

# Planned Updates to the STAR BUFR and GRIB Tailoring System for Satellite Operational Products



Walter Wolf<sup>1</sup>, Qiang Zhao<sup>2</sup>, and Thomas King<sup>2</sup>

<sup>1</sup>NOAA/NESDIS/STAR, College Park, MD 20749

<sup>2</sup>MSG at NOAA Center for Satellite Applications and Research, College Park, MD 20749

## Abstract

A tailoring software system that converts satellite operational products into Binary Universal Form for the Representation of meteorological data (BUFR) and GRIB2 formatted files has been developed at NOAA/NESDIS's Center for Satellite Applications and Research (STAR). This Reformatting Toolkit converts the products from the National Polar-orbiting Partnership (NPP)/Joint Polar Satellite System (JPSS), the Global Change Observation Mission 1st - Water (GCOM-W1) Advanced Microwave Scanning Radiometer 2 (AMSR2), the Japanese next generation Himawari-8/9 Advanced Himawari Imager (AHI), and the Geostationary Operational Environmental Satellite data into BUFR and GRIB2 files. The toolkit is running in the NOAA Data Exploitation (NDE) system within NOAA's Environmental Satellite Processing Center (ESPC) operationally run by the Office of Satellite and Product Operations (OSPO). OSPO is distributing these tailored products to the NOAA Environmental Modeling Center (EMC) and the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) in real-time. With the upcoming launch of JPSS-1, the toolkit has already been updated for the generation of the JPSS-1 Cross-track Infrared Sounder (CrIS) radiances and Advanced Technology Microwave Sounder (ATMS) antenna temperatures. Additional planned updates to the toolkit include the VIIRS Aerosol Detection BUFR, Ozone Mapping Profiler Suite (OMPS) Limb Profile BUFR, GOES-16 clear and all sky radiances in BUFR, and the VIIRS Land Surface Temperature in GRIB2 format. The planned BUFR and GRIB2 file contents for each instrument are provided and discussed.

## Development History of BUFR and GRIB Reformatting Toolkit at NOAA/NESDIS

- July 08: IPT Branch Lead was informed to begin product development.
- July 08: Worked with NDE to verify product requirements.
- Aug 08: Started to design the operational BUFR and GRIB Tailoring toolkit.
- Apr 09: Preliminary Design Review.
- Sep 09: Critical Design Review.
- Oct 11: SST, AOT and OMPS Nadir Profile BUFR tables were approved as pre-operational.
- May 12: Delivered the BUFR/GRIB2 Toolkit phase 1 products (NPP CrIS, ATMS, VIIRS M-Band and I-Band radiances) to NDE operation system.
- Feb 13: Delivered the BUFR/GRIB2 Toolkit phase 2 products (VIIRS AOT, IDPS SST, OMPS NP and TC) to NDE for operation.
- Sep 13: Delivered the BUFR/GRIB2 Toolkit phase 3 products (VIIRS Polar WINFS, Global and Regional GVF, ACSPO SST) to NDE operational system.
- Nov 13: Delivered the GRIB2 formatting program for Interactive Multisensor Snow and Ice Mapping System (IMS) Snow and Ice products.
- Jan 14: Delivered the GCOM-W1 AMSR2 Microwave Brightness Temperature BUFR converting program to OSPO operational system.
- Mar 14: Distributed sample BUFR files for new GOES Atmospheric Motion Vectors (AMV) algorithm products.
- Aug 14: Delivered the AMSR2 SST BUFR converting program to OSPO operational system.
- May 15: Distributed the JMA AHI radiance BUFR program as pre-operational.
- Jul 15: Began pre-operational distribution of CrIS Full spectral resolution BUFR to support validation and user readiness.
- Jan 16: Finalized the GPM BUFR capability and delivered it to NDE for operational implementation.
- Mar 16: Integrated the AMSR2 ICE GRIB2 program into the Toolkit and delivered it to NDE.
- Mar 17: Delivered the GOES-R ABI Derived Motion Winds (DMW) BUFR converting program with the new BUFR table.
- Apr 17: Delivered OMPS Version 8 ozone nadir profile BUFR converting program to NDE for operation.
- Apr 17: Delivered OMPS Version 8 total column ozone BUFR converting program to NDE for operation.
- Apr 17: Delivered BUFR converting program for CrIS high resolution full set (2211 channels) and subset (431 channels) radiance products.
- Apr 17: Delivered BUFR converting program for VIIRS ASCPO SST to NDE for operation.
- Aug 17: Updated, delivered, and verified the capability to generate CrIS and ATMS BUFR from J1 proxy data during the NDE 8-day end-to-end testing.
- Dec 17: Provide GOES-R Clear and All Sky radiance BUFR sample files to the user community.

## Planned Development for the BUFR/GRIB2 Reformatting Toolkit at NOAA/NESDIS

- BUFR converting capability for VIIRS Aerosol Detection Product (ADP)
- BUFR converting capability for OMPS Limb Profile (LP)
- BUFR converting capability for GOES-16 Clear Sky Radiance (CSR)
- BUFR converting capability for GOES-16 All Sky Radiance (ASR)
- GRIB2 converting capability for VIIRS Land Surface Temperature (LST)

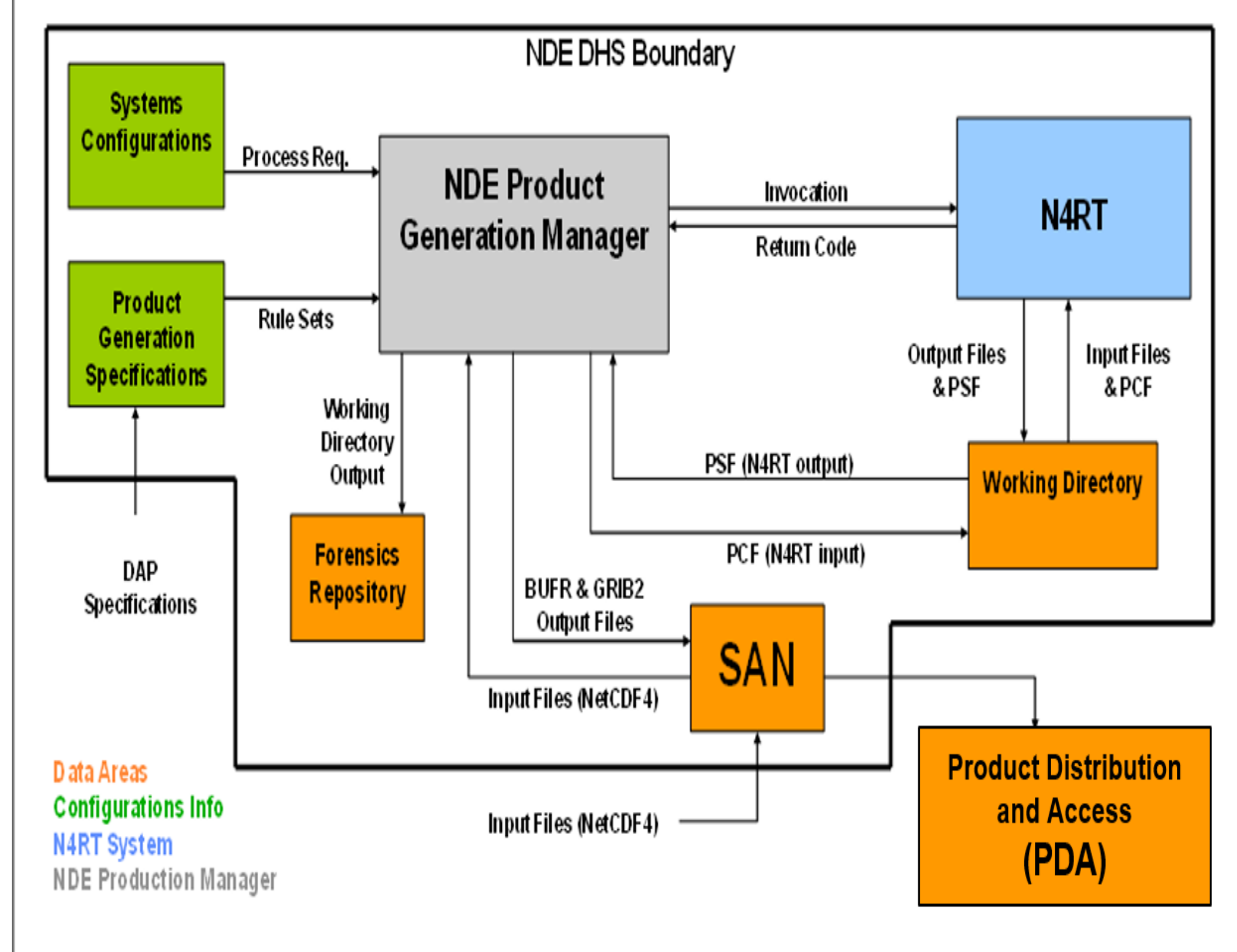
## System Information

- BUFR and GRIB Tailoring System development is conducted on the NESDIS/STAR Linux machine. It is Intel(R) Xeon(R) CPU X5460 with Red Hat Enterprise Linux 5.9 . GNU compiler (gfortran and gcc) and Intel compiler (ifort, icc) are on it.
- All data handling and algorithms are written in C++ and Fortran 90.
- NCEP BUFRLIB 10.2.3, NCEP GRIB2 library 1.4.0, NetCDF4.1.3 and HDF5 1.8.9, the latest versions, are used in this system.

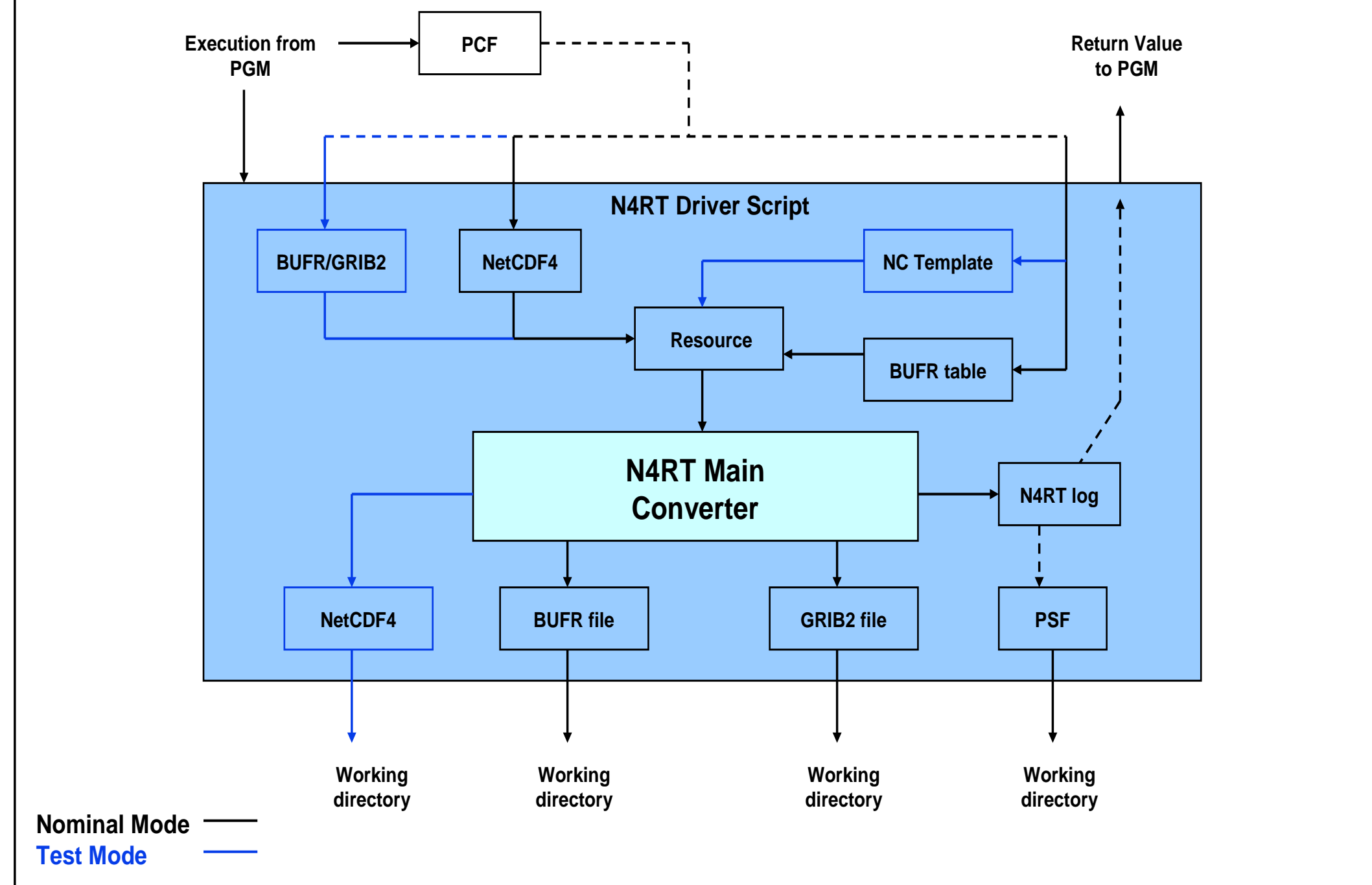
## System Design

- External interfaces:**
  - NDE is the location for all NESDIS-unique data production within OSPO.
  - NDE DHS will schedule, manage, and monitor all processing operationally.
  - NDE handles all product distribution and access for input CrIS, ATMS, VIIRS radiance, SST, AOT, Polar Winds and Nadir Profile Ozone BUFR data.
  - The NetCDF4 Reformatting Toolkit code will run as a stand-alone unit within the NDE DHS.
- Composed of 4 Components:**
  - NC2BF: Converts NetCDF4 file (input) to BUFR file (output).
  - NC2GB: Converts NetCDF4 file (input) to GRIB2 file (output).
  - BF2NC: Converts BUFR file (input) to NetCDF4 file (output).
  - GB2NC: Converts GRIB2 file (input) to NetCDF4 file (output).

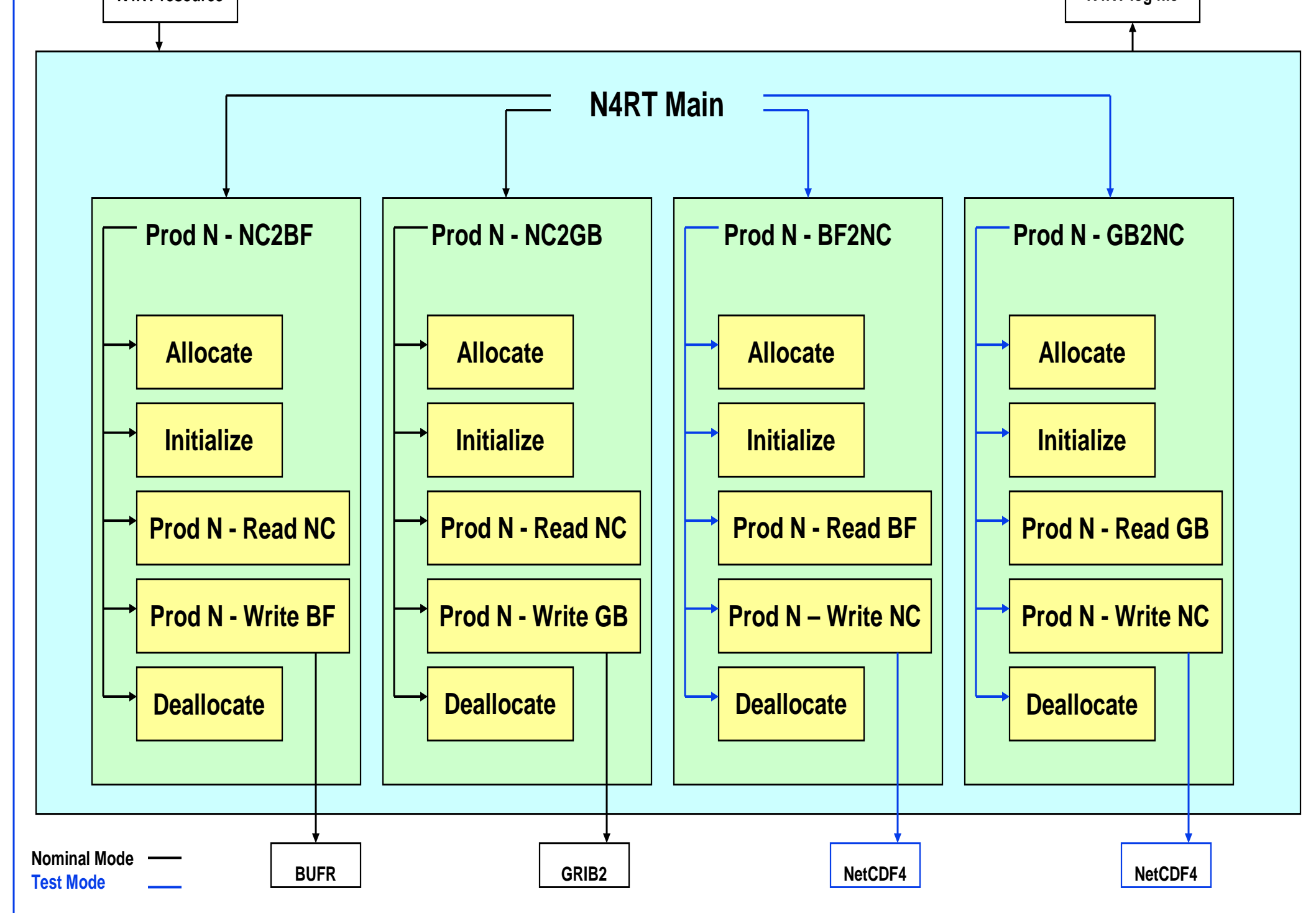
## Reformatting Toolkit External Interfaces



## NetCDF4 Reformatting Toolkit System Level Data Flow



## NetCDF4 Reformatting Toolkit UNIT Level Data Flow



## Main Entries in VIIRS ADP BUFR Table

Satellite ID	Hour	Smoke flag
ID of originating center	Minute	NUC flag
ID of originating sub-center	Second	Cloud flag
Satellite instrument	Orbit number	Snow ice flag
Satellite classification	Latitude	Scaled absorbing aerosol index
Year	Longitude	Smoke concentration
Month	Vocanic ash flag	Quality flag
Day	Dust flag	Product quality information flags

## Main Entries in OMPS LP BUFR Table

Satellite ID	Second	UV ozone profile
Satellite instrument	Latitude	UV ozone profile precision
Year	Longitude	UV ozone profile quality flag
Month	Solar zenith angle	Visible ozone profile
Day	Atmospheric density	Visible ozone profile precision
Hour	Temperature	Visible ozone profile quality flag
Minute	Pressure	

## Main Entries in GOES-16 CSR BUFR Table

Satellite ID	Longitude (high accuracy)	Satellite instrument
ID of originating centre	Number of pixels per row	Integrated mean humidity computational method
Satellite classification	Number of pixels per column	Pressure
Segment size at nadir in x-direction	Land/sea qualifier	Relative humidity
Segment size at nadir in y-direction	Satellite zenith angle	Radiance type
Year	Solar zenith angle	Radiance computational method
Month	Height	Spectral radiance
Day	Satellite channel centre frequency	Radiance
Hour	Satellite channel band width	Brightness temperature
Minute	Cloud amount in segment	Per cent confidence
Second	Amount segment cloud free	Method of derivation of percentage confidence
Latitude (high accuracy)	Cloud type	First-order statistics

## Main Entries in GOES-16 ASR BUFR Table

Satellite ID	Second	Cloud amount in segment
ID of originating centre	Latitude (high accuracy)	Satellite instrument
Satellite classification	Longitude (high accuracy)	Radiance computational method
Segment size at nadir in x-direction	Number of pixels per row	Satellite channel centre frequency
Segment size at nadir in y-direction	Number of pixels per column	Satellite channel band width
Year	Satellite zenith angle	Brightness temperature
Month	Solar zenith angle	Meteorological feature
Day	Height	Per cent confidence
Hour	Amount segment cloud free	First-order statistics
Minute	Land/sea qualifier	

## Variables in VIIRS LST GRIB2 file

Latitudes of first/last grid point	Latitude direction increment
Longitude of first/last grid point	Longitude direction increment
Number of points along a parallel	Number of points along a meridian
Map projection	Land surface temperature

## Product Quality Assurance

- All code development platforms are nearly identical to the production target platforms.
- Only the official releases of the NCEP BUFRLIB, GRIB2, HDF5 and NetCDF4 libraries will be used in the software..
- The generated BUFR and GRIB2 files will be decoded and compared with the source input files before distributing.
- All the BUFR files will maintain consistency with the heritage products.
- The contents of the original HDF5/NetCDF4 will be kept as exact as possible; the negative radiances will be stored in BUFR files.
- The BUFR and GRIB2 products, tables, and additional resources will be released early to allow for WMO approval and customer validation of products.