OpenXDF

Discussion on an XML-based open file format for PSG

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What is OpenXDF?

- An open standard for the digital storage of time-series physiological signals and annotations. Its primary focus is on electroencephalography and polysomnography.
- OpenXDF is based on XML which has become a widely accepted standard for the digital storage of data. XML was adopted by the World Wide Web Consortium (W3C) in 1998 for data exchange over the Internet. Since then, many industries have developed standardized data exchange and storage formats based on XML.
- The FDA has proposed an XML-based standard for submission of ECG data used in studies.
- International Federation of Clinical Neurophysiology (IFCN) standards for digital recording of clinical EEG, Electroencephalography and clinical Neurophysiology 106 (1998) 259–261
  http://www1.elsevier.com/homepage/sah/ifcn/pdf/106_259.pdf

Design Considerations

- Multi-byte character encoding (all language support)
- Support unlimited number of channels
- Channel specific sampling rate, range, and bytes-per-sample
- Well-defined standard for storing common information (montages, events, scoring) Ability to store proprietary or non-standard information
- Expandability with 100% backward and forward compatibility
- Encryption for HIPAA compliance

Design Considerations Cont.

- Must store the original sampled signal
- Support unipolar, bipolar, and DC signals
- Files should be as few and as small as possible
- Should be simple to implement for maximum acceptance
- Should be backward compatible with current standard (EDF)
- Support discontinuous data and multiple files per record (MSLT, MWT)
- Should be adaptable to Neurology for routine EEGs and long term monitoring etc.

Two file implementation

- XML header file including
  - Patient information
  - Events, annotations, scoring results
  - Montage(s)
  - Binary file description
- Binary data file including
  - Digitally sampled physiological data

Why XML

- Extensible
  - Backward and forward compatible
  - Able to accommodate proprietary information
  - Easily expandable
- Widely accepted standard

Why Binary Data File

- Backwards compatible with EDF and possibly other formats
- Binary is the most compact way to store data while preserving the original information
- Fast retrieval and processing for display

OpenXDF Encryption

- RC-4 128-bit encryption
- Encryption of the XML header file with a proprietary and/or password key
  - Proprietary key allows reading by originating software only
  - Password key allows reading by anyone with the password
- Type of key and password is user selectable.

OpenXDF Features

- Support for multiple scorers
- Supports multiple files and multiple sessions per file
- Stores last used montage and as acquired montage(s)
- Supports variable sampling rates and variable signal range
- Backwards compatible with EDF
- Free OpenXDF/EDF reader
- Free development tools

OpenXDF Benefits

- Using an extensible format will allow OpenXDF to be both backward and forward compatible and allow for unlimited expansion. Since the protocol has a basis in XML, there will be fewer limitations, making integration into existing systems easier. Some advantages of using XML are:
- Both standard and proprietary information can be stored in the file without affecting compatibility
- No limitations on annotations or scoring information
- No limitations on patient information
- There is no limitation on string lengths, and only loose limitations on sample sizes (1, 2, 4, and 8 bytes) and frequencies
- Text encoding and language support is not limited by XML
- Uses ISO8601 for robust, uniform, Y2K compliant date/time representation
- Allows for data encryption
- To make adoption easier, software converters will be written for existing open file formats such as EDF. Converters for other formats can be produced in a short period of time if the existing file format is made available.

XDFviewer by Neurotronics, Incorporated

- XDFviewer is a light-weight, intuitive application for viewing Open eXchange Data Format (OpenXDF) and European Data Format (EDF/+) files on Microsoft Windows ™ platforms.

