# Updating the "IDC Processing of SHI Data" User Guide

Christopher J. Young, Sandia National Laboratories
Christos Saragiotis, International Data Centre

P4.1-113

POSTER

Sandia National Laboratories

CTBTO
PREPARATORY COMMISSION

# SnT 2021
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

# Updating the "IDC Processing of SHI Data" User Guide

Poster No.: P4.1-113

Chris Young (Sandia National Laboratories) & Christos Saragiotis (International Data Centre)

CTBTO
PREPARATORY COMMISSION

**ABSTRACT**

National Data Centre (NDC) staff need to interpret International Data Centre (IDC) seismic, hydroacoustic, and infrasonic (SHI) data processing results, which requires detailed knowledge of IDC SHI data processing. Similar understanding is needed by those that want to propose new IDC SHI data processing algorithms. To find the required information, NDC staff access the "IDC Processing of SHI Data" document, a comprehensive, detailed and accurate (at the time when it was written in 2002) user guide. Unfortunately, this document is currently outdated as many techniques recently adopted by the IDC are not described in it. Furthermore, not all technologies and techniques are described at the same depth and there are some inevitable errata. To significantly update this lengthy user guide and maintain the high overall quality is no trivial endeavor. Hence, in January 2020 a platform to note problems with the document and propose fixes was made available as an NDC Forum Topic, to take advantage of the considerable collective technical expertise of the NDC staffs. In this presentation we will provide an introduction to the platform, review results that have been entered so far, and discuss the path forward to producing an updated version of the document.

**SnT 2021**
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

**Updating the "IDC Processing of SHI Data" User Guide**

Poster No.: P4.1-113

Chris Young (Sandia National Laboratories) & Christos Saragiotis (International Data Centre)

**CTBTO**
PREPARATORY COMMISSION

## What is this Document & Why is it Important?

INTRODUCTION

- This document describes comprehensively and in detail the processing of seismic, hydroacoustic, and infrasonic (SHI) data by the IDC.

- It is perhaps the best single reference for processing SHI data for nuclear explosion monitoring.

- Much of this information is not found in seismology textbooks.

- If you want to understand an IDC SHI data processing result, this is where you should look (reading source code is impractical, ~1M lines).

- Similarly, if you want to look for opportunities to improve IDC SHI processing, you should start here.

User Guides

IDC DOCUMENTATION
**IDC Processing of Seismic, Hydroacoustic, and Infrasonic Data**

Revision 1

**SnT 2021**
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

**Updating the "IDC Processing of SHI Data" User Guide**

Poster No.: P4.1-113    Chris Young (Sandia National Laboratories) & Christos Saragiotis (International Data Centre)

CTBTO
PREPARATORY COMMISSION
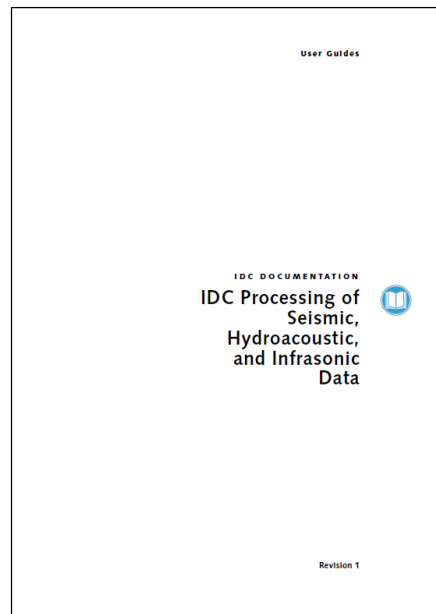
# Known Issues With Document

PROBLEM

- Errors
  - o Creating this document was a huge undertaking.
  - o Many algorithms are complex and highly specialized; some mistakes were made in text and/or equations (only experts reading carefully would be likely to notice).

- Omissions
  - o There had to be choices made about what level of detail to include.
  - o Some things were left out, particularly specific details about processing (e.g., actual filters applied for a data processing task).

- New Algorithms
  - o New calculations have been added to the IDC system, some major (e.g., PMCC processing of infrasound).
  - o Few of these have been added to the document.

