Specification

Definition and provenance of target and object identifiers in the 4MOST data flow

Document No.: VIS-SPE-4MOST-47110-9700-0001

Issue No.: 1.00

Document URL: https://ds-web.aip.de/docushare/dsweb/Services/Document-14005

Prepared by	*David Alexander / Peder Norberg*	2024-10-14
Approved by	Jakob Walcher Digital unterschrieben von Jakob Walcher Datum: 2024.10.14 13:27:53 +02'00' *Jakob Walcher, OM*	Click here to enter date.
Released by	Digitally signed by Roelof Sybe de Jong Date: 2024.10.14 13:53:15 +02'00' *Roelof de Jong, PI*	Click here to enter date.

Change Record

Issue	Date	Page, Section, Paragraph Affected	Reason, Remarks
0.01	2022-12-5	all	New document
0.02	2023-1-22	all	Updates to SPECUID definitions, addition of transient target flowchart, and the addition of the 4MOST astrometry section. Plus, changes to text, appendices, tables, and figures following feedback.
0.03	2023-2-3	all	Changed IAU-approved target to IAU-approved object. Footnote 2 on object-target connection.
0.04	2023-2-5	all	Updated sections 6.2 and 6.5, Table 3, and Appendix C (object catalogue).
0.10	2023-2-15	Section 4, figures, and table 3	Updated transient target description, combined Figures 1 and 2, and updated Table 3 to include if transient target. Addressed points 4, 6, 7, and 13 from the ESO feedback.
0.20	2023-2-21	all	Fixed some typos and added reference to the shared-target algorithm document. Bold-face notes are given on areas where feedback is required.
0.21	2023-12-05	Section 6.5	(DMS@IoA) Changed stack level specification and associated SPECUID example
0.22	2024-03-27	Sections 4, 6.3, 6.4, 6.5	Addressing points made from ASG feedback
0.23	2024-06-18	Section 6.2	Update on the U_OBJ_ID example to include transient bit
0.30	2024-10-01	New section 7, Section 6.4	Added information about unique keys , added transient idenfication
0.31	2024-10-13	Small edits	Comments from stakeholders before release
1.00	2024-10-14	None	Release

List of Contributors

Name	First Name	Institute	Comments
Alexander	David	Durham	
Norberg	Peder	Durham	
Matijevic	Gal	IAS	
Murphy	David	IoA	
Worley	Clare	IoA	
Laas	Jake	MPE	
Kacharov	Nikolay	AIP	
Walcher	Jakob	AIP	
Couto	Guilherme	AIP	
Herpich	Fabio	IoA	
Bellstedt	Sabine	UWA	

Table of contents

List of Figures

List of Tables

1 Scope

This document describes the various 4MOST target identifiers, indicates where they are produced, and highlights how they relate to each other.

Applicable Documents (AD)

The following applicable documents (AD) of the exact issue shown form a part of this document to the extent described herein. In the event of conflict between the documents referenced herein and the contents of this document, the contents of this document are the superseding requirement.

Table 1: Applicable Documents

AD ID	Document Title	Document Number	Issue	Date
[AD1]	Definition of the shared-target algorithm	VIS-SPE-4MOST-47110-9700-0002	1.00	2024-10-13

2 Reference Documents (RD)

The following reference documents (RD) contain useful information relevant to the subject of the present document.

Table 2: Reference Documents

RD ID	Document Title	Document Number	Issue	Date
[RD1]	4MOST User Manual	VIS-MAN-4MOST-47110-9800-0001	10.0	2022-12-08
[RD2]	Facility Control System – Data Management System ICD	VIS-ICD-4MOST-47110-1314-0001	2.82	2022-02-09
[RD3]	Front-end Operations ICD	VIS-ICD-4MOST-47110-9700-0001	2.0	2018-03-13
[RD4]	DMS Level 1 Pipeline DXU	VIS-TNO-4MOST-47110-0143-0001	1.1	2022-07-06
[RD5]	Data Management System – Operations System	VIS-ICD-4MOST-47110-1417-0001	2.0	2018-03-14
[RD6]	Design and Analysis Report – Operations System	VIS-TNO-4MOST-47110-9232-0003	3.0	2018-03-13
[RD7]	ESO Science Data Products Standard	ESO-044286	6.0	2020-06-15

3 Overview

The objectives of this document are to (1) describe the various target identifiers within 4MOST, (2) indicate where they are produced, (3) highlight how they are related to each other, and (4) propose modifications to the unique object identifier (U_OBJ_ID) and the object catalogue. It is anticipated that this document will be useful in the construction of target-identification tools and to identify any issues in the propagation of target information, including to the back-end spectroscopic pipelines.

To help understand the propagation of the target information, three target-related catalogues are presented in the appendices: target catalogue (Appendix B), object catalogue (Appendix C), and the FIBINFO table (Appendix D). However, it should be noted that the target catalogue and FIBINFO table are defined in [RD1] and [RD2], respectively. Additionally, details for many of the keywords are available from [RD3] and [RD5]. Consequently, the reader should not assume that the presented information is the latest update but, instead, should use these tables to help understand (1) the basic format and structure of each catalogue, and (2) how they are related to each other, as illustrated in the data flow chart (see *Figure 1*).