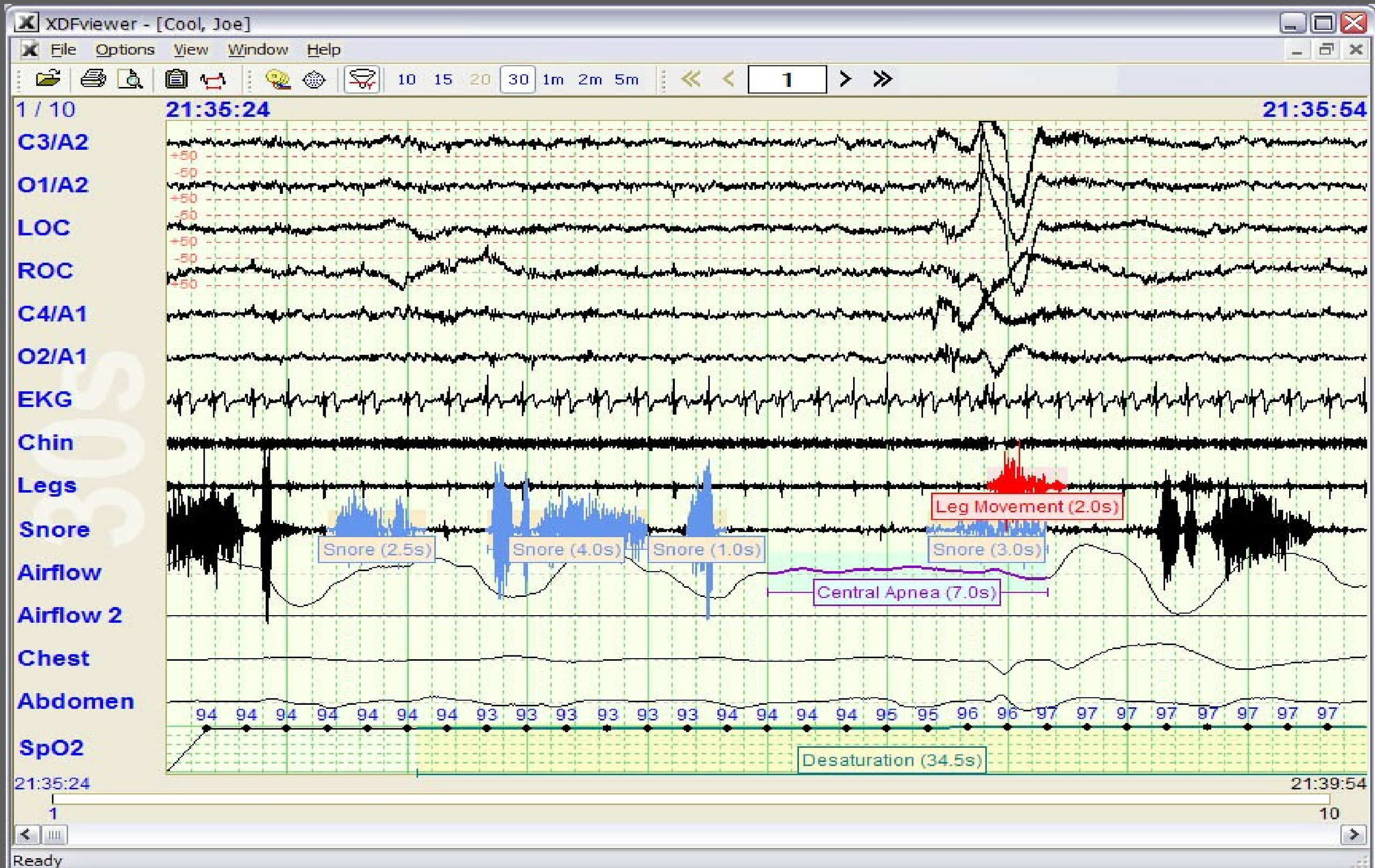
- XDFviewer incorporates elements of successful commercial PSG and EEG software to provide collaborative research and diagnostic efforts with a powerful, easy-to-use, FREE viewer.

XDFviewer cont.

