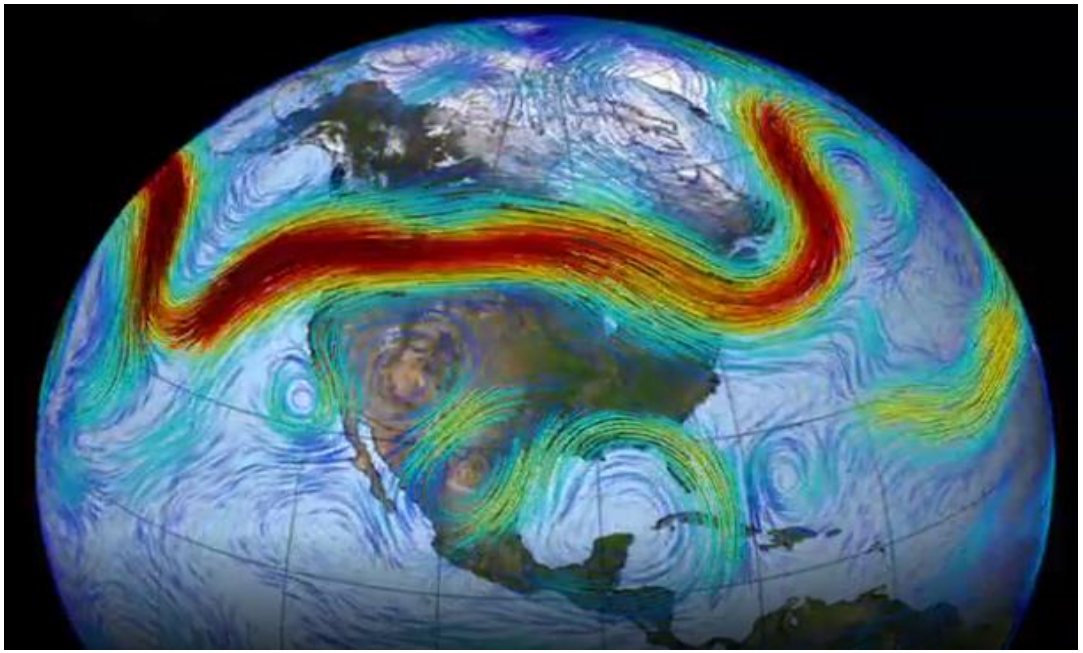
# SAFETY AND ECONOMIC ASPECTS OF THE WIND ON AVIATION



NASA – Goddard Space Flight Center; Nasa Visualization Explorer;
https://svs.gsfc.nasa.gov/10902


## Roland Winkler

# Outline

- Introduction
- Airport / Terminal

Credit: Wikimedia Commons – Bae146 Titan Crosswind Landing ; Photo: Maarten Visser

# INTRODUCTION

# Introduction

In general there is a simple relationship between aviation and wind:

