ARI Research Note 86-70

FINAL REPORT FOR A PROTOTYPE NATIONAL TRAINING CENTER RESEARCH DATA BASE SYSTEM

Science Applications, Inc.

for

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The research described in this report was to develop the software necessary to set up a prototype research data base for retrieving information on past exercises at the National Training Center.

The National Training Center was set up to provide realistic unit training for armor and mechanized infantry battalion task forces. A byproduct of this training is the exercise history data base, the only archive of fully-instrumented, battalion level, force-on-force combat interplay. To retrieve this data (over)

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20. Abstract.(continued)

two software components were developed: 1) a Translator program, which accesses the NTC data base, processes the data, and creates readable files, and 2) a Loader program, which takes the output of the Translator program, and uses it to fill data tables.

FINAL REPORT FOR A PROTOTYPE NATIONAL TRAINING CENTER (NTC) RESEARCH DATA BASE SYSTEM

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1.0 INTRODUCTION

1.1 Description Of The Project

The National Training Center (NTC) was conceived to provide realistic experiential unit training for armor and mechanized infantry battalion task forces. A byproduct of unit training is the exercise history data base generated at the NTC. This data base is the only archive of fully-instrumented, battalion level, force-on-force combat interplay. As such, it represents a powerful research base to support training technology research, as well as addressing issues of tactics, doctrine, organization, and equipment effectiveness.

Recognizing the value of NTC exercise history data, USA/TRADOC has requested the U.S. Army Research Institute (ARI-POM) to perform training technology research using NTC data bases. Over the past year, ARI has been building a research capability at POM to support their training technology research mission. This research facility will serve as a tool to support the upgrade and refinement of the NTC training concept, data collection, training feedback techniques, and data bases.

The purpose of this effort was to assist ARI-POM in structuring the prototype research data base and to provide research support capabilities to manipulate and analyze NTC exercise history data. The primary goal was to develop a prototype research aid which could be used to analyze NTC data and place this tool in the hands of ARI-POM users as quickly as possible. Through use of the prototype, more refined requirements could then be determined. This approach was deemed necessary due to the fact that a more complete understanding of the ultimate post exercise feedback (TEP) structure and research objectives were required before a final and completely tailored system could be successfully developed.

1.2 Architecture Of The NTC History Data

The data contained in the NTC history files is primarily received from two sources: the field instrumentation system and operator-entered interactive command and control inputs. The NTC Computational Component (CC) software is responsible for receiving all data, formatting the data into a stream data message format, storing the data in appropriate tables and archiving the data to disk. Data filtering is performed on the incoming data to eliminate position/location messages which do not indicate player movement of at least 12.5 meters. The CC, via the Formatter routine, also eliminates all messages which pertain to rounds remaining and RDMS/MILES self-test.

These messages are not used by the NTC training feedback function.

The Disk Archiver process is called by the CC to write information from shared memory to the disk, thereby building the NTC History data files. The data which is written to disk each five minute update period includes stream data messages and segment snapshot data (i.e., vector tables, side panel statistics tables, control measure tables, indirect fire target/group tables and kernel statistics).

The data maintained in the NTC history files is used for the purpose of replaying a history and generating statistical reports on the performance of tactical units during an engagement. All data which is needed to generate graphic displays, alerts or statistical/graphical reports is saved. Statistical data is aggregated and maintained by unit from the player data received from field inputs. Player level information is maintained in the stream data and vector tables. Because the history data is intended for the purpose of historical graphical replay, the data is formatted to facilitate this process and reduce the large data storage and archival requirements. The data is not in a format which facilitates data base management system access and analysis. For this reason, special software is needed which takes the information available in the NTC history format and translates it to a format which facilitates analysis.

1.3 Scope

As part of this effort, a Translator program and a Loader program were developed. The Translator program accesses the NTC data base, processes the data, and creates human-readable ASCII files. This output can then be used to manually review the available data and is used by the Loader program to fill INGRES data tables which can be more easily analyzed.