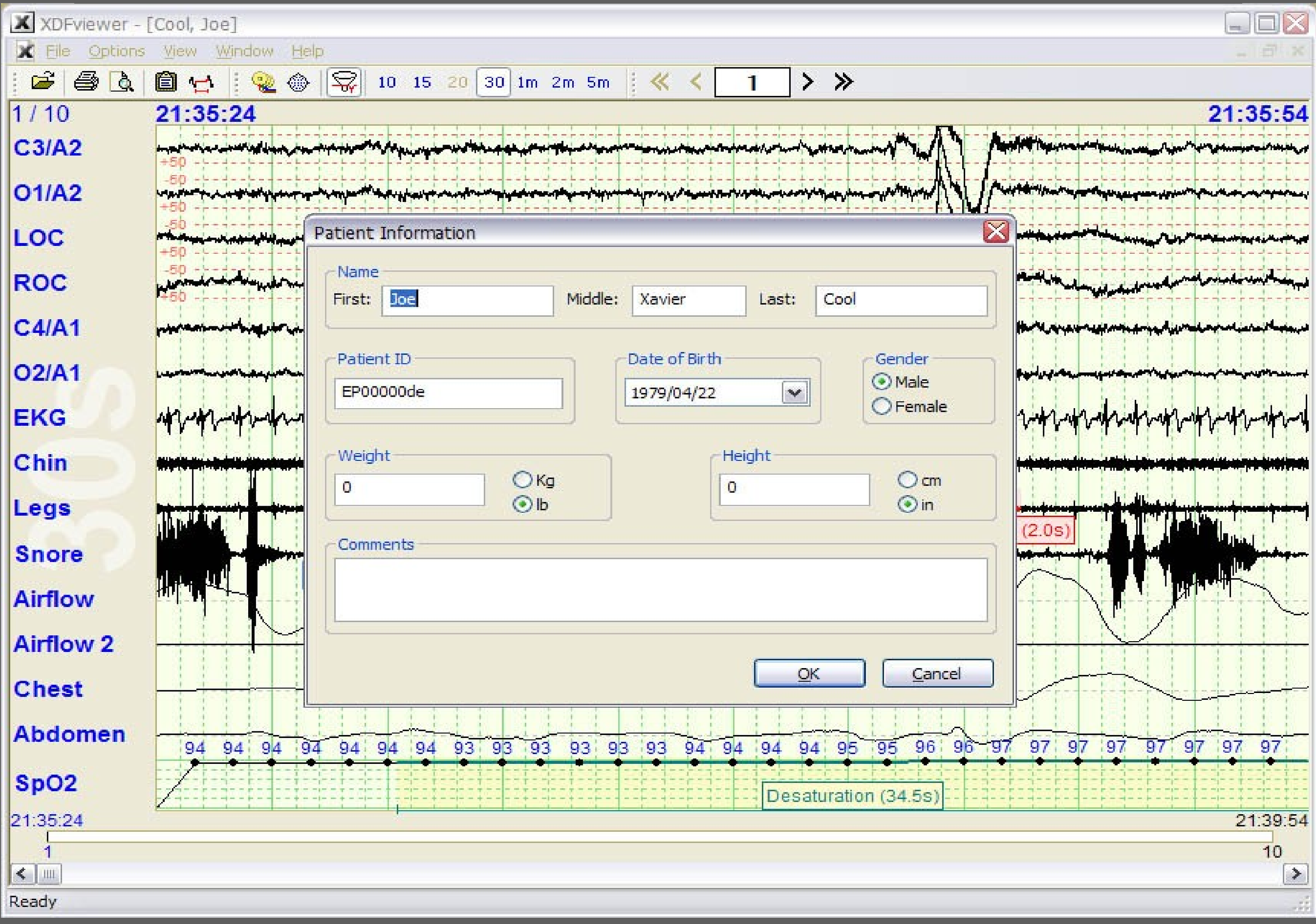
- XDFviewer provides the following features for both OpenXDF AND EDF files:
  - 32 display channels
  - An electrode editor for editing source electrode properties
  - An intuitive montage editor
  - On-plot polarity, filter, and sensitivity settings
  - Fast high-pass, low-pass, and notch (50/60Hz) filters
  - 10s, 15s, 20s, 30s, 1m, 2m, and 5m time bases
  - EEG-style (6mm) time reference lines of 1/2s, 1s, 5s etc.
  - Intuitive file navigation
  - Configurable display colors
  - Supports disjoint recording sessions within a data file
  - Annotation display (event log)**
  - Printing
- XDFviewer provides the following additional features for OpenXDF files:
  - Supports displaying multiple data files as one continuous plot
  - Highlighted events
  - Extended patient information