The information in this document is primarily presented from a 4MOST front-end perspective. However, to allow the reader to understand the connection between the input-target catalogues and the observed targets, basic elements of the operations and back-end processes are also described. But the reader is reminded that other documents provide more detailed information on each of the processes described in this document.

4 Target identification and data flow charts

Overall, the following target identifiers are used within 4MOST:

- TARG_ID: unique target identifier.
- U_OBJ_ID: unique object identifier, discriminated based on spectroscopic resolution mode (LR or HR). Note it is referred to as OBJ_UID in the FIBINFO table.
- CNAME: internal object identifier based on celestial coordinates. Note it is referred to as OBJ_NME in the FIBINFO table.
- SPECUID: unique object spectrum identifier.
- SPECUID_P: SPECUID but with additional provenance-related identification information.
- IAU-approved object name used in published catalogues.

Descriptions of these identifiers are provided in Section 6. To provide context, and to indicate where each identifier is used, we first provide a basic overview of the data flow and processes in the 4MOST operations.

The flowchart in *Figure 1* illustrates the basic 4MOST data flow for both transient and non-transient targets. Most of the data-flow steps are the same between transient and non-transient targets but there are several key differences which we highlight below when describing the overall data flow. The majority of the targets in the 4MOST surveys are non-transient.

Target catalogues are created by the survey users. For survey operations they will be uploaded to the 4FS_WI at milestones that are defined by IWG2 for non-transient targets and to 4FS_API on a daily cadence for transient targets.[1] All target catalogues are then concatenated. To ensure that each target is uniquely identifiable within the concatenated catalogue, an identifier (TARG_ID) is calculated for each target. The shared-target procedure (described in [AD1]) is then used to identify all unique objects (U_OBJ_ID) from the concatenated target catalogue, which are stored along with the associated targets in the object catalogue.[2] As indicated in *Figure 1*, the object catalogue grows each time the shared-target procedure is run following a target-catalogue ingest. Consequently, all targets uploaded through 4FS, from the first ingest of target catalogues through to the latest target-catalogue ingest, are linked to objects, providing not only a catalogue of unique objects but also the provenance of each target. Each object also has an associated name, which encodes the object position using sexagesimal coordinates (CNAME).

Targets are selected for nightly observations with the key object properties stored within the FIBINFO table. All target spectra are given a unique identifier (SPECUID) which is linked to each object through DMS@CASU. Targets are identified in publishable 4MOST catalogues using the IAU-approved object name calculated from the astrometric properties of the observed object.[3]

---

[1] See section 7 of [RD1] for a description of the target catalogue upload systems, 4FS_WI, and 4FS_API.
[2] We note that all targets are related to an object and highlight that some objects are related to multiple targets when identified as being associated through the shared-target procedure; these are referred to as shared targets.
[3] Published catalogues are based on objects, since it is objects that are observed; i.e., targets (selected by the surveys) are matched to objects via the shared-target procedure.

A key difference between the transient and non-transient targets is that the former will be automatically selected as live targets for the upcoming night of observations. Transient targets may only be submitted for one observation, as part of one or more exposures during a single visit. The responsible survey must then decide independently, and in relatively short order, whether the observation(s) was/were successful and, hence, whether a subsequent transient target submission is needed for follow-up observations. Transient targets are also distinguished from non-transient targets in not having their exposure time automatically calculated using the Exposure Time Calculator (ETC) – instead the responsible survey/sub survey independently calculates the exposure time for each transient target.

Another difference between transients and non-transients targets is that they populate separate target pools within the shared-target procedure. This means that while comparing targets within the shared-target procedure, a transient target can never match with a non-transient target.

5 Astrometry adopted in 4MOST

To gain an appropriate understanding of the target identifiers it is useful to first describe the astrometric system adopted by the 4MOST consortium. 4MOST has selected the Gaia equatorial coordinate system to be used throughout the project, of which the latest public release is Gaia DR3.

Gaia DR3 provides an updated materialisation of the celestial reference frame at optical wavelengths over previous Gaia data releases. The so-called Gaia-CRF3 is based solely on extragalactic sources and is aligned with the International Celestial Reference Frame (ICRF). An ad-hoc correction has been introduced to ensure that the bright-star reference frame has no net spin with respect to the reference frame defined by faint quasars. The Gaia tables AGN_CROSS_ID and FRAME_ROTATOR_SOURCE provide the source IDs for the Gaia-CRF3 sources.

4MOST input target catalogues that do not use target positions from Gaia are required to match their astrometry to the Gaia-CRF3 sources and provide match statistics to demonstrate the accuracy of their target positions. The precision of the target coordinates must be better than 0.1 arcsec or to at least 5 meaningful decimal points. In the case of selecting the unique object coordinates within the shared-target procedure, the parent catalogue with the highest astrometric precision is chosen using the following ranking scheme: 1. Gaia; 2. Legacy Survey (LS; e.g., the latest DR10 release of the LS); 3. Astrometry from any other source catalogues which are then separately ranked based on the demonstrated astrometric accuracy from a comparison to Gaia using the 4MOST-developed astrometric-verification procedure. See **Fehler! Verweisquelle konnte nicht gefunden werden.** for more details of the shared-target procedure.

