NATS

TBS for Arrivals: Operational Concept

Wakenet Europe Workshop 2007

Introductions

- Charles Morris – NATS R&D Technical Leader
  - Advanced Separation Criteria
    - Time Based Separation for Arrivals
      - Provision of landing rate resilience to Heathrow
    - EC 6FP RESET (Reduced Separation Minima) Project
  - NATS Approach Tools
    - Final Approach Spacing Tool
    - Sequencing Advisories & Stack Support
    - Planned Spacing Tool
    - Mode S: Vertical Stack Lists and Extended Target Labels

Presentation Overview

- TBS Operational Objectives
- TBS Landing Rate Resilience Proposal

- ICAO Arrival Separation Delivery
- ICAO Proposed TBS Separation Minima

- NATS Arrival WV Separation Criteria
- NATS Proposed TBS Separation Minima

- TBS Impact on Distance Separations
- Controller/Pilot System Support

- ICAO WVE Separation Management

- Stakeholder Input Session Issues

TBS Operational Objectives

- Provision of landing rate resilience to challenging headwind conditions for segregated mode operations
- Requirement for short to medium term operational gains to alleviate holding delays and airline schedule disruptions
- