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# Dynamic Weather Routes Architecture Overview

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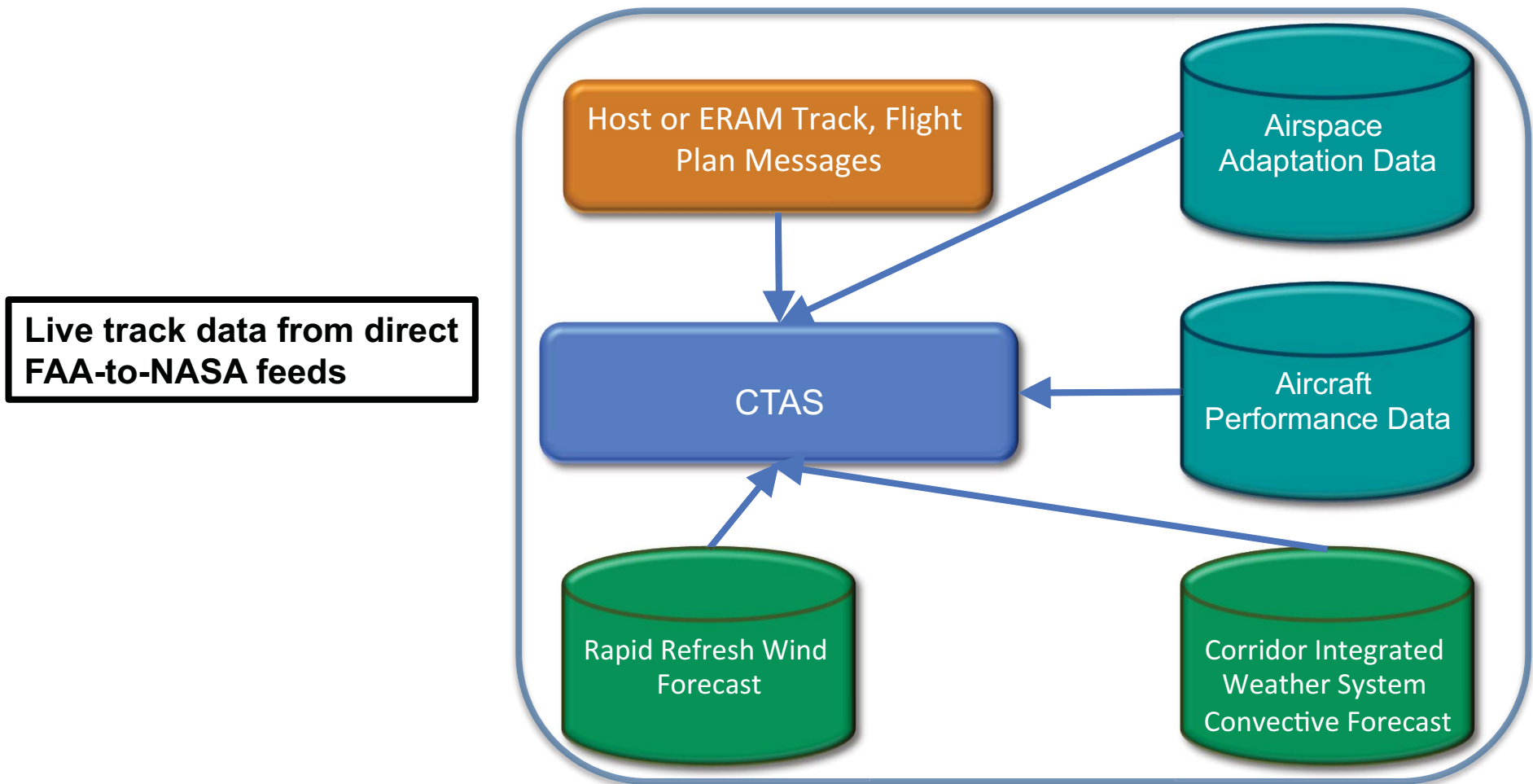
# CTAS (Center/TRACON Automation System) Software Platform Overview

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- CTAS: A platform for real-time, trajectory-based automation and controller decision support tools
- Notable controller decision support tools based on CTAS
  - Traffic Management Advisor (TMA)
  - Direct-To (D2)
  - Terminal Sequencing and Spacing (TSS)
  - Dynamic Weather Routes (DWR)
- CTAS main internal functions:
  - External input data processing (Flight plans, Tracks, Weather, Wind)
  - 4-D trajectory generation
  - Decision automation algorithms
  - Advisories generation
  - Interactive decision support graphical user interface



