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NATURAL LANGUAGE QUERY SYSTEM DESIGN FOR INTERACTIVE INFORMATION STORAGE AND RETRIEVAL SYSTEMS: PRESENTATION VISUALS

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NATURAL LANGUAGE QUERY SYSTEM DESIGN

FOR

INTERACTIVE INFORMATION STORAGE

AND RETRIEVAL SYSTEMS

A Thesis

Presented to

The Graduate Faculty of

The University of Southwestern Louisiana

In Partial Fulfillment of the

Requirements for the Degree

Master of Science

I-Hsiung Liu

April 1985
OVERVIEW

* INTRODUCTION

* WHY STUDY CASUAL USER/SYSTEM INTERACTION

* RESEARCH OBJECTIVES AND METHODOLOGY

* SCOPE OF THE RESEARCH

* IMPORTANCE OF NATURAL LANGUAGE QUERY SYSTEMS DEVELOPMENT

* DYNAMICS OF INFORMATION STORAGE AND RETRIEVAL SYSTEMS

* FORMAL QUERY INTERFACE AND INFORMATION RETRIEVAL

* NATURAL LANGUAGE INTERFACE AND INFORMATION RETRIEVAL

* FORMAL QUERY APPROACH AND NATURAL LANGUAGE APPROACH
OVERVIEW (CONT'D)

* NATURAL LANGUAGE QUERY SYSTEMS DEVELOPMENT
* NATURAL LANGUAGE PROCESSING
* LANGUAGE CAPABILITIES OF NATURAL LANGUAGE QUERY SYSTEMS
* PHASES OF NATURAL LANGUAGE PROCESSING
* FRAMEWORK
* DESIGN METHODOLOGY
* INTERFACES OF NATURAL LANGUAGE QUERY SYSTEMS
* INFORMATION RESOURCES FOR NATURAL LANGUAGE PROCESSING
* FUNCTIONAL FEATURES OF THE SYSTEM
* CONCLUSIONS
WHY STUDY CASUAL USER/SYSTEM INTERACTION

* CASUAL USERS: THE POTENTIALLY LARGEST USER GROUP
* NATURE OF CASUAL USERS
  * IRREGULAR INTERACTION WITH THE SYSTEM
  * LACK KNOWLEDGE ABOUT COMPUTERS, PROGRAMMING, ETC.
  * NOT WILLING TO LEARN ANY ARTIFICIAL LANGUAGE
* PROBLEMS OF CONVENTIONAL MULTI-LEVEL QUERY SYSTEMS
  * HUMAN INTERFACES AS A ONE-WAY COMMUNICATION PROCESS
  * LANGUAGE INTERFACES FOR EXPERIENCED USERS
  * HUMAN INTERMEDIARY OFTEN STILL REQUIRED
OBJECTIVES AND METHODOLOGY

* OBJECTIVES
  * PROPOSE A FRAMEWORK FOR EXPLORING NATURE, SCOPE, AND CONTENT OF THE EVOLVING TOPIC OF NATURE LANGUAGE QUERY SYSTEMS (NLQS)

* METHODOLOGY
  * EXAMINE THE RATIONALE FOR NLQS DEVELOPMENT
  * REVIEW CONCEPTS AND APPROACHES TO NLQS DEVELOPMENT
  * PRESENT THE FRAMEWORK FOR NLQS DEVELOPMENT
SCOPE OF THE RESEARCH

* THE TARGET SYSTEM OF THE RESEARCH

* INFORMATION STORAGE AND RETRIEVAL SYSTEMS (IS&R SYSTEMS)

