GUVI Science Algorithms

Detailed Design

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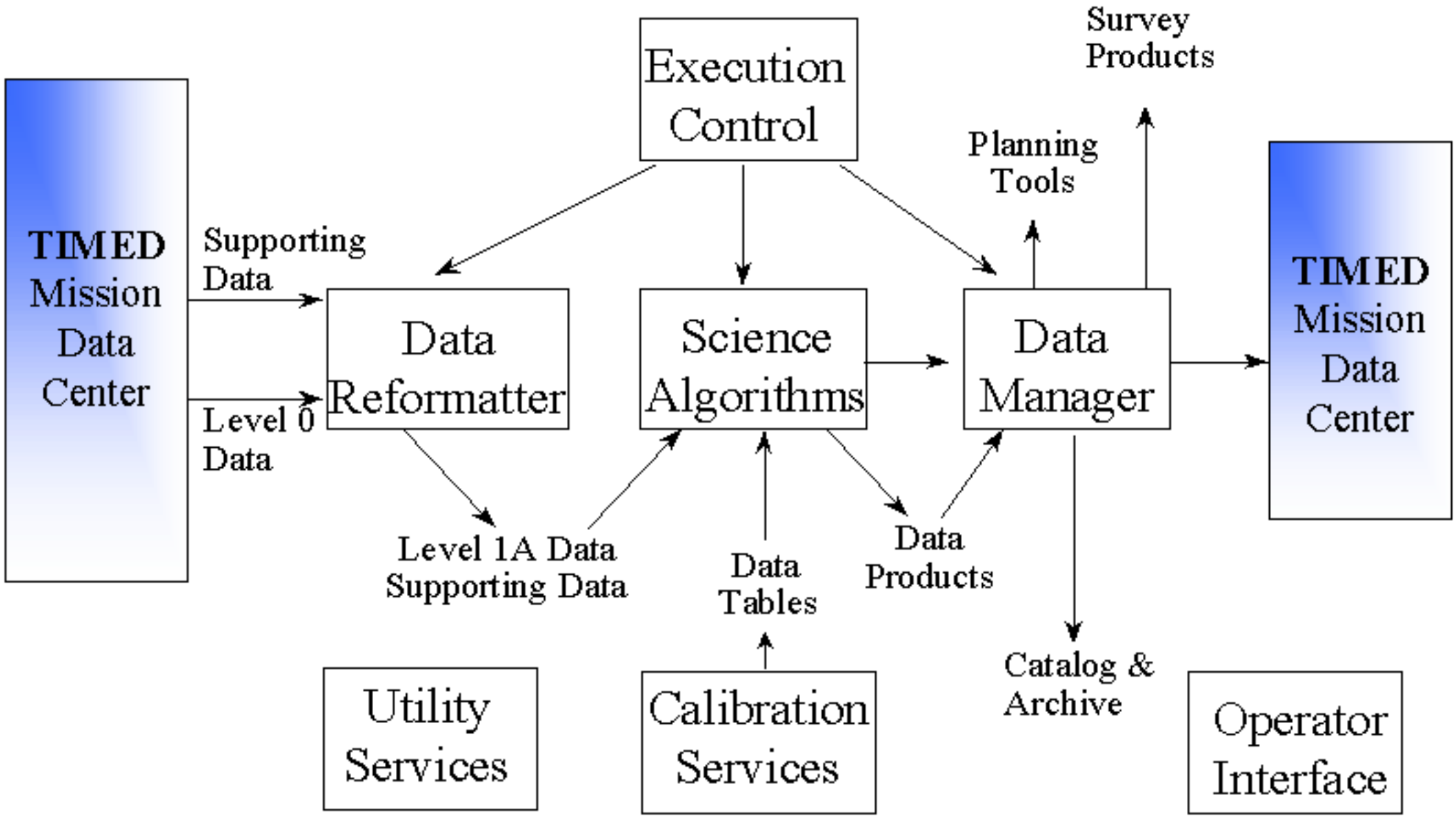
Algorithms Top-Level Design



Science Algorithms CSC

- Main package for Science Algorithms CSC
- Implemented as a task type
- Executed by Scheduler
- Directs the processing of up to one orbit of Level 1A data into Level 1C and Level 2B data products

Science Algorithms (cont.)

- Execution Flow:
  - Utilities CSU initializations
  - Data Table CSU initializations
  - Level 1B Grid and Pixel CSU initializations
  - Level 1C Grid and Pixel CSU initializations
  - Level 2 Grid and Pixel CSU initializations
  - Finalizations

GUVI Types CSU

- **Encapsulates common types used by all CSUs**
  - Base types (Float, Integer, Natural, Positive,...)
  - Unit types (length, time, Rayleighs,...)
  - Geolocation types (altitude, latitude, longitude,…)
  - Count types
  - others...

GUVI Exceptions CSU

- Encapsulates common exceptions used by all CSUs
- Exceptions:
  - Initialization_Failed
  - Finalization_Failed
  - State_Error

Iterator Exceptions CSU

- Encapsulates common exceptions used by CSUs containing an iterator sub-package.
- Exceptions:
  - Iterator_Error

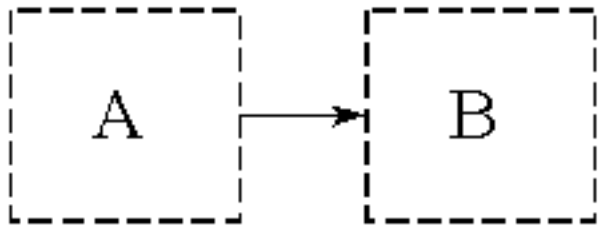
Title: Graphics produced by IDL
Creator: IDL Version 3.5.0 (IRIX mipseb)
CreationDate: Thu Oct 27 07:58:56 1994

Title: Graphics produced by IDL
Creator: IDL Version 3.6.1c (IRIX mipsel
CreationDate: Thu Apr 10 12:00:00 1997

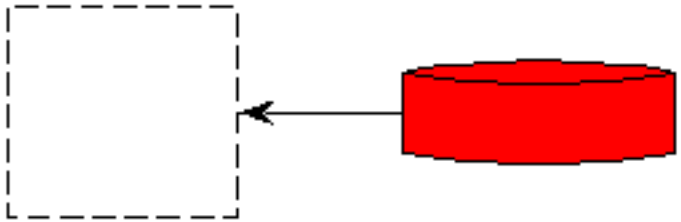
Level 1B Data CSC

- Computes Level 1B radiances from compressed counts using Decompression Data Table and Calibration Data Table.
- Computes Level 1B spectrograph data from compressed counts using Decompression Data Table.
- Provides services to get Level 1A ephemeris information.
- Provides services to get Level 1B radiance data.
- Provides services to get Level 1B spectrograph data.

