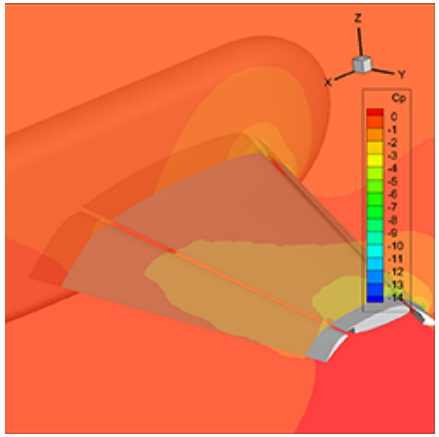
Overcoming the I/O Bottleneck using Subzone Load-on-demand (SZL)

Scott Imlay, CTO
Scott Fowler, Product Manager



tecplot®
Master the View

Agenda:

1. Introduction
2. SZL Technology Explained
3. Using SZL in Tecplot 360 EX
4. Using TecIO to write SZL files

Products:

Tecplot 360 and Tecplot Chorus

360™

CFD Visualization & Analysis

Quickly plot and animate your CFD data exactly as you like.

- Analyze complex data
- Arrange multiple layouts
- Communicate results

chorus™

Design Space Exploration

Manage and analyze collections of CFD simulations.

- Compare multiple runs
- Evaluate overall system performance
- Identify trends and anomalies

SZL Technology:

Motivation

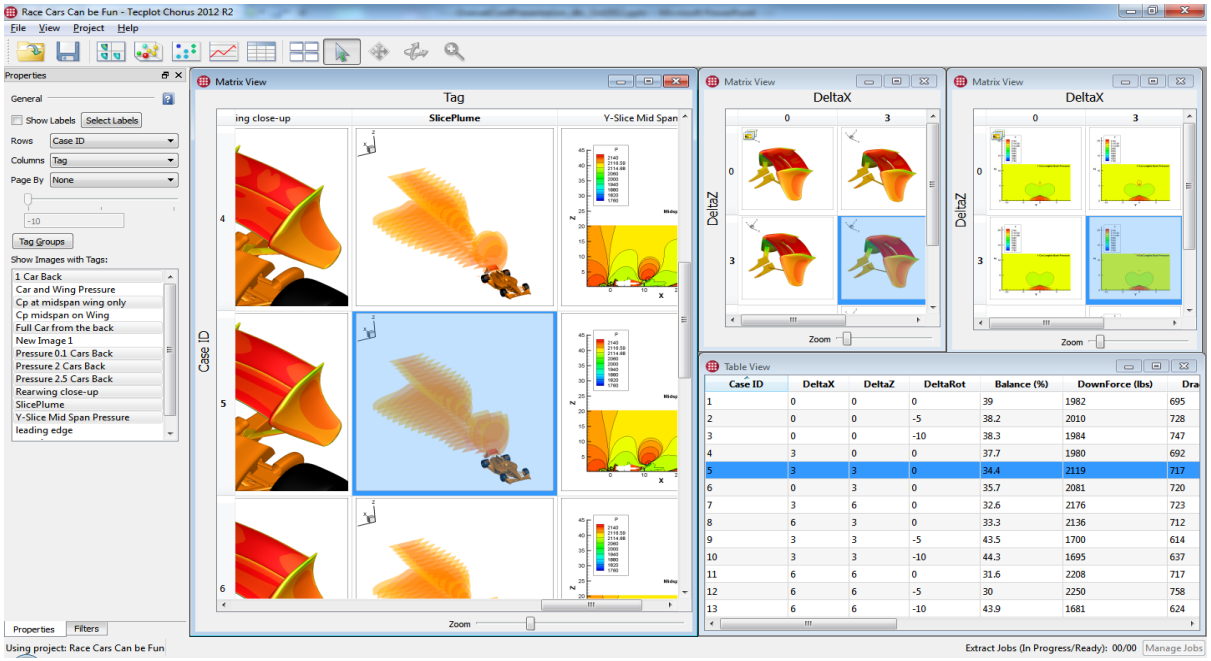
- Wide range in length scales
- Resolution of grid
  (# of grid points)
  constrained by computer
  performance
  (growing with Moore's law)



SZL Technology:

Motivation

- Tecplot Chorus adds parametric dimensions
- Increases size of data analyzed by orders of magnitude



SZL Technology:

