NASA/IPAC Extragalactic Database

Title: **Best Practices for Data Publication to Facilitate Integration into NED: A Reference Guide for Authors**

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This document includes a
Checklist of NED Recommendations for Publishing Data
for authors and data providers to consult before submission of the final version of their journal articles or source catalogs.

Abstract

We provide an overview of challenges encountered in ongoing efforts to improve the automation, efficiency, and accuracy of the procedures required to extract, transform, cross-identify, and integrate data from the electronic astrophysics literature into the NASA/IPAC Extragalactic Database (NED). Recommendations for best practices for publishing data are provided, from the perspective of the NED Team,

to serve as a reference guide for authors, referees and editors of astrophysics journal articles. Also included are examples of problematic displays of data in the literature. If more authors follow the guidelines recommended here before final publication, this will improve the quality of the published research record and also expedite the integration of data from the literature into NED with as little lag time and with as few errors as possible.

Our goal is to streamline the extraction, preservation, and integration of valuable data, and to enable new modes of science discovery that better exploit the vast quantities of panchromatic and multi-dimensional data associated with the literature. Continuing progress in this area can result through an improved collaboration between the NED project, authors of articles presenting new data, and other astronomical archives and service providers. We encourage authors, journal editors, referees, and publishers to implement the best practices reviewed here, as well as related recommendations from international astronomical organizations such as the IAU and IVOA for publication of nomenclature, data, and metadata. This document includes a convenient *Checklist of NED Recommendations for Publishing Data* for authors and data providers to consult before submission of the final version of their journal articles or source catalogs.

1 Introduction

The ongoing mission of NED is to provide a comprehensive and easy-to-use database of fundamental multi-wavelength information for known (cataloged and published) objects beyond our Milky Way galaxy. The current database is the result of a systematic integration of data from hundreds of large sky surveys and from over 89,000 research publications (as of September 2013). The data and services span the entire spectrum from gamma rays through radio frequencies. This thematic, on-line research facility supports scientists, educators, space missions, and observatories in planning, data analysis, discovery, and publication of research on extragalactic objects. As new observations are published, they are cross-identified or statistically associated with previous data in NED and integrated into a unified database to simplify queries and retrieval of data across all spectral regions. Seamless connectivity is also provided to data in NASA's astrophysics mission archives

(IRSA, HEASARC, MAST) and other data centers around the world, and to the online literature via ADS. NED also provides a repository for FITS images and spectra contributed by authors of journal articles, and the Level 5 Knowledgebase that augments review articles in extragalactic astrophysics and cosmology with object names and graphical content within the articles linked directly to relevant database searches. Further information about NED content and functionality is available at the NED website and in various publications (*e.g.*, Mazzarella et al. 2007; Schmitz et al. 2011).

2 Challenges to Keeping NED Up-To-Date and Accurate

The database contents and relationships between measurements in NED are augmented and revised continuously to keep up with the current astrophysics literature and with new sky surveys. However, this work is increasing in difficulty given the rapid growth of data volume and complexity, combined with various challenges presented by the way data are currently published in electronic journal articles. Recurring problems in the presentation of object identifiers and various physical measurements (data and metadata) in the literature currently impede automation of data extraction and unification. Most of these problems can be avoided, or at least minimized, with a relatively small effort on the part of authors and data providers.

The NED team workflow begins with identification of articles in the primary astrophysics literature (ApJ, ApJS, ApJL, AJ, A&A, MNRAS, CBET, etc.) and large sky survey catalogs (*e.g.*, SDSS, NVSS, COSMOS) containing data pertaining to extragalactic objects and topics. Relevant digital data then need to be extracted and reformatted for the process of computing cross-identifications and associations, and entry of selected information into the database. This is done using a combination of scripting/programming and spreadsheets or database macros, all specifically written for the NED production staff. Data in the literature and in very large sky surveys present different challenges. In this document, we focus on difficulties in extraction and integration of measurements from the modern digital literature and associated data files (typically catalogs). Due to the fact that every dataset in the literature is presented differently (more on this below), in many cases

the NED staff has to resort to manual data transformations (i.e., using a text editor or spreadsheet) rather than general purpose scripts or programs, which slows down the data integration process. Cross-identification and association of millions of entries in catalogs and publications is based on a programmed procedure that utilizes positions, positional uncertainties, and background source density information. This is followed, when necessary, by human inspection and vetting to resolve complex cases that cannot be fully automated.

3 Best Practices for Publishing Data in Journal Articles

This document clarifies what is needed to prevent various problems with (meta)data presented in the literature, requiring minimal additional effort by authors, referees and editors. We encourage all stakeholders to follow these recommended best practices during the preparation, submission, referee and editing stages of the publication process. This is a working document that is part of the NED documentation and help pages, and the NED Team will evolve these Best Practices with feedback from authors, the AAS journals and Publication Board, the NED Users Committee and other interested readers. We welcome feedback from all authors of journal articles and other data providers who are attempting to put these guidelines into practice.

Although these recommendations are presented from the perspective of NED, clearly other services such as the NASA Exoplanet Archive and SIMBAD will also benefit from small additional efforts by authors to make the ingestion of new data associated with their journal articles as straightforward and accurate as possible. Indeed, a number of issues discussed here are also addressed by Cambresy et al. (2011) in the context of the SIMBAD and VizieR services of CDS. Active and consistent participation from authors in presenting their (meta)data in the literature is crucial for the publication record and to facilitate integration into astronomical information systems (*e.g.*, Schwarz 2005). The topics discussed here are also crucial to achieve the goals of data sharing, open access, and reproducibility of science results (*e.g.*, "President's Column: Making Excellent Journals Even Better" (Helfand 2013)).

