

Dynamic Weather Routes Architecture Overview

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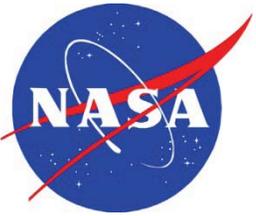
Michelle Eshow (NASA)

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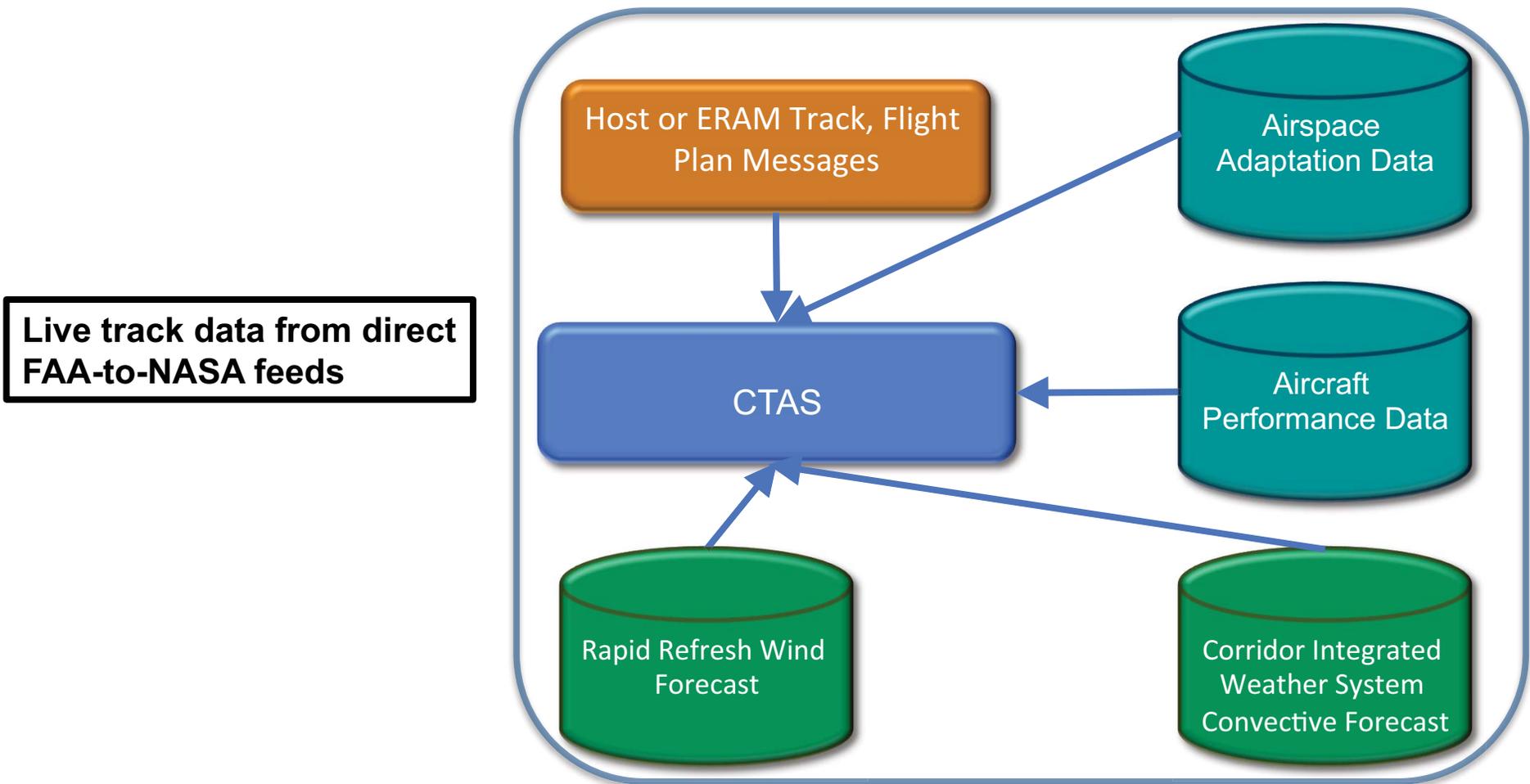


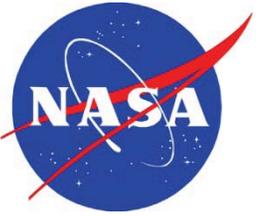
CTAS (Center/TRACON Automation System) Software Platform Overview

