibility and Study Group, SD 61-167, dated 27 September 1961, (Xerox copy of Copy 8). Taken from the Minuteman holdings designated INV-14 of General Phillips' File.

Document Classification	Identification	Nr of Pages
S	Report on Minuteman Flexibility and Study Group, SD 61-157, 27 September 1961, in 3 volumes:	
	Vol I, SDN 1-91555/10G	14
	Vol II, SDN 1-91556/10G	27
	Vol III, SDN 1-91557/10G	72
S	Vol I, (SDN1-91555/10G) titled Summary Report - Minuteman Flexibility and Safety Study Group, 27 September 1961. Classified pages (S): Title Pages - 3 Contents - 1 Text -10	14
S	Vol II, (SDN1-91556/10G) titled Report on Minuteman Flexibility and Safety Study Group, 27 September 1961. Classified pages (S): Title Page - 1 Contents - 1 Text - 25	27
S	Vol III, (SDN1-91557/10G) titled Engineering Subcommittee Report for the Minuteman Flexibility and Safety Study Group, 27 September 1961. Classified pages (S): Title Page - 2 Contents - 2 List of Illustrations & Tables - 1 Subtitle - 1 Text - 37	43

Document Classification	Identification	Nr of Pages
S	Vol II (Appendices I - IV). Titled <u>Minuteman Flexibility and Safety Study Group Subcommittee Report</u> (no date). Classified Pages (S): Title Page - 1 Appendix I - 5 Appendix II - 12 Appendix III - 8 Appendix IV - 3	29

Total Classified Pages from above: 14 & 27 & 43 & 29 = 113

The Xerox copy of the above was taken from Copy #8 from the original.

BALLISTIC SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND

FLETCHER COMMITTEE

Folder One of Three Folders *

This folder contains Fletcher Committee, Documentation on Minuteman Flexibility and Safety, taken from the Minuteman holdings designated INV-14 of General Phillip's File.

Document Classification	Identification	Nr of Pages
S	Memorandum for Secy of the Air Force, subj: MINUTEMAN Flexibility and Safety, Jul 14, 1961, from the Secy of Defense.	2
S	Memorandum for Dep Secy of Defense, subj: MINUTEMAN Flexibility and Safety, Jul 27, 1961.	2
S	Report, manuscript, dated July 1961, titled: Part I. Increased Flexibility in the Hardened and Dispersed Portion of the Minuteman Force, no auther.	14
	Part 2. Technical Considerations Related to Increased Flexibility in the Minuteman Weapon System.	11
	Part 3. Nuclear Safety.	6
S	Msg 0255, from SAC to RJWZBK/DCAS Los Angeles, 9Jan62, subj: Minuteman Schedule Impact on SAC.	2
C	Msg 89770 from AFSDC, 2Jan62.	1
C	Msg SCG 26-12-45 from Hq AFSC, 26Dec61 (reply to Msg 4478, 9 Dec61).	2
S	Msg 4478 from SAC to Gen Schriever, 9Dec61, regarding impact of Fletcher Committee Program Change to Minuteman.	3

*See folder listed for documents.

Document Classification	Identification	Nr of Pages
S	Ltr from Dr. James C. Fletcher, Glendale, Calif., to Dr. Brockway McMillan, Asst Secy of the Air Force dated 22 Nov 1961, regarding Minuteman Flexibility and Safety Study Group, review of Committee's recommended equipment changes. Ltr Control Number JCF-61-54, Copy 2 of 46.	3
C	Memorandum for the Secy of the Air Force, subj: MINUTEMAN Safety, Flexibility and Extended Survivability, Dec 19, 1961, Signed Roswell Gilpatric.	1
S/RD S C/RD	Ltr to Dr. C. C. Furnas from Donald P. Ling, Executive Director, Military Research Division, Nov 8, 1961, reference to EMP problems, with excerpts (attached) from DASA 1226, "Electromagnetic Effects from Nuclear Test" by Edgerton, Germeshausen and Grier, Inc. (SECRET), and from "Measurements of Electrical Transients in the Earth," WT-813, published by Sandia Corporation, (Confidential/RD).	3
S	Manuscript, Operational Priority Msg to AFSC, Msg DWTM-17-11-78-E, subj: Safety - Flexibility Changes to Minuteman Weapon Systems. Msg in two parts. Manuscript dtd 17 Nov 1961.	3
S	Memorandum for the Secy of Defense, subj: Minuteman Safety, Flexibility and Extended Survivability, manuscript dtd 16 Nov 1961, draft. Control Number BSQ-132. [Author unknown.]	2
C	Msg AFOOP-ST 30503 from Hq USAF to SAC, subj: Minuteman Safety Plan. Msg in two parts.	1

SIFIED

Document Classification	Identification	Nr of Pages
S	Ltr BSQ/Gen Phillips to BSC (Gen Gerrity), subj: Fletcher Changes to MINUTEMAN, dated 6 Nov 1961, Control Number BSQ-123.	2
S	STL Ltr, Doc Nr GM61-0000-13168, Letter from J. R. Burnett to B/Gen S. C. Phillips, subj: Required Changes to Electronic Ground Equipment, dated 27 Sep 1961.	2
S	Ltr from DCAS USAF Office, AFSSA-LO/ Lt Col Owens, to Maj Gen M. F. Cooper(SCS) Hq AFSC, subj: Systems Review Board Meeting, 20 Sep 1961, dtd 22 Sep 1961. Control Nr AFSSA-LO 612569.	2
S	Ltr to Dep Secy of Defense, subj: Minuteman Lead Time, and Key Decision Dates, manuscript, dated 21 Sep [1961]. Control Nr AFSSA-LO-612570.	2
C	STL Letter Doc Nr 6600-172 from R. R. Bennett, subj: Material Required for Fletcher Committee, dated 12 Sep 1961.	2
S	From Office of the Secy, Dept of the Air Force, Signed by Col Herman Dorfman, dtd August 22, 1961, Transmittal Letter (1 page) of Attachment 1 summarizing Minuteman Flexibility and Safety Areas and Attachment 2 [Dr. J. L. Bower's study "Modifications to the Fixed MINUTEMAN (Configuration "A") for Flexibility, Hardness, and Safety (U)"--not included]. Attachment 1 Minuteman Flexibility and Safety Study Group, dated 21 Aug 1961. (No Attachment 2.) Control Nr BSQ 61-76.	3
C	STL Letter, Doc Nr 9310-42, from J. R. Burnett to Col S. C. Phillips, subj: Required Action from Fletcher Committee Meeting, 17-18 Aug 1961, dtd 21 Aug 61. Control Nr (Typed on Pages 2&3): BSQ RC-11.	3

Document Classification	Identification	Nr of Pages
S	Title Page only of Preliminary Copy of STL Doc GM 61-0000-30298, dated 31 Aug 1961: WS 133A (MINUTEMAN), A Study of Possible Increased Protection Against Inadvertent Launch and Improved Selective Launch Flexibility.	1
S	Msg Hq USAF to SAC, Control Number AFSDC-S-1, Personal from General LeMay for Gen Powers, dated 16 Aug 1961. [Very faint copy].	1
S	Msg, C. W. Besserer (Associate Minuteman Program Director) to the Boeing Co, et al, subj: Unauthorized Launch Protection Technical Directive, 14 Aug61.	5
S	<u>Terms of Reference Minuteman Flexibility and Safety Study Group</u>, 26 July 1961, on Dept of Air Force Letterhead.	3
S	Msg AFSDC-S-1 88213 from Hq USAF to SAC, request for appraisal of potentialities of Clandestine Attack on SAC.	2
S	Msg BSD, L. A. Calif to COFS USAF Wash, D. C. BSQ-17-7-33, subj: Minuteman Operational Flexibility, dated 17 July 61. Control Number BSQ 61-14.	6
S	Ltr from [Col] Phillips to Gen Gerrity, 27 June 61, 2 copies of same letter, 1 Page.	2
S	Draft ltr to Maj Gen K. U. Compton, Dep Dir of Operations, Hq SAC, no date. Control Number BSQ-61-77.	2

Document Classification	Identification	Nr of Pages
S	Control Number BSQ-61-77 has Attachment 1, a Msg in Rough Draft, SCSB4-8-10 from Hq BSD to AFSC regarding study to improve Minuteman susceptibility.	2
S	Memorandum from McNamara for Secy of the Air Force, subj: Minuteman Flexibility, dated 15 April 1961. Control Number BSQ-61-75.	1
S	Staff Summary Sheet, ARDC Form 149, subj: Flexibility in the MINUTEMAN Weapon System, dated 22 Dec 1961.	1
S	Communications to ARDC, Andrews AFB, subj: (U) Flexibility in the Minuteman Weapon System, manuscript dated 22 Dec 1960. Control Number WDTQ-60-58.	2
S	Memorandum for Gen Schriever from CHS, subj: Minuteman Operational Characteristics of Concern to DOD, dated 9 Dec 1960 (Control Number CO-92246), with 2 Attachments: TAB A, Copy of Memorandum for the Asst Secy of the Air Force (Research and Development) subj: Minuteman (Control Number CO-0384[N/C], 2 Nov 60, Signed Rubel, and TAB B, Ltr to RDG (Gen Schriever) from ARDC, subj: Minuteman (Control Number CO-95562).	5
S	Memo for the Record from AFORQ-SA, regarding Minuteman, dated 27 Oct 1960. Control Number WDTQ-60-130.	2

BALLISTIC SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND

FLETCHER COMMITTEE

Folder Two of Three Folders *

This folder contains Fletcher Committee Documentation of Minuteman. Flexibility. Safety. Includes Minuteman "WHITE PAPER". Taken from the Minuteman holdings designated INV-14 of General Phillip's File.

Document Classification	Identification	Nr of Pages
C	STL Ltr, Control Number 9310-43, from J. R. Burnett to R. R. Bennett, subj: Further Cost Estimate for J. C. Fletcher, dated 15 Sep 1961.	1
S	Ltr from BSQ/Col Phillips to BSG (Gen Gerrity), subj: Department of Defense Force Reappraisal, dated 11 July 1961. Document Control Number BSQ-61-12.	3
S	Memo for the Chief of Staff, USAF, from Joseph V. Charyk, subj: Minuteman Flexibility, dated June 27, 1961. Document Control Number BSL-15.	1
C	Memo for the Secy of the Air Force from McNamara, subj: Minuteman Flexibility. Document Control/Sec Def Cont No. S-665.	1
S	"WHITE PAPER" on Minuteman, manuscript dated 6 July 1961. Document Control Number BSQ-61-78. Minuteman Force Plan for CY 1964.	31
	Annex A: Minuteman Force Mix Study, Document Control Number BSLPS-63.	13
	Annex B: Cost Effectiveness Comparison of the Polaris and Minuteman Weapon Systems (No Doc Cont No.)	15
	Study of Sabotage of Mobile Minuteman (No Doc Cont No.)	8

*See folder listed for documents.

Document Classification	Identification	Nr of Pages
S	Msg BSQR 11-8-238 to Hq AFSC, subj: Security of ICBM Against Clandestine Attack, dated 11 Aug 1961. Document Control Number BSQR 61-130.	7
S	Msg, SAC DORQ-0893, subj: Security of ICBM Sites Against Clandestine Attack, dated 8 Aug61.	2
S	Msg AFSC SCSB 2-8-4, subj: Security of ICBM Sites Against Clandestine Attack, 2Aug61.	4

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REPORT ON MINUTEMAN FLEXIBILITY AND STUDY GROUP

SD61-157

27 SEPTEMBER 1961

VOLUME I, SDN1-91555/10G
VOLUME II, SDN1-91556/10G
VOLUME III, SDN1-91557/10G

CLASSIFIED by SD61-157
EXEMPT FROM GDS - EO 11652
EXEMPTION CATEGORY 3
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SD61-157

~~SECRET~~

Dr. James C. Fletcher
777 Flower Street
Glendale, California

September 27, 1961

Dr. Brockway McMillan
Assistant Secretary of the Air Force
The Pentagon
Room 4E978
Washington, D. C.

Dear Dr. McMillan:

I am forwarding twenty complete copies of the report of the Minuteman Flexibility and Safety Study Group. Twenty additional copies of the Summary Report are included. The report consists of three volumes; a summary volume, an over-all discussion volume and an engineering subcommittee volume.

The summary volume is organized in the manner of the "Terms of Reference" attached to the Minuteman Flexibility and Safety Memorandum from the Secretary of the Air Force to the Deputy Secretary of Defense dated July 27, 1961. The second volume is organized in the same manner, but contains more detailed discussion. The third volume considers the "measures" of flexibility and safety and concludes with an evaluation chart showing the strengths and weaknesses of the five implementations considered. Recommendations are made in each volume.

The Committee believes that it would be of value to convene once again during the latter part of November to review the actions taken by the Air Force in providing Minuteman with additional safety and flexibility.

Yours very truly,

[signature] for
J. C. Fletcher
Chairman,
Minuteman Flexibility and
Safety Study Committee

MINUTEMAN FLEXIBILITY AND SAFETY STUDY COMMITTEE

Dr. J. C. Fletcher, Chairman	Space General Corporation
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REPORT ON MINUTEMAN FLEXIBILITY AND STUDY GROUP

SD61-157

27 SEPTEMBER 1961

VOLUME I, SDN1-91555/10G
VOLUME II, SDN1-91556/10G
VOLUME III, SDN1-91557/10G

DOWNGRADED AT 12 YEAR INTERVALS: NOT AUTOMATICALLY DECLASSIFIED. DOD DIR 5200.10

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SUMMARY REPORT - MINUTEMAN FLEXIBILITY AND SAFETY STUDY GROUP

SD61-157

27 SEPTEMBER 1961

VOLUME I, SDN1-91555/10G

DOWNGRADED AT 12 YEAR INTERVALS: NOT AUTOMATICALLY DECLASSIFIED. DOD DIR 5200.10

SD61-157

CONTENTS

I. Task Number One

"Evaluate proposed, and possible other, means to provide increased flexibility, such as dual targeting and varying degrees of selective launch, in the hardened and dispersed 'MINUTEMAN' ballistic missile system, with specific emphasis on:

1. The earliest time at which any particular means can be incorporated into production without compromising the standards of operational safety that now apply in the design and test of the 'MINUTEMAN' system;

2. The cost of such incorporation;

3. The time required to retrofit into squadrons not originally equipped."

The Committee examined in detail several possibilities in regard to this Task. The four systems judged to have most merit are described. Costs of the systems were estimated by BSD/STL bur could not be rigorously validated by the Committee.

A. BOEING/BOWER SYSTEM

This system is the most flexible in regard to selective launch and multiple targeting. It also provides for LF status reporting on a squadron basis which, consequently, enhances the command and control capability under covert conditions. Safety from inadvertent or unauthorized launch is only slightly improved over the present "MINUTEMAN" system. Although individual changes to the system are small, the aggregate results in changes to almost every subsystem and, therefore, the estimated (by STL) time of incorporation is the 5th wing. No estimate was made for retrofit of this system.

B. SUPPORT INFORMATION NETWORK SYSTEM (SIN-TWO, SIN-SIX)

These two systems are characterized by a manual launch enable system utilizing the Support Information Network for communication. The dual target version is termed SIN-TWO; the six target version SIN-SIX. These systems possess the greatest safety from inadvertent launch and have significantly greater flexibility than the present "MINUTEMAN" system. The principal features of the system can be incorporated into Wing 1 and all other features can be incorporated by Wing 2. Retrofit is exceptionally easy and can be completed by Wing 3.

C. STL # FOUR

This system possesses modest flexibility with dual targeting and 64 options of selective launch. Safety from inadvertent and unauthorized launch is substantially identical to the present "MINUTEMAN" system. Significant changes are required but can be incorporated by Wing 3. The system is not readily amenable to retrofitting.

