



Flight Management Computer System Vertical Navigation aka VNAV

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Very Short History

- **Lateral Navigation (LNAV) and Vertical Navigation (VNAV) were first implemented on 757 and 767 in 1982.**
- **Original intent of the features was for enroute navigation. No early vision into future operations such as RNP / RNAV (terminal area) / GPS / 4 D paths.**
- **Performance of both LNAV and VNAV has been enhanced and continue to be improved as performance-based operations mature.**

Feature Description

LNAV

- LNAV provides a precise lateral path defined by waypoints and legs (Flight Plan Route).
- LNAV computes guidance commands for the Autopilot or Flight Director to follow the path.



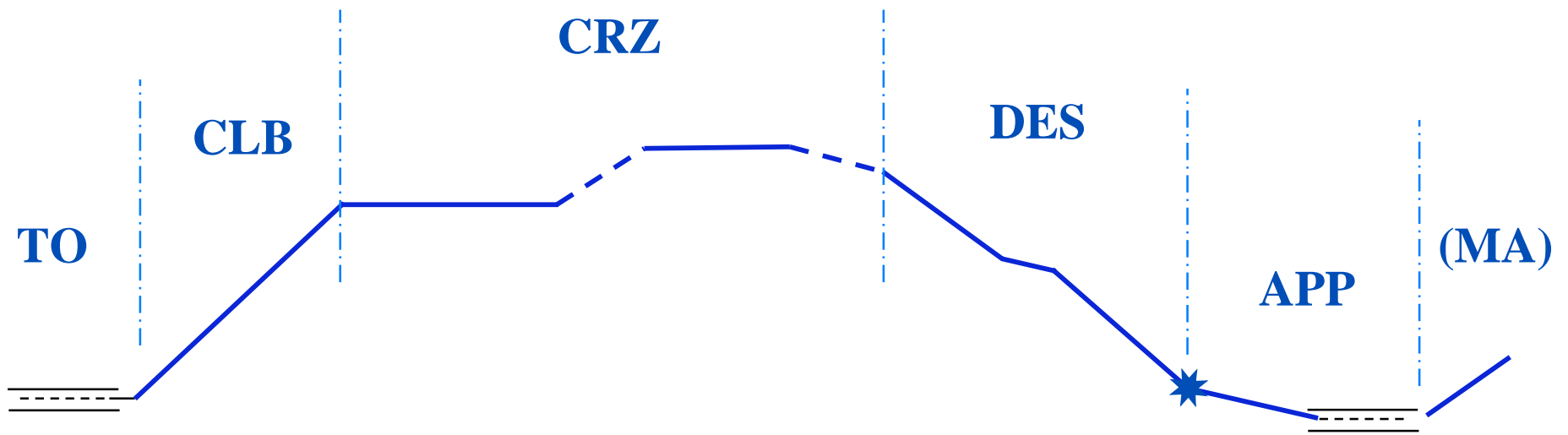
Feature Description

VNAV

- **VNAV is the vertical navigation flight profile which is the predicted flight trajectory of the airplane in the vertical plane as a function of distance along the horizontal flight path defined by the LNAV flight plan.**
- **The flight profile reflects all speed and altitude restrictions specified in the guidance flight plan while honoring airplane operating limits.**
- **VNAV computes guidance commands for the Autopilot or Flight Director and Autothrottle to follow the vertical profile.**

