ESO - EUROPEAN SOUTHERN OBSERVATORY

EUROPEAN SOUTHERN OBSERVATORY

Organisation Européenne pour des Recherches Astronomiques dans l'Hémisphère Austral
Europäische Organisation für astronomische Forschung in der südlichen Hemisphäre

Reflex User Manual

VLT-MAN-ESO-19000-5037

Issue 3.4
11/04/2013
24 pages

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CHANGE RECORD

Issue	Date	Affected Paragraphs(s)	Reason/Initiation/Remarks	Author(s)
0.1	18/01/10	All	First version	V. Forchì
0.2	28/01/10	All	Added installation and troubleshooting sections	V. Forchì
0.3	16/03/10	All	Many corrections	V. Forchì
0.4	07/04/10	4, 5	Added Iteration	V. Forchì
0.5	28/05/10	All	Updated to beta2	V. Forchì
0.6	14/06/10	All	Added ProductRenamer chapter, minor fixes	V. Forchì, C. Garcia
0.7	29/06/10	All	Minor fixes, preparing for first public release.	V. Forchì
1.0	27/07/10	4.4.1, 4.12	Parameter order, actor description	V. Forchì
2.0	16/12/10	4.5, APPENDIX B:	Updated to Reflex 1.1 and some minor fixes	V. Forchì
3.0	05/04/12	All	Updated to Reflex 2.0	V. Forchì
3.1	16/05/12	2	Updated to Reflex 2.1	V. Forchì
3.2	12/11/12	3.2, 3.3, 4.8	Updated to Reflex 2.2	V. Forchì
3.3	15/01/13	APPENDIX B:	Updated to Reflex 2.3	V. Forchì
3.4	11/04/13	3, 4	Updated to Reflex 2.4	V. Forchì

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1. INTRODUCTION

The ESO Recipe Flexible Execution Workbench (Reflex) is an environment which allows an easy and flexible way to execute VLT pipelines. It is built using the Kepler workflow engine (https://kepler-project.org), which itself makes use of the Ptolemy II framework (http://ptolemy.eecs.berkeley.edu/ptolemyII).
The Kepler project has thorough documentation both for the casual and experienced user (https://kepler-project.org/users/documentation).
Reflex allows the user to process his scientific data in the following steps:

- Associate scientific files with required calibrations
- Choose datasets to be processed
- Execute several pipeline recipes

This process, also called a workflow in Kepler terminology, is visually represented as a sequence of interconnected boxes (actors) that process data: the workflow allows the user to follow the data reduction process, possibly interacting with it. The user can visualize the data association and the input files and decide what scientific data he wants to process. It is also possible to visualize intermediate products, using components provided by Reflex, or modify the data flow with custom components.
Reflex uses EsoRex (http://www.eso.org/sci/data-processing/software/pipelines) to execute the pipeline recipes, but this is not exposed to the user.

2. INSTALLATION

The prerequisite to run Reflex is the installation of EsoRex and the pipeline you are interested in (please refer to the VLT pipelines webpage for more detailed information http://www.eso.org/pipelines).
A script that takes care of all the steps required to run a workflow is available at the following URL: ftp://ftp.eso.org/pub/dfs/reflex/install_reflex. The tool downloads and installs reflex and the desired pipeline(s), that contain(s) one or more workflows and a demo dataset.
If you have already installed the pipeline and you have your own dataset, you can skip some steps and proceed to the Reflex installation. Note that only some pipelines contain Reflex workflows.
Note: at the moment Reflex is supported on Linux and Mac OS X.

2.1 Reflex installation

This step is not required if you used the installation script.

- Download the latest version of reflex for your architecture from the ESO website (http://eso.org/sci/software/reflex) or FTP server (ftp://ftp.eso.org/pub/dfs/reflex):

```
$ curl -O ftp://ftp.eso.org/pub/dfs/reflex/reflex-{version}-{linux|osx}.tar.gz
```

- Install Reflex:

```
$ cd /path/to/install/reflex
$ tar xzf /download/location/reflex-{version}-{linux|osx}.tar.gz
```

2.2 Execute Reflex

If you used the installation script execute:

```
$ /path/to/install/bin/reflex
```

Otherwise execute:

```
$ /path/to/install/reflex-{version}-{linux|osx}/eso-reflex/bin/reflex
```

2.3 Upgrading from previous Reflex versions

Reflex 2.4 changes some internal structures in the JSON objects, therefore it cannot reuse bookkeeping directories generated from previous Reflex versions. It is therefore recommended to clear such directories, otherwise you will find in the logs a lot of errors similar to this (and more):

```
[null] org.json.JSONException: JSONObject["display_name"] not found.
```

3. REFLEX OVERVIEW

3.1 General concepts

Kepler visually represents a workflow as a sequence of actors with a single director: the latter schedules the execution of the actors and the former manipulates the data.
The main components of a workflow are:

- Director: determines the execution order of the actors and tells them when they can act. There are several director types, the default for Reflex is the Dynamic Dataflow (DDF) director. There must only be one director per workflow.
- Actor: represents a single step of execution. The actor takes data from the input ports, processes them and sends the results to the output ports. Each actor can have a number of parameters that control its execution: to edit the parameters double click on the actor.
- Port: each actor can possess one or more ports, which allow it to exchange data with other actors. Ports can be input-only (a triangle pointing into the actor), output only (a triangle pointing out from the actor), or bidirectional (a circle). A port can be singular or multiple: the former can be connected to only one port, the latter can be connected to many. Singular ports are black, multiple ports are white.
- Token: an object that encapsulates data. Actors exchange data in the form of tokens through ports. A token can contain several types of data: integers, strings, floating point, etc.