* REASONS FOR STUDYING IS&R SYSTEMS

* WELL-DEFINED PROBLEM AREA

* WELL-UNDERSTOOD SEMANTICS

* WELL-STRUCTURED DATA ORGANIZATION

* COLLECTIONS OF PUBLICATIONS

* DATA OF NATURAL LANGUAGE TEXTUAL FORM

* PRE-PROCESSED DATA

* THE PRIMARY FUNCTION OF IS&R SYSTEM

* INFORMATION RETRIEVAL
DYNAMICS OF IS&R SYSTEMS

* FOUR COMPONENTS OF MAN/COMPUTER COMMUNICATION PROCESS

* TASK OF INFORMATION RETRIEVAL

* USERS

* USER INTERFACES

* DATABASES
DYNAMICS OF IS&R SYSTEMS (CONT'D)

* LEVEL OF DIFFICULTY

* COMPLEXITY

* NUMBER OF STATES (NUMBER OF EVENTS OR WAYS OF ARRANGING THEM) IN A PARTICULAR APPLICATION

* DETERMINISM

* EXTENT TO WHICH THE OCCURRENCE OF EVENTS OR THEIR SEQUENCE CAN BE PREDICTED IN ADVANCE
DYNAMICS OF IS&R SYSTEMS (CONT'D)

* KNOWLEDGE REQUIRED

* DOMAIN-SPECIFIED KNOWLEDGE

* INFORMATION EXISTING IN THE DATABASE ENVIRONMENT E.G., WELL-STRUCTURED DATABASE STRUCTURES

* WORLD KNOWLEDGE

* INFORMATION EXISTING IN REAL WORLD ENVIRONMENT E.G., UNSTRUCTURED DATA OR LINGUISTIC DATA
DYNAMICS OF IS&R SYSTEMS (CONT’D)

* DATABASES

* MODELS OF CERTAIN REALITY

* LEVELS OF ABSTRACTIONS

  * ENSURE BOTH PHYSICAL AND LOGICAL DATA INDEPENDENCE

  * ALLOW RETRIEVED DATA CLOSER TO USER’S VIEW
DYNAMICS OF IS&R SYSTEMS (CONT’D)

* USERS

* END USERS

* CUSTOMERS OF COMPUTER SYSTEMS

* PROGRAMMERS

* BUILDERS OF APPLICATION PROGRAMS

* DATABASE ADMINISTRATORS

* MANAGERS OF INDIVIDUAL DATABASES
DYNAMICS OF IS&R SYSTEMS (CONT'D)

* USER INTERFACES

* CONCEPTS OF HIERARCHY OF USER LANGUAGES

* EACH INTERFACE IS DEFINED IN TERMS OF A LOWER INTERFACE

* EACH INTERFACE MAY SERVE AS THE BASIS FOR THE DEFINITION OF A HIGHER INTERFACE

* EXACTLY ONE INTERFACE SERVES AS THE ULTIMATE BASIS FOR ALL OTHER INTERFACES
DYNAMICS OF IS&R SYSTEMS (CONT'D)

* USER INTERFACES (CONT'D)

* ADVANTAGES OF THE CONCEPT
  * IT IS ALWAYS POSSIBLE TO DEVELOP AN INTERFACE ON TOP OF THE CURRENT LANGUAGE HIERARCHY
  * THE DEVELOPMENT OF A HIGHER INTERFACE REDUCES THE BURDEN ON END USERS
  * THE DEVELOPMENT OF HIGHER INTERFACE IMPLIES THE REDUCTION OF SYNTACTIC RESTRICTION ON THE USE OF LANGUAGE FACILITIES

* TWO MAJOR TRENDS OF USER INTERFACES DEVELOPMENT
FORMAL QUERY INTERFACE AND INFORMATION RETRIEVAL

* TASK OF FORMAL QUERY DATABASE SEARCHING
  * NARROW DOWN THE SEARCH SPACE
  * MAJOR FUNCTIONS
    * EXIST / COUNT
  * PRIMARY OPERATIONS -- FETCH OPERATIONS
  * DEMANDS ON DATABASE DESIGN
    * OPTIMIZE THE SPEED OF FETCH OPERATIONS
      * INVERTED FILE STRUCTURES
      * SEARCH TERM CLASSIFICATIONS
  * KNOWLEDGE REQUIRED
    * SYSTEM -- DOMAIN SPECIFIED KNOWLEDGE
    * USERS
      * FORMAL LANGUAGE SYNTAX
      * SEARCH TERMS AND INDEXES
      * BOOLEAN AND RELATIONAL OPERATIONS
N. L. INTERFACE AND INFORMATION RETRIEVAL