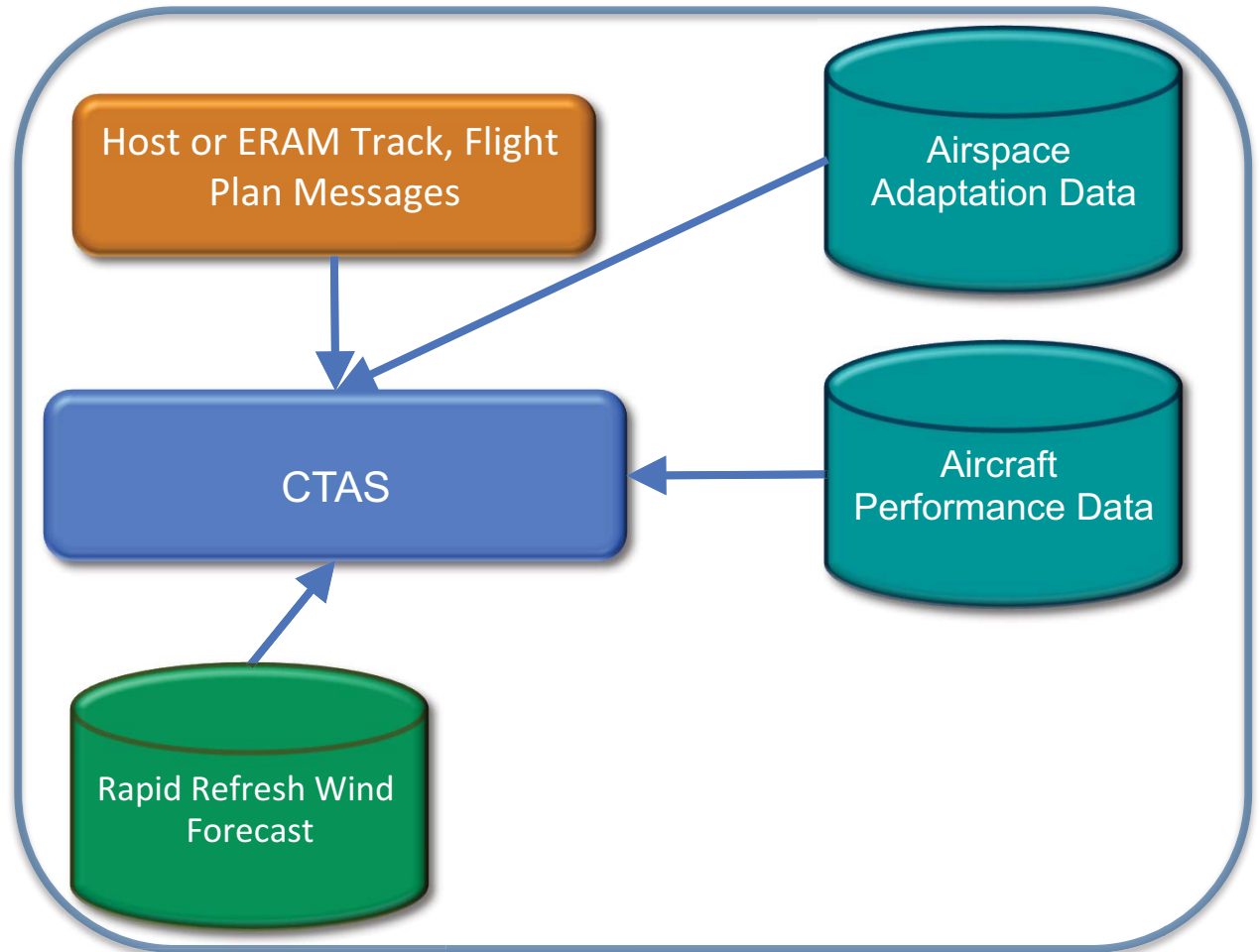
# General CTAS System in Live Data Context