TASK I RECOMMENDATION

Install the Support Information Network System immediately to achieve a desired level of safety and, secondarily, flexibility. Retrofit missiles to accommodate multiple targets.

II. Task Number Two

"In the light of DOD Directive 5030.15, of 10 June 1960, evaluate the provisions for safety that have been made in the design and testing of the 'MINUTEMAN' system, making recommendations as appropriate."

The Committee found that provisions for safety which are incorporated by BSD are quite adequate to cover the DOD Directive with the following reservations:

A. FIRE HAZARD

An analysis should be made of the effect of a fire in the silo on the one point safety requirement.

B. UNAUTHORIZED PENETRATION

There is some concern about the ability of unauthorized people to penetrate the silo area and, therefore, have access to the warhead.

III. Task Number Three

"Examine generally the criteria of safety which are appropriate to highly automated nuclear weapons and evaluate DOD Directive 5030.15 in this light. Make recommendations as appropriate."

The Committee found the DOD Directive inadequate for highly automated weapons such as "MINUTEMAN." This has also been recognized by BSD who have taken the following additional steps:

- An attempt has been made to redefine the failure problem in a way which is more applicable to the "MINUTEMAN" system.
- An independent organization (Western Electric Company) has been set up to examine modes of failure, at least from the electrical and mechanical point of view.
- A Nuclear Weapon System Safety Group has been set up which will convene on a frequent schedule to continually examine the safety problem.

RECOMMENDATION

The Committee believes the safety problem to be sufficiently severe to require additional actions:

A. LAUNCH ENABLE SYSTEM

A Launch Enable System should be installed which, independent of the sensitive command network, disables each of the missiles until Enable orders are received over the primary alert system.

B. MECHANICAL DECODER WHEEL STATUS MONITOR

The Committee believes that the decoder wheel is such a critical part of the system that it should be monitored at all times. BSD agreed that this can be provided in the Second Wing and can be retrofitted into the First Wing. Missiles should not be put into strategic alert without some form of monitor.

(b) (1) (A)

[redacted]

D. VOLATILIZE CODES AT LF

The Committee recommends an improvement in the decoders at the LF's to the effect that the codes are volatilized as soon as access is gained to the "innards" of critical equipments.

E. PROCEDURAL SECURITY

There are three areas of procedural security of concern to the Committee:

1. The present intrusion security at LF's does not seem practical. It is recommended that the procedures be thoroughly examined.

2. Handling of the codes does not appear to be consistent. This is particularly apparent when comparing practices at the LCF with those at the LF. A consistent 2-man security practice is recommended.

3. The 2-man security of launch control officers is of concern in the special case presented by the "MINUTEMAN" system. It is recommended that a simple barrier be installed to separate visually the men during the launch operation.

IV. Task Number Four

"Suggest guidelines for an independent engineering analysis of the safety of the 'MINUTEMAN' launch control system."

The Committee suggests the following:

A. SAFETY PROCEDURES

1. Supplement the NWSSG with a strong technical group to examine all phases of safety.

2. Investigate the incremental safety derived by including additional people in the performance of critical functions. These people may not be at the same location while performing these functions.

3. Provide a consistent set of procedures for code handling from manufacture through maintenance in the LCF's and LF's.

4. Re-examine the procedures of initial system activation (several of the system safeguards may be inoperative or not effective).

B. HUMAN EFFECTS

1. The Committee recommends that a competent group be assigned to investigate human behavior characteristics in regard to confined environment, level of assignment, response to continued "false alarms", and other conditions related to "MINUTEMAN".

C. FAILURE MODES

1. Perform a continuing study of the modes of failure of the system including such effects as those introduced by cross talk in the communication system. More realistic estimates of failure probability should be obtained.

2. Determine by analytical and empirical methods the failure characteristics of subsystems such as the electromechanical decoder (and associated electronics).

D. COMMAND AND CONTROL

1. Perform critical studies of new command and control systems (recommended for Wing 5) with special regard to safety. Consider the separate effects of equipment and personnel.

V. Additional Actions Suggested

Although it was not within the charter of the Committee, several problems occurred to the group which should be investigated further and hence are listed here:

A. Although the Committee made an attempt to examine the operational need for flexibility, (in order to make appropriate suggestions for various implementation schemes,) this should certainly be done in more detail and by a more qualified group. There are certainly more flexibility possibilities than have been stated in the Committee's charter. For example, it is quite conceivable that the ultimate in target change capability is a rapid input to the missile upon reception of the appropriate longitude and latitude of the target in question from the SAC Commander. Whether this is desirable or not depends, to some extent, on flexibility of the primary command and control network.

B. The Committee suspects that the decision problem in the primary command and control system, although formidable already, will be much more so if advantage is taken of the flexibility that the Committee now proposes for the "MINUTEMAN". Although it is conceivable in principle that the primary command and control network can be modified to transmit other than simple pre-programed war plans, it is not evident that this is the present plan and, furthermore, it is not clear how the decision making authority can make appropriate decisions from the multitude of possibilities presented to him concerning reassignment of weapons to targets.

C. Because of the interdependence of strategic policies and weapons system capabilities the Committee recommends that "extra" capacity be provided in critical areas of new systems. The Committee strongly suspects that similar safety and flexibility problems exist in connection with Polaris and other strategic weapon systems. It is recommended that a similar examination be made of their problems.

D. In the course of the investigation of the "MINUTEMAN" system, a dangerous defect in the primary alerting system for SAC aircraft was discovered. This was discussed with Headquarters, USAF, and presumably corrective action is being taken.

E. Considerable effort has been made at STL and BSD toward protection of the system from large electric currents generated by nuclear blasts. Although available data has been used to maximum effect, it would seem that this is a more general problem than "MINUTEMAN" alone. It is therefore recommended that a national agency be assigned the primary responsibility to conduct empirically supported studies of the primary electrical effects due to nuclear blasts. These effects can be as important to weapon system design as any other nuclear effect such as radiation, ground shock, air blast, etc.

F. The Committee feels that all of the safety features suggested in the course of this investigation could have been made two or three years ago (when the system was conceived) when DEI's, etc., were held for this weapon system. It is anticipated that there is interest on the part of PSAC and DOD, that they be invited to the DEI's and asked to submit comments at this time. Apparently, in the case of the "MINUTEMAN" program, SAC inputs were included but these were not at all coincident with inputs that would have come from DOD and PSAC. With the current Air Force concept of concurrency in the development of weapon systems, it would seem a "must" to obtain all inputs early in the development program, rather than gradually phase them in as the program develops.

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REPORT ON MINUTEMAN FLEXIBILITY AND SAFETY STUDY GROUP

SD61-157

27 SEPTEMBER 1961

VOLUME II, SDN1-91556/10G

DOWNGRADED AT 12 YEAR INTERVALS: NOT AUTOMATICALLY DECLASSIFIED. DOD DIR 5200.10

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CONTENTS

I. Introduction

In the "Terms of Reference" document (Reference a.) given to the Committee on 26 July 1961 by the Secretary of the Air Force, the group was asked to look into several problems involving both Operational Flexibility and Safety. It would seem desirable, before going into the answers to the specific questions that were raised in Reference a., to discuss the problem of flexibility and how it may or may not relate to the safety problem. Flexibility, in this case, includes the capability of switching between any targets preset into each missile with a reasonably short time delay. It also includes the possibility of selective launch of any single missile or group of missiles at a pre-selected command from SAC Headquarters. Lastly, "interrupting ripple fire" was suggested as an additional flexibility feature in an earlier DOD document (Reference b.), but was not specifically mentioned in the "Terms of Reference" given to the Committee by the Secretary of the Air Force.

The issue of safety is concerned with the chance of an accidental or unauthorized launch resulting from some unexpected event occurring over a period of years. The problem exists because of incomplete knowledge of the system and what might happen to it. Statements of the probabilities of accidental launch are statements about what is known; the uneasiness about safety results from what is not known, not calculable. This is not unique to "MINUTEMAN"; it is characteristic of systems, including the human components. (The history of Naval accidents is preserved in the safety devices aboard ship.) The risks associated with missile systems are too great to wait for experience to show up deficiencies. The real objective of the equipment testing program should be to extend understanding of the system by revealing the unexpected.

Uncertainty is greatest in predicting the behavior of the launch control personnel. This is particularly true in the missile systems which differ so from prior systems in their demands on operators. There is a basic incompatibility between the quality of the personnel and the skill level of the task. Responsible, professional officers are required to turn a switch on command. A professional officer may consider this a poor assignment which adds only negatively to his career: the well done job is doing nothing.*

One other observation is relevant here. Probability calculations involving several events customarily assume independence of the events. This assumption, on which results are strongly dependent, is not appropriate when considering the actions of people in similar environments. No systematic data are available on this point; however, it is pertinent that aircraft hijacking and attacks on police officers occur in spurts.

As a principle, any measure which increases safety and at the same time does not reduce force utilization should be adopted. The fundamental question, what is the proper balance between safety and utilization, has not yet been answered.

This problem of relating safety to flexibility depends, first of all, on appropriate definitions of what is involved in each and, therefore, this Introductory Section will discuss each of these flexibility features in some detail. Although no discussions of the reasons for incorporating flexibility were given, the Committee has tried to look into this to the degree possible considering the background of the members of the Committee and attempted to justify incorporation of these flexibility features. This, although not part of the Committee's charter, was necessary to effect what the group felt were "reasonable

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*In addition, little is known about the long term stability of behavior in a restrictive environment of this type. It seems clear that the length of duty periods and duration of assignment must be studied carefully. If the assignment is protracted, it may be combined with something more constructive or productive - - War College type courses; additional duty.

compromises", taking into consideration schedule problems and changes in committed hardware. After discussion of each of these flexibility features, plus a discussion of "MINUTEMAN" test philosophy, the remaining sections of the report deal directly with answers to the specific questions addressed to the Committee.

A. SELECTIVE LAUNCH

Selective Launch implies the ability to launch any one or groups of several missiles out of the entire force. It must be recognized that the system, as it now stands, gives some flexibility in this regard since, although the entire force consists of 600 missiles, they can be launched in units of 50 and, therefore, with no changes at all, a degree of flexibility can be obtained by withholding any group, or groups of 50, from the full 600. This presumably is inadequate for current war strategy.

(b) (1) (A) [redacted]

Perhaps the most compelling argument for selective launch follows this line. The greatest danger we face is that any conflict will escalate to a full scale nuclear exchange. One should adopt a plan which impedes this. There exists a precedent for tacit agreement limiting the scale of a conflict (Korea); the same may be true for a nuclear exchange.

On the other hand, as those who have been concerned with missile defense know too well, simultaneity of arrival, to saturate the defense, limits defense effectiveness. The coordination required to launch from dispersed control points to achieve simultaneous arrival is difficult at best. It will probably be impossible under the disruptive conditions after an attack. A selected salvo of missiles penetrating a single defense is perhaps the best way to achieve simultaneous arrival. This is the real value of a salvo capability (whatever the number).

It is certainly true that salvo, along with quick reaction, results in maximum survival of our missiles; however, this applies more to survivability than to flexibility.

The implication of these considerations is that a selective launch capability is needed. Salvo is a special case of selective launch and has enough utility to be justified.

Fast reaction capabilities need not be considered as reactive to warning or even to attack, but as reactive to decision. Under conditions of heavy attack it is conceivable that the highest authority would demand a quick and decisive counter blow. The capability should be present.

B. TARGETING CAPABILITY

(b) (1) (A)

[redacted]

In many ways, the ultimate in target flexibility of all would be to incorporate, with a minimum time delay, any target into any missile after the initial longitude and latitude numbers are given to the Launch Control Center. This, then, would allow complete flexibility on a second strike basis. The best that can be hoped for, with a dual targeting capability, is that primary targets would be doubly covered although, secondary targets could not be since the second target stored in each missile would probably be programmed to the more important targets.

C. INHIBIT RIPPLE FIRE

It is not clear what the operational value of being able to inhibit the ripple fire will be if selective launch capability is already incorporated into the [redacted] (b) (1) (A)

(b) (1) (A)

[redacted]

On the other hand, there might be some reason to stop a ripple if word came that the first war plan was wrong, or even that the first missile or two had been fired inadvertently. This should be considered as a safety requirement, rather than a flexibility requirement. However, since this is not a difficult thing to do, using the Launch Enable System discussed in Section II, the feature has been automatically added.

D. QUICK REACTION

An additional degree of flexibility has already been incorporated in the system by requiring that the missiles each be launched within two minutes of Primary Alert System signal. It was not apparent at first, to the Committee, why this feature was incorporated since it did seem to increase the danger of inadvertent launch due to human error (say, perhaps, due to an impetuous launch control officer). However, looking at the problem from a defensive aspect; i.e., to insure the maximum number of missiles surviving, it would seem to be of some value to launch the entire force at some short period of time either pre-programed or at a signal from an appropriate warning system. It is further conceivable, although not likely, that for some targets there would be value in launching a large number of missiles simultaneously at the targets to saturate any ballistic missile defense system which the enemy might have. It should be recognized, though, in connection with this latter point, that the missiles must arrive closer than 30 seconds to each other to saturate defense systems as now visualized (such as the Nike-Zeus). Since this quick reaction time did not seem to influence whether or not we incorporated the other flexibility features, the Committee did not try to evaluate the relative merit of this versus the preceding three discussed.

E. SAFETY

The problem of safety, as applied to the "MINUTEMAN" system, is difficult since there is no precedent known to the Committee for safety rules which apply to such a highly automated system as the "MINUTEMAN". Some of the specific problems for example, are as follows:

(b) (1) (A)

[redacted]

2. Automation

The degree of automation in the "MINUTEMAN" system is greater than most other strategic weapon systems. For example, of the order of 1,000 wires proceed from each LCC and are connected into an overall net which includes a squadron of 50 missiles. Many different codes proceed over these wires to carry out various functions, including the maintenance and checkout function of each silo. In a sense it is analogous to one big digital computer carrying out an operation of 50 missiles. Since there has been no operational experience on such a highly automated system, it is extremely difficult but extremely important to analyze the various failure modes. Past experience allows us to estimate modes of failure due to human error to some degree but not for equipment errors. In fact, past experience with equipment would indicate high probability of failure except that unusual precautions have been taken in the case of the "MINUTEMAN" system. For example, the criterion used for the equipment itself is that the probability of launch is 1 in 10^{10} over a 10 year period and, one instance, a probability of 1 in 10^{25} for a particular piece of equipment was specified. It is quite likely that the probability of not being able to figure the worst mode of failure is much higher than the quoted probability and, therefore, probabilities that small have very little meaning.

3. Underground Cables

Although there has been a great deal of experience by the A T & T Company on the reliability of underground cables, cables are rarely used to this extent to generate so many different coded signals that have to work so reliably under such a wide variety of conditions at such great distances. For example, it is not known what effect the nuclear weapons blast will have on the cables, nor was it possible to analyze modes of failure which might be caused by corrosion, shorts in the cables, etc. BSD has recognized this problem and has asked the Western Electric Company to make an analysis of failures in connection with the "MINUTEMAN" system which should give more information than now exists on the problem.

4. Maintenance

Because of the fact that the system is so highly automated and also, since the maintenance is done only at irregular intervals, most of the time the missile sits idle. It is not known, even for this case, what modes of failure might be caused by human errors or by "cranks" during the maintenance period. Some modes of failure of this type are suggested in the Supplement.