3.2 Reflex specific actors

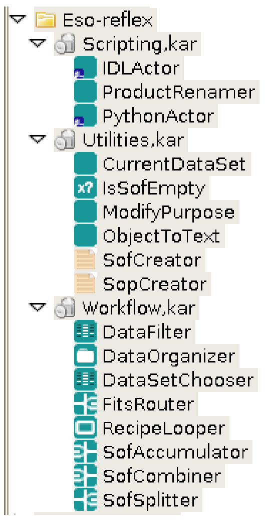
Reflex is composed of a number of custom actors that allow the workflow to interact with the VLT pipeline and with FITS files, namely:

- DataOrganizer
- DataSetChooser
- FitsRouter
- RecipeExecuter
- PythonActor
- DataFilter
- SofAccumulator
- SofCombiner
- SofCreator
- SofSplitter
- SopCreator
- ObjectToText
- RecipeLooper
- ProductRenamer
- CurrentDataSet
- IsSofEmpty
- ModifyPurpose
- IDLActor

All these actors, except for the RecipeExecuter, can be inserted into the workflow from the component tree on the left hand side of the Reflex window, in the Eso-reflex sub-menu (Figure 1).
The RecipeExecuter is not present in the menu and must be instantiated from the menu bar: click on Tools -> Instantiate Component, change the Class name to org.eso.RecipeExecuter and click OK (Figure 2). You will then be presented with a combobox containing all the available CPL recipes (the list is obtained from the output of the command "`esorex --recipes`"): select the desired one and click OK (Figure 3). Once a

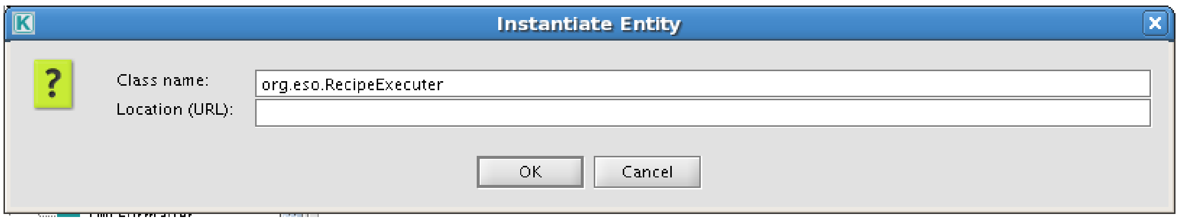
particular recipe has been chosen it cannot be changed: if you chose the wrong one then you have to remove the actor and instantiate a new one.
In the same component tree that contains Reflex actors you can find many other actors, which are part of the standard Kepler distribution; a detailed description can be found in the Kepler User Manual, but they mostly solve general needs, such as:

- Mathematical operations (arithmetic, statistical, logic...)
- File manipulation (open, read, write...)
- File system interaction (list directory content, remove directory...)
- Command execution (shell, ssh, condor...)
- Workflow control (switch, pause, stop...)



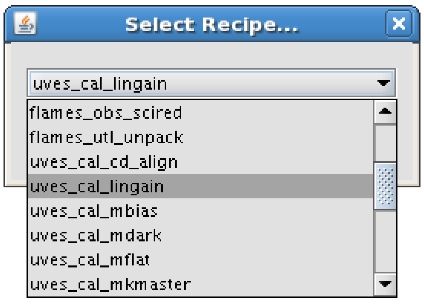
```
Eso-reflex
  Scripting.kar
    IDLActor
    ProductRenamer
    PythonActor
  Utilities.kar
    CurrentDataSet
    IsSofEmpty
    ModifyPurpose
    ObjectToText
    SofCreator
    SopCreator
  Workflow.kar
    DataFilter
    DataOrganizer
    DataSetChooser
    FitsRouter
    RecipeLooper
    SofAccumulator
    SofCombiner
    SofSplitter
```

Figure 1: ESO specific actors



Class name: org.eso.RecipeExecuter
Location (URL):

Figure 2: How to instantiate the RecipeExecuter



```
uves_cal_lingain
flames_obs_scired
flames_utl_unpack
uves_cal_cd_align
uves_cal_lingain
uves_cal_mbias
uves_cal_mdark
uves_cal_mflat
uves_cal_mkmaster
```

Figure 3: Recipe selection

3.3 Data types

Reflex specific actors exchange data in the form of Datasests, Set of Files (SoF) and Set of Parameters (SoP): they are all represented as a JSON structure and are not meant to be read by a human. Use the dedicated actor ObjectToText to see them.