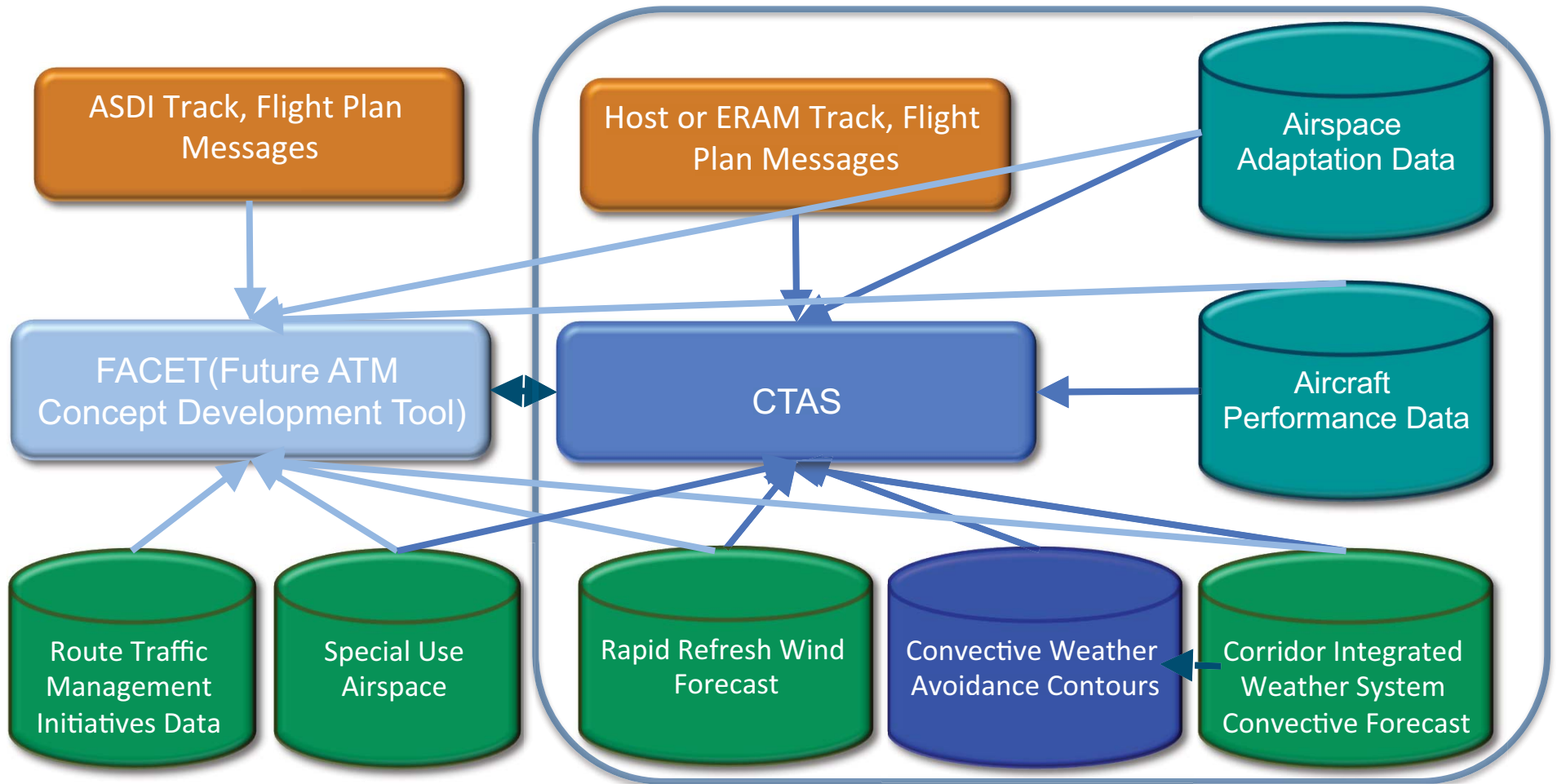
# Direct-To System in Live Data Context

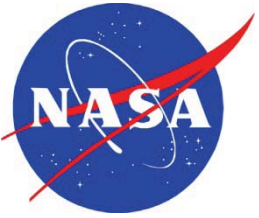
**Direct-To does not use weather data**





# DWR System in Live Data Context

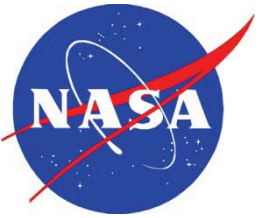




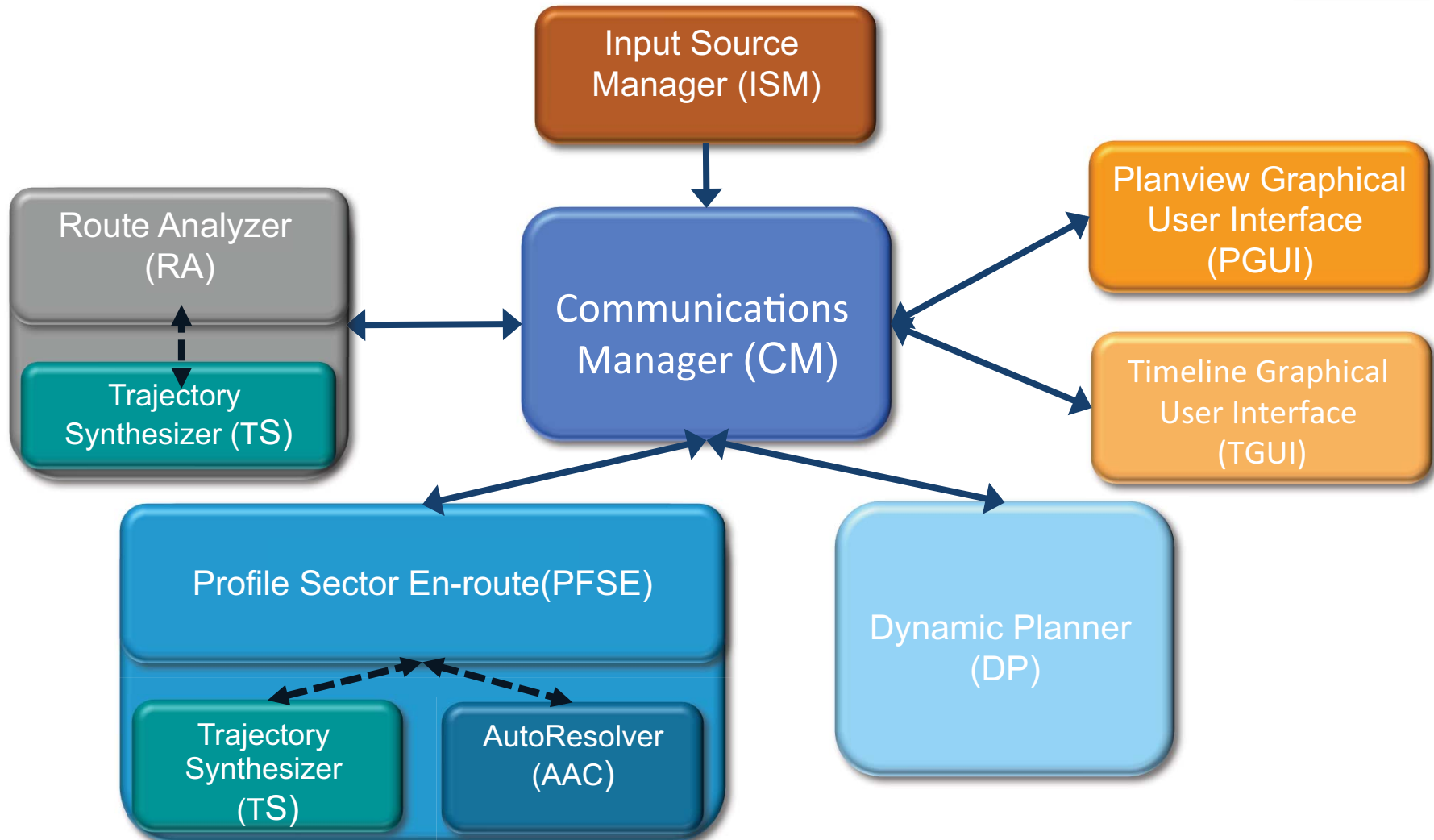
# DWR Input Data Sources and Update Rates

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- Host/ERAM data (Flight plan, Track, etc.): Direct NASA-FAA feeds - 12 sec
- NAS configuration Chart Change Update from FAA (adaptation): From FAA - 56 days
- Aircraft performance data: NASA - static
- Corridor Integrated Weather System (CIWS) Convective Forecasts: From FAA - 5 Min, 120 min forecast
- Convective Weather Avoidance Contours (CWAM): Data derived from CIWS by CTAS weather processing scripts - 5 min, 120 min prediction
- Wind information (Rapid Refresh – RR): From NOAA - 60 minutes update and prediction
- Special Use Airspace (SUA) data: From public web site - 15 min
- Aircraft Situation Display to Industry (ASDI) data: FAA - 1 min
- Traffic Flow Management Data to Industry (TFMDI) for route traffic management initiative information: FAA - 5 min