Diagram Symbolism

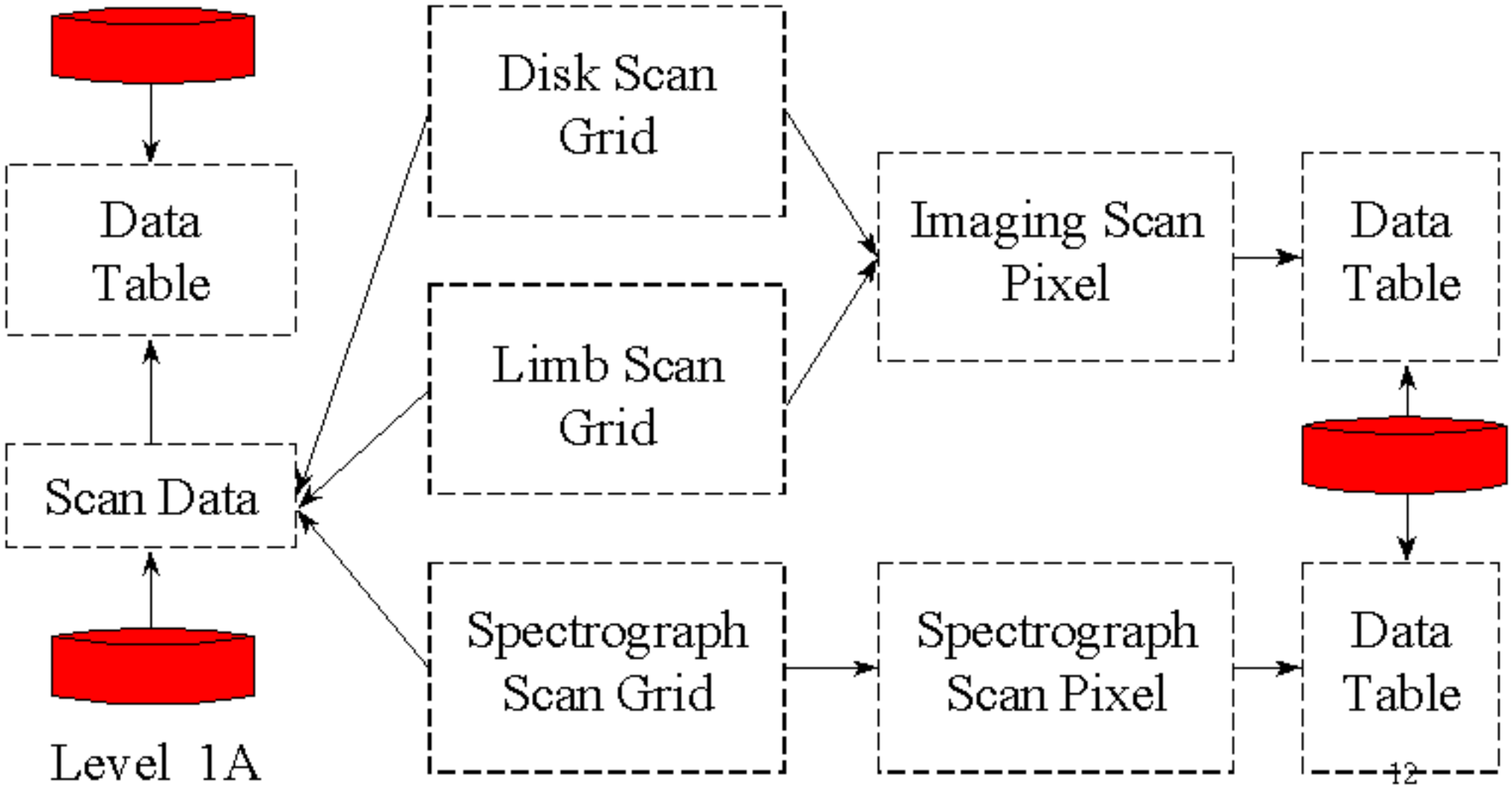


- Read as “A uses the services of B”



- Arrow indicates direction of data flow

Level 1B Data CSC (cont.)
Control Flow



Level 1B Types CSU

- Encapsulates common types used by Level 1B Data CSUs
  - Grid specification
  - Region Types
  - others…

Level 1B Exceptions CSU

- Encapsulates common exceptions used by Level 1B Data CSUs
- Exceptions:
  - Initialization_Failed_No_Data
  - Derivation Failed
  - Invalid_Data_Product
  - Invalid_Pixel

Level 1B Grid CSUs

- Model scanning characteristics of each mode of operation, i.e. Imaging Disk, Imaging Limb, and Spectrograph
- Provide for the calibration and orbit referencing of sensor data in an environment which models the actual recording of the sensor data

Level 1B Grid CSUs (cont.)

- Classes :

  (using Grid Class Manager)
  - Level 1B_Disk_Grid
  - Level 1B_Limb_Grid
  - Level_1B_Spectrograph_Grid
- Operations:
  - Initialize
  - Finalize
  - Get_Pixel

  Sub-Package: Iterator
    - Initialize
    - Advance
    - At_End
- Exceptions:
  - *Initialization_Failed*
  - *Finalization_Failed*
  - *State_Error*
  - *Initialization_Failed_No_Data*
  - *Iterator_Error*
  - Internal_Failure

Level 1B Pixel CSUs

- Model individual data elements of GUVI instrument scans for Imaging and Spectrograph modes
- Provide capability for calibrating and orbit referencing a scan pixel
- Level 1B Grid CSUs are built upon Level 1B Pixel CSUs

Level 1B Pixel CSUs (cont.)