3.1 Nomenclature for Astronomical Sources (Objects)

3.1.1 IAU Conventions

Problem: *Perhaps the most common and "simple" type of data in observational journal articles is the name of an astronomical source. It is very important to provide unambiguous names and to follow recommended standards for nomenclature when referring to astronomical objects. Although journal publishers and the IAU encourage following established conventions (e.g., see "How to refer to a source or designate a new one" from IAU Commission 5;), and many authors are diligent in this regard, substantial problems are introduced when authors, editors and referees relax these standards, leaving NED with a lot of verification work to determine what the author truly meant to say. Often ambiguities cannot be resolved without contacting authors or modifying the names as-published in order to correctly merge new information with the correct objects in the database.*

Best Practice: The following examples illustrate the recommended form of astronomical designations:

```
UGC 12151
SDSS J094027.02+482015.4
2MASX J09402705+4820158
```

The following examples illustrate some improper astronomical designations that have appeared in the literature:

Table 1: Object Nomenclature Problems

As published	**Why it is improper**	**Required for NED use**
GR+15°6	Use of non-ASCII character	[R83] 15deg006
DEM45	Catalog unclear; HII region in LMC should be indicated with "L", or SMC with "S". No spacing after acronym.	DEM L 045 or DEM S 045
HESS J232+202	Leading zero in RA portion of the name is missing	HESS J0232+202
0008+006	Object is ambiguous. The name prefix "ZC" is needed to distinguish a z=2.34 object from a z=1.49 object designated with prefix "IERS".	ZC 0008+006 or IERS B0008+006
SDSS J144157.2+094859	Insufficient precision in decimal RA and DEC can cause confusion with a nearby source	SDSS J144157.24+094859.1
BR 0529-3526	Missing letter **J** to specify Julian 2000 equatorial coordinates	BR J0529-3526
Joe	Personal names are not recommended because there will be conflicts in common usage	[BAA2011] Joe

The following sections address specific topics on source name representation in publications. (See Specifications concerning designations for astronomical radiation sources outside the solar system [http://cds.u-strasbg.fr/vizier/Dic/iau-spec.htx] for a review of the IAU recommendations.)

There are on-line tools which can be used to determine if a known object designation is properly formatted. The NED Name Resolver can be used to

validate object names via the Object List input service. There is also a service provided by CDS called Sesame to check both NED and SIMBAD object names. Check the IAU Dictionary of Nomenclature of Celestial Objects at `http://cds.u-strasbg.fr/cgi-bin/Dic-Simbad` for a list of acronyms currently in use.

3.1.2 Nicknames

Problem: *Nicknames and truncated coordinates are often used in order to provide an easier way for an author to represent a long coordinate-based name. Although this is convenient in some situations, identifying the unique source intended by the author for proper cross-identification with other measurements in NED can be very difficult and error prone.*

Best Practice: NED recommends that complete object names **ALWAYS** be presented in data tables and article titles. A shortened version may appear in the text (typically by saying "hereafter referred to as ", but this should be used sparingly). Nicknames, such as "Supernova Joe", should not be used since more than one group may accidentally come up with the same nickname and there would be no way of uniquely identifying the intended object. Again, IAU recommendations for proper astronomical source nomenclature have good reasoning behind them.

3.1.3 Newly discovered objects

Problem: *Newly discovered objects are handled in quite a few different styles by different authors. Sometimes they are given in sequential order, maybe starting at 1, but sometimes starting at 0. Often an apparently random number is assigned (as in the case of an ID number from an automated plate scanning routine), sometimes as a partial coordinate (with or without the J to indicate J2000) which truncates or rounds the coordinate to make the name; sometimes as an (x,y) offset coordinate; sometimes (in the cases of parts of galaxies or gravitationally lensed arcs) as a decimal number following the integer name of the host object; sometimes without any designation at all.*

Best Practice: NED recommends that the author think carefully about

how to designate newly discovered objects in terms of the big picture of astronomy. The key to object designations is that each one **MUST** be unique when compared to objects identified at other observatories and wavelengths.

Examples of what NED has done to ensure uniqueness of object names are:

- In a survey published in 2012 of 20 individual galaxies in Abell 1365, authors A, B, and C may name the galaxies as 1, 2, 3, etc. However, these galaxies may already have been given names of 3, 15, 23 in a 2003 work by authors X, Y, and Z. In order to clarify that the object called 3 is actually referring to different objects in these two studies, NED assigns names such as ABELL 1365:[ABC2012] 01, ABELL 1365:[ABC2012] 02, and ABELL 1365:[ABC2012] 03 for sources identified by authors A, B and C and ABELL 1365:[XYZ2003] 03, ABELL 1365:[XYZ2003] 15, and ABELL 1365:[XYZ2003] 23 for sources identified by authors X, Y and Z. (Leading zeroes are inserted where needed based on the maximum sequential number given by the authors.)
- In a radio survey in 2011 by authors D, E, F, and G, the new objects were given truncated names such as 1034.2+3211. If the authors didn't provide a particular name to their survey, NED assigns a catalog name to the article. In this case, the acronym would be [DEF2011] only the first three author initials are used. If the coordinates are based on epoch J2000, then NED prepends a J to the truncated coordinate-based source names. Without the J, IAU convention would place these coordinates on the B1950 system. Thus, NED would create a name of [DEF2011] J1034.2+3211 for this object. The square-bracket nomenclature indicates that this is an acronym invented by NED (or SIMBAD) when an author doesn't provide one (or provides an ambiguous one).

3.1.4 Duplication of Object Names

Problem: *The same object name is used for different objects in the same journal article. In recent years, the situation has arisen more often than it should whereby identical object names are used for very different ob-*

jects (in the same article). These often are sequential number designations "1", "2", "3" for different patches of sky, but also for overlapping fields which were processed separately, but then cross-matched together. When these duplications are found, we need a method of differentiating between the sources, and NED might assign a "NED01" or "NED02" suffix as a "tie breaker" to separate the duplicates. In most cases, we inform the authors of this problem seeking help of confirmation, but frequently we do not get a response. The "NEDxx" suffix is used to indicate that NED has created the tie-breaker. We do not presume that an "A", "B", suffix nor an "NE", "SW", cardinal direction indicator nor any other scheme is what the author might have preferred. This all takes substantial time and is error prone.