- Dataset: contains some general information and a tree structure that describes the calibration cascade.
- SoF: contains a set of science frames and associated calibration files which are required to process them
- SoP: contains the values of the parameters for the execution of the pipeline recipes.

3.4 General workflow structure

The general structure of a Reflex workflow is depicted in Figure 4. On the top there are a number of parameters required for the workflow execution:

- RAWDATA_DIR: a directory containing all the raw data to be processed (Note: subdirectories are recursively scanned)
- BOOKKEEPING_DIR: a directory where each pipeline recipe execution will create a subdirectory to use as a working directory
- LOGS_DIR: a directory where the recipe logs will be saved
- TMP_PRODUCTS_DIR: a directory where the workflow intermediate products will be saved
- END_PRODUCTS_DIR: a directory where the workflow final products will be saved
- FITS_VIEWER: executable used to visually inspect FITS files
- ESORexArgs: additional parameters passed to esorex by the RecipeExecuter

The data under each directory, except the one containing the final products, are organized in the following way:
BASE_DIR/ActorName/ExecutionTime
e.g. /home/reflex/reflex_tmp_products/Uves_Blue/uves_cal_mbias_1/2010-01-01T12:23:12.123 contains the products of the execution of the actor named uves_cal_mbias_1 at the timestamp "2010-01-01T12:23:12.123".
If you double click one of these parameters you will be presented with a configuration window, where you can select the value of the parameter, either by typing it or browsing the filesystem (do not forget to save your modifications).

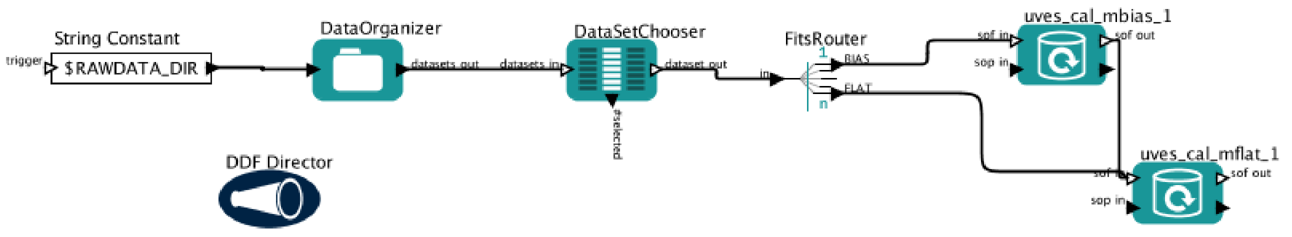


Figure 4

The preferred director for Reflex workflows is the DDF director, but the PN director can also be used. The first step of the workflow execution is the DataOrganizer, which organizes a set of files and groups them together in Datasets according to some classification and grouping rules, written with the OCA language (a full set of rules is provided together with each workflow): the output is a list of Datasets, which contain science frames and all the associated raw and static calibrations required to process them.

The second step is the DataSetChooser, which displays all the Datasets provided by the DataOrganizer, and allows the user to view their contents and select the ones that are to be processed. The output of this actor is the serialized list of selected Datasets. The output of the DataSetChooser must be connected to a FitsRouter, which splits the Dataset and sends the files to different output ports based on their observation type: these ports can then be used to feed the various pipeline recipes of the workflows.

3.5 File purpose

The file purpose is a new concept introduced in Reflex 2 that represents what a file is needed for; the purpose of a file describes the whole reduction cascade that will make use of the file. For example, a raw BIAS might have the purpose MASTER_BIAS/SCIENCE if it's going to be used to produce the master bias that will be used to reduce the science frames, or MASTER_BIAS/MASTER_FLAT/SCIENCE, if the master bias will be used to generate a master flat, which in turn will be used to reduce the science frames.
This new concept allows Reflex to recreate the whole calibration cascade, for instance we might have different master biases in different points of the workflow, produced with different recipe parameters.
The purpose is used in many places of the workflow to decide the routing and the scheduling of files, for example:

- The SofSplitter groups the files by purpose and emits a number of tokens equal to the number of different purposes present in the input SoF;
- The SofCombiner, and any input multiport that accepts SoFs as an input, combine the input SoFs based on their purpose, collecting only those files whose purpose is present in all input ports.

In order to help the users in the process of customizing the workflow, e.g. by plugging in their own reduction steps or precomputed files, a special purpose has been defined, named UNIVERSAL, that matches any other purpose when it comes to combining or splitting SoFs.

3.6 General features

- Workflow execution: you can start, pause, stop and resume the workflow by using the buttons in the toolbar. The highlighted button indicates which state the workflow is in. Please note that the stop button immediately interrupts any running pipeline recipe, while the pause button lets the current recipe or actor finish before the workflow is actually paused. After pressing the pause button, it is also possible that more than one actor is executed, since this behaviour depends on the scheduling policy. For instance, if there are two actors in parallel, and you pause the workflow while one is being executed, then both of them will be executed before the workflow is actually paused.
- The DDF and the PN directors support actor highlighting; this feature is disabled by default: if you want to enable it click on Tools->Animate at Runtime, select an interval (e.g. 10ms) and click ok. From now on the active workflow actor will be highlighted in red. Note: if you pause and resume a workflow the actor is not highlighted upon resume.

4. ACTOR DOCUMENTATION

The following documentation is also available on the workflow, by right-clicking on an actor and selecting Documentation->Display. Furthermore, RecipeExecuter instances display the help of all the recipe parameters.

4.1 DataOrganizer

The DataOrganizer organizes a set of files (science and calibration) in groups called datasets, that can be processed independently by the workflow. A dataset has a tree structure and represents the complete calibration cascade. The logic used to generate the datasets is described using OCA rules: OCA is a SQL-like language developed at ESO to define associations through files based on certain FITS keywords. Please refer to the user documentation for more information about OCA.

4.1.1 Parameters

- **OCA File**: the filename (full path) containing the OCA rules used for classification and organization.
- **Keywords to be displayed**: A list of FITS keywords to be extracted from the FITS files and attached to the datasets.
- **Lazy Mode:** if true, the actor will look into the bookkeeping directory for a previous execution with the same files and the same OCA rules
- **Bookkeeping Dir:** the directory where the actor stores the information about its executions

4.1.2 Ports

- **input data:** it can be either a directory, an array of directories or a previously generated list of datasets
- **datasets out:** the generated datasets

4.2 DataSetChooser

The DataSetChooser allows you to view and select the group of files created by the DataOrganizer: it displays a list of datsets and gives the possibility of selecting, deselecting and analyze them.
It produces one token on the output port per selected dataset.

4.2.1 Parameters

- **Mode:**
    - Skip: automatically select all datasets and do not show any window.
    - Display: select all datasets and allow the user only to view them.
    - Select: standard mode, allows the user to inspect the datasets and select the ones he wants to process.

- **FITS Viewer:** the application used to inspect FITS files

4.2.2 Ports

- datasets in: the input datasets
- dataset out: the current selected dataset
- #selected: the number of selected datasets

4.3 FitsRouter

The FitsRouter sorts files based on their category: by default, all files are routed to the rejected directory, but the user can add an additional port and configure the actor to route particular files to the new port. The

category is defined by the value of either HIERARCH.ESO.PRO.CATG (keyword added to the file by the pipeline recipes) or REFLEX.CATG (virtual keyword created by the DataOrganizer).
Basic Mode: create an output port named as a category (e.g.: FLAT). All files belonging to that category will be routed to that port.
Advanced Mode: create an output port with any name (e.g.: MyPort), and then create a string parameter whose name is the port name plus "_config" (e.g.: MyPort_config). This parameter can be a list of regular expressions separated by a comma or a space (you can mix both in the same parameter): each file whose category matches at least one of the regular expressions will be routed to this port.
If you want to define the minimum or maximum number of files that the actor sends to a port, then you can define a parameter whose name is the port name plus "_min_number" or "_max_number", respectively. If there are too many files, then the actor selects the first, and if there are too few files, then an error is reported.
Note: one file can be routed to many ports and, if a file is not routed to any port, it is routed to the rejected port.

4.3.1 Ports

- **in:** the input data
- **rejected:** the rejected SoF

4.4 RecipeExecuter

The RecipeExecuter executes one CPL recipe. The recipe can be chosen only when you instantiate the component: at the moment the user is presented with a list of the available recipes (the output of `esorex --recipes`). After the user selects the recipe the actor queries EsoRex for the recipe parameters and adds them to the actor. Each parameter is set to the default value: if the user wants to change any of the parameters then he can enter his own value or he can write the special value PORT, in which case the value is taken from the input port SoP.
The actor has three modes: Run, Skip and Disabled.
Note: since this actor has very different behaviour depending on the pipeline recipe to which it is associated, it is not present in the left hand side actor list, and instead it must be instantiated from the menu (see section 3.2).

4.4.1 Parameters

- **Recipe:** the selected pipeline recipe (cannot be changed)
- **Mode:**
  - Run: the recipe will be executed (see lazy mode)
  - Skip: the inputs are broadcast to the output with the following modifications: input files will be filtered according to input and output tags and recipe parameters will be filtered based on the recipe and whether the parameter is set to PORT
  - Disabled: the recipe is not executed and an empty SoF is generated on the output port
- **Lazy Mode:** if true then the actor will check whether the pipeline recipe has already been executed with the same input files and with the same recipe parameters. If this is the case then the recipe will not be executed, and instead the previously generated products (which are the same as those that would have been generated if the recipe were executed, except for a timestamp) will be broadcast to the output port.
- **Recipe Failure Mode:** it specifies the behavior of the actor if the recipe fails
  - Stop: the actor produces an error message and the workflows stops. This is the default
  - Continue: the actor outputs an empty SoF
  - Ask: the actor pops up a window and asks the user whether he wants to continue or stop the execution