The NTC system on which the software requirements for the prototype is based are as specified in the NTC 500 Player System Software Requirements Design Specification (RDS), NTC-1221-18, dated 24 May 1982, including ECRs NTC-101 - NTC-122; and Supplement Integration of the Live Fire Exercise Area, NTC-1221-29, dated 1 December 1982, including ECRs LF-101 - LF-118. This prototype system supports analysis of available NTC data for the baseline NTC system; the Translator program does not, however, accommodate data which is not contained in the NTC data base (e.g., vehicle manning levels, participant social security numbers or terrain data). Such data can, however, be added to the system by creating the appropriate INGRES tables and through entry of data into these tables. Any new data

structures added to the NTC software to accommodate additional NTC capabilities (e.g., AGES/AD) will probably not be handled by the system without updating the Translator and Loader software.

While the system was not designed to handle data from exercises preceeding the Live Fire baseline, it was determined during our July installation that with certain modifications to the Loader software this could be accomplished for data types having a format identical to the October, 1983 exercise. Since this was of importance to ARI, these changes were made.

2.0 TECHNICAL APPROACH

Figure 2-1 depicts an overview of tasks performed under this contract. The primary areas of effort included requirements analysis and definition, system development, test and evaluation, training, and documentation. Each of these areas is described in detail in subsequent paragraphs.

The Prototype National Training Center (NTC) Research Data Base System is comprised of three major components: a Translator program, a Loader program, and an INGRES data base management system. The Translator and Loader programs were developed by SAI; INGRES is an off-the-shelf data base management system procured from Relational Technology, Inc. (RTI) for ARI under this contract, as per direction by ARI.

The purpose of the Translator program is to convert the NTC display-oriented data base into a format which facilitates both the manual analysis of the data and/or its conversion into an INGRES compatible format. The purpose of the Loader program is to read the data included in the translated data base file and fill the appropriate INGRES tables. The Loader utilizes the ASCII data file created by the Translator program to fill the INGRES tables. The INGRES data base management system is used for data analysis and manipulation.

The design of the system has been driven by ARI-POM research objectives, a preliminary ARTEP data base structure provided by ARI-POM, and the structure of the NTC data base and was constrained by the hardware configuration at ARI. SAI was provided with two versions of the ARTEP structure; one which indicated how data was intended to be collected (e.g., automatically, or manually through digital, audio, visual or written means) and who was responsible for the collection of the data (i.e., OC, TAF, OPFOR, CGSC, or Bde). The other document, "NTC Training Recording and Reporting Plan Company OC Book" describes the type of data that the Command and General Staff College expects to receive from NTC. This documentation served primarily to assure that the

