OPD Challenges for Regional Jets

Exploring solutions for enhanced safety and increased efficiencies while conducting Optimized Profile Descents

ACF 13-01
RD 13-01-264

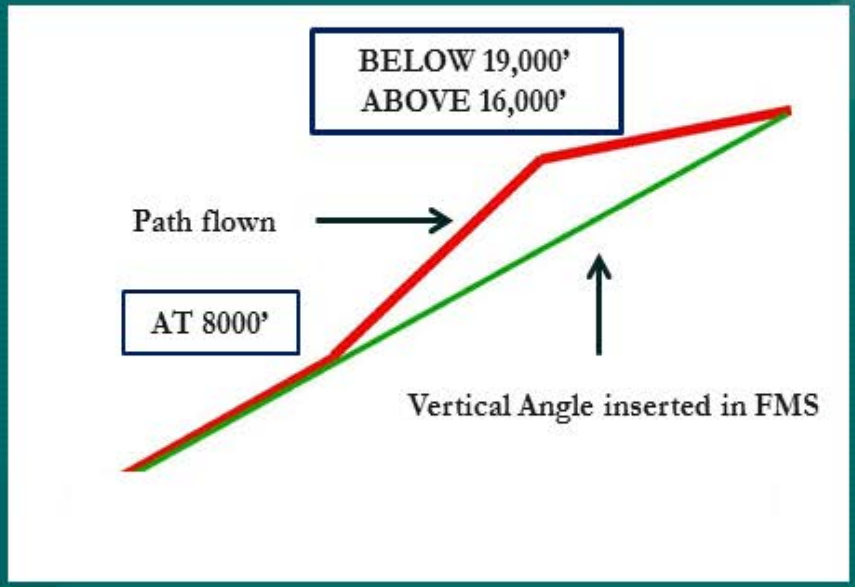
VNAV and CRJs

- Background
  - Brand new CRJ aircraft have ‘coupled VNAV’ capability. Not many new CRJ orders / deliveries
  - Current CRJ aircraft do not have:
    - Autopilot coupled VNAV
    - Auto-throttles
    - FMS altitude / airspeed alerting

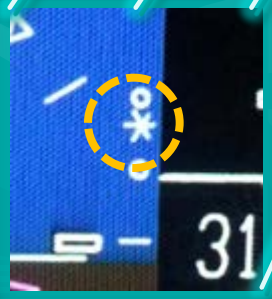
What the FMS does

- Uses a calculated vertical path angle.
- The angle comes from the defaults page (we set it to 3.0°).
- The angle can be changed by the flight crew.

- The FMS then creates a line from the first HARD altitude at the programmed angle.
- If the line does not fit an entered altitude limitation then the FMS adjusts the line to comply with the entered restrictions.
- This is called 'VNAV Smoothing'.



