

# TECHNICAL REPORT

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## Technical and User Review of the Nodal Analysis Tool

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## **EXECUTIVE SUMMARY**

This document presents the results of a technical and user review of the Nodal Analysis Tool (NAT), a web-based e-learning model of the oil and natural gas industry. The primary purpose of this review has been to obtain objective input on the current usefulness, functionality and maintainability of the application, as well as obtain specific recommendations for improvement. A cross-section of users representing academia, industry, technology vendors, non-for-profit environmental organizations, government and environmental engineering consultants was surveyed. In addition, a technical review of the application architecture and programming was completed.

Overall, the reviewers felt the NAT was a useful tool. While there were some areas of general agreement, there were also some areas of conflicting opinion. Clearly, it is not possible to make the NAT satisfy the needs and expectations of all users. Nonetheless, sufficient input was provided to facilitate the development of key recommendations for future enhancement and refinement of the application.

The key areas for improvement comprised the following:

- Refinement of the architectural design of the application to facilitate improved maintainability and on-going enhancement of the applications.
- A variety of improvements to the navigational functionality of the application.
- Enhancement of the database content.

It is recommended that these improvements be implemented as part of the next phase of development.

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## 1 **INTRODUCTION**

This report presents the results of a technical and user review of a web-based interactive flowsheet-style model of the oil and natural gas industry. This application is referred to throughout the remainder of this report as the Nodal Analysis Tool (NAT). The primary purpose of the review has been to develop recommendations for further refinement and enhancement of the application. The review comprised a limited survey of potential industry, government, technology vendor, researcher and institutional end users, and a critical review of the current program architecture. Input and comments were sought in two general areas: (1) NAT content and (2) Ease of use. The reviewers were requested, via a list of questions, to focus on the usefulness of the NAT as a training tool for users from industry, research and government groups. The overall aim was to obtain guidance for development of the NAT in a manner that best meets the needs of the key user groups.”

The current version of the NAT, available on the internet at <http://osio.clearstone.ca>, was used as the basis for this review. The NAT, as partially updated in March 2010 under contract with PTAC, was developed as an NRCan version from the original USEPA Global Methane Initiative (formerly known as the Methane to Markets [MTM] Partnership) platform.

A copy of the instructions and questions provided to the reviewers is presented in Append 1. The information requested was very comprehensive and required the trial users to thoroughly and critically search the NAT, taking into consideration the perspective of the potential audience, from technical novices to industry experts. Some of the experts contacted (ten in all) were not able to respond due to personal work and schedule commitments. Those that provided input are listed in Appendix 2. The feedback from the six reviewers was very comprehensive and as such it was not necessary to solicit further input via another round of requests (copies of the responses provided by each reviewer are presented in Appendix 3).

An overview of the reviewer responses is provided in Section 2.

Section 3 delineates the key recommendations based on the reviewer input.

Section 4 summaries the technical review of the NAT architecture and code provided by Dr. Dan Field. A complete copy of his report is presented in APPENDIX 4.

The final recommendations of this study and a work plan for prioritization of these recommendations is presented in Section 5.

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## **2 EXPERT FEEDBACK**

The majority of the reviewers addressed all of the questions on the list, with some providing comprehensive detail on technical content, NAT structure and mechanics of use. Most recommended areas for additional technical content and advised they would be willing to participate in development of such content. The reviewers were unanimous in defining a need for substantially more information on the subject of the environment, particularly industry impacts, technologies and controls, as well as attendant regulations.

Significant problems were identified in the NAT ease of use related to accessing or searching for information. Comments were also received that pointed to the problem of achieving consistency across the industry sectors (Oil, Natural Gas and Oil Sands) in terms of type and level of information.

The sections below present the consolidated views of the expert reviewers. Differences of opinion are noted such that decisions will ultimately be required to resolve the best approaches when the NAT is upgraded in future work.

### **2.1 Current Content of the NAT**

#### **2.1.1 NAT Objective and User Focus**

All of the reviewers agreed with the objective of the NAT as being primarily a learning and education tool for those being introduced to the oil and gas industries. However, one key comment was that this objective was not clear to the first-time user, and it should be identified as a first display when the NAT is accessed. This objective would clearly state the anticipated audience and identify the purpose of the learning program. Additional comments supported the idea of a “Home” page as a starter page.