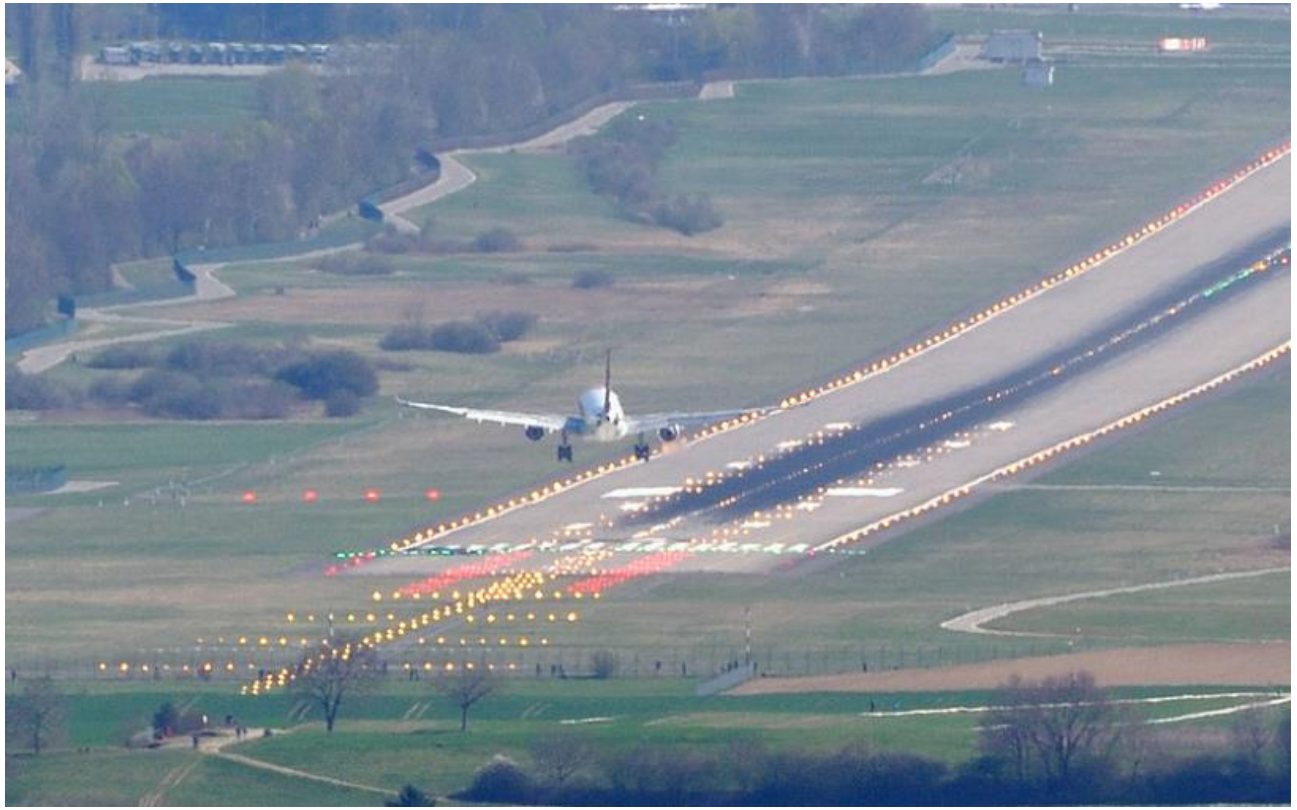
- Take Off / Landing

  **against the direction of the wind**

- En-Route

  **in the direction of the wind**

**BUT:**



Credit: Wikipedia – Seitenwindlandung; Photo: Hansueli Krapf

# AIRPORT / TERMINAL

# Airport / Terminal

Credit: Wikipedia – Windsack; Photo: Olaf Oliviero Riemer

**Hazard and Economic Impact**

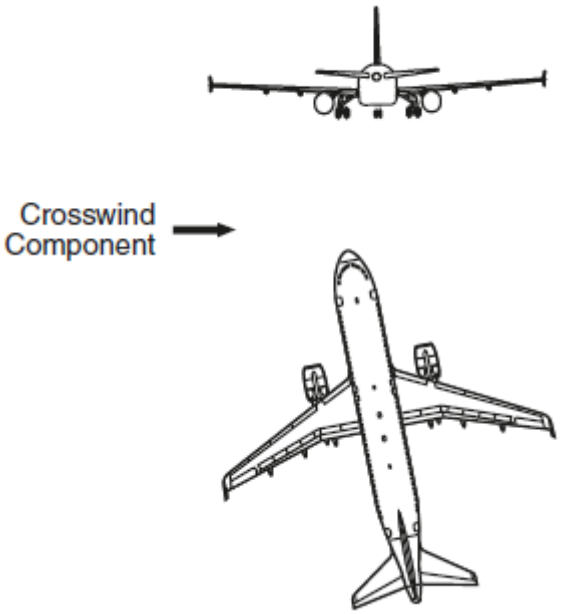
- Crosswind
- Tailwind
- Windshear

# Crosswind – Effect On Aircaft

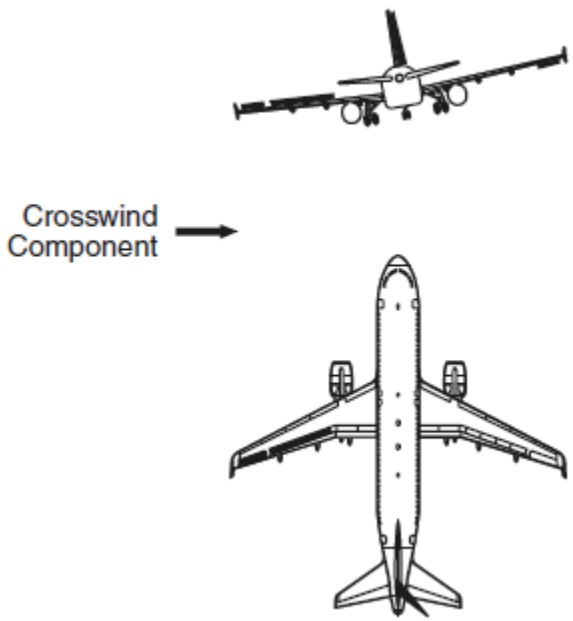
- wind with a component directed perpendicular to heading of an aircraft
- critical to air navigation – biggest impact during takeoff and landing
- landing into the wind
  - ✓ minimized groundspeed
  - ✓ shorter runway required to achieve lift-off
  - ✓ pilots have more time making adjustments for smooth landing
- crosswind – aircraft directional control is affected
  - ✓ aircraft may drift off the side of the runway
  - ✓ sideload on landing gear may occur

# Crosswind

**Crabbed Approach**




**Sideslip Approach**




Credit: FSF ALAR Briefing Note, 8.7 – Crosswind Landings; Flight Safety Foundation / Flight Safety Digest, November 2000

# Crosswind

**Factors Included in Typical Recommended Maximum Crosswind**

| Reported Braking Action (Index) | Reported Runway Friction Coefficient | Equivalent Runway Condition | Recommended Maximum Crosswind |
|---|---|---|---|
| Good (5) | 0.40 and above | (See Note 1) | 35 knots |
| Good / Medium (4) | 0.36 to 0.39 | (See Note 1) | 30 knots |
| Medium (3) | 0.30 to 0.35 | (See Notes 2 and 3) | 25 knots |
| Medium / Poor (2) | 0.26 to 0.29 | (See Note 3) | 20 knots |
| Poor (1) | 0.25 and below | (See Notes 3 and 4) | 15 knots |
| Unreliable (9) | Unreliable | (See Notes 4 and 5) | 5 knots |

Note 1: Dry, damp or wet runway (less than three millimeters [0.1 inch] of water) without risk of hydroplaning.

Note 2: Runway covered with dry snow.

Note 3: Runway covered with slush.

Note 4: Runway covered with standing water, with risk of hydroplaning, or with slush.

Note 5: Runway with high risk of hydroplaning.

Source: Flight Safety Foundation Approach-and-landing Accident Reduction (ALAR) Task Force

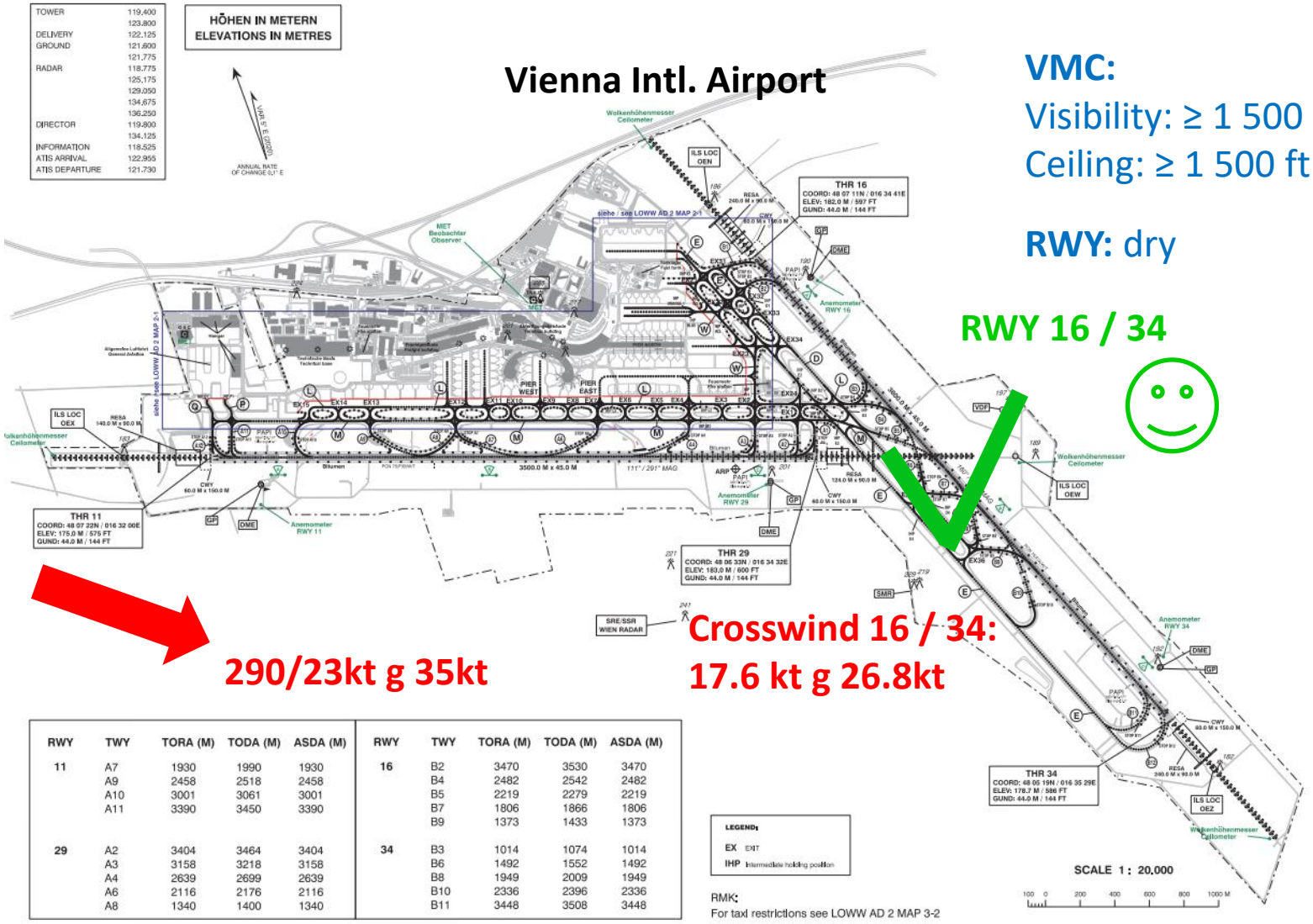
**Vienna Int. Airport**

Dry: mean: 25 kt, gusts: 30 kt

Wet: mean: 20 kt, gusts: 25 kt

Credit: FSF ALAR Briefing Note, 8.7 – Crosswind Landings; Flight Safety Foundation / Flight Safety Digest, November 2000

# Crosswind – Case Study LOWW (1)

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**VMC:**
Visibility: ≥ 1 500 m
Ceiling: ≥ 1 500 ft / no

**RWY:** dry

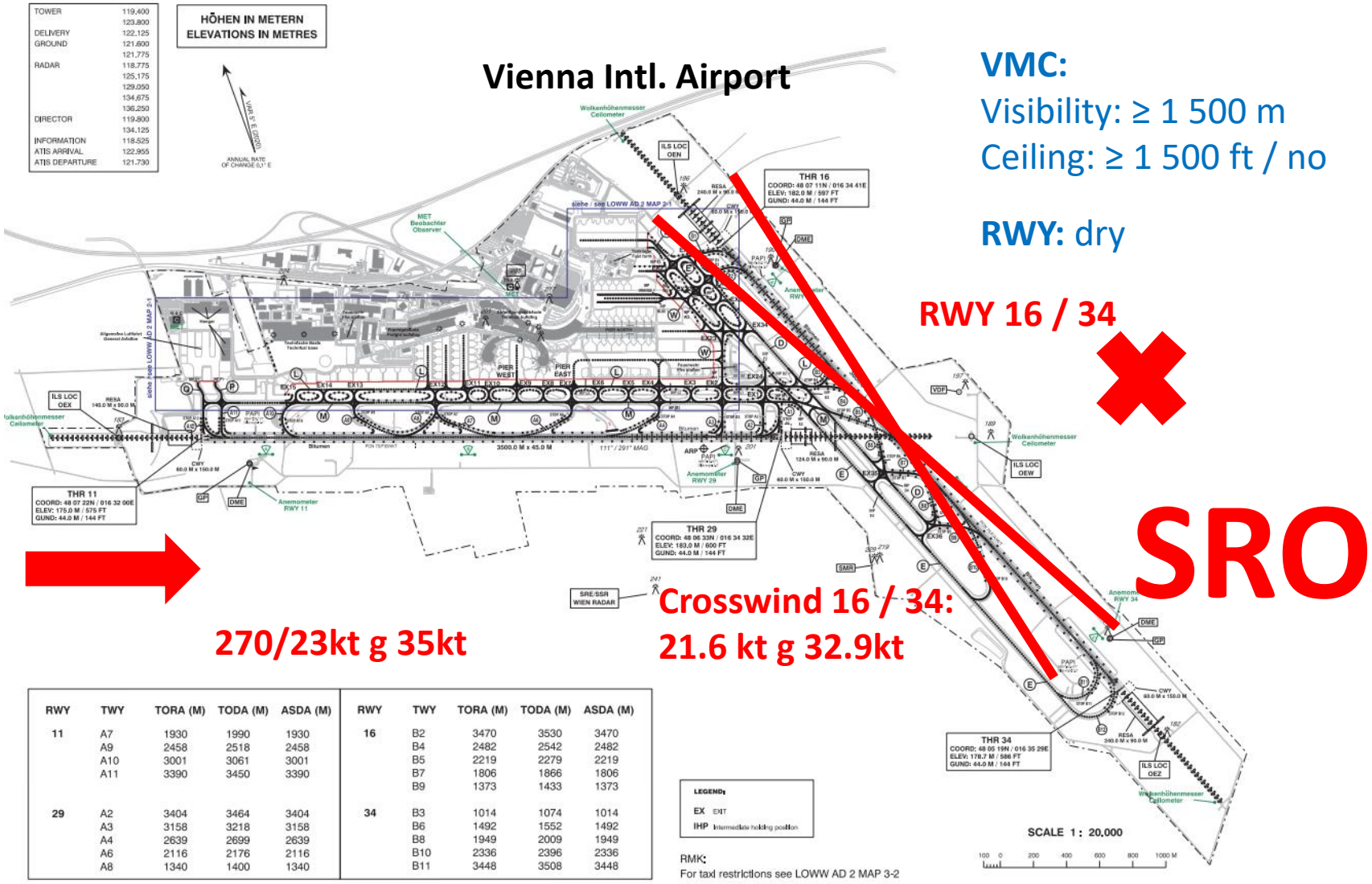
**RWY 16 / 34**

**290/23kt g 35kt**

**Crosswind 16 / 34:**
**17.6 kt g 26.8kt**

Credit: Roland Winkler; Figure Airport: Austro Control GmbH – LOWW AD 2 MAP 1-1 AIRAC AMDT 244 / 22 APR 2021

# Crosswind – Case Study LOWW (2)

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LEGEND:
EX EXIT
IHP Intermediate holding position

RMK:
For taxi restrictions see LOWW AD 2 MAP 3-2

Credit: Roland Winkler; Figure Airport: Austro Control GmbH – LOWW AD 2 MAP 1-1 AIRAC AMDT 244 / 22 APR 2021

# Crosswind Accident

Credit: Wikipedia – Continental Airlines Flight 1404; Original: NTSB – https://aviation-safety.net/photos/displayphoto.php?id=20081220-0&vnr=2&kind=C
Continental Airlines Flight 1404 wreckage

- December 20, 2008
- Denver Int. Airport, RWY 34R
- take off – veered off the side of the runway
- speed plane: 87 – 90 kt
- reported wind: 24 – 27 kt, gusts nearly 32 kt
- crosswind limitation for 737: 33 kt (dry runway)
- 40 kt crosswind at end of the runway

**Aircraft was hit with a peak gust crosswind of 45 kt.**

# Crosswind Accident

Credit: AIID Ref No: CA18/2/3/10070 – Preliminary Report; Accident and Incident Investigations Division, South African Civil Aviation Authority, Republic of South Africa

- November 6, 2021
- Tambo Int. Airport, RWY 03L
- FNA: ATC reported 300/22kt
- crosswind landing technique
- pilot attempt to land within touchdown zone
- was not possible
- pilot concluded wind shear
- go-around – during initial stage

**gust from left caused aircraft to bank (wing scratches 110 m long over the runway)**

# Tailwind

## ➢ Take Off

- ✓ take off run will be longer
- ✓ reduced allowable take off weight → **Economic Impact**
- ✓ reduced climb gradient → **CFIT**

## ➢ Approach

- ✓ increased ground speed
- ✓ increased rate of descent

## ➢ Landing

- ✓ greater ground speed at landing
- ✓ longer landing roll
- ✓ increased stopping distance → **Runway Excursions**

# Tailwind

**Running Out Of Runway Analysis Of 35 Years Of Landing Overrun Accidents**

| Factor | Number of accidents | Percent |
|---|---|---|
| Non-precision approach | 289 | 72.3% |
| Long landing | 211 | 52.8% |
| Excess approach speed | 111 | 27.8% |
| Hydroplaning of the tires | 60 | 15.0% |
| Late or no application of available stopping devices | 60 | 15.0% |
| Visual approach | 56 | 14.0% |
| Tailwind present | 49 | 12.3% |
| High on approach | 29 | 7.3% |
| Brakes inoperative | 21 | 5.3% |
| Reverser inoperative | 10 | 2.5% |
| Ground spoilers inoperative | 2 | 0.5% |

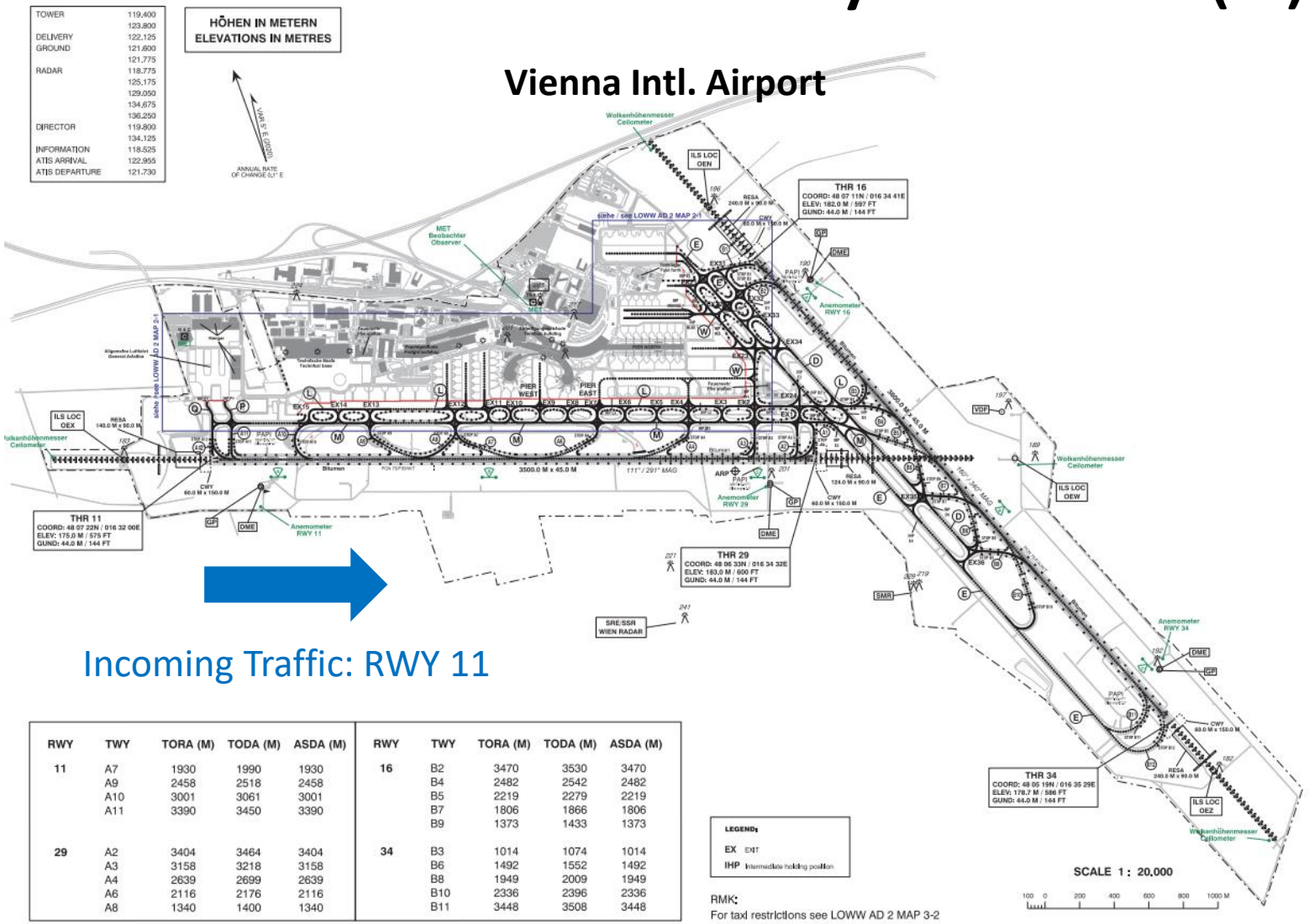
Credit: Nationaal Lucht- en Ruimtevaartlaboratorium (NLR); Database: National Aerospace Laboratory Air Safety database

# Tailwind – Accident

Credit: Wikimedia Commons; Original: NASA Langley Research Center; Source: https://aviation-safety.net/photo/4347/DC-9-31-N961VJ

- February 21, 1986
- Erie Int. Airport
- wind: 030/10 kt; wind picked up
- **tailwind: 10 to 11 kt**
- runway covered snow
- breaking action:  fair to poor
- touch down some 2 000 ft beyond displaced threshold
- spoilers, reverse thrust, brakes activated

# Tailwind – Case Study LOWW (3)




Incoming Traffic: RWY 11

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Credit: Roland Winkler; Figure Airport: Austro Control GmbH – LOWW AD 2 MAP 1-1 AIRAC AMDT 244 / 22 APR 2021