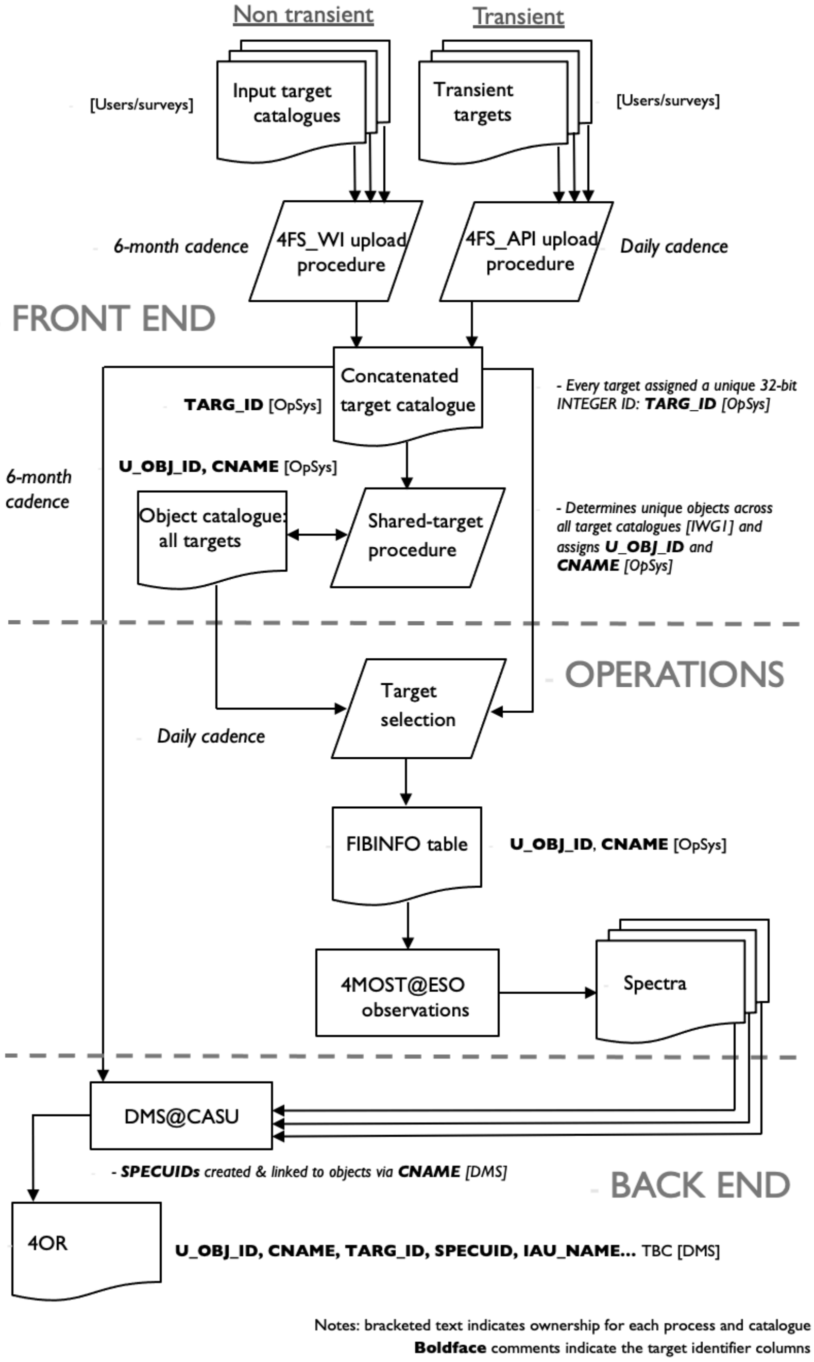

Figure 1: Target and object identification flow chart for both transient and non-transient targets. The brackets indicate ownership for each process or catalogue within the 4MOST consortium. The boldface comments indicate the target identifier column names within the associated catalogue/table. Brief process descriptions are highlighted in italicised text.

6 Target identifiers

In this section we describe each of the target identifiers used by the 4MOST consortium, as referenced in *Figure 1*.

6.1 TARG_ID

The target identifier (TARG_ID) is unique to each target uploaded to 4FS. TARG_ID is a 32-bit integer number. The value of TARG_ID is increased by 1 each time a new target is accepted for ingestion into the target database, including all targets uploaded from previous input target catalogue. In SQL terms this can be achieved by creating a column of SERIAL type with AUTO_INCREMENT rule. In the PostgreSQL dialect the SERIAL type enables labelling records with numbers between 1 and 2,147,483,647 (i.e. 2^{31}-1) which suffices for the expected volume of targets.[4]

6.2 U_OBJ_ID (or OBJ_UID)

The unique object identifier (U_OBJ_ID, although referred to as OBJ_UID in the FIBINFO table; see Appendix D) is shared between all targets that are directly associated to the same object, as determined by the shared-target procedure. The imposed requirement for the data type of this identifier is a signed 64-bit integer number. The capacity of this type greatly exceeds the number of different objects that will appear among all targets. Therefore, additional information can be packed into the 64-bit integer besides the consecutive number. The schema adopted by the 4MOST consortium is similar to that adopted in the Gaia missions and is listed in Table 3 below.

