



# Linking Cockpit and Air Traffic Control Automation: CTAS/FMS Integration

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## DAG-TM Industry Workshop

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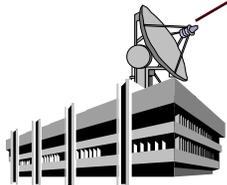
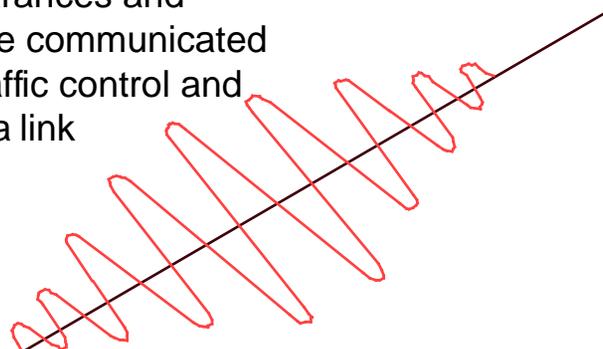
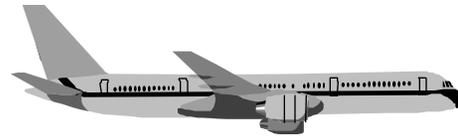
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# Efficient Arrival Management Utilizing ATC and Aircraft Automation



## Cockpit Automation

- ✧ Trajectory clearances and aircraft data are communicated between air traffic control and aircraft via data link