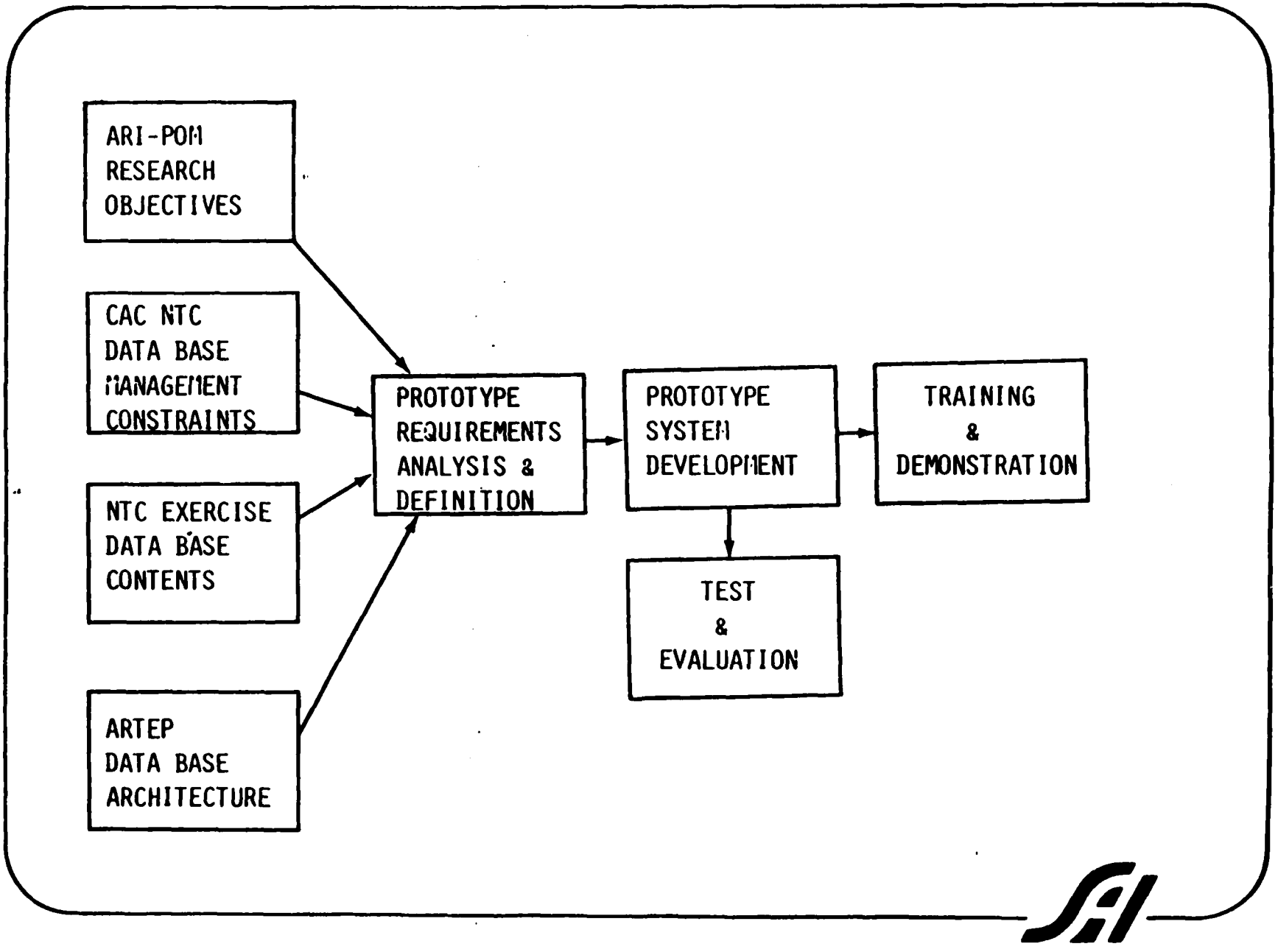

FIGURE 2.1 OVERVIEW OF TECHNICAL APPROACH
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Army (i.e., CAC and ARI) understood the type of data which was available from NTC and the fact that certain calculations (principally maneuver) would have to be calculated manually.

2.1 Requirements Analysis

The Translator and Loader software is intended to provide an initial operating capability which will allow the ARI-POM researchers to gain experience with the use of the system. As agreed upon at our first requirements meeting with ARI, the prototype system being developed under this contract would provide for the direct translation of NTC data, with the exception of a defined list of redundant information. Not all redundancy was eliminated; some duplication of information was included due to the manner in which the NTC data base is designed. A description of the untranslated data is contained in Appendix A, "Requirements Design Specification for A Prototype National Training Center (NTC) Research Data Base System". Even with the untranslated data, this approach provides for the flexible access to all pertinent NTC data.

Because of the diversity of possible needs, the system was designed primarily for flexibility in order to more easily accommodate changes in the direction of the ARI research effort and, therefore, the data is not necessarily in the optimum format for the generation of all INGRES queries. It was determined by ARI and SAI that the decision of exactly which data would be used by ARI in their research tasks could better be made at a later date. This understanding formed the basis for our technical approach. Additional requirements will most likely evolve from continued use of the system for performing their analysis tasks.

The requirements document, as shown in Appendix A, was completed as part of the requirements task. This document defines the functional performance requirements for the Translator and Loader programs, defines the ASCII output of the Translator and defines the INGRES data base design for the system. Also, in response to a request from ARI for more information on the NTC data being provided, a description of each field of data contained in the INGRES tables was also provided in the document. This description is intended to provide ARI with a detailed understanding of the data which is available for analysis and to describe some of the limitations of the data.

