Exploration & Production **Technology**

delivering breakthrough solutions

FreeUSP & FreeDDS

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Outline

- Introduction
  - why open source?
- FreeUSP
- FreeDDS
  - using
  - developing new applications
- Looking to the future

Why Open Source ?

- FreeUSP was released as open source in 2001.
- FreeDDS followed in 2003.

- “to foster education, understanding and collaboration”
  - collaboration with academia
  - technology deployment via contractors

→ fast application of technology

Industry scale research…

- USP & DDS enable ideas to be tested, verified, then scaled
- 99% of the usage of one of the world's largest research computing systems
  - used for applied research – NOT production processing
  - 450 teraflops, almost 5000 times bigger than 1999
  - 3500 computers with over 40,000 CPUs
  - 230 terabytes of physical memory
  - 15 petabytes of raw disk storage
  - optimized systems:
    - computers with big memory allow fast development
    - clusters to allow cost-effective scaling
  - team of geophysicists, mathematicians, computer scientists

FreeUSP

- “Unix Seismic Processing”
- Started in ~1980
- Used for processing Amoco/bp data for ~30 years
- Unix based
- Command-line driven (there is a GUI, but no-one uses it)
- Unix like syntax

```
utop –N input.usp –O output.usp –dt 4
```

- ~600 codes, mostly in signal analysis and preprocessing
- 3D cubes, designed for fast access
- Similar format to SEGY
  - Line header, with processing history
  - 256 byte trace header, followed by samples

FreeDDS (next release coming in a few days)

- “Data Dictionary System”
- Started in ~1990
- Used for processing & imaging Amoco/bp data for ~20 years
- Unix based
- Command-line driven
- SepLib/SU/Madagascar like syntax

```
editd in= input 3s=100 3e=110 out=records_100_110
```

- ~100 codes in FreeDDS, ~400 not yet released, annual updates
- Covers signal analysis, preprocessing, imaging...
- Up to 9 dimensional cubes, designed for fast access
- There is no “DDS format”!

“There is no DDS format!”

- DDS is heavily influenced by SEPlib, so resembles Madagascar
- Normal use is with a dictionary file + binary file
  - Dictionary is text; line header type info describing the binary
  - Binary file can be fcube (samples only), USP, SEGY, SU, ASP,…
- Autodetects format
  - No dictionary needed for USP, SEGY.
- Every program can change format on the fly
  - compute in= input.usp scale=10 out_format=segy out_data=output.segy

Mixing Software Packages: DDS+USP+SU+…

- We can pipe between different software packages

  →DDS can act as the glue between processing packages

- Often preprocessing uses USP format because we need headers, then we use fcube (we separate the headers) when we are imaging.

```
editd \
    in= input.segy 3s=100 3e=200 \
    out_format=usp out_data=stdout: |\
utop \
    –dt 4 |\
bridge \
    out_format=su out_data=stdout: | \
suximage \
    legend=1 …
```