- **Input Files Categories:** a comma separated list of file categories: only input files belonging to one of these categories will be passed to the recipe
- **Output Files Categories:** a comma separated list of file categories: only products belonging to one of these categories will be broadcast to the output port
- **File Purpose Processing:** how the purpose of the input files will be sent to the output:
  - Do nothing: leave the input purpose unmodified
  - Strip last: remove the last section of the input purpose, if there is only one section set the purpose to universal
  - Set to universal: set the output purpose to universal
- **Allow empty inputs:** if true then an empty sof on the input port will be broadcasted to the output without executing the recipe
- **Pause before execution:** if true then the execution is paused just before executing the recipe
- **Pause after execution:** if true then the execution is paused after the execution of the recipe.
- **Clear Products Dir:** indicates if and when the products directory for this actor will be cleaned: possible values are BEFORE, AFTER and NEVER
- **Clear Logs Dir:** indicates if and when the log directory for this actor will be cleaned: possible values are BEFORE, AFTER and NEVER
- **Clear Bookkeeping Dir:** indicates if and when the bookkeeping directory for this actor will be cleaned: possible values are BEFORE and NEVER
- **Products Dir:** a directory where the products will be created
- **Logs Dir:** the directory where the EsoRex logs will be saved
- **Bookkeeping Dir:** the directory the recipe will use as a working directory
- **EsoRex default args:** additional parameters passed to EsoRex
- **recipe_param_xx:** dynamically generated by the actor when a recipe is selected. Each recipe parameter is mapped to an actor parameter with this name pattern. The parameter value must be in the format “par_name=par_value”: if the user tries to change the parameter name an error will be reported. Note: in case of a pipeline upgrade that modifies the number of parameters of a recipe you can end up with duplicated or missing parameters. In that case it is suggested to instantiate the actor again
- **Reuse Inputs (Expert Mode):** if true then the actor uses the inputs from the last execution, ignoring the input ports
- **Reuse Outputs (Expert Mode):** if true then the actor broadcasts the output from the last execution.

4.4.2 Ports

- **sof in:** the input files
- **sof out:** the output files
- **sop in:** the recipe input parameters
- **sop out:** the parameters used in the last execution of the recipe
- **rejected inputs:** the inputs not matching any of the input tags
- **rejected outputs:** the outputs not matching any of the output tags
- **logs:** the logs generated by EsoRex, empty if lazy mode is triggered
- **warnings:** the warnings generated by EsoRex, empty if lazy mode is triggered
- **errors:** the errors generated by EsoRex, empty if lazy mode is triggered

4.5 PythonActor

The PythonActor executes custom python scripts. The interface between the actor and the script is the following:

- the tokens on the input ports will be written in JSON format to a file, which will be passed to the script as a command line parameter;

- the outputs will be written in JSON format to another file, which will be parsed by Reflex.

In order to implement this interface the user has to include the module reflex.py and add a couple of statements to define inputs and outputs (see example.py in the Reflex distribution). Upon selecting a script, input and output ports are automatically created. If applicable, output tokens are automatically converted to Reflex objects. If the object is an SoF, all the files must exist on disk. The checksum information is also extracted from the file and added to the final SoF, therefore allowing the lazy mode to work for downstream actors.

The Reflex distribution includes the script `example.py`, which explains how to write python scripts that can be used from within the PythonActor. It's a simple script that has two input parameters (`input1` and `input2`) and two output parameters (`output1` and `output2`) and copies the value of the input parameters to the output parameters. The content of the script is listed and commented in APPENDIX B:.

Every python script that is compatible with the PythonActor can be executed outside Reflex, provided that `reflex.py` is in the `PYTHONPATH`. In particular, you can execute `example.py` in the following way:

```
$ ./example.py –i /scratch/file1.fits –j /scratch/file2.fits
```

Or

```
$ ./example.py --input1 /scratch/file1.fits --input2 /scratch/file2.fits
```

In both cases the output will be the following:

```
{
  "output1": "/scratch/file1.fits",
  "output2": "/scratch/file2.fits"
}
```

It is also possible to write the input parameters to a file, and pass it to the script using the `--input-parameters-file` option: this is what Reflex does to minimize parsing problems.

This is a sample command line used by the PythonActor to call one of the scripts in the UVES workflow, formatted and simplified to improve its readability:

```
python /usr/bin/uves_cal_predict_interact.py
--stdout-file=/log/PythonActor/2013-02-20T14:25:11.899/stdout.txt
--stderr-file=/log/PythonActor/2013-02-20T14:25:11.899/stderr.txt
--input-parameters-file=/bookkeeping/PythonActor/2013-02-20T14:25:11.899/input_parameters.json
--output-parameters-file=/bookkeeping/PythonActor/2013-02-20T14:25:11.899/output_parameters.json
```

You can find some commands in the bookkeeping directory, saved in files named cmdline.txt.

Note that all parameters are passed to and from the script as strings.

4.5.1 Parameters

- **Run in terminal:** If true, then the script is invoked through an external xterm, which is required for scripts that write on the standard output or require standard input (e.g. some pyraf tasks). Note: since xterm masks the script exit code, if this flag is enabled the script execution is considered successful if the standard error is empty.
- **Python script:** the filename of the script to be executed (full path).
- **Disable logging:** if true, the script does not save the standard output and the standard error of the script execution in the logging directory. This feature is useful if you are using Pyraf and you experience occasional crashes.

4.5.2 Ports

- **stdout:** the standard output of the python script, meaningful only if "Run in terminal" is false (hidden by default).

4.6 DataFilter

The DataFilter displays all the files in a given SoF and allows the user to view their header, view them in an external application, select or deselect only some of them, and then continue or pause the workflow.

4.6.1 Parameters

- **Mode:**
    - Skip: automatically select all files and don't show any window.
    - Select: standard mode, it allows the user to view the headers of the files, to inspect the files with an external application and to select the files he wants to broadcast to the output port.
- **FITS Viewer:** The application used to inspect FITS files

4.6.2 Ports

- **sof in:** the input SoF
- **sof out:** the selected SoF
- **sof rejected:** the rejected SoF

4.7 SofCreator

The SofCreator reads all the FITS files contained in a directory and creates a SoF: the file category is based on the header keyword PRO.CATG or REFLEX.CATG (Note: the latter is created by the DataOrganizer, and is not present in any file). If both are missing from the primary header then the Default Category is used.

4.7.1 Parameters

- **Default Category:** the default category to be used to classify FITS files if they do not possess any of the required keywords.
- **Filename Pattern:** a wildcard pattern representing the files to be included (e.g. *.fits)

4.7.2 Ports

- **data dir:** the input directory. If an empty string is provided the actor generates an empty SoF
- **sof out:** the output SoF

4.8 ObjectToText

The ObjectToText converts the JSON objects used by ESO actors (i.e. datasets, sof and sop) into a human-readable form.

4.8.1 Parameters

- **Include Header and Footer:** if true then the output string contains a simple header and footer

4.8.2 Ports

- **json in:** the input JSON string
- **text out:** a human-readable formatted string

4.9 SopCreator

The SoPCreator reads a formatted string and converts it into an SoP. The input string must be a list of tokens in the following format: recipe_name:par_name=value separated by either a comma or a newline

4.9.1 Ports

- **param in:** a string in the format described in Appendix APPENDIX A:
- **sop out:** the output SoP

4.10 SofCombiner

The SofCombiner takes as input a number of set of files and combines them into one set of files that contains only the files whose purposes are present in all the input tokens. With this respect empty tokens (i.e. containing no files) are ignored and files with universal purpose are always collected.

4.10.1 Ports

- **sof in:** the input SoFs
- **sof in opt:** the optional input sofs, these files are added to the output only if their purpose is present in one of the input SoFs
- **sof out:** the combined SoF

4.10.2 Example:

Consider the following SoFs:
SoF1: File1(Purpose1), File2(Purpose2), File3(Purpose3)
SoF2: File4(Purpose2), File5(Purpose3), File6(Purpose4), File7(UNIVERSAL)
SoF3:
SoF4: File8(Purpose2), File9(Purpose5), File10(Purpose6)
SoF5: File11(Purpose2), File12(Purpose3), File13(Purpose7)
SoF6:
SoF7: File14(UNIVERSAL)

If SoF 1-3 are connected to sof in and the SoF 4-7 are connected to sof opt in, then the output SoF will be:
File2(Purpose2), File3(Purpose3)
File4(Purpose2), File5(Purpose3), File7(Purpose2,Purpose3)
File8(Purpose2)
File11(Purpose2), File12(Purpose3)
File14(Purpose2,Purpose3)

4.11 RecipeLooper

The RecipeLooper is an actor designed to implement looping capabilities within workflows. It has two set of input ports and a control port: at first it receives a token from the “standard” input ports, and then it receives a token from the looping input ports until the control port contains a string token whose value is “false”. When the control port contains a “true” the actor returns to the initial condition, waiting for the next token from sof in and sop in. You can find a more detailed description in chapter 5.

4.11.1 Ports

- **sof in:** the input files
- **sop in**: the initial recipe parameters
- **sof loop:** files to be used for iteration
- **sop loop:** parameters to be used in the current iteration
- **iteration complete:** control port
- **sof out:** output files
- **sop out:** output parameters to be used by the recipe executer

4.12 ProductRenamer

This actor renames files based on some FITS keywords and stores them in a destination directory.
It is usually connected to the output of recipes that produce final products. If the recipe produces some products that are not relevant to rename, an output filter can be configured in the RecipeExecuter.

The ProductRenamer is a simple script that can be easily modified to fine tune the names of the output file by manipulating the header keyword strings. Double-clicking on the actor in Reflex opens it up for editing. The script is in Jython, a Java implementation of the Python scripting language, with which it shares much of the syntax.
The script source code is saved in the workflow XML structure, so every change made by the user applies only to the specific instance of the actor he has modified.

4.12.1 Parameters

- **FinalProductDirectory:** the directory where the files are going to be copied/linked or renamed. It is usually set to END_PRODUCTS_DIR
- **SubDir:** if it is not empty, then a subdirectory will be created with this string. The value can contain slashes, in which case intermediate directories will be created. It will usually be END_PROD_SUBDIR, defined in the workflow
- **CopyMode:** there are several options: "copy", "move" or "link"
- **OutputExistMode:** it specifies the behavior in case the target file already exists. Possible values are:
    - stop: the actor produces an error message and the workflows stops.
    - append_version: the actor appends a suffix like _1, _2 to the filename.
    - overwrite: the old file is overwritten.
- **RenameKeywords:** it specifies a set of FITS keywords that collated together will give the pattern to create the output filename. It is also possible to add fixed strings using 'my-string' format. For example, if the value of this parameter is `'MyPrefix_',HIERARCH.ESO.OBS.NAME`, then the output filename will be, assuming that the value of the keyword is M51, `MyPrefix_M51.fits`.