The reviewers also were consistent in concurring with the present general format based on flow diagrams, icons and direct links to more detailed flow schemes and the sub subjects, e.g. Industry Description. Opinions varied as to the amount of content that should be included in various areas and the extent and depth of knowledge that could be added. In other words, there was some variation in opinion on the ultimate level of user background and user expertise that should be targeted. These opinions are further expanded in the detailed sections below.

#### **2.1.2 Flow Diagrams and Graphics**

All of the reviewers stated that the flow diagrams themselves were good and very useful. The main critique was that there was not consistency across the industry sectors and across the various nodal levels. For example, one sector (Oil) contains some flow sheets at the P&ID level, and it is recommended to eliminate these. Two reviewers also suggested strongly that some technologies, the main example being flaring, were treated too generally and that flaring should be included in only those processing areas where flaring is practiced, but also with appropriate detail of description.

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The majority of the reviewers advised that the NAT requires substantially more graphics and photos, particularly in the Industry Descriptions. This has always been the objective of the NAT developers, subject to the availability of these materials. In particular, representative photos of many of the processes presented as flow diagrams have not been available due to confidentiality restrictions by industry operators. This challenge has to be addressed going forward.

Specific comments were made regarding the need to expand the span of the conventional oil and gas sectors, including land use issues, exploration, drilling, completions, pipelining, water supply, waste water handling and sour gas handling and processing. Addition of the refinery processes with detailed flow schemes and related sub subjects and levels was also proposed. The reviewers were again unanimous in the need to address all areas of environment management as required and practiced in each of the industry sectors (land use, energy use, greenhouse gases, air emissions, water management, waste management, and land reclamation). This topic is discussed further in Section 3 below.

### **2.1.3 Industry Descriptions**

The comments received focused mainly on suggested additions to the technical subject areas (as mentioned above, e.g. exploration, wells, environmental) and on inconsistencies across the sectors, rather than the relevancy or accuracy of the current content in the NAT. This is quite understandable given the volume of information currently in the NAT and the limited time given to the reviewers. Inconsistencies addressed included comments on questionable contents such as detailed PowerPoint presentations, and deficiencies in other areas, e.g. some nodes such as gas wells, flaring & venting need to be more industry specific. The industry consultants recommended that some areas need quality upgrades. It is proposed that other themes should be added as well, such as comparative resource utilization amongst the various options for oil production, perhaps even including biofuels. As mentioned elsewhere, the recommendation to add discussion on industry impacts in the areas of water, waste and land issues is paramount.

Some reviewers commented that it was cumbersome to access the descriptions, and the formatting is inconsistent. More review is presented on this issue in Section 2.2 “NAT Architecture and Ease of Use” below. The need to link to key outside sources was a common theme and also perhaps the use of more active graphics such as video clips. These topics are also discussed in Section 2.2.

### **2.1.4 Control Technologies**

One reviewer considered this information as the most useful component of the NAT. Some reviewers questioned, again, the inconsistency of information across the industry sectors and subsectors, where it was not clear why some technologies were presented and others weren't. One reviewer suggested that in any given industry sector, technology options could be presented in detail with a process selection flow chart, with the NAT serving as good practical tool for junior engineers. Another expert went even further, with the suggestion that ultimately an interactive training system could be added, for example in the area of waste water treating.

Some experts cautioned against allowing vendor input to the NAT, as there is too much competition amongst vendors on technologies and equipment for processing and for

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environmental controls. It is recommended that vendor featured equipment could be referenced in cases where a typical piece of equipment is used by the industry, for example flare tips.

### **2.1.5 Environmental Issues R&D**

The reviewers generally agreed that all environmental areas need to be addressed if the NAT is to be adequately comprehensive as a learning tool given today's emphasis on the environment. However, after that, this topic elicited the most diversity in the feedback. One expert suggested that only high-level needs for environmental management should be included, whereas at least one reviewer proposed that comprehensive impact analysis of industry's effect on the environment should be addressed for all operating sectors. Finally, it was suggested by another that control options should be addressed in detail for all areas of regulation. Providing links to the web sites of regulators and their pertinent current regulations was also recommended. Overall, this area will require reevaluation in view of these recommendations. Firstly, the original purpose of this topic was to address required R&D so that prospective researchers and research institutions would have a reading from industry on the priority areas for resolving their environmental management challenges. Secondly, the original mandate from NRCan was to address Air Issues which is why this heading in the NAT was titled "Air Issues R&D". The reviewer recommendations on the added content means this component of the NAT would be retitled to "Environment Issues R&D". Finally, this component of the NAT should retain its focus on research needs, as the discussions on environmental impacts and current environmental practices would be included in the Industry Descriptions.