DDS: select records 100-200

USP: set the sample rate to 4ms

DDS: convert to SU

SU: display the data

Multi-file Support

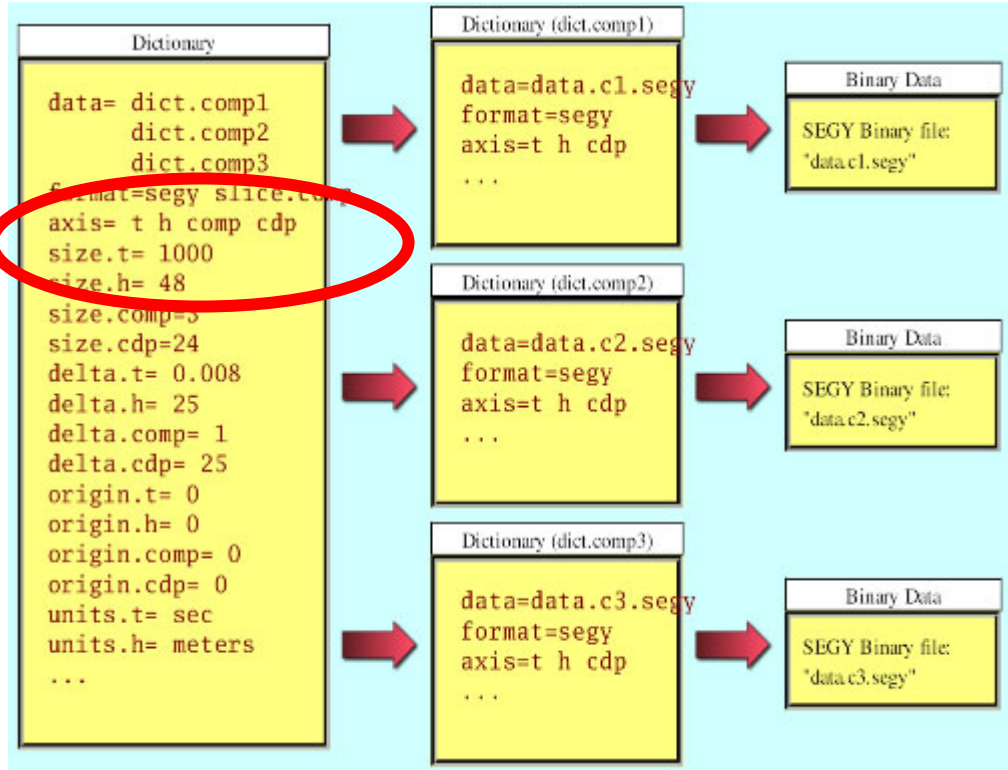
- The data can be in several different files
  - “sliced” across 1 axis (e.g. separate offset volumes),
  - or across several axes (e.g. organized as many sub-cubes)
- The dictionary allows to access it as 1 big file, or many small files.

Change the axis order* to change the effective order of the data:

axis=t comp h cdp

axis=t h comp cdp

axis=t h cdp comp

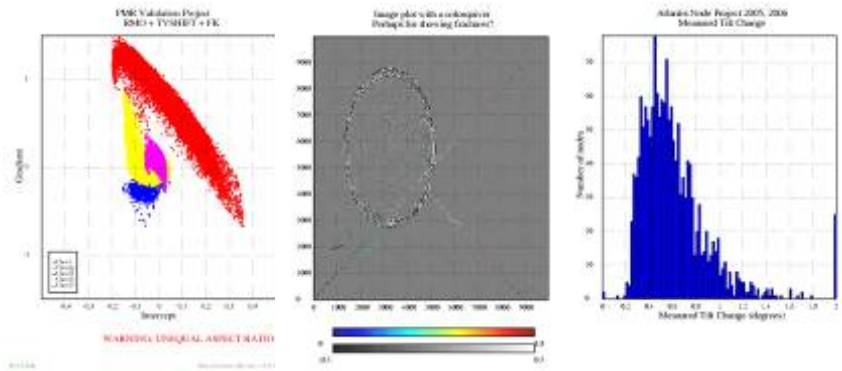


*on the command-line or by editing the dictionary. For example:

editd in=input.segy axis=t x y h size.y=10 size.h=10 4e=10 | compute …

Viewing Data: command line

- ddsplot
  - Emulates most matlab plots, plus a few extra
  - Can create plots on top of plots
  - Reads DDS/ascii; writes post-script



- Joe Dellinger uses vplot

- SU Tools
  - Wrapper scripts that convert the data to SU format:

    “bridge in=$in out_format=su out_data=stdout: | suximage legend=1…”

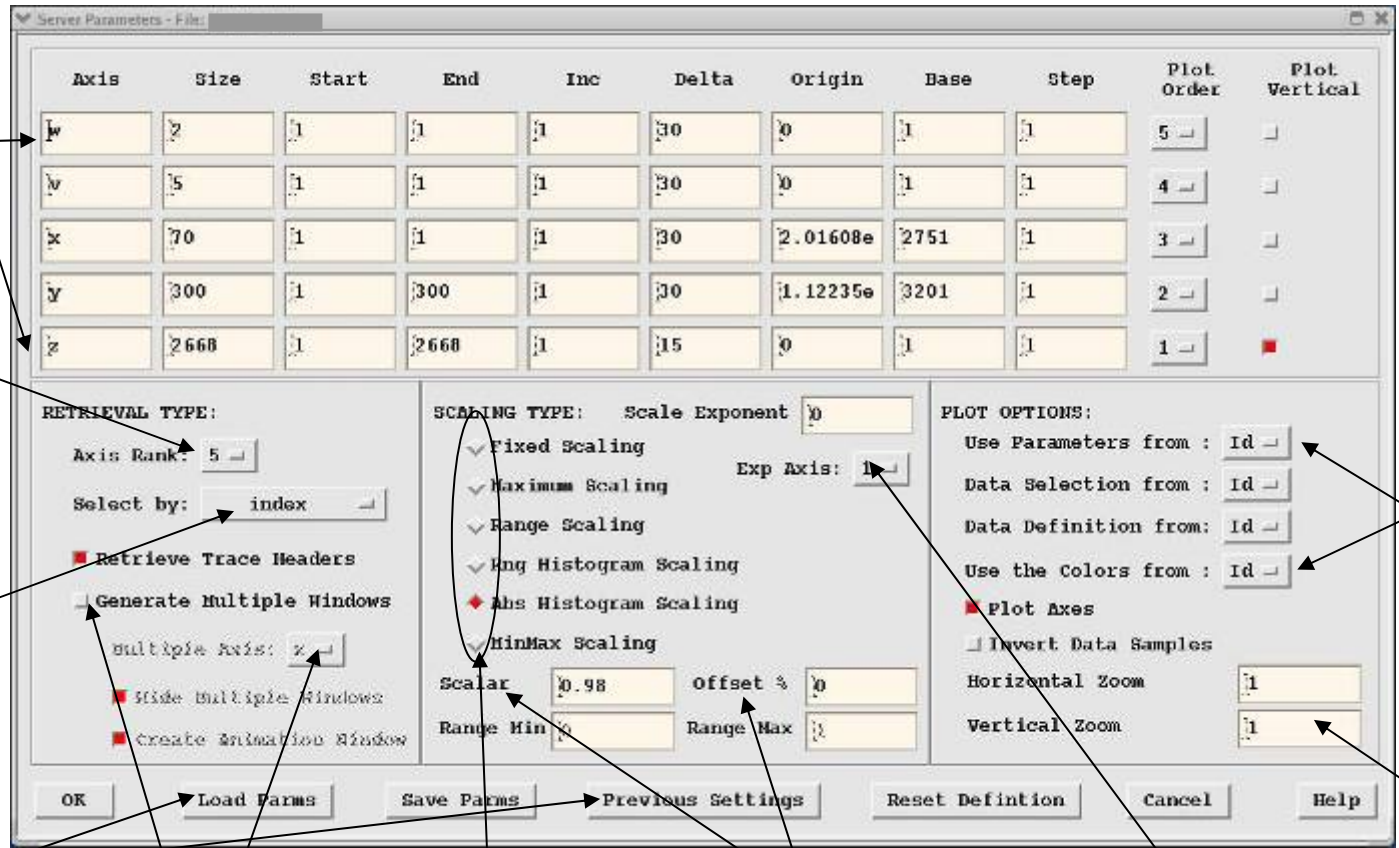
Viewing Data: GUI

- XSD
  - 2D Graphical viewer
  - Data server/client – designed for use with a remote HPC and low bandwidth
  - Interleave, animations, picking,…

Note: watch for missing X libraries during installation that can cause XSD to not compile!

Displaying data: XSD

- Once seismic data is selected to be opened, the following window appears:



Current DDS applications… +30 in next release

AutoHTMLIndex	Automatically build HTI
ChkMCHeaders	check the headers for ar
asciidump	Utility to dump binary d
boxdesign	An interactive aid to des
bridge	Convert seismic data bet
checkpolarity	check that the hydroph
chgaxis	Rename dds axis names
chkdata	Check/Correct data for
compute	general trace computati
create_hdr	Create trace headers to
ddsServer	remote data server for x
dds_defn	- Utility to return a defi
dds_if	Conditionally change he
dds_in	- Utility to return axes i
ddsarg	a utility program for bui
ddscan	Interactive dds scan utili
ddsplot	emulates the matlab plo
ddstats	print out statistics of a d
dmo3d	3D dmo (DDS)
dmofold	pre 3D dmo fold determ
dmute	Apply mute (DDS)
dnoise	spectral balancing noise
dstack	Stack data along any sel
editd	General N-dimensional e
efficientz	Resample Vzxy file for
expandz	resample between irregu
extractND	extract traces from one

fd_deriv	Frequency domain
fill	Read surfaces and f
fkdmo	3D common-offset
fkidmo	3D common-offset
freq	frequency transfor
gensort	General sorting on
green	traveltime maps fr
grid2lndmrk	Create Landmark a
gridt2d	Grid Time-to-Dept
horizon_extract	extract either a wir
interp_headers	interpolate arbitrar
lndmrk2grid	create dds grid from
makedict	- Utility to make a
makemodel	make simple test v
mbs-list	- Utility to list all
mbs-show	- Utility to list any
mbs-which	- Utility to list the
mcampbalance	record consistent s
mcappfilt	apply a multi\-char
mclean	kill multi-compone
mcrecdecon	record consistent r
mcsplit	split multiplexed O
memorysort	in memory sorting
mergeND	Multidimensional d
muteqather	apply mute to gath
mutesalt	mute selected trace
mutestk	apply mute and ver

nmo	Apply/remove hyperbolic normal move
obsazcheck	vector fidelity correction of multi-com
pad3d	Pad first 3 axes of an N-dimensional dat
pick2dds	interpolate xsd picks over 2D surface (DDS)
radar	Interactive Box Wave Test Analysis (DDS)
resetlive	Reset live header flag in geometry file (DDS)
restore_hdr	Restore trace headers from a separate (DDS) dataset
reverse	reverse order any selected axes (DDS)
rotatexy	3D coordinate rotation (DDS)
rsamp2d	resample first 2 axes of ND dataset (DDS)
rsampND	resample any axes of ND dataset (DDS)
save_hdr	Save trace headers to a separate (DDS) dataset
skewrot	Apply a skew rotation on traces (DDS)
slicecube	slice a cube from the values in a surface (DDS)
slicevol	Slice horizons out of a volume (DDS)
smooth3d	smooth on any of 1st 3 axes (DDS)
sort4coamig	sort data for Vxyz 3D common-offset migration (DDS)
surfs2volume	interpolate volumes from surfaces (DDS)
taper3d	Apply a taper on any of first 3 axes (DDS)
tdconv	Time-to-Depth/Depth-to-Time Conversion (DDS)
transpose	General transpose program (DDS)
trcpik	Interactive first break picking on traces (DDS)
tscan	Tape Scan to Determine Tape/Data Format (DDS)
varotate	rotate H1 and H2 components to radial and transverse. (DDS)
velfill	Fill velocity between two surfaces (DDS)
vzd2t	V(z) time to depth/depth to time moveout (DDS)

wtstk	apply weights and stack traces (DDS)
xsd	an X window seismic display program (DDS)
z2d_horizon	depth correct a 3D volume (DDS)

- If you are not a software developer, then you can start to nap now….

Writing a DDS Program

- API's in C & Fortran
  - Template examples with "core" DDS functions on the website
  - Matlab API in progress
- Compilers
  - Requires a recent version of gfortran (that supports pointers) or Intel, PGI,…
- Not thread safe
  - "Those geophysicists would shoot themselves with it anyway" - Comp. Sci Guru
  - Many codes use both OpenMP & MPI
- MPI
  - Template, convenience routines
  - Parallel input and output
  - Largest OpenMP+MPI job to date had 20,000 threads/processes.

Cat Herding…

“It compiled and ran. I’m done!”

- Documentation
  - Man pages required!
  - Automated template man page
- Regression testing
  - On-line test results (run with memory checking)
- Run-time Logging
  - Internal only!
  - Connections (*who has used the program I need help with?)*
  - “Risk” warning (*production/test/where did you get this?)*

What you are probably thinking…

“That all sounds complicated.”

- It’s not!
- Let’s look at a simple Fortran example ignoring headers…
  - record by record processing
  - can read input files of different formats
- Using headers is only slightly more complicated
  - requires extra trace buffer, and calls to extract headers/sampes

Reading and writing parameters…

```
#include <fdds.h>

If( fdds_openpr(prog,'') .gt.0 ) call help()

ier=fdds_dict('par:','scan')

verbose = (fdds_switch('verbose',0) .eq.1)

ntaper=10
ier=fdds_scanf('ntaper nt','%d\0',ntaper)
ier=fdds_printf('ntaper=%d\0',ntaper)

ptr_taper=fdds_malloc8(dble(ntaper)*SIZEOF_REAL)
```

Open the print file, unless the user specified help= or -?

Scan from the parfile or command-line (not an input file)

Logical parameter: yes/no/true/false

Read integer parameter, with synonym. Write value to log file.