CFD 2030

NASA is forecasting trillion cell unsteady CFD cases by 2030

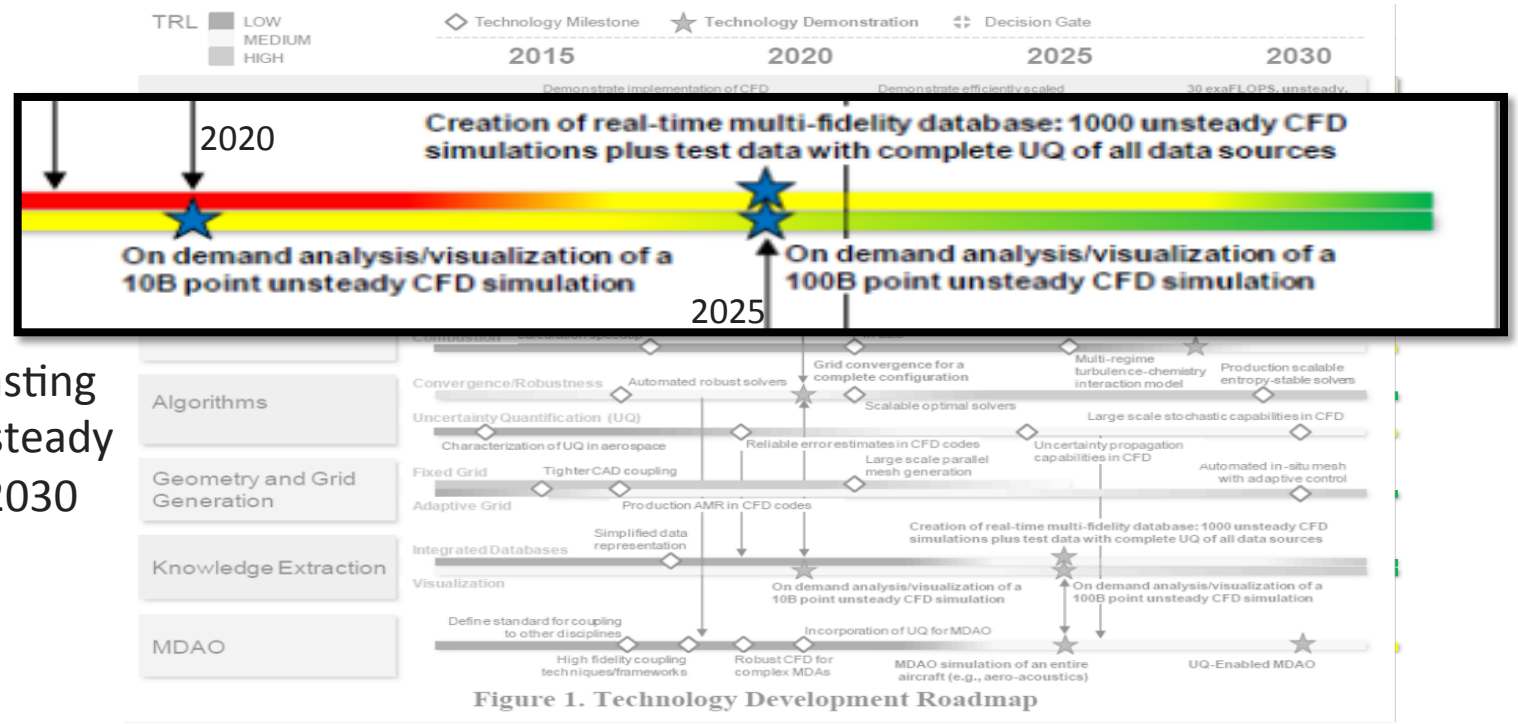
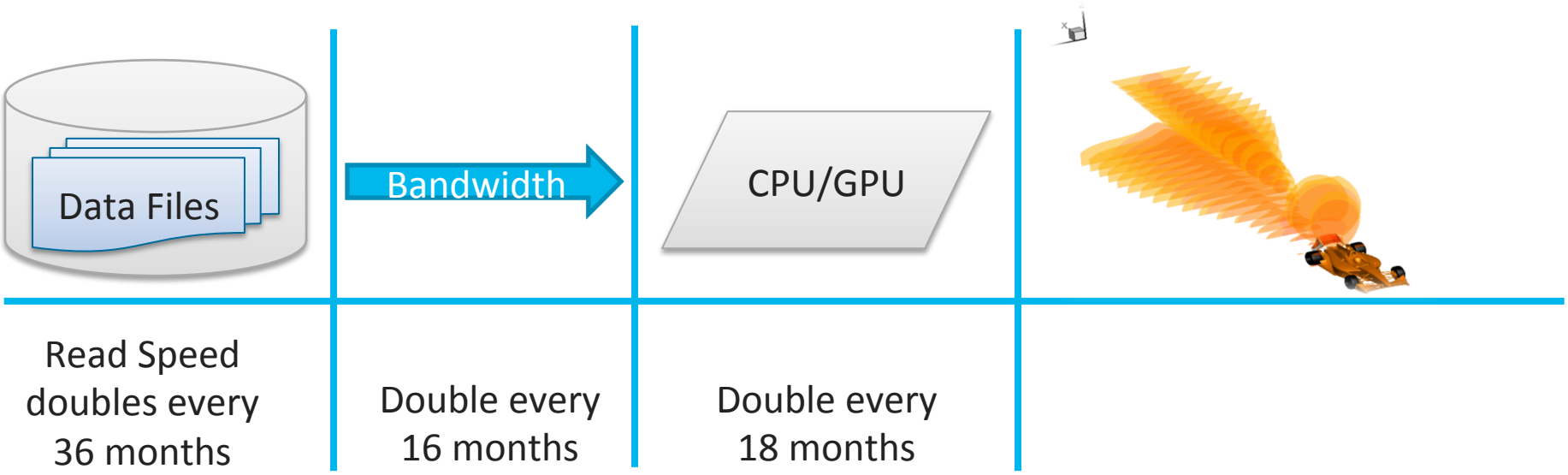