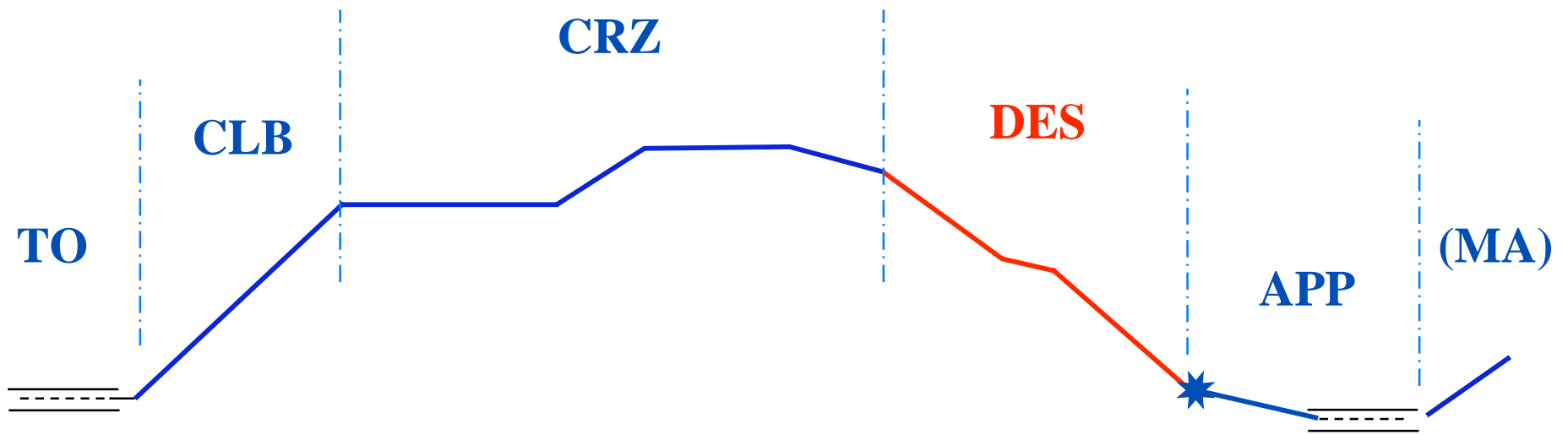
VNAV

Flight Phases



VNAV

CDA - Descent Phase



VNAV

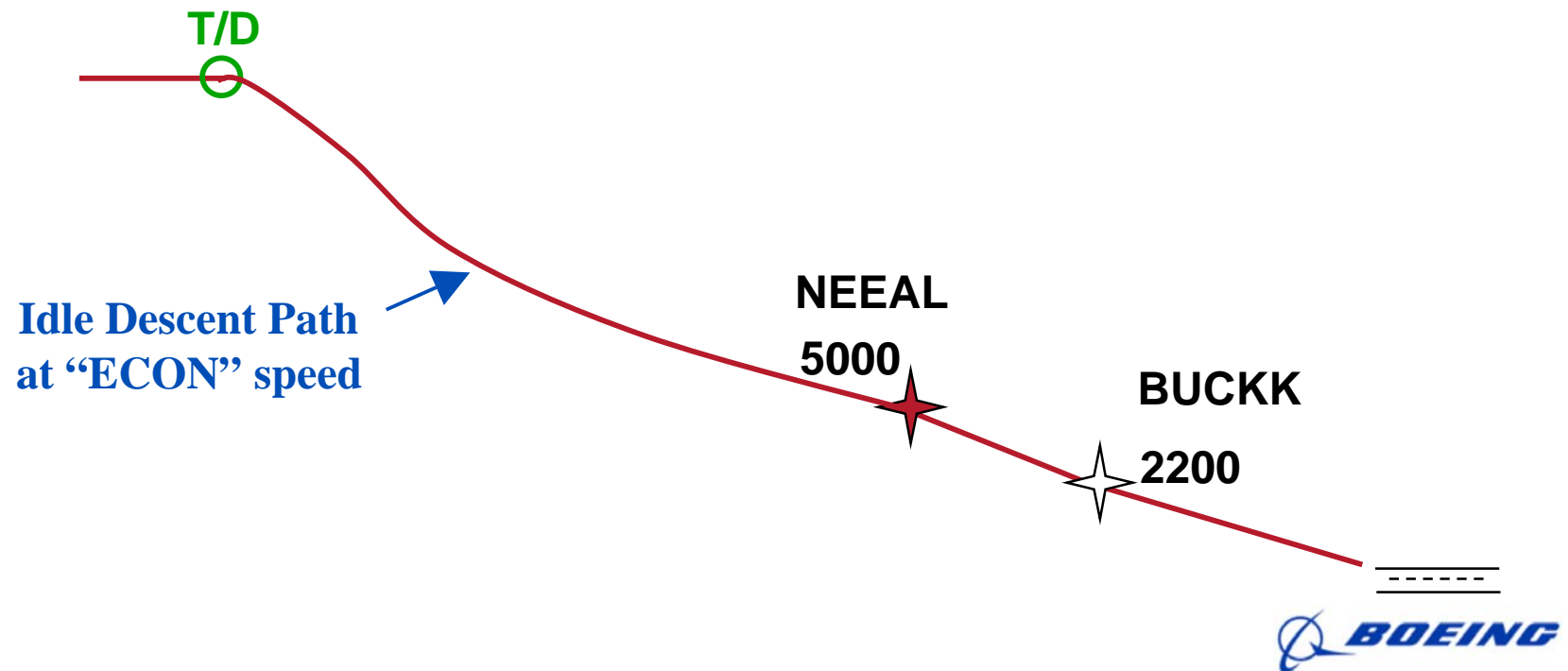
Ground Rules

- **The VNAV Path is constructed upstream beginning at the lowest waypoint constraint (generally the runway or missed approach point) up to the final cruise altitude.**
- **The path is constructed by connecting one or more altitude constrained waypoints and the top-of-descent point.**
- **Depending upon the number of constrained waypoints in the descent, two path types exist:**
 - **Performance Path**
 - **Geometric Path**