4.12.2 Ports

- **sof in:** the files to be processed
- **sof out:** the final list of files produced

4.13 CurrentDataSet

This actor extracts the dataset name for an SoF or a Dataset and sends it to the output port.

4.13.1 Ports

- **in:** the input SoF or Dataset
- **dataset name:** the dataset name

4.14 IsSofEmpty

This actor emits a true token if the input SoF is empty.

4.14.1 Ports

- **sof in:** the input SoF or Dataset
- **is empty:** true if the input is empty
- **is not empty:** true if the input is not empty

4.15 SofAccumulator

This actor is usually used together with the SofSplitter, and it puts back together in a single set of files the tokens generated by SofSplitter (and usually processed by the RecipeExecuter). It can also be used to accumulate, for instance, SoFs coming from different OBs to compose a mosaic.
The actor collects a number of tokens from every input port and simply appends all the files to generate one SoF, that is than sent to the output port.

4.15.1 Parameters

- **same dataset:** if true the SofAccumulator throws an error if the input tokens do not belong all to the same dataset

4.15.2 Ports

- **sof in:** the input SoFs
- **#groups:** the number of groups to collect
- **sof out:** the grouped SoF

4.16 SofSplitter

This actor takes a set of files as input and split it into smaller sets, grouping them by purpose. This smaller sets can then be sent to e.g. a RecipeExecuter

4.16.1 Ports

- **sof in:** the input SoF
- **sof out:** the grouped SoFs
- **#groups:** the number of groups generated

4.16.2 Example

Consider the following SoF as input:
SoF IN: File1(Purpose1), File2(Purpose2), File3(Purpose3), File4(Purpose2), File5(Purpose3),File6(UNIVERSAL)

In this case the SofSplitter generates the following SoFs as output:
SoF1: File1(Purpose1), File6(Purpose1)
SoF2: File2(Purpose2), File4(Purpose2), File6(Purpose2)
SoF3: File3(Purpose3), File5(Purpose3), File6(Purpose3)

4.17 ModifyPurpose

This actor allows to modify the purposes of files, in case the user wants to deviate from what is described in the OCA rules.

4.17.1 Parameters

- **File Purpose Processing:** how the purpose of the input files will be sent to the output:
  - Do nothing: leave the input purpose unmodified
  - Strip last: remove the last section of the input purpose, if there is only one section set the purpose to universal
  - Set to universal: set the output purpose to universal

4.17.2 Ports

- **sof in:** the input SoF
- **sof out:** the output SoF

4.18 IDLActor

The IDLActor executes an IDL script: the idl command must be in the shell path when reflex is executed.
Input and output ports must be manually created and their names must match the names used by the script.
SoFs and SoPs are converted using the same convention used for the PythonActor and described in the user manual.
An important difference with respect to the PythonActor is that the IDLActor does not create input and ouput ports automatically upon selection of the script, they have to be manually created by the user.

4.18.1 Parameters

- **IDL script:** The IDL script (full path) that has to be executed

4.18.2 Ports

- **stdout:** This port emits a token containing the standard output generated by the script execution

5. RECIPE ITERATION

It is sometimes useful to be able to visualize the products of a recipe execution, tweak some recipe parameter and execute the recipe again, until the products are as expected.
This can be easily achieved in Reflex by means of the RecipeLooper and the PythonActor.
A typical subworkflow that allows iteration is depicted in Figure 5, and it is composed of the following elements:

- Sof coming from previous actor
- Sop containing recipe parameters' initial values
- A RecipeLooper
- A RecipeExecuter containing the pipeline recipe to be optimized
- A PythonActor containing a custom python script that allows the user to view the results of the recipe execution and decide whether he wants to change some parameters or not. The script should either generate a "true" token on the control port and a SoF to the next downstream actor or a "false" token on the control port and a SoF and a SoP to the RecipeLooper loop input port.

This general structure must be customized for each pipeline recipe. The user must:

- Identify sensible recipe parameters he wants to tweak to optimize the products
- Define some initial conditions for these parameters and provide them to the sop_in port of the RecipeLooper. The simplest way to do this is to define a string in the format described in APPENDIX A: and connect it to a SopCreator.
- Configure the RecipeExecuter, changing the value of the recipe parameters you want to optimize to PORT (e.g. if you want to optimize a recipe parameter called `par1` look for a parameter in the RecipeExecuter called `recipe_param_nn` whose value is `par1=some_value` and change it to `par1=PORT`).
- Write a python script that allows the user to evaluate the product quality, change the value of the parameters and decide whether he wants to continue or not. The script does not have to be interactive, it can implement an optimization algorithm defined by the user.