The OpenXDF / EDF Viewer http://www.openxdf.org/viewer.html

Main plot display with highlighted events



Patient Information



Electrode Editor

XDFviewer - [Cool, Joe]

File Options View Window Help

10 15 20 30 1m 2m 5m | 6

6 / 10 | 21:38:04 | 21:38:14

C3/A2
O1/A2
LOC
ROC
C4/A1
O2/A1
EKG
Chin
Legs
Snore
Airflow
Airflow 2
Chest
Abdomen
SpO2

Montage (Cool, Joe)

	Pos.	Label	G1	G2	Type	High-pass	Low-pass	Sens.
✓	1	C3/A2	C3	A2	EEG1	0.3000	35	10
✓	2	O1/A2	O1	A2	EEG2	0.3000		10
✓	3	LOC	LOC	A2	EOG1	0.3000		10
✓	4	ROC	ROC	A1	EOG2	0.3000		10
✓	5	C4/A1	C4	A1	None	0.3000		10
✓	6	O2/A1	O2	A1	None	0.3000	35	10
✓	7	EKG	EKG-	Gnd	EKG	0.1000	70	7
✓	8	Chin	EMG1-	Gnd	CHIN	0.0030	70	80
✓	9	Legs	EMG2-	Gnd	LEG	0.0030	70	5
✓	10	Snore	EMG3-	Gnd	SNORE	0.1000	70	5
✓	11	Airflow	RSP1-	Gnd	AIRFLOW	1.0000	15	7
✓	12	Airflow 2	Gnd	DC05	AIRFLOW2	Off	Off	15
✓	13	Chest	RSP2-	Gnd	CHEST	1.0000	15	10

Low-pass dropdown: Off, 15, 30, 35, 60, 70

Options | OK | Cancel | Apply

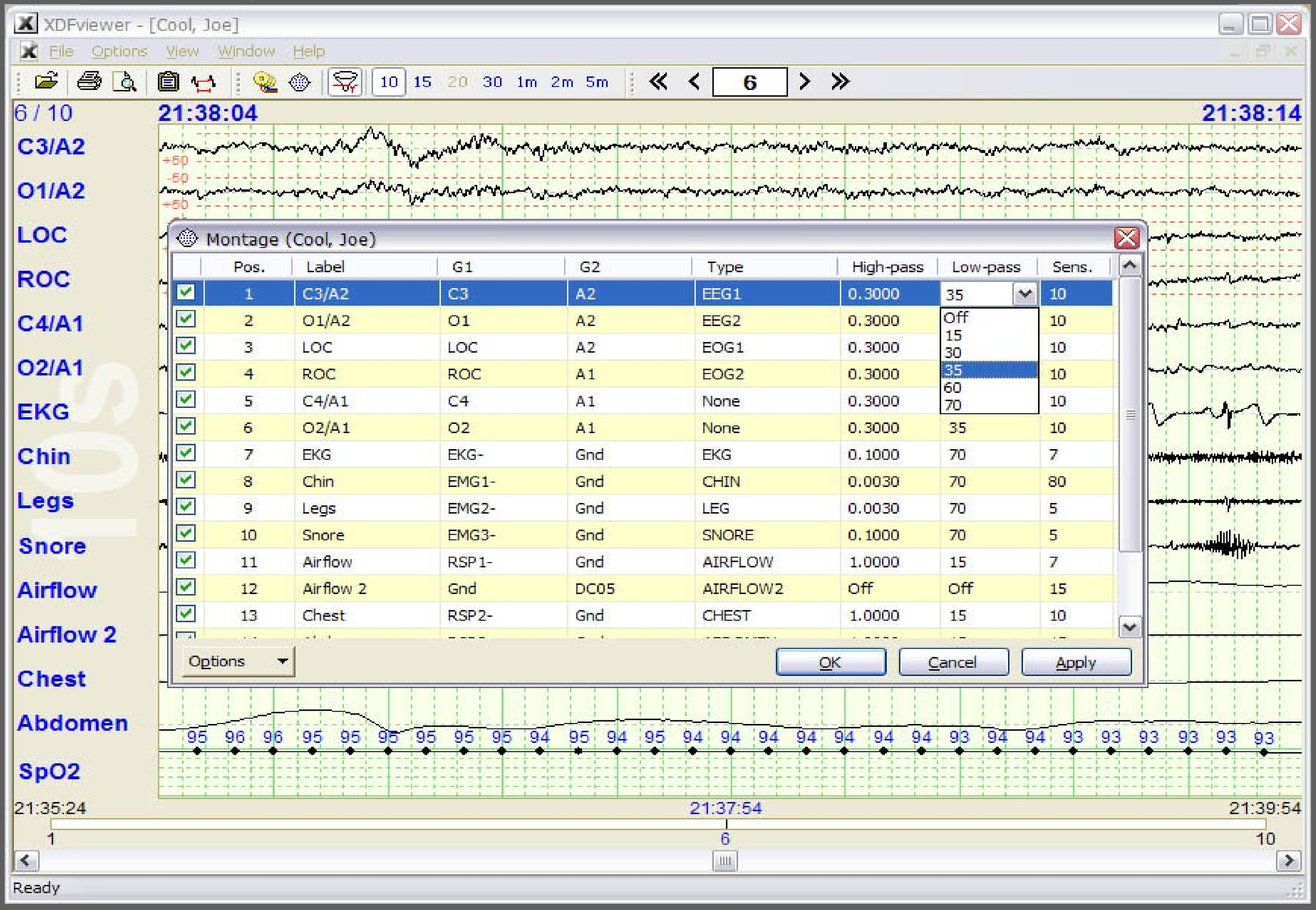
95 96 96 95 95 95 95 95 95 94 95 94 95 94 94 94 94 94 94 94 93 94 94 93 93 93 93 93 93