**SnT 2021**
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

**Updating the "IDC Processing of SHI Data" User Guide**

Poster No.: P4.1-113

Chris Young (Sandia National Laboratories) & Christos Saragiotis (International Data Centre)

**CTBTO**
PREPARATORY COMMISSION

## Previous Efforts to Track Issues

- Working Group B Waveform Experts Group
    - The Chairman (David Bowers) has been compiling a list of issues from WEG members over many years.
    - Many of these are about omissions related to processing details.

- Geophysical Monitoring System (GMS) Development
    - GMS is the new data processing and analysis system being developed by Sandia Labs for the USNDC (a large portion of this code is being shared with the PTS).
    - To meet modernization standards, the GMS developers were directed to minimize re-use of existing code, hence virtually all the algorithms must be recoded.
    - The starting point for recoding each algorithm is a clear, concise description of how that algorithm works; much of the USNDC processing is similar to IDC, so Sandia has made extensive use of the IDC SHI document
    - Coding algorithms means understanding them completely (every equation), so if there are mistakes in the document, Sandia will find them.
    - The result (in progress) is perhaps the most comprehensive, detailed review of the IDC SHI document to date.

**PROBLEM**

**SnT 2021**
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

**Updating the "IDC Processing of SHI Data" User Guide**

Poster No.: P4.1-113

Chris Young (Sandia National Laboratories) & Christos Saragiotis (International Data Centre)

**CTBTO**
PREPARATORY COMMISSION

OPPORTUNITY

# Opportunity for Collaborative Issue Tracking System

- Goals
  - o Note issues with the document (all); fix document (IDC staff).

- Synergistic
  - o GMS can benefit from IDC knowledge (including NDCs), and IDC can benefit from GMS development.

- How do we facilitate this?
  - o Need a means to make sharing of information easy; needs to be a good fit for a global set of users (domain experts).
  - o Should be self-guided (i.e. automated, requiring little if any supervision); limited resources available to set up (people, time, $).

SnT 2021
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

Updating the "IDC Processing of SHI Data" User Guide

Poster No.: P4.1-113

Chris Young (Sandia National Laboratories) & Christos Saragiotis (International Data Centre)

CTBTO
PREPARATORY COMMISSION

# Our Solution: NDC Forum Topic

- Document is a "Topic"; Chapters are "Sub-Topics"; anyone with NDC Forum access can contribute.

SOLUTION

**Alpha Tester Groups (ATG)** 27

Under this category all Alpha Test Groups are available. Usually, Alpha Tests are performed in closed groups and you will only have access to those groups where you are a member.

🔷 🔒 IDC Reengineering    ⬛ NET-VISA ATG

**Atmospheric Transport Modelling (ATM)** 2

🔷 Web-Grape Internet Based Service (IBS)    🔷 Web-Grape Desktop

**IDC SHI Data Processing Document** 18
2 unread

This category is used to track known issues with the IDC SHI Data Processing document ⬇ IDC_Processing.pdf (9.8 MB) , i.e errors, missing information, unclear descriptions. Forum participants can view the known issues with each Chapter by selecting the appropriate Chapter subcategory. Forum participan...

🟥 **Chapter 9: Algorithms** 1 unread
🟪 **Chapter 8: Post-Location Processing** 1 unread
🟨 **Chapter 2: Seismic Station Processing**    🟥 **Chapter 1: Overview**
🟩 **Chapter 3: Hydroacoustic Station Processing**
🟦 **Chapter 4: Infrasonic Station Processing**
🔵 **Chapter 5: Network Processing**    🔵 **Chapter 6: Event Location**
🟪 **Chapter 7: Analyst Review**

S    📌 National Data Centre (NDC) FAQ    1
faq    Jul '18

T    Documentation of IDC Reengineering API    2
🔷 🔒 IDC Reengineering    2d

T    [Solved] Automatic PMCC processing disabled    1
🔷 🔒 IDC Reengineering    6d