Best Practice: Check to make sure that identical object names are not used to refer to very different objects within the same article.

3.1.5 Inconsistent cross-identifications, names, and positions

Problem: *Many examples exist in the literature where multiple columns of cross-identifications disagree with each other or with the listed coordinates.*

Best Practice: Always verify that all of the names given to an object are valid cross-identifications for that object and that the listed positions are for that same object. When there is disagreement among these items, it is unclear whether the problem lies with the name or with the coordinates. A check of NED or SIMBAD for each object is recommended. Also, when there are already multiple catalog source cross-identifications for an object in NED, there is no need to list them in a journal article, unless the intent is to correct an error in NED. Often typos occur in the aliases listed by authors, which leads to unnecessary complications in the cross-identification process. A single, unambiguous object name that has been validated using the NED Name Resolver or that comes from a published catalog is usually sufficient in addition to the object's coordinates.

3.2 Coordinates and Uncertainties

3.2.1 Coordinate Formatting

Problem: *Providing accurate celestial coordinates for objects is a recommended practice in general. Unfortunately, there are several formats in which the coordinates can be represented. Until recently, sexagesimal equatorial had been the most frequently used system for extragalactic astronomy. (Before the year 2000, the Besselian 1950 equinox was preferred, while after 2000 the Julian 2000 equinox is being used; although even today coordinates in B1950 are still being published.) With computer programs and spreadsheets typically computing coordinates, there has been a trend toward keeping the coordinates in decimal degrees (or even decimal hours). This is a convenient method of handling coordinates electronically, but is more cumbersome than sexagesimal display for the human. There is also a tendency to provide more decimal values than are warranted by the processing. For example, a decimal degree coordinate of (131.32134587°, -0.01243229°) implies an accuracy of* 10^{-8} *degrees (or 0.00001″), which is not obtainable by most telescopes.*

Best Practice: If authors provide J2000 sexagesimal coordinates in their data tables, including the proper number of significant figures depending on the uncertainty of the astrometry, there will be less room for errors in translation between what is published and what NED needs. Care must also be used to ensure that declinations of "$-0°$" do not lose the minus sign and that minutes and seconds of RA or DEC do not contain the value 60. Also, the number of significant figures should properly represent the positional accuracy of the telescope and detectors used to obtain the data. When it is more convenient to tabulate machine-generated coordinates in decimal format, it is crucial to label the units clearly (i.e., to distinguish decimal degrees from decimal hours in RA), and it is equally important to use only as many significant digits as justified by the precision of the astrometric measurements.

3.2.2 (x, y) offsets

Problem: *Another style often in use is to present (x,y) offsets from some*

reference object or position. This has been used, for example, for objects within the disk of a galaxy or the location of gravitationally lensed objects. Unfortunately, sometimes authors don't provide the reference position or the orientation angle of the image. This requires the NED staff to make an effort to determine the position of the origin, which may not always agree with what the author intended.

Best Practice: If coordinate offsets are presented, it is essential that authors ALWAYS provide the reference coordinates accurately and clearly, including the angle of rotation (if North is not up or East is not to the left), and the sense of the offset (*e.g.*, [reference point minus source] or [source minus reference point]). Rather than offsets (or in addition to the offsets), it is preferable and highly recommended that authors compute and publish complete, absolute coordinates and uncertainties.

3.2.3 Position accuracy

Problem: *Quite often, newly discovered sources are presented with coordinates, but without a clear indication of the accuracy of those coordinates.* Sometimes internal relative errors are reported, whereas the uncertainty in the absolute position is needed in order for NED software to compute proper cross-identifications or associations with prior observations from different telescopes and detectors.

Best Practice: All efforts should be made to determine the probable absolute uncertainty in the measurement of positions. Indications of the reference frame being referred to (*e.g.*, AGK3; FK5; ICRS) should also be included. (Yes, they are different). If needed, please refer to the official IERS website. These uncertainties should also be in the same units as the coordinates they refer to.

3.2.4 Measurement uncertainties

Problem: *Position measurement uncertainties are not given or are not clearly described.*

Best Practice: NED recommends that the **ABSOLUTE** (not relative) measured uncertainty in EACH measured position be clearly identified and presented in the units of the coordinates. Also, an indication of the confidence of the uncertainty (*e.g.*, 1σ; 95%) needs to be clearly presented.

3.3 Photometry

Photometry is a big part of astronomy and one which NED has devoted much effort to collate and present as clearly as possible to the community. However, there are data tables published for which the information required to properly represent the data and to accurately convert the measurements to standard units is not readily available.

3.3.1 Photometric passbands

Problem: *Frequently, incomplete or ambiguous shortcuts are used to indicate the filter or passband used for photometry. For example, an i magnitude might refer to either a Gunn-Thuan "i" or a Cousins "i". Also, 2MASS used a 'K short filter', but is sometimes presented in the literature as just "K".*

Best Practice: Specify passbands unambiguously.

Use standard passband identifiers consulting NED's web page listing of selected passbands. An additional listing is available at the Spanish Virtual Observatory Filter Profile Service. The IVAO is developing standards for representation of photometric bands. For the current status of available notes and draft recommendations, see `http://www.ivoa.net/`.

3.3.2 Time of observation

The precise time of the observations should also be provided when possible, preferably as Modified Julian Date (MJD), otherwise Coordinated Universal Time (UTC). It is also important to specify the duration (exposure time)

and whether the observation time is the beginning, midpoint, or end of the exposure time.