A meeting was held at ARI on April 6, 1984 to review all requirements, as presented in the requirements design specification. At this meeting our design approach was reviewed and known system limitations were addressed. SAI

discussed a probable disk space limitation in the evaluation of a number of histories and segments. SAI recommended that in order to review the multiple segments, it may be necessary to copy the INGRES tables to tape and reload only the data which is required for a specific evaluation. In recogniition of disk space limitations, the Translator program has been made flexible enough to provide the operator with the option of not translating certain data (i.e., position/location information, AAR command files and statistical tables) for particular segments. Eliminating the translation of position/location messages can, in itself, preserve a large amount of storage space.

During this meeting SAI also discussed the fact that the Translator program would not be able to accommodate the AGES/AD upgrade to the NTC software. The Translator process involves parsing the many carefully compacted and streamlined, but delicately intertwined NTC data structures and, therefore, it must be able to recognize each data type encountered in the NTC software. A hold file was developed which would prevent the Translator from aborting from the occurrence of an unrecognized message type, however, it was identified and discussed that the system would not be able to accommodate any major changes to the NTC data structures. As the AGES upgrade is still under development and the data structures for that program are still uncertain, this information could not be incorporated into the current version of the Translator program.

Also presented at this meeting were benchmarks which compared the INGRES system with ORACLE, another relational data base which can run on the VAX. ARI had expressed interest in perhaps using ORACLE instead of INGRES. The benchmarks indicated a superior performance with INGRES and the decision was made to continue with INGRES development for the present time.

ARI provided comments on the requirements and information on the types of queries to be performed on May 11, 1984. In their letter, ARI discussed a desire to eliminate redundancy in the data base. Some of the redundancy occurred due to the structure of the NTC data while in other instances certain data fields could be combined. These issues were discussed with ARI and appropriate actions were taken. The requirements document was subsequently reissued to reflect the changes and to include the data field descriptions. Certain of the suggested queries could not be performed because they required arithmetic operations on position/location data which was stored as UTM coordinate values. This problem was also discussed with ARI, however, no direction was given to change the format of the position location information.

2.2 Software Development

The components of the prototype system are shown in Figure 2-2. The system requires the use of NTC history tapes, which may be used for both the NTC review/replay capability or as inputs to the Translator program. The Translator program takes the data contained in the NTC data base format and creates an ASCII output file which can be printed and used for manual analysis or can serve as an input to the Loader program. The Loader program takes the translated NTC data and loads it into the appropriate INGRES tables. The INGRES data base management system is then used for all data queries, manipulations, and reports. Programs can also be written in other languages, such as FORTRAN to support data analysis functions.

The NTC Software Development Facility (SDF) and the SAI Corporate Computer Center were used in the development of the software. The SDF was used to develop the Translator program and to perform initial work on the INGRES data base and Loader program. ARI needed delivery of the INGRES system prior to close of contract so that the system could be installed prior to the installation of the Translator and Loader program. This would allow ARI to set up INGRES training with RTI. Once the licensing for INGRES was changed from SAI (as a temporary licensee) to ARI, development of the INGRES tables and testing of the Loader program was performed on the SAI Corporate VAX, where SAI maintains a licensed copy of INGRES.

A common user interface was developed for the Translator and Loader software. An effort was made to be consistent in the naming of INGRES tables and data fields to facilitate the comparison of data contained in the translated data base and the data loaded into INGRES tables. When operating with INGRES, the INGRES interface facilities will be used exclusively.

While SAI was prepared to deliver the Loader software on 12 June, there were some known problems in the code which prevented certain types of queries from operating. Because of these problems, the contract COR asked that SAI resolve these problems and return with the corrected software on 2 July. When SAI returned on 2 July with corrections, ARI required that the Translator and Loader programs operate on pre-Live Fire software. While this was beyond the scope of the effort, the changes to the software were feasible and were made. SAI returned to La Jolla with the software for further test and evaluation to ensure that the changes did not affect the integrity of the code. The revised software was then mailed to ARI on 12 July.