21:35:24 | 21:37:54 | 21:39:54

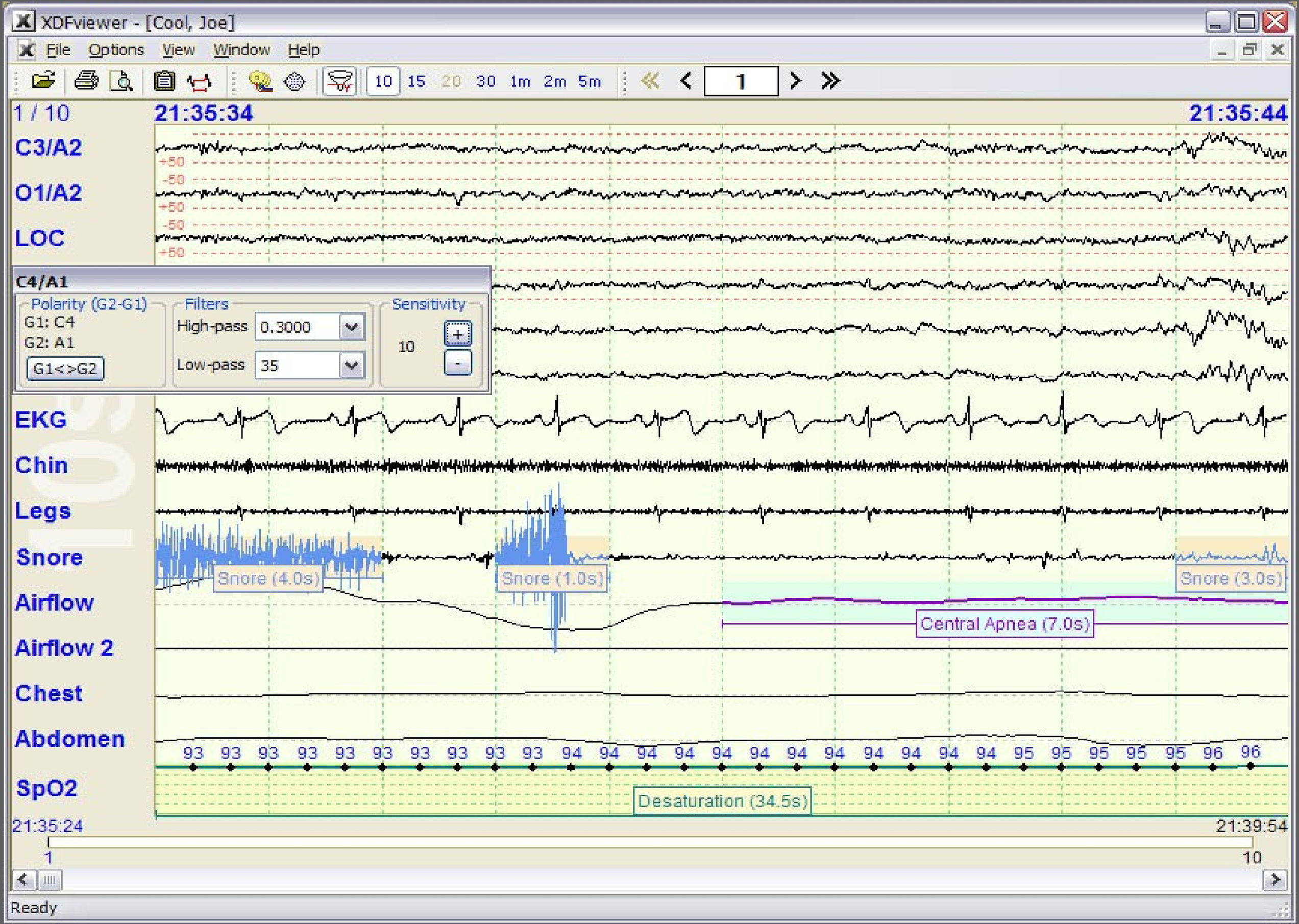
1 6 10