* PURPOSE OF NLQS DEVELOPMENT
  * COPE WITH THE NATURE OF CASUAL USERS
  * ALLOW USERS TO EXPRESS THEIR NEEDS BASED ON THEIR OWN PERCEPTIONS
  * ALLOW USERS PERFORM QUERIES BASED ON THEIR ABILITY TO DEAL WITH NATURAL LANGUAGE SYNTAX
  * ONE-STEP TRANSLATION PROCESS

* KEY ISSUES OF NATURAL LANGUAGE QUERY SYSTEM DEVELOPMENT
  * DEVELOP SYSTEM ABILITY TO PERFORM NATURAL LANGUAGE TRANSFORMATION
  * IMPACT OF THE DEVELOPMENT ON OTHER INFORMATION RETRIEVAL COMPONENTS IN THE SYSTEM
FORMAL QUERY APPROACH AND N. L. APPROACH

* SIMILARITY

* BOTH ALLOW A USER TO SPECIFY "WHAT" HE WANTS THE MACHINE TO DO

* DIFFERENCES

* USER ORIENTED VERSUS SYSTEM ORIENTED

* USER REQUIREMENTS

* NATURAL OF THE LANGUAGE FACILITY

* LANGUAGE TRANSLATION PROCESS
FORMAL QUERY APPROACH AND N. L. APPROACH (CONT'D)

* ARGUMENTS AGAINST NATURAL LANGUAGE APPROACH
  * AMBIGUOUS AND IMPRECISE
  * TIME CONSUMING
  * RECOGNITION OF THE IMPORTANCE OF NATURAL LANGUAGE APPROACH

"WHILE THE QUESTION OF THE EFFECTIVE INTERFACE BETWEEN MAN/MACHINE INTERACTION IS RAISED, THE ISSUES OF CONCERN ARE THE HUMAN FACTOR ISSUES."
NATURAL LANGUAGE PROCESSING

* ACTIVITIES OF NATURAL LANGUAGE PROCESSING
* TRANSLATING NATURAL LANGUAGE STATEMENTS INTO THEIR FORMAL COUNTERPARTS
* GENERATING NATURAL LANGUAGE RESPONSES TO USER'S REQUESTS
* INTELLIGENT USE OF SYSTEM KNOWLEDGE
* TYPES OF SYSTEM KNOWLEDGE
* USE OF SYSTEM KNOWLEDGE
NATURAL LANGUAGE PROCESSING (CONT’D)

* ISSUES RELEVANT TO NATURAL LANGUAGE PROCESSING
* LANGUAGE CAPABILITIES
* PHASES OF NATURAL LANGUAGE PROCESSING
* OPERATIONS REQUIRED FOR EACH PHASE
* KNOWLEDGE APPLIED IN EACH PHASE
LANGUAGE CAPABILITIES OF NLQS

* DIFFICULTIES OF IDENTIFYING LANGUAGE CAPABILITIES
* COMPLEXITY OF NATURAL LANGUAGE
* UNPREDICTABILITY OF HUMAN ERRORS

LANGUAGE CAPABILITIES EXHIBITED IN MOST SYSTEMS
* ANSWER DIRECT QUESTIONS
* HANDLE SIMPLE USE OF PRONOUNS AND ELLIPSIS
* ANALYZE NULL ANSWERS
* RESTATEMENT OF USER INPUTS
* CORRECT TYPOGRAPHIC OR SPELLING ERRORS
PHASES OF NATURAL LANGUAGE PROCESSING