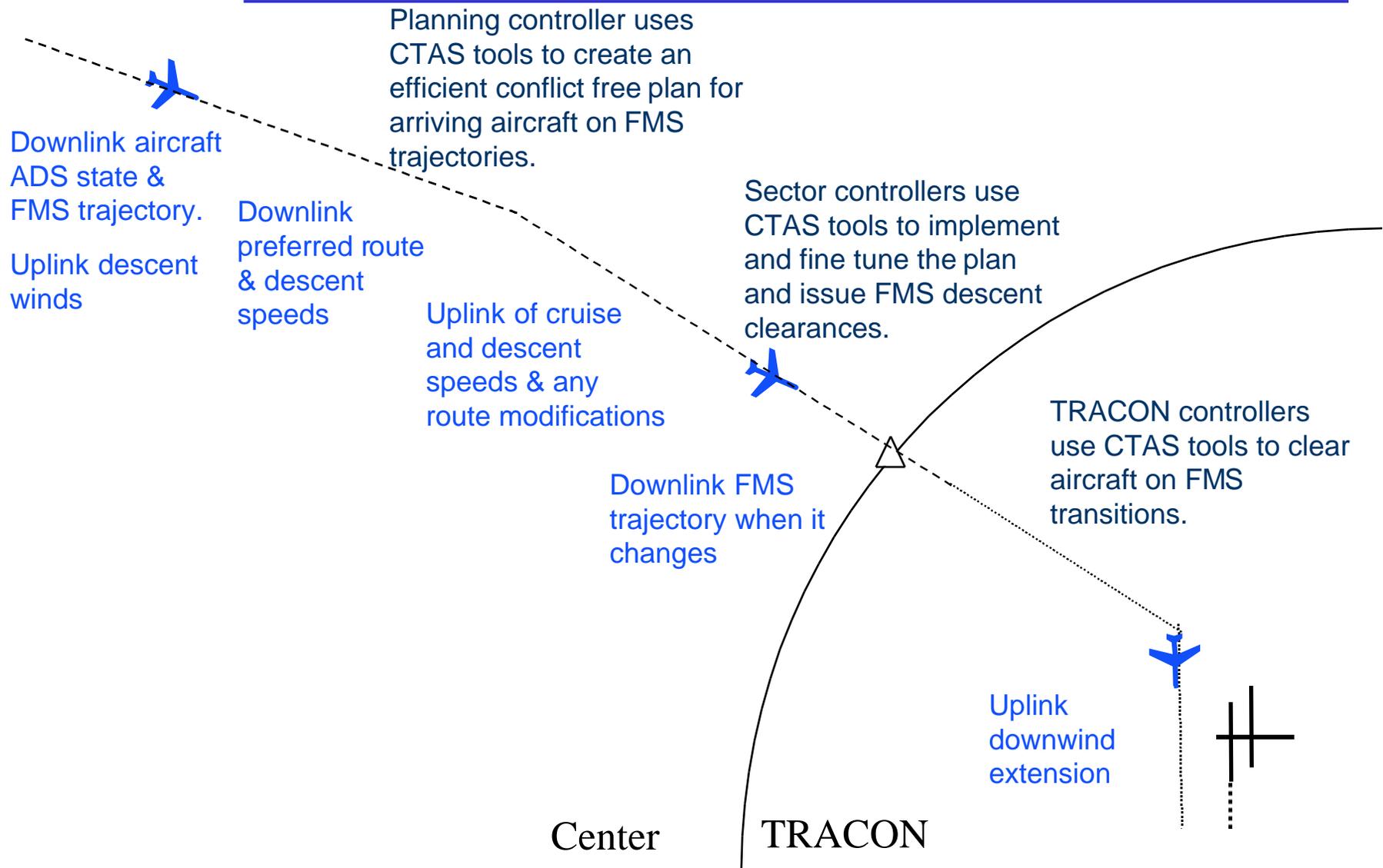


*Center TRACON  
Automation System  
CTAS*



- ✧ Flight crews follow these trajectories accurately using the aircraft's FMS automation.
- ✧ Air traffic controllers determine an efficient conflict free plan for arriving aircraft using the Center TRACON Automation System (CTAS) in order to:
  - ✧ **reduce flight delays**
  - ✧ **increase throughput**
  - ✧ **ensure flight safety**

# CTAS/FMS Integration Scenario



# CTAS/FMS Operational Concept

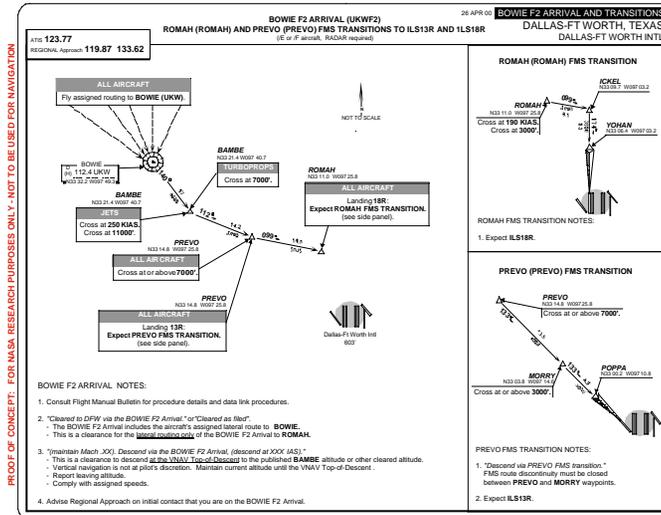
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- Air/ground information exchange for better trajectory predictions.
- CTAS compatible FMS routes and descent procedures.
- Downlink of user preferred arrival and descent trajectories for arrival planning in Center airspace.
- Uplink of CTAS advised cruise & descent speed and route modifications in Center airspace.
- Uplink of CTAS/FAST routes to FMS aircraft for more precise control of interarrival spacing in TRACON airspace.

# Charts and Procedures



- Operator Task Models
  - Cognitive Walkthrough Methodology
  - Crew Activity Tracking System
- Charting
  - FMS Arrival & VNAV Descent
  - FMS transitions
- Phraseology
  - "Descend via the BOWIE F2 Arrival, maintain 290 knots in the descent."
- Training Material
  - Flight Manual Bulletin