- Classes:
  - Level_1B_Imaging_Pixel
  - Level_1B_Spectrograph_Pixel
- Operations:
  - Initialize
  - Finalize
  - Get_Along_Track_Angle
  - Get_Across_Track_Nadir_Angle
  - Get (Pixel)
- Exceptions:
  - *Initialization_Failed*
  - *Finalization_Failed*
  - *State_Error*
  - *Invalid_Data_Product*

Scan Data CSU

- Serves as interface to Level 1A data via pointer provided by Scheduler CSU
- Performs data quality checks:
  - Packet sequencing
  - Validate slit width
  - Validate mode
  - Validate mirror angle
- Provides access to:
  - Decompressed counts
  - Instrument mode, slit width, and mirror angle
  - Background counts
  - Dark counts

Scan Data CSU (cont.)

- Operations:
  - Initialize
  - Finalize
  - Get_Next (Disk,Limb,Spectrograph)
  - Get_Mode
  - Get_Slit_Width
  - Get_Mirror_Angle
  - Is_There_Imaging_Data
  - Is_There_Spectrograph_Data
  - At_End_of_Disk_Data
  - At_End_of_Limb_Data
  - At_End_of_Spectrograph_Data
- Exceptions:
  - *Initialization_Failed*
  - *Finalization_Failed*
  - *State_Error*
  - Internal_Error

Ephemeris List CSU

- Provides access to ephemeris data from Level 1A pointer provided by Scheduler CSU
- Derives required information not included in Level 1A pointer
- Performs data quality checks:
  - Time sequence
- Interpolates ephemeris at specific times

Ephemeris List CSU (cont.)

- Operations:
  - **Initialize**
  - **Finalize**
  - **Get_Geodetic_Latitude**
  - **Get_Longitude**
  - **Get_Altitude**
  - **Get_Greenwich_Hour_Angle**
  - **Get_Psi**
  - **Get_Inclination**
  - **Get_Right_Ascension**
  - **Get_Solar_Latitude**
  - **Get_Solar_Longitude**
  - **Get_Solar_Distance**

  Subpackage: Contents
  - Get (time information)

- Exceptions:
  - *Initialization_Failed*
  - *Finalization_Failed*
  - *State_Error*
  - **Internal_Failure**

Orbit Reference CSU

- Provides service to map Level 1B pixel to Level 1C pixel
- Used by Level 1B Pixel CSUs

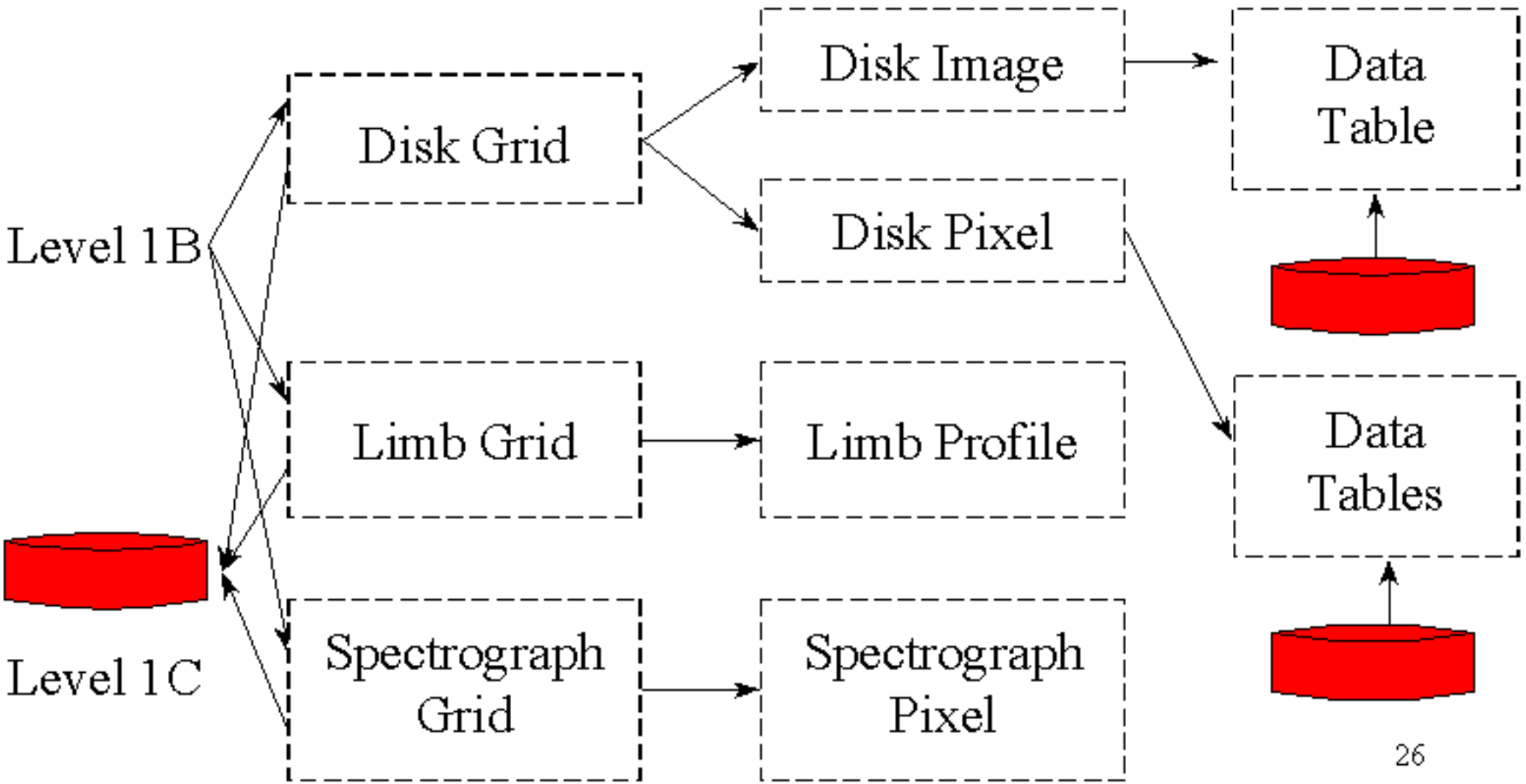
Orbit Reference CSU (cont.)

- Operations:
  - **Calculate**
- Exceptions:
  - *Derivation_Failed*
  - **Invalid_Argument**

Level 1C Data CSC

- Computes Level 1C radiance data by binning Level 1B radiance data
- Computes Level 1C spectral radiances by binning Level 1B spectrograph data
- Provides services to access Level 1C geolocation information
- Provides services to access Level 1C radiance data.
- Provides services to access Level 1C spectrograph data

Level 1C Data CSC (cont.)
Control Flow



Level 1C Types CSU

- Encapsulates common types used by Level 1C Data CSUs
  - Grid specification
  - Region Types
  - Data Product Types
  - others…

Level 1C Exceptions CSU

- Encapsulates common exceptions used by Level 1C Data CSUs
- Exceptions:
  - Derivation_Failed
  - Invalid_Region
  - Invalid_Data_Product

Level 1C Grid CSUs

- Model Level 1C grids for each mode of operation, i.e. Imaging Disk , Imaging Limb, and Spectrograph
- Orthogonal grids of calibrated sensor data for a full orbit
- Provide services to access Level 1C GUVI data products
- Provide capability to:
  - Load Level 1B data into Level 1C pixels
  - Subtract geocoronal and dayglow backgrounds
  - Locate aurora boundaries (e^- + H^+/H and H^+/H)
  - Locate unknown data regions
  - Correct geolocation for night pixels to 350 km reference altitude

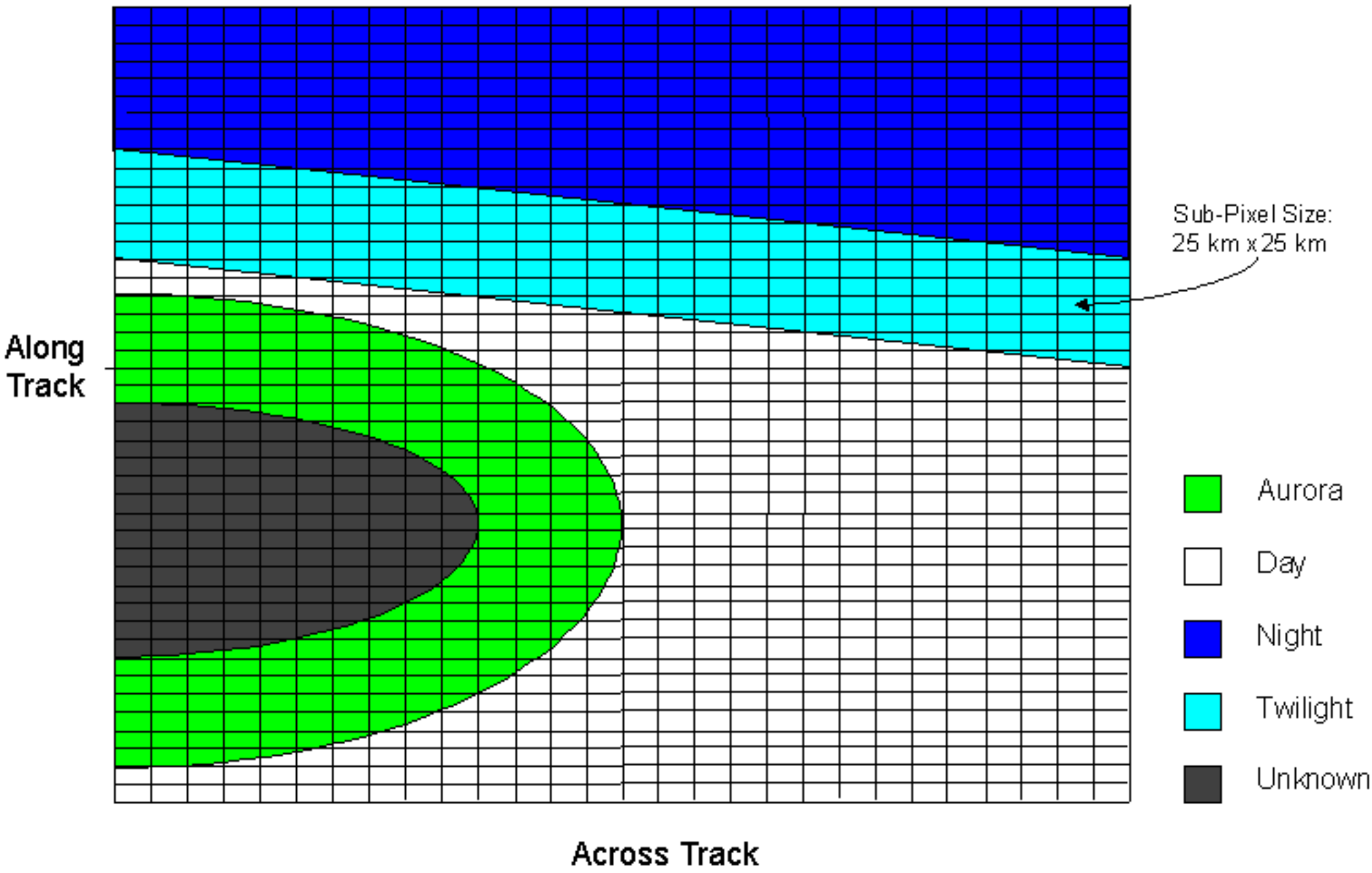
Level 1C Grid CSUs (cont.)

- Classes:

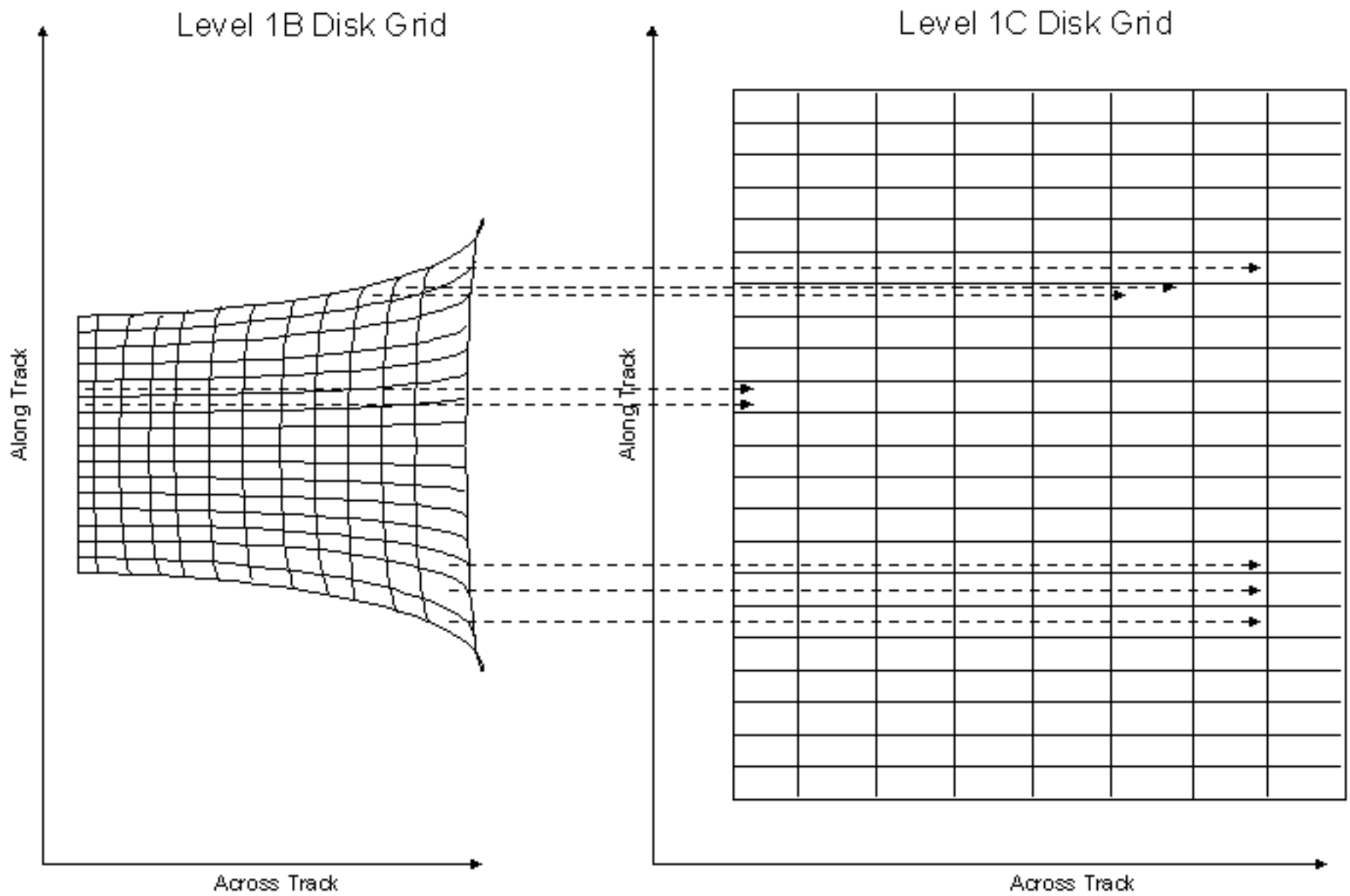
  (using Grid Class Manager)
  - Level 1C_Disk_Grid
  - Level_1C_Limb_Grid
  - Level_1C_Spectrograph_Grid
- Operations:
  - Initialize
  - Finalize
  - Get_Pixel
  - Get_Auroral_Boundary
  - Get_Along_Track_Pixel_ Center_Grid
  - Get_Across_Track_Pixel_ Center_Grid
- Operations (cont.):
  - Is_There_Day
  - Is_There_Night
  - Is_There_Aurora

  Sub-Package: Iterator
    - Initialize
    - Advance
    - Place
    - At_End
    - Get_Along_Track_Index
    - Get_Across_Track_Index
- Exceptions:
  - *Initialization_Failed*
  - *Finalization_Failed*
  - *State_Error*
  - *Derivation_Failed*
  - *Invalid_Region*
  - *Invalid_Data_Product*
  - *Iterator_Error*
  - **Internal_Failure**

Level 1C Disk Grid



Mapping from Level 1B Disk Grid to Level 1C Disk Grid



Level 1C Pixel CSUs

- Model the individual data elements of Level 1C grids for Disk, Limb, and Spectrograph
- Level 1C Grid CSUs are built upon the Level 1C Pixel CSUs
- Provide capability to:
  - Bin Level 1B data into Level 1C grid
  - Geolocate grid pixel centers
  - Flag data regions (day, night, aurora, twilight, and unknown)
  - Load background subtracted aurora intensities
  - Rectify dayside and auroral data to remove slant path enhancements

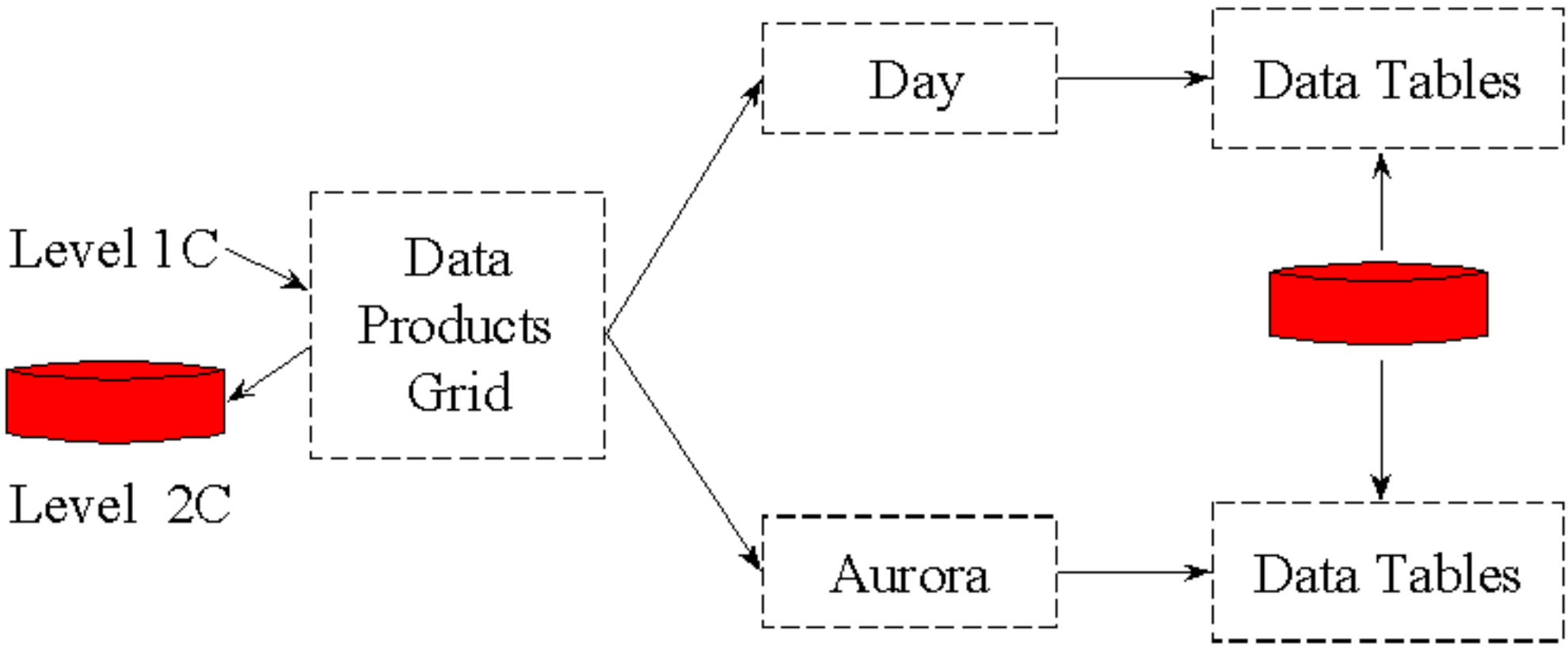
Level 1C Pixel CSUs (cont.)

- Classes:
  - Disk_SDR_Pixel
  - Limb_SDR_Profile
  - Spectrograph_SDR_Pixel
- Operations:
  - Initialize
  - Finalize
  - Geolocate
  - Bin
  - Flag unknown regions
  - Load_Auroral_Data
  - Rectify
  - Get (region flags)
  - Get (geolocation information)
  - Get (intensities)
- Exceptions:
  - *Initialization_Failed*
  - *Finalization_Failed*
  - *State_Error*
  - *Invalid_Data_Product*
  - *Invalid_Region*
  - *Derivation_Failed*

Level 2 Data CSC

- Computes Level 2 radiances from binned Level 1C data
- Derives Level 2C dayside and aurora data products using Level 2B radiances
- Provides services to access Level 2 geolocation information
- Provides services to access Level 2C data products

Level 2 Data CSC (cont.)
Control Flow



Level 2 Types CSU

- Encapsulates common types used by Level 2 Data CSUs
  - Grid specification
  - Region Types
  - Data Product Types
  - others…

Level 2 Exceptions CSU

- Encapsulates common exceptions used by Level 2 Data CSUs
- Exceptions:
  - Invalid_Data_Product

Level 2 Grid CSUs

- Model Level 2 grids for Imaging mode of operation, i.e. Imaging Disk and Imaging Limb
- Orthogonal grids of Level 2B calibrated sensor data for a full orbit
- Provide services to access Level 2C data products
- Provide capability to:
  - Load Level 1C pixel data into Level 2 pixels
  - Derive data product from Level 2B radiances

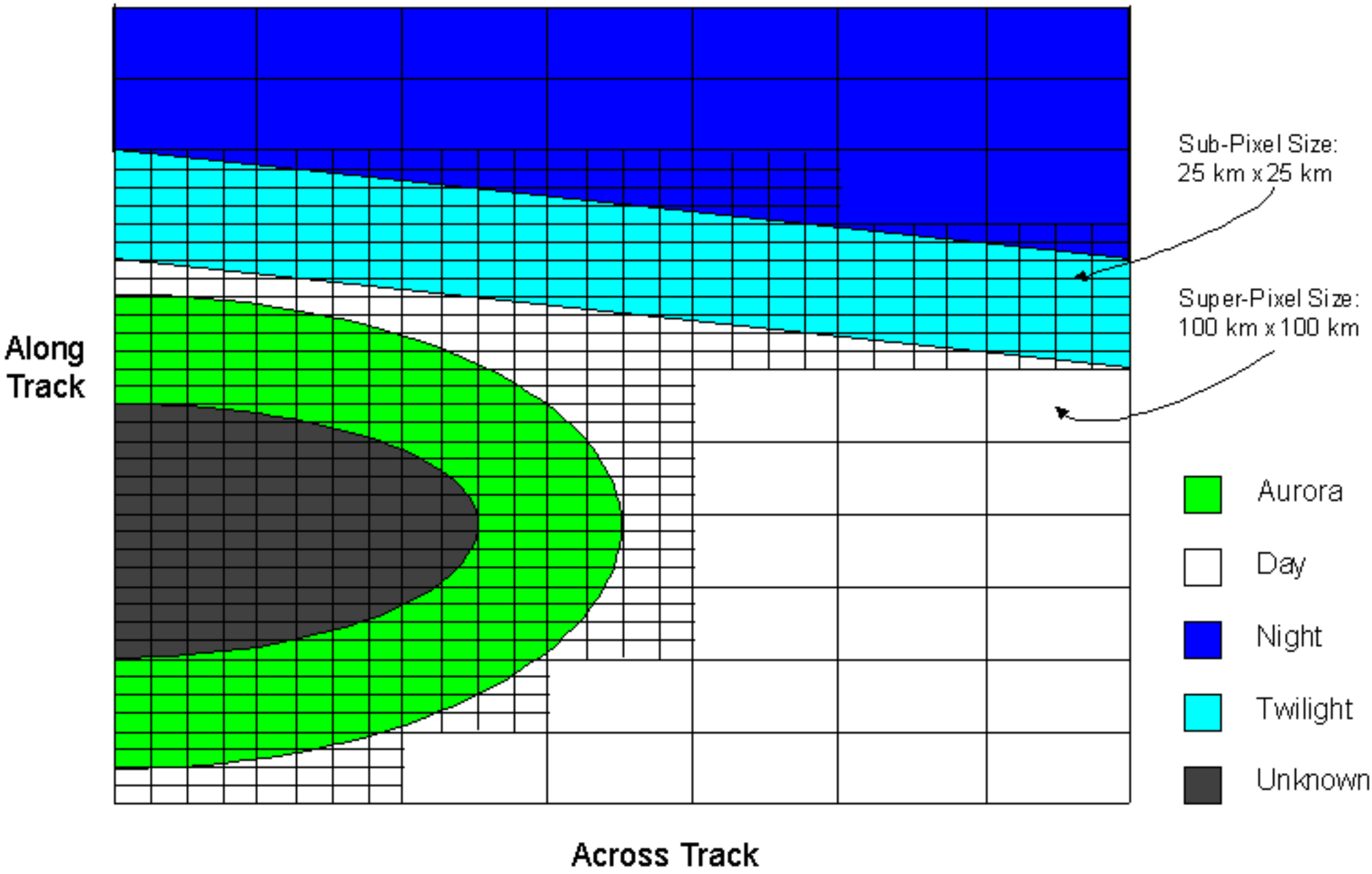
Level 2 Grid CSUs (cont.)