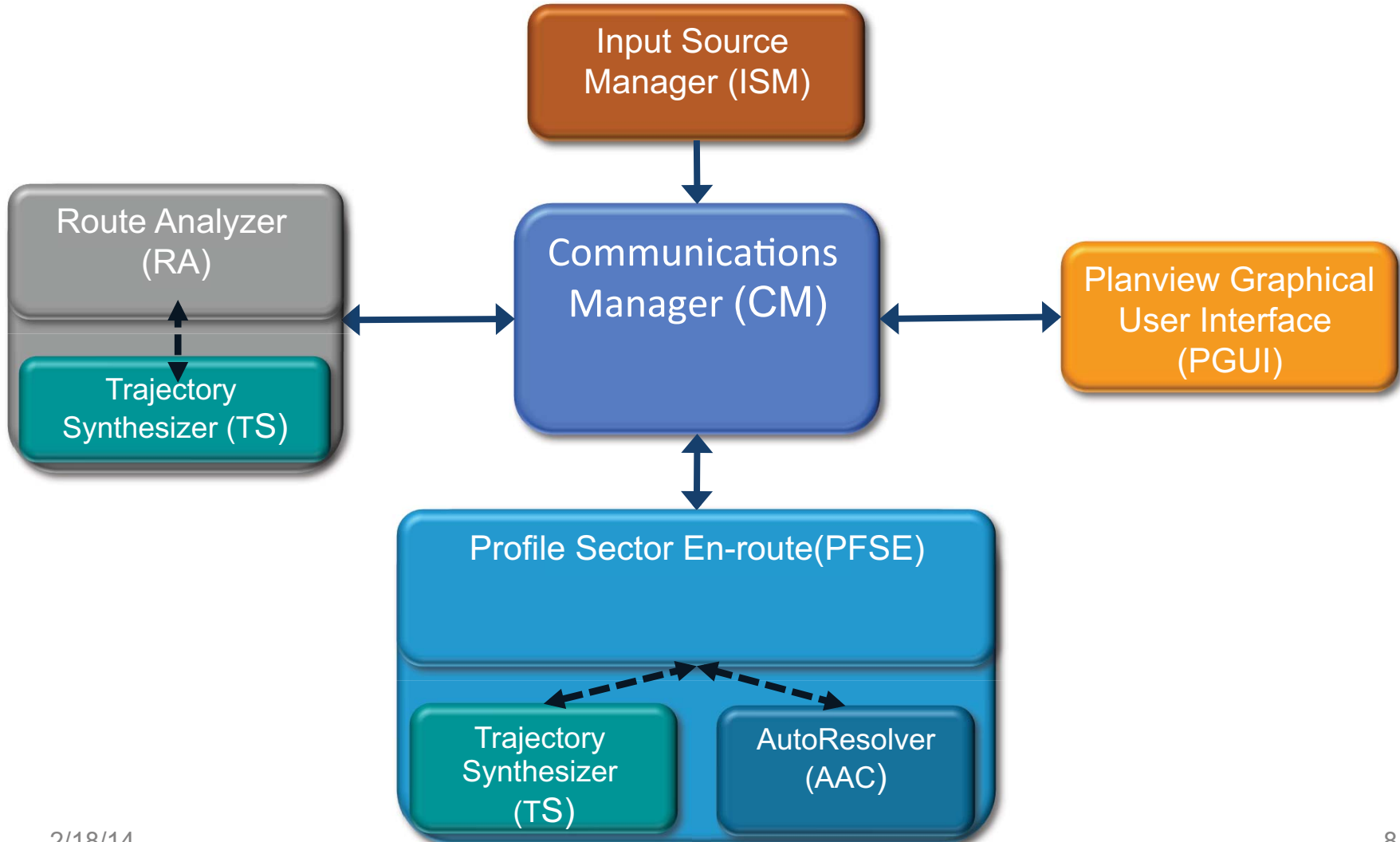


# CTAS Software Components





# DWR Software Components







# DWR Software Components

## ISM, CM, RA

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- **ISM (Input Source Manager)**
  - Integrates and consolidates data from Center Host Computers (Host or ERAM)
  - Performs flight state filtering and state estimation (heading, vertical speed)
- **CM (Communications Manager)**
  - Internal data exchange hub for CTAS processes (PFSE, RA, PGUI)
- **RA (Route Analyzer)**
  - Generates all possible horizontal trajectories a flight may take, using TS (Trajectory Synthesizer)
  - Intended for arrival traffic; only one route generated for DWR case

**Note: All processes read adaptation data at start-up**



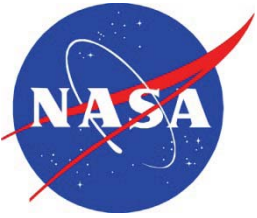
# DWR Software Components

## PFSE, PGUI

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- **PFSE (Profile Selector En-Route)**
  - Multi-threaded algorithm engine
  - Uses multiple threads of **TS (Trajectory Synthesizer)** and **AAC (Advance Airspace Concept/Auto Resolver)** for trajectory and maneuver calculations
  - Generates among many data types, conflict and advisory information
- **PGUI (Planview GUI)**
  - Interactive decision support graphical user interface
  - Mimics the controller DSR