The detailed requirements for the software are included in Appendix A. Program documentation for the Translator program is included in Appendix B. Program documentation

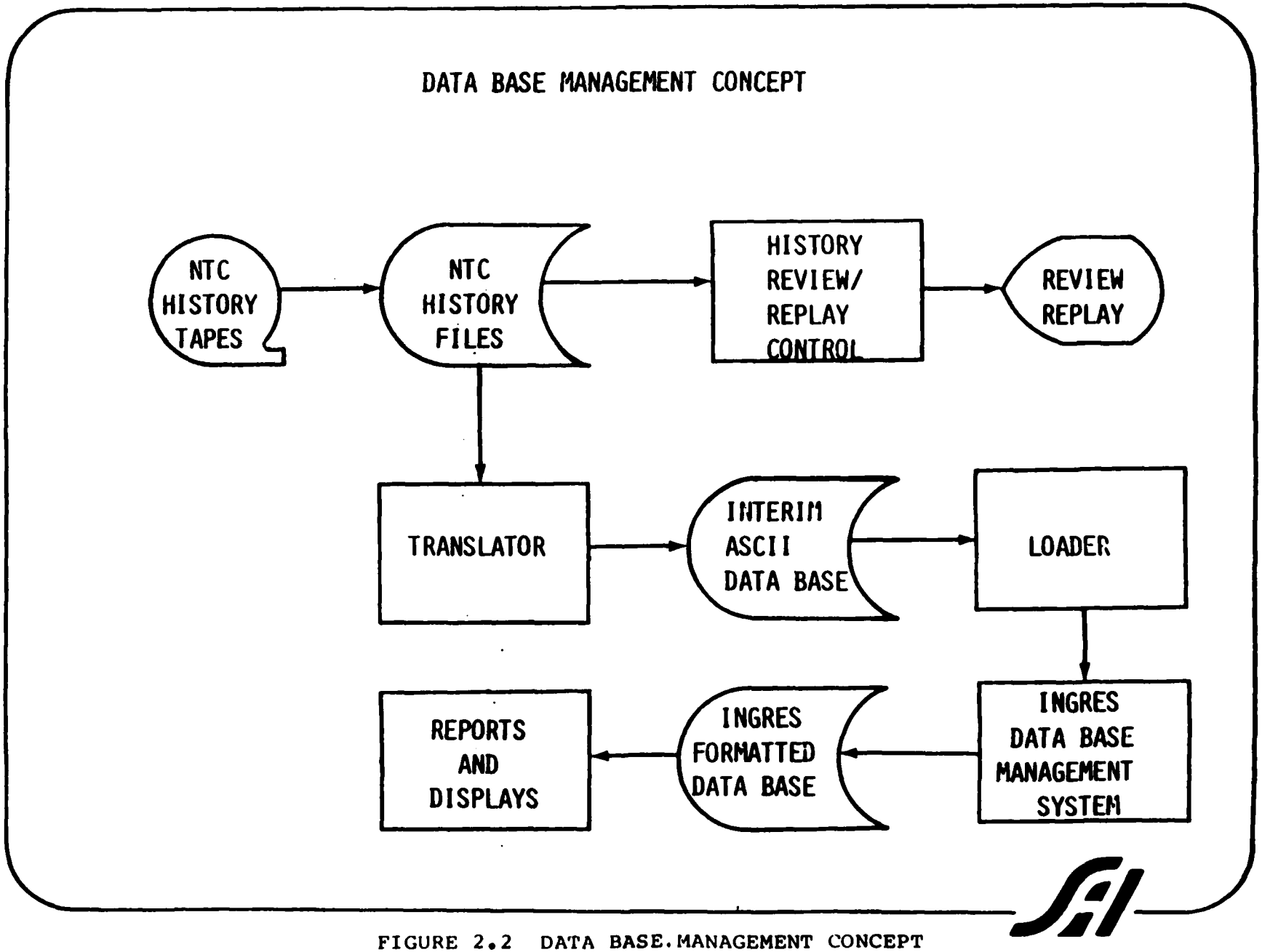

FIGURE 2.2 DATA BASE MANAGEMENT CONCEPT
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for the Loader program is included in Appendix C.