5. An attempt has been made by the Ballistic System Division to take care of one human problem, both in the maintenance phase and the command phase, by requiring cooperative effort by several people to execute any portion of the program. On the other hand, it is not known to what degree collusion is possible between groups of people. A "rule of thumb" has been used which requires two people for almost any operation used by SAC, including nuclear weapons. This procedure may be satisfactory for most cases, but the "MINUTEMAN" problem is, in many ways, more severe than SAC aircraft because of the possibility of 50 missiles going at once. Because of this special danger it is suggested that more than two people are required for adequate safety. Closely related to this problem is the restrictive environment of personnel. See footnote at the end of the Introduction.

F. TEST PHILOSOPHY

A large number of features were examined by the Committee which would provide improvement in flexibility as well as safety; but, whether or not they should be incorporated always involved not only cost but, more often, schedule. Although the First Wing is not scheduled to be activated until July of 1963, BSD has been instructed to provide that the first missile be ready for use by SAC in July of 1962. Furthermore, succeeding wings after the first are activated at three month intervals which means that the difference in time between the Fourth Wing and the Second Wing is only nine months. Consequently, many of the changes that were suggested, or discussed by the Committee, were suggested either for the Fifth Wing (which, of course, is not yet authorized by the Defense Department) or they were regarded as sufficiently small changes to the system to be incorporated late in the First Wing or possibly in the Second Wing. A further problem is that of the reliability of the system. BSD is justifiably very sensitive about making "quick and dirty" changes to the system. There is considerable concern about safety; no compromise to the "calculated" possibility of a false launch being less than 1 in 10^{10} is encouraged. Further, BSD is anxious to minimize the maintenance problem since a fair cost of the system amortized over a five year period is the maintenance cost. Of course, the problem of calculating the change in false launch probability is next to impossible, so engineering judgement must be used.

Perhaps the main issue in whether a change can or cannot be incorporated in the First Wing leads inevitably to a discussion of the difference between a "major" change and a "minor" change. A major change is required to go completely through the test cycle and through the Change Control Board. This cycle could take as long as two years from the time the change was first presented to the STL organization until it is implemented in an operational squadron. A minor change, however, might be inserted anywhere in the test phase. At first thought, one might be convinced that there are no minor changes because of the need for the very high reliability and extensive testing; but, it is a practical certainty that changes will be discovered during the course of the flight test program or in the systems test program itself which requires an improvement in the system. Furthermore, serious defects in the system will undoubtedly arise from design error or from new effects which come into play which, even though they are major changes, must be introduced into the system to make it operate properly. The principal difficulty is to keep these large changes to a minimum in order to carry out a sensible test program. Most of the discussion

II. Task Number One

"Evaluate proposed, and possible other, means to provide increased flexibility, such as dual targeting and varying degrees of selective launch, in the hardened and dispersed 'MINUTEMAN' ballistic missile system, with specific emphasis on:

1. The earliest time at which any particular means can be incorporated into production without compromising the standards of operational safety that now apply in the design and test of the 'MINUTEMAN' system;

2. The cost of such incorporation;

3. The time required to retrofit into squadrons not originally equipped."

For discussions, see attached "MINUTEMAN" Engineering Subcommittee Report.

III. Task Number Two

"Evaluate 'MINUTEMAN' Safety Provisions in Light of DOD Directive 5030.15" (Reference c.).

The DOD Directive (of 10 June 1960) is a first step towards setting up procedures for carefully evaluating safety problems on nuclear weapons. However, it is, at most, a guide for further action and, more specifically applies primarily to the handling of the nuclear weapons themselves, but not necessarily to the operation of highly automated weapon systems such as "MINUTEMAN." BSD has recognized this inadequacy and attempted, in a very energetic fashion, to set up their own set of provisions. In response to the Directive, however, a Nuclear Weapon System Safety Group was convened to review the safety provisions as prescribed in Paragraph III. C. a. of Reference c. and, with the following exceptions, gave the system a clean "bill of health."

A. UNAUTHORIZED PENETRATION

There was considerable concern about unauthorized penetration of the silo area and also about the security of the warhead itself during the transportation from storage to the silo.

B. ACCESS TO CRITICAL COMPONENTS

The Group was quite worried about the problems during maintenance and also during time on alert of personnel having access to critical areas including locks, alarms on sensitive components, etc. They have asked that a study be made by BSD to identify these critical areas and to recommend fixes. According to the information given to the Committee, this study is already under way and has uncovered some of the critical problems which were independently brought to light by the Committee.

C. EFFECT OF FIRE ENVIRONMENT

The safety group was quite concerned at the "Single Point Safety Requirement" and also the Arming and Fusing protection in the case of a fire in the silo. This resolved into the problem of: with what force and how much energy is released from an accidental detonation of the rocket engines due to fire.

The biggest concern of the Nuclear Weapon Systems Safety Group seemed to be the third (C) and the Committee was informed that vigorous study was under way to settle this problem. On the whole, the Ballistic Systems Division Safety Provisions more than adequately carry out the spirit of the DOD Directive. But, as will be indicated in the next Section, the DOD Directive is not considered adequate for this weapon system.

IV. Task Number Three

"Examine generally the criteria of safety which are appropriate to highly automated nuclear weapons and evaluate DOD Directive 5030.15 in this light. Make recommendations as appropriate."

For at least the following reasons, the Committee feels that the directive in Reference a. is inadequate for highly automated weapon systems such as "MINUTEMAN."

(b) (1) (A)

[redacted]

B. HIGH DEGREE OF AUTOMATION

Since so many of the functions of the "MINUTEMAN" system, such as maintenance, status report, firing commands, safety commands, etc. , are sent over wires in the same cable and are distributed in a very complicated network, the number of possible modes of failure becomes almost impossible to analyze. In particular, since the DOD Directive applied primarily to human errors or, at most, to simple mechanical failures, there is very little relation between the Directive and the weapon system under consideration.

C. CONCURRENCY CONCEPT

Because of the Air Force Policy of concurrency of development of the R & D test program, the operational system program, the training program, etc., in order to shorten the development cycle, new concepts of lead times must be obtained. Thus, as in the Directive, only one study is made prior to ninety days before system operation (i.e., Study Number 1. under III. C.). The remaining studies (i.e., 2. 3, and 4) have very little value since they, at most, can correct human errors that may have crept into the system. Because of the concurrency principle, something like three years lead time is necessary for most of these studies in order to effect necessary changes for complete safety on a timely basis.

Basically, then, the safety rules that have been traditionally used for problems involving nuclear weapons have usually applied to people and rules of conduct for people. Since the people have been replaced by a machine, and apparently (at least in the"MINUTEMAN" system) the lead time for changing machines is greater than the lead time for changing human procedures, the concept of safety is quite a different thing for an automated system. Not that the human errors are absent from the "MINUTEMAN" system (on the contrary, looking at the problem of access to the silo, they are very much present, perhaps more so than in a normal system) but, rather, that additional restrictions must be made.

D. RECOMMENDATIONS REGARDING DOD DIRECTIVE 5030.15

The Committee recommends the following actions:

1. That DOD Directive 5030.15 be supplemented by a much more detailed directive in a way which will make it more applicable to highly automated systems such as "MINUTEMAN."

2. Complement the Nuclear Weapon System Study group by a strong technical organization which is an inherent part of the group. BSD has recognized, to some extent, the inadequacy of the DOD Directive and has instigated their own set of safety criteria which certainly is an improvement over the DOD Directive. In addition, they have set up a strong technical group at the Western Electric Company to investigate major modes of failure in the system. The Committee recommends that the NWSSG have a group such as this working with them on a continuing basis.

3. It is further recommended that the Air Force conduct a formal review of the human safety problem, particularly in connection with the maintenance of the missile in the silo. Perhaps this group can establish suitable criteria for protection against human error which are a function of the degree of automation of the system.

E. ADDITIONAL SAFETY CONSIDERATIONS

BSD, as well as the Committee is quite aware of the extremely difficult safety problem and, in most respects, has been cooperative in suggesting new ways of improving safety. Some of the possible safety compromises illustrated in the Supplementary material have already been detected by BSD and were a source of concern. BSD, however, has the primary problem of implementing the current schedule and are necessarily reluctant to recommend changes.

In the opinion of the Committee, however, a major change should be made in the system, at least during the early phases of operation of the system, to provide the confidence that the Nation must have that accidental launch will not occur. An apparent approach to the situation is a system considered by the Committee which involved one or more persons in a room adjacent to each silo, hardened to the same p.s.i. as the silo itself. These individuals would have the responsibility of: (1) surveillance of the local site on a continuing basis and (2) by means of a switch, break the power to the igniter, to the silo door motor and to the various operations involved in the firing sequence. At an appropriate command from the launch command center, the missile would be enabled. There is indeed, in the present system, a switch called the "Safety Exchange Device" which carries out this function. It is designed primarily for the maintenance operation and is thrown as soon as someone enters the silo to check out the equipment.

Any accidents in the electronic equipment or human errors could not cause the missile to fire unless the enable switch was thrown. The Launch Enable Officer could be tied into the Primary Alert System and, if there were two such officers, the go-code could be generated by these individuals much the same as at the LCC before the "Safety Exchange Device" is thrown. Further, the Launch Enable Officer could check back with his Launch Command Officer to be sure that he had indeed interpreted the message correctly. This operation, together with surveillance of the area by an above-ground closed circuit TV, should give the system a degree of safety.

In presenting this approach to BSD, it was pointed out that a major cost problem would result in requiring the large number of individuals to man each silo. (A number large enough to man each of 600 silos on a 24-hour basis.) It was estimated that this would double the operating cost of the missile over a 5-year period which would have a major effect on the cost of the system as a whole. Another major problem that was pointed out by BSD was that of "hardening the man" in the silo. A third argument against putting a man next to each silo is felt, by the Committee, to be a questionable one: if it was felt that the system had the additional safety of a man in each silo throwing an enable switch, precautionary measures on other parts of the system would be relaxed. It seems to the Committee that this is a matter of procedure and training and should not be regarded as a major objection.

As an alternative procedure, the Committee examined various ways of retaining the major features of a man in each silo but, perhaps relaxing on one or two points to reduce the cost and the difficulty of installation. For example, one could conceive of the switches being remoted to a point where one Launch Enable Officer could control several missiles. For example, if he were in a room adjacent to one of the LCC's, he could use existing trenches and be able to control 10 missiles. One could proceed one step further and require the Wing Commander to enable all 150 missiles in his Wing. As each successive remoting is considered, the vulnerability to sabotage is increased.

As soon as the man is removed from the vicinity of the silo, the problem of surveillance at the silo becomes more significant. For this case a superior surveillance system should be set up to partially alleviate this problem. This could be done by enlarging the force and requiring visual checkups on the area more often. No real solution to this problem was presented to or invented by the Committee.

In summary, the Launch Enable System that is recommended in Section II is a compromise between the concept of a separate Launch Enable Officer adjacent to each silo and the present system. The principle problems remaining in the proposed system are:

1. The Enable System is in the same room as the Launch Control Officer. (However, this characteristic is an advantage from the standpoint of flexibility.)

2. A long cable separates the Safety Exchange Device from the person operating the Launch Enable switches.

3. The silo intrusion detection and prevention system is inadequate.

4. The switch is not closed directly by the Launch Enable Officer but, rather, by means of a motor which is actuated by the Launch Enable Officer. The Committee feels that this is a reasonable compromise to obtain a marked improvement in the degree of safety in the system but, at the same time, providing it for the First Wing.

F. RECOMMENDED EQUIPMENT AND PROCEDURAL CHANGES

In addition to the Launch Enable System, the Committee recommends the following changes:

1. Mechanical Decoder Wheel Status Monitor

For reasons of accidents, such as described in B and D of the Supplement, the Committee believes that the decoder wheel is such a critical part of the system that it should be monitored at all times. BSD agreed that this could be provided in the Second Wing and retrofitted into the First Wing.

In general, visual inspection of the firing mechanism has been required on ordnance devices. The Committee feels, therefore, that visual inspection, even though it requires periodic trips to the launch facility, should be provided in addition to the remote monitor.

2. Inhibit System

One feature of the system concerns its response to an inhibit order. At present, if a launch order is followed by an inhibit order, the system is primed and ready to go upon receipt of a single launch order (from a different LCF). The system is returned to the normal state only after an action taken at each launch facility (silo). Clearly, the inhibit action should automatically reset the system after a short time delay even though the logic must be arranged to prevent one LCO from permanently inhibiting launch.

There are several reasons for this. After a launch-inhibit sequence, a real emergency exists. The LCO's will be poised and waiting for the go-code. They will be quite trigger happy.

A second LCO may not wait for a Noah's ark message and respond immediately to any emergency sounding message. A psychotic can now act effectively.

3. LF Decoders

The Committee found that, during the maintenance period, it is possible for a single individual to gain access to the decoders in the LF's and thereby learn the launch codes. He could then, given sufficient time, generate two launch codes and fire the entire squadron. This danger can be partially alleviated by requiring several guards to go with the maintenance people on every occasion, thus requiring collusion of three or more people to allow such an accident. In addition to improving the maintenance procedure, the Committee recommends an improvement in the decoders to the effect that the codes are volatilized as soon as access is gained.

4. LF Intrusion

The Committee believes that it is not a difficult thing for unauthorized persons to gain access to the silo in a time short compared to the action time of the security people. Although the Committee does not have a specific recommendation here, a better solution must be determined.

V. Task Number Four

"Suggest guidelines for an independent engineering analysis of the safety of the 'MINUTEMAN' launch control system."

As was indicated earlier, a group has been set up (Western Electric Company) to conduct engineering analyses of the "MINUTEMAN" safety problem. The Committee regards this as a highly competent group. In addition, the Committee would recommend the following studies be made:

A. The NWSSG, supplemented by an integral, strong technical group should again examine the system. In fact, the NWSSG has looked carefully at the safety procedures problem, but it is probably not properly qualified to look into details of the various electronic errors which can occur in an automated system.

B. It is further recommended that a competent group investigate "human" problems with emphasis on (1) behavior in the confines of an LCF, (2) behavior of maintenance personnel and (3) behavior of security personnel (especially in response to frequent false alarms of the LF intrusion system).

C. It is suggested that the modes of failure analyses continue and be augmented if possible. It is hoped that more realistic estimates of failure probability be made.

D. It is suggested that analysis of possible defects in the system be continually made even though it is certain that all possible defects will not be found. This is an inherent part of the measures-countermeasures problem which is a never ending sequence.

E. Procedures for handling the codes, from manufacture to maintenance in the LCF's and LF's, should be analysed. It is suggested that the two-man rule be applied throughout the entire process.

F. It is suggested that USAF consider a complete redesign of the command control system to be retrofitted into the first Four Wings. It is suggested that a mechanism for accomplishing this is to request an in-house organization, or contractor, to make a parallel study on what to use and how to implement.

G. The Committee is concerned that crosstalk from wires used by 465L and PAS and the SCN cable may be high. RCA states that there may be only 10db decoupling. If so, and if the other systems do not have the same security control, the SCN might be monitored by monitoring 465L or PAS. Similarly, it might be jammed and since the networks may be coupled throughout the SCN, the jamming might be more effective than jamming on one or a few of the wires in the SCN itself. This may not be a serious problem but it should be given proper consideration.

H. The mechanical decoder should be so built that if it once started its mechanical sequence and received the wrong code, it would not be capable of trying another signal for at least one minute. This would vastly improve a mean time to generation of an acceptable code. Also, the position of the decoder wheel should be monitored at the LCF.

I. There is always concern when an intelligent, well prepared individual with access to good test equipment is the one trying to determine the code. This is not the random sampling type of issue discussed previously but much more analogous to the situation of trying to break a combination on the safe by listening to when the tumblers fall in place. In many equipments, the type of electrical activity taking place internally can often be detected by simply examining the external radiations. Thus, for example, very often the checking of a code can be reflected in terms of impedance level at terminals, external radiations at frequencies which are harmonic to clock frequencies, possibly even detection of current flow on parts of the chassis. It is suggested that the Western Electric engineers, with a circuit diagram in front of them, attempt to deduce the code by using the best available test equipment.