**Note: All processes read adaptation data at start-up**



# DWR Software Components

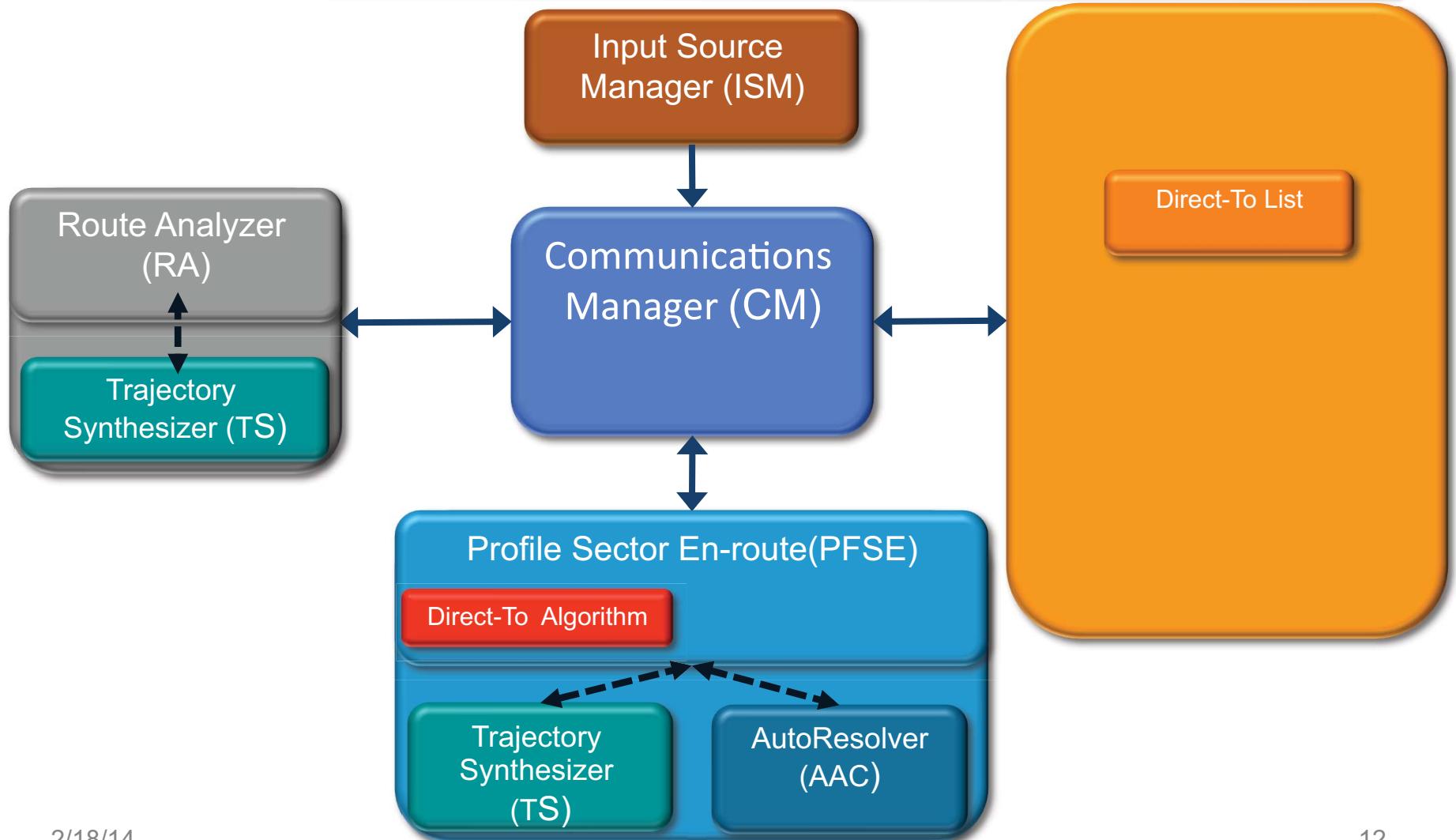
## TS, AAC

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- **TS (Trajectory Synthesizer)**
  - Invoked by PFSE and RA
  - Uses aircraft's position data (initial and destination), performance data, speed information, route list, and wind information to predict flight path profile (horizontal, vertical, speed, time, turns, etc.)
- **AAC (Advance Airspace Concept/Weather and Traffic Auto Resolver)**
  - Invoked by PFSE
  - Accepts as input data the trajectory, route, and conflict information
  - Proposes potential conflict free maneuvers
  - PFSE and AAC reiterate on intermediate maneuvers and conflict information towards a final conflict free maneuver