S    Python - plotting single channel    2
🔷 🔒 IDC Reengineering    7d

T    Testing data request against local program    2
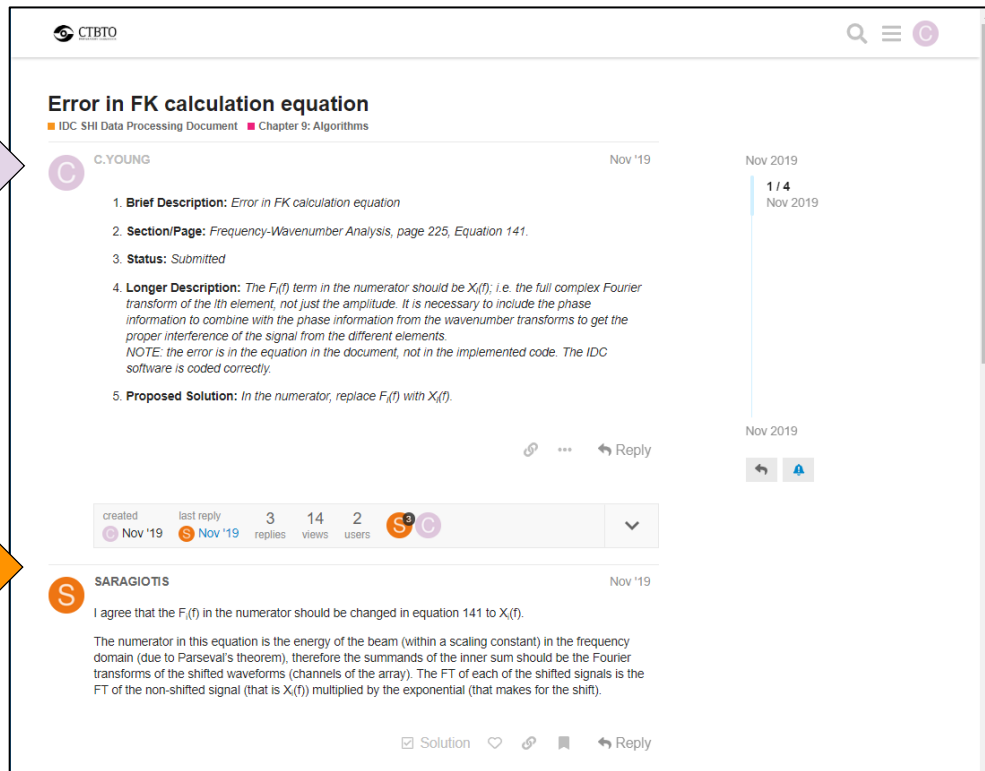🔷 🔒 IDC Reengineering    8d

T    Kick-off meeting April 2021    0
🔷 🔒 IDC Reengineering    14d

M    Upgrade of Web-Grape IBS    0
🔷 Web-Grape Internet Based Service (IBS)    19d

**SnT 2021**
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

**Updating the "IDC Processing of SHI Data" User Guide**

Poster No.: P4.1-113

Chris Young (Sandia National Laboratories) & Christos Saragiotis (International Data Centre)

**CTBTO**
PREPARATORY COMMISSION

**SOLUTION**

*Original issue entry (author noted), follows templated format.*

*Reply by another user (identity noted), discussing issue.*



**Error in FK calculation equation**

■ IDC SHI Data Processing Document   ■ Chapter 9: Algorithms

**C.YOUNG**                                                    Nov '19

1. **Brief Description:** *Error in FK calculation equation*

2. **Section/Page:** *Frequency-Wavenumber Analysis, page 225, Equation 141.*

3. **Status:** *Submitted*

4. **Longer Description:** *The $F_l(f)$ term in the numerator should be $X_l(f)$; i.e. the full complex Fourier transform of the lth element, not just the amplitude. It is necessary to include the phase information to combine with the phase information from the wavenumber transforms to get the proper interference of the signal from the different elements.*
*NOTE: the error is in the equation in the document, not in the implemented code. The IDC software is coded correctly.*