Figure 1. Technology Development Roadmap

SZL Technology:

Pipeline

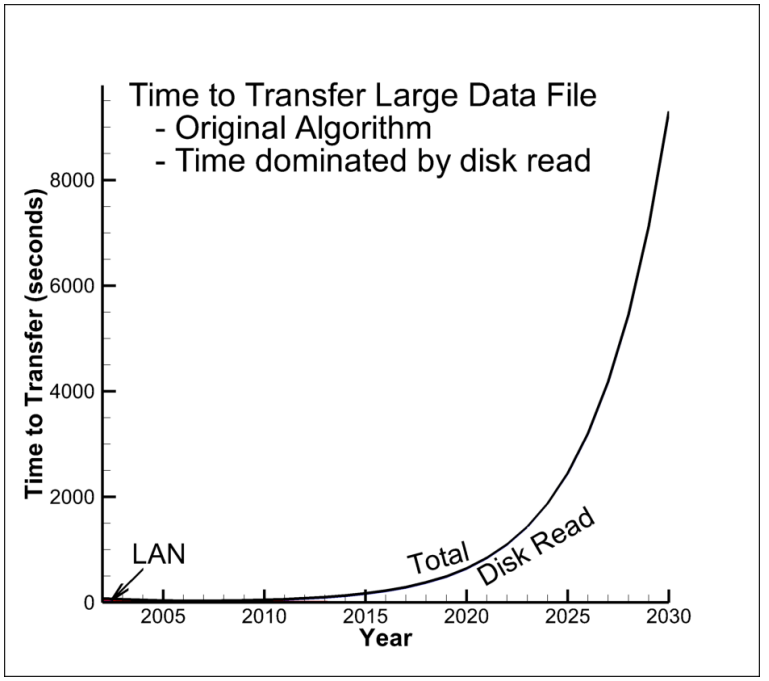


Data IO is the rate-determining step in the visualization pipeline.

SZL Technology:

Impact of Disk I/O Bottleneck

- Disk read performance growing slower than grid size
- Current visualization architectures will perform dramatically worse as time goes on!



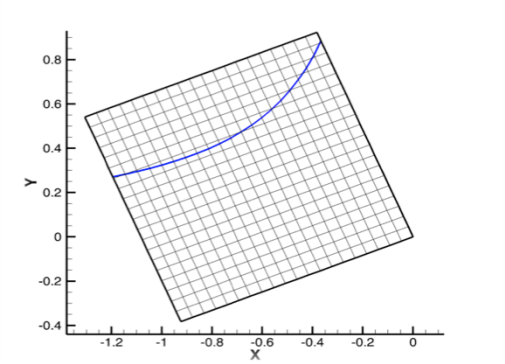
SZL Technology:

Basic Idea

- Reduce the amount of data you read
  - Must scale sub-linearly with the size of the grid
- Subzone Load-on-Demand (SZL)
  - Save indexed data file
  - Load only the data you need (Lazy Loading)

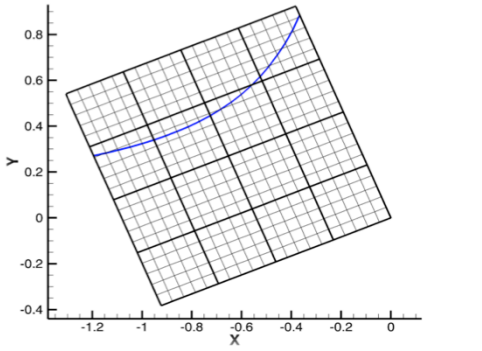
SZL Technology:

How SZL Works



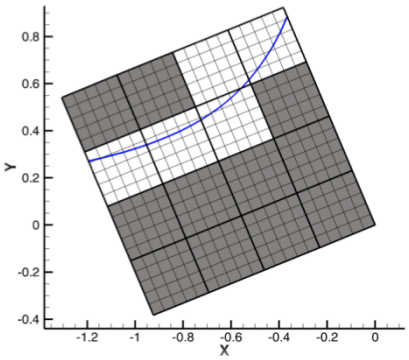
Example 2D contour line

- Current methods require loading data for zone
- For large data loading can be time intensive



Domain can be indexed

- Decomposition of domain into smaller subdomains
- These subdomains can be indexed



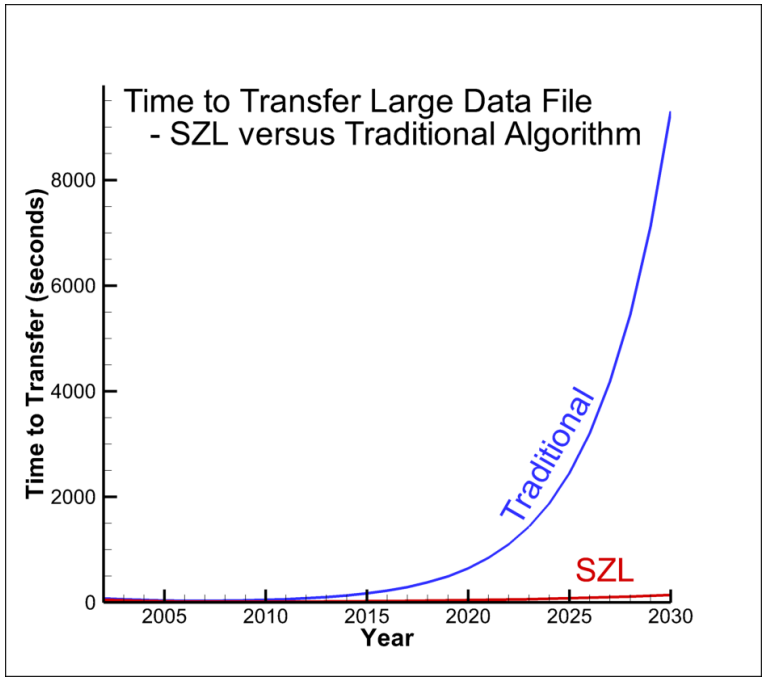
Data required for line is 5/16 of total data

- Loading time reduced
- Memory requirements reduced

SZL Technology:

Performance Improvements

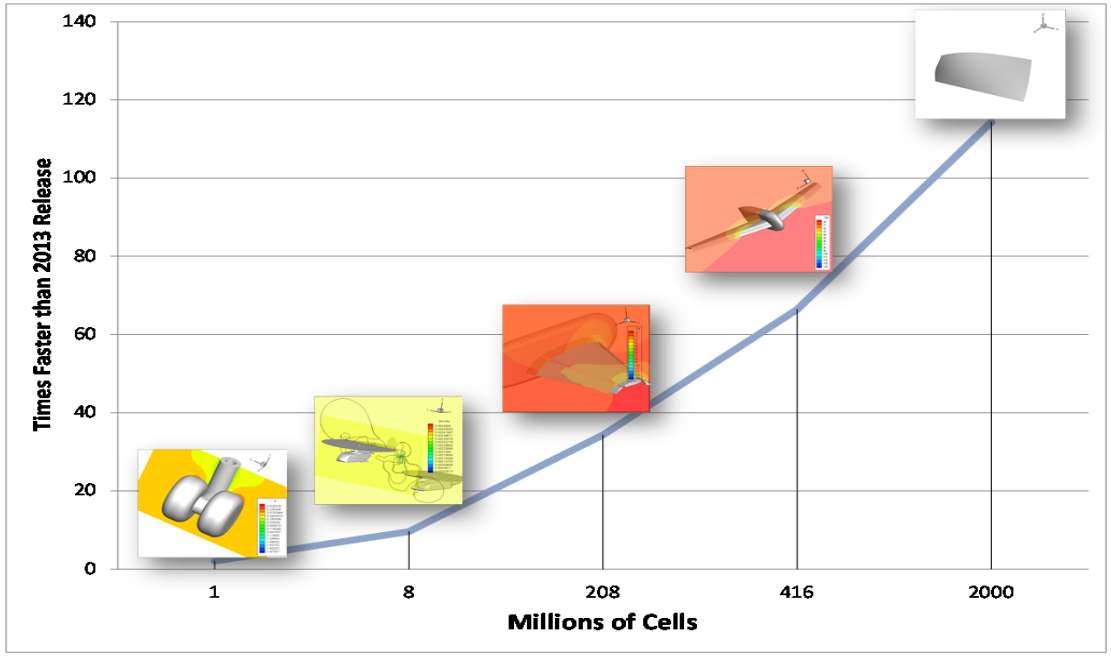
- Amount of data used is dramatically less with SZL
  - SZL advantage grows exponentially with time
- Transfer time grows much slower than before