VNAV

More Ground Rules

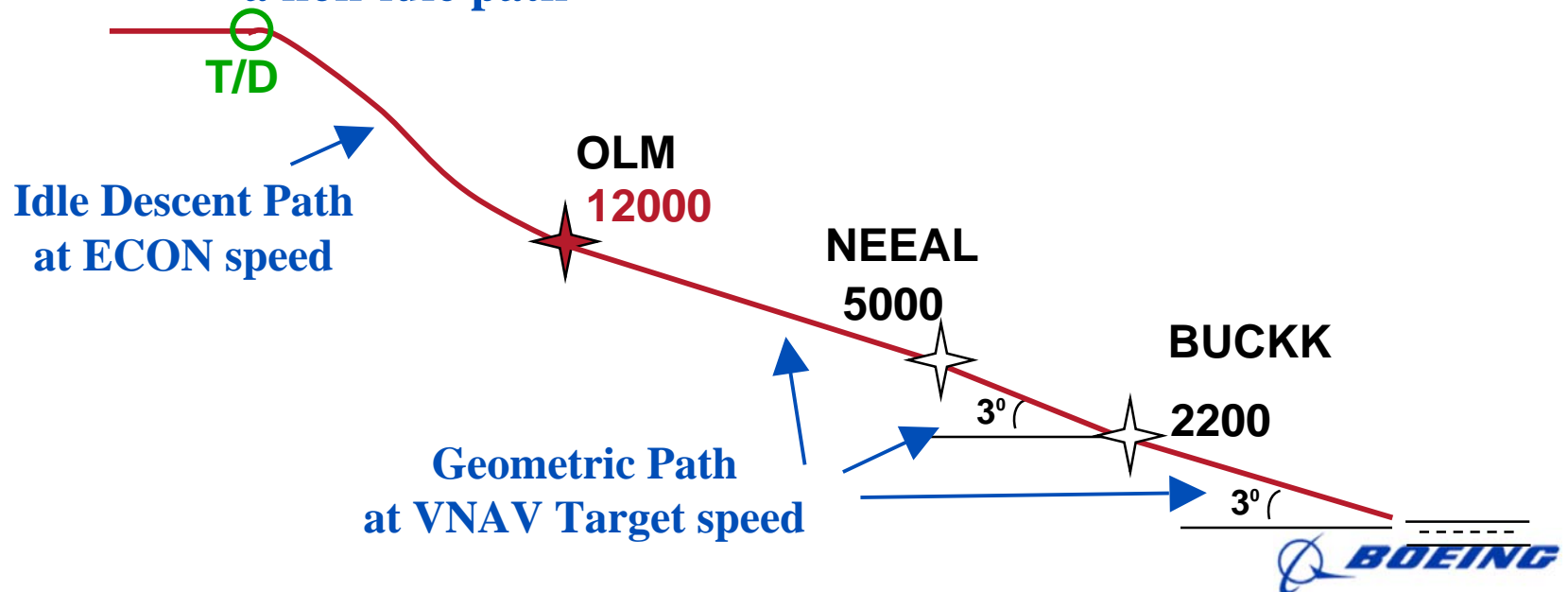
- **Performance Path - computed path descent at idle power from top-of-descent to the first constrained waypoint**



VNAV

More Ground Rules

- **Geometric path - computed “point-to-point” path descent between two constrained waypoints or when tracking a prescribed vertical angle**
 - The geometric path is a shallower descent and typically a non-idle path



VNAV

Path Construction

- **The flight profile reflects all speed and altitude restrictions specified in the guidance flight plan while honoring airplane operating limits.**

- **Altitude Constrained Waypoints**

- “AT” altitude



- “AT or Above”



- “AT or Below”