* SYNTACTIC ANALYSIS
  * LEXICAL ANALYSIS -- CLEAN UP THE USER INPUT
  * WORD BY WORD TRANSFORMATION
  * LEXICON

* PARSING -- GENERATE TREE STRUCTURE OF INPUT
  * TEMPLATE MATCHING PARSER
  * PHRASE STRUCTURE GRAMMAR PARSER
  * TRANSFORMATIONAL GRAMMAR PARSER
  * SEMANTIC GRAMMAR PARSER
PHASES OF NATURAL LANGUAGE PROCESSING (CONT'D)

* SEMANTIC ANALYSIS

* GENERATE INTERNAL TARGET REPRESENTATIONS FROM NATURAL LANGUAGE INPUTS

* TYPES OF INTERNAL TARGET REPRESENTATIONS
  * WEIGHTED VECTORS
  * FIRST-ORDERED PREDICATES
  * SEMANTIC NETWORKS
  * CASE FRAMES
PHASES OF NATURAL LANGUAGE PROCESSING (CONT'D)

* EXECUTION PHASE

* PERFORM DATABASE SEARCHING

* APPROACHES TO EXECUTION

  * DIRECTLY USING INTERNAL TARGET REPRESENTATION

  * USING BOOLEAN CONDITIONS

  * USING SYSTEM-DEFINED FORMAL QUERY REPRESENTATIONS
PHASES OF NATURAL LANGUAGE PROCESSING (CONT'D)

* RESPONSE GENERATION
  * PROVIDE PRECISE NATURAL LANGUAGE RESPONSE
* TYPES OF RESPONSES
  * DETECTED/CORRECTED ERRORS
  * RESTATEMENT OF LOGICALLY COMPLETED QUERY
  * DIRECT AND CORRECT ANSWERS TO THE QUERY
  * COOPERATIVE RESPONSES
FRAMEWORK

* GOALS OF THE FRAMEWORK
* DESCRIBE DESIGN METHODOLOGY
* STATE MAJOR DESIGN PROBLEMS
* DESCRIBE INTERFACES OF THE SYSTEM
* DESCRIBE FLOW OF CONTROL
* IDENTIFY SYSTEM COMPONENTS AND THEIR FUNCTIONS
* DESCRIBE RELATIONSHIPS BETWEEN SYSTEM COMPONENTS
DESIGN METHODOLOGY

* PROBLEMS OF TRADITIONAL APPROACH
  * UNABLE TO PROVIDE COOPERATIVE ANSWERS
  * UNABLE TO "UNDERSTAND" THE USER'S INPUTS
  * RESTRICTED NATURAL LANGUAGE INPUTS

* BASIC CONSIDERATIONS OF THE DESIGN
  * SYSTEM'S ABILITY TO "UNDERSTAND" NATURAL LANGUAGE
  * SYSTEM'S REQUIRED LINGUISTIC KNOWLEDGE
    * GRAMMAR RULES
    * SEMANTIC RULES
    * INTERNAL REPRESENTATIONS OF NATURAL LANGUAGE
DESIGN METHODOLOGY (CONT’D)

* DESIGN APPROACH
  * EXPERIMENTAL APPROACH
  * RESTRICTED DOMAIN KNOWLEDGE
  * RESTRICTED LANGUAGE CAPABILITIES

* MAJOR DESIGN PROBLEMS
  * REDUNDANT WORDS OR PHRASES
  * AMBIGUITY AND VAGUENESS
  * ERROR DETECTION AND CORRECTION
INTERFACES OF NLQS

* NATURAL LANGUAGE INTERFACE

* INTERFACE OF CASUAL USER/SYSTEM INTERACTION

* MAJOR CONCERNS

* SYNTACTIC ANALYSIS OF NATURAL LANGUAGE INPUTS

* INTERPRETATION OF NATURAL LANGUAGE INPUTS

* NATURAL LANGUAGE RESPONSE GENERATION

* USER/SYSTEM DIALOGUE CONTROL
INTERFACES OF NLQS (CONT’D)