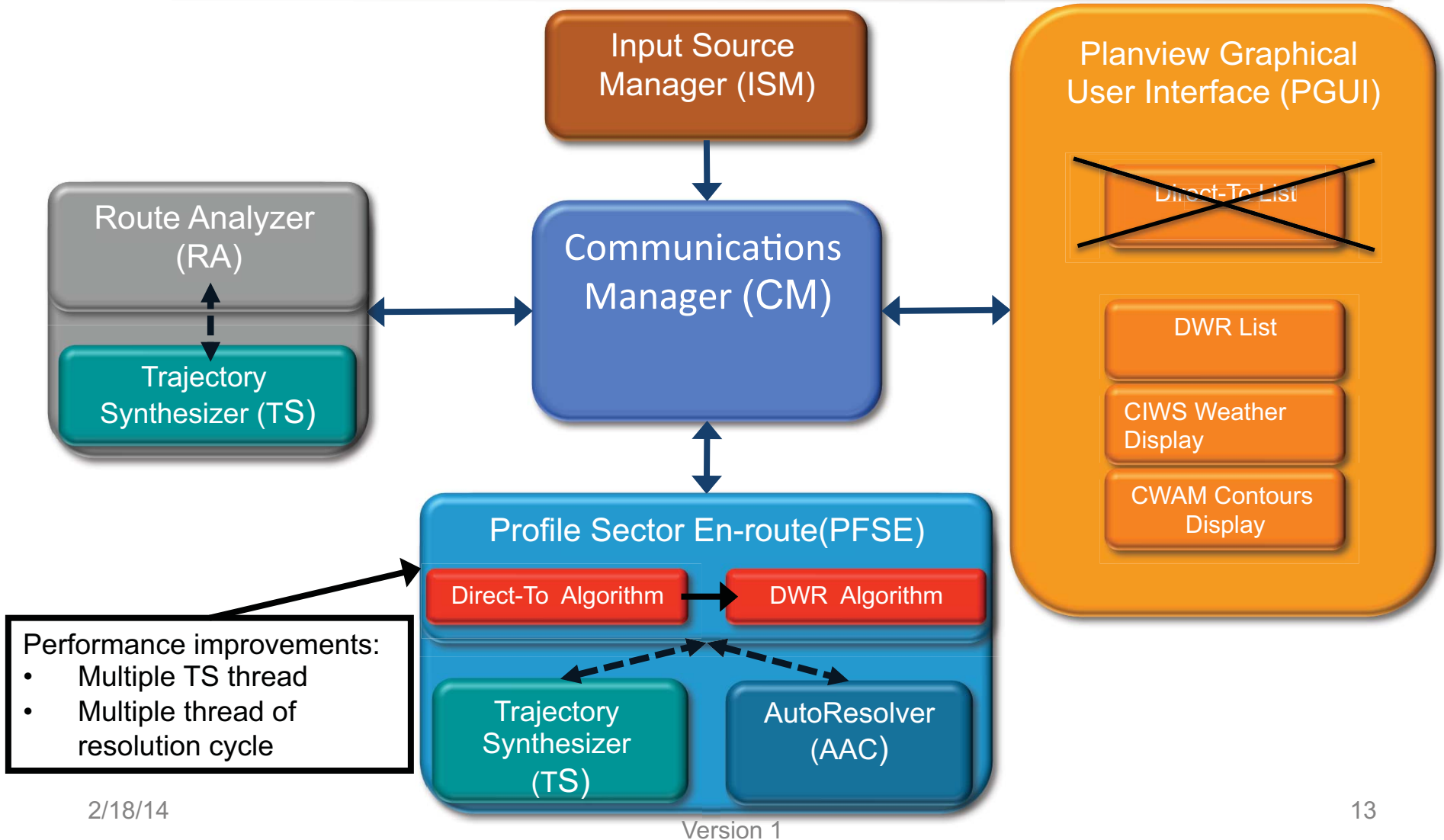


# Direct-To Software Components – Foundation for DWR



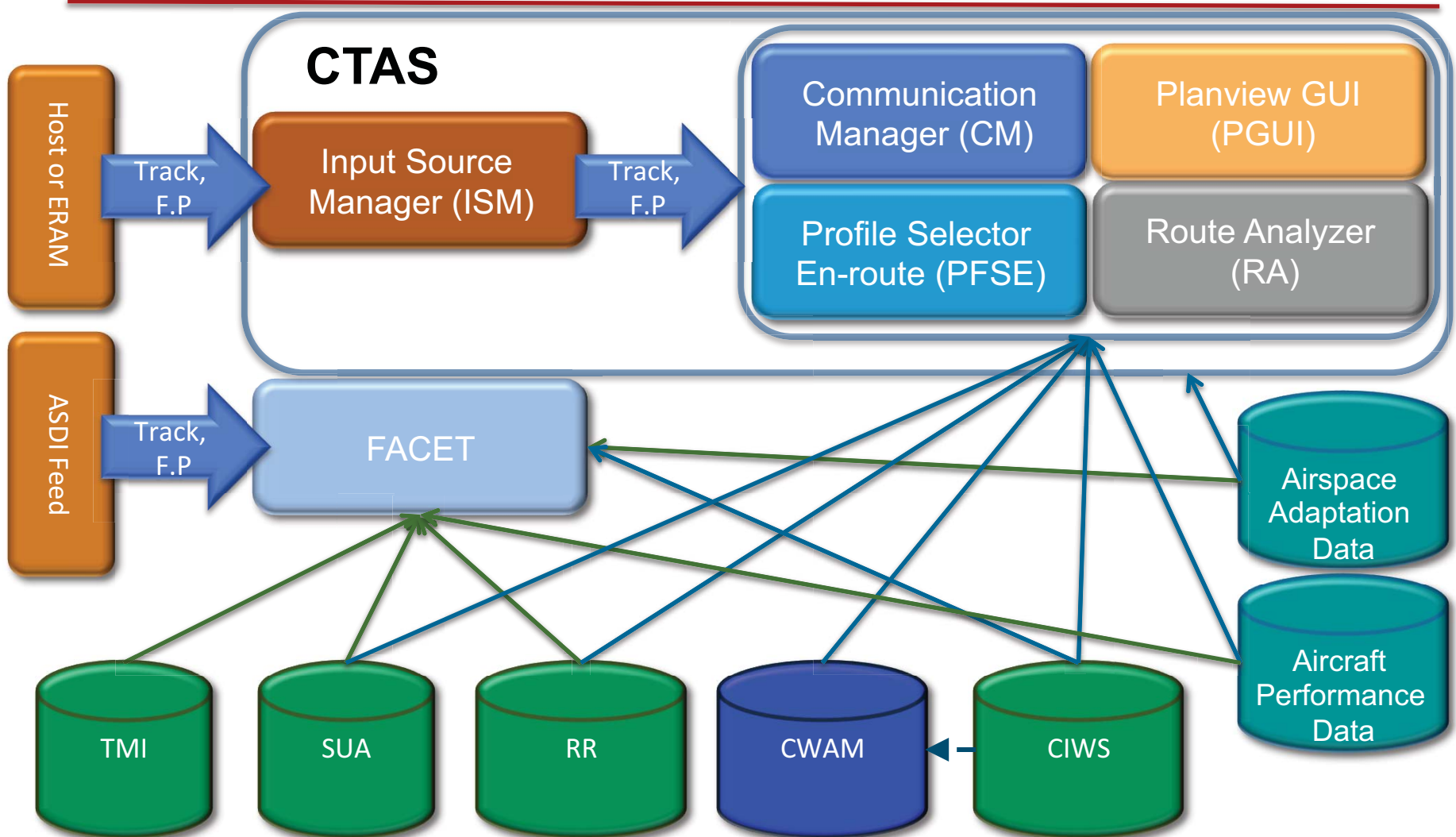


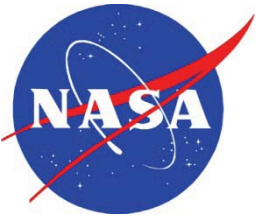
# DWR Changes to Direct-To Software



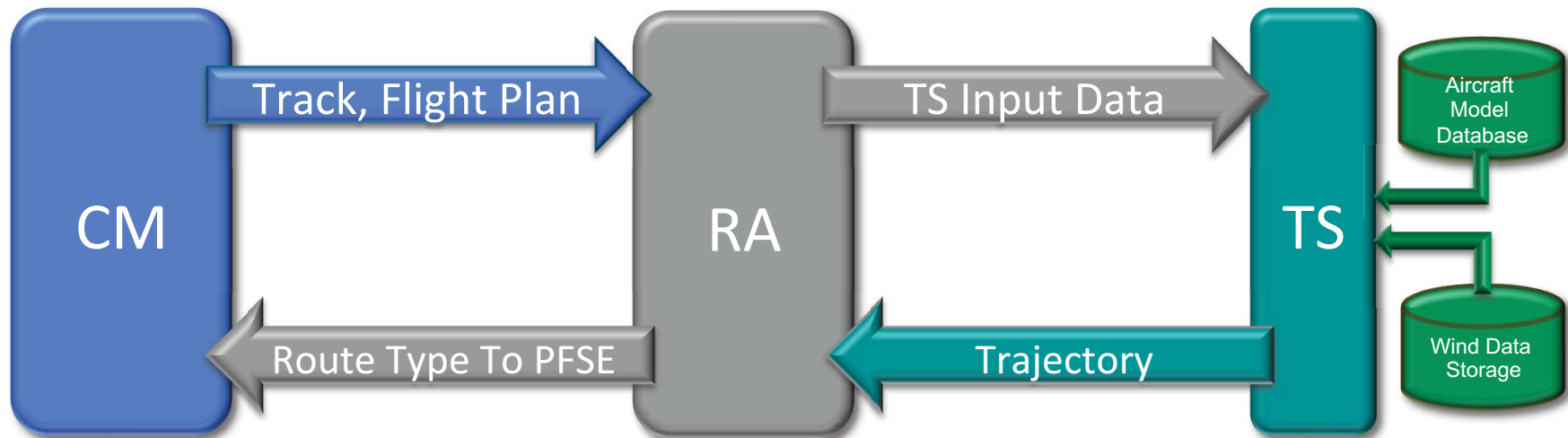


# DWR Data Flow: External Data



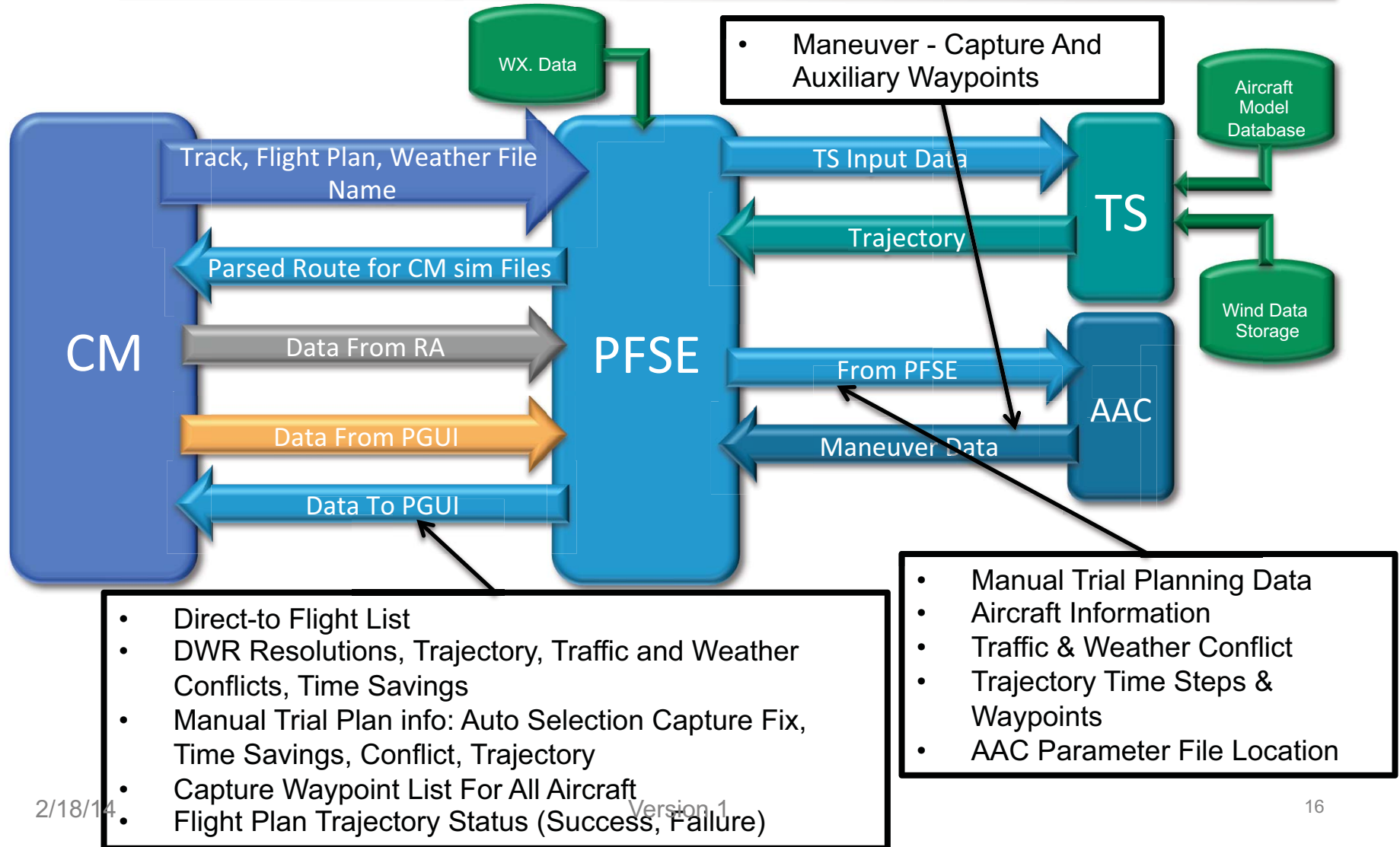


# DWR Internal Data Flow: RA





# DWR Internal Data Flow: PFSE



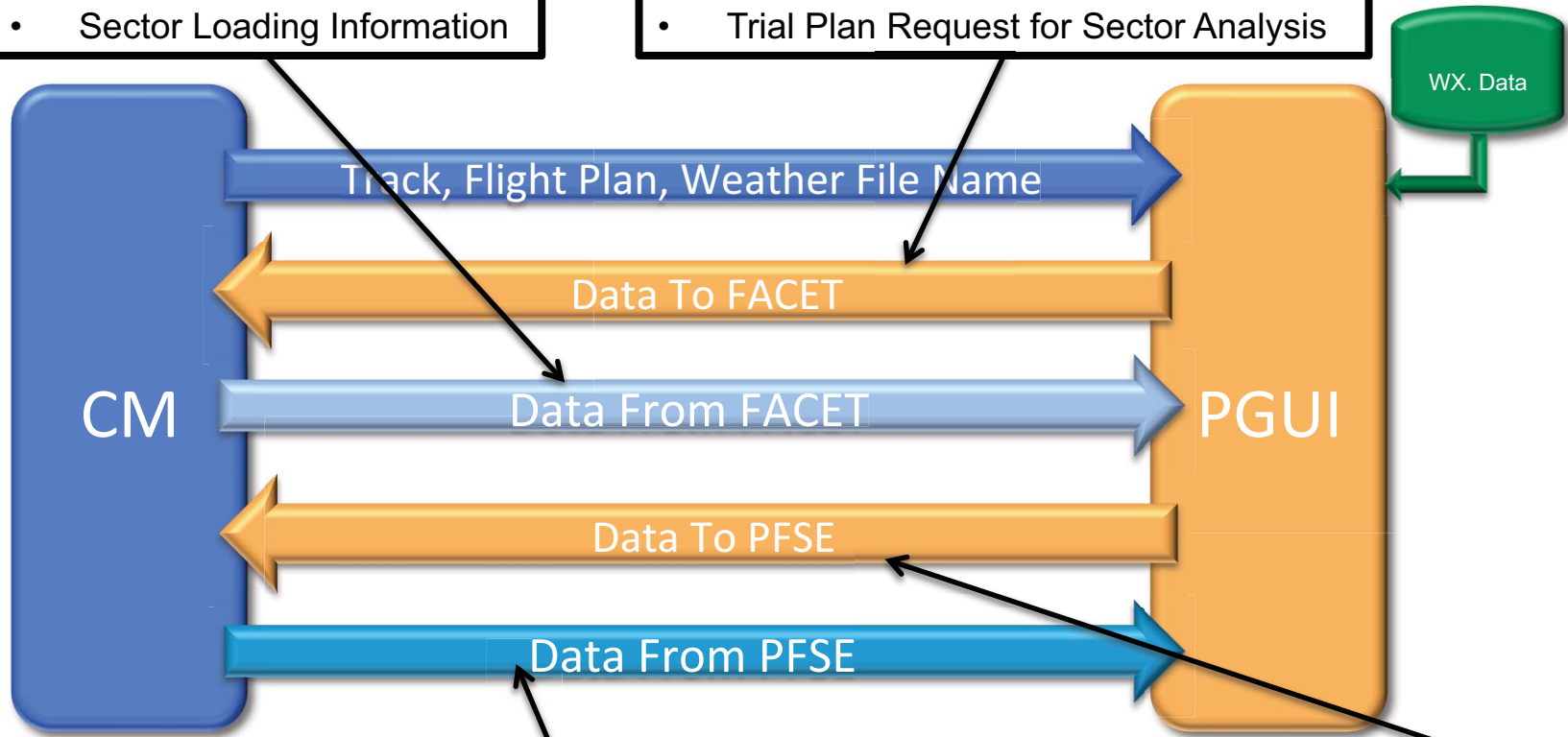




# DWR Internal Data Flow: PGUI

- Sector Loading Information

- Trial Plan Request for Sector Analysis



- Direct-To Flight List
- DWR Resolution, Trajectory, Traffic and WX Conflicts, Time Savings
- Manual Trial Plan info: Auto Select Capture Fix, Time Savings, Conflict, Trajectory
- Capture Waypoint List For All Aircraft
- F.P. Trajectory Status (Success, Failure)

- Trial Plan Maneuver Request
- Trajectory Data Request
- Conflict Prediction Parameters (adjusted from PGUI)

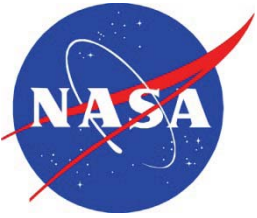


# DWR/CTAS Host Data Elements: Host Flight Plan

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- **Time received**
- **Aircraft Identification**
  - Host Computer Aircraft ID
  - Call sign
  - Aircraft data/type (FAA designated type)
  - Beacon code
- **Facility Information**
  - Controlling Facility

**Note: Flight plan information is required on initiation of a flight and whenever the value of an element changes**



# DWR/CTAS Host Data Elements: Host Flight Plan – Cont'd

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- **Flight Information**

- Filed true airspeed