Ready

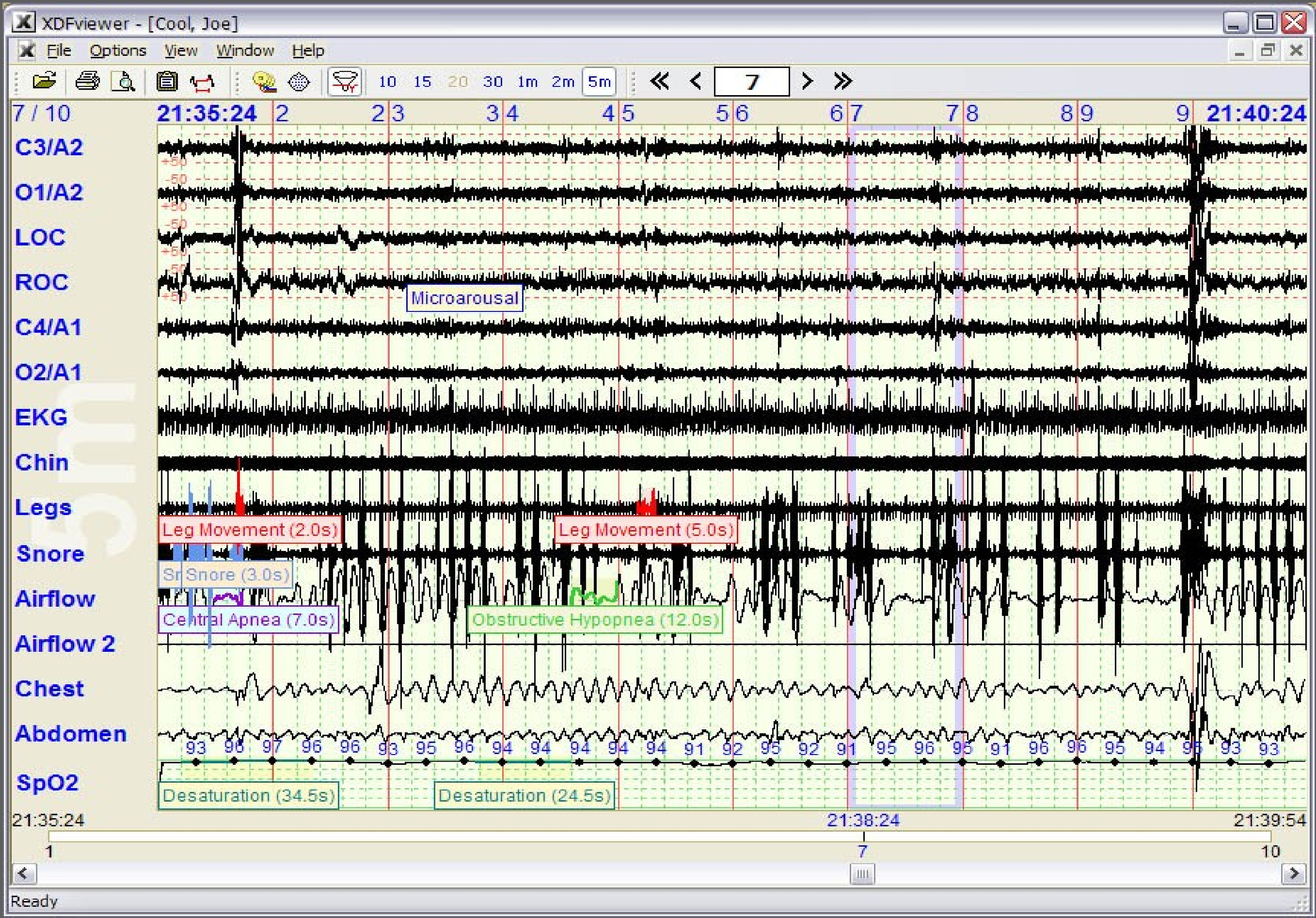
Montage Editor