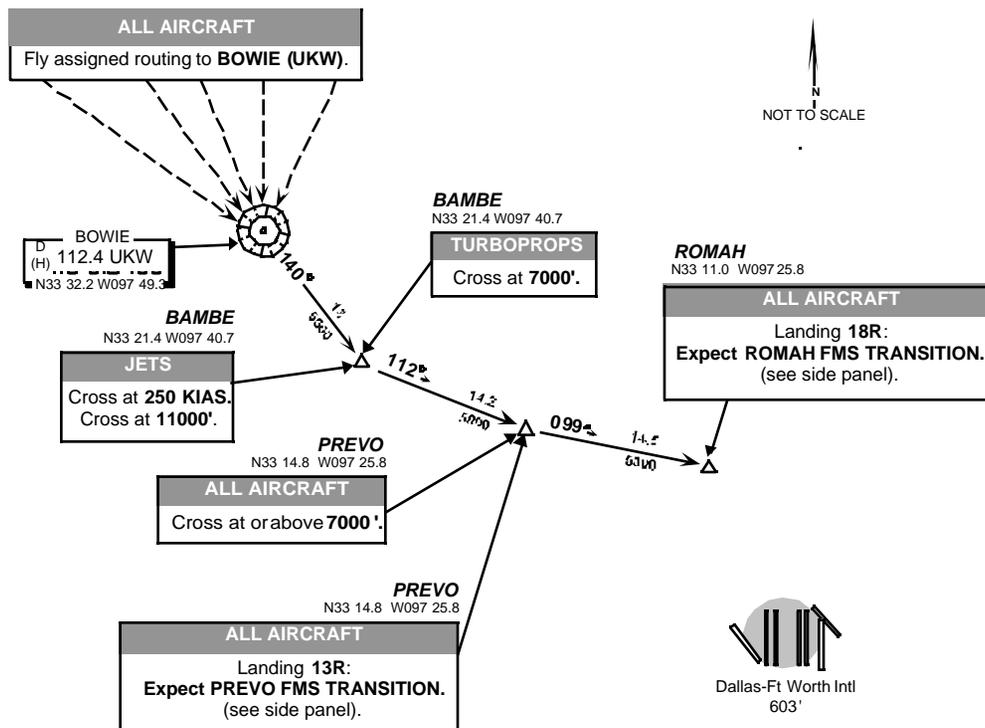


FLIGHT MANUAL BULLETIN		Insert	757-000-00-10
		Remove	N/A
<p><b>FMS ARRIVALS AND APPROACH TRANSITIONS</b></p> <p>Two FMS arrivals (Bowie F2 (UKWF2), and Glen Rose F2 (JENF2)) and approach transitions are being tested at Fort Worth Center and Dallas-Fort Worth Regional Approach Control. They are designed to enable efficient FMS descents to be flown from the VNAV top-of-descent to the final approach fix. These FMS arrivals and approach transitions are used in combination with an ATC traffic-planning tool, and can be used in conjunction with data link. Data link is not required to fly these FMS arrivals and approach transitions, but helps to accurately plan an efficient descent. Use of lateral FMS guidance (e.g., LNAV, NAV) is required, and use of vertical FMS guidance (VNAV, PROF) is strongly recommended.</p> <p>These four pages describe voice and data link methods for flying the FMS arrival and approach transitions.</p> <p><b>FMS ARRIVALS FOR DFW (FORT WORTH CENTER)</b></p> <p>Described on this page are the FMS arrival clearances to be issued by voice. This applies to both the Bowie F2 arrival and the Glen Rose F2 arrival, regardless of whether or not data link is used.</p> <p><b>FMS ARRIVAL CLEARANCES</b></p> <p><b>Lateral Route Clearance:</b> "Cleared to DFW via the Bowie F2 Arrival" (60) "Cleared as filed." The aircraft is cleared to fly the assigned or filed lateral FMS arrival route using coupled FMS guidance.</p> <p><b>Descent Clearance:</b> Both data link and non-data link equipped aircraft must receive a descent clearance by voice before descent may be initiated: "Descend via Bowie F2 Arrival". The aircraft is cleared to descend via the FMS arrival route to the final charted altitude restriction. The ATC traffic planning tool has knowledge of the aircraft's FMS trajectory, and expects the aircraft to remain within 10 kts and 1000 ft of vertical FMS profile or risk additional delay vectors. Use of vertical FMS guidance (e.g., VNAV, PROF) is recommended.</p> <p><b>Speed Assignments:</b> In addition to the crossing restrictions on the FMS Arrival chart, cruise and descent speeds may be assigned. For example: "Maintain mach .80. Descend via Bowie F2 Arrival, descend at 300 knots." If ATC assigns cruise or descent speeds:  <ul style="list-style-type: none"> <li>Enter assigned cruise mach or airspeed in the CDU CRZ page.</li> <li>Enter assigned descent speed in the CDU DES PAGE.</li> <li>"Execute" the speed modification.</li> </ul> </p> <p><b>NOTES:</b> Entry of the descent speed affects the FMS top-of-descent and is important for ATC descent planning. The ATC tools assume that FMS automation manages the cruise-to-descent speed transition.</p>			

**BOWIE F2 ARRIVAL (UKWF2)**  
**ROMAH (ROMAH) AND PREVO (PREVO) FMS TRANSITIONS TO ILS13R AND 1LS18R**  
 (/E or /F aircraft, RADAR required)

**DALLAS-FT WORTH, TEXAS**  
**DALLAS-FT WORTH INTL**

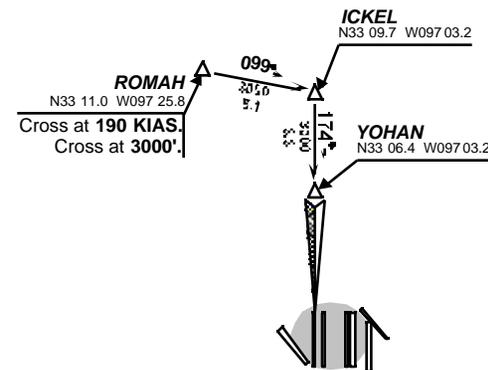
ATIS **123.77**  
 REGIONAL Approach **119.87 133.62**



**BOWIE F2 ARRIVAL NOTES:**

- Consult Flight Manual Bulletin for procedure details and data link procedures.
- "Cleared to DFW via the BOWIE F2 Arrival." or "Cleared as filed".
  - The BOWIE F2 Arrival includes the aircraft's assigned lateral route to **BOWIE**.
  - This is a clearance for the lateral routing only of the BOWIE F2 Arrival to **ROMAH**.
- "(maintain Mach .XX). Descend via the BOWIE F2 Arrival, (descend at XXX IAS)."
  - This is a clearance to descend at the VNAV Top-of-Descent to the published **BAMBE** altitude or other cleared altitude.
  - Vertical navigation is not at pilot's discretion. Maintain current altitude until the VNAV Top-of-Descent.
  - Report leaving altitude.
  - Comply with assigned speeds.
- Advise Regional Approach on initial contact that you are on the BOWIE F2 Arrival.