What the Crew does



Snowflake

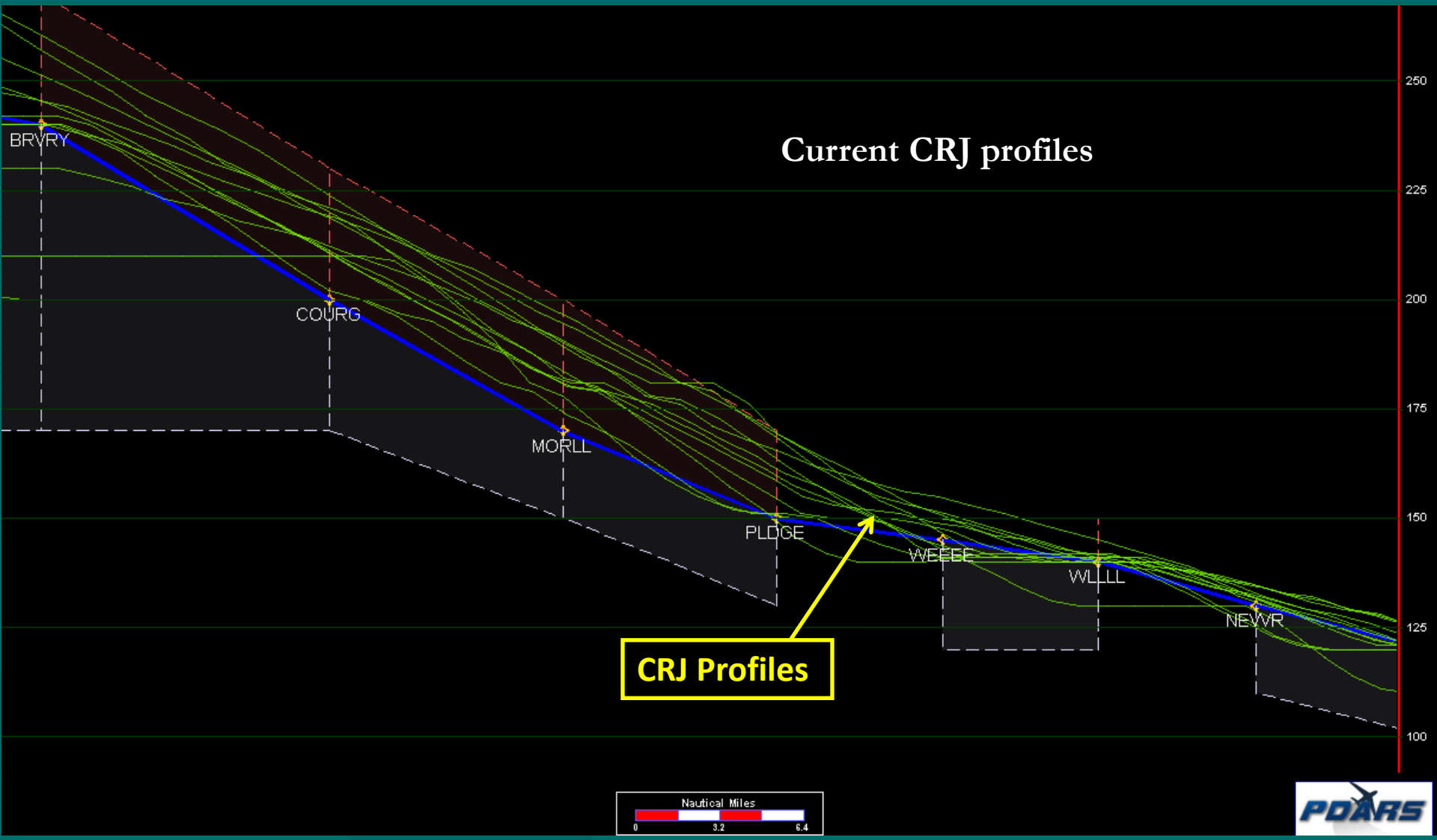
- Once the FMS is programmed the crew will manually fly the profile.
- The aircraft displays an 'advisory VNAV' on the PFD.
- When the aircraft is within 1/2 ° the advisory VNAV will display on the PFD.