J. It is suggested that plans and procedures be devised for continued testing of the system and subsystems in regard to safety.

K. The period between activation of the first missile and the first 50 missiles is extremely dangerous because several squadron safety rules are not in effect. Extra caution must be exercised and a carefully organized plan of activation must be prepared. The committee has not addressed this problem in detail but recognizes it as being significant in scope.

VI. Additional Actions Suggested

Although it was not within the charter of the Committee, several problems occurred to the Committee which should be investigated further and hence are listed here:

A. Although the Committee made an attempt to examine the operational need for flexibility in order to make appropriate suggestions for various implementation schemes, this should certainly be done in more detail and by a more qualified group. There are certainly more flexibility possibilities than have been stated in the Committee's charter. For example, it is quite conceivable that the ultimate in target change capability is a rapid input to the missile upon reception of the appropriate longitude and latitude of the target in question from the SAC Commander. Whether this is desirable or not depends, to some extent, on flexibility of the primary command and control network.

B. The Committee suspects that the decision problem in the primary command and control system, although formidable already, will be much more so if advantage is taken of the flexibility that the Committee now proposes for the "MINUTEMAN." Although it is conceivable in principle that the primary command and control network can be modified to transmit other than simple pre-programed war plans, it is not evident that this is the present plan and, furthermore, it is not clear how the decision making authority can make appropriate decisions from the multitude of possibilities presented to him concerning reassignment of weapons to targets.

C. Because of the interdependence of strategic policies and weapons system capabilities the committee recommends that "extra" capacity be provided in critical areas of new systems. The Committee strongly suspects that similar safety and flexibility problems exist in connection with Polaris and similar strategic weapon systems. It is recommended that a similar examination be made of its problems.

D. In the course of the investigation of the "MINUTEMAN" system, a dangerous defect in the primary alerting system for SAC aircraft was discovered. This was discussed with Headquarters, USAF, and presumably corrective action is being taken.

E. Assuming "MINUTEMAN" is to be considered wholly as a deterrent-retaliatory system, i.e., will be fired only under a missile attack:

1. What are the optimum steps that should be taken to convince the enemy of the strength, inevitability and survivability of the system?

2. What steps, if any, need to be taken to convince the enemy, and our own allies, of the safety of the system against inadvertent launch?

3. What is the decision chain above the launch control officer and what safety measures similar to the above have been taken?

4. Even more important, how are allies convinced as to the safety of the command and control system and the upper level decision chain?

F. Considerable effort has been made in STL and BSD toward protection of the system from large electric currents generated by nuclear blasts. Although available data has been used to maximum effect, it would seem that this is a more general problem than "MINUTEMAN" alone. It is therefore recommended that a national agency be assigned the primary responsibility to conduct empirically supported studies of the primary electrical effects due to nuclear blasts. These effects can be as important to weapon system design as any other nuclear effect such as radiation, ground shock, air blasts, etc.

G. The Committee feels that all of the safety features suggested in the course of this investigation could have been made two or three years ago (when the system was conceived) when DEI's, etc., were held for this weapon system. It is anticipated that there is interest on the part of PSAC and DOD, that they be invited to the DEI's and asked to submit comments at that time. Apparently, in the case of the "MINUTEMAN" program, SAC inputs were included but these were not at all coincident with inputs that would have come from DOD and PSAC. With the current Air Force concept of concurrency in the development of weapon systems, it would seem a "must" to obtain all inputs early in the development program, rather than gradually phase them in as the program develops.

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MINUTEMAN ENGINEERING SUBCOMMITTEE REPORT FOR THE MINUTEMAN FLEXIBILITY AND SAFETY STUDY GROUP

SD61-157 27 SEPTEMBER 1961

VOLUME III, SDN1-91557/10G

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MINUTEMAN ENGINEERING SUBCOMMITTEE REPORT FOR THE MINUTEMAN FLEXIBILITY AND SAFETY STUDY GROUP

I. Introduction

The engineering aspects of Minuteman flexibility and safety are examined in this subcommittee report. System descriptions are organized in a common format and measures of performance are outlined. Schedule and cost implications are examined. An evaluation chart summarizes the findings of the subcommittee in regard to the merits of the five systems considered. The report is concluded with a summary of recommendations.

II. General

The Minuteman problem addressed is particularly elusive to engineering evaluation. Evaluations are necessarily based on certain "measures" or basic desired-performance criteria. "What do you want it to do?" is the basic question asked. In Minuteman recent significant changes have taken place in what constitutes desired performance. Future changes are certainly expected.

Analysis of the Minuteman problem has indicated that pre-conflict safety and post-attack effectiveness will serve as fairly stable top-layer performance criteria. The following evaluation reflects this hypothesis.

III. Evaluation Categories

In reference to these top-layer performance criteria, four methods for improving flexibility are compared with the present Minuteman-A system. The comparisons are made with respect to system implementation and performance. Implementation considers cost, schedule and retrofit problems. Performance is judged in two regimes — pre-conflict and post-attack. These two regimes, which concern widely separated requirements, are further categorized into flexibility, safety and survivability. Flexibility in the pre-conflict period provides a base for global gamesmanship and limited war capability while in the post-attack period it dramatically increases force effectiveness. Safety is, of course, almost entirely the concern of the protracted (hopefully) pre-conflict period. Of major concern to safety is unwanted launch because of the awesome consequences to human life and the possibility of precipitating escalation tactics. On the other hand, survivability is the overwhelming problem of the post-attack period.

Within the foregoing categories, and relating always back to pre-conflict safety and post-attack effectiveness, the relative merits of the four proposed systems for increasing flexibility and safety are evaluated. Quantitative measures are presented in support of conclusions reached.

IV. Flexibility

SYSTEM DESCRIPTIONS

Before considering the measures of flexibility it is well to review the salient features of each of the four systems to be evaluated. General descriptions of all the systems have been prepared by BSD, STL and the several contractors and are abstracted in Appendices I through IV. Minuteman-A, the Boeing/Bower system, the Support Information Network (SIN) systems, and the "fourth" STL system are included.

The highlights of these systems are presented here for reference purposes.

MINUTEMAN-A

(b) (1) (A)

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Communication to squadrons from the upper level command is by coded voice messages over wire and radio links. Provision is made for authentication and verification of all messages. Communication between the five Launch Control Facilities (LCF's) of a squadron and the fifty unattended Launch Facilities (LF's) is by buried cable lines. Commands are sent over a redundant

Sensitive Command Network (SCN), status of LF's is sent over the Support Information Network (SIN), and inter-LCF voice messages are sent over the Hardened Voice Channel (HVC).

(b) (1) (A)

[redacted]

BOEING/BOWER SYSTEM

There are several variations of what is termed the Boeing/Bower system. For the purposes of this report, the system selected for comparison is characterized by the same squadron configuration as Minuteman-A but with the following additional capabilities: (1) provision for each missile to be remotely retargeted to one of six preselected targets, (2) provision for individual or group launching of missiles in any of several preselected options, (3) provision for reporting missile status (no-go, missile away, etc.) over the sensitive command network and (4) automatic reset of LF's to "strategic alert" after a five-minute delay following a single LAUNCH command.

These additional functions are accomplished by (1) increasing the number of bits in a message, (2) altering the command structure to be "target" rather than "missile" oriented, (3) introducing two new message types, (4) eliminating automatic calibrate as a function and using the resulting computer memory space for storing target information on six targets and (5) restricting the selection of targets to within ten degrees of a primary target to avoid slewing of the guidance platform.

SUPPORT INFORMATION NETWORK SYSTEMS (SIN-TWO, SIN-SIX)

The names for these systems are derived from the manner in which they are implemented and the number of targets to which each missile can be retargeted. Essentially the present Minuteman-A LCF's and LF's remain unchanged except for an "overlay" launch enable system utilizing the Support Information Network. The missiles accommodate storage of information for two to six targets by eliminating the automatic calibrate function.

In operation, additional safety from unwanted launch is attained through an enable system completely separate from the rest of the system. All of the normal safeguards are retained but, additionally, a manually operated fail-enabled switch allows the final functions such as first stage ignition and opening of the silo door to occur. The ENABLE switches are located in each of the LCF's of the squadron and have effect over the ten LF's associated with each LCF.

Because the ENABLE switches are located in the LCF's, a withhold capability exists at each LCF. Hence, selective fire of missiles is an immediate by-product of the safety overlay. Also, by means of a simple tone system, remote retargeting is controlled.

(b) (1) (A)

Additional features which define SIN-Two and SIN-Six are: [redacted]

(b) (1) (A)

[redacted]

STL # FOUR SYSTEM

Because of the position in which it was delivered at the opening committee briefing at BSD, this system for increased flexibility and safety has become known as the fourth option offered by STL (STL # Four). This system is characterized by provision for 128 firing options. In operation, the LCF would independently select Targets A or B and would select one of 64 possible combinations for launching. The response to each of the 64 combinations would be set at the LF causing the missile to hold, launch immediately, or launch upon expiration of the ripple timer. Plans 1 through 50 would be reserved for launch of single missiles. The remaining 14 options would select pre-determined combinations of missiles to be launched. The target would always be specified independently from the combination number.

This flexibility is achieved by adding six bits to the present launch message.

TIME DEPENDENCE OF SYSTEM FLEXIBILITY

To clarify the operation of these systems, a common format has been prepared in Table I showing the time dependence of system flexibility. Flexibility has different "values" during different operational time periods. As shown in Table I, the pre-conflict period is partitioned into three decreasing intervals preceding time of launch. Notice that Minuteman-A has considerable flexibility if enough time is allowed to make on-site changes. The post-attack period is partitioned into only two intervals, the longer of which considers only that time when emergency power is available.

THE TWO PARTS OF FLEXIBILITY

Flexibility is considered in two parts, e.g., targeting and launching. Grossly speaking, multiple targeting has as its major objective the increasing of

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(b)(1)(A)

[redacted]

(b)(1)(A)

[redacted]

(b) (1) (A)

(b) (1) (A)

[redacted]

residual force-effectiveness and also the reprogramming of targets for different war strategies. The method of accomplishment is through retargeting of missiles or groups of missiles according to status of the force and enemy targets yet to be killed. Selective launching is a means for adapting the system to a more flexible strategy. This is accomplished through selecting specific targets for destruction and withholding all missiles or groups of missiles not assigned to those targets (in addition to withholding "overkill" missiles as desired). Note should be made of the requirement for damage assessment, force status, and command survival together with multiple targeting and selective launching to obtain the desired flexibility.

SQUADRON FLEXIBILITY

Table 2 shows the comparative and quantitative flexibility of the five systems. For clarity all numbers are referred to the squadron configuration. Most of the columns are self-explanatory. The second column, Maximum Number of Targets, indicates intrinsic targeting capability. Within the capability (limitation) of the command system, a larger number of targets provides greater flexibility. The fifth column, Smallest Group, indicates the ultimate fineness-of-control that can be exercised by the system. The sixth column, Launch Groups, shows the maximum number of groups that can be fired singly and the number of combinations in which groups can be fired. A large number of combinations, of course, complements the multi-target capability and increases force effectiveness.

A significant increase in the number of "assignable" targets over that of the Minuteman A system is apparent in the four new systems. This is understandable because it is a design objective of the new systems. Further increases in this number have been postulated in systems not considered here. The value of increasing this number will, at a future date, have to be traded-off with command ability, survivability, status reporting, and damage assessment. Hopefully, the number will not be chosen so low as to limit future flexibility demands.

(b) (1) (A)

[redacted]

* Pre attack numbers are used as an indicator of post attack capability.

** The useful number of combinations is dependent on the number of surviving LCF's. See Table 3.

Retargeting time, as described earlier in Table 1, is not at this point in time of primary concern per se. Future requirements can be visualized which could alter this condition. The manner in which retargeting is accomplished is most important to post-attack effectiveness. Remote methods, of course, characterize the new systems.

Similarly, and also shown on Table 2, the consequences of reasonably slow reaction time are not serious as seen at this time. As with retargeting time, future requirements can be visualized which would make a short reaction time of primary importance. SIN-Two and SIN-Six are shown to be the slowest of all the systems because of the requirement to open a safe and set up a set of conditions prior to initiating launch.

MEASURES OF POST-ATTACK FLEXIBILITY

Table 3 shows the deleterious effects on flexibility of overt damage to the lower level command structure. For purposes of comparison with the previous table the full squadron of 50 missiles is presumed to survive the attack. All but a single LCF have been destroyed. Thus the effects of limited command are clearly illustrated and a comparative assessment of post-attack flexibility between the five systems is obtained.

It is interesting to note that the SIN-Two and SIN-Six systems are the only ones to suffer degradation. This is true because of the cooperative nature of launching and targeting required between flights of the squadron. Missile and target selection is accomplished at the flight level.

OPERATIONAL IMPLICATIONS

Table 4 summarizes factors which are important in considerations of system flexibility from the standpoints of both implementation and operation.

Table 3

MEASURES OF POST ATTACK FLEXIBILITY*

Method	Target: Maximum Number of Targets	Launch: Maximum Number of Groups	Launch: Available Selections of Group-Size
Minuteman-A	50	1	0, 50
Boeing/Bower	300	50	0 → 50
SIN-Two	60	11	0 → 10 40 → 50
Sin-Six	100	11	1 → 10 40 → 50
STL # Four	100**	50	0 → 50

* Squadron flexibility under the conditions of:

- One surviving LCF
- Fifty surviving LF's

** Limited flexibility because the 100 targets are contained in "set A" and "set B"

Table 4

OPERATIONAL IMPLICATIONS

Method	LF Survival Required for SCN?	Survival of Flight-LCF Import?	Cooperation Between LCF's Required?	Overkill Tactics?	Flight Status and Damage Assessment Without LCF?
Minuteman-A	No	No	No	Yes	No
Boeing/Bower	Yes	No	No	No	No
Sin-Two	Yes	Yes	Yes	No	No
Sin-Six	Yes	Yes	Yes	No	No
STL # Four	Yes	No	No	Yes	No

Column one shows the need for hardening the LF equipment in order to preserve squadron communications after a portion of the force has been launched. Even with the several alternate communications paths provided by the propagating arrangement, adequate post "attack and counter-attack" conditions require survival of a minimal set of modes.

As discussed previously and included again for emphasis in another context, survival of flight - LCF's is important to the flexibility of the SIN systems. This characteristic is one of the serious limiting factors of post-attack flexibility of these systems.

Bearing heavily on the same limiting characteristic of the SIN systems are the cooperation (contrasted to survival) requirements for proper operation. Because flight-status is shown only at the parent LCF the launch order can't, in most situations, be given without voice tel between all LCF's of the squadron.

As shown in column four, overkill tactics are necessarily employed in Minuteman-A and STL # Four Systems. The pros and cons of these tactics will not be discussed here. There are good arguments for each. However, in the time period under consideration by the committee it is assumed that there is an undersupply of missiles and force effectiveness is a strong function of individual missile effectiveness. Under these conditions gross-overkill is not a desirable tactic.

An ultimate system would include provision for displaying to the commander full knowledge of target damage and target-destruction capability. Significant portions of the requisite information exists within the Minuteman structure. LF status (no-go, missile away) and missile proper-guidance provide relatively high quality indirect sources. As noted in column five of Table 4, none of the systems have a capability for providing any of this information if the parent LCF is disabled. In general, the redundant characteristics of the communications system are not exploited in this regard. Owing to the magnitude of the task of providing this important function incorporation will be recommended for post Wing-five systems.