Allocate (maybe >2Gb)

Open the input and output…

```
fd_in=fddx_in('in','stdin:',’title’)
if (fd_in.lt.0) then
    ier=fdds_prterr('Unable to open input data file!\n\0')
else
    ier=fdds_scanf('size.axis(1)','%d\0',n1)
    ier=fdds_scanf('size.axis(2)','%d\0',n2)
    n3=fdds_axis_prod(3)
endif

fd_out=fddx_out('out','stdout:',’title’,fd_in)
if (fd_out .lt. 0) then
    ier=fdds_prterr('Unable to open output!\n\0')
endif

If ( fdds_errors().gt.0 ) fdds_closepr()
```

Open the input, look for in= *filename*. Default to stdin:

Get the data dimensions.

Open the output, look for out= *filename*. Default to stdout: Use the input file for the history, and defaults.

Stop if there were errors.

Reading and writing data…

```
do i3 = 1,n3
    if (fddx_read(fd_in,record,n2).ne.n2) then
            ier=fdds_prterr('Reading record %d\n\0',i3)
            ier=fdds_closepr()
    endif

    call do_some_stuff()

    if (fddx_write(fd_out,record,n2).ne.n2) then
            ier=fdds_prterr('Writing record %d\n\0',i3)
            ier=fdds_closepr()
    endif
end do

ier=fdds_closepr()
```

Read n2 traces into array *record*.

Write n2 traces from array *record*.

Close any open files. Stop.

Simple makefile…

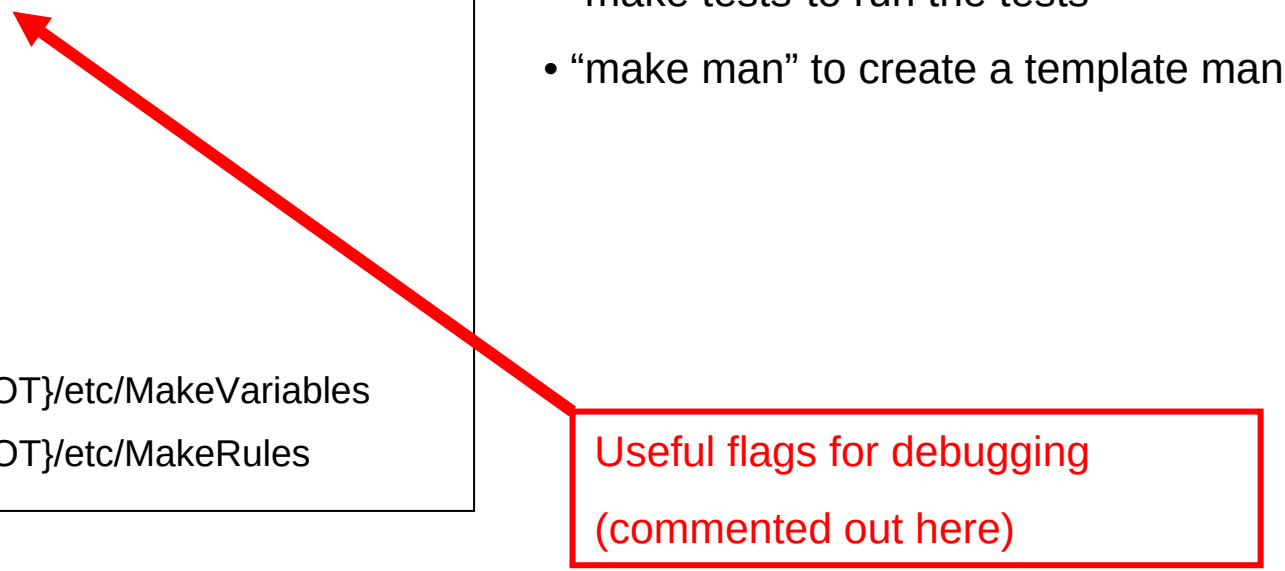
```
Name := my_program
FSrcs := my_fortran_code.F

#DEBUG := TRUE
#WARN := TRUE
#CHECK := TRUE

MP := TRUE
MPI := TRUE

include ${DDSROOT}/etc/MakeVariables
include ${DDSROOT}/etc/MakeRules
```

- “make” to compile
- “make help” for options
- “make newtest” to create a test template
- “make tests”to run the tests
- “make man” to create a template man page