The first 28 most significant bits are used for the level 12 HEALPix value (Nside = 4096), which is based on the equatorial coordinates of the target in the nested HEALPix tiling. This step encodes an approximate object position to a precision of about 1 arcminute. All targets falling within a given HEALPixel need to be additionally distinguished. To achieve this the TARG_ID is stored in the next 32 most significant bits; note, the lowest TARG_ID value amongst all shared targets associated to a given object is stored. The 4th least significant bit is used to encode the spectral resolution of the target. Low resolution targets have this bit set to 0, high resolution targets to 1. This leaves 3 empty bits. We propose that one of these bits is used to indicate whether an object is a transient target (i.e., whether the target is ingested through 4FS_API as opposed to 4FS_WI) since this will be a useful flag for operations and back-end procedures; the proposed implementation of the transient-target indicator flag is shown in Table 3.

Table 3: U_OBJ_ID structure

Bit	Definition	Info
1:28	**Target position**	Level 12 HEALPix value based on target equatorial coordinates

[4] With less than 100 million targets per upload during survey operations, this allows for 4MOST to have at least 20 full ingests. With at most 2 full ingests each year, this is safe for at least 10 years of operation.

29:60	**Target ID**	Lowest TARG_ID amongst all targets matched to the unique object
61	**Resolution**	1:high resolution, 2:low resolution
62	**Transient**	0: non transient target, 1: transient target
63:64	**Empty**	TBD

U_OBJ_ID is distributed among the group of all targets requiring the same spectral resolution and pointing to the same object, as defined from the shared-target procedure. As noted above, U_OBJ_ID is defined using the smallest TARG_ID value in the group of shared targets. Note that since groups of targets pointing to the same object are built separately for low- and high-resolution targets, it is not possible for a low-resolution target to acquire a U_OBJ_ID of a high-resolution target or vice versa and hence they are distinguished in U_OBJ_ID.

Example using python language:

The U_OBJ_ID of a low-resolution non-transient target with coordinates RA, DEC = 202.4695750 deg, 47.1952583 deg and TARG_ID = 52489133 is computed as

U_OBJ_ID = (hpix << 35) + (TARG_ID << 5) + ((resolution - 1) << 4) + (transient << 3) = 1551988770551461280

where

hpix = ang2pix(4096, np.radians(90 - dec), np.radians(ra), nest=True) = 45168818

HEALPix value, TARG_ID, and resolution can be recovered from U_OBJ_ID by

hpix = U_OBJ_ID >> 35
TARG_ID = (U_OBJ_ID >> 5) & (2 ** 30 - 1)
resolution = ((U_OBJ_ID >> 4) & 1) + 1
transient = (U_OBJ_ID >> 3) & 1

Another low-resolution non-transient target with coordinates RA, DEC = 202.4695321 deg, 47.1952778 deg and TARG_ID = 71234567 would be assigned a U_OBJ_ID = 1551988771151315168. However, since it is pointing to the same object (0.126 arcsec difference) and its TARG_ID is higher, it receives the same U_OBJ_ID as the first target. Thus, explicitly, U_OBJ_ID=1551988770551461280. (not 1551988771151315168).

6.3 CNAME (or OBJ_NME)

CASU uses a standard format for the 'coordinate name' or CNAME (although referred to as OBJ_NME in the FIBINFO table; see Appendix D) that is used across projects. The basic CNAME is constructed from the unique object properties as follows:

<Project identifier>_<Right Ascension Sexagesimal 2 d.p.><Signed Declination Sexagesimal 1 d.p.>

In the basic construction, a 4MOST CNAME for an object at $00^h51^m09.38^s$ –42° 26′ 33.8 would be:

QMOST_00510938-4226338[5]

CNAME is constructed within OpSys.[6]

The reference epoch of 2016.0 will be used throughout the entire survey to apply space motion to all input coordinates.

6.4 IAU-approved object name for published catalogues

The 4MOST project has been registered with the IAU who have approved the following naming format for 4MOST targets:

4MOST JHHMMSSss+DDMMSSs (example "4MOST J12290568+0512035")

where there is a space (and not an underscore) between the name and coordinates, and where the J indicates that we are using Equinox J2000 coordinates, and where the coordinates shall be truncated, not rounded.

The reference epoch of 2016.0 will be used throughout the entire survey to apply space motion to all input coordinates. For confirmation and details see Appendix E and JIRA ticket https://4most-tickets.atlassian.net/browse/SOP-31. The IAU-approved object name will be used in all published 4MOST catalogues. OpSys is responsible for the creation of the IAU-approved object name.

The IAU name uniquely identifies each source within the survey. It is compliant with the source identifier requirement #3 on the ESO Science Data Products Standard document [RD8].

As mentioned in Sec. 4, transient targets cannot be matched with non-transient targets within the shared-target procedure, as they have separate target pools to be compared with. This means that they will have different U_OBJ_ID by definition. To additionally make the IAU_NAME unique also with respect to transients, a suffix will be appended. This suffix is encoded as "_T#". Here # can be any number from 1 to 9, which caters for the case that more than one transient is observed in any target galaxy within the lifetime of 4MOST.