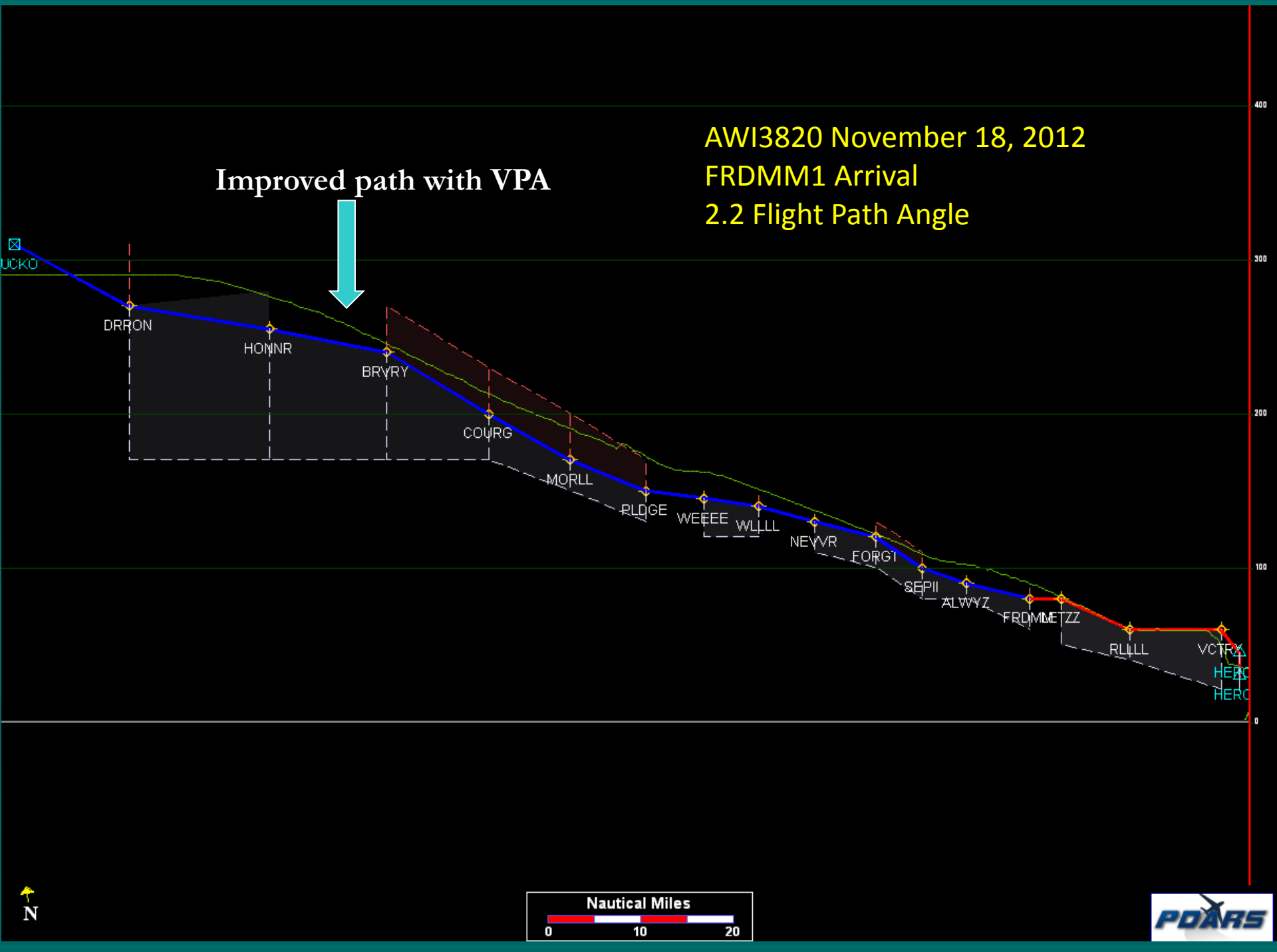
- The crew will then adjust vertical speed and thrust to maintain the programmed or adjusted vertical path and airspeed.
- When adjustments are needed due to VNAV smoothing the crew will see the advisory VNAV diverge from their current course. Then more adjustments are needed to stay on desired path.

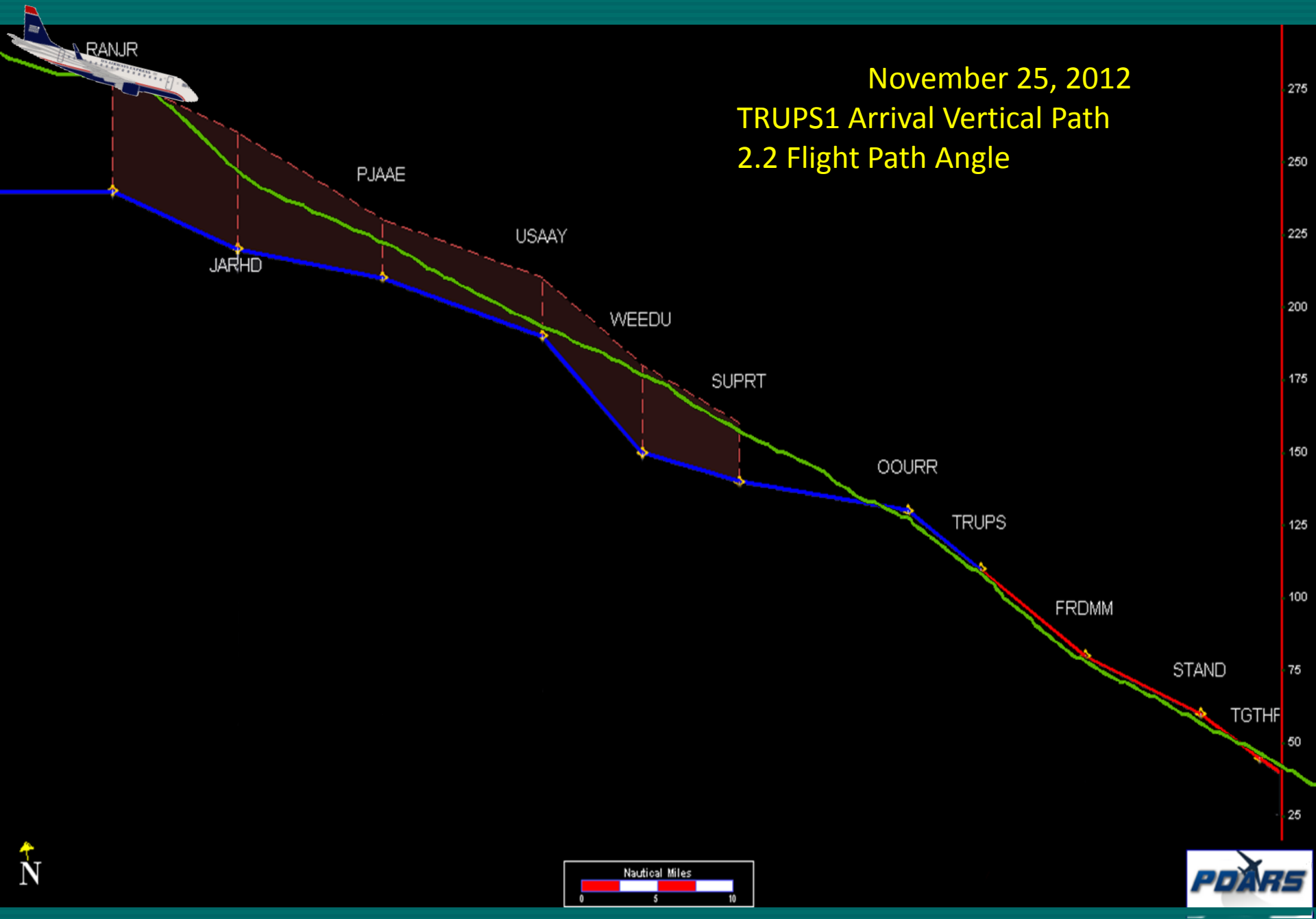
Differences in Flight Path Angle

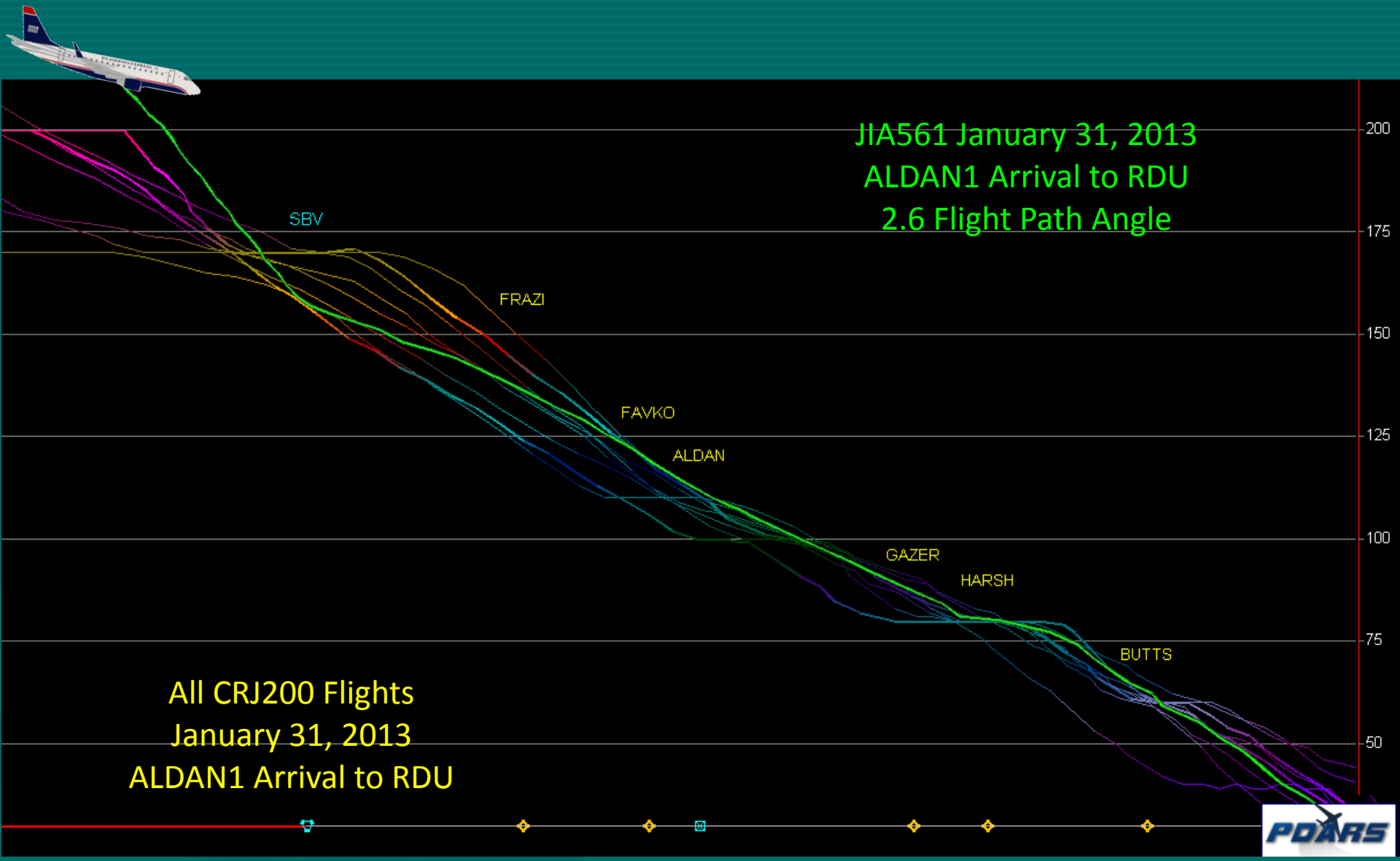
KDCA FRDMM 1

- Using default 3.0° flight path angle
  - Vertical speed changes from 1100 fpm to 2200 fpm along the arrival
  - There are three locations the FMS advises the crew to level off. (After WEEEE, NEVVR, and ALWYZ)
  - Thrust adjustment are necessary after most fixes due to changes in vertical speed.
- Using a calculated 2.2° flight path angle
  - Vertical speed changes from 1400 fpm to 1800 fpm along the arrival.
  - There are NO level offs.
  - Minimal thrust adjustments needed to maintain airspeed.