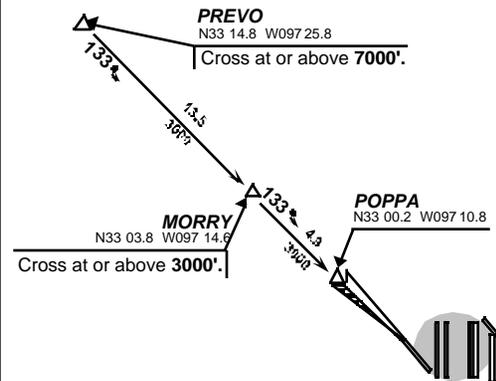
**ROMAH (ROMAH) FMS TRANSITION**



ROMAH FMS TRANSITION NOTES:

- Expect ILS18R.

**PREVO (PREVO) FMS TRANSITION**



PREVO FMS TRANSITION NOTES:

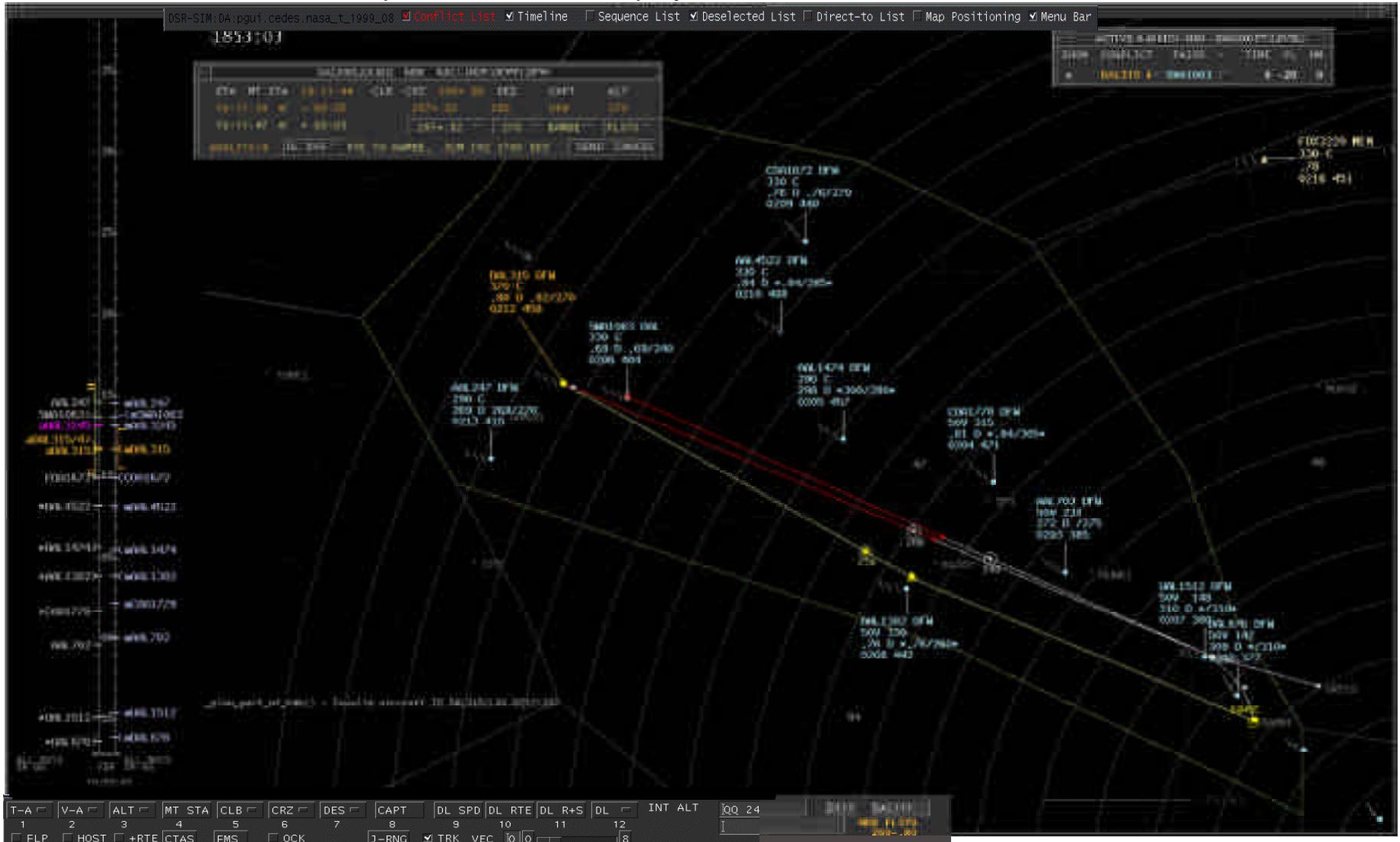
- "Descend via PREVO FMS transition." FMS route discontinuity must be closed between **PREVO** and **MORRY** waypoints.
- Expect ILS13R.