- 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



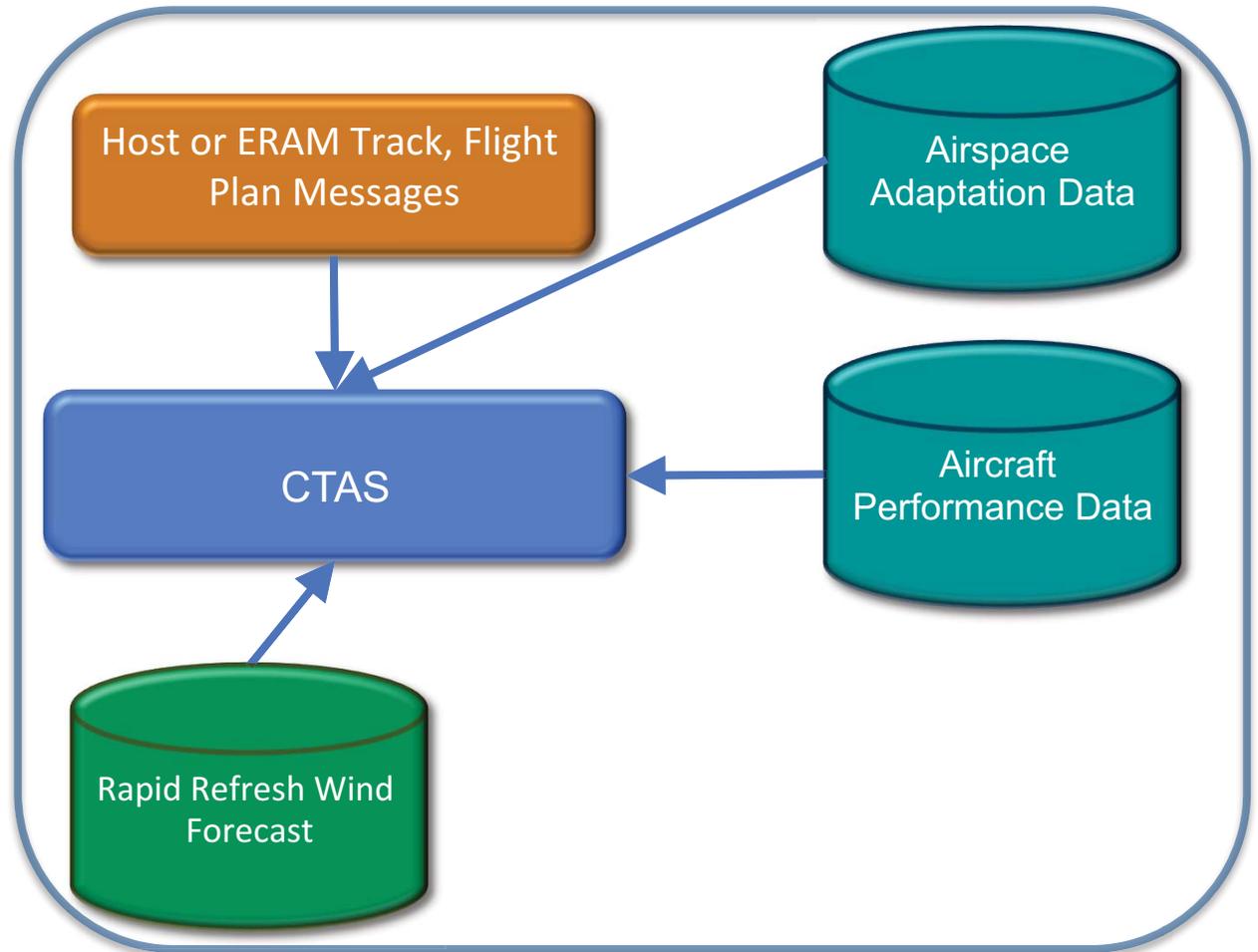
General CTAS System in Live Data Context