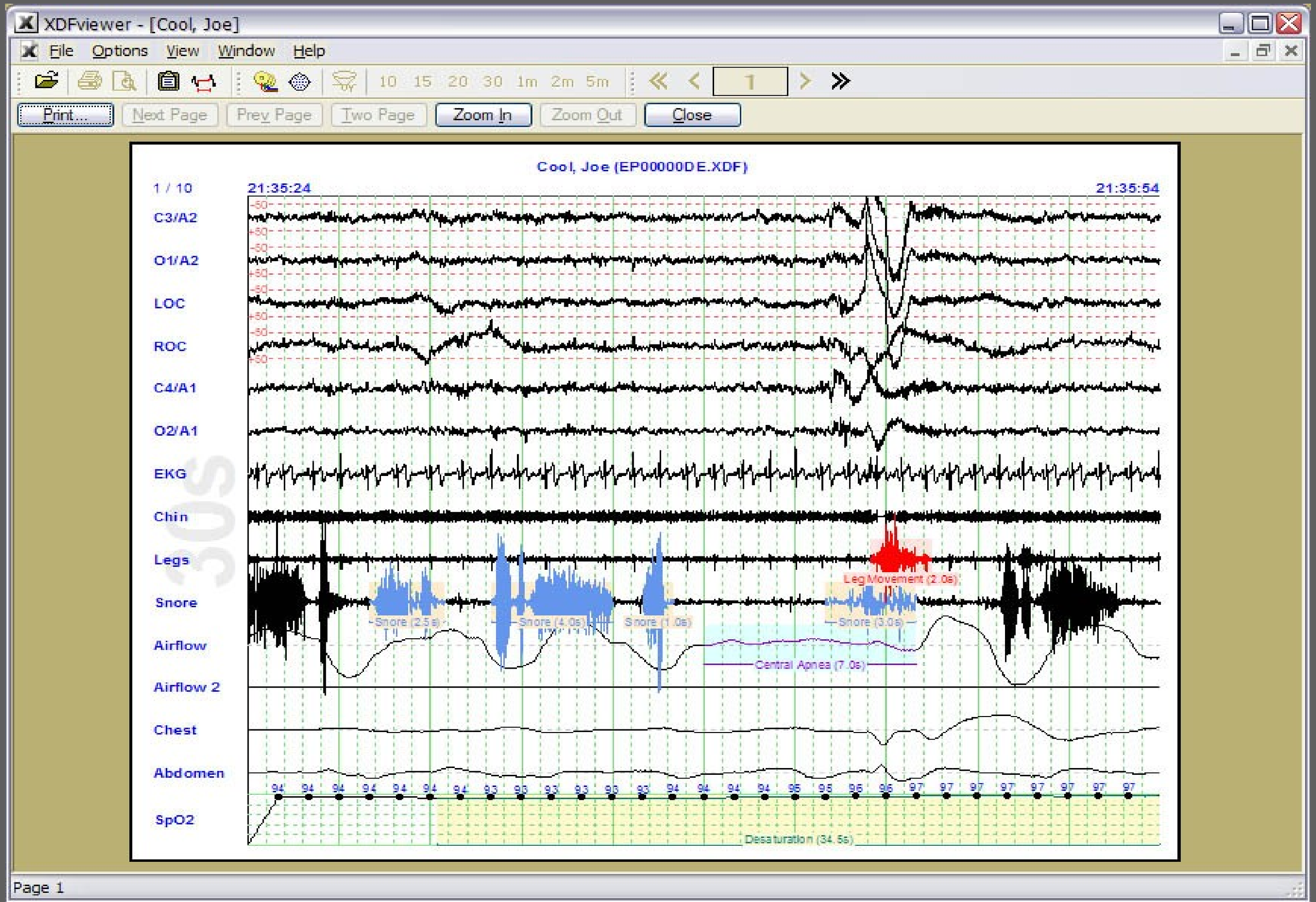
On-plot polarity, filter, and sensitivity settings



5 minute view with events



Printing


XDFviewer - [Cool, Joe]
File Options View Window Help
10 15 20 30 1m 2m 5m
1
Print... Next Page Prev Page Two Page Zoom In Zoom Out Close
Cool, Joe (EP00000DE.XDF)
1 / 10
21:35:24
21:35:54
C3/A2
O1/A2
LOC
ROC
C4/A1
O2/A1
EKG
Chin
Legs
Snore
Airflow
Airflow 2
Chest
Abdomen
SpO2
30s
Leg Movement (2.0s)
Snore (2.5s)
Snore (4.0s)
Snore (1.0s)
Snore (3.0s)
Central Apnea (7.0s)
Desaturation (34.5s)
Page 1

XDFviewer Discussion

- Since XML uses text tags to describe content, it creates larger files than comparable binary storage formats.
  - For polygraph recordings this increase in file size would be prohibitive. If the binary waveform data is stored **separately** from the descriptive data, (ie. patient information, montages, and annotations) this problem is alleviated. By keeping the waveform data in a separate file, there is the added advantage of adapting existing formats without converting the binary waveform data. This would make for easier integration into existing systems and would eliminate the risk of distorting the data upon conversion. For example, it will be possible to create the XML descriptor file from an existing EDF file without changing the original file. This will make OpenXDF backward compatible with EDF and possibly other formats.

XDFviewer Discussion cont.

- Separating the descriptive data from the binary waveform data also allows multiple waveform files to be linked together under one OpenXDF header file.
- XML files are human readable by design, but this feature is not always desirable for security reasons. Thus, software components will be created to facilitate encryption of sensitive patient information and password protect files. This option will be user-configurable for maximum flexibility.
- The security component will be a standard add-on component that can easily be integrated into existing systems.

Opinions of Claude Albertario, RPSGT
"It should all be a Web browser viewer."

- The acquisition should be a system that utilizes a SSL web browser interface to control the hardware.
- Using this scenario allows the data to exist outside of the recorder, and/or a specific "software."
- "Template viewers" would be created by manufacturers so that the usage of their template could be through payment/licensure.
- This template viewer controls how one interacts with said recorded data.
- Coupled with export functions for demographic data, scoring, etc., this affords consistency of acquisition across laboratories, ability to exchange XDF data files across templates independent of systems, and a thriving market for a "better mousetrap" (viewer.)
- This then helps ensure competition and technological advancement, benefiting the field and not just market niches.
- Acquisition system manufacturers would not require heavy investments, and Template manufacturers would be forced to constantly improve their product.