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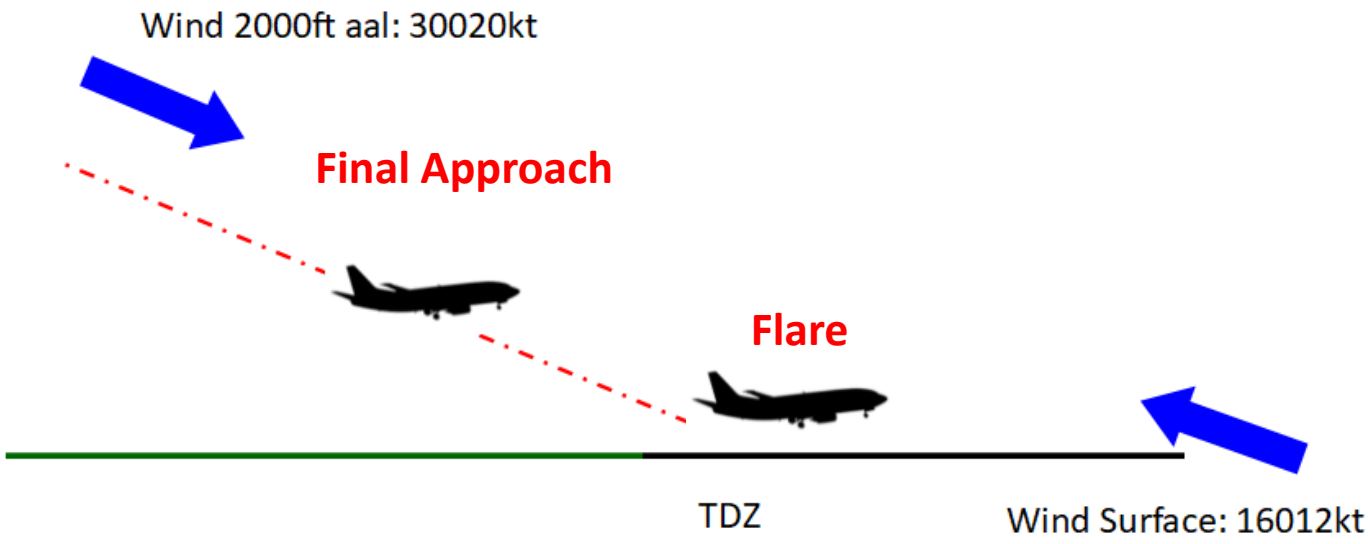
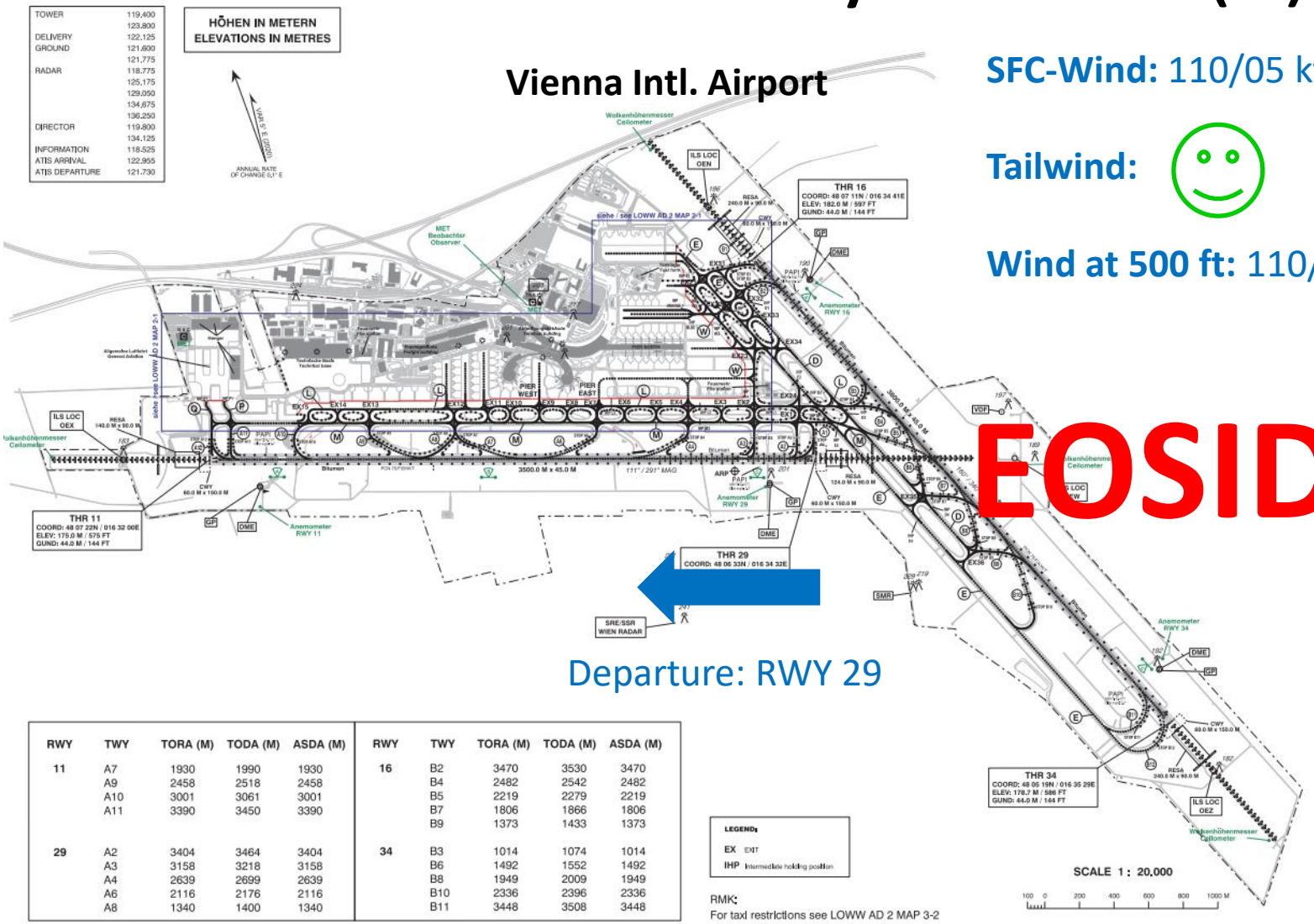