SZL Technology:

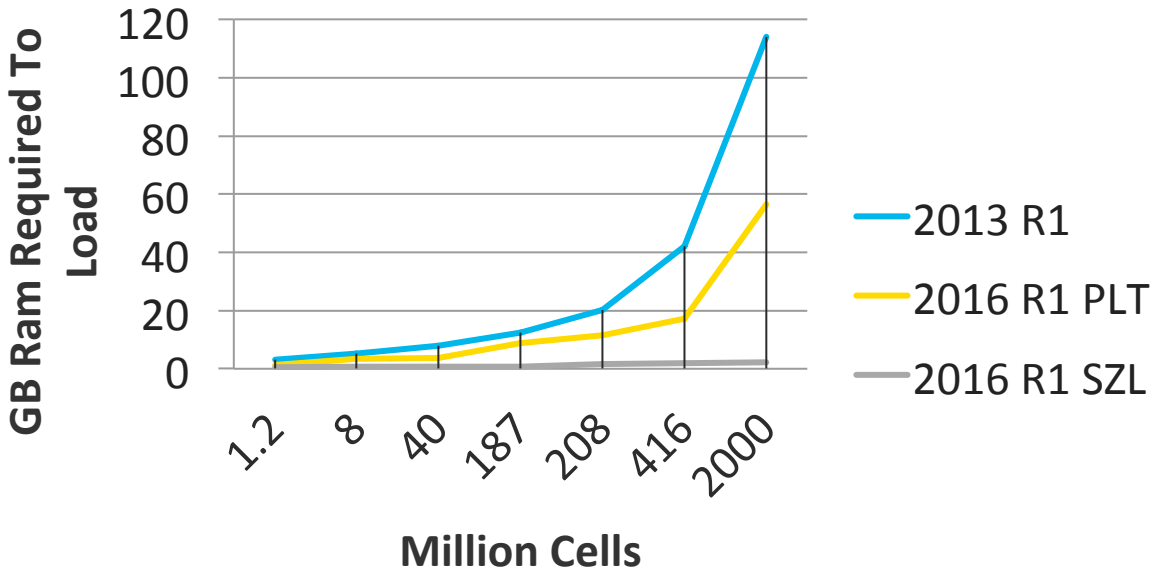
Performance Improvements

- 100% of the test show improved performance with SZL
- Results vary depending on specific data set, but all but the smallest test showed >10x speedups (FE data)



SZL Technology:

Memory Reduction



Memory reduction is what makes the impossible possible. With SZL you can load extremely large solutions on machines with limited memory.

SZL Technology:

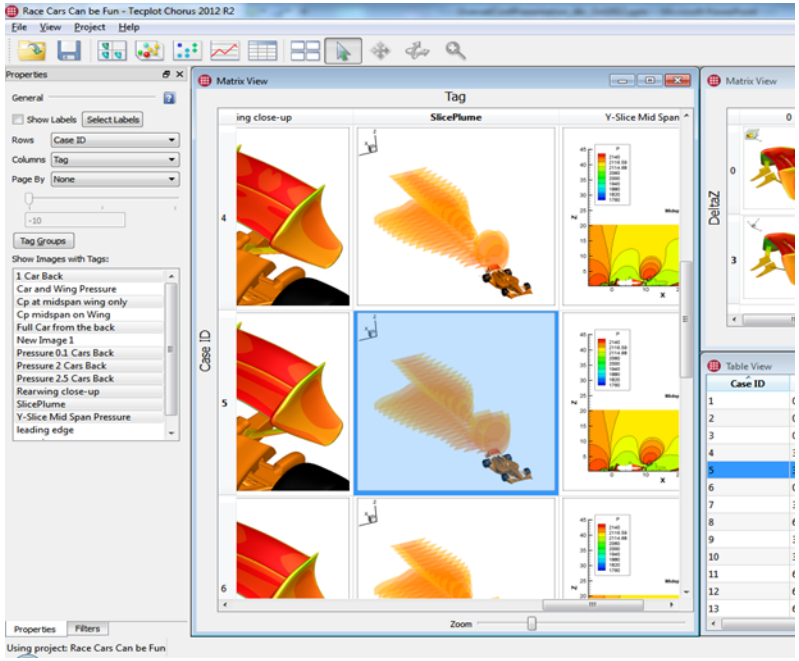
Benefits for Tecplot Chorus Users

Race Car Study

- 13 cases with 35M cells (FE) each
- Study of rear wing position on wake to get clean air for passing car