Current CRJ profiles
BRVRY
COURG
MORLL
PLDGE
WEEEE
WLLLL
NEWVR
250
225
200
175
150
125
100
CRJ Profiles
Nautical Miles
0
3.2
6.4
PDARS


Improved path with VPA
AWI3820 November 18, 2012
FRDMM1 Arrival
2.2 Flight Path Angle
UCKO
DRRON
HONNR
BRVRY
COVRG
MORLL
RLDGE
WEEEE
WLLLL
NEVVR
FORGT
SEPII
ALWYZ
FRDMMETZZ
RLLLL
VCTRX
HERC
HERC
400
300
200
100
0
N
Nautical Miles
0
10
20
PDARS


November 25, 2012
TRUPS1 Arrival Vertical Path
2.2 Flight Path Angle
RANJR
PJAAE
USAAY
JARHD
WEEDU
SUPRT
OOURR
TRUPS
FRDMM
STAND
TGTHF
275
250
225
200
175
150
125
100
75
50
25
N
Nautical Miles
0
5
10
PDARS


JIA561 January 31, 2013
ALDAN1 Arrival to RDU
2.6 Flight Path Angle
SBV
FRAZI
FAVKO
ALDAN
GAZER
HARSH
BUTTS
200
175
150
125
100
75
50
All CRJ200 Flights
January 31, 2013
ALDAN1 Arrival to RDU
PDARS

Lessons Learned

Hard altitude is set, based on runway transition in use

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ACT LEGS 201                1/6
                          SEQUENCE
DRRON                  AUTO/INHIBIT
 106°    11NM     2.2°          ↓
HONNR              280/FL280B
 105°    13NM     2.2°          ↓
BRVRY              280/FL240AFL270B
 106°    11NM     2.6°          ↓
COURG              280/FL200AFL230B
 106°     9NM     2.2°          ↓
MORLL              280/17000AFL200B
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<LEG DATA              LEG WIND>
[                                  ]
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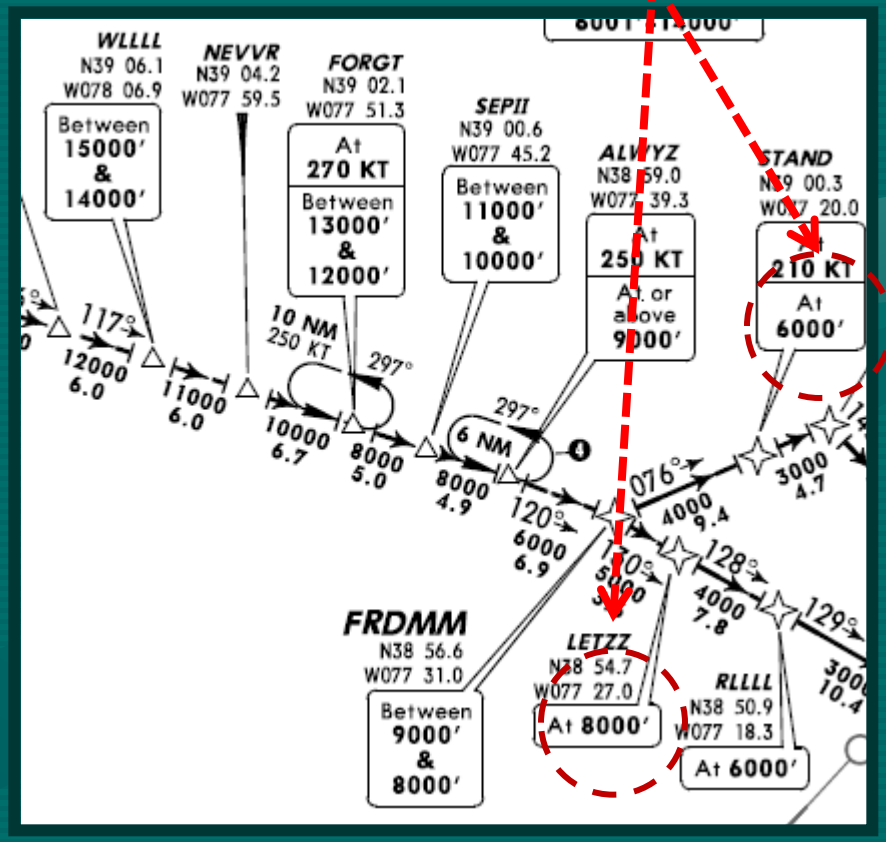

