ADVANCED PHOTON SOURCE

The SDDS Toolkit

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What do the following items from recent operations logbooks have in common?

- SCR files of the injectors were saved.
- RMS beam motion is: x=4.028um, y=1.821um.
- 102mA stored beam, running orbit correction.
- Storage Ring tunes are: x=0.1948, y=0.2753.
- The Storage Ring RF configuration was compared to the reference file.
- Steering complete for 33ID.
- G. Decker is collecting fast beam history data.
- No problems detected with 48 data loggers.
- Louis Emery topped up the ring to 100mA using the top-up software.
- Singlet bunch pattern studies were performed by M. Borland until R. Merl arrived to do the top-up current monitor studies.

Answer:

All of these entries are referring to activities that depend on a software system called the SDDS Toolkit.

The Toolkit was **not** designed with any of these activities in mind.

Paradoxically, this is why it is so useful.

What is SDDS?

- SDDS stands for “Self Describing Data Sets.”
- SDDS is just a standardized way to store and access data, i.e., a “file protocol.”
- SDDS also refers to a group of ~85 programs that use this file protocol.
- These programs are the “tools” in the SDDS Toolkit.

The Toolkit Analogy

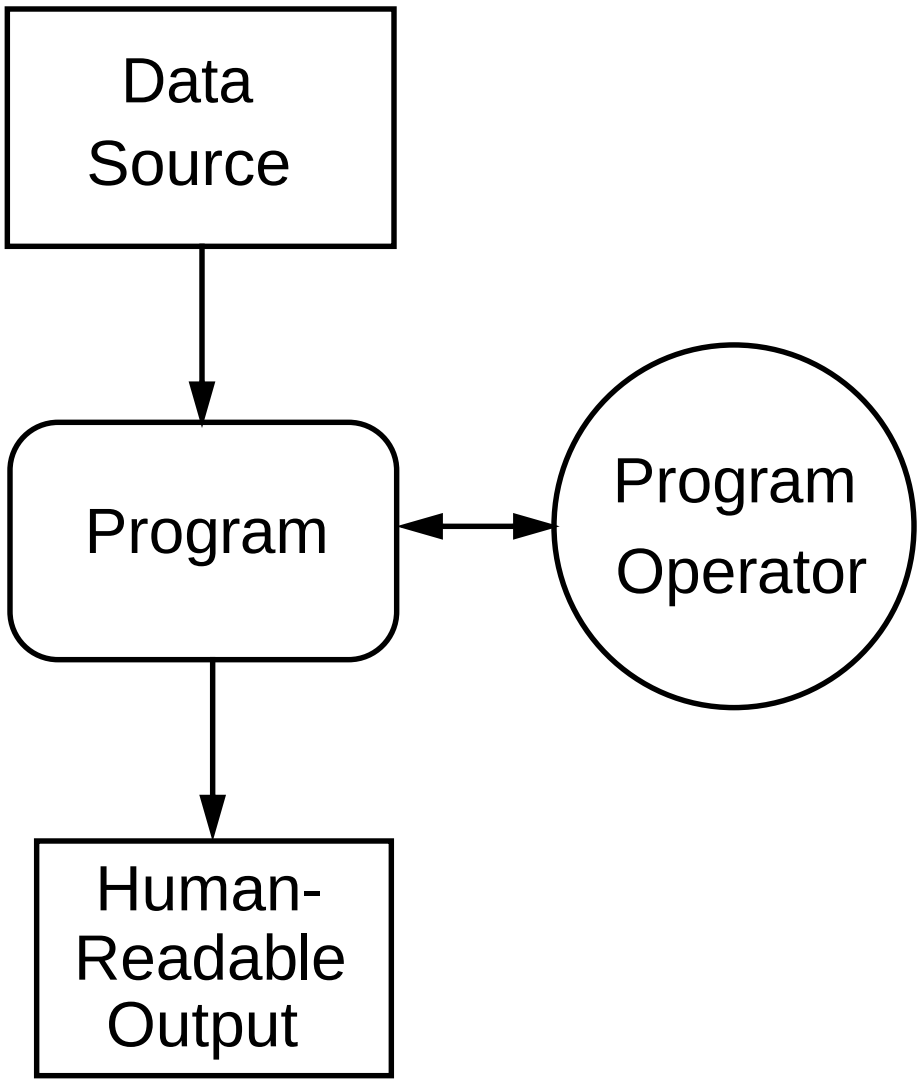
- A hammer, a saw, a drill, etc., can be used together or sequentially to create and modify physical objects.
- The programs in the SDDS toolkit can be used to sequentially transform SDDS data sets.
- Within some limits, it isn’t determined ahead of time what physical objects can be modified or what can be created.
- SDDS toolkit programs are generic and operate on any SDDS data set. The meaning of the operations is not predetermined.

- Both physical and SDDS tools can be used in arbitrary sequences of arbitrary length. The capability of the toolkit grows very rapidly with the number of tools.

- Every new tool that is created makes the existing ones more useful, without any advance planning or coordination by developers.

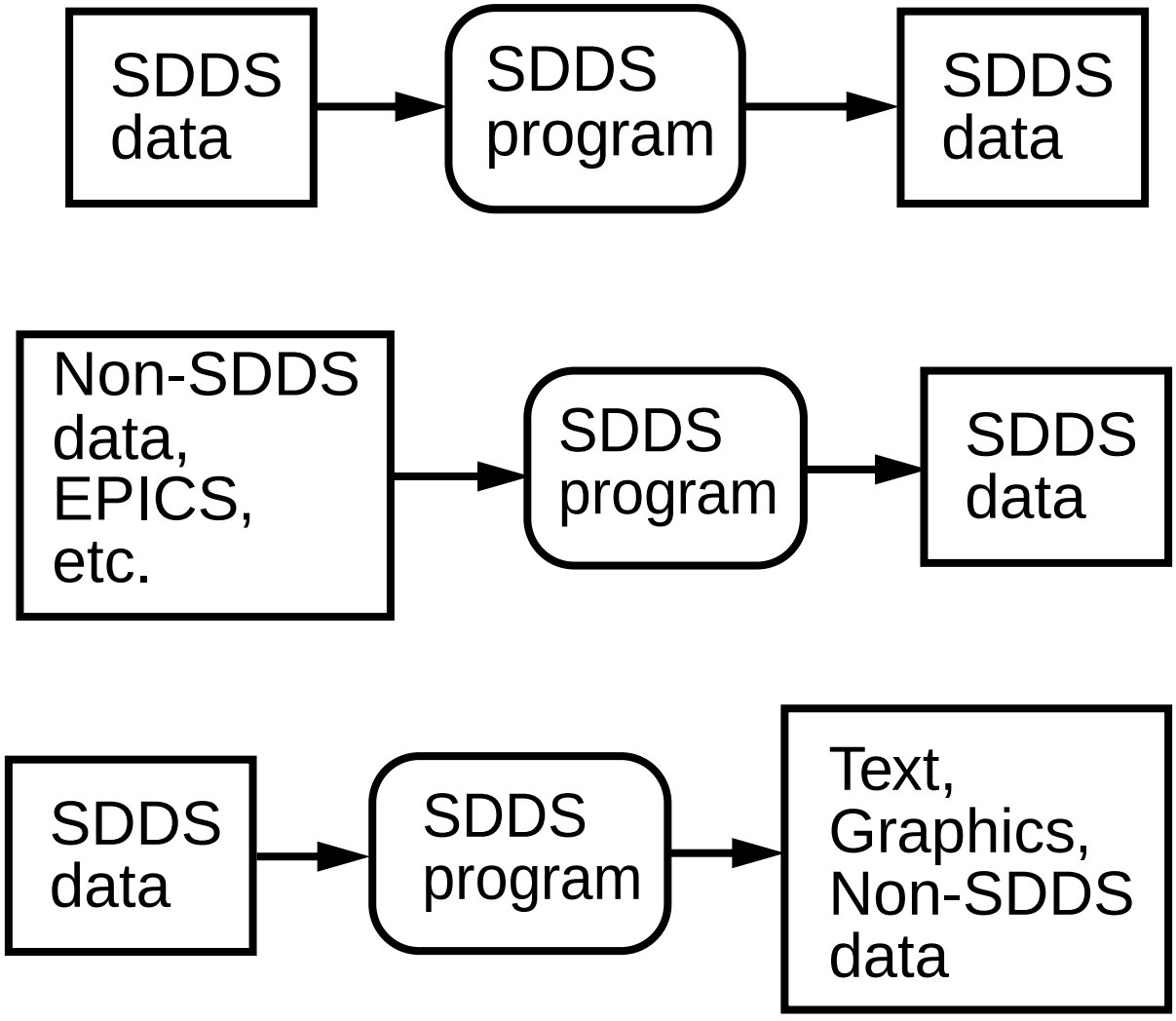
- A new tool need not be useful by itself in order to be very useful as part of a toolkit. Most SDDS tools produce no directly useful result. This freedom makes new tools much easier to create.

Conventional Paradigm

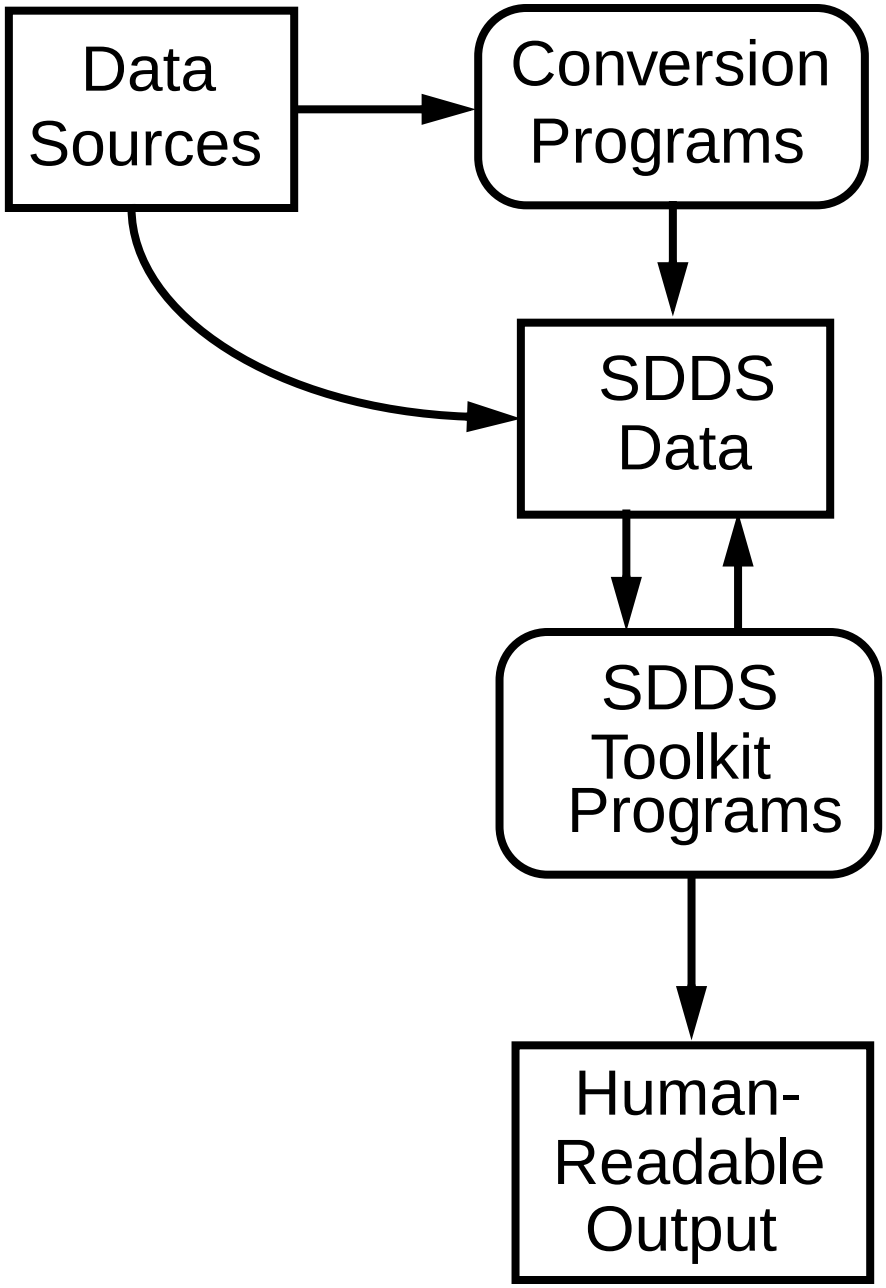


SDDS-Compliant Programs

Three types of SDDS-compliant programs



SDDS Toolkit Paradigm



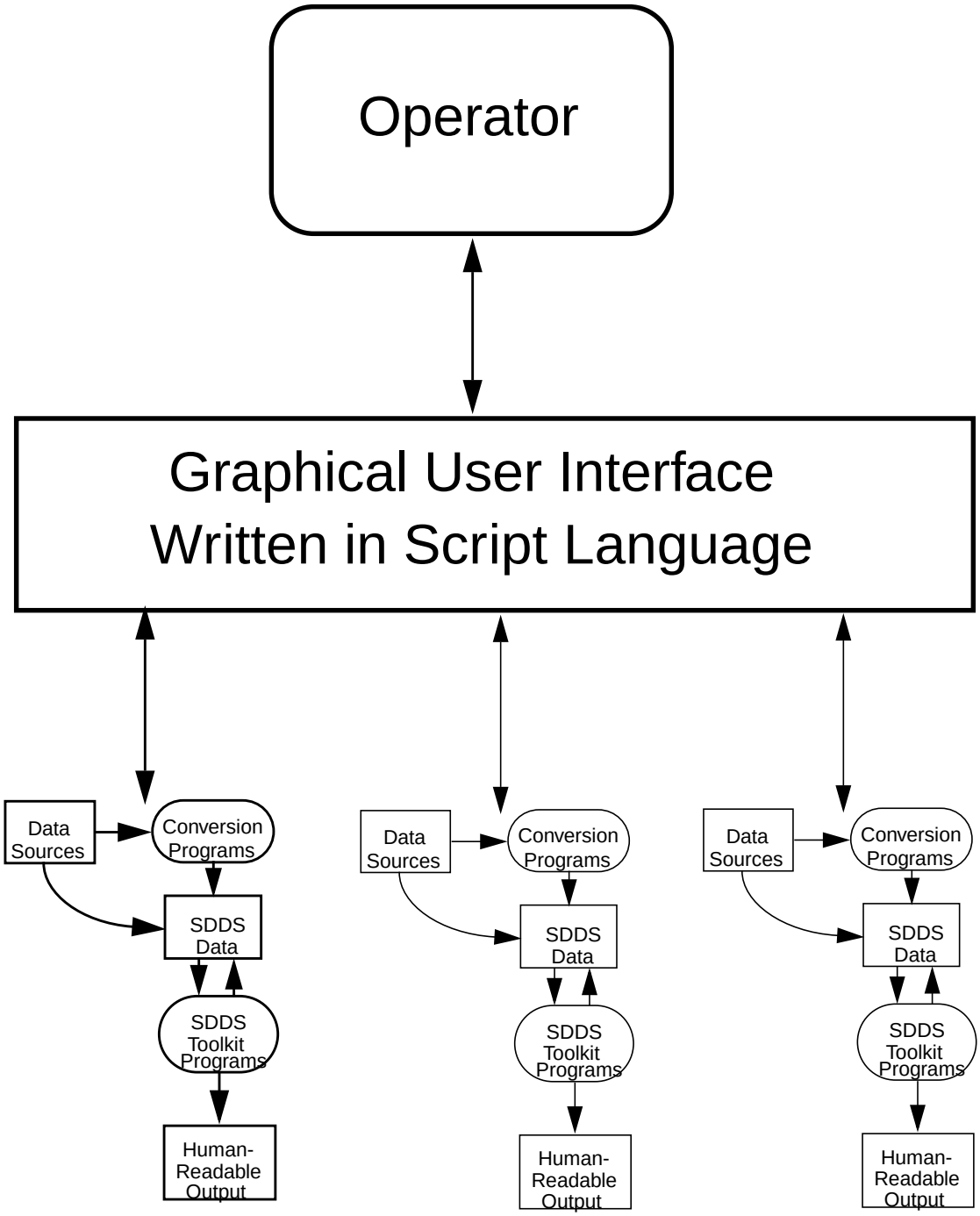
Examples of SDDS Tool Functions

- Data display
  - plotting (2 programs)
  - printing data as formatted text
  - summarizing data set contents
- Data processing
  - equation evaluation
  - data filtering and outlier removal
  - statistics, histograms, and correlations
  - fitting and smoothing
  - matrix operations (e.g., SVD)
  - cross-referencing, sorting, and collation
  - FFTs and digital filtering

- Data collection from EPICS
  - logging data at fixed time intervals
  - event-driven data logging
  - alarm logging
  - n-dimensional experiments
  - save/restore of EPICS data
- Control functions for EPICS
  - generalized feedback control
  - generalized optimization

Making Tools into Applications

- Because the SDDS tools are commandline driven, they can be embedded in scripts..
- Tcl/Tk is used to make graphical user interfaces (GUIs) that depend on SDDS tools for computational “muscle,” data collection, and data display.
- Engineers and physicists can use SDDS tools directly to develop new algorithms. Once finished, those results can easily be put into a GUI script.


Operator
Graphical User Interface
Written in Script Language
Data Sources
Conversion Programs
SDDS Data
SDDS Toolkit Programs
Human-Readable Output