Note: in a nearby, spatially resolved galaxy, the transient will be offset from the galaxy center by more than the object linking length (currently 0.4"). Also, a transient can occur in a galaxy that is not being targeted in any of the main surveys. Then a transient would have an

[5] Note for some earlier OpRs, the temporary construction was *QMST00510938-4226338* due to a predefined string length limit of 20A in the FIBINFO table column *OBJ_NME.*
[6] The code to produce CNAME is available on GitLab: https://gitlab.4most.eu/OpSys/ostd/-/blob/master/ostd/extras/cname.py

IAU_NAME with transient suffix, but no IAU_NAME without suffix would be present in the database. This is a normal occurrence.

Important note: although qualitatively similar to CNAME, there are several key differences and the two target identifiers should not be confused. CNAME is an internal 4MOST name and is not the target name to be used in published 4MOST catalogues.

6.5 SPECUID and CASU survey operations and dataflow

CASU requires a unique identifier that acts as a primary key for ingestion of *DMS events* into the 4MOST Operational Repository Database. A *DMS event* is defined as the output of either the 4MOST instrument or one of the pipelines, culminating in either the creation of a container data file, in full (“singlespec files”) or in part (“multispec files”).

We describe this identification scheme here, which is correct up to the current implementation (OpR3), but note it is subject to change following a DMS review.

Context
The requirement for a primary identifier is driven by 3 factors:
1. Serving files from the 4OR
2. Bookkeeping the stacking of the same astrophysical targets as they are observed
3. Defining a linkage between different DMS events both horizontally (e.g. multispec – singlespec) and vertically (e.g. RAW – L1)

The SPECUID identifies a *DMS event* via a signed 64-bit integer. This integer ultimately encodes information such as:

- The type of data (raw, L1, L2…)
- Where relevant, an identification of the stack level (single exposure, stack, superstack)
- The instrument configuration (spectrograph arm, resolution, binning)
- When the target was observed
- The fibre with which the target was observed

Depending on context, some information is redundant – the SPECUID for a RAW exposure will not contain meaningful information about the fibre identifier of the “target” because, in reality, there are many targets contained within this file.

Operational implications
We note that SPECUID does not contain spatial information. An astrophysical source in the sky can (and generally will) always map to multiple SPECUIDs. At minimum, this is because we differentiate between a *DMS event* generating data with the red, green, or blue spectrograph arms. This is important within the context of performing spectral stacking of targets: we do not wish to stack blue spectra with red spectra.

CASU therefore uses a combination of the SPECUID, CNAME (describing the spatial location of the target) and a sub-survey ID (to determine stacking policy) in order to group *DMS events* that should undergo spectral stacking.

SPECUID structure

We construct the SPECUID by concatenating a series of strings; see also [RD4].

Table 4: SPECUID structure

Indices (python)	Definition	Info
0	**Data product**	-1:RAW, 1:L1, 2:L2GP, 3:L2XP, 4:L2SP
1	**Spectrograph**	0:N/A, 1:LRS-A, 2:LRS-B, 3:HRS
2	**Stack level**	1:single (ie. none), 2:OB, 3:nightly, 4:super
3:9	**Date**	YYMMDD
9:12	**Run number**	e.g. 003
12	**Resolution**	1:LRS, 2:HRS
13	**Arm**	1:RED, 2:GREEN, 3:BLUE, 4:JOINED
14	**Binning**	1:1x, 2:2x, 4:4x
15:19	**Fibre ID**	e.g. 0954

As a worked example, for an L1 DMS single-exposure, single-binned event for the HRS spectrograph, observed on the 4th September 2020, assigned run number 3, specifically looking at fibre ID 954 in the blue arm, we construct the following SPECUID:

“131”	**“200904”**	**“003”**	**“231”**	**“0954”**
product (L1)	**YYMMDD**	**run number**	**res (HRS)**	**fibre ID**
spectrograph (HRS)			**arm (BLUE)**	
stack level (single)			**spec binning (1)**	

“131” + “200904” + “003” + “231” + “0954” → SPECUID = 1312009040032310954

Each SPECUID is linked to objects through the observing blocks (OB); see [RD4] for more information.

Survey operations and dataflow

CASU will be the distributor of SPECUID for all DMS event generators. DXUs must provide columns that describe the provenance (i.e., input) SPECUID and the output SPECUID. For example, the 4XP pipeline might create a binary FITS table to write redshift classification results. A column describing the L1 SPECUID that was used must be included – this should be filled with the value provided in the source data. Alongside this will be an L2XP SPECUID column. This should be left blank; CASU will populate these once the data files are transferred to CASU. Pipelines are naturally welcome to specify additional IDs for their internal use, but these will not be used in any relational way within the 4OR database.