### **2.1.6 Projects**

One expert recommended against project tracking since updates would be costly and there are many other sources published regularly. Other reviewers ignored this item or stated that they were not able to understand the utility of the topic. It was also stated that the details and formats were inconsistent across the NAT.

It is noted that this node is relatively unpopulated in the Oil and Natural Gas sectors, and was not utilized in the Oil Sands component, where it was replaced with the "Air Issues R&D" topic. The general impression from the feedback is that this node does not serve a useful purpose. This will have to be considered in going forward with NAT development.

### **2.1.7 Glossary**

The feedback from those that commented on the current Glossary was mixed. Two reviewers found it useful and important and one even suggested enhancing it. Others found it deficient in both means of access (where placed in the architecture) and in content. One reviewer recommended that an external glossary (via linking) would be best since there are many sources of industry definitions.

It is noted that the bulk of the current Glossary was built for the original US EPA version. Oil Sands terms were added during the 2010 work. The architecture allows accessing the glossary separately or selectively when in lower levels in each industry sector, but one expert suggested that direct links from the text terms be incorporated to allow the reader to quickly go back and

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forth as each term of interest is encountered while reading. The mechanics options for handling the Glossary require attention and are discussed further in Section 4. Overall, the majority opinion is that a Glossary is an imperative feature of such a learning tool. Based on the feedback, a critical look at the content and the means of accessing the definitions should be undertaken.

### **2.1.8 Depth of Technical Information**

It might be expected that opinions would vary on this subject, and that was the case but only to a moderate degree. The reviewers generally approved the level of technical detail currently in the NAT – independent of their many suggestions for what should be added or revised. Two reviewers suggested that a more advanced level of technical expertise could be incorporated, but one conceded this would be a future exercise depending on the evolution of the NAT's use. Another expert commented that for clients at the “management level” the reader may not wish to enter immediately, if at all, into the current technical levels, and there should be an overview level of material.

### **2.1.9 Other Additions to Technical Content**

One reviewer strongly emphasized the need to define the purpose of the NAT in terms of target audience and objectives for learning. Otherwise it would be difficult to tailor the contents with a consistent approach.

Most of the reviewers gave a strong recommendation that the subject matter must include additions to the Environmental content, e.g. energy, water, land, GHG's, air emissions, waste management, safety, reclamation, noise, life cycle analyses (LCA), resource recovery, human impacts & regulations. One reviewer proposed that the presentations should start with a detailed discussion of current impacts the industry is having on the environment. Others emphasized the need to include related controls requirements, control measures and cost & economic impacts. An emphasis on the needed solutions to these impacts (procedures, technology, R&D) is required.

One user suggested that the refining sector would be enhanced with added descriptions of the individual refining processes, plus there should be more description of refined products handling.

One expert's opinion was that the key components are the flow diagrams, the Control Technologies, Environmental R&D requirements and environmental regulations. Generally, more photos, schematics and simplified flow diagrams are desired. The addition of industry case studies should also be considered. As mentioned above, the support flow diagrams in some cases need simplification for the target user levels as well as giving a consistent approach across the NAT. Again, it was opened for discussion as to whether, and when in the development progress, a more detailed industry expert level would be added.

Regarding industry case studies, suggested above, it is noted that certain presentations, including PowerPoint slides, are currently in the NAT which do give a sampling of case studies. The consideration is that the NAT could balloon if such studies are added ad hoc. This topic invites a critical review during the next phase of work.