- Assigned altitude
- Planned route
- Center Parsed Route (AK Route)
- Coordination fix
- Coordination time
- Temporary Altitude
- **Status**
  - P(proposed): Flight that will take off at some future time(Proposed or planned)
  - E(Estimated): Flight that is crossing center boundaries and will be picked up in the air at the coordination fix and coordination time.
  - D(Departed): Flight that is departing an airport. Will be tracked soon.



# DWR/CTAS Host Data Elements: Host Track

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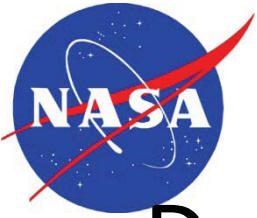
- **Data arrival time to CTAS**
- **Host track time**
- **Aircraft Identification**
  - Host Computer Aircraft ID
  - Call Sign
- **Track Source Information (ARTS, STARS, HOST, ERAM)**
  - Source type (used by ISM to filter)
  - Facility ID
  - Sector ID



# DWR/CTAS Host Data Elements: Host Track – Cont'd

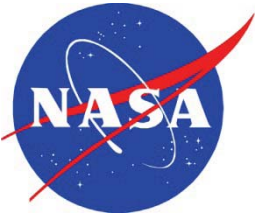
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- **Flight Information**
  - Altitude (feet above MSL)
  - Ground speed
  - Coasting indicator (Coast bit == 'C' if true)
  - Latitude
  - Longitude



# DWR/CTAS Host Data Elements: Drop Track, Delete Aircraft, Time Sync

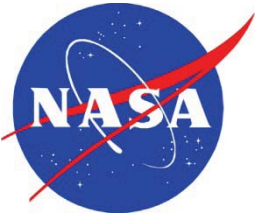
- **Drop Track:**
  - Aircraft Identification
    - Host Computer Aircraft ID
    - Call Sign
  - Controlling Facility
- **Delete Aircraft:**
  - Host Computer Aircraft ID
  - Call Sign
- **Host/Application Time Synchronization:**
  - Host time sync
  - Hours
  - Minutes
  - Seconds



# CTAS Adaptation

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- Each ARTCC adapted separately and updated on the 56-day FAA cycle
- Vast majority of adaptation from FAA sources, including NFDC, ACES, and ERAM data
- Definition of arrival procedures generated by hand (e.g., meter fixes, stream classes, etc.)
- About 12K lines of custom adaptation per site
  - Much can be modeled on existing sites
  - If arrivals not of interest, can be simplified



# Software Characteristics

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- Mixture of C, C++, Java, scripts
- Multi-threading used as necessary
- Message-passing is by TCP/IP message, defined by C data structures
- Each process maintains internal database of flights, via a binary tree
- Common code shared among processes, via libraries





# CTAS Software Stats

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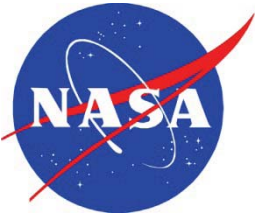
- C/C++ stats:
  - 1M lines of code in 5K files
  - 800K lines of comments
- Java stats:
  - 165K lines of code in 800 files
  - 180K lines of comments
- Stats come from Understand product



# CTAS Software Dependencies

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- Linux or Mac OSX (NOT Windows)
  - Currently supporting RedHat 5.8, CentOS 6.4, OSX 10.7
  - 64-bit compilation using GNU GCC, Oracle Java compilers
- Various free libraries:
  - X11/Motif (graphics)
  - QT, QWT (graphics)
  - HDF5 (weather format)
  - XML (adaptation format)
  - Python
  - MySQL (optional)



# CTAS Directory Structure

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