Data Sources
Conversion Programs
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Data Sources
Conversion Programs
SDDS Data
SDDS Toolkit Programs
Human-Readable Output

How the SDDS Toolkit is Used at APS

- Automated data collection
  - ~19000 channels of time-series data
  - ~1000 channels of glitch data
  - ~9000 channels of alarm data
  - storage ring beam dump data
- Used to create high-level applications for operators, engineers, and physicists:
  - beamline steering
  - orbit correction
  - configuration control
  - routine monitoring
  - history review
  - problem diagnosis

- Used by engineers and physicists for
  - data collection
  - automated experiments
  - analysis of accelerator and simulation data
  - equipment checkout

Self Describing Data Files

- Self-describing data files require more information in the file besides the data itself.
- At minimum, a self-describing file protocol
  - *requires* that every data element in the file has a name.
  - *forbids* access to data except via the name.

The SDDS File Protocol

- SDDS is a specific self-describing data protocol, developed at APS for accelerator commissioning.
- Highly successful application of SDDS to commissioning lead to its use for operations.
- An SDDS file consists of
  - A file header describing a structure composed of an arbitrary number of parameters and arrays, and a data table of arbitrary rows and columns.
  - Zero or more instances of the structure.

- There are many extremely general self-describing file protocols around today.
- In using these protocols, users find it necessary to create elaborate data standards of their own, which inhibits use of the toolkit approach.
- In contrast, the SDDS file protocol is simple enough to be used in “daily life,” but general enough to be widely useful.
- Only the simplicity of the data model makes the SDDS Toolkit feasible.

Examples of SDDS Files

- Accelerator configuration data:
  - Parameters: time stamp, configuration description, username, etc.
  - Columns: process variable name, value, access mode, category, subcategory, tolerance, etc.
- Storage ring orbit glitch records
  - Parameters: time of glitch, trigger conditions, etc.
  - Columns: readouts of all BPMs, time of readout, beam current, etc.

Interest in SDDS Outside APS

- IPNS—Used for data logging, analysis, and display.
- CEA (France)—Used by a group of particle physicists doing underwater experiments in the Mediteranean.
- SRRC (Taiwan)—Installed by request.
- LEDA (LANL)—Installed by request.
- CEBAF (TJNAF)—Installed by request.

To Learn More

- Look for an upcoming four-part class on using SDDS.
- See the OAG web page at
  APS Overview —>
  Accelerator Systems Division —>
  Operations Analysis —>
  OAG Software Documentation
  (www.aps.anl.gov/asd/oag/oagSoftware.html)
  In particular, see
  - SDDS tools, and
  - SDDS Compliant EPICS tools.