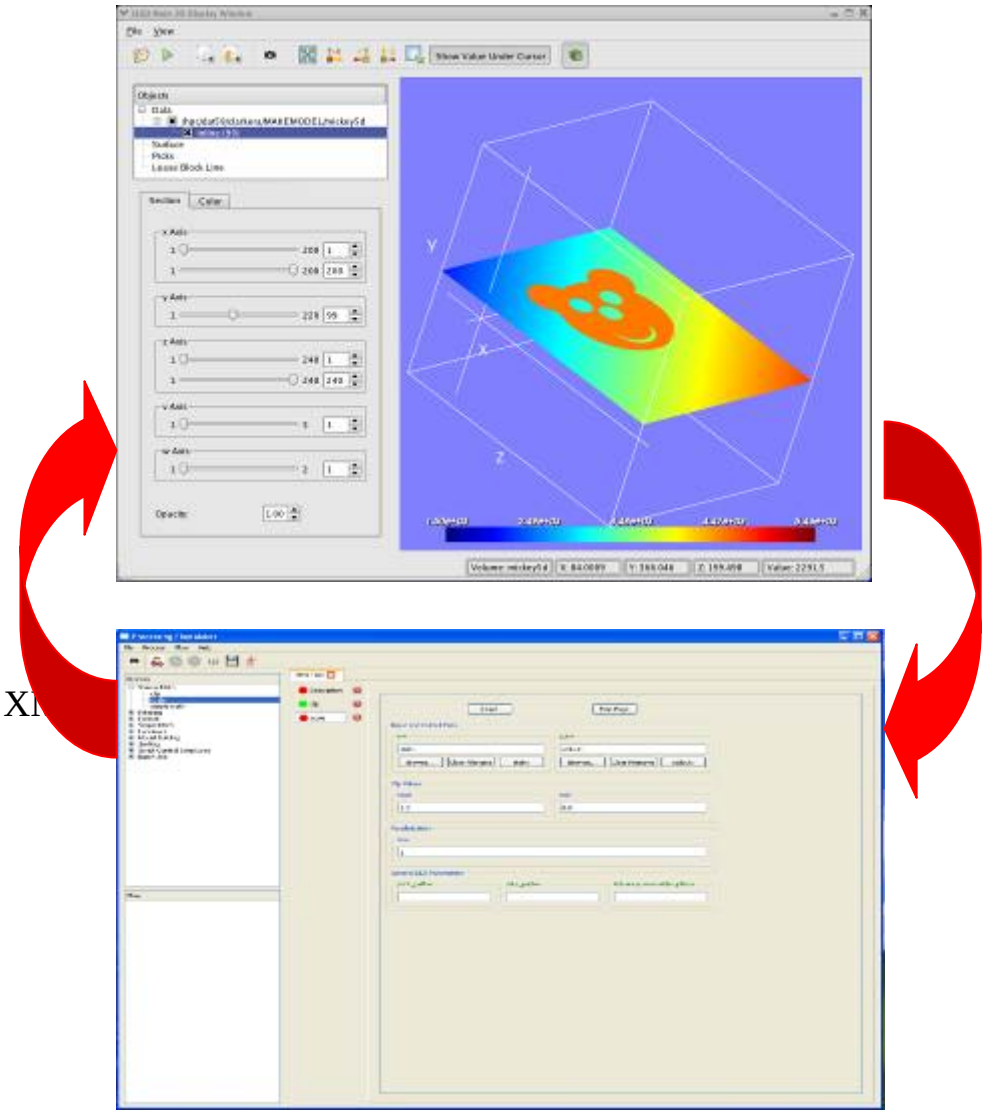
- If you were napping, you might want to wake up now…

Looking ahead…

- R&D platform for seismic processing & imaging in bp
- Simplification
  - We are trying to move from USP to DDS
  - Less maintenance, training; more flexible formats (less use of integer2!)
- More user-friendly
  - GUI integrating a script builder with more powerful graphical QC tools
- Improvements to DDS
  - Parallel I/O with compressed data?
  - Thread safe?
  - Stub libraries for other packages?
  - Looking for opportunities to collaborate

“DDSGUI” – in progress

- 3D viewer for:
  - Slices of N-dimension data
  - Very large datasets
  - Surfaces
  - Well paths and Markers
  - Lease block lines
  - Scriptable
- Script builder
  - Ability to save and reload scripts
  - Very easy to add new functions (through XI
  - Foreach loops
  - SGE job submission
  - Framework for error checking
- Based on Qt and VTK



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- BP management for permission to make USP & DDS open source and for permission to deliver this presentation.

For information about USP and DDS:

FreeUSP.org

Note: FreeDDS is currently hosted on FreeUSP.org