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One reviewer raised several suggestions for potentially including themes that would go beyond strictly technical material and enter into the realm of social and/or political matters. These themes include areas of current “debate” among industry, government and public (including NGO’s) stakeholders. The expert felt that this would be an appropriate forum to present balanced views (i.e. not industry lobbying) to the users. Examples proposed were: (a) Explanation of the “wells to wheels” debate - clarification is direly needed on the framework options quoted by the various players to explain the comparative emissions from oil and oil sands production, i.e. from production site only, from production through refinery tankage, or from production to consumption (wells to wheels); (b) The economic and social benefits and/or penalties of upgrading bitumen in Canada vs. shipping raw bitumen for export; (c) The externality issues related to aggressive exploitation of resources (primarily oil sands) that result in a social legacy, e.g. GHG emissions, disrupted land, tailings deposits; (d) The social implications of (beneficial) royalty and tax structures to induce development of resources. The purpose of delving into these topics is to objectively present the views on all sides of the debates such that readers would be better educated on the issues and be able to make their own conclusions from non-biased discussions. It would be up to the nodal project sponsors to determine the role of such material and insert it in the appropriate place in the NAT (Industry Description?).

## **2.2 NAT Architecture and Ease of Use**

A large number of questions on this subject were directed at the reviewers as it was felt necessary at this time to take a critical look at the software platform. If the current ACCESS data base architecture is too cumbersome for expansion of the NAT, user interface, and/or ease of navigation this would likely be the appropriate time in the NAT development to convert to a new system. The sample feedback as obtained from the select reviewers is discussed below.

### **2.2.1 Navigation Amongst Levels (Finding Information)**

Opinions received on this topic were quite diverse. Two reviewers found the navigation generally ok, with the flow diagrams and side bars working fine. The remaining reviewers commented that the navigation was clumsy beyond the flow diagrams, as it was cumbersome to “dig down” for sought information, hence, more capability in the ease to drill down to detail from the flow diagrams is desired.

One expert suggested eliminating the side bars. The method of linking to auxiliary files and opening them, particularly the WORD files, was undesirable. Cross linking capability is clumsy and a search option is not available. More cross linking across the NAT, e.g. back and forth from the Glossary is recommended. Reversing some buttons did not produce the desired page. It was also suggested that the buttons should be more descriptive and the arrows on the flow diagrams could even be active. Finally, it is agreed that the inconsistency of information at the particular levels across the NAT add confusion in navigation.

The reasons for the diversity of opinions are not entirely clear, but it is obvious that different users have varied opinions on how information search engines should perform. Another consideration may be how much the NAT was explored by each individual and how much “digging down” and cross referencing was attempted.

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### **2.2.2 Information Levels and Detailed Content**

There was general agreement that the number of “levels” used and the information contained in each (in terms of targeted technical detail) is appropriate for this learning tool. The main area of critical feedback focused on the Inconsistency of information in the levels across industry sectors, for example, one reviewer stated that the Oil Sands component contains plenty of information whereas some of the oil and gas sub sectors require much more input. Another expert stated that the levels are ok but respective details across the NAT need much more work on consistency and some areas require “much more work”.

One reviewed commented that the flow charts in levels 1 to 3 for all of the sectors levels should be more basic. Another expert recommends a review of the staging of the technical detail from the higher to the lower levels, and it is implied this is due to inconsistency. .

Most reviewers felt that the level of technical detail was appropriate for the education of junior staff. Over and above this it was questioned as to whether there should be a separate “overview” level for management and non-technical staff, and further, a more detailed level for industry experts.

All reviewers recommend the use of quick links to access auxiliary information and to search for specific topics. More graphics and photos should be available at the lower levels. Videos would be useful as would be more exterior links to training and workshops

Most reviewers cautioned against adding other industries such as Chemicals at this time. The current focus should be on the upgrading of the NAT according to this review.

### **2.2.3 Links to External Sources**

There should also be links to outside sources to access other training, workshops, reports and BMP’s, e.g. PTAC and CAPP. Also of high importance would be links to the web sites of the regulators, and a quick link list of relevant regulations.

Another suggestion is to add a feedback site to allow users to comment on the NAT content and its use.

### **2.2.4 NAT Platform**

There was no strong recommendation to change the NAT platform at this time if the recommended upgrades could be made with the current architecture. This caution centers on the concern that a large amount of effort could be required. It is also recommended to assure the NAT does not become too large and unwieldy, but no examples are provided as to what would be considered too large.