5. **Proposed Solution:** *In the numerator, replace $F_l(f)$ with $X_l(f)$.*

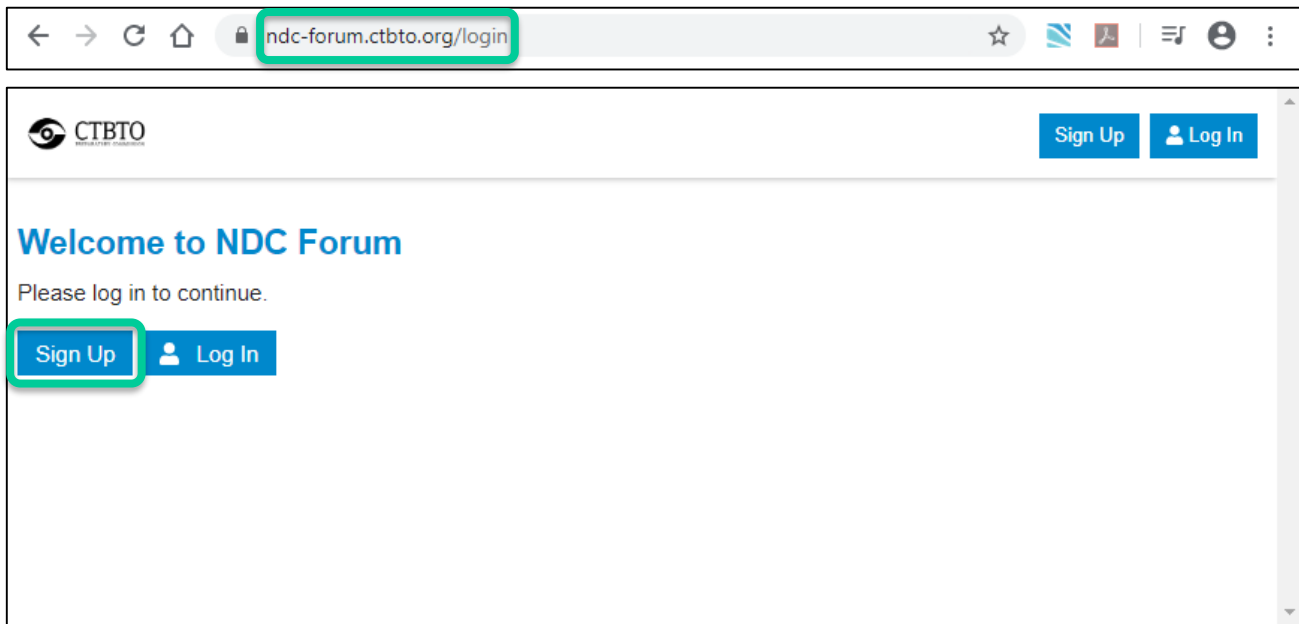| created | last reply | 3 | 14 | 2 | |
|---|---|---|---|---|---|
| Nov '19 | Nov '19 | replies | views | users | |

**SARAGIOTIS**                                                Nov '19

I agree that the $F_l(f)$ in the numerator should be changed in equation 141 to $X_l(f)$.

The numerator in this equation is the energy of the beam (within a scaling constant) in the frequency domain (due to Parseval's theorem), therefore the summands of the inner sum should be the Fourier transforms of the shifted waveforms (channels of the array). The FT of each of the shifted signals is the FT of the non-shifted signal (that is $X_l(f)$) multiplied by the exponential (that makes for the shift).

Nov 2019

**1 / 4**
Nov 2019

Nov 2019

**SnT 2021**
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

**Updating the "IDC Processing of SHI Data" User Guide**

Poster No.: P4.1-113

Chris Young (Sandia National Laboratories) & Christos Saragiotis (International Data Centre)

**CTBTO**
PREPARATORY COMMISSION

SOLUTION



- To get access to our Forum topic, access the NDC Forum website and request an account.

- IDC website administrator reviews requests and will send notification via email.

SnT 2021
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

**Updating the "IDC Processing of SHI Data" User Guide**

Poster No.: P4.1-113

Chris Young (Sandia National Laboratories) & Christos Saragiotis (International Data Centre)

CTBTO
PREPARATORY COMMISSION

**CONCLUSIONS**

- The "IDC Processing of SHI Data" Users Guide is an excellent resource for those that want to understand SHI nuclear explosion monitoring in general and particularly for those that want to understand IDC data processing results.

- However, the Guide has errors and omissions, hence it needs to be corrected and updated; this is a huge task given the breadth of topics covered and the level of detail.

- The IDC can update the document, but needs help from the combined pool of NDC experts to note problems and propose new text.

- We have created an NDC Forum Topic to facilitate this collaboration amongst NDCs.

- Our Forum Topic allows NDC staff to note issues and to make comments about issues already noted by other Users.

- Eventually our Forum Topic will be used by the IDC staff to update the Guide; in the meantime, our Forum Topic can be referred to by users of the Guide to alert them to known errors and omissions.