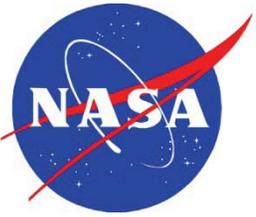




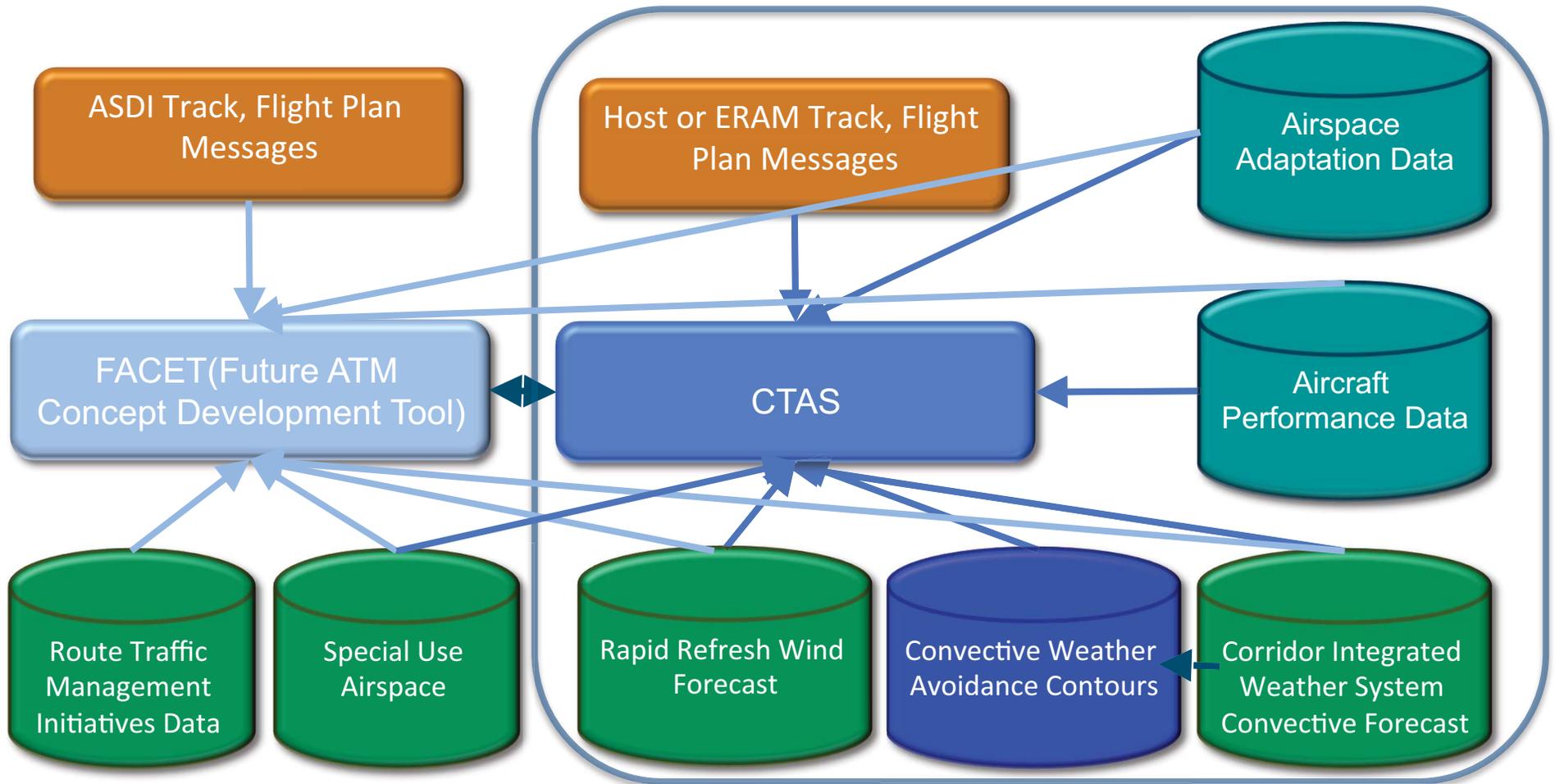
Direct-To System in Live Data Context

Direct-To does not use weather data





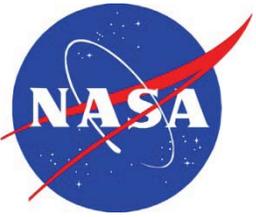
DWR System in Live Data Context



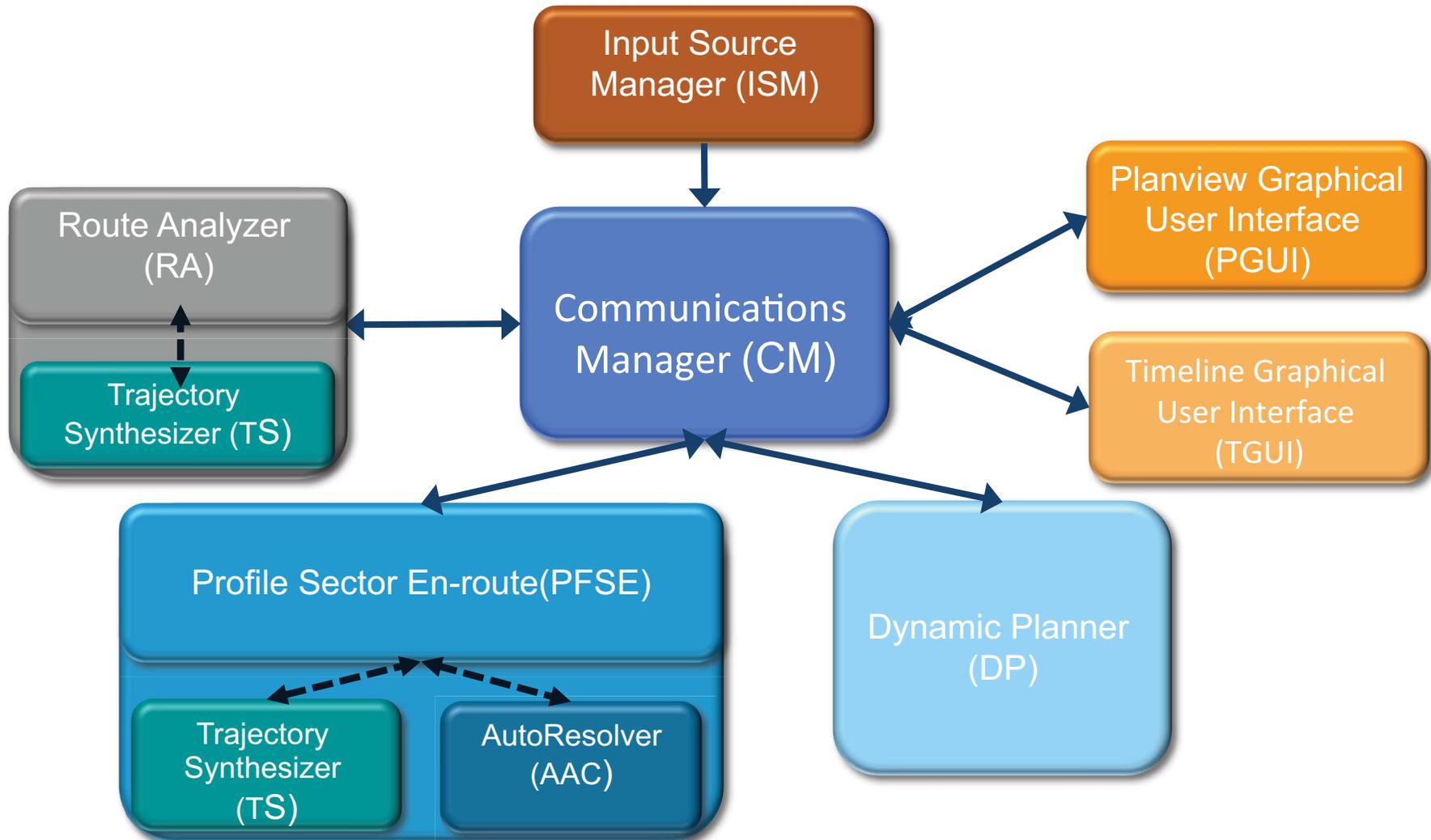


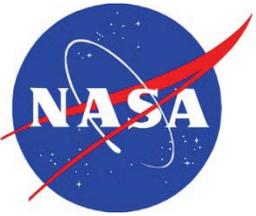
DWR Input Data Sources and Update Rates

- 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

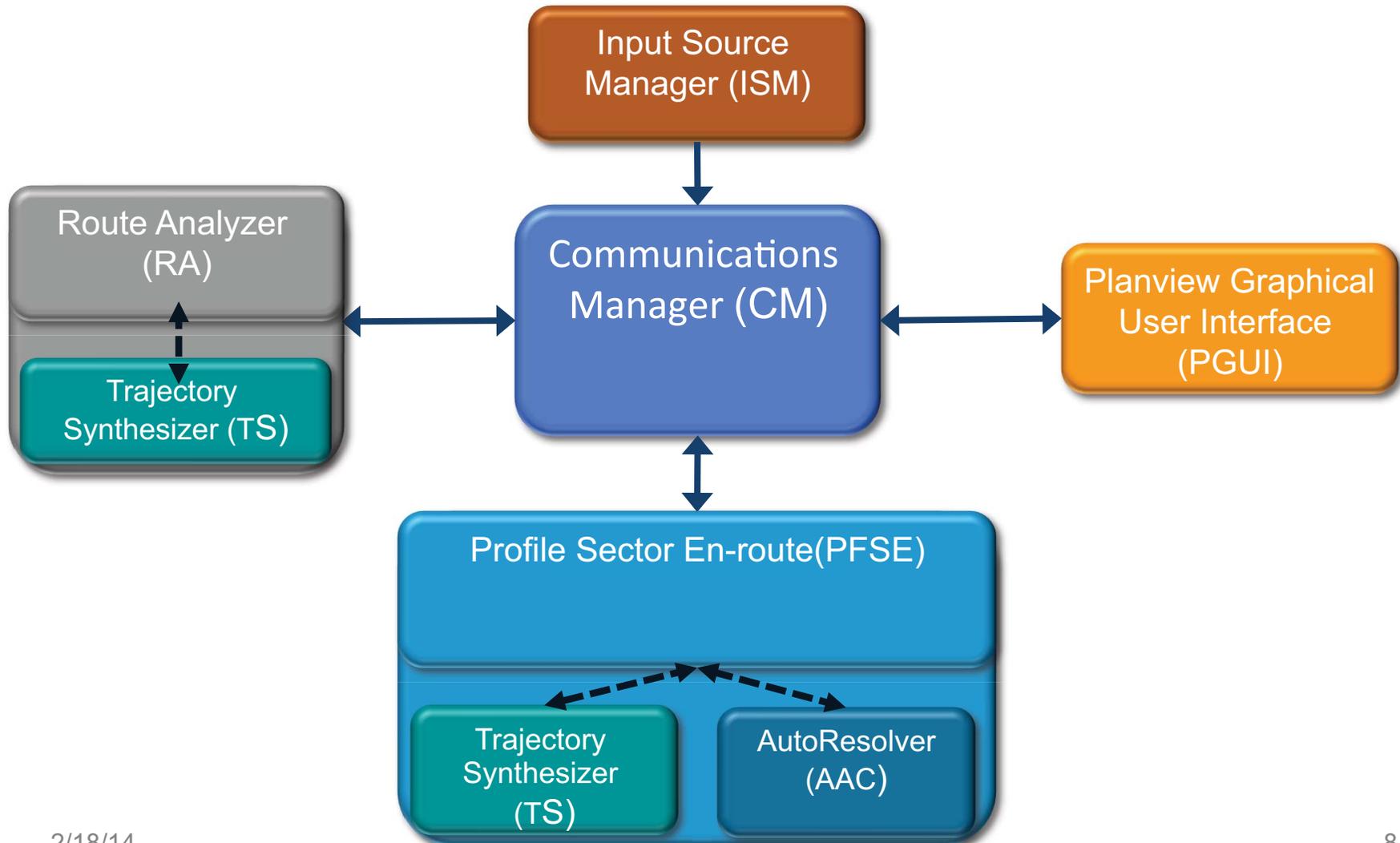


CTAS Software Components





DWR Software Components





DWR Software Components

ISM, CM, RA

- **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

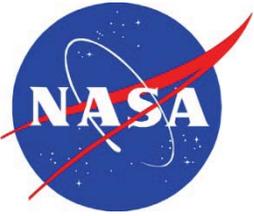


DWR Software Components

PFSE, PGUI

- **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

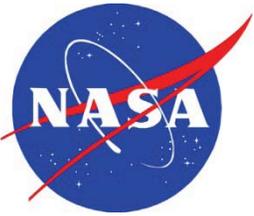
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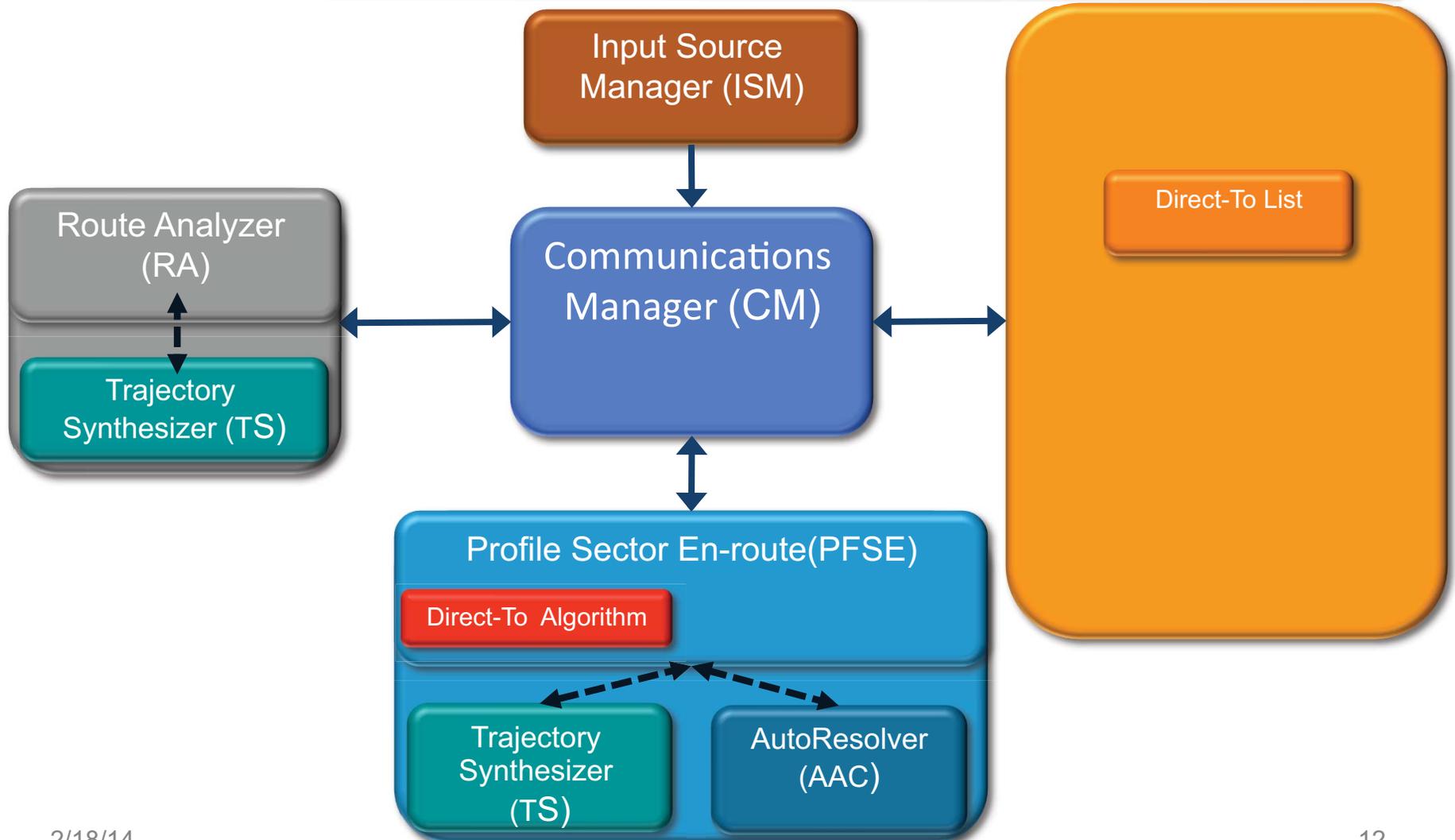
DWR Software Components

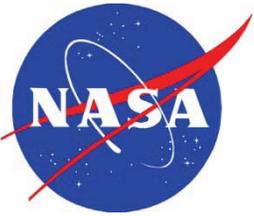
TS, AAC

- **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

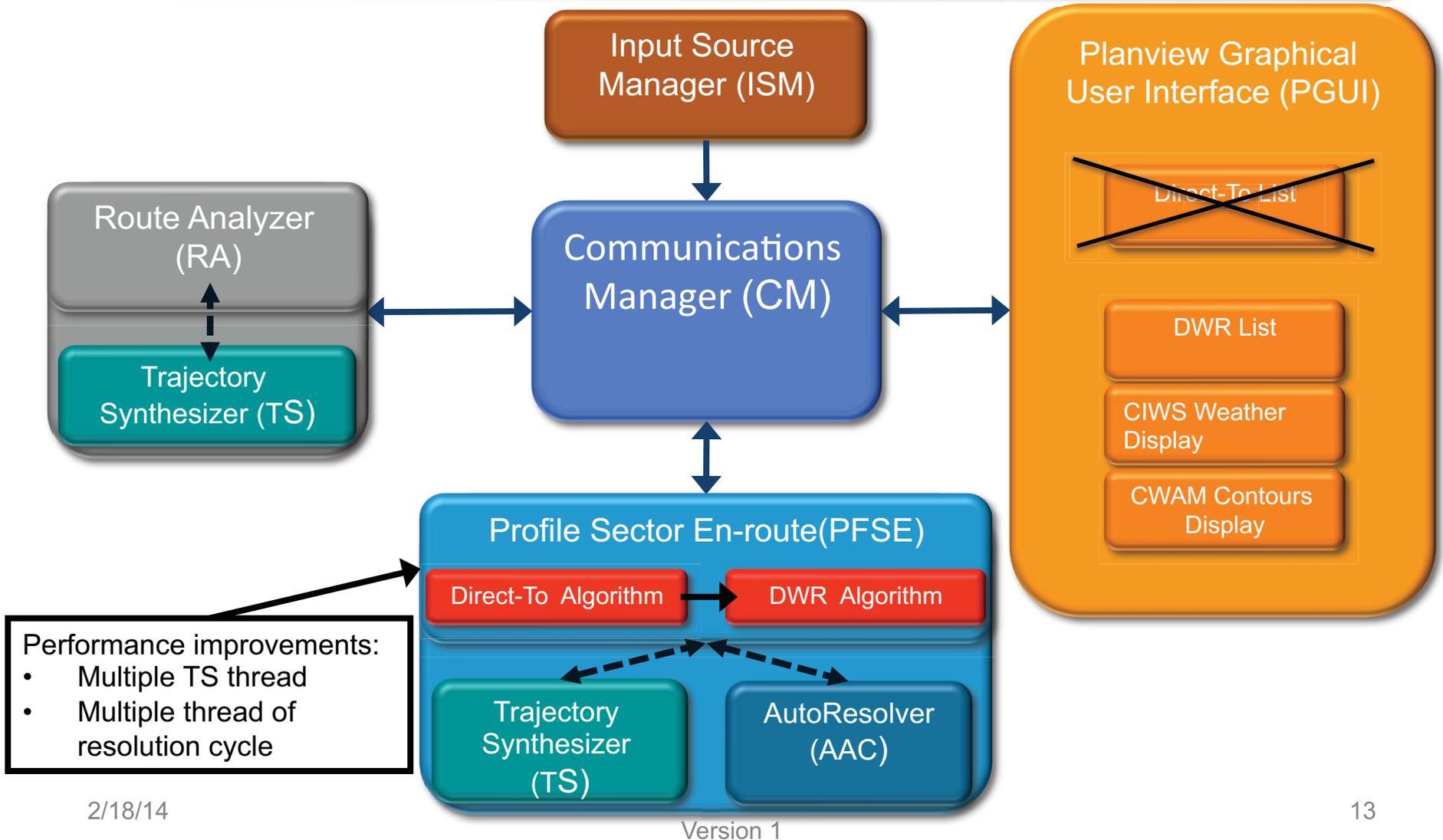


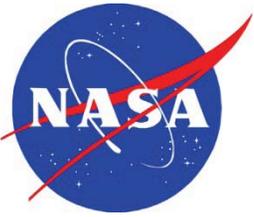
Direct-To Software Components – Foundation for DWR