6.6 SPECUID_P: SPECUID with provenance related identification

To uniquely identify the history of 4MOST data products, a unique identifier is required that updates whenever a product is built. For spectra, this identifier consists of the SPECUID and an identifier that is unique to a processing event. Since DMS guarantees to process the spectra at most once a day, the proposal is

<SPECUID>p<PROCESSING_DAY>

where <PROCESSING_DAY> is in the YYMMDD format. For example:

1312009040032310954p221007

For other data products (like target and object catalogues), the provenance related ID would be created in a similar way by appending p<PROCESSING_DAY> to the target/object ID. Note there will need to be a way to query DMS and/or 4PA for a specific provenance related ID and retrieve the according data product. The provenance related ID could be stored within the product itself (i.e. in the header). In this case, it must be ensured that a run outside of the DMS does not produce an official ID (i.e. by appending a random string to the ID).

7 ESO approved unique IDs

ESO defines in [RD8] that each data product (typically catalogues) shall have a unique key to identify each row in the catalogue. The following was agreed with ESO.

TARG_ID will be used as the unique key for the target catalogue.

SPECUID_P will be part of the name of the file submitted on Phase 3 FTP for spectral data (singlespec). SPECUID_P will also be the unique key in L2 products, as L2 products are tied to a particular observed spectrum (or stack thereof).

Appendix A List of Acronyms

Acronym	Definition
4MOST	4-metre Multi-Object Spectroscopic Telescope
4FS	4MOST facility simulator
4OR	4MOST observations repository
4PA	4MOST public archive
4XP	4MOST extragalactic pipeline
AD	Applicable Document
A&G	Acquisition and Guiding
CASU	Cambridge Astronomy Survey Unit
CCD	Charge-Coupled Device
DEC	Declination
DMS	Data Management System
HOWFS	High Order Wavefront Sensor
HR	High Resolution
HRS	High Resolution Spectrograph
ID	Identifier
LOWFS	Low Order Wavefront Sensor
LR	Low Resolution
LRS	Low Resolution Spectrograph
M1	Primary Mirror
M2	Secondary Mirror
OpR	Operational Rehearsal
RA	Right Ascension
RD	Reference Document
TBC	To be confirmed
TBD	To be defined
VISTA	Visible and Infrared Survey Telescope for Astronomy

Appendix B Target catalogue format

The format of the input target catalogue as submitted by each survey and as taken from version 10.0 of the 4FS user manual ([RD1]). We note that the concatenated target catalogue has the same format but with the addition of TARG_ID, the unique target identifier.

Column Name	Type	Description	Notes
NAME	String (up to 256 chars)	Human readable target identifier. As supplied by the science team.	Required to be unique for each target within a sub-survey (uniqueness exception: transients), and must be alphanumeric.
RA	Float (1D, double)	Right Ascension, in units decimal degrees (as **deg**)	Range: 0 to 359.99999999
DEC	Float (1D, double)	Declination, in units decimal degrees (as **deg**)	Range: -89.99999999 to +40
PMRA	Float (1E)	Proper motion wrt. RA, in units mas/yr (as **mas/yr**)	Range: -1e6 to +1e6
PMDEC	Float (1E)	Proper motion wrt. DEC, in units mas/yr (as **mas/yr**)	Range: -1e6 to +1e6
EPOCH	Float (1E)	Epoch of coordinate position, in units Julian Date (as **yr**)	Range: 1950 to 2050 Example: 2016.0, e.g. GAIA DR3
RESOLUTION	Integer (1I, short int)	Desired resolution mode for this target	Options: 1: LRS 2: HRS
SUBSURVEY	String (up to 256 chars)	Sub-survey name for target's membership	Alphanumeric
CADENCE	Integer (int64, long long int)	An integer that encodes information regarding observing cadence.	Range: 0 to (2**22 – 1). See below for details about encoding.[1]
TEMPLATE	String (up to 256 chars)	Spectral template filename describing the predicted spectral shape of this target,	Alphanumeric, see also §7.3 of the 4FS-WI User Manual.
RULESET	String (up to 256 chars)	Name of the ruleset describing the target's spectral success criteria.	This should be the named ruleset and not the filename containing possibly multiple rulesets. Alphanumeric, must begin with a letter. See also §7.4.2 of the 4FS-WI User Manual.
REDSHIFT_ESTIMATE	Float (1E)	Estimated redshift of target at time of targeting (e.g. from photo-z)	Range: -0.01 to 10. See below about usage.[4]
REDSHIFT_ERROR	Float (1E)	1 sigma uncertainty in REDSHIFT	Range: 0 to 10.
EXTENT_FLAG	Integer (1I, short int)	Flag defining the model to compute the flux.	Options: 0: POINT SOURCE; 1: Box/Flat; 2: Sersic profile. See below for details.[2]
EXTENT_PARAMETER	Integer or Float (1I or 1E)	Parameter describing the spatial extent (radius) of the Sersic profile in units arcsec (as **arcsec**).	Ignored if not EXTENT_FLAG=2 (Sersic profile). Range: 0.1 to 100. See below for details.[2]
EXTENT_INDEX	Integer or Float (1I or 1E)	Index of the Sersic profile	Ignored if not EXTENT_FLAG=2 (Sersic profile). Range: 0.1 to 10. See below for details.[2]
MAG	Float (1E)	Apparent magnitude for the target already reddened, in	Magnitude should be consistent with the