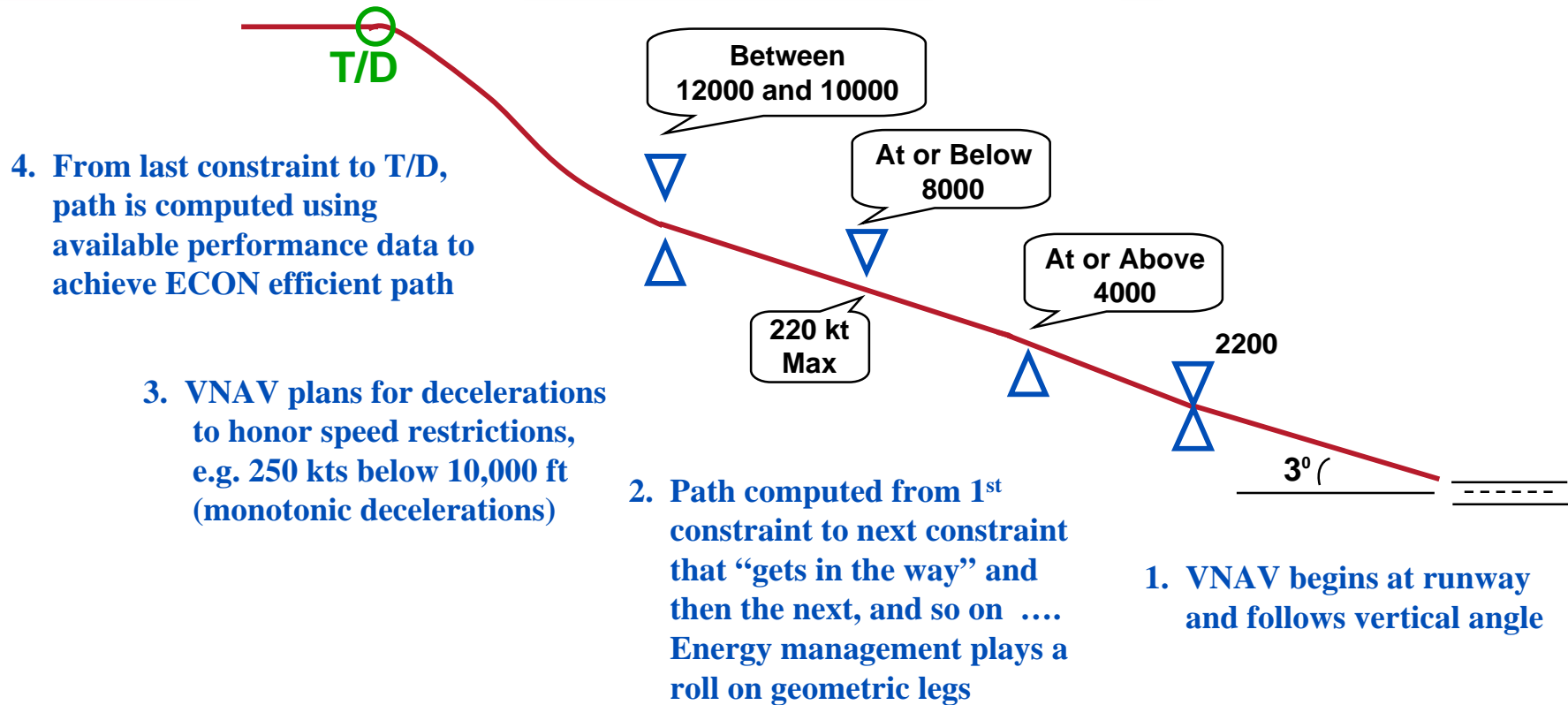


- “Window”



VNAV

Path Construction



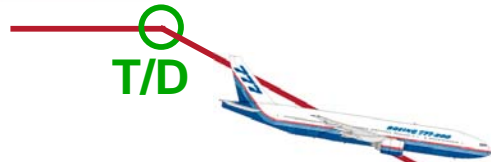
VNAV

Influences on Path Construction

- **Computation of the path is influenced by several factors**
 - **Airplane type and performance**
 - **Gross weight**
 - **Anti-icing (higher idle thrust)**
 - **Weather**
 - **Winds**
 - **Temperature**

VNAV

Influences on Path Construction



- VNAV will attempt to maintain path
- If speed increases and approaches VMO, VNAV will sacrifice the path for a safe speed



Unforecast wind



VNAV

Operation Summary

- **The path is determined via speed and altitude constraints along the LNAV path.**
- **The path can be either “performance” or “geometric.”**
 - **The geometric path is typically a shallower descent and a non-idle path. VNAV will manage energy to comply with speed restrictions.**
- **Numerous factors influence path computation.**
- **Given good data (wind, temp, e.g.), VNAV will provide a consistently operational path.**

CDA

Operational Considerations

- **Not all airplanes are equipped with VNAV and those that are equipped may vary in operation.**
- **Different airframes perform differently.**
- **Given the variability in equipage, disciplined procedure design may be the preferred CDA methodology.**
- **Procedures that incorporate a well-defined path may have the best opportunity for success.**
 - **I.e., procedures that define altitude targets and speeds and incorporate a flight path angle that accommodates the users will provide consistent paths.**
- **However, less restrictive paths may accommodate more users, save fuel, but increase variability and spacing down the chute.**