- Classes:

  (using Grid Class Manager)
  - Level_2_Disk_Grid
  - Level_2_Limb_Grid
- Operations:
  - Initialize
  - Finalize
  - Get (Pixel)

  Sub-Package: Iterator
    - Initialize
    - Advance
    - Place
    - At_End
- Exceptions:
  - *Initialization_Failed*
  - *Finalization_Failed*
  - *State_Error*

Level 2 Disk Grid



Level 2 Pixel CSUs

- Model the individual data elements of Level 2 grids for disk and limb
- Level 2 Grid CSUs are built upon Level 2 Pixel CSUs
- Provide capability to:
  - Bin Level 1C pixel radiance into Level 2 pixels
  - Geolocate grid pixel centers
  - Flag data regions
  - Derive Level 2C data products

Level 2 Pixel CSUs (cont.)

- Classes:
  - Level_2_Disk_Pixel
  - Level_2_Limb_Pixel
- Operations:
  - Initialize
  - Finalize
  - Derive
  - Get (region)

  Sub-Packages in Level_2_Disk_Pixel:

  Day and Aurora
    - Get (data products)

  Sub-Packages in Level_2_Limb_Pixel:

  Day
    - Get (data products)

- Exceptions:
  - Initialization_Failed
  - Derivation_Failed
  - Finalization_Failed
  - Invalid_Data_Product
  - Invalid_Region
  - State_Error

Level 2 Day Data Product CSU

- Provides services for deriving and accessing Level 2C dayside data products.
- Uses Data Table CSUs for rapid data product calculation
  - ROVCDN2VCD Data Table CSU
  - QEUV Data Table CSU
  - DIT Data Table CSU
- Used by Level 2 Pixel CSUs

Level 2 Day Data Product CSU (cont.)

- Operations:
  - **Initialize**
  - **Finalize**

  Sub-Package: Disk
    - Initialize
    - Finalize
    - Get (data products)

  Sub-Packages: Limb
    - Initialize
    - Finalize
    - Get (data products)

- Exceptions:
  - *Initialization_Failed*
  - *Derivation_Failed*
  - *State_Error*
  - *Invalid_Data_Product*

Level 2 Aurora Data Product CSU

- Provides services for deriving and accessing Level 2C aurora data products.
- Uses Data Table CSUs for rapid data product calculation
  - Aurora Ionization Data Table CSU
- Used by Level 2 Disk Pixel CSU

Level 2 Aurora Data Product CSU (cont.)

- Operations:
  - **Initialize**
  - **Finalize**

  Sub-Package: Disk
    - Initialize
    - Finalize
    - Get (data products)

- Exceptions:
  - *Initialization_Failed*
  - *Derivation_Failed*
  - *State_Error*
  - *Invalid_Data_Product*

Data Table CSC

- Used to model presistent data objects
- Aids in reducing runtime of data product algorithms

Data Table CSC (cont.)

- Required CSUs:

- Data Table Exceptions CSU
- Decompression Data Table CSU
- Calibration Data Table CSU
- Geomagnetic Data Table CSU
- Day Rectification Data Table CSU
- Aurora Rectification Data Table CSU
- Backgrounds Data Table CSU
- Statistical Aurora Data Table CSU
- ROVCDN2VCD Data Table CSU
- QEUV Data Table CSU
- DIT Data Table CSU
- Aurora Ionization Data Table CSU

Data Table Exceptions CSU

- Encapsulates common exceptions used by Data Table CSUs
- Exceptions:
  - Search_Failed
  - Invalid_Argument

Decompression Data Table CSU

- Provides services to decompress compressed Level 1A counts
- Used to process Level 1A data into Level 1B data

Decompression Data Table CSU (cont.)

- Operations:
  - **Initialize**
  - **Finalize**
  - **Decompress**
- Exceptions:
  - *Initialization_Failed*
  - *Finalization_Failed*
  - *State_Error*
  - *Invalid_Argument*
  - *Search_Failed*

Calibration Data Table CSU

- Provides services to convert counts to Rayleighs
- Used to process Level 1A data into Level 1B data.

Calibration Data Table CSU (cont.)

- Operations:
  - **Initialize**
  - **Finalize**

  Sub-Package: Spectra
    - Get_Across_Track_Angle
    - Get_Along_Track_Angle
    - Get_Inegration_Time
    - Get_Reference_Pixel
    - Get_Wavelengths

  Sub-Package: Covariance
    - Get (covariance)

- Operations (cont.):

  Sub-Packages: Disk and Limb
    - Get_Across_Track_Angle
    - Get_Along_Track_Angle
    - Get_Intagration_Time
    - Get_Scan_Time
    - Get_Background_Mask
    - Get_Dark_Mask
    - Get_Responsivity
    - Get_Variance_Ratio
    - Get_Overlap_Fraction

- Exceptions:
  - *Initialization_Failed*
  - *Finalization_Failed*
  - *State_Error*
  - *Invalid_Argument*
  - *Search_Failed*

Geomagnetic Data Table CSU

- Provides service to covert geodetic coordinates into geomagnetic coordinates
- Used to geolocate Level 1C and Level 2 pixels

Geomagnetic Data Table CSU (cont.)

- Operations:
  - **Initialize**
  - **Finalize**
  - **Convert**
- Exceptions:
  - *Initialization_Failed*
  - *Finalization_Failed*
  - *State_Error*
  - *Invalid_Argument*
  - *Search_Failed*

Day Rectification Data Table CSU

- Provides services to remove (and add) slant path enhancements from non-nadir dayside pixel radiances
- Used by Level 1C Pixel CSUs

Day Rectification Data Table CSU (cont.)

- Operations:
  - **Initialize**
  - **Finalize**
  - **Get (rectified radiance one color)**
  - **Unrectify (rectified radiance one color)**
- Exceptions:
  - *Initialization_Failed*
  - *Finalization_Failed*
  - *State_Error*
  - *Invalid_Argument*
  - *Search_Failed*

Aurora Rectification Data Table CSU

- Provides services to remove slant path enhancements from non-nadir aurora pixel radiances
- Used by Level 1C Pixel CSUs

Aurora Rectification Data Table CSU (cont.)

- Operations:
  - **Initialize**
  - **Finalize**
  - **Get (rectified radiance for color)**
- Exceptions:
  - *Initialization_Failed*
  - *Finalization_Failed*
  - *State_Error*
  - *Invalid_Argument*
  - *Search_Failed*

Backgrounds Data Table CSU

- Provides services to update and retrieve stored radiances for midlatitude dayside nadir pixels
- Used by Level 1C Disk Grid CSU

Backgrounds Data Table CSU (cont.)

- Operations:
  - **Initialize**
  - **Finalize**
  - **Update**
  - **Retrieve**
- Exceptions:
  - *Initialization_Failed*
  - *Finalization_Failed*
  - *State_Error*
  - **Update_Failed**
  - **Retrieve_Failed**

Statistical Aurora Data Table CSU

- Provides services to determine if a pixel location is statistically likely to be within an auroral oval
- Used by Level 1C Disk Grid CSU

Statistical Aurora Data Table CSU (cont.)

- Operations:
  - **Initialize**
  - **Finalize**
  - **Is_Aurora**
- Exceptions:
  - *Initialization_Failed*
  - *Finalization_Failed*
  - *State_Error*
  - *Search_Failed*
  - *Invalid_Argument*

ROVCDN2VCD Data Table CSU

- Provides services to compute and access the ratio of O vertical column density to N_2 vertical column density
- Used by Level 2 Day Data Product CSU

ROVCDN2VCD Data Table CSU (cont.)

- Operations:
  - **Initialize**
  - **Finalize**
  - **Get (O / N_2)**

- Exceptions:
  - *Initialization_Failed*
  - *Finalization_Failed*
  - *State_Error*
  - *Search_Failed*
  - *Invalid_Argument*

QEUV Data Table CSU

- Provides services to compute and access the integrated Extreme UltraViolet energy flux below 40 nm
- Used by Level 2 Day Data Product CSU

QEUV Data Table CSU (cont.)

- Operations:
  - **Initialize**
  - **Finalize**
  - **Get (QEUV)**

- Exceptions:
  - *Initialization_Failed*
  - *Finalization_Failed*
  - *State_Error*
  - *Search_Failed*
  - *Invalid_Argument*

DIT Data Table CSU

- Provides services to compute and access dayside limb neutral density profiles, temperature profile, and the ratio of O vertical column density to N_2 vertical column density
- Used by Level 2 Day Data Product CSU

DIT Data Table CSU (cont.)

- Operations:
  - **Initialize**
  - **Finalize**
  - **Get (N_2,O_2,O,T)**
  - **Get (data table radiances)**
  - **Get (density scale factors)**
- Exceptions:
  - *Initialization_Failed*
  - *Finalization_Failed*
  - *State_Error*
  - *Search_Failed*
  - *Invalid_Argument*

Aurora Ionization Data Table CSU

- Provides services to compute and access Q_{eff}, $\langle E_{eff} \rangle$, H_mE, and the column ionization production rate
- Used by Level 2 Aurora Data Product CSU

Aurora Ionization Data Table CSU (cont.)

- Operations:
  - **Initialize**
  - **Finalize**
  - **Get (Q,<E>, H_mE, CIPR)**
- Exceptions:
  - *Initialization_Failed*
  - *Finalization_Failed*
  - *State_Error*
  - *Search_Failed*
  - *Invalid_Argument*

Utilities CSC

- Provides system-wide services and utilities

Grid Class Manager CSU

- Provides generic capability for managing one and two dimensional grids
- Used to build Level 1B Grid CSUs, Level 1C Grid CSUs, and Level 2 Grid CSUs

Grid Class Manager CSU (cont.)

- Operations:

  Sub-Packages: One Dimensional & Two Dimensional
  - Initialize
  - Finalize
  - Load
  - Get_Element

  Sub-Package: Iterator
  - Initialize
  - Advance
  - Place
  - At_End

- Exceptions:
  - *Initialization_Failed*
  - *Finalization_Failed*
  - *State_Error*
  - *Iterator_Error*
  - Internal_Failure

Geolocation Utilities CSU

- Provides services for coordinate transformations
- Provides services to aid in geolocation of grid pixel centers
- Used by Level 1C Grid CSUs and Level 2 Grid CSUs

Geolocation Utilities CSU (cont.)

- Operations:
  - Spherical_to_Cartesian
  - Cartesian_to_Spherical
  - Geodetic_to_Geocentric
  - Geocentric_to_Geodetic
  - Radius_of_Earth
  - Longitude_to_Right_Ascension
  - Right_Ascension_to_Longitude
  - Derive_Local_Time
  - Geomagnetic_Local_Time
  - Derive_Solar_Zenith_Angle
  - Derive_Solar_Azimuth_Angle
  - others...
- Exceptions:
  - Invalid_Input
  - Derivation_Failed

Grid Geolocation CSU

- Provides services to geolocate grid pixel centers
- Used by Level 1C Grid CSUs and Level 2 Grid CSUs

Grid Geolocation CSU (cont.)

- Operations:
  - **Derive_Geolocation_Data_Set**
- Exceptions:
  - *Derivation_Failed*
  - **Invalid_Input**

Message Handling Interface CSU

- Provides interface to Write to Software Log CSU
- Used by CSUs to send exception messages
- Used by CSUs to send general messages
- Used as a debugging service

Message Handling Interface CSU (cont.)

- Operations:
  - **Initialize**
  - **Finalize**
  - **Send_Start_Message**
  - **Send_End_Message**
  - **Send_Exception_Message**
  - **Send_General_Message**
- Exceptions:
  - *Initialization_Failed*
  - *Finalization_Failed*
  - *State_Error*
  - **Send_Message_Failed**

Math Utilities CSU

- Provides required math functions and procedures
- Provides interface to pre-defined math functions

Math Utilities CSU (cont.)

- Operations:
  - Radians
  - Degrees
  - Sin, Cos, Tan, …, Exp, **, …

  Sub-Package: Correlated
    - (Value,Variance) operations

  Sub-Package: Uncorrelated
    - (Value,Variance) operations

  Sub-Package: Matrices
    - +, -, *, Transpose, …

  Sub-Package: One_Dimensional
    - Is_Monotonic
    - Search
    - Interpolate
    - Derivative
    - Parabola

- Exceptions:
  - Internal_Error
  - Floating_Point_Underflow
  - Floating_Point_Overflow
  - Log_of_Zero_or_Negative_Number
  - Square_Root_of_Negative_Number