Target catalogue format (cont)…

		units magnitude (as **mag**).	MAG_TYPE column and its band. Range: 3 to 50. Note that usage depends on EXTENT_FLAG.[2]
MAG_ERR	Float (1E)	1 sigma uncertainty on entries in MAG column, in units magnitude (as **mag**)	Range: 0 to 50. Can be zero or NULL; not currently used
MAG_TYPE	String (up to 256 chars)	Identifier for the magnitude or flux density system which describes the MAG and TEMPLATE columns.	Only a limited set of standard "Filters" and standard "Systems" are accepted, see below for options.[3]
REDDENING	Float (1E)	Foreground reddening E(B-V) to apply to the template, in units magnitude (as **mag**).	Range: 0 to 100. Can be zero or NAN. See below about usage.[4] Modified in FMTVERS=2.0.
TEMPLATE_REDSHIFT	Float (1E)	Redshift used by template.	Range: -0.1 to 10. See below about usage.[4] Introduced in FMTVERS=2.0.
DATE_EARLIEST	Float (1E)	Earliest date when this target can be observed, in units days (as **d**).	Julian Date (decimal days). See below about usage.[5]
DATE_LATEST	Float (1E)	Latest date when this target can be observed, in units days (as **d**).	Julian Date (decimal days). See below about usage.[5]
CAL_MAG_BLUE	Float (1E)	Apparent magnitude to suggest for object during fibre calibration in the blue arm, in units magnitude (as **mag**).	Range: 0 to 50. See below about usage.[6] Introduced in FMTVERS=2.0.
CAL_MAG_ERR_BLUE	Float (1E)	1 sigma uncertainty on entries in CAL_MAG_BL column, in units magnitude (as **mag**).	Range: 0 to 50. See below about usage.[6] Introduced in FMTVERS=2.0.
CAL_MAG_ID_BLUE	String (up to 256 chars)	Identifier for the magnitude system which describes the CAL_MAG_BL.	See below about usage and acceptable options.[6] Introduced in FMTVERS=2.0.
CAL_MAG_GREEN	Float (1E)	Apparent magnitude to suggest for object during fibre calibration in the green arm, in units magnitude (as **mag**).	Range: 0 to 50. See below about usage[6] Introduced in FMTVERS=2.0.
CAL_MAG_ERR_GREEN	Float (1E)	1 sigma uncertainty on entries in CAL_MAG_GR column, in units magnitude (as **mag**).	Range: 0 to 50. See below about usage.[6] Introduced in FMTVERS=2.0.
CAL_MAG_ID_GREEN	String (up to 256 chars)	Identifier for the magnitude system which describes the CAL_MAG_GR.	See below about usage and acceptable options.[6] Introduced in FMTVERS=2.0.
CAL_MAG_RED	Float (1E)	Apparent magnitude to suggest for object during fibre calibration in the blue arm, in units magnitude (as **mag**).	Range: 0 to 50. See below about usage.[6] Introduced in FMTVERS=2.0.
CAL_MAG_ERR_RED	Float (1E)	1 sigma uncertainty on entries in CAL_MAG_RD column, in units magnitude (as **mag**).	Range: 0 to 50. See below about usage.[6] Introduced in FMTVERS=2.0.
CAL_MAG_ID_RED	String (up to 256 chars)	Identifier for the magnitude system which describes the CAL_MAG_RD.	See below about usage and acceptable options.[6] Introduced in FMTVERS=2.0.
CLASSIFICATION	String (up to 256 chars)	Expected/estimated classification type(s) for target.	See below about usage and acceptable options.[7] Introduced in FMTVERS=2.2.
COMPLETENESS	Float (1E)	Per-target completeness within sub-survey	Range: 0.0 to 1.0. See below about usage.[8] Introduced in FMTVERS=2.3.
PARALLAX	Float (1E)	Stellar parallax of target, in units milliarcseconds (as **mas**).	Required for 4MOST fibre positioning and CNAME definition. Undefined values should be set to 0. Introduced in FMTVERS=2.5.

Appendix C Target catalogue proposed format

The target and object catalogue used to define unique 4MOST objects. The proposed format of the object catalogue is shown below; an earlier version was presented in [RD5]. Note although referred to as a catalogue it is a schema table where the number of entries can be increased as required. This table is just a preliminary suggestion made at the time of releasing this document for the purpose of discussion. The actual target catalogue format will be an outcome of OpR3 Ph3 TargCat.