* FORMAL LANGUAGE INTERFACE
* INTERMEDIATE INTERFACE BETWEEN NATURAL LANGUAGE INTERFACE AND DATABASE INTERFACE
* MAJOR CONCERNS
  * TARGET REPRESENTATION AND FORMAL QUERY TRANSFORMATION
  * PORTABILITY
* DATABASE INTERFACE
* EXECUTION LEVEL
INFORMATION RESOURCES FOR NL PROCESSING

* DOMAIN SPECIFIED KNOWLEDGE
  * INFORMATION ABOUT PART OF A DOCUMENT FILE
  * SOURCES OF THE KNOWLEDGE
    * BIBLIOGRAPHIC DATABASES
    * INVERTED FILES AND THESAURUS
* WORLD KNOWLEDGE
  * LINGUISTIC KNOWLEDGE
    * INFORMATION ABOUT A DOCUMENT FILE
    * SOURCE OF THE KNOWLEDGE
    * SEMANTIC NETWORKS
FUNCTIONAL FEATURES OF THE SYSTEM

* PARSER
* INTERPRETER
* FORMAL QUERY GENERATOR
* NATURAL LANGUAGE RESPONSE GENERATORS
* ERROR GENERATOR
* RESTATEMENT GENERATOR
* REPLY GENERATOR
FUNCTIONAL FEATURES OF THE SYSTEM (CONT'D)

* PARSER

* LEXICAL ANALYZER

* DELETE NOISE WORDS

* REPLACE INPUT WORDS BY THEIR LEXICON CLASS ENTRIES

* SUBSTITUTE ROOTS AND INFLECTION MARKERS

* PHRASE CONSTRUCTION ROUTINE

* SPELLING CORRECTION AND ENTRY ADDITION ROUTINE
FUNCTIONAL FEATURES OF THE SYSTEM (CONT'D)

* PARSER (CONT'D)

  * ATN PARSER
    * NON-DETERMINISTIC ANALYSIS
    * RESOLVE LEXICAL AMBIGUITY
    * QUALIFIER HANDLING
    * ELLIPSIS AND PRONOUN REFERENCE HANDLING
  * FAILURE OF PARSING
FUNCTIONAL FEATURES OF THE SYSTEM (CONT'D)

* INTERPRETER
  * GENERATE A SUBSET OF SEMANTIC NETWORK FOR USER INPUTS

* CASE FRAMES
  * REPRESENTING A SUBSET OF SEMANTIC NETWORK IDENTIFIED BY THE VERB OR CHARACTERISTICS-
  * CONSISTING OF A LIST OF INTERRELATED NP'S

* SEMANTIC AMBIGUITY HANDLING

* FAILURE OF SEMANTIC ANALYSIS
FUNCTIONAL FEATURES OF THE SYSTEM (CONT’D)

* FORMAL QUERY GENERATOR

* TRANSLATE FILLED-IN CASE FRAMES INTO ONE OR MORE FORMAL QUERY EXPRESSIONS

* DETERMINE THE TYPES OF THE USER REQUEST

* SELECT SPECIFIC SEARCH COMMAND WORD(S)

* SELECT SEARCH TERMS

* EXAMPLE

CONTAIN: DESTINATION

= TEXT TERM(SUBJ) = "COMPUTER"

OBJECT - DOC REF CODE(OBJ) = ?