Sample implementations of this system are provided with the workflows included in the pipeline distribution.
Note: it is possible to iterate over an arbitrary number of actors, you are not forced to iterate over one RecipeExecuter.

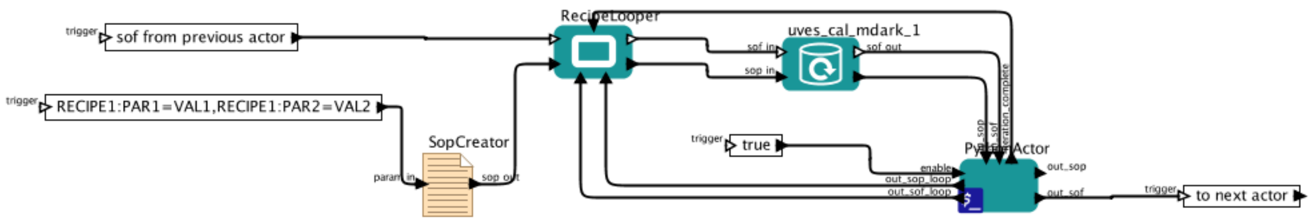


Figure 5: sample looping workflow

6. TROUBLESHOOTING

6.1 Debug mode

By default, Reflex displays some information on the console: it is possible to change the level of logging for debugging purposes by editing the file `kepler-2.3/resources/log4j.properties` in the Reflex distribution.
You can increase the logging level by adding new lines at the end of the file (the default logging level is WARN, defined at the beginning of the file).

Log4j, the logging library used by Reflex, defines the following logging levels, starting from the most verbose: `TRACE`, `DEBUG`, `INFO`, `WARN`, `ERROR`, `FATAL`.

If you want to put all Reflex actors in debug mode change the first line as follows:
```
log4j.logger.org.eso=DEBUG, CONSOLE
```

If you want, for example, to raise the logging level of the RecipeExecuter to `DEBUG`, then you have to add the following line:
```
log4j.logger.org.eso.RecipeExecuter=DEBUG, CONSOLE
```

Note that the most restrictive condition is applied.

6.1.1 Logging to file

By default Reflex logs only to the console, so that if you want the logs to be saved also to a file, then you have to modify the first line of the configuration file (see 6.1) from
```
log4j.rootLogger=WARN, CONSOLE
```
to
```
log4j.rootLogger=WARN, CONSOLE, R
```
The log filename is defined in the section `LOGGING TO FILE` of the same configuration file.

6.2 Reflex hangs

Some users have experienced a Reflex hang when they were browsing the ESO workflows: the origin of this issue is unclear, but it can be solved by increasing the maximum memory from 512MB to 1024MB.
To do so, open the menu entry “Tools->JVM Memory Settings” and change Max Memory to 1024m.

APPENDIX A: SIMPLIFIED SOF AND SOP FORMAT

Some actors (i.e. the PythonActor and the SopCreator) use a simplified version of the SoF and SoP format in order to ease interaction with the user and with custom scripts. These formats are described here.

- SoF: FILE1;CATEGORY1;PURPOSE1,FILE2; CATEGORY 2;PURPOSE2…
    - Example: UVES.2010-01-01T01:01:01.000.fits;DARK;SCIENCE,UVES.2010-01-01T01:01:01.001.fits;FLAT,SCIENCE
- SoP: RECIPE1:PAR1=VAL1,RECIPE2:PAR2=VAL2…
    - Example: uves_cal_mdark:process_chip=both,uves_cal_mflat:backsub.mmethod=median

In order to extract the information about the SoF in python scripts it is possible to use the function `parseSof()` from the `reflex.py` module: it returns a list of FitsFile objects, that contain the name and category of the file.

```
for file in parseSof(insof):
  print 'File name: ' + file.name ', File category: ' + file.category
```

APPENDIX B: example.py

```
#!/usr/bin/env python

# import reflex module
from reflex import *

import sys

if __name__ == '__main__':

  # create an option parser
  parser = ReflexIOParser()

  # define inputs (Note: you must define at least long option)
  parser.add_option("-i", "--input1")
  parser.add_option("-j", "--input2")

  # define outputs (Note: you must define at least long option)
  parser.add_output("-o", "--output1")
  parser.add_option("-p", "--output2")

  # get inputs from the command line
  inputs = parser.get_inputs()
  # get output variables
  outputs = parser.get_outputs()

  # read inputs and assign outputs
  if hasattr(inputs, "input1"):
    outputs.output1 = inputs.input1
  else:
    outputs.output1 = 'test1'

  if hasattr(inputs, "input2"):
    outputs.output2 = inputs.input2
  else:
    outputs.output2 = 'test2'

  # write outputs
  parser.write_outputs()

  sys.exit()
```

APPENDIX C: SOFTWARE REQUIREMENTS

Reflex has been tested on Scientific Linux 5.5 32bits plus java6 update 26: in principle every recent Linux distribution should be compatible, but this can not be guaranteed.
Workflows may have specific requirements (e.g. python, pyfits, etc.): please refer to the pipeline manual or to the workflow tutorial for more information.