3.4 Redshifts/Velocities and Uncertainties

For many astrophysical applications, the radial velocity of an object is of major importance. These are often presented as a recessional velocity or as a redshift. We highly recommend reading the special description of extragalactic redshifts (`http://ned.ipac.caltech.edu/help/zdef.html`) written by Dr. John Huchra for NED. In recent years there has been much progress made in using non-spectroscopic methods to determine redshifts. Techniques such as photometric methods, matched filter algorithms, Friends-of-Friends methods, etc. (see a list of various redshift methods known to NED) have become increasingly popular. For various astrophysical reasons, there may be the need for an author to present velocities/redshifts in a galacto-centric or LSR reference frame or some other system. Within NED we publish the original measurement, but where possible we also convert all published redshifts to heliocentric values and apply various derived cosmological corrections. Therefore, it is important that the reference frame of the original redshift measurements be provided.

3.4.1 Non-heliocentric velocities

Problem: *For NED's purposes, velocities need to be heliocentric, but they are not always presented as such or indicated as not being heliocentric. NED's conversion from an author's system may not always use the same conversion factors that the author used.*

Best Practice: NED recommends that authors always provide the heliocentric velocity/redshift in addition to any variation needed and to clearly indicate each reference frame used (including the heliocentric one).

3.4.2 Non-spectroscopic redshifts

Problem: *Although the state-of-the-art in photometric redshifts has improved considerably in recent years, there is still debate on their usefulness in all situations. However, basic assumptions in the models used and a strong dependence on the source intrinsic SED convolved with the photometric observations cause some determinations to be wildly different from a spectroscopically determined redshift.*

Best Practice: We recommend that **clear** descriptions of non-spectroscopic redshifts be identified not only in the text, but also in each data table and figure.

3.4.3 Velocity/redshift measurement uncertainties

Problem: *Often authors do not present the measurement uncertainties. Even more rarely is there an indication of the quality of the measurement.*

Best Practice: NED recommends that EACH measured velocity/redshift uncertainty be clearly identified and presented in the same units as the velocity/redshift measurement itself. We understand that some radio redshift uncertainties are given in terms of FWHM or FW at 20% or other forms, and these are also encouraged to be published.

3.4.4 Citing previously published values

Problem: *Velocities/redshifts taken from the literature often do not indicate the origin of those values.*

Best Practice: NED recommends that references be provided from which data are reproduced. For example, if you used NED to locate the redshift for objects in your article, it is important to also cite the original data provider. We suggest phrasing such as: "We adopted a Heliocentric redshift of #.### (Smith et al. 2012, journal, vol., page) as provided in NED." We also recommend that original data in your article be clearly distinguished from data taken from another article (perhaps using a phrase such as "This work").

3.5 Galaxy Classifications

Problem: *Inconsistency in specifying galaxy classifications*

Best Practice: Authors are encouraged to refer to NED's extensive suite of searchable galaxy classifications and attributes which have been standardized to enable unified queries across journal articles and catalogs within NED. (See `http://ned.ipac.caltech.edu/forms/OBJatt.html`.) If new classifications must be created, please define them clearly so they can be easily integrated into NED and easily adopted by other researchers.

3.6 Object/Source Lists

Problem: *Object identifiers in journal articles are typically scattered throughout the text, or sometimes among multiple tables. Using computer algorithms, the former in particular are very difficult to locate reliably, and it is difficult to distinguish casual mentions from key objects that are the main topic of the article. Newly discovered objects that are named for the first time cannot be reliably captured by a computer program, because there is no precedent to search for in the database.*

Best Practice: Provide a list of valid astronomical object IDs, either as an appendix in the article itself or in a separate file to be archived with the article. Use NED's Object List service to validate object names for known (cataloged) objects. Clearly identify sources or regions that are being named/identified for the first time in the astrophysics literature.

4 Literature Citations

4.1 REFCODE/BIBCODE

A document detailing the proper usage of the 19-digit reference code used by NED, SIMBAD, and ADS is given in Schmitz, et al. (1995).

4.2 Citing Original References and NED

Problem: *It is apropos to quote Dr. John Huchra, from his President's Column in the May/June 2009 AAS Newsletter (Huchra 2009):*

> "Authors have a strong tendency to under-attribute, that is not to properly cite both previous ideas and basic data. The phrases data are available or it is known that should never be used; someone had to work fairly hard to get that data or develop that idea and they deserve credit, even if they are your competitors. Also complicated is the use of master compilations, easy, but again not giving credit where credit is really due. Would you really cite NED for Sloan Digitial Sky Survey redshift data? Credit NED as the compilation, but credit the basic sources whenever you can."

Best Practice: Use the suggestions given in Dr. Huchra's message. We suggest phrasing such as: "We adopted a Heliocentric redshift of #.### (Smith et al. 2012, journal, vol., page) as provided in NED." We also recommend that original data in your article be clearly distinguished from data taken from another article (perhaps using a phrase such as "This work").

5 Data Presentation – Formatting, Standards, etc.

5.1 Tabular Data (Usually ASCII Text)

README files created from LaTeXtables by the authors or publication staff are extremely useful and the NED team makes use of these on a regular basis.

Problem: *ReadMe files can be of limited use when uniform column descriptors are not available or not properly used. Different authors often use different strings or codes to label photometric filters (for example), or sometimes the specifics of which passband was used are not defined.*

Whether an H- band magnitude is on the CIT, Johnson or 2MASS system has an impact on the conversion to flux density units to construct a reliable SED.

Best Practice: A good starting point for generating ReadMe files is to review the CDS document "Astronomical Catalogues and Tables Adopted Standards" (Ochsenbein, 2000) which has proven to be quite successful for the needs of VizieR. From the NED perspective, a "Good Table" is a tabular data presentation with the following characteristics (including references to relevant section numbers in Ochsenbein's document):

> A description explaining which are the columns of the tables, how to get the values stored in these columns, and what is their meaning, is introduced by the Byte-by-byte Description of file: section header. This line may specify that data files include header lines which are not part of the data (they are metadata); the existence of header lines can be specified either by a number (i.e., the first n lines of the files are not data), or by a character which introduces a comment (usually a hash #). The existence of header lines is specified in parentheses as *e.g.*, Byte-by-byte Description (12 headlines): or when header lines are introduced by a hash sign:
>
> Byte-by-byte Description (# headlines):
>
> The description is presented as a five-column table with the following elements:
>
> (a) the starting byte (from 1) and ending byte of a column, separated by a dash -; this dash, however, is not required for a single-byte column.
>
> (b) a FITS format which specifies how to interpret numbers or symbols, composed of a letter A, I, F or E indicating to interpret the data as ASCII text, Integer number, Floating-point number with a fixed number of decimals, or a floating-point number written in Exponential notation followed by a number indicating the width of the column in bytes, eventually followed by a dot and a number indicating the number of decimal digits (for F and E notations).
>
> This format could be preceded by an iteration factor to designate an array of values all written with the same format.
>
> (c) the Unit in which the value is expressed; unit standards are

detailed elsewhere. The symbol — indicates unitless values, and the square brackets [unit] indicates values tabulated as decimal logarithmic values.

(d) a label or column header. Standard names and name building rules are detailed in section 3.3.

(e) a short explanation of the contents of the column. This last field may also specify: a set of valid characters for an alphabetical column, or limits for numeric columns see section 3.4. whether the column is ordered: see section 3.4 whether blank (unspecified) numbers are allowed: see section 3.4 a key to more detailed notes: see section 3.4

5.2 FITS Images, Spectra, and Data Cubes

NED provides a repository for authors to contribute FITS images and spectra for observations that have extragalactic sources as their primary targets. All data are preserved in their original, submitted format, which is usually FITS for images, and FITS or ASCII text for spectra. In the case of spectra, the contributed data are also converted to MKS units in a uniform NED-specific format, and also converted into simple VOTable files to enable visualization by the SpecView (STScI) applet or similar tools.

Key metadata are required to visualize the position and orientation of the apertures on imagery, including the aperture dimensions, center coordinates, and position angle, as well as the telescope pointing uncertainty.

Images and spectra in NED can be queried by object name from the query forms and from links in the NED interface. Spectra can also be queried by bibliographic reference, passband, and spectral line. Further information about the image and spectral services in NED is given in Mazzarella et al. (2007).

Problem: *The original data files, in FITS, ASCII, or whatever format was used to generate the figures presented in journal articles, are not part of traditional journal publications. This situation greatly limits the ability to reproduce (validate) and build upon published results. Unique and valuable highly-processed images and spectra are often lost. Scientists wishing to re-use data to make further discoveries, often by compar-*

ing new observations with data at other wavelengths, typically have to contact the authors to request the data. If a year or more has passed since the original article was published, there is a high probability that the data are either no longer available, or the authors are unable to put in the time required to dig it out of their personal archives, remind themselves of the content, etc.

Best Practice: Consider contributing your science-grade images and spectra (those corresponding to the figures in your peer-reviewed journal article) to NED during the publication process. The current method is to simply send an email to ned@ipac.caltech.edu, indicating the relevant publication (REFCODE), a brief description of the available data, a list of the primary extragalactic target names, and URLs where the files can be downloaded for preservation and ingestion into NED. The NED image & spectra curator will then follow up with you if there are problems or questions. At the time of writing, the NED repository contains over 2.7 million images and 494,000 spectra searchable using their primary extragalactic target names (or any cross-identification) and linked to other information in the database.

5.3 Formats and Metadata

Problem: *Incomplete or missing metadata in contributed images and spectra*

Best Practice: NED recommends the inclusion of the following information (metadata), ideally in a table with one record for each contributed image or spectrum.

5.3.1 Images

Images should be provided in standard FITS format, preferably calibrated and highly processed. That is, they should be the files that were used to make the measurements and the figures that appear in the journal article. (Raw or minimally reduced images are rarely acceptable.) In some cases, where FITS files are not available, JPGs may be used to represent the data.

The following pieces of information (metadata) are required to make images searchable and to link them to other information in NED. These metadata are typically obtained from the headers of the images or from the publication, but the process of locating and validating this information is quite labor intensive and prone to error. Integration of images into NED can be greatly expedited, and errors will be minimized, if the author (data provider) submits this information in a table containing one record for each contributed image and the following columns:

- Name of the primary targeted object, as recognized by the NED name resolver
- Coordinates of the imaged object, preferably in decimal degrees, equinox J2000.0
- Bibliographic reference for the associated journal article
- Bandpass, central wavelength or frequency, band width, and units (Example: Visual, B, 4.4e-07, 1.0e07, 4400A, 1000A)
- Pixel size (preferably in arcseconds)
- Spatial resolution as the FWHM (arcseconds) of the seeing or the major axis of the beam for radio/millimeter imagery
- The date and time of the observation (MJD or UTC)
- Exposure time (seconds)
- Telescope
- Instrument
- Dimensions of the FITS file: NAXIS, NAXIS1, NAXIS2 (in pixels)
- The field of view fov1 and fov2 (in arcminutes, or calculated from the data above)
- A flag indicating if the FITS keywords encoding the astrometry are WCS compliant (see `http://fits.gsfc.nasa.gov/fits_wcs.html`)
- Size in Kbytes of the FITS files (uncompressed)
- Indicator of whether the data have been flux calibrated: Yes = 1; No = 0

- Flux density units

5.3.2 Spectra

Spectra should be provided in FITS or as plain text (ASCII), as available. In addition to the two columns containing the spectral axis (channel) values (*e.g.*, in microns) and the flux density values (*e.g.*, in Jy), ideally a third column is included that contains the corresponding flux density uncertainty (1-sigma). As for images, information about the spectra (metadata) is needed in order to make spectra searchable and to properly link them to other information in NED. Such metadata is typically obtained from the headers of the FITS files or from the publication, but the process of locating and validating this information is quite labor intensive and prone to error. Integration of spectra into NED can be greatly expedited, and errors will be minimized, if the author (data provider) submits this information in a table containing one record for each spectrum and the following columns:

- Name of the targeted object, as recognized by the NED name resolver
- Observed region (Example: Nucleus, Integrated/Drift-Scan, Multiple objects. . .)
- Coordinates of the targeted object, units, position angle, and equinox
- Bibliographic reference indicating the associated journal article
- Bandpass: X-ray, UV, Optical, Near-Infrared, Far-Infrared, mm, Radio
- Spectral feature: H I, CO, HCN, etc.
- Starting channel value
- Ending channel value
- Channel resolution
- Channel units: Angstrom, micron, cm, $km\ s^{-1}$, Hz, etc.
- A flag indicating if FITS keywords encoding the astrometry are WCS compliant (see http://fits.gsfc.nasa.gov/fits_wcs.html)
- Flux density units: Jy, $[erg/cm^2/s/A]$, etc.

- Seeing (arcseconds)
- Airmass
- The date and time of the observation (MJD or UTC)
- Exposure time (seconds): start, mid-point, stop
- Telescope
- Instrument
- Disperser: Grism, Prism, Echelle, Fourier-Transform, Blazed-Grating, etc.
- Observation mode: Long-Slit, Slit-Mask, Fiber-Feed, Integral-Field, etc.
- Detector: CCD, Correlator, Scanner, Photographic-Plate, etc.
- NAXIS: 1 (1D), 2 (2D), 3 (3D)
- Number of pixels/channels in each dimension
- Aperture (in arcseconds) diameter or slit width
- Slit-length, for long-slit observations, otherwise N/A (arcsec)
- Size of the extraction region, for 2D spectra, otherwise N/A (arcsec)
- Position angle of aperture/slit (degrees)
- Sensitivity or detection limit, in flux density units
- Data quality flag
- A flag indicating if the spectrum has been baseline-subtracted (Yes or No)
- A flag indicating if the spectrum is flux calibrated, absolute or relative (Yes or No)
- A flag indicating if the spectrum has an absolute flux calibration (Yes or No)
- A flag indicating if the spectrum has been sky-subtracted (Yes or No)

- A flag indicating if the spectrum has been de-redshifted to the rest frame of the source (Yes or No)
- A URL link to the archive service where the data originated (if available)

5.4 Data Set Identifiers (Tags)

Coming in a future update to this document.

6 Data Access in Publications

6.1 Tabular Data Hosted by the Journals, CDS/VizieR or Other Data Centers

Problem: *Data tables (as well as figures, images, spectra, etc.) are of great importance to any scientific journal article, and such data need to be readily available to readers and for data integration services such as NED. Original data tables created by authors should be accessible via permanent links to the data, either at the website maintained by the original journal, in CDS/VizieR, or another data center.*

Best Practice: The VizieR service at CDS and their various mirror sites are well established and uniform repositories for tabular data (catalogs). NED highly recommends data tables be made to conform to VizieR standards and deposited there. Note that NED does not store or serve data in separate catalogs as they are originally published and provided by the electronic journal sites, VizieR, or other archive services. The NED team uses those data files to extract key information for integration into a unique database structure (schema) including derived information such as cross-identifications, standardized units, redshift/velocity corrections, cosmological corrections, etc.

6.2 Personal and Institutional URLs to Data Sets

Problems: *Links (web URLs) in the literature to external data sets often present a number of problems. Many data sets no longer exist even only a short time after an article is published. (For example, the journal article announcing the Subaru Deep Field provides a link to the data as* `http://soaps.naoj.org/sdf/` *but the link is currently broken and we have yet to find where the data currently reside. As another example, a URL which was published in an article about supernovae was given as* `http://oir-www.harvard.edu/cfa/oir/Research/supernova` *It has since been changed to* `http://www.cfa.harvard.edu/oir/sp/supernova.html` *. (The former URL no longer works.) Related practical issues are that some astronomers move frequently, some lose interest or funding to maintain their data sets online after publication of the associated journal article, and/or they cannot take the time to repair failed servers or disk drives. In addition, data published outside of the main e-journal article are often poorly formatted, contain major errors, or have insufficient metadata for understanding their contents. Also, they are rarely refereed to meet the same standards of formatting, column descriptions, etc. that are used for the main tables included in journal articles. Therefore, although the concept of astronomers essentially self-publishing data sets is technologically feasible and has become commonplace (whether 'attached' to journal articles or not), this practice is leading to an incomplete research record. This makes it very difficult (if not impossible) for NED and other informatics services to locate and use the data, and it will result in a chaotic and unstable Virtual Observatory. This underscores the continued importance of dedicated teams of people operating electronic journals, archives, data centers and thematic portals such as NED, curating data and maintaining relationships between the various observations as part of a robust and long-lived astrophysics research environment.*

Best Practice: We **strongly discourage** the publication of personal URLs to data sets for which the author or institution has no means to maintain more than a year or two after the publication of the associated journal article. Instead, we **strongly recommend** including the data as part of the original publication to be archived by the journal

publisher, or otherwise contribute the data to an established archive center with the means to provide long-term curation and preservation.

7 Data Content Keywords

NED automated procedures currently make a best effort to assign keywords based on the presence of specific data content found in a journal article. This helps us categorize and organize the articles in the data integration 'production line' workflow, and it also enables NED users to filter articles based on data availability via NED's Search For References By Object Name service. However, automated procedures miss some data content, and no one knows the types of data contained in journal articles as well as the authors.

Problem: *Traditional keywords used in journal articles do not capture information about the types of data presented in the article, for example whether the article presents new position measurements (astrometry), photometric data, spectroscopic data, etc. This greatly limits the possibility of filtering literature searches based on the availability of these specific types of data. This situation also increases the amount of work required by the NED team to analyze the content of each article to determine what types of information are embedded in the article and data tables that need to be integrated into the database.*

Best Practice: Include a list of relevant Data Content Keywords at the end of your journal article, particularly any of those listed below. If there are other categories of data that you feel should be added to this list, please contact the NED team at ned@ipac.caltech.edu.

We have been holding ongoing discussions with the AAS Journals office and the ADS to expand and standardize a data content keyword list. Also, in June 2012 we submitted a request to the AAS Publication Board recommending that the Editors of the AAS Journals include a brief questionnaire for authors during the publication acceptance process and (ideally with an automated procedure) and please send the responses to NED (ned@ipac.caltech.edu) once the article is published and issued a REFCODE/BIBCODE that NED/ADS will use to identify and to build links to the ar-

ticle. *At the time of writing, an agreement to insert a questionnaire into the workflow of the AAS journal submission process has not yet been reached.* Until this is achieved, we recommend and request that authors simply copy and fill in the following brief questionnaire from this document (or the companion Checklist) and email it to NED.

```
To: ned@ipac.caltech.edu
Subject: Data content keywords for journal article <insert reference code>
Message body:

Dear NED:

My new journal article <insert reference code here>
contains data and results that should be incorporated
into the NASA-IPAC Extragalactic Database (NED).
The article contains original information in the
following categories for extragalactic objects
(with checkmarks on all entries that apply):

( ) Attributes or Classifications
( ) Diameters
( ) Distances (excluding Hubble flow distances)
( ) Galaxy Sub-Components (HII regions, SNe, PNe, star clusters, etc.)
( ) Images
( ) Kinematics
( ) Notes (detailed source descriptions)
( ) Photometry
( ) Positions
( ) Redshifts
( ) Spectra
( ) Other? Please specify:


Thank you.
```

8 Summary

Data from the current astrophysics literature and new sky survey catalogs are being incorporated into NED on an ongoing basis. This involves substantial challenges due to non-uniformity or incompleteness with the way data are often published. We have reviewed various obstacles to keeping NED as current and accurate as possible, using as many automation procedures as is practical, and we have recommended corresponding Best Practices for the publication of data associated with journal articles in the peer-reviewed literature. Following the Best Practices outlined in this document during the preparation, review, and revision stages before final publication will improve the quality of the published research record and expedite the integration of data from the literature into NED with as little lag time and with as few errors as possible. A small amount of extra work on the part of authors, referees, and editors to follow these guidelines during the publication process will enable more rapid and error-free integration of information into NED, resulting in long-term preservation of unique, highly-processed data, enhanced discovery capabilities through linkage with other information in NED, and increasing reuse of valuable data. This in turn will enable more scientific discoveries than would otherwise be possible or practical, and increase citations for authors.

This is a working document, part of the NED documentation and help pages, and the NED Team will evolve these Best Practices and its companion Checklist with feedback from authors, the AAS journal editors and Publication Board, the NED Users Committee, and any interested NED users. We welcome and encourage inputs from all authors and data providers who are attempting to put these guidelines into practice. Please contact us at ned@ipac.caltech.edu with any related comments or questions.

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Checklist of NED Recommendations for Publishing Data

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Revision Date: September 25, 2013
Author: Marion Schmitz, Joseph Mazzarella, Barry Madore, Patrick Ogle, Rick Ebert, Kay Baker, Ben Chan, Tracy Chen, Dario Fadda, Cren Frayer, Jeff Jacobson, Cheryl LaGue, Tak Lo, Olga Pevunova, Ian Steer, Scott Terek

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The current version of this document may be accessed at http://ned.ipac.caltech.edu/docs/BPDP/NED_BPDP.pdf

This Checklist is a digest version of detailed information given in the *Best Practices for Data Publication to Facilitate Integration into NED: A Reference Guide for Authors.* It is intended to be a short, practical reference for authors, referees, and science editors to consult in order to avoid various pitfalls that often impede the interpretation of data and metadata by readers, and therefore also complicate and delay integration of the (meta)data into NED and other astronomical information systems. For convenience, links with the name "BP" followed by the relevant section number are provided for each item to assist the reader in locating further examples, explanations and rationale in the main body of the *Best Practices* document.

1. Nomenclature for Astronomical Sources (Objects) (BP §3.1)
   (a) **Provide a unique, unambiguous name for each object.** (BP §3.1.1)
      i. *e.g.*, `NGC 4321` **NOT** `N4321`
      ii. *e.g.*, `VIPS 1001` **NOT JUST** `1001`
   (b) Use established nomenclature when available.

i. Check NED and SIMBAD for existing names and formats.

ii. Check the IAU Dictionary of Nomenclature of Celestial Objects via `http://cds.u-strasbg.fr/cgi-bin/Dic-Simbad`

iii. Use `http://cdsweb.u-strasbg.fr/cgi-bin/Sesame` for name resolution.

(c) If new designations are required, follow guidelines of IAU Commission 5 Working Group on Designations found in "How to refer to a source or designate a new one" `http://cdsweb.u-strasbg.fr/how.html` (BP §3.1.3)

(d) Insert spaces between a catalog name and the sequence number of an object. Although a single, contiguous name is useful in an electronic file, users and Name Resolver software can more readily recognize object names that contain spaces in them.

i. *e.g.*, B3 2327+391 **NOT** B32327+391

(e) **DO NOT shorten object names!** A name which has the coordinate portion truncated will likely be ambiguous (confused with a nearby object) and require much effort to identify. If a "nickname" is to be used in an article, give its full name first using something like "hereafter referred to as . . . ". (BP §3.1.2)

i. *e.g.*, `2MASS J12073346-3932539` **(hereafter referred to as 2M1207) NOT** merely `2M1207`

(f) Check object lists to avoid using the same name for different sources. (BP §3.1.4)

2. Coordinates and Uncertainties (BP §3.2)

(a) Use standard coordinate systems

i. *e.g.*, Equatorial J2000 or B1950 or Galactic

ii. Supergalactic and ecliptic coordinates when appropriate

(b) Use decimal degrees or sexagesimal formats – avoid decimal hours or decimal radians.

i. Check that "negative zero" declinations have the minus sign.

A. A blank in the sign location implies "+"

ii. Check that "60." does not appear in minutes or seconds.

A. *e.g.*, `01h34m60s` needs to be `01h35m00s`

(c) Measurement uncertainties need to always be provided in the same units as the measurement. (BP §3.2.4)

i. When the uncertainty in RA must be specified separately from the DEC, use *e.g.*, 01h23m34.5s ± 0.2s **NOT** 01h23m34.5s ± 2″

(d) List the **absolute uncertainties** in the astrometry – not merely the relative uncertainties. (BP §3.2.3)

(e) Absolute coordinates are always preferred over offsets. If coordinate offsets are given, the absolute position and uncertainty of the reference coordinate must also be provided, including the angle of rotation and the sense of the offset (*e.g.*, [reference point – source] or [source – reference point]). (BP §3.2.2)

(f) The Equinox used needs to be indicated

i. *e.g.*, B1950 or J2000

3. Redshifts/Velocities (BP §3.4)

(a) Heliocentric velocities are preferred. If other variations are appropriate, give them in addition to the heliocentric values and clearly indicate how they were computed. (BP §3.4.1)

i. *e.g.*, v_{LSR} AND v_{helio}

(b) Measurement uncertainties should always be given, and provided in the same units as the measurement itself. (BP §3.4.3)

i. *e.g.*, use 15.2 ± 0.5 km/sec **NOT** 15.2 $km/sec \pm 500$ m/sec

(c) Indicate the quality of the spectrum, not just measurement uncertainty.

i. *e.g.*, Indicate poor seeing or blended objects in a spectrum

(d) Clearly indicate when redshifts are not spectroscopic: Photometric, Estimated, Presumed by Proximity, etc. Include uncertainty estimates. (BP §3.4.2)

4. Significant Figures

   (a) For any use of information involving numerical digits, only present the number of significant figures which are appropriate.

      i. V mag of 16.2 **NOT** 16.213543

   (b) Nomenclature should not imply higher positional accuracy than the data actually provide.

      i. *e.g.*, `SDSS J092712.64+294344.0`
      NOT `SDSS J092712.644+294344.02`

      ii. Coordinates for clusters of galaxies should not be given to milli-arcseconds.

5. Photometry (BP §3.3)

   (a) Units must be provided clearly, in standard units as appropriate.

      i. *e.g.*, Jy, mag, or $Wm^{-2}Hz^{-1}$

   (b) Passbands need to be specified unambiguously. (BP §3.3.1)

      i. *e.g.*, "Cousins i" or "Gunn I" **NOT** merely "i"

   (c) Measurement uncertainties on photometry should be given and in the same units as the measurements.

      i. *e.g.*, $15.2 \pm 0.3mJy$ **NOT** $15.2 \pm 300\mu Jy$

   (d) The magnitude system should be indicated

      i. *e.g.*, AB or Vega

   (e) Aperture sizes should be reported clearly, when appropriate.

   (f) The precise date and time of the observations should also be provided when possible, preferably as Modified Julian Date (MJD), otherwise Coordinated Universal Time (UTC). It is also important to specify the duration (exposure time) and whether the quoted

observation time marks the beginning, midpoint, or end of the exposure. (BP §3.3.2)

6. Galaxy Classifications (BP §3.5)
   (a) For basic morphological types, use the well established schemes (*e.g.*, `http://en.wikipedia.org/wiki/Galaxy_morphological_classification`)
   (b) Refer to NEDs extensive suite of searchable galaxy classifications and attributes which have been standardized to enable unified queries across journal articles and catalogs (within NED). See `http://ned.ipac.caltech.edu/forms/OBJatt.html`
   (c) If new classifications must be created, please define them clearly.
7. Citing Original References (BP §4.1)
   (a) Always credit the origin of data when they are not original (new). (BP §4.2)
   (b) Verify the accuracy of each citation with ADS.
   (c) If services such as ADS, NED, and SIMBAD are used, cite them accordingly, as well as the original reference for the data.
8. Tabular Data (BP §5.1)
   (a) Simple text (ASCII) data files are preferred.
   (b) Always include a ReadMe file which defines the columns and the units.
   (c) See `http://www.ivoa.net/documents/VOTable` for the VOTable standards.
9. FITS Images, Spectra (BP §5.2)
   (a) FITS formatted files need to have **clearly** labeled headers.
   (b) Images should have astrometry encoded in standard WCS keywords.
   (c) Clearly indicate observing conditions and quality of the data.

(d) Include the metadata itemized in the Best Practices Reference Guide. (BP §5.3)

(e) Send information to ned@ipac.caltech.edu with metadata and download information for images and spectra that you would like to make available to researchers via NED.

10. Data Set Identifiers (BP §5.4)

    (a) When using specific data sets which have established Data Set Identifiers, provide the full identifiers in your article.

11. Journal Sites, CDS/VizieR and Other Data Repositories (BP §6)

    (a) Deposit copies of tabular data files and ReadMe files with the journal website or with CDS when practical (see http://vizier.u-strasbg.fr/vizier/index.htx#desc). (BP §6.1)

    (b) If updates or corrections are needed for files already published, inform the journal or data center of changes and provide updated data files.

    (c) Smaller data files may be included as part of the journal article and retained by the publisher. These also need ReadMe files.

    (d) If updates or corrections are generated for files already published, an appropriate document needs to accompany the new data files.

12. Personal and Institutional URLs to Data Sets (BP §6.2)

    (a) Personal URLs are NOT recommended.

    (b) CDS or journal publishers should be used to ensure longevity of data files.

13. Send data content keywords relevant to your article to ned@ipac.caltech.edu (BP §7)

    (a) A brief email indicating the types of data contained in your article (Classifications, Diameters, Distances, Sub-components, Images, Kinematics, Notes, Photometry, Positions, Redshifts, Spectra, Other) will be helpful to the NED team to establish the types of information that should be integrated into the database.