MEASURES OF FORCE EFFECTIVENESS

Attention has largely been centered at the squadron level in previous paragraphs. Attention will now be directed at the total force capability extending from the present to the end of current authorization in mid-1964.

Force effectiveness is very strongly dependent on force size. Figure 1 shows, for reference purposes, the currently scheduled rapid buildup of operational squadrons. Buildup of the force is the pacing item for consideration of the other aspects of flexibility.

Figure 2, obtained by simply multiplying the number of missiles by the number of targets per missile, illustrates the intrinsic targeting flexibility of the systems under consideration. (Caution is again expressed that the number of targets is only one measure of targeting flexibility.) The lower bound of flexibility is shown by the curve for Minuteman-A. An upper reference is given by a hypothetical six target system which is introduced without any program delay. Note that the SIN-Six system approaches this reference. The STL #4 system is not as flexible as its position on the figure would indicate. Although it can address as many targets as SIN-Two, it can do it in one of two sets, not individually. SIN-Two has considerably more intrinsic targeting flexibility. Not shown on Figure 2 is the Boeing/Bower system. Best estimates of its earliest introduction into the system place it at Wing 5, the cut-off date of Figure 2. If the abscissa was extended it is fairly evident that after a very short time the Boeing/Bower curve would cross the STL #4 and SIN-Two curves at a sharp angle.

Figure 3 shows the buildup of launching flexibility. The SIN and STL #4 systems generally lie on the upper curve. However, in the instance of heavy LCF damage the SIN systems degrade to about the level of the central curve. Minuteman-A is represented by the bottom curve. The impact of these curves is not appreciated if the logarithmic scale is overlooked. Implicit in realizing the benefits of the increased flexibility is, again, an effective reporting and command structure.

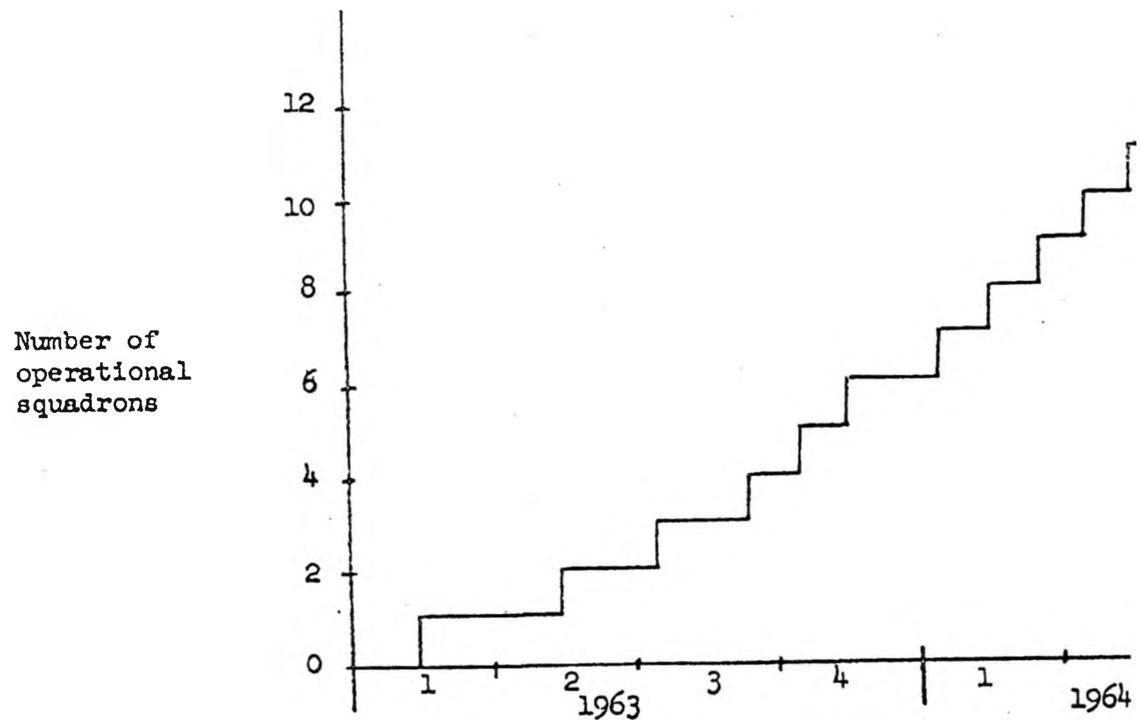

Figure 1

SCHEDULED SQUADRONS

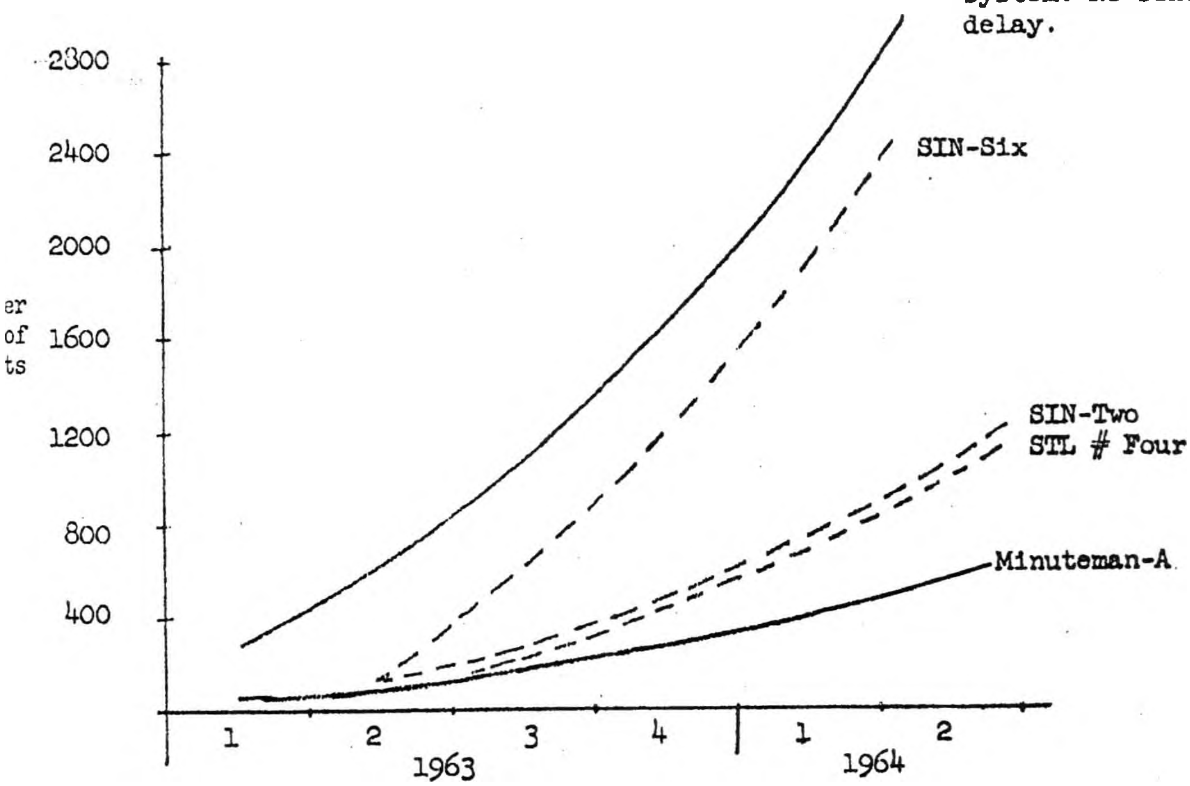

Figure 2

A MEASURE OF INTRINSIC TARGETING FLEXIBILITY

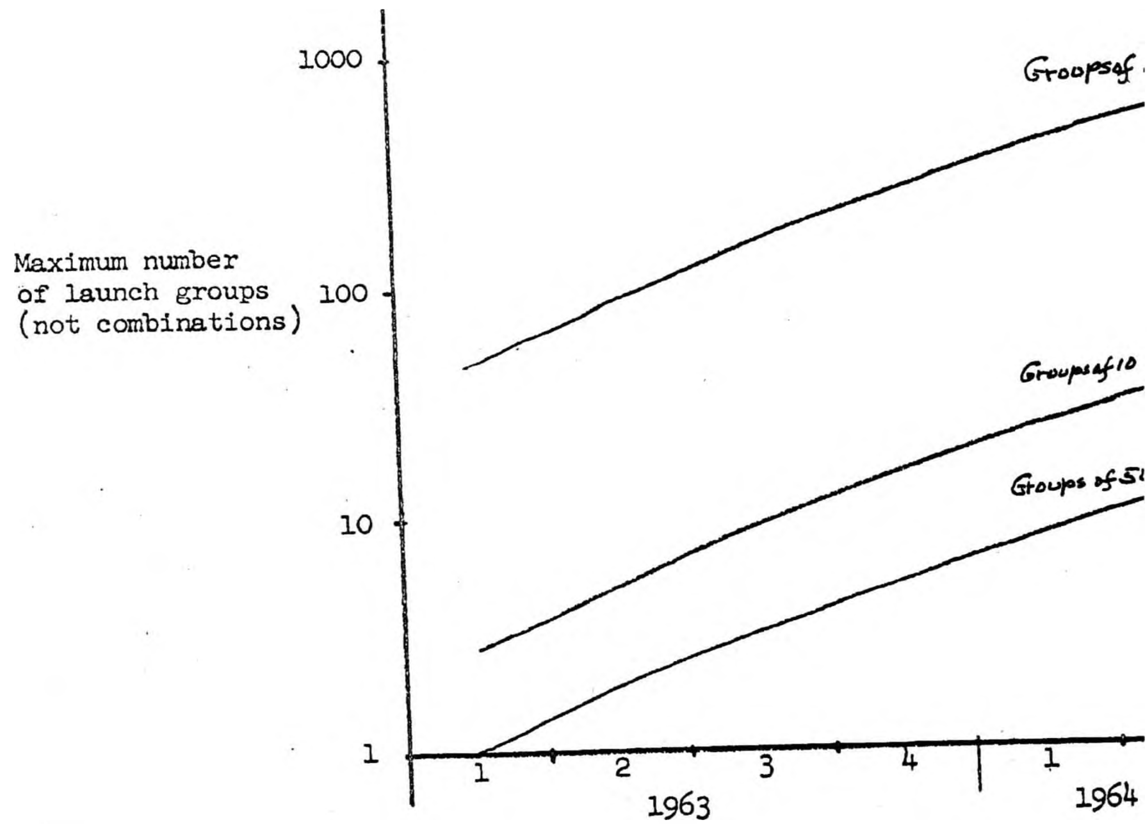

Figure 3

MEASURE OF INTRINSIC LAUNCH FLEXIBILIT

V. Safety

The problem of safety is discussed in other parts of the committee report. This section will confine itself to a brief discussion of the testing programs and to analyses of critical subsystems.

BACKGROUND

By specific and concerted design effort the Minuteman system is characterized by very low failure rate of critical functions. The critical functions are the very ones for which tests should be devised to verify the failure rate. As this problem is reviewed it becomes painfully clear that the only effective test program for determining safety from unwanted launch, for example, will consist of 600 poised missiles scattered about the north-central portions of the United States. Adding to this alarming condition is historical evidence that indicates that any major weapons system has a good probability of incurring a major accident. Reducing the probability that a major accident will be disastrous is an approach that should be pursued further.

Other historical evidence shows that major accidents have occurred most frequently during periods of test or exercise. This is reasonable because these are the periods when one or more of the safeguards are removed. This is the operational area, too, where Minuteman is most vulnerable. During "Test," for example, electrical activity is taking place in all of the vital launch elements of the system. The safeguards of the input decoder have been partly bypassed.

Almost parenthetically it might be noted that the committee recognizes the "other" aspect of safety, namely, "unsafety" of an oversafe system. Certainly the lack of a system is guarantee against unwanted launch. This condition, of course, places the nation in the least safe military posture. In the following discussion consideration is given only to making the system more safe against unwanted launch.

TEST PROGRAMS

Testing programs, although they will never be completely adequate in regard to safety, should reflect determined attention to the principles alluded to above. In the committee review of the Seattle and Vandenberg test programs it is noted that plans have not been totally formulated and documented.

STP III

The Seattle engineering Test Program has been necessarily designed around system integration. Primary attention at this time is given to getting it to work. The facilities are constructed as nearly identical to actual installations as is practical. Favorable conditions have been provided for complete testing. However, at present there doesn't appear to be any definitive explicit plan formulated for testing several aspects of safety. The committee is given to understand that such a plan is forthcoming.

The STP III is open ended and will, after integration tests are downstream, be directed towards evaluation of changes with heavy emphasis placed on safety. The STP III and operational programs are separated by enough time to accomplish significant tests before actual operation if a determined effort is made. Also during this period it is likely that additional effective methods for increasing safety can be conceived and implemented if an objective for so doing is established.

VTP

The general purposes for the Vandenberg Test Program are pre-operational testing and personnel training. The program laps STP III in phasing and, in general, appears to nicely complement it. Many of the aspects of "reality" are introduced in this program that are not present in STP III.

A stated objective is to certify that inadvertent or unauthorized launch cannot be accomplished. At the moment it is not clear how this is going to be done. Specific methods and procedures have not been examined. Detailed tests have not been documented. In any event, the VTP provides and excellent environment for testing several aspects of the operational safety problem. Note is again made concerning the occurrence of improbable events. They occur with highest probability during testing periods when some safeguards are bypassed and when "different" operations are performed. Vandenberg provides a good test bed for some of these conditions. Unfortunately, an infinite amount of time would be required to completely certify the system. In this regard various "acceleration" techniques might be explored.

The Vandenberg program of combined engineering and operational testing provides an excellent open ended vehicle for performing continuing tests of safety. The immediate problem is one of setting up meaningful plans for certifying safety.

EDL

The Engineering Development Laboratory provides an excellent facility for verifying the statistical behavior of critical components and operations of the safety system. In all calculations of probability of occurrence of an event, various estimates are placed on the behavioral performance of the elements involved. Many of these performance characteristics can be empirically verified by suitable simulations. Noteworthy of the applicability of this kind of testing is the electromechanical decoder. Another type of simulation would employ digital computer modeling.

The subcommittee has not investigated the EDL test program and is, therefore, unable to offer an evaluation of it. Since "safety" is a main test objective in the program, much productive and significant information can be obtained with modest effort expended.

SPECIFIC EVALUATIONS

Certain of the system implementation characteristics fall into a "suspect" category so far as safety from unwanted launch is concerned. These characteristics are reviewed at this time.

MESSAGE LENGTH

Table 5 is indicative of the probabilities of generating the required code through random process. Since the STL #Four System requires obtaining 3 bits from some part of the message, the effect of this bit-borrowing is shown. Note that the removal of three bits does not increase the probabilities to significant values. The one-month duration of random input is relevant since a hardware failure could go undetected for that length of time.

Based on the values shown in the table, the code is judged to be satisfactorily long. This is particularly true when all of the other restraining conditions are considered.

ELECTRO MECHANICAL DECODER

The mechanical decoder is sequentially operated and resets when an erroneous bit is detected. Thus, in essence, it is capable of testing a given electrical sequence at reasonably frequent intervals -- perhaps averaging something of the order of one-tenth of a second per test given a random electrical input. In view of the 2^{18} code possibilities, it can be see that in about 15 hours a

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(b) (1) (A)

[redacted]

random electrical signal would probably trigger a launch. This observation could be tested by Western Electric. A "delayed reset" could increase the random triggering time to a more satisfactory value. Clearly the amount of current necessary to actuate these mechanical relays is large; but in view of the failures that can occur in power supplies, this type of current flow may not be particularly unlikely. Another possibility concerns generation of the code within the launch enable unit since only low level signals are required and properly timed clock pulses are present.