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### **3 RECOMMENDATIONS FOR NAT IMPROVEMENT**

This section intends to consolidate the input from the experts review process to provide specific recommendations for the next phase of the NAT development. The information provided by the six reviewers is deemed sufficient as a critical review of the NAT, along with some input from the authors who have familiarity with the NAT. In instances where the experts had differing opinions, these will be addressed, but still with the intention of making final recommendations. This means that in the end, some suggestions will likely be set aside.

#### **3.1 Content of the NAT**

##### **3.1.1 NAT Objective**

It is evident from some feedback that the objective of the NAT is not stated clearly as part of an introduction to users. Additional comments support the idea of a “Home” page as a starter page. This would lead the developers to consider the contents of such a page and the following are recommendations:

- (a) welcome the users and indicate who would benefit from exploring the learning tool
- (b) present the expressed purpose of the NAT.
- (c) advise the user of the general NAT architecture, i.e. topics and levels of information
- (d) provide the user with instructions on how to use the various tools available for learning and searching (the latter one would depend on the scope of the search capability).
- (e) provide a link to the starter page, i.e. on the general industry sectors flow diagram.

##### **3.1.2 Flow Diagrams**

The flow diagrams with descriptive icons that also provide triggers to subject material are the backbone to the NAT. All reviewers responded to this feature positively and It is recommended that the current structure and method of presentation be retained, which would also apply to any new diagrams (e.g. refining) and any revisions inside the sectors (e.g. flaring on oil and gas operations).

##### **3.1.3 Industry Description**

Several significant complaints were registered regarding this NAT content: firstly, there is considered to be inconsistency in the volume of material across industries and secondly, there are contradictions as to what amount and depth of discussion is presented as one migrates through the four levels. Further, more photographs and graphics are required to allow unfamiliar users to obtain a good picture of the hardware employed in the various steps of exploration, drilling, completions, mining, processing, etc.

Addressing this issue would be important to improve the overall presentation of information and facts. A substantial work effort by a team of experts would have to be utilized to conduct this remedial effort. Most of the reviewers advised they would be willing to participate in these activities and, depending on Phase 2 funding, this work plan is highly recommended.

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The restrictions related to obtaining industry photographs are well known and this road block has to be broken. It is recommended that industry operators and perhaps vendors of key equipment be contacted and agreements reached on what can be photographed and whether there are limits on the use of the material.

#### **3.1.4 Control Technologies**

The feedback comments in this section are a repeat of those listed directly above in Section 3.1.3 for the Industry Descriptions. Again, there was questioning as to the observed variations in detail across the NAT, including questioning as to why certain technologies were not mentioned. These comments warrant a review similar to that recommended above for Industry Descriptions

#### **3.1.5 Air Issues R&D**

Limited feedback was received on this specific topic in the NAT. The recommendations focused on the importance of including all environmental areas (land, air, water, waste, etc.) starting with current impacts and issues and proceeding through remedial requirements, available controls and governing regulations. Populating the NAT with this extent of topics and detail requires input by select specialists across all of the industry sectors and across technologies. It is recommended that an Environmental task team including the current reviewers be assembled to roadmap the proposed contents in detail and devise a work plan to assemble the input and incorporate same into the NAT.

#### **3.1.6 Projects**

This node caused the most confusion and its intent and need were questioned. It is recommended that this category be eliminated from the NAT and replaced with the above Environmental subject.

It was suggested that case studies be used as practical learning material. It is noted that some examples already exist in the oil and natural gas sections and others can be added in the NAT as reasonable. Such studies would normally fit in the Control Technologies area and it is recommended to place them there.

#### **3.1.7 Glossary**

Since opinions varied widely on the need, placement and access to the definitions, a careful evaluation is required. The original US EPA NAT contains a very large compendium of definitions, and this was expanded in 2010 to include Oil Sands. The majority of the reviewers advised that the Glossary is important therefore the mechanics related to the access issue need to be addressed during the review of the NAT architecture.

#### **3.1.8 Other Additions**

As detailed in Section 2.1.9 above, the reviewers proposed a significant quantity of information that should or could be added to enhance the educational utility of the NAT. Overall, it is recommended that the expansion of the Environmental component is mandatory and in the

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succeeding phases of work, industry experts would need to be contracted to develop this material. Regarding the inclusion of case studies, these would need to be carefully scrutinized for relevancy and added value, again by the experts, since these can readily increase the bulk of the NAT. Finally, the suggestion to add the topic of social/political issues would be up to the sponsors of this NAT project.

### **3.2 NAT Architecture and Ease of Use**

Generally, the reviewers found the NAT navigation to be straight forward as long as only the flow sheets and select information nodes were accessed. This would say that this part of the platform is generally acceptable as a “one way” learning tool. In other words, if a user is studying a given industry sector while following the flow sheets the “down linking” process is adequate. The major deficiencies can be listed as follows:

- a) The ability to readily find material by subject or by cross searching amongst nodes is severely limited. This is attributable to the deficiency in “hot buttons” and the absence of search capability which hinder this process. It is likely the current database platform does not render such mechanics as readily workable.
- b) The use of the side-bar was found to be questionable by some users, with comments that it only confused the search process. Others found the side-bar to be ok. It is unknown as to extent that the side bar feature was attempted during the limited time for review. But this feedback should be considered as an item to be addressed, since any expressed user confusion or cumbersome operation will result in frustration and a tendency to ignore the NAT.
- c) It is reported that the ability to use “back arrows” is not workable in parts of the architecture. These areas need to be identified and rectified.
- d) Some material, e.g. in the Industry Descriptions, is included where the subject area is opened, whereas other material requires triggering a link. Further, the formatting of the linked material varies, including WORD, pdf, etc. Standardization of the linking is required along with substantial “clean up” of the formatting. All documents requiring linking due to their volume are to be converted to pdf format for security purposes.

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## **4 ARCHITECTURAL IMPLEMENTATION AND REVIEW**

### **4.1 Review Approach**

Dr. Dan Field, an information technologies specialist, provided an evaluation of the current software platform used of the NAT. Specifically, Dr. Field was requested “to conduct a study of the architecture, implementation, functionality and usability of the NAT as implemented in a systematically designed and hierarchic fashion”. In assessing the functionality and usability of the platform, Dr. Field considered his own trial use and the feedback reported by the expert reviewers. He then assessed the construction of the architecture and its ability to provide the desired functionality and usability.

### **4.2 Overall Assessment**

Dr. Field identified significant deficiencies in the manner in which the current data base architecture is employed, leading to limited NAT flexibility and limitations in the ability to readily make additions to NAT content. Dr. Field provided several recommendations for programming adjustments and additions necessary to rectify the deficiencies. Overall, substantial rework is required to revise the required portions of the program code.

#### **4.2.1 Functionality**

Since users normally expect search capability, this feature should be built in and can be readily accomplished within the current program. The use of “flash” architecture for the flow diagrams inhibits printing capability and an alternate graphics tool should be employed to enhance the management of the flow diagrams and their images, including the ability to print them. It is recommended to utilize “*sitemap*” files to enhance browser access.

#### **4.2.2 Usability and User Interface**

1. Ease of forward and backward navigation amongst the side bar and the flow diagrams was a common complaint of the reviewers and this was also recognized by Dr. Field. He proposed that features such as additional buttons be implemented to rectify this problem.
2. The formatting of the text files (converting to HTML and pdf) is required to enhance navigation and provide standardization.
3. Consideration should be given to the requirements for “internationalization” and “unsighted person” access.
4. It is recommended that “error handler” pages be added to guard against browser user errors.

#### **4.2.3 Maintainability and Extendability**

The current file linkage structure in the program is too complex, which makes it very difficult to maintain, augment and verify the program. A couple of remedial options are suggested, i.e. either building a sub program to handle the current data base structure or using a different programmed tool for this particular operation.

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#### **4.2.4 Code Duplication**

Mr. Field reports that the original program was built without the use of templates or other duplication techniques, hence making modifications in many cases necessitates handling large numbers of files individually. He advises this issue is resolvable but he does not comment on the extent of work that would be required.

#### **4.2.5 Web Site Security**

The web site is currently vulnerable to hacker activity and it is imperative that this shortcoming be addressed.

#### **4.2.6 Summary Recommendations**

It is concluded that the current database architecture could be retained, but a number of new programming features are needed to improve the considerations of functionality and usability and, moreover, the ability to make additions and maintain the NAT. This suggests that user-interface modifications are required along with a rework of information handling routines.