Credit: Roland Winkler; Aircraft: Publicdomainvectors.org

# Tailwind – Case Study LOWW (4)

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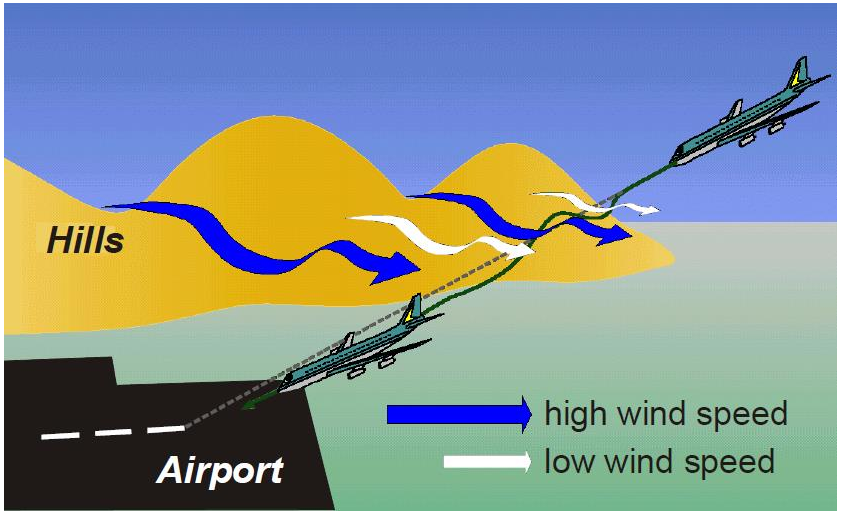
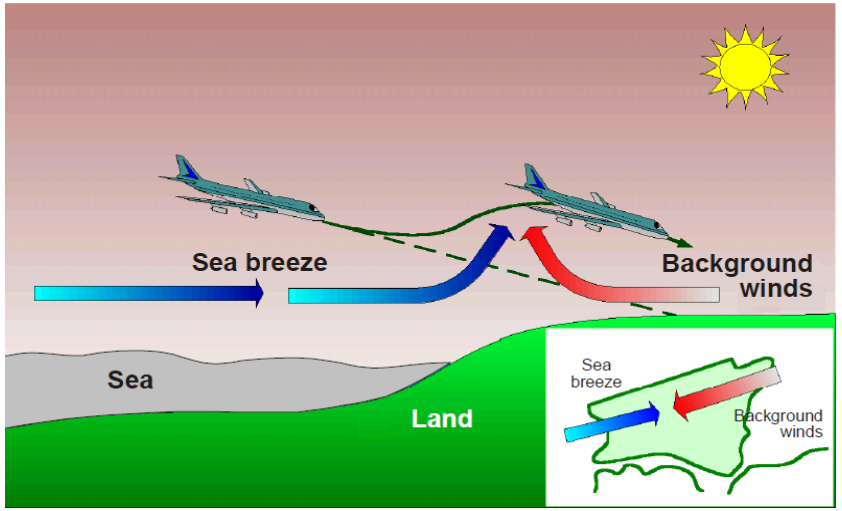
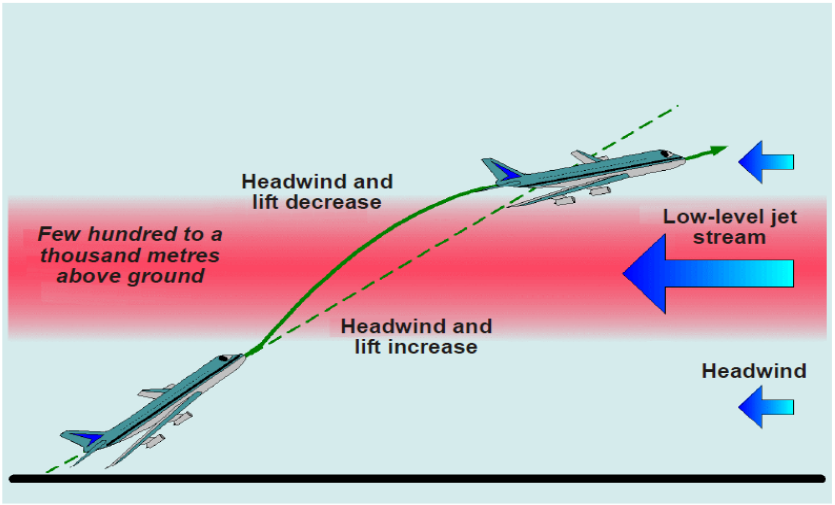
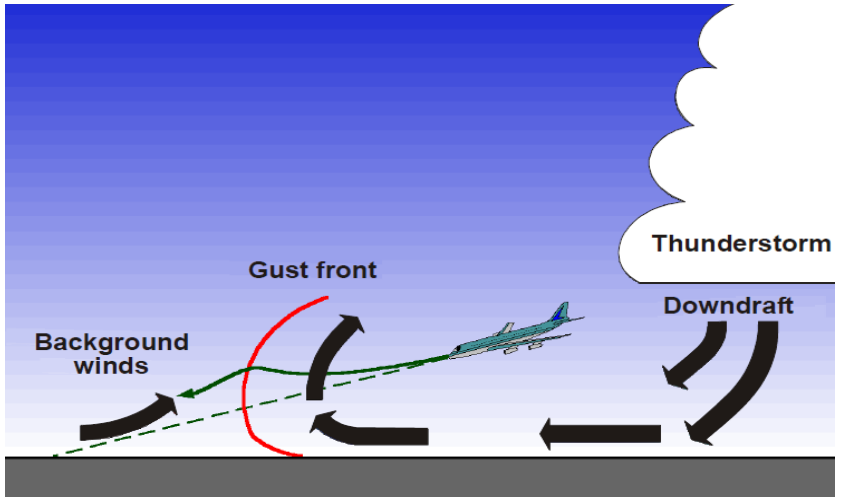
Credit: Roland Winkler; Figure Airport: Austro Control GmbH – LOWW AD 2 MAP 1-1 AIRAC AMDT 244 / 22 APR 2021

# Wind Shear



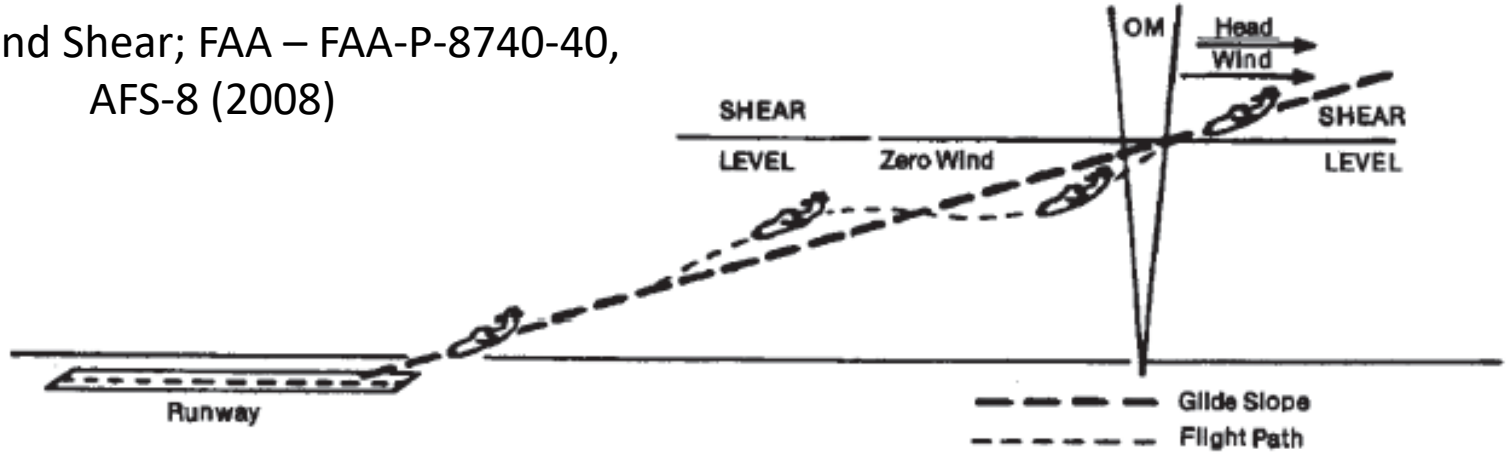




Credit: Manual on Low-Level Wind Shear; ICAO Doc 9817 AN/449

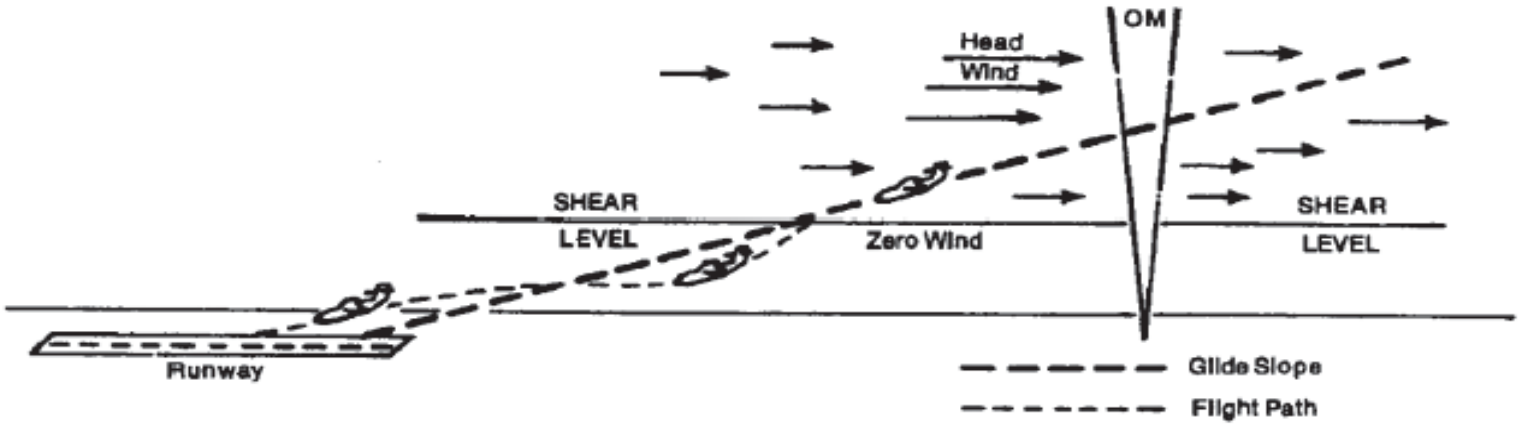
# Wind Shear

Credit: Wind Shear; FAA – FAA-P-8740-40, AFS-8 (2008)

**High Enough for Recovery**




**Landing Long and „Hot“**



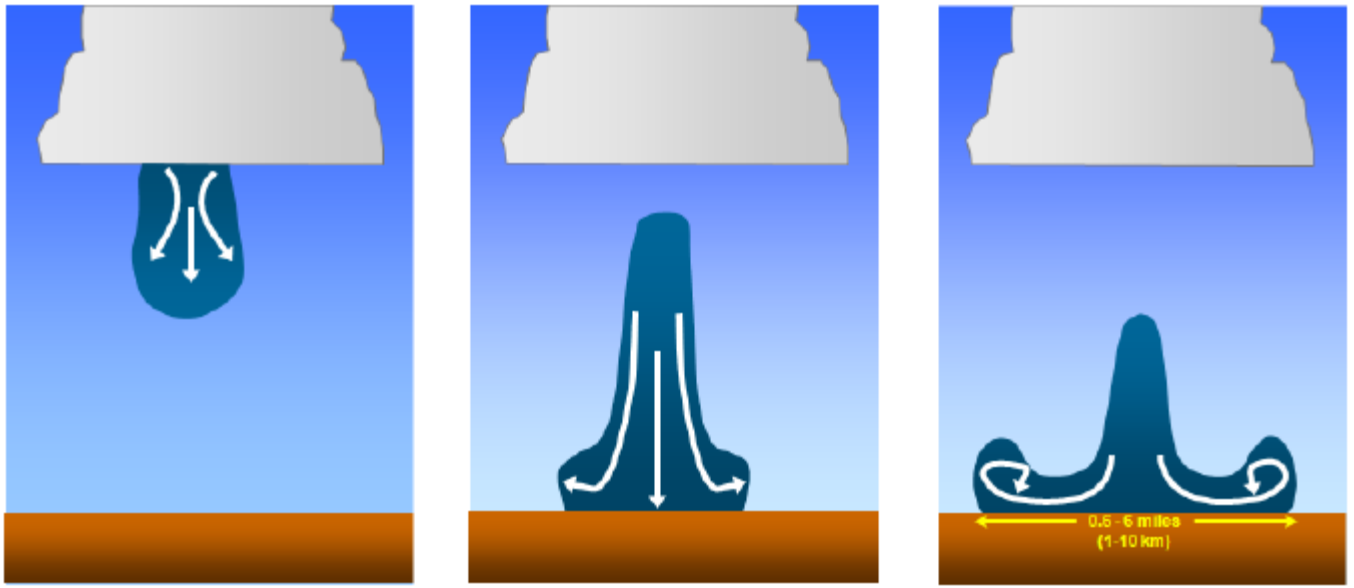
# Wind Shear Accident

Credit: Wikipedia – Lufthansa-Flug 2904;
Photo: Mariusz Siecinski –
http://www.airliners.net/photo/Lufthansa/Airbus-A320-211/0265541/L/

- September 14, 1993
- Warsaw Int. Airport
- wind shear on approach
- ground contact of right main gear after 770 m
- pilot operated wheel brake
- ground contact of left main gear after 1 525 m
- fly-by-wire systems released spoilers and thrust reversers as braking aids after left landing gear came into contact with the ground

change of software - the landing gear's touchdown pressure for releasing spoilers and reversing thrust has been reduced from 12 to 2 t for A320 family

# Thunderstorm – Downburst




**FORMATION –**

**Evaporation and precipitation drag forms downdraft**

**IMPACT –**

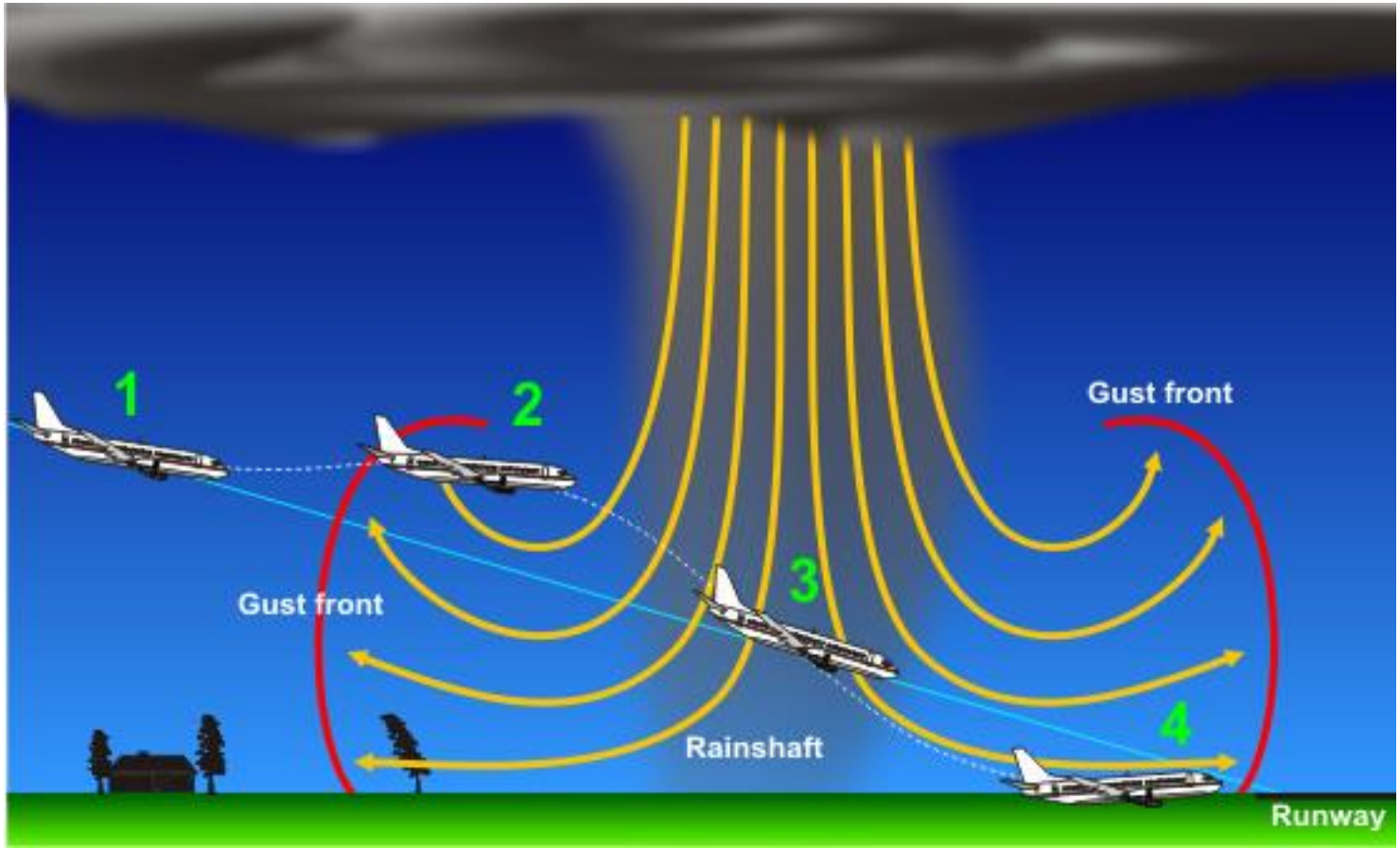
**Downdraft quickly accelerates and strikes the ground**

**DISSIPATION –**

**Downdraft moves away from point of impact**

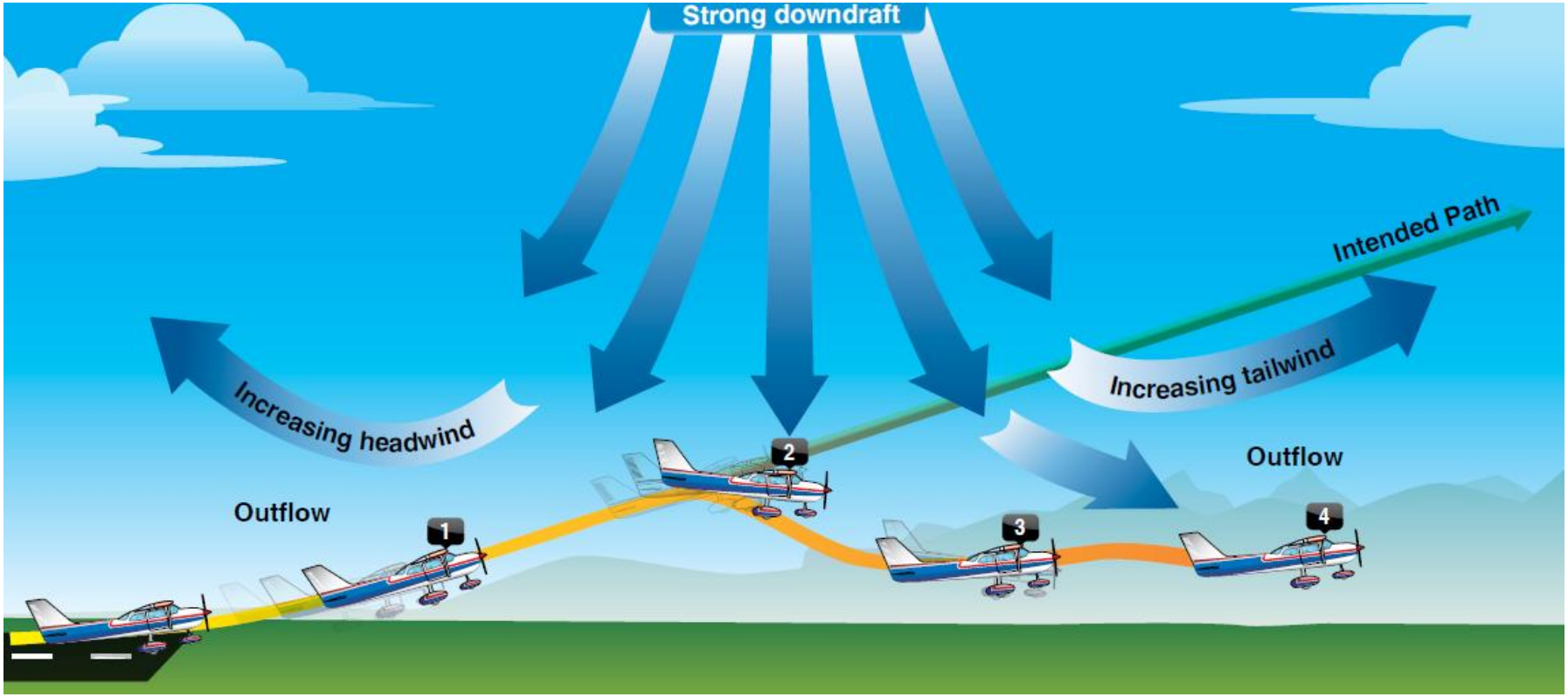
Credit: FAA – Advisory Circular AC No: 00-6B: Aviation Weather

# Thunderstorm – Downburst

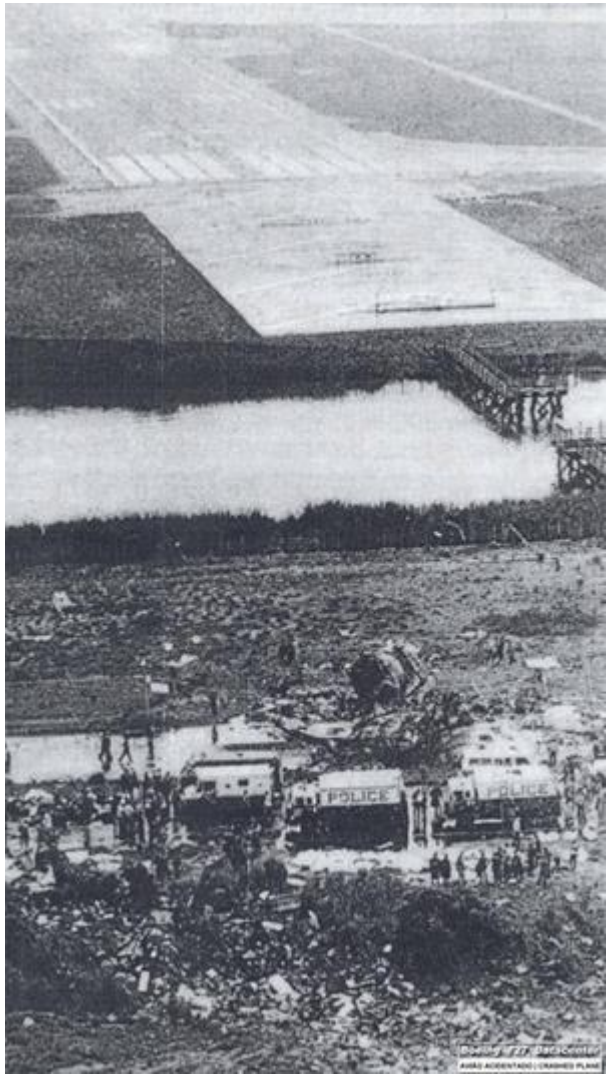



Credit: NOAA – JetStream - An Online School for Weather

# Thunderstorm – Downburst




Credit: FAA – Pilots Handbook of Aeronautical Knowledge:
Chapter 12 – Weather Theory




Credit: Wikipedia – Eastern Air Lines Flight 66; Original: FAA – https://lessonslearned.faa.gov/ll_main.cfm?TabID=1&LLID=67&LLTypeID=2

# Thunderstorm Downburst – Accident

- June 24, 1975
- Eastern Airlines Flight 66
- severe thunderstorm at JFK
- very light rain showers, haze, zero visibility
- final approach RWY 22L
  - ✓ enter microburst – wind shear
  - ✓ striking appraoch lights 730 m before threshold
  - ✓ aircraft banks to the left and burst into flames (along Rockaway Boulevard)
- deadliest crash in US-history
  - ✓ 107 passenger, 6 crew members died
  - ✓ 9 passengers, 2 crew members survived