LCF AND LF EQUIPMENT DESIGNS

Examination of general equipmenting practices indicates that insufficient attention was given to problems posed by agents in the facilities. This condition is particularly evident in the LF. Changes are being incorporated at the present time to corrent the most serious of the problems. Code volitalization is one such example. Applying the two-man system for code protection from manufacture through installation would aid significantly in this area. Detailed investigation will reveal several "soft" spots.

INHIBIT INDICATOR

As presently implemented if a launch command is followed by inhibit, some of the LCF's of the squadron may not be aware of the "cocked" condition without resorting to voice tel. [redacted] (b) (1) (A)

usual "strategic alert." [redacted] (b) (1) (A) (b) (1) (A)

VI. Schedule and Cost

The engineering subcommittee does not understand the schedules and costs presented by BSD in sufficient depth to be qualified to make comments.

SCHEDULE

The estimates of STL (Brandel and Klinge) are summarized in Table 6. All systems involve testing at AMR, Seattle and Vandenburg. Further, all systems require portions of the work to be done by Boeing, Autonetics and RCA.

COST

Costs are also summarized in Table 6. The estimates are those of STL.

Table 6

SCHEDULE AND COST

Method	Schedule (Wing)				Cost ($M)		
	Electro Mech. Decode	Manual Launch Enable	Flight Computer and G&C	*OGE & *MGE	Install *OGET	Install *FTET	Retrofit
Boeing/Bower	2	NA	2	5	115	45	X
SIN-Two	2	1	2	NA	20	45	10
SIN-Six	2	1	2	NA	20	45	10
STL # Four	2	NA	2	3	55	45	X

NA indicates entry is not applicable.

X indicates information is not available.

* OGET is operational ground equipment and test.
FTET is flight equipment and test.

* OGE is operational ground equipment.
MGE is maintenance ground equipment.

VII. Evaluation

Based on the foregoing facts and analysis, together with numerous discussions with committee, BSD, STL and contractor personnel, the conclusions summarized in Table 7 were reached.

EVALUATION CHART

Table 7 is constructed so that the several interrelationships that exist can be readily interpreted. The three ratings of satisfactory, marginal and unsatisfactory are selected as the best compromise between meaningful numerical evaluations and relative ranking scales. However, because the engineering subgroup did not obtain detailed schedule and cost information, relative ranking scales are employed in these columns.

A brief review is now given of the reasons for selecting the ratings given.

MINUTEMAN - A

Targeting and launching flexibility are two of the factors which prompted formation of the committee and so it is not surprising that they receive an unsatisfactory rating from Minuteman-A. Prior discussion has covered this area in sufficient detail.

Safety of the system is one of the major concerns of the committee. Because of the several possible modes of failure of Minuteman-A, the probability of accidental launch of a single missile appears too high to warrant anything but

Table 7

EVALUATION SUMMARY CHART

Method	PERFORMANCE											IMPLEMENTATION (Rank Only)		
	Pre Conflict							Post Attack						
	Flexibility		Safety			Survivability		Flexibility		Survivability		Cost	Schedule	Retrofit
	Target	Launch	Accidental Launch 1	Accidental Launch 50	Unauthorized Launch	Covert	Reliability	Target	Launch	Overt	Command			
Minuteman-A	U	U	U	M	M	S	S	U	U	S	S	-	-	-
Boeing/Bower	S	S	U	M	M	S	S	S	S	S	M	C	C	C
Sin-Two	S	S	S	S	M+	S	S	S	M	S	M	A	A	A
Sin-Six	S	S	S	S	M+	S	S	S	M	S	M	B	B	B
STL # Four	M	S	U	M	M	S	S	U	S	S	M	C	C	C

S = Satisfactory

M = Marginal

U = Unsatisfactory

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an unsatisfactory rating. Similarly, although lower, the probability of launching the entire squadron is marginally high.

None of the systems investigated possess completely satisfactory protection from a well equipped espionage team. The SIN systems provide some margin of safety over the others. Much of the previous discussion has dealt with safety from the standpoints of both accidental and unwanted launch and no further comment is required here.

The precautions taken against accidents causing damage to the LF have not been thoroughly investigated but from all indications the procedures and planned tests appear reasonable and adequate for the problem.

Pre-conflict survivability of all of the proposed systems appears roughly the same. The clandestine stand-down tactics of clever agents equipped with the best kinds of equipment do pose serious problems to the survivability of the system. Cross talk characteristics of the communications system and frequent entry to LF's by maintenance crews seem particularly susceptible to enemy action. Continuation of work with Army espionage teams should provide pre operational information to allow several of the weak spots to be bolstered. A continuing effort should certainly be maintained in this area.

Post attack survivability is the concern of several simulation studies, analytical work and empirical testing. With the exception of recommending much further work on the EM pulse problem this area seems well covered.

Since Minuteman-A is the "reference" system for cost, schedule and retrofit problems no comments can be made.

BOEING/BOWER SYSTEM

As pointed out in previous technical discussions this system has very favorable flexibility characteristics. Provision for status display throughout a squadron provides a first-step to supplying a commander with information necessary to increase total system flexibility.

Pre attack safety is marginal for the same reasons as Minuteman-A. Improvement could be attained through incorporation of devices similar to those in the SIN systems (excluding LCF - launch-enable which would have the effect of altering system operation).

As is true for all of the remaining systems, post attack survivability of command leaves much to be desired. Post attack survivability is presumed to include the effects of launching of Minuteman as well as sustaining of overt damage. Between the two, several of the communications lines and nodes will be destroyed. The launch command will not propagate to all strategic-alert missiles. Also, survival of an effective upper level command structure is open to question in the minds of several committee members.

Schedule and retrofit problems affect almost every element of the system in some way or another. Although it doesn't seem impossible to incorporate this scheme prior to the 5th wing the nature of the modifications point to block changing.

SIN-TWO/SIN-SIX

Modifications to the launch enable system, automatic reset of the "cocked" condition of the squadron, indication of the cocked condition at LCF's, volitilization of codes at the LF's and monitoring of the position of the electro-mechanical decoder wheel elevate rating of the SIN systems for the pre conflict period.

During the post attack period, however, targeting flexibility is just barely satisfactory owing to the requirement for each LCF to survive in order to exercise control. "Failing" to a known position of preferred targeting is in its favor.

Launch flexibility also requires a surviving and cooperative system of LCF's for proper operation. There is no launching control beyond that possessed by Minuteman-A at the flight whose LCF is inoperative. Unless LCF survivability is very high the system is marginal in this regard.

Considering the cost, schedule and retrofit part of the problem, this system is exceedingly attractive. Almost everything is in its favor. Even compatibility of "unmatched" ground and flight equipment is achieved.

STL # FOUR

This system is hampered most by lack of targeting flexibility. Although target "set A" or "set B" provides a favorable improvement over Minuteman-A, it is seriously limited when fine control is required. This is partially offset by the very satisfactory launching flexibility provided.

Safety against unwanted launch is the same as for Minuteman-A.

Cost, schedule and retrofit problems follow those of the Boeing/Bower system.

VIII. Recommendations

A. MAJOR RECOMMENDATIONS

1. Immediately implement the Support Information Network system with provision for six targets in the command system. As soon as possible (presumably second wing) expand the number of targets in the missiles to six. The essential features of the SIN system include (1) the "overlay" enable system, (2) status indication of the position of the electromechanical decoder wheel, (3) volitalizing of the code at each LF, (4) automatic reset of each LF to "strategic alert" (after a time delay) following a launch command from a single LCF, (5) indication of the "cocked" condition described in (4), and (6) provision of extended emergency power. The SIN system possesses the greatest safety from unwanted launch and has the best balance between flexibility and implementation schedule. During the early stages of field operation this system allows for greatest force effectiveness.

2. Plan for a completely new command and control system at Wing 5. Although SIN-Six provides a very good compromise between early introduction and capability, it is not an optimal solution to the over-all problems of total force effectiveness, flexibility and safety. It is recommended that another committee be set up to review the design of this new system before it is implemented.

B. DETAILED SUB-RECOMMENDATIONS

1. Study all aspects of safety of the electro-mechanical decoder. (Western Electric)

2. Determine the levels of cross talk between the 465L, PAS and SCN. (Western Electric)

3. Re-examine equipmenting techniques in respect to vulnerability to personnel in the LF's.

4. Set up permanent "devil's advocate" teams.

5. Devise objectives and plans for continued testing of the system in regard to safety.

6. Perform an investigation of patterns of occurrence of low probability events; relate it to Minuteman.

7. Perform a detailed review of schedules and costs.

8. Engage a competent agency to devise and recommend a satisfactory system for the warning of intrusion and the protection of LF's and cable trenches. The present security system is inadequate on both counts.

9. Provide better visual isolation between the two launch control officers in the LCF during the launch operation. A simple wall to prevent coersion is thought to be adequate.

10. Carry out an operational study of the "overlay" system with the enabling function performed at squadron or wing level. Survivability under covert action should be of prime consideration.

11. Perform an investigation to determine "balanced" code handling procedures. There should be no weak links from manufacture through system maintenance.

12. Examine the overall operational need for flexibility. Measure the adequacy of different schemes to provide flexibility against this standard.

APPENDICIES I - IV
MINUTEMAN FLEXIBILITY AND SAFETY STUDY
GROUP SUBCOMMITTEE REPORT

Appendix 1

MINUTEMAN - A

The present system, herein termed Minuteman - A for convenience, has been well summarized by Dr. John Bower of RAND Corp. in RM-2815. The following description is an excerpt from this document:

COMMUNICATIONS INTO THE SQUADRON

Assuming the order to launch a squadron originates at SAC headquarters, it proceeds to the squadron by any or all of several channels, consisting of 465L, Primary Alert System, HFSSB, and commercial telephone. Telephone and 465L are received at the LCF used as squadron headquarters, and at the one used as alternate headquarters. All LCF's, however, receive the Primary Alert and HFSSB transmissions directly. The LCF's are interconnected by buried telephone cable, so that a message received at one can be relayed to all others, if necessary, and so that action can be coordinated.

LCF CONSOLES AND DATA PROCESSING EQUIPMENT

The buried cable communication system within the Minuteman squadron is called the Sensitive Command Network. It consists of three subnetworks that are functionally independent, but occupy the same cables and terminal racks in the LF's and LCF's. The subnetworks are the Command Subnetwork, whose function is to convey secure coded commands from the LCF's to the LF's (LAUNCH, INHIBIT, CALIBRATE, TEST, SELF-VERIFICATION TEST); the Status Subnetwork, which reports from each LF to its LCF the current state of the LF; and the Hardened Voice Channel (HVC) that provides a non-redundant

(b) (1) (A)

[redacted]

INTRA-SQUADRON CABLE NETWORK

The pulses generated in the LCF Data Processing Equipment are transmitted directly by buried cable from the LCF to each of its ten missile LF's. In addition, to minimize the chance of losing effectiveness through enemy action against the cables, each of the LF's is connected by cable to its neighbors, and to three other possible relay points, including LF's in other flights. Each LF is equipped to relay LAUNCH and INHIBIT orders received. Thus, a valid message entered at any point in the network is propagated to all points in the squadron even though many of the links and facilities may be destroyed by enemy action. The network is provided with various devices and logic controls to make it difficult for false messages to be entered into the network or to propagate.

LF DATA PROCESSING EQUIPMENT AND SEQUENCER AND MONITOR

The received signals entering the LF's are examined and, if valid, are relayed and acted upon locally in the Launch Enable Logic Unit (LELU) as follows:

1. the address of the originating LCF is recognized and is used to block acceptance of other launch messages from that LCF;

(b) (1) (A) [redacted]

3. the War Plan is interpreted to specify whether or not to include the ripple-fire time delay (hereafter designated timer Y), pre-set up to 0.5 hour;

4. the "Fire Code" section, 18 bits long, is stored;

5. the signal for LAUNCH IN PROCESS is sent to the Status Unit (see below) to signal the LCF of that flight the fact that launch is in process.

(b) (1) (A) [redacted]

(b) (1) (A)

[redacted]

The Mechanical Decoder, located in the Sequencer and Monitor, is an electro-mechanical stepping device that advances its rotor one step for each correct bit of the Fire Code presented to it, returning to start position at any bit not in agreement with the correct code. It performs a check on the 18-bit Fire Code in a way that is mechanical and therefore different from the action of the diode logic used to perform previous checks. A correct Fire Code causes the LAUNCH command to be sent on five wires to start the count-down for launch in a fraction of a minute.

LAUNCH INHIBIT AND OTHER MESSAGES

(b) (1) (A)

[redacted]

In addition to the operational messages, LAUNCH and LAUNCH INHIBIT, there are three others, the missile TEST message, with ten different addresses, used to command a variety of tests on any of the ten missiles of a flight; the CALIBRATE message, also with ten different addresses, used to call out the 2-hr cycle of automatic calibration of the guidance system; and a SELF-VERIFICATION command, which calls for a self-check of the communication equipment. The results of these tests are reported on the Status Network back to the single LCF that issued the command for test.

STATUS NETWORK

The Status Network is an independent one-way communication system from the ten LF's of a flight to the parent LCF. There are five such networks in the squadron. The Status Network reports LAUNCH IN PROCESS, and the states of CALIBRATE, TEST, and SELF-VERIFICATION TEST commands, as well as Warhead Alarm, Strategic Alert, Alarm, No-Go, Inner Security Violation, and Outer Security Violation. The transmissions are sent over wires in the buried cables, (not coded for security).

GUIDANCE

The parameters of the system that are committed to a particular target consist of the azimuth setting and about 60 "words" of 27 bits each, stored on the magnetic disc memory of the Autonetics guidance computer. Target azimuth is held accurately by a precise autocollimator, part of the ground support equipment, which must be aligned manually on a star reference. In addition, the rough azimuth setting (±1° to 2°) must be made by cranking the missile around on its support. It is evident that the target azimuth is not designed to be changed readily, and that the only command to which the missile can respond is one calling for launch after a pre-set time delay and at the pre-set target.

Appendix II

BOEING/BOWER SYSTEM

Changes to Minuteman-A suggested by the Boeing Co. and by Dr. Bower of Rand are strikingly similar and probably represent the products of considerable mutual work. Highlights of the resulting system have been abstracted from Rand report RM-2815 and are presented below. Because of the nature of the investigations performed by Boeing and Dr. Bower, several variants to a central theme are considered. In the subcommittee report the remote retargeting option selected for comparison with other systems assumes the conditions of (1) an unslewed guidance platform, (2) information for six targets stored in the missile computer, and (3) no automatic calibration. Launching and status reporting methods are assumed as outlined in the Rand Report.

SUMMARY OF IMPROVEMENTS

The description of Minuteman-A indicates the hardware commitment to present doctrine, and by implication suggests what parts must be changed in order to make it possible to fire one or several missiles by a single command and to cover multiple targets in each missile. These changes are set down in some detail in the next section. Other alterations are suggested implicitly by the change in the duration and nature of warfare possible with more flexible weapons. These alterations include:

1. elimination of the INHIBIT command and the substitution of an automatic re-set in the LAUNCH command, making it expire after a preset time;

2. inclusion of a SECURE STATUS REQUEST and a SECURE STATUS REPLY message that makes available at each LCF the status of each LCF and LF in the squadron; in case a single LCF survives, that LCF is given control of the squadron, and status information;

3. provision for guidance azimuth re-set after the shock of a near burst;

4. re-location or environmental protection of LF communication Data Processing Equipment to enable it to survive the launch of its own missile;

5. hardening of the diesel power-supply at each LF;

6. improvement of the safety of the Sensitive Command Network by reporting, through the Status Network, attempts at penetration by enemy agents.

SELECTIVE LAUNCH WITH MULTIPLE TARGETS: CHANGES IN THE SENSITIVE COMMAND NETWORK

From the standpoint of the missile force commander, a Minuteman is a device for destroying a target, which is a point on the earth's surface that can be designated by a code number. If any one of several targets can be hit as alternates by each missile, then the commander knows that he can strike a wider variety of targets, but he does not care about the association between targets and missiles. He selects a missile, not by its number in the squadron, but by the target it carries. He does recognize, of course, that if there are two or more targets for each missile, then he must choose: if he strikes T_1, he cannot use the same missile to strike T_2 or T_3.

Accordingly, the essential function to be carried out by the squadron equipment is to see that the proper target or targets are hit on command. This can be done for a single missile launch by adding to the LAUNCH message the code number of the target to be hit, and by arranging for the missile to launch only upon receipt of one of the target code numbers preassigned to that missile. These requirements, interpreted in hardware, become:

1. the addition of a dial encoder or combination of switches on the command consoles in each LCF, by which the operators can designate the desired target number and cause its code to be generated;

2. modification of the console to permit a succession of LAUNCH commands, rather than one from each LCF;

3. an increase in the LAUNCH message from 56 to 64 bits to convey the information as to which target number is commanded.

These additions do not conflict with the capability to fire the entire squadron in salvo or ripple-fire modes, according to the present war plans. Still further quick-firing flexibility can be provided at no extra cost by assigning the same target number to a group of, say, ten missiles. Implicit in this is the idea that a selection of "primary" targets must form a strategically useful pattern or group.

The purpose of the INHIBIT message in the present system is to cover the requirement for safety in the presence of human error. It is possible that the pair of men in one LCF may generate a LAUNCH signal through error, confusion, or even in a deliberate act of disloyalty. The INHIBIT enables the action on any LAUNCH, including the cases mentioned, to be suspended by placing the missiles in a HOLD state. Any such capability in the system, however, provides a means by which an agent can impede the firing of missiles simply by use of the INHIBIT command. For this reason a second LAUNCH command must and does start the countdown process, regardless of the INHIBIT.

The resolution of the classical dilemma of command introduced above calls for a somewhat different solution in a squadron where each missile can be addressed individually with a target assignment number. The consequences of any error extend only to the particular missiles addressed, and depend upon some choices that can be made in design of the Data Processing Equipment for interpretation of the messages. As an alternative to INHIBIT, it would be possible to substitute a RESET command, having the effect of wiping out a LAUNCH command including a specific target number. Such a RESET might be made valid only after a delay of a few minutes to prevent its use as a means of unauthorized holding of the squadron. A simpler method, however, is to make the LAUNCH command with its target number valid for only a limited time, (b) (1) (A) say 5 min. [redacted]

(b) (1) (A)

[redacted]

Having the LAUNCH message of limited valid lifetime has the effect that a single LCF can never launch a missile. This effect becomes important when all but one of the LCF's have suffered destruction under attack. The present system does allow a single surviving LCF to launch the squadron after a 6-hr delay, and so offers a compromise solution. To remove this shortcoming, it is proposed to enable launch by a single LCF in the new system when all other LCF's are known to have expired. For this function the SECURE STATUS REQUEST message is sent by the surviving LCF. If only a single LCF replies, that fact generates a permanent HOLD at each of the LF's, thus allowing any subsequent LAUNCH message to be valid on the basis of the target number it specifies. This mechanization of the single-LCF launch provides all of the safety of the present system, and, in addition, removes the 6-hr delay under the condition when the single-LCF launch is appropriate. It also enables a squadron to remain effective even if cut into several pieces by attack.

MODIFICATIONS FOR THE TRANSMISSION OF SQUADRON STATUS TO ALL LCF's

The present facilities for transmission of status information from LF to LCF consist of (1) equipment at the LF's for encoding the nine different status messages that can originate in the missile, ground support equipment, security means, or communication equipment; (2) cable terminal equipment; (3) buried cables from LF to the LCF of its flight; (4) decoding equipment; (5) status display at LCF. The request for status is transmitted on the Command Subnetwork from the LCF only to LF's in the same flight, and the coded status information is transmitted back on the Status Subsystem.

The Status Subsystem for the mode of operation described above has several shortcomings. Clearly, the possibility for reporting status on the squadron depends strongly upon the survival of the LCF's. Since there is no redundancy of path, severing any of the cables containing a status link would leave one of the missiles unreported as to status. The complete squadron status is not reported to any single point and the squadron commander must therefore depend upon the other LCF occupants to report status on their separate flights of missiles through the hardened voice channel--an inefficient, vulnerable, and time-consuming process.

For the commander of a Minuteman force of the type proposed, the status of surviving missiles and LCF's is essential to deciding the best course of action at any instant. Indeed, it is reasonable to say that such feedback to the squadron commander and to upper levels of command has approximately the same importance as the capability to command launch.

To raise the level of survivability of the facility for reporting these important data we might (1) make the present Status Subsystem redundant by reporting status to all LCF's and by providing automatic retransmission of status messages from point to point; (2) modify the Command Subnetwork to enable it to carry the status reports in the same way and with the same redundancy as the LAUNCH messages and to all LCF's in the squadron; and (3) introduce a radio link for the purpose. Of the three possibilities, the third involves the greatest problems of cost and reliability. The first would require modification of the Status Subnetwork to process messages received at all points, in the same general manner as is now done on the Command Subnetwork. The second appears to require the least modification because its capabilities for command transmission are essentially the same as those now considered for status transmission. Accordingly, the proposal in this memorandum follows (2)-- to introduce such equipment and policy modifications as are needed to use the Command Subnetwork for secure status transmissions.

In order to preserve the security of the post-attack status report, it is necessary to reserve certain messages for this purpose alone and never call for their use until enemy attack has begun or launch is imminent. Accordingly, it is proposed that the Command Subsystem be designed to request from all LCF's and LF's a status roll call by means of a coded message.

A communication network of the kind being constructed for Minuteman invites attempts at systematic penetration. Being dispersed over a large territory, not coverable by security guards, there is no reason why a well-equipped underground room could not be constructed in which agents could carry out complete measurement and experimental transmission of the messages used in the network, this despite the use of pressurized cables and the like. The system must depend primarily upon the use of coded language for its security, and upon quick and effective reaction to any indication that penetration is being attempted.

At present there is provision for a NETWORK TRAFFIC status signal at the LF, signifying that at least one valid synch signal has been received on a line but not followed by a valid message in the next twenty messages on the same line. This status signal is to be stored at the LF to be read by the maintenance crew on the next visit. No status signal is planned to be sent to the LCF's to alert the crews when the NETWORK TRAFFIC signal is first generated. A partial explanation for this policy results from the lack of a secure status report in the present plans. Under the modifications proposed, however, it would be possible (1) to report immediately any NETWORK TRAFFIC signal, giving the LF of origin; and (2) to give the number of such signals received, when requested by an LCF. With such information on the entire squadron, the extent and nature of the danger could be evaluated at the LCF's and appropriate action taken immediately.

GUIDANCE CHANGES FOR MULTIPLE TARGETING

Although the inertial guidance system for Minuteman was intended to provide only single-target capability, various estimates have been made to determine what might be done to add to the target capacity. Assuming the missile is aligned to fire at some target, what would be the result if, at the time of launch, the guidance parameters of another target were substituted in the computer?

It will be recalled that the commitment to a particular target is in several forms: (1) the missile structure is aligned approximately--within about 1°--on the azimuth of the target, so as to bring the autocollimator within optical range; (2) the autocollimator is set precisely on the correct azimuth by use of astronomical reference; (3) the parameters of the guidance equation are chosen for the selected target; (4) the program used in guidance computation is optimized for the particular target; (5) the attitude control system equations involve limitations of azimuth; (6) the calibration of the velocity meters is correct only for the azimuth of the selected target, and large errors in the inertial elements are related to the amount of off-axis acceleration. It is not a trivial matter to consider shifting the target, especially in azimuth, in view of the above. Nevertheless, one would expect that some small shift in azimuth and range could be introduced, especially since many of the guidance parameters have to be set to an accuracy approaching 1 part in 10^5.

(b) (1) (A)

[redacted]

To make such a change effective, it is necessary to store at a convenient point the guidance parameters for the number of targets handled, and to provide the necessary signals to transfer the 1500 bits of data for the selected target into the guidance computer before launch. While it is possible to consider storage of this information at the LCF's, and the transmission of it over the Sensitive Command Network to the missile to be launched, such an arrangement would require extensive network changes and would be faced with great problems of reliability of transmission. Storage at the LF is the reasonable solution for the Minuteman "A" system, therefore. To avoid the reliability problems of external storage means such as tape readers, the simplest solution is indicated: store the targets on the memory disc of the guidance computer itself. Fortunately, by rearranging the use of the memory, several possibilities can be made available. The several variants on this scheme that have been considered include:

1. make no modification in the missile guidance computer hardware, but store one additional target by more efficient arrangement of the data on the disc;

2. remove the presently-stored calibration routines to make available as many as seven targets.

There are, of course, other possibilities that are intermediate and others that go beyond, calling for removing the azimuth limitations and azimuth errors discussed above. The two above are recommended for consideration with the present guidance system because they represent a minimum change in hardware, are compatible with the communication system, and do not degrade the reliability or security of Minuteman. The next logical step in improvement is to introduce continuous re-targeting without azimuth limitation by substitution of a new guidance system.

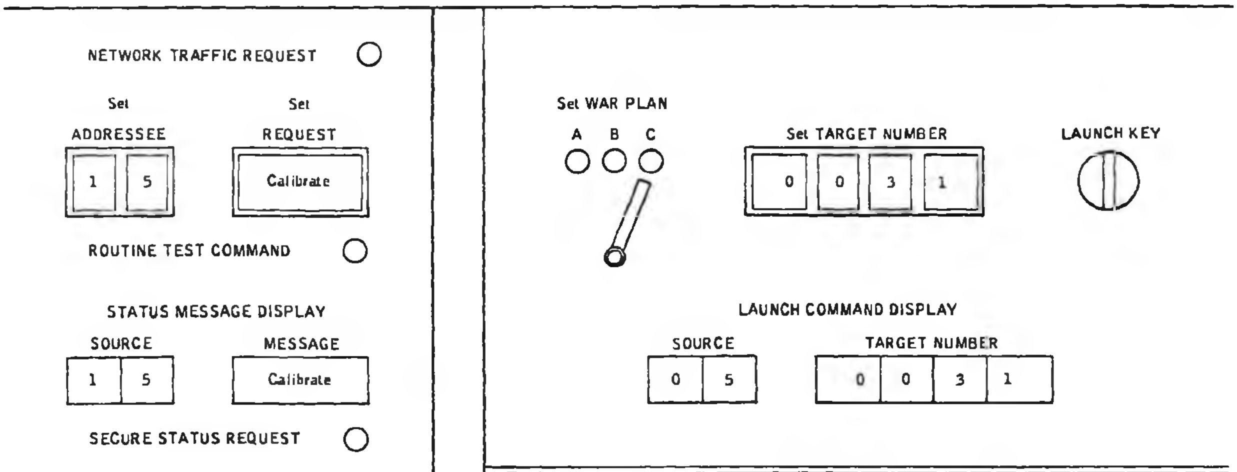
Either of the above arrangements, storing two or seven targets on each memory, is compatible with the cable communication system described in the foregoing sections, since the maximum number of single-target selections would be 350, at 7 per missile. This would leave 162 target numbers available for commanding launch in various groups, for changing burst altitude, and other purposes.

It should be noted that the re-assignment of space on the memory disc for option (2) above is based upon the assumption that the calibration can be performed manually rather than automatically. The practical feasibility of such a substitution depends upon the frequency with which the calibration is needed in order to maintain errors within tolerance. Since the communication system, as altered, would accommodate either the two- or the seven-target mode it would be possible to make the change initially to the two-target mode in guidance until operating experience showed that the frequent automatic calibration could be omitted. As an intermediate policy, the seven-target mode of operation could be applied to those missiles nearest the maintenance centers to minimize the effort of manual calibration.

The principal need for guidance calibration is for correcting velocity-meter drift. This problem has been attacked recently by (1) improvement in the Autonetics velocity-meter design, and (2) introduction of the Arma vibrating-string instrument used on Atlas E, and already oduced in hundreds of units. One of these velocity meters will be used on all Minuteman squadrons after Malmstrom is equipped. Since two improved instruments will actually be available for selection of the one with superior characteristics, there is good reason to expect that the stability of the velocity meters will be sufficient to allow the automatic calibration mode to be eliminated in favor of the seven-target capability. This plan seems especially reasonable in view of the fact that the mean time to failure of the guidance system is such as to require its replacement and calibration every few months regardless of the drift problem.

MODIFICATION OF THE COMMAND CONSOLE

The operation of the modified command system can be understood by reference to the modified command console panel shown in Fig. 4. The panel is divided into four parts as described below.



Status Indicator Lights — Target Number Assignment Sheet — Launch Command Record

Alarm	Test Cal.	Alert	Hold	Missile Away	LF No.	TARGET NUMBERS							Targ. No.	LCF1	LCF2
				O	10	1	11	31	315	336	400		31	1	5
				O	11	2	12	32	316	337	401		316	1	5
O					12	3	13	33	317	338	402				
		O			13	4	14	34	318	339	403				
		O			14	5	15	35	319	340					
		O			15	6	16	36	320	311					
		O			16	7	17	37	301	312	333				
		O			17	8	18	38	302	313	334				
	O				18	9	19	39	303						
		O			19	10	20	40							
		O			20	1	21	41			etc.				
		O			21	2	22	42							
		O			49	20	30	50							
	O				50	11	31	51							
O					51	12	32	52							
		O			52	13	33	53							
		O			53	14	34	54							
		O			54	15	35	55			etc.				
		O			55	16	36	56							
		O			56	17	37	57							
		O			57	18	38	58							
		O			58	19	39	59							
		O			59	20	40	60							

Figure 4. Suggested Console Arrangement

In the upper left-hand corner is the set of devices for entering NETWORK TRAFFIC REQUEST, SECURE STATUS REQUEST, and commands for routine TEST, CALIBRATE, and SELF-VERIFICATION TEST; in addition there is shown a display for status messages received, both the requests and the replies, as a check on the men and equipment in the system.

In the lower left-hand corner are placed the indicator lights showing the current status of each of the missiles. For the ten missiles in the flight for which this is the LCF, the status would be indicated at all times, through the Status Subnetwork. For other LF's the status would be available only after a SECURE STATUS REQUEST message had been sent by one of the LCF's, after which status changes would be transmitted by the LF's and received at all LCF's as they occurred.

The upper right-hand corner of the panel includes the "War Plan Switch" by which the choice can be made between the two types (A, salvo, and B, ripple) of full squadron launch, and the selective launch, C, for which the target numbers are valid. Provision is made for setting the desired target number in the drum encoder. The key switch for causing the LAUNCH command to be sent is shown to the right of the encoder. The last-received LAUNCH command transmitted over the Command Subnetwork is displayed to indicate the source and content of all LAUNCH commands.

At the time the targets are assigned in the squadron, with target numbers placed in the Data Processing Equipment of the LF's, a sheet showing target numbers is placed on the panel, as shown in the lower right-hand corner. It would be possible to provide automatic display of the launching by illuminating all target numbers when they have been given LAUNCH commands--perhaps with red illumination for one command and green for those receiving two commands. However, this degree of automation seems unnecessary. Consequently, it is proposed to provide the LCF commander a space to the right for the "Launch Command Record" in which he can record the target numbers and the LCF's that took part in the launch process. At the time a launch occurred, of course, each LF would transmit its status report.