FORMAL QUERY:

SELECT TEXT TERM EQ COMPUTER
FUNCTIONAL FEATURES OF THE SYSTEM (CONT’D)

* NATURAL LANGUAGE RESPONSE GENERATORS
  * GENERATE APPROPRIATE FEEDBACK TO THE USER
  * ERROR GENERATOR
    * SYNTACTIC ERRORS
    * SEMANTIC ERRORS
  * RESTATEMENT GENERATOR
    * TO OBTAIN THE USER’S APPROVAL
    * RESTATEMENT CONSTRUCTION
      -- CASE FRAMES
  * REPLY GENERATOR
  * OUTPUT SEARCH RESULTS
CONCLUSION

* ACHIEVEMENTS OF THE FRAMEWORK
* PROVIDE A SOLID THEORETICAL FOUNDATION FOR IS&R NLQS DEVELOPMENT
* CONSTRUCT A SOUND IS&R NLQS ARCHITECTURE

* THE THEORETICAL FOUNDATION
* DYNAMICS OF INFORMATION RETRIEVAL
* LEVELS OF ABSTRACTIONS
* HIERARCHY OF USER LANGUAGES
* NATURAL LANGUAGE PROCESSING
* EXPERIMENTAL APPROACH TO SYSTEM DEVELOPMENT
CONCLUSION (CONT’D)

* THE ARCHITECTURE

* MAJOR ASSUMPTIONS

* NLQS DEVELOPMENT IS TO BUILD A SYSTEM WHICH CAN SIMULATE HUMAN BEHAVIOR

* NLQS DEVELOPMENT WOULD AFFECT THE DYNAMIC RELATIONSHIPS AMONG SYSTEM COMPONENTS

* INTERFACES

* PORTABILITY

* EXTENDABILITY

* FUNCTIONAL MODULES

* FUNCTIONAL DECOMPOSITION

* BLACK BOX APPROACH
*  INTERPRETER

WRITE: DESTINATION

= AUTHOR (OBJ)

OBJECT = AUTHOR (OBJ)

WRITE -----> AUTHOR --------> "MARTIN, T."

OBJ

+-----> ARTICLE

"INFORMATION RETRIEVAL"
<table>
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<tr>
<th>INDEX TERM</th>
<th>DOC REF CODE</th>
<th># DOC'S</th>
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<tr>
<td>COMPUTER</td>
<td>3, 5, 8, 9</td>
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<tr>
<td>INFORMATION</td>
<td>1, 2, 4, 7, 9</td>
<td>5</td>
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USER

natural language query

NATURAL LANGUAGE INTERFACE

internal representation (semantic nets)

FORMAL LANGUAGE INTERFACE

formal query

DATA BASE INTERFACE

DATA BASE
<table>
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<tr>
<th><strong>FACT</strong></th>
<th><strong>REALITY</strong></th>
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<td><strong>Information Structure</strong></td>
<td><strong>USER'S LOGICAL LEVEL</strong></td>
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<td><strong>Information Structure Description Language (ISDL)</strong></td>
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<td><em>(logical data independence)</em></td>
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<td><strong>Data Structure</strong></td>
<td><strong>SYSTEM'S LOGICAL LEVEL</strong></td>
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<td><strong>Data Structure Description Language (DDL)</strong></td>
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<td><em>(physical data independence)</em></td>
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<td>FACT RETRIEVAL</td>
<td>* PRE-PROCESSED DATA</td>
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<td>* EXTENSIVE USE OF FETCH OPERATION</td>
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<td>* RESULTS DIRECTLY OBTAINED FROM DATABASES</td>
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<td>* SIMPLE REQUEST-RESPONSE SEQUENCE</td>
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<td>* EXTENSIVE USE OF GET-NEXT OPERATIONS</td>
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<td>* DATA REDUCTION PROCESS</td>
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<td>DEDUCTIVE INFERENCE</td>
<td>* SEMI-STRUCTURED DATA AND RULES INFERENCE</td>
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<td>* SYSTEM MUST ANSWER WHY-QUESTIONS</td>
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<td>* RESULTS DEPENDENT ON THE SEARCH FOR POSSIBLE RELATIONS BETWEEN DATA</td>
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<td>Level of Difficulty</td>
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**Abstract**


This report represents one of the 72 attachment reports to the University of Southwestern Louisiana's Final Report on NASA Grant NGT-19-010-900. Accordingly, appropriate care should be taken in using this report out of the context of the full Final Report.