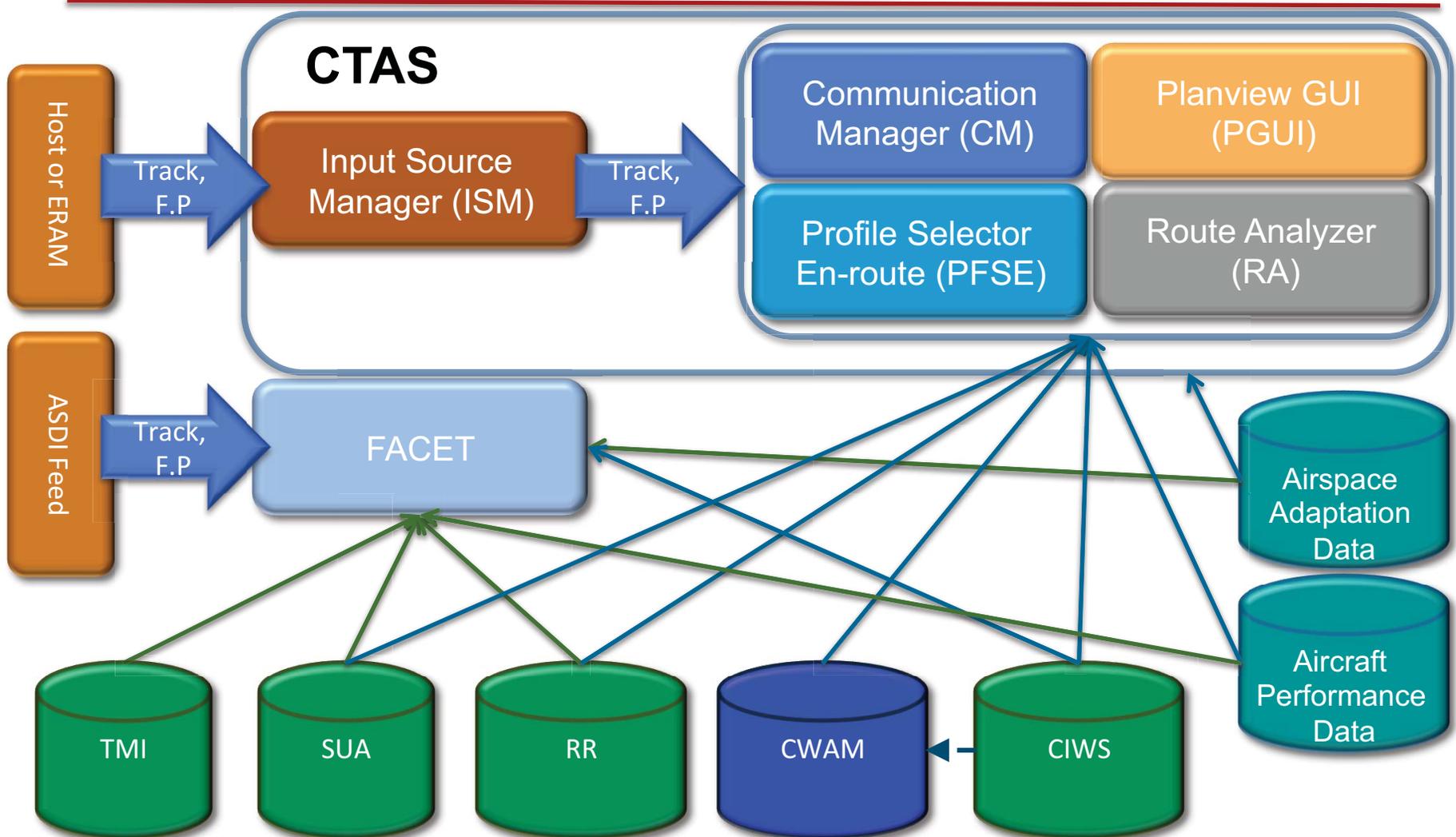


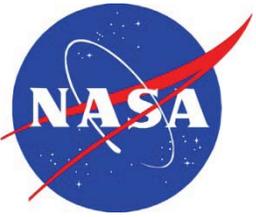
DWR Changes to Direct-To Software



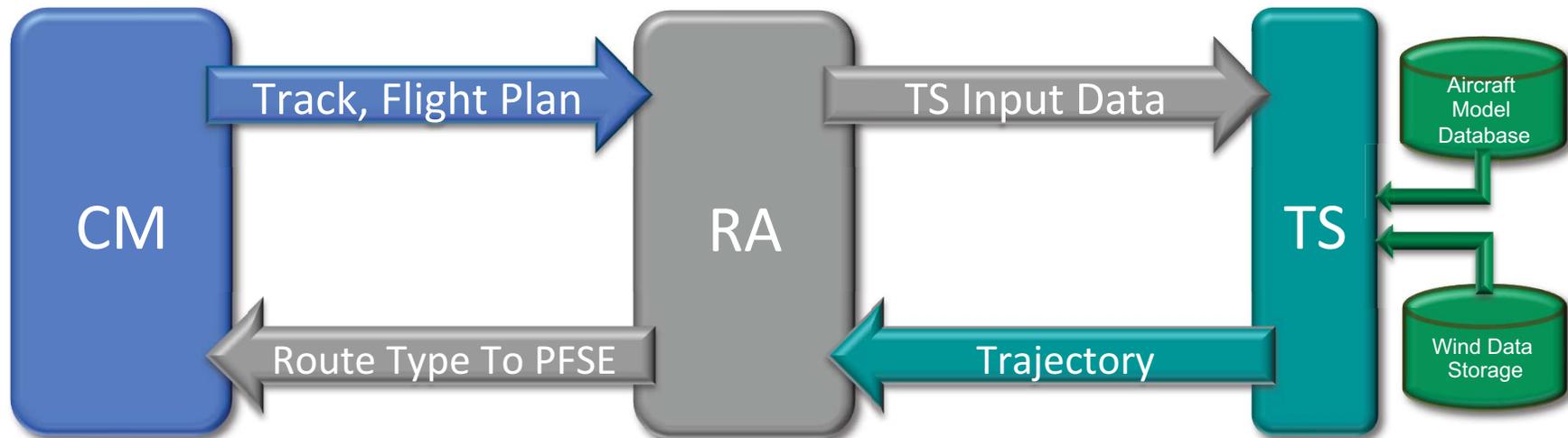


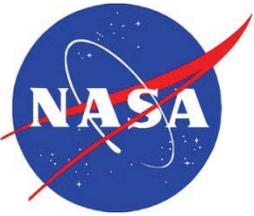
DWR Data Flow: External Data



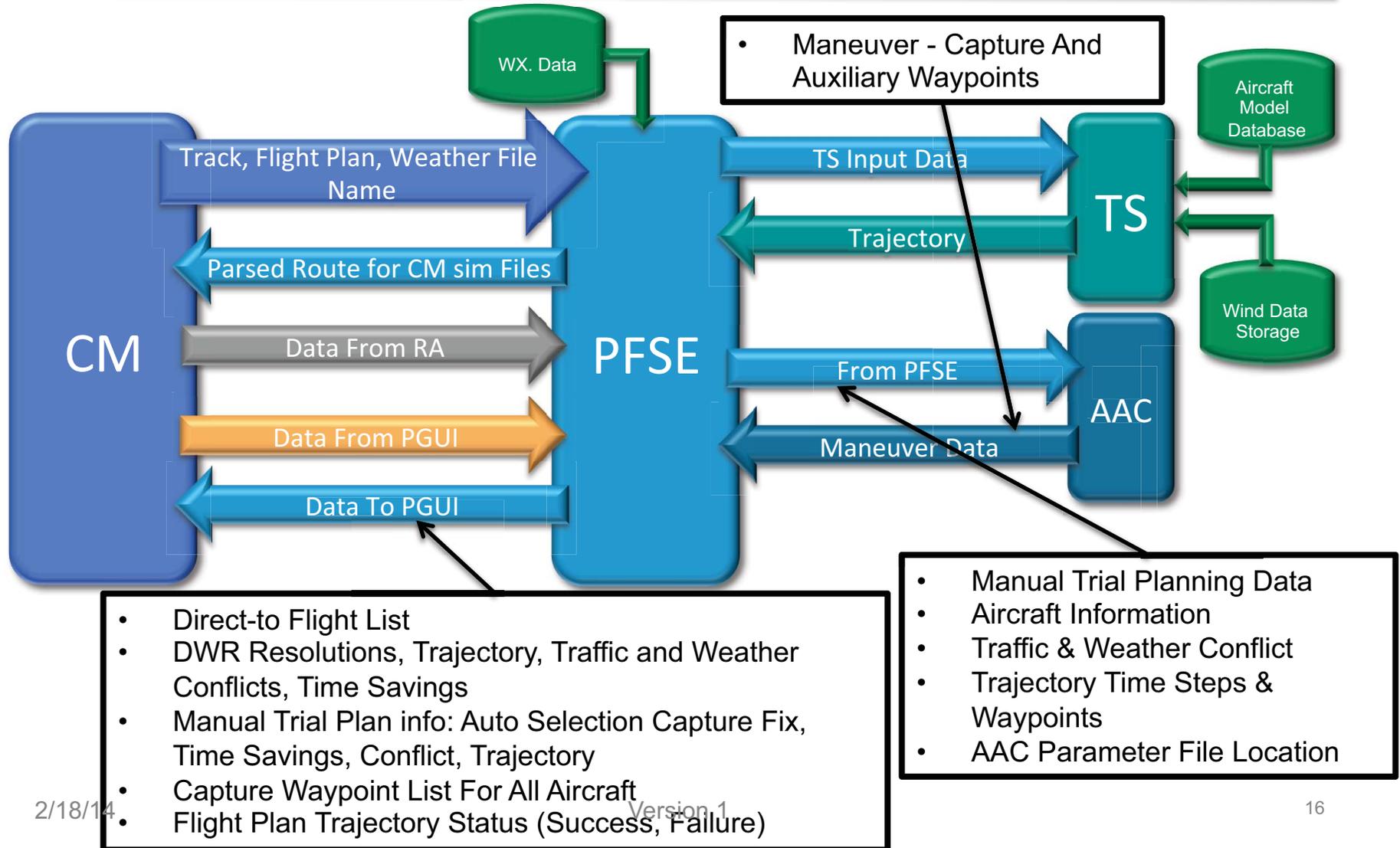


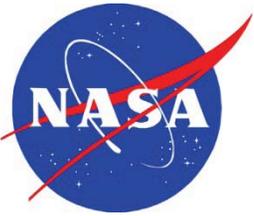
DWR Internal Data Flow: RA



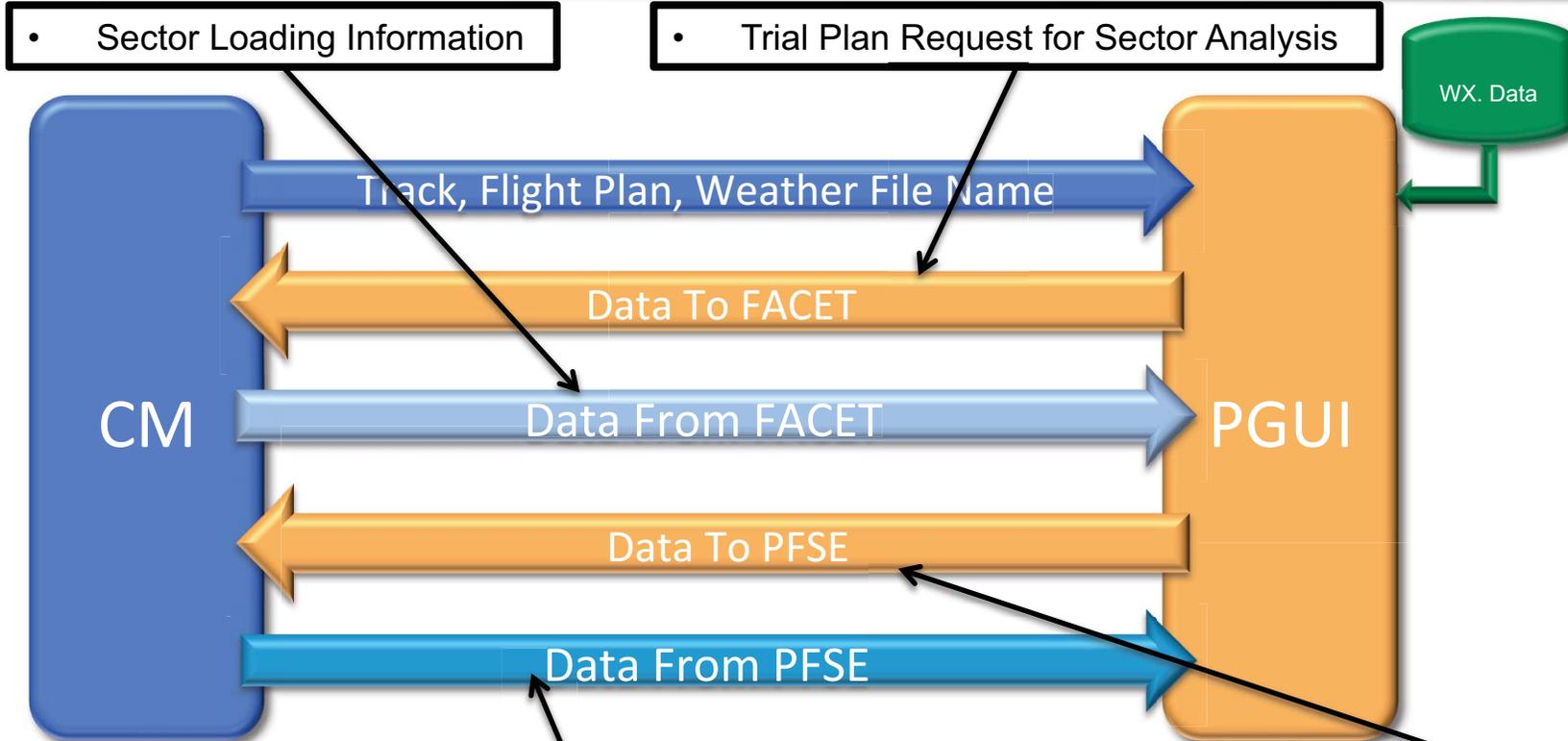


DWR Internal Data Flow: PFSE



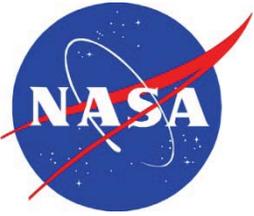


DWR Internal Data Flow: PGUI



- 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)

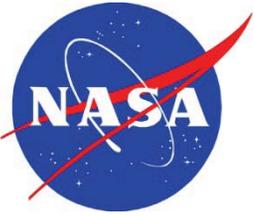
- Trial Plan Maneuver Request
- Trajectory Data Request
- Conflict Prediction Parameters (adjusted from PGUI)



DWR/CTAS Host Data Elements: Host Flight Plan

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

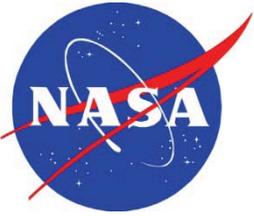
Note: Flight plan information is required on initiation of a flight and whenever the value of an element changes



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

- **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.



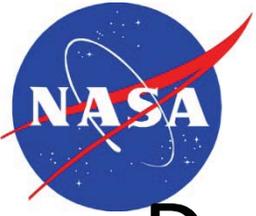
DWR/CTAS Host Data Elements: Host Track

- **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



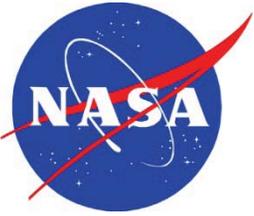
DWR/CTAS Host Data Elements: Host Track – Cont'd

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



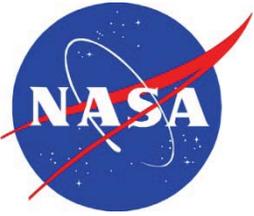
DWR/CTAS Host Data Elements: Drop Track, Delete Aircraft, Time Sync

- **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

- 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



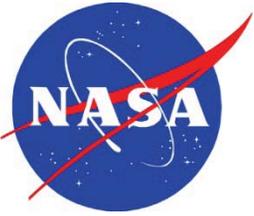
Software Characteristics

- 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



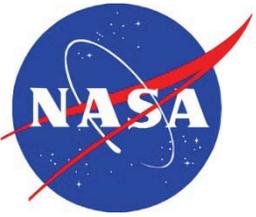
CTAS Software Stats

- 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

- 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