VPA increases between BRVRY and COURG. Pilot anticipates increased vertical descent

OPD Improvements

- Adjust / create the altitude constraints to allow for a constant angle from cruise altitude to the bottom of the procedure.
- The flight path angle works in all wind conditions as a 'Non-VNAV' aircraft FMS does not use wind inputs. Thrust required and vertical speed will be the only differences for wind.
- Publish on the chart the angle that was used in procedure design. This will allow the crew to adjust the vertical path specific to the arrival.

FRDMM1

	Angle	ft/NM	FRDMM	ALWYS	SEPII	FORGT	NEVVR	WILLL	WEEEE	PLDGE	MORLL	COURG	BRVRY	HONNR	DRRON
Distance between fixes			0	6.9	4.9	5	6.7	6	6	6.4	8.2	8.9	11	12.8	15.2
Total distance from FRDMM			0	6.9	11.8	16.8	23.5	29.5	35.5	41.9	50.1	59	70	82.8	98
BELOW			9,000	11,000	11,000	13,000	15,000	15,000	17,000	17,000	20,000	23,000	27,000	28,000	31,000
ABOVE			8,000	9,000	10,000	12,000		14,000		15,000	17,000	20,000	24,000		27,000
Actual Altitude	2.2	233	8,000	9,608	10,749	11,914	13,476	14,874	16,272	17,763	19,673	21,747	24,310	27,292	30,834
			Good	Good	Good	Good	Good	Good	Good	Higher	Good	Good	Good	Good	Good
			Good	Good	Good	Lower	Good	Good	Good	Good	Good	Good	Good	Good	Good

Specific Recommendations

- IVANE1 Runway 23 transition (KCLT)
  - Use 2.5°
  - Decrease bottom of KIYEN to 21,000 feet
- IVANE1 Runway 36R transition (KCLT)
  - Use 1.8°
  - Increase top of GIZMO to 14,000 feet
- LTOWN6 Runway 36 transition (KMEM)
  - Use 2.4°
  - Increase top of LTOWN to 17,000 feet

Calculated VPA

- RDU
  - ALDAN1 5L/R – 1.7 °
  - ALDAN1 23L/R – 2.6 °
  - FRAZI1 5L/R – 3.0 °
  - FRAZI1 23L/R – 2.6 °
  - KAROO1 5L/R – 1.7 °
  - KAROO1 23L/R – 3.0 °
  - MALNR1 – 2.3 °
  - ZODAS2 – 3.0 °
- STL
  - AARCH1 – 2.4 °
  - KAYLA1 11, 12L/R – 2.6 °
  - KAYLA1 29, 30L/R – 2.0 °
  - LORLE1 11, 12L/R – 2.6 °
  - LORLE1 29, 30L/R – 2.2 °
- CLT
  - IVANE1 – 18 L/C/R, 23 – 2.5 °
  - IVANE1 – 36L/C/R – 1.8 °
- MEM
  - LTOWN6 – 2.4 °
  - MASHH1 – 2.4 °
  - MONAA1 – 2.8 °
- DCA
  - FRDMM1 – 2.2 °
  - TRUPS1 – 2.2 °
- IAD
  - GIBBZ1 – 2.9 °
- SDF – 3.0°

Questions?

- Darren Harris
  - PSA Airlines (CRJ 200 / 700)
  - darrenharris@psaairlines.net
  - 919-656-4474