The degree of duplication of this display and control facility at the two stations in the LCF is capable of great variation. At least in the setting of war plan, target number, and the launch key, complete duplication is demanded by policy. There is, however, no similar requirement for safety and checking on the other commands and the received signals, and consequently the duplication of the other controls is a matter in which cost must be balanced against convenience.

Appendix III

SUPPORT INFORMATION NETWORK SYSTEMS (SIN-TWO, SIN-SIX)

Safety and flexibility improvements to the present Minuteman - A System, as suggested by STL, are presented. For convenience the resulting systems have been designated SIN-Two and SIN-Six for Support Information Network systems with retargeting capability of two and six targets respectively. Although the six target option is not discussed in the STL report, mutual agreement was reached between BSD, STL and committee members that such an option can be provided. There is little conceptual difference between the two systems.

The information presented is taken from STL report GM-61-R001-30298 prepared by R.F. Brandel and W.H. Klinge.

DISCUSSION

It is desired to furnish a function of enabling such that each missile is maintained safe, i.e., unlaunchable, until such time as it is positively enabled. The enabling act is to be initiated remotely inorder to save costs of manning every site. The enabling function is, however, to be distinct from the launch function.

A Launch Enable System is proposed which maintains the site unlaunchable until enabled by its parent LCF. The Launch Control Officer would control the enabling of each site with ten individual switches at the LCF. A higher level of command can be provided by denying access to the switches until a four letter code word had been set on four dials. Access to the secure enclosure containing the switches could be procedurally controlled by the Wing Commander or direct SAC communications. A tamper detection system would indicate attempts to guess the setting of the code wheels.

The enable system would be integrated with the Support Information Network signaling system so that interruption of the SIN cable would result in the site being armed. A fail-enabled system was chosen instead of a fail-safe system because of strong survivability considerations. A fail-safe system would disable ten missiles if a single explosion cut the cables radiating out from one LCF.

Modification to the present Launch Control System would not be required. The overlay LES would interface only with the SIN system, the main J-Box, and the cabling between the data processing equipment racks.

IMPLEMENTATION

FUNCTIONS DISABLED

The following functions at the LF are to be disabled as shown in Figure 5.

a. First Stage Ignition,
b. Launcher Closure Removal,
c. Arming of Downstage Primary Ordnance,
d. LCF Launch Decode Signals from SCN Secure Decoder to Launch Enable Unit Number One.

The ordnance functions are to be interrupted in the main J-Box so as to place the enable switch directly in series with the ordnance devices. The enable switch will be a SAFETY EXCHANGE DEVICE (SED) modified for remote operation.

An SCN enable will control the launch command signals between the two DPE racks at the LF. Prior to enabling the site, the DPE at the LF would retransmit valid launch, inhibit, and addressed SCN test commands; however, the launch enable unit would neither register a launch vote nor store the 18 bit common code. The inhibit command is to operate independently from the enable system;

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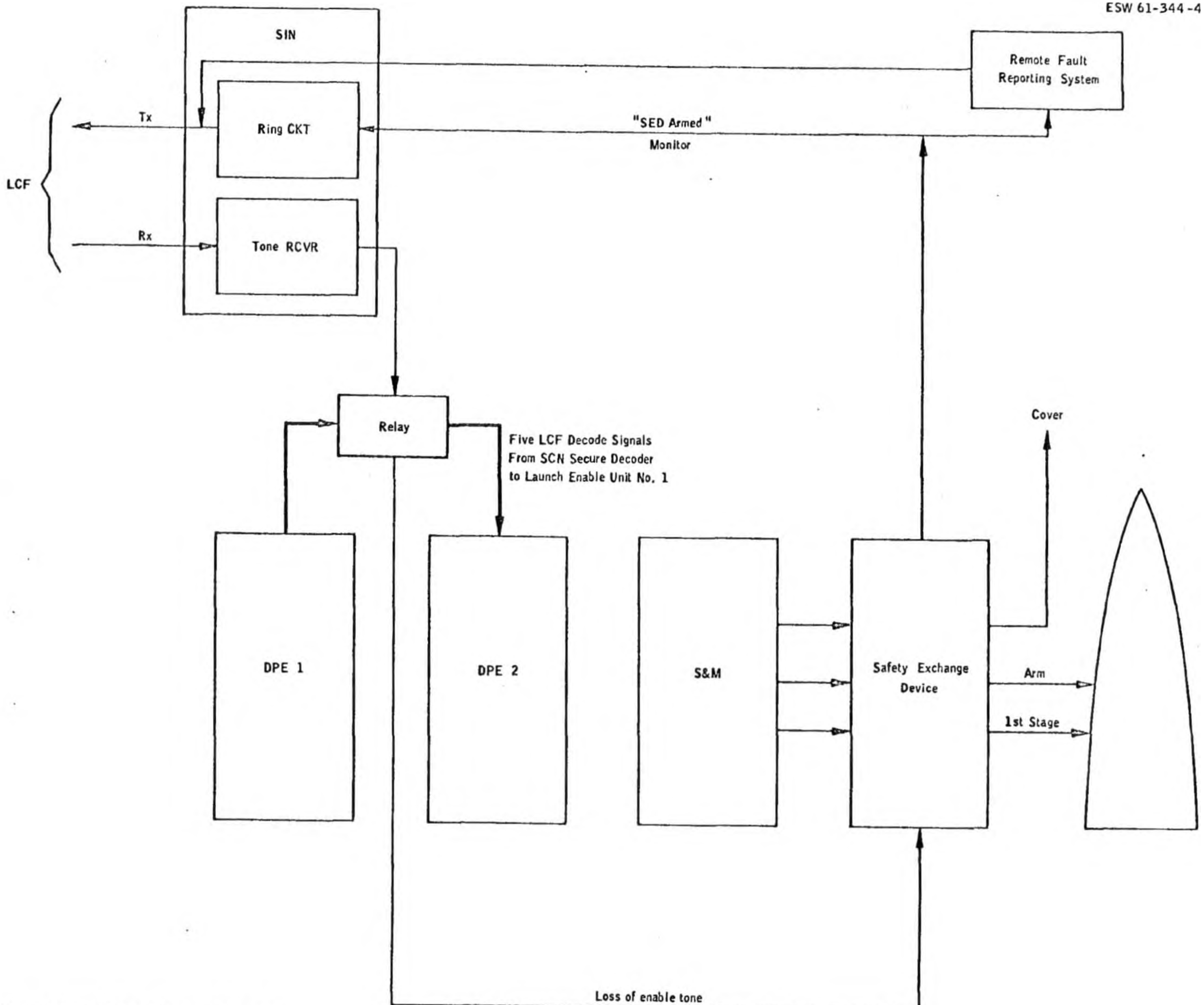

Figure 5. Launch Enable System - Launch Facility

hence, disabling a site after receipt of a single launch command would not prevent the normal functioning of an inhibit command.

ENABLE COMMAND LINK

The enable signal used to operate the Safety Exchange Device and the SCN enable switch would be provided by an additional signaling tone on the Support Information Network. An enabling switch for each LF would be provided at the LCF. The switches would interface with the SIN equipment to provide an independent tone to each site when the enabling switch was in the safe position. Switching the enable switch to the arm position would cause the enable tone on the SIN line to cease.

Loss of the enable tone at the LF is to result in the immediate arming of the Safety Exchange Device and the SCN Enable Switch. Re-application of the enable tone is to safe the SED and SCN enable after a time delay. The time delay would be of sufficient duration to prevent chattering of the SED due to EM pulse effects.

STATUS RETURN

The SIN system and the remote fault reporting system are to be used to monitor the position of the SED. A cable between the SED and the SIN equipment would cause actuation of the telephone ring circuit when the SED switched to the "arm" position. The report of an "armed" SED received by the LCF would be the same as that indicating removal of the telephone set from the hook at the LF. The "SED Armed" signal at the LF would also be cabled to the remote fault reporting system.

MAINTENANCE

When maintenance is being performed at the LF on equipment other than the the Launch Enable System, the motor-driven Safety Exchange Device would be manually pinned in the safe position. The launch enable system would be tested during installation and checkout and as a part of the LF end-to-end check using a missile simulator. The SED would be armed by the LCF to test the complete enable system and status return. End-to-end checks of launch control equipment at the LF are being programmed for the period of time between the removal and replacement of the missile downstage. It is anticipated that an end-to-end test will be performed approximately at six-month intervals.

FLEXIBILITY

SELECTIVE LAUNCH

The Launch Enable System proposed provides a selective launch capability. Since one of the functions controlled by the Launch Enable System is the vote store in the Launch Enable Unit, launch commands may be propagated without effecting sites not enabled by their parent LCF; thus a limited number of missiles may be selectively enabled and launched. If additional missiles are subsequently armed for a second launch, two launch commands are again required for immediate launch.

Use of the Launch Enable System as a selective launch capability requires coordination between all five LCF's. Loss of communications with one of the LCF's should lead to the assumption that the associated ten launch facilities are enabled. Individual sites having the direct LCF-LF lines out of commission will also arm without positive indication at the LCF, and will receive launch commands on alternate lines.

MULTIPLE TARGETING

DISCUSSION

It is proposed that a dual target capability be provided with the present flight computer memory capacity by eliminating the remote calibrate capability.

Local calibration requires inserting the calibration program with the C24 targeting van, waiting three hours for the completion of platform alignment and instrument calibration, inserting the operational program, and commanding a second platform alignment. Installation of vibrating string accelerometers in the Second Wing should reduce the calibration period below that required by the First Wing velocity meters. It is expected that Second Wing calibration will be required only during normal maintenance calls by the targeting van.

The system to be described provides two targets in the memory of the flight computer. The choice of target can be selected at any time prior to transmission of the launch command. The target for each site may be individually selected.

FLIGHT SYSTEM

The target dependent constants for each target would be stored on separate channels of the memory disk. The channel (or channels) having target dependent constants would be paralleled by an equivalent channel for each constant. Additional switches would be added to the flight system to select the read heads for the channels corresponding to the selected target. The target switches would be set prior to flight by independent signals from the ground equipment. Since the position of the additional switches would clearly define the set of target constants that would be utilized upon entering the flight program, monitoring the switch positions would provide a high level of confidence in the target verification.

Modification to the flight system would provide additional switches for the read heads on channels containing target dependent constants. Additional amplifiers and signals interfacing with the C & C umbilical would be required for the target command and the target switch position monitor. A minor modification to the C24 computer input equipment would be required to provide for channel switching during load verification.

The target constants for all targets would be checked at two minute intervals by the cold storage sum check. The set of constants to be used during flight would be directly controlled by the target channel switches.

LAUNCH CONTROL SYSTEM MODIFICATIONS

The removal of the remote calibrate capability frees a command thread from the LCF and a status return to the LCF. The "Calibrate" command can be designated "Retarget". A particular site can be selected and the target reversed by the procedure now used to command calibration from the Command Control Console. The "Strategic Alert" and "Calibrate in Process" lights would be re-labeled "Alert A" and "Alert B". Only one of the lights would be lit during strategic alert indicating the position of the target switch in the flight system.

G & C COUPLER

Additional interface signals between the flight system and the G & C coupler would be required to control the flight system target switch and to monitor its position. Receipt of a "Retarget" command on the present calibrate line from the Sequencer and Monitor would reverse the position of the target switch in the flight system. The G & C Strategic Alert would be routed to either the present Strategic Alert signal or the Calibrate in Process signal, depending on the target switch monitor.

Elimination of the remote calibration capability allows a reduction in G & C coupler requirements. The precision time reference can be removed from the coupler and placed in the targeting van. The one megacycle crystal and its binary divider chain could therefore be removed from the Launch Facility.

SEQUENCER AND MONITOR

Logic in the Sequencer and Monitor presently prevents the commanding of calibration during the presence of an Autocollimator Alarm, or the initiation of a launch sequence while receiving "Calibration in Process". These gates would be removed in the Sequencer drawer because of the revised application of the calibrate command and status signals.

COMMAND CONTROL CONSOLE

The "Strategic Alert" and "Calibrate in Process" lights would be relabeled "Alert A" and "Alert B". The "Calibrate" position on the function selector switch would be relabeled "Retarget".

Appendix IV

STL # FOUR SYSTEM

Because of its position in the opening committee briefing at BSD, this system for increasing flexibility and safety has become known as the fourth option offered by STL, or, STL # FOUR. The system is well described in STL Report GM-61-R001-30298 prepared by R.F. Brandel and W.H. Klinge. The information presented here has been abstracted from that document.

DISCUSSION

Flexibility can be achieved by adding bits to the present launch message which would designate the missiles to be launched and a choice of two targets. The system to be proposed adds six bits making a total of eight war plan bits, providing a total of 128 war plans. An error detecting scheme would prevent a single failure or bit inversion from launching unwanted missiles when a limited launch is commanded.

The Command Control Console would independently switch the target (A or B) and the LF selection (64 combinations). The response to each of the 64 combinations would be set at the LF, causing the missile to hold, launch immediately, or launch upon expiration of the ripple timer. Combination plans 1 through 50 would usually be reserved for launch of the single missile specified by the plan number. The remaining 14 options would select combinations of missiles to be launched. The target would always be specified independently from the combination number. To limit hardware requirements, a given site could respond to no more than 8 of the 64 combination plans. In normal usage, the site would respond to its own unique address, and a maximum of 7 of the 14 multiple salvo plans.

A few examples might clarify the operation of the system. War Plan 32B is commanded. Missile number 32 launches to Target B without ripple delay. Next, War Plan 53A is commanded. Eight of the missiles launch to Target A without ripple delay. Finally, War Plan 59B is commanded. Twenty of the missiles launch to Target B after the expiration of their ripple timers.

Normally, War Plans 1 through 50 would launch a single missile without ripple delay, and War Plans 51 through 64 would launch combinations of missiles with or without ripple delay. However, the actual response is programmed at the LF by a strapped plug or a punched paper card. The important constraint is that a given site can launch in response to only 8 of the 64 combination options. The site can also be set to either ripple or salvo for any of the 8 possible combinations. The target is commanded independently, so that the site can launch in response to 16 of the 128 war plans.

SYSTEM MODIFICATIONS

The Command Control Console encodes the 6 launch combination bits (64 plans), the target bit, and the error detection parity bit. The message injection drawer in the data processing equipment and its interface would be expanded to accept 8 rather than two war plan bits. The line selector drawer would be modified to correctly clock the increased word length.

The data processing equipment at the LF would require substantial modification. The line selector drawer would be modified to clock the increased work length. Six stages would be added to the secure decoder for the additional war plan bits.

The major modification would be required in the decoder and launch enable drawers to perform the programmed launch acceptance logic. Eight-six variable decoder gates would be provided to allow the acceptance of eight of the 64 combination plans. The inputs to the eight gates would be set by a removable plug or card reader. Any of the eight gates could also be programmed for ripple fire. When setting a gate for a particular war plan, a separate switch would be set for odd or even parity. If one of the war plan gates were to come on without being in agreement with the parity bit in the launch message, a critical error would result. By carrying this error detection scheme through the launch enable logic, unselected missiles would not launch with selected missiles as a result of any single failure.

The target bit would be decoded from the independent decoder stage reserved for target. To confirm the target, a new parity bit would be derived by combining the LF selection plan parity and the message parity bit. Both the target bit and the target parity bit would be cabled through the single thread to the flight computer.

EQUIPMENT MODIFICATIONS

1. LCF
   a. Command Control Console
   b. Message Injection Drawer
   c. Line Selector Drawer
   d. Cabling

2. LF
   a. Decoder Drawer
   b. Launch Enable Unit
   c. Store, LEU and Verification
   d. Line Selector
   e. Inter-drawer and Inter-rack Cabling
   f. Dual Targeting Modifications to Single Thread and Flight Computer.