Based upon interest expressed by CAC in being able to read the translated data base files on their Univac system, a study was made to determine how this could be done. As reported in a letter to Dr. Banks at ARI, two possibilities were identified. In option one, a program would need to be developed which reads the translated data output file and creates fixed record length blocked data which can then be written to tape using the VAX QIO command. Due to the variable record length format of the translator's output file, this program would have to be comparable in capabilities to the Loader software developed for ARI. With this program, the Univac system would be able to read standard record length, stardard blocking factor, 9 track, 1600 bpi tapes. This would mean, however, that regardless of the actual data content of any record, it would be of maximum length (i.e., 132 bytes). The Univac user would then need to strip trailing blanks from the tape. The second option would be to write a program which reads a record from the translated output file, searches for the last non-blank character and then pads the record out to 132 bytes. A program would then have to be written which reads this fixed record length file, blocks the records as appropriate and writes to tape using standard VAX QIO to the device.

2.3 Test And Evaluation

Testing of the Translator and Loader programs was conducted at SAI prior to installation of the software at ARI. A combination of techniques was utilized to ensure that each type of NTC data was translated correctly. These techniques, which are described below, were required due to the various types of information which must be considered by the Translator program.

To verify history and segment names and the segment start and end times provided by the Translator, the selected NTC history was restored to an NTC replay slot and the History Segment Select menu was used to verify the segment names. The segment start time was verified by selecting the segment and recording the time at the start of the segment. The segment end time was verified by using the "Step to End of Segment" button on the graphics tablet and recording the time. The data recorded from the replay of the history was then compared to the output of the Translator program.

The segment header and trailer data could not be verified in full, however, the segment name displayed in the menu is comprised of the battalion operations mission code, the date and the key training objective codes. By looking at the translated header data and the segment name, these

items could be verified. Since the data comes from various places in the header data it was determined that the remainder of the data was being correctly translated. A visual check was also made to ensure that appropriate data was provided in each field.

After selecting a history and segment, the segment was replayed to determine which significant events occurred. The time of the events was then recorded. The Translator program was then run for the period of time in which the events occurred and the data was checked to see that it corresponded to the displayed events. A utility program which counts stream data messages (DMPSTR) was used to verify message counts. This program does not verify message content; that activity had to be done manually.

To verify the Unit State Vector Table, the Player State Vector Table, the Control Measure Vector Table Index and the Control Measure Vector Table, an NTC dump utility (DMPVT) was used. This utility provides a formatted (but not ASCII translated) dump of the tables. This output was then used to verify the content of the translated tables.

To verify the remaining logs and tables, the NTC replay software was used to call up the statistical displays which access this data. By choosing the correct times in the display request menus, the data which was translated can be duplicated and verified.

Figure 2.3-1 describes which history segments were used for evaluation of the translated data and indicates those fields for which data could not be verified. Each NTC data item is broken out individually, including all translated message types. Test segment 1 is a TSD segment from March, 1984; test segment 2 is segment 9 from the April, 1984 NTC rotation; test segment 3 is segment 10 from the April, 1984 NTC rotation; and, test segment 4 is segment 3 from the October, 1983 NTC rotation.

To verify the Loader software, printouts from the Translator program were compared with printouts of the filled INGRES tables. This data was then visually checked to ensure that all fields were loaded into the tables correctly. INGRES queries were then written, based upon inputs from ARI, which would ensure that data loaded into the tables could be accessed with INGRES. These queries were reviewed and discussed as part of the training program at ARI.

Item	Seg 1	Seg 2	Seg 3	Seg 4
1. Segment Header	X	X	X	X
2. Segment Summary	X	X	X	X
3. Miles Firing	X	X	X	X
4. Pairing	X			X
5. Ground Player PL	X	X	X	X
6. Air Player PL				
7. Miles Commo		X	X	X
8. Equip Status (B Unit)				X
9. Equip Status (A Sta)				X
10. Equip Status (C Sta)				X
11. Equip Status (D Sta)				X
12. Live Fire Scenario		X	X	
13. Live Fire Target Status		X		
14. Live Fire Target Event		X	X	
15. Ground Unit PL	X	X	X	X
16. PSVT Status Change	X	X	X	X
17. Unit Engagement	X			X
18. IFCAS Target Engagement				X
19. IFCAS Casualty Recommendation				X
20. IFCAS Alert				
21. Mixed Unit				X
22. Player ID		X		X
23. Player Redesignate				
24. Control Measure Add	X		X	X
25. Control Measure Delete	X	X	X	X