Benefits of SZL

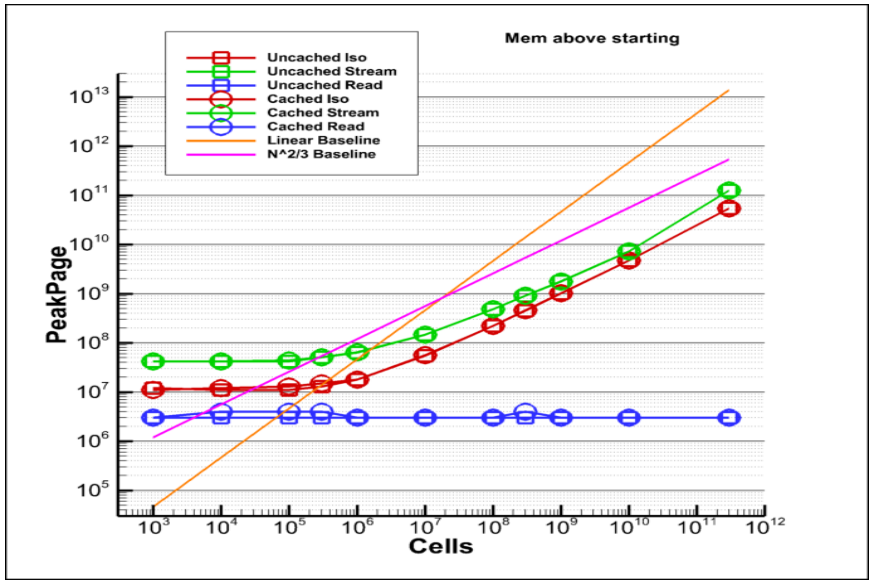
- Task: cycle through all 13 cases and create images with streamtraces
- Results with PLT: 9:53, 2.8GB RAM
- Results with SZPLT: 2:10, 0.3GB RAM
- SZL compression saves 8GB of disk space (31% compression)



SZL Technology:

Trillion Cell Challenge

- Achieved our goal of visualizing one-trillion cells in 2015
- Scaling is as predicted



SZL Technology:

Research: In-Situ

- Motivation: the disk I/O bottleneck when writing.
- Ongoing In-Situ Research at Tecplot Inc.
  - Write out only the volume subzones needed for desired images
  - Advantages compared to traditional In-Situ
    - Very little overhead on the solver
    - Some exploration of volume data possible
  - Disadvantages
    - Writes out some volume data (larger than image)

Using SZL:

When should I use SZL?

- Using volume data*
- Want faster load times
- Want smaller files on disk (FE-only)
- Can't load your data due to insufficient RAM

*IJK-Ordered, FE-Brick, FE-Tetrahedron. Polyhedral data will be supported in the future

Using SZL:

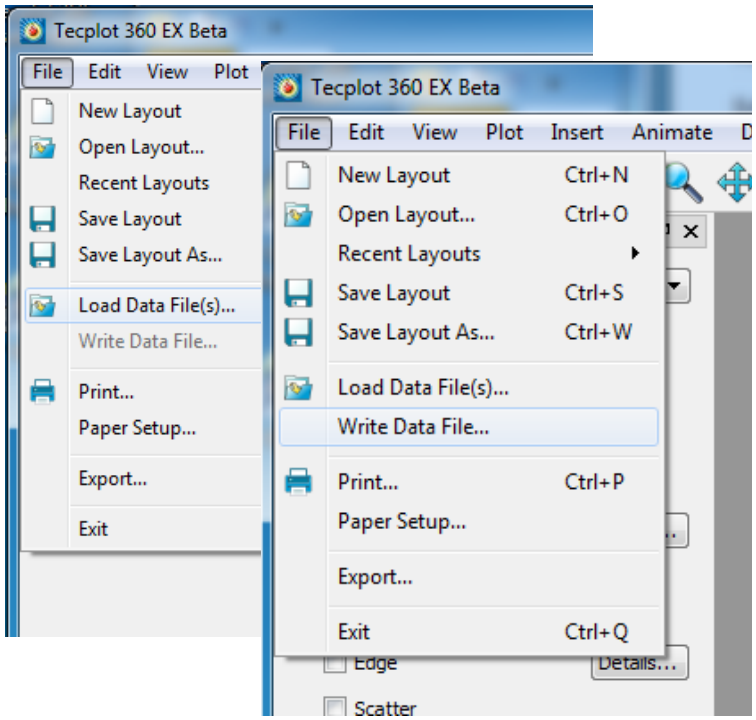
Creating SZL Files

1. Load into Tecplot 360 EX and write as SZL
2. Automate step 1 with scripts
3. Write SZL directly from your code using TecIO

Using SZL:

Writing SZL Files from Tecplot 360 EX

- Load Data using File->Load Data File(s)
- Write SZL file using File -> Write Data File
  - Select “Tecplot Subzone Data Writer (*.szplt)” as type



Using SZL:

Batch Conversion

For batch execution, use command line

```
tec360 -b [datafiles] [macrofile]
```

`[datafiles]` are the input data files

`[macrofile]` is a file containing a Tecplot macro to write *.szplt files

Using SZL:

Macro to Write SZL Files

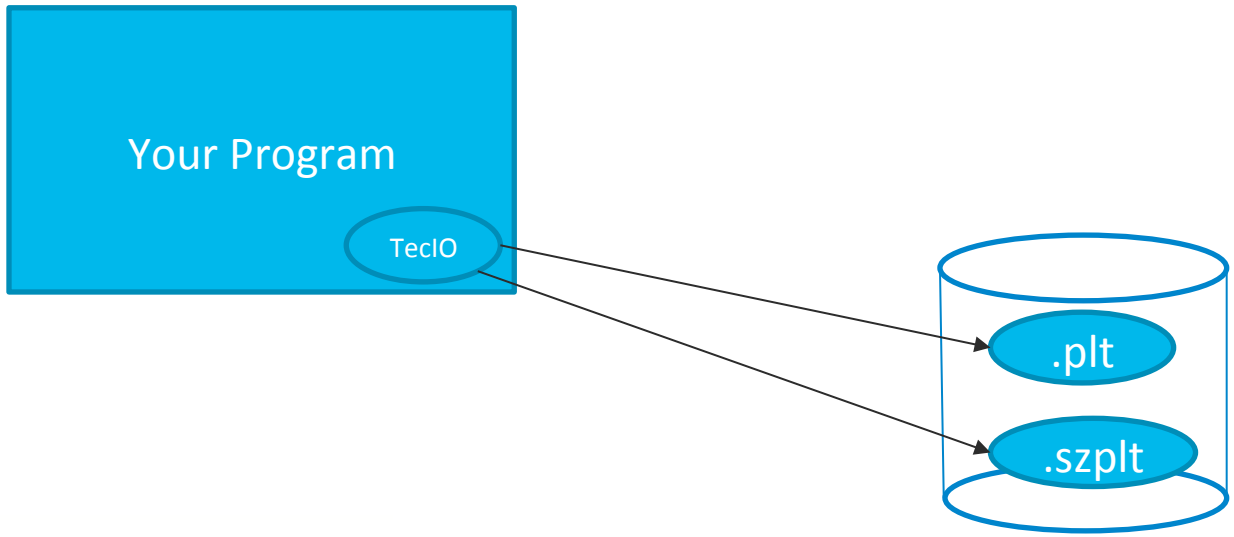
Tecplot Macro:

```
#!MC 1200
$!EXTENDEDCOMMAND
    COMMANDPROCESSORID = 'Tecplot Subzone Data Tools'
    COMMAND = 'WRITEDATASET FILENAME="myfile.szplt"
```

TecIO:

What is TecIO?

TecIO is a library for writing Tecplot binary files



TecIO:

APIs

TECINI142 opens a new file

TECZNE142 adds a zone to that file

TECDAT142 adds variable data to the zone

TECNODE142 specifies FE connectivity

TECEND142 closes the file

Other APIs for advanced features

TecIO:

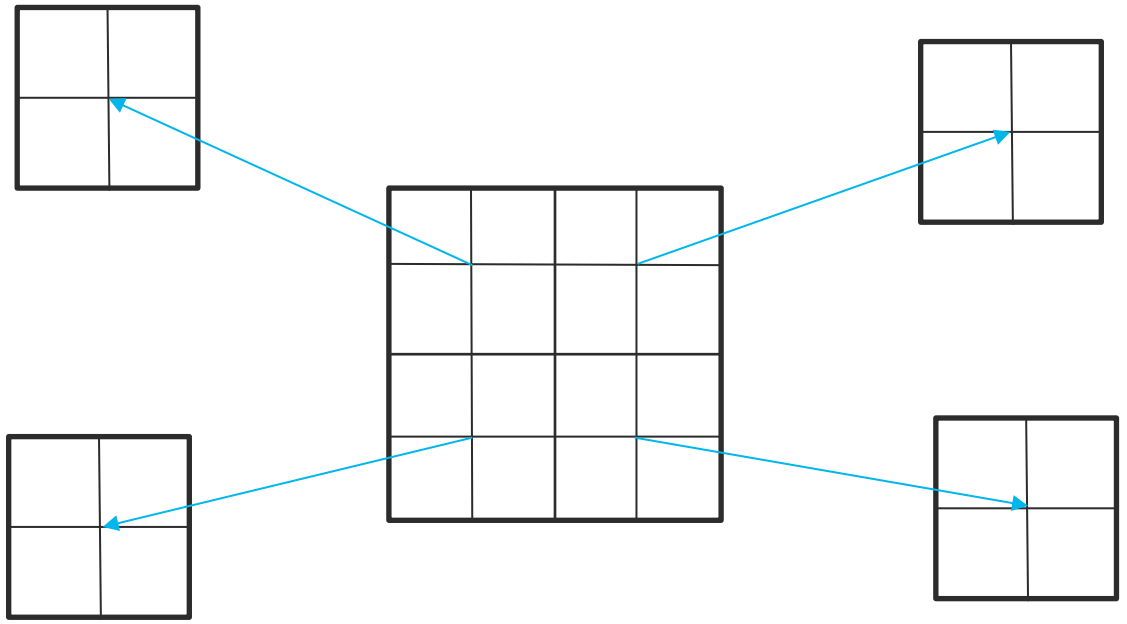
Example: IJK Ordered Zones

```
I = TecIni142('DATASET'//CHAR(0), 'X Y Z P'//CHAR(0), 't.szplt'//CHAR(0), &
        '.'//CHAR(0), FileFormat, FileType, Debug, IsDouble)

I = TecZne142('Simple Zone'//CHAR(0), ZoneType, IMax, JMax, KMax, 0, 0, 0, &
        SolTime, 0, 0, 1, 0, 0, 0, 0, 0, Null, Null, Null, 0)
! Create X, Y, Z, P...
III = IMax*JMax*KMax
I = TecDat142(III,X,0)
I = TecDat142(III,Y,0)
I = TecDat142(III,Z,0)
I = TecDat142(III,P,0)
I = TecEnd142()
```

TecIO:

MPI Does Partitioned Zones



TecIO:

Partition-specific APIs

TecMPIInit142 (MPI only) provides MPI-specific information

TecZneMap142 (MPI only) maps zone partitions to MPI ranks

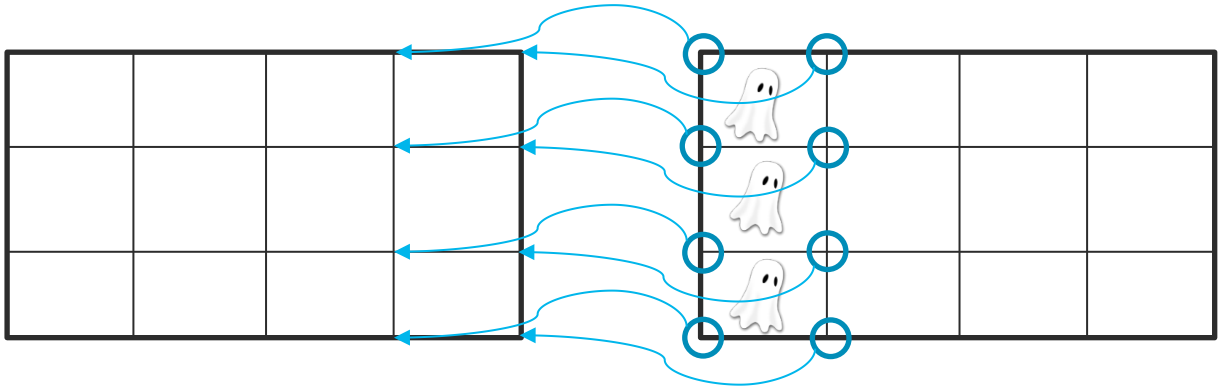
TecFEPtn142 adds a partition to the current zone (finite-element)

TecIJKPtn142 adds a partition to the current zone (IJK ordered)

Only volume zones may be partitioned

TecIO:

FE Partitions Connected by “ghost nodes”



TecIO:

MPI Example: Partitioned Brick Zone

```
// Call TecIni142, then...

MPI_Comm mpiComm = MPI_COMM_WORLD;
INTEGER4 mainRank = 0;
ret = TECMPIINIT142(&mpiComm, &mainRank);

// Call TECZNE142, then...
ret = TECZNEMAP142(&nPartitions, partitionOwners);

ret = TECFEPTN142(&ptn, &nNodes, &nCells, &nGNodes, ghostNodes,
                  gNPartitions, gNPNodes, &nGCells, ghostCells);

// Call TECDAT142, TECNODE142; include any ghost nodes and cells

ret = TECEND142();
```

SZL Technology:

Future Development

- Reading Tecplot binary data using TecIO
- Standalone SZL converter
- Polyhedral support for SZL format
- In-Situ

Summary:

SZL Technology Is More Efficient:

- Faster
- Uses less memory
- Compresses FE files

Three Ways to Create SZL Files:

- Interactively using Tecplot 360 EX
- In batch mode using Tecplot 360 EX
- Using TecIO or TecIO-MPI

Thanks!

Trial Software
www.tecplot.com/trial

TecIO Library
www.tecplot.com/downloads/tecio-library

Questions
scottimlay@tecplot.com