PROOF OF CONCEPT: FOR NASA RESEARCH PURPOSES ONLY - NOT TO BE USED FOR NAVIGATION

# CTAS/FMS Center Tools & Controller Interface



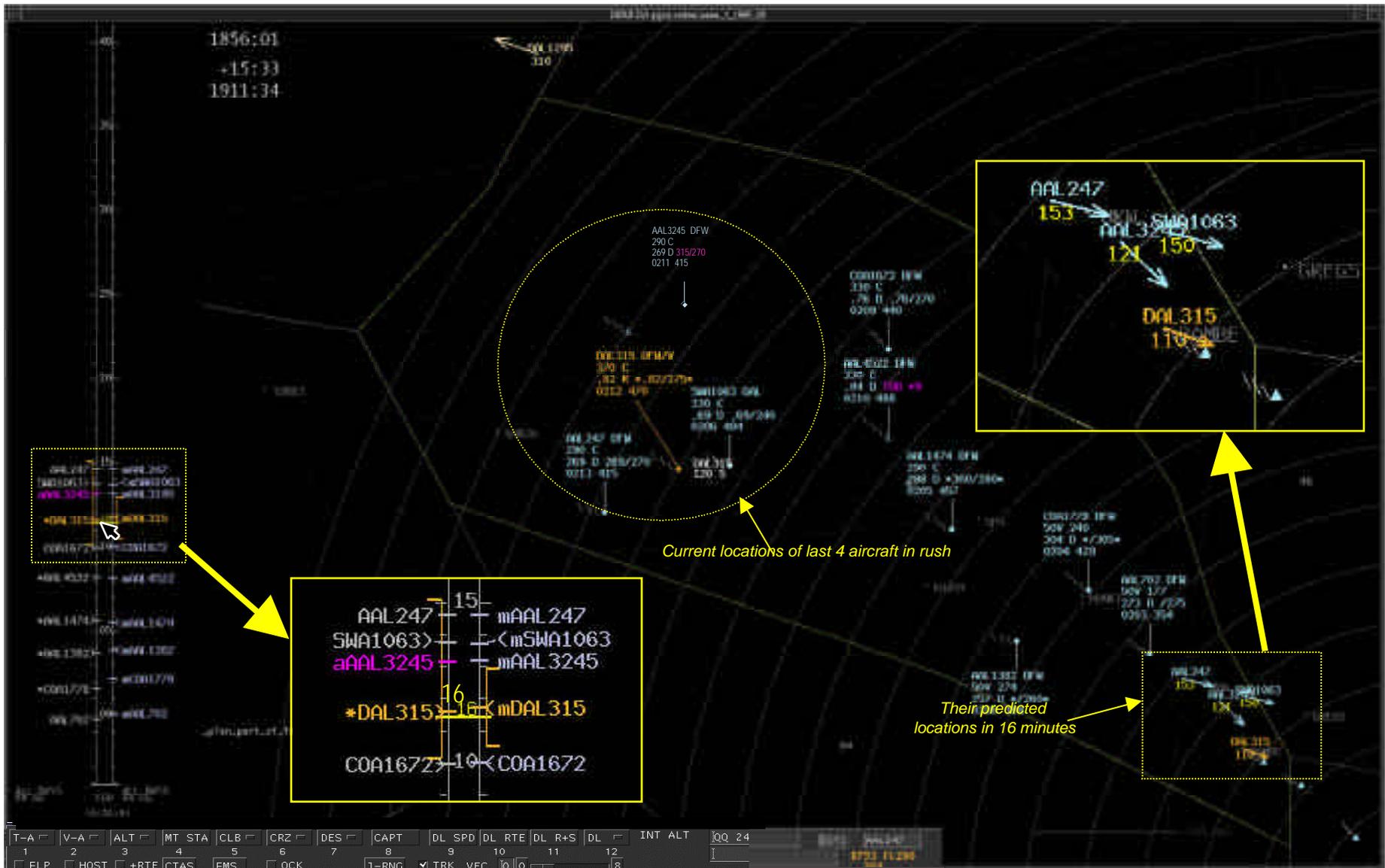
- Meet time cruise and descent speed advisories
- Multi-aircraft trial planning for transition airspace
- Multi-aircraft trajectory preview display
- Datalink for information exchange & trajectory clearances
- Toolbar for clearance input, datalink and display control.





