Dynamic Weather Routes
Architecture Overview

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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

Live track data from direct FAA-to-NASA feeds

Host or ERAM Track, Flight Plan Messages
Airspace Adaptation Data
Aircraft Performance Data
Rapid Refresh Wind Forecast
Corridor Integrated Weather System Convective Forecast
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
DWR Software Components

Input Source Manager (ISM)

Communications Manager (CM)

Planview Graphical User Interface (PGUI)

Route Analyzer (RA)

Trajectory Synthesizer (TS)

Profile Sector En-route (PFSE)

Trajectory Synthesizer (TS)

AutoResolver (AAC)

2/18/14
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

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

Input Source Manager (ISM)

Communications Manager (CM)

Direct-To List

Profile Sector En-route (PFSE)

Route Analyzer (RA)

Trajectory Synthesizer (TS)

AutoResolver (AAC)

Direct-To Algorithm

Trajectory Synthesizer (TS)
DWR Changes to Direct-To Software

Performance improvements:
- Multiple TS thread
- Multiple thread of resolution cycle

Planview Graphical User Interface (PGUI):
- Direct-To List
- DWR List
- CIWS Weather Display
- CWAM Contours Display

Profile Sector En-route (PFSE):
- Direct-To Algorithm
- DWR Algorithm

Route Analyzer (RA):
- Trajectory Synthesizer (TS)

Communications Manager (CM):
- Input Source Manager (ISM)
DWR Internal Data Flow: RA

CM

RA

TS

Track, Flight Plan

Route Type To PFSE

TS Input Data

Trajectory

Aircraft Model Database

Wind Data Storage

Version 1 2/18/14
DWR Internal Data Flow: PFSE

- Direct-to Flight List
- DWR Resolutions, Trajectory, Traffic and Weather Conflicts, Time Savings
- Manual Trial Plan info: Auto Selection Capture Fix, Time Savings, Conflict, Trajectory
- Capture Waypoint List For All Aircraft
- Flight Plan Trajectory Status (Success, Failure)

- Maneuver - Capture And Auxiliary Waypoints
- Manual Trial Planning Data
- Aircraft Information
- Traffic & Weather Conflict
- Trajectory Time Steps & Waypoints
- AAC Parameter File Location

CM
- Track, Flight Plan, Weather File Name
- Parsed Route for CM sim Files
- Data From RA
- Data From PGUI
- Data To PGUI

PFSE
- WS. Data
- TS Input Data
- Trajectory
- From PFSE
- Maneuver Data

AAC

Aircraft Model Database

Wind Data Storage
DWR Internal Data Flow: PGUI

- Sector Loading Information
- Trial Plan Request for Sector Analysis
- Trial Plan Maneuver Request
- Trajectory Data Request
- Conflict Prediction
- Parameters (adjusted from 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)

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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 OS X (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)