Column name	Type	Definition	Notes
TARG_ID	Integer (int64)	Unique target identifier	Primary key
U_OBJ_ID	Integer (int64)	Unique object identifier	see Table 3 for definition
OBJ_NME	Char(32)	Object name	CNAME
OBJ_RA	Float (double)	Object right ascension	
OBJ_DEC	Float (double)	Object declination	
OBJ_PMRA	Float (double)	Object proper motion in right ascension	
OBJ_PMDE	Float (double)	Object proper motion in declination	
OBJ_PRLX	Float (real)	Object parallax	
OBJ_EPOC	Float (real)	Object position epoch	
OBJ_SRV	Integer (int64)	Unique survey and sub survey identifier	Default 0
OBJ_PRIO	Integer (int8)	Special flags for two categories of targets (for z-classifier feedback and backend processing of transients)	Default 0
OBJ_RLID	Float (real)	Currently unused	Default 0
OBJ_WAV	Float (real)	Wavelength to target when centroiding	Default 545
OBJ_BL	Float (real)	Apparent magnitude for object in blue band (blue-arm fibre calibration)	
OBJ_BLER	Float (real)	1 sigma uncertainty on OBJ_BL	
OBJ_BLID	Integer (int8)	Identifier for magnitude system which describes OBJ_BL	
OBJ_GR	Float (real)	Apparent magnitude for object in green band (green-arm fibre calibration)	
OBJ_GRER	Float (real)	1 sigma uncertainty on OBJ_GR	
OBJ_GRID	Integer (int8)	Identifier for magnitude system which describes OBJ_GR	
OBJ_RD	Float (real)	Apparent magnitude for object in red band (red-arm fibre calibration)	
OBJ_RDER	Float (real)	1 sigma uncertainty on OBJ_RD	
OBJ_RDID	Integer (int8)	Identifier for magnitude system which describes OBJ_RD	
OBJ_WAV	Float (real)	Wavelength at which the target center is defined	Default 545

Appendix D FIBINFO table format

The FIBINFO table is constructed from the object catalogue and concatenated target catalogues. It is used for object targeting. The FIBINFO table is described in [RD2]. However, since it is at the interface between the front end and operations it is useful to understand the catalogue format. The current format of the FIBINFO table is listed below, however the present document is NOT the authoritative source for the FIBINFO table content.

Column	Type	Unit	Description (TCOMMi)
FIB_ID	uint16		Fibre ID
OBJ_UID	uint64		Unique object identifier
OBJ _NME	char24		Unique name/id of catalog entry
OBJ _RA	double	deg	Catalogue object right ascension
OBJ _DEC	double	deg	Catalogue object declination
OBJ _PMRA	double	mas/yr	RA proper motion of target
OBJ _PMDE	double	mas/yr	Dec proper motion of target
OBJ _PRLX	float	mas	Object parallax
OBJ _EPOC	float	yr	Epoch of coordinates
OBJ _SRV	uint64		Unique identifier for which surveys and subsurveys a target belongs
OBJ _PRIO	uint8		Target relative priority within survey
FIB_PHI	double	deg	Ideal PHI, focal surface fibre coord
FIB_THET	double	deg	Ideal THETA, focal surface fibre coord
FIB_ST	uint8		0:DISABLED 1:PARKED 2:ALLOCATED
OBJ _RLID	uint16		Predefined algorithm
OBJ _BL	float	mag	Object magnitude estimate for blue arm (e.g. SDSS-like AB g-band)
OBJ _BLER	float	mag	Error on TRG_BL
OBJ _BLID	uint8		Identifier ID for MAG.IDi header dictionary
OBJ _GR	float	mag	Object magnitude estimate for green arm (e.g. SDSS-like AB r-band)
OBJ _GRER	float	mag	Error on TRG_GR
OBJ _GRID	uint8		Identifier ID for MAG.IDi header dictionary
OBJ _RD	float	mag	Object magnitude estimate for red arm (e.g. SDSS-like AB i-band)
OBJ _RDER	float	mag	Error on TRG_RD
OBJ _RDID	uint8		Identifier ID for MAG.IDi header dictionary
FIB_USE	uint8		1:OBJECT 2:REF 3:SKY 4:CALIB 5:ACTIVE GUIDING 6:INACTIVE GUIDING
OBJ _WAV	float	nm	Wavelength to target when centroiding
FIB_ROOT	uint8		1:CCDHR 2:CCDLRA 3:CCDLRB 4:GUIDING FIBRE
SLIT_POS	uint16		Specifies slit position of fibre

Appendix E IAU-approved 4MOST name format confirmation

From: The IAU Commission B2 Working Group on Designations

marianne.brouty@astro.unistra.fr

cc: Cecile Loup, IAU WG Designations (cecile.loup@astro.unistra.fr)

IAU WG Designations members (iau-wgd@unistra.fr)

Date: 16-Jun-2022

Topic: Acceptance of your new acronym 4MOST in the "IAU Registry"

Dear Dr de Jong,

We are pleased to announce acceptance of your acronym 4MOST submitted to the IAU Registry. It is being entered into the on-line Reference Dictionary of Nomenclature of Celestial Objects.

The details of the registered acronym can be found at the URL http://cds.u-strasbg.fr/cgi-bin/Dic?4MOST (and soon on the mirrors at http://vizier.cfa.harvard.edu/viz-bin/Dic , http://vizier.nao.ac.jp/viz-bin/Dic)

If, for any reason, the "format" (JHHMMSSss+DDMMSSs) used to identify the 4MOST objects has to be modified (e.g. a suffix has to be added to distinguish close-by objects), we would appreciate if you could submit any revision to http://cdsarc.u-strasbg.fr/viz-bin/DicForm?AcA=4MOST&AcM=rdejong%40aip.de

Thank you again for using the "IAU Registry of a new acronym".

Best regards,

Marianne Brouty

for the IAU Working Group on Designations