FIGURE 2.3-1 TEST AND EVALUATION HISTORY SEGMENTS (PAGE 1 OF 2)

26. Unit ID				
27. Unit Redesignate				X
28. PSVT Instrumented Bit Change				
29. Player Edit				
30. Unit Edit				
31. Tracking Status		X	X	X
32. Unit State Vector Table	X	X	X	X
33. Player State Vector Table	X	X	X	X
34. Control Measure Vector Table		X	X	X
35. IFCAS Pre-Planned Target Table		X	X	X
36. IFCAS Target Group Table		X	X	X
37. Target Matrix Vector Table		X	X	
38. OC Assessments				X
39. Personnel Casualty Log				
40. Fire Support Log				X
41. Minefield Casualty Log				
42. Engagement Range Table	X	X	X	X
43. Firing and Pairing Table	X	X	X	X
44. Unit Engagement Table	X	X	X	X
45. Unit Transmission Table	X	X	X	X
46. Unit Movement Table	X	X	X	X
47. Unit Vehicle Status	X	X	X	X
48. Personnel Casualty Summary	X	X	X	X
49. Viper/Dragon Engagement Table	X	X	X	X
50. Other Weapons Table	X	X	X	X

FIGURE 2.3-1 TEST AND EVALUATION HISTORY SEGMENTS (PAGE 2 OF 2)

2.4 Training

Following installation of the software at ARI-POM on 12 June, SAI trained ARI personnel in the use of the Translator and Loader programs. As part of the training, SAI reviewed the "Operator's Manual For the Use of the Translator and Loader Programs for the Prototype NTC Research Data Base System" which is included in Appendix D of this document. This training reviewed the purpose of the programs, how the programs are run, the outputs of the program, and any error conditions which might occur during processing. Since operation consists of a single command, training on the Loader program was provided even though installation of the software was deferred per ARI's request.

Following the operator training, SAI provided a seminar/discussion period with ARI researchers to discuss general capabilities of the software and to describe in detail the structure of the INGRES data base developed as part of this effort. As part of this training, SAI provided a description of each INGRES table and the type and source of data which is included in the tables. The material presented at this training session is included in Appendix A. SAI was prepared for discussion of this information, however, ARI felt that at this time discussion would be unnecessary since the document was available for reference.

Following installation of the Loader software on 2 July, SAI ran several queries on the NTC data to demonstrate successful operation of the programs. While this demonstration was necessarily short due to our on-site initial evaluation effort of the relative feasability of translating pre-Live Fire data, the capabilities of the system were shown. Since ARI had not yet received INGRES training (scheduled for September 1984) there was some question as to how much ARI understood the command language associated with the queries. SAI left a command file which contains the sample queries which can be reviewed by ARI following INGRES training.

All training associated with the use of the INGRES system will be provided by RTI and must be arranged for by ARI. The success of the prototype system involves a detailed and complete understanding of the capabilities of INGRES. The development of queries and the ability to manipulate the data contained in the tables requires a full and detailed knowledge of INGRES capabilities and procedures.

2.5 Documentation

Documentation has been provided in all major areas of work. A Requirements Design Specification (Appendix A) details the requirements of the software; Translator program documentation (Appendix B) and Loader program documentation (Appendix C) describe the software routines associated with each program; and, an Operator's Manual (Appendix D) provides assistance in running the Translator and Loader programs. INGRES documentation, as provided by RTI, was delivered to ARI with the shipment of the INGRES software.

3.0 RECOMMENDATIONS

SAI recommends that the following operational issues be resolved by ARI in order to fully utilize the capabilities provided with the Translator and Loader programs:

1. SAI recommends that a single person be assigned as a Data Base Administrator and this should be the only person with the authority to run the Translator and Loader programs. It is our opinion that without this type of control the integrity of the INGRES data base cannot be maintained.

2. INGRES training must be attended by as many researchers as possible. The real power of the tool which has been provided to ARI lies in the data base management system, INGRES. SAI has provided software to load NTC data into INGRES; the manipulation of that data lies in the features which are provided in INGRES. A thorough understanding of the capabilities provided by the data base management system will greatly facilitate all research performed.