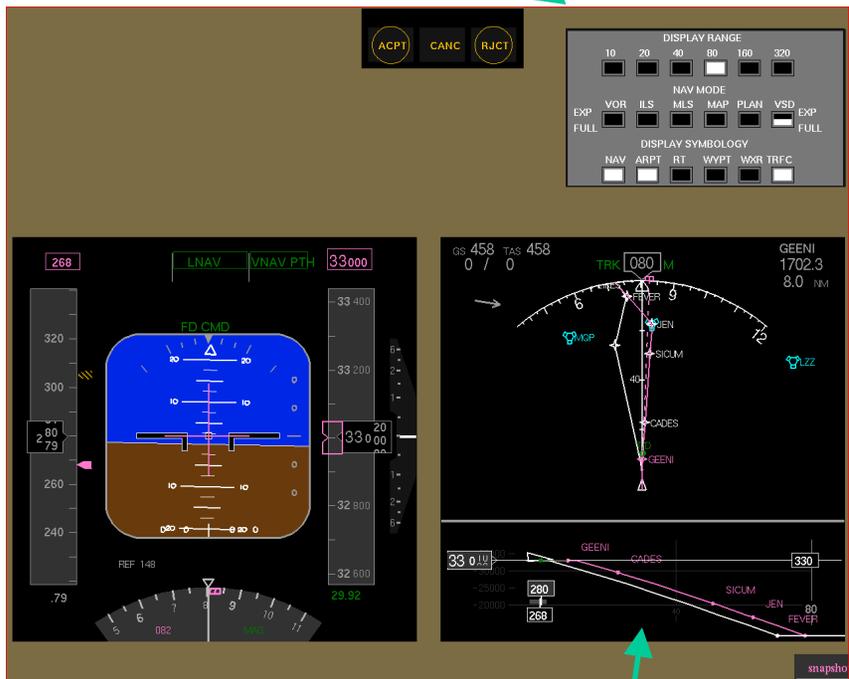
# CTAS/FMS Center Tools & Controller Interface

- Multi-aircraft trajectory preview display



# Flight Crew Interface Enhancements

data link interface (~777)



vertical situation display

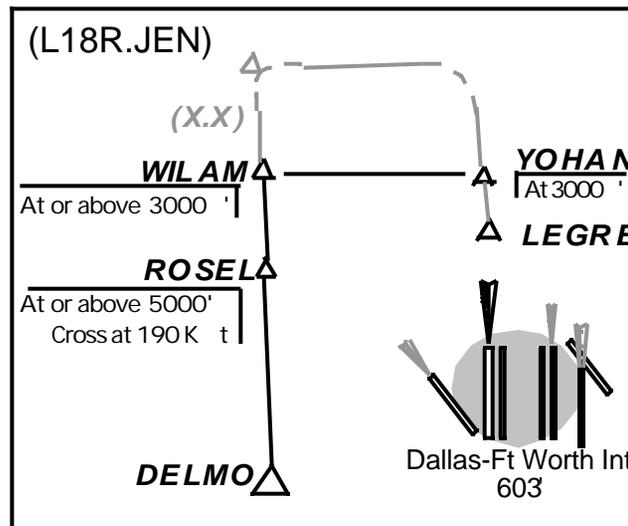


- Fewer button presses for less headdown time on the CDU
- VSD to aid assessment of route uplinks

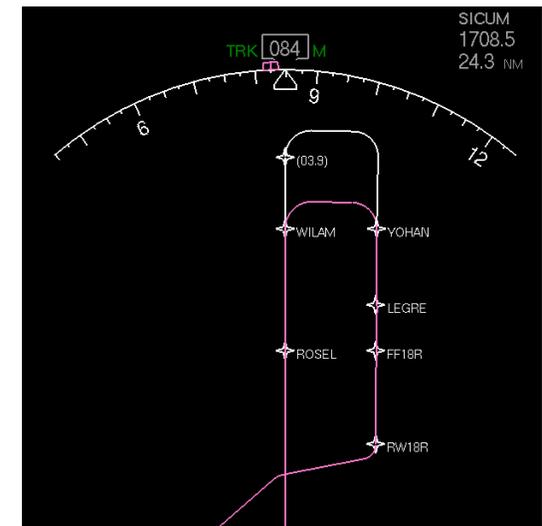
# Common CTAS & FMS Route Databases & Charts



The CTAS TRACON PGUI with a PFS route

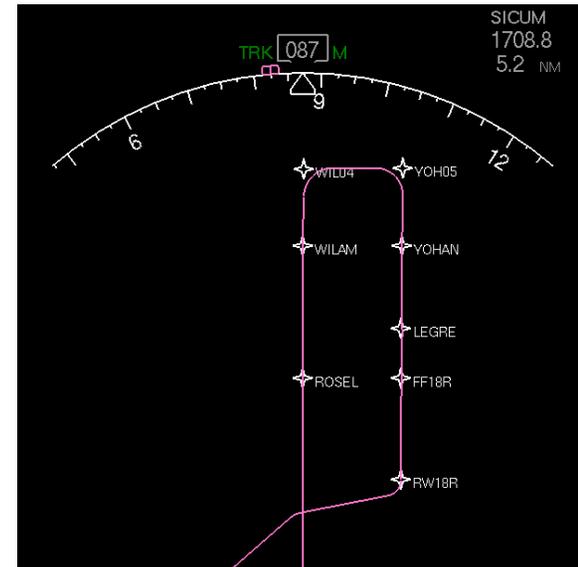
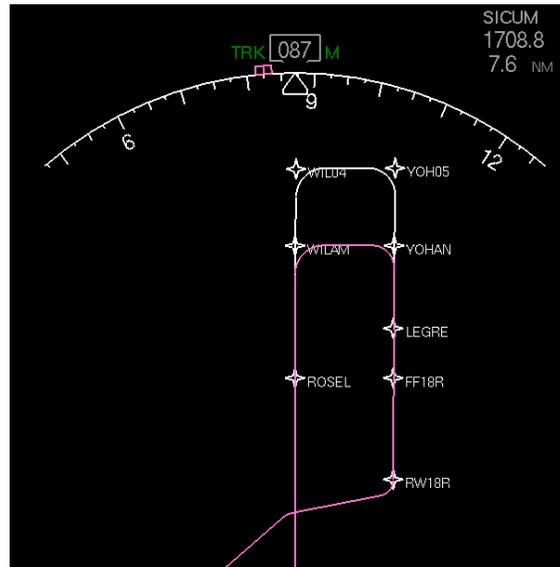
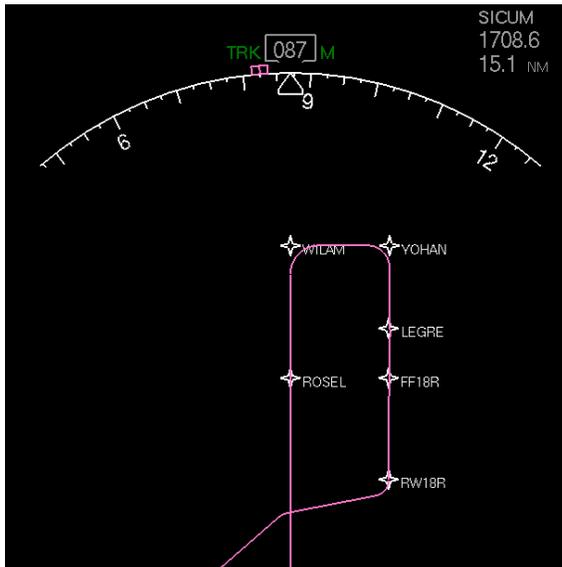


Section of the JEN FMS Arrival Chart



Flight Deck Navigation Display

# A Datalink Function Route Modification Uplink



```

2010z ATC UPLINK          1/1
                        STATUS
                        OPEN

----- MOD ROUTE CLEARANCE -----
JEN.18R FMS ARRIVAL
DOWNWIND EXTENSION 3.9 NM

LOAD>

<REJECT
<PRINT          LOG>
    
```

LOAD

```

2010z ATC UPLINK          1/1
                        STATUS
                        OPEN

----- MOD ROUTE CLEARANCE -----
JEN.18R FMS ARRIVAL
DOWNWIND EXTENSION 3.9 NM

ACCEPT>

<REJECT
<PRINT          LOG>
    
```

ACCEPT

```

MOD RTE 1 LEGS          1/1
353°          14 NM          190/5000A
ROSEL
353°          6 NM
WILAM          <CTR>          190/3000
353°          3 NM
WIL05          190/3000
004°          5 nm          190/3000
YOH05
174°          5 nm          170/3000
YOHAN
----- MAP CTR
<ERASE          STEP>
    
```

EXECUTE

# CTAS/FMS Simulation Study

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- ATM simulation at Ames
  - 3 Center sectors + a planning position
  - 3 TRACON sectors
- Aircraft simulators at Langley & Ames
  - Full-Mission B757 Simulator
  - Advanced Concepts Flight Simulator (ACFS)
- Participants
  - 6 controller teams
  - 12 flight crews
- Conditions
  - 2010 time frame
  - CTAS Tools: TMA, DA, FAST
  - All aircraft FMS equipped
  - 20% & 80% datalink equippage
  - Piloted simulators have traffic displays
  - A no tool control condition

# Sources of Potential Benefits

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- Information exchange for trajectory prediction accuracy
- User preferences for more cost effective descents
- FMS routes for more controllable & precise trajectories
- FMS routes for increased safety
- Fewer clearances

Key idea: if an aircraft can remain on FMS trajectory until the final approach fix a number of sources of arrival time error are eliminated.

# Concluding Remarks

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What we plan to demonstrate ...

- Center
  - Increased efficiency of arrival traffic management.
    - Reducing average delays
    - Accomodating user preferences
- TRACON
  - Increased throughput.
    - Reducing inter-arrival time variability

... with minimal changes to today's FMS and datalink systems.

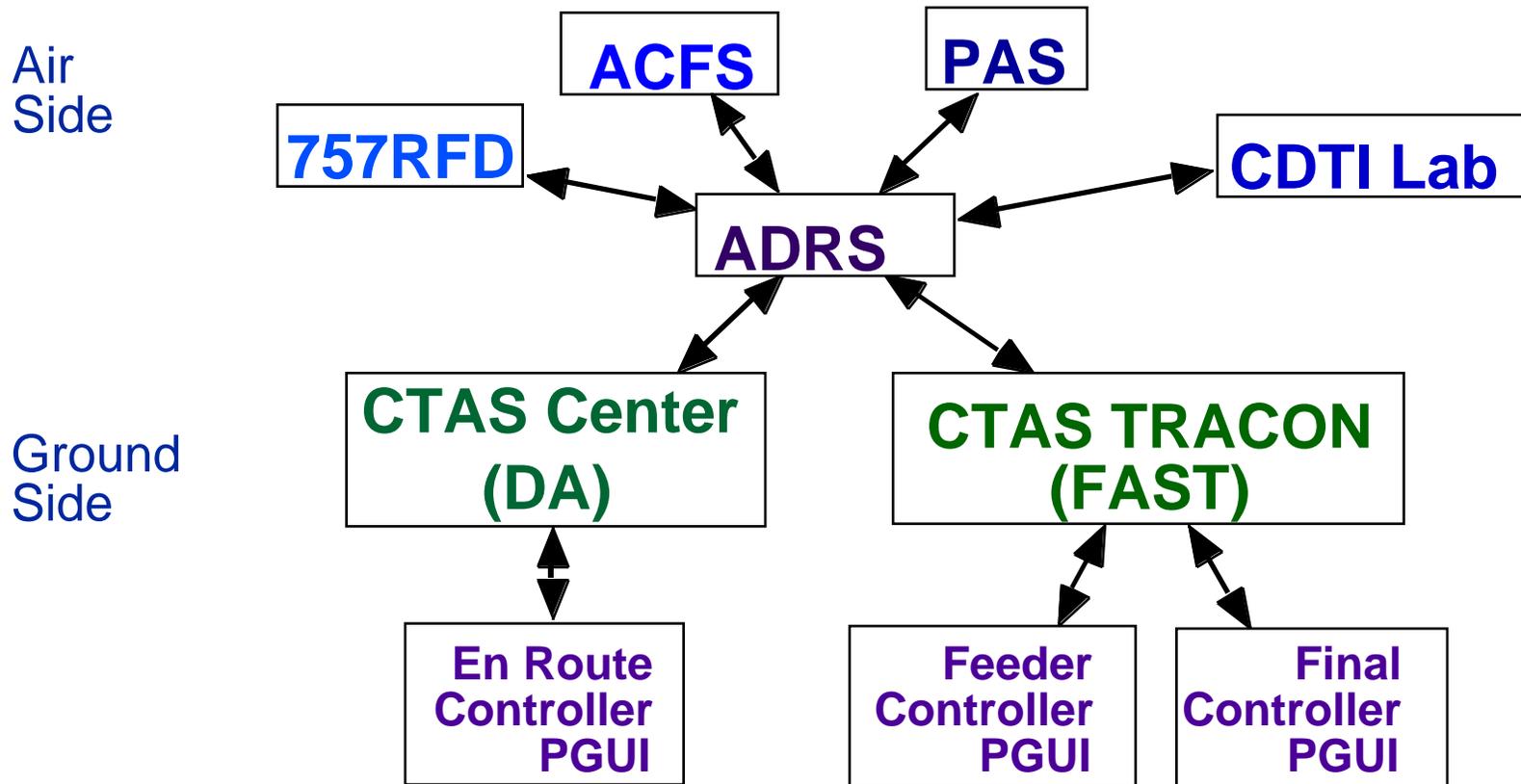
# Plans for FY01

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CE-11 Pilots use traffic displays and guidance to fine tune spacing.

CE-5 Pilots and controllers both use trajectory manipulation tools to coordinate deviations around weather.

# CTAS/FMS Simulation Components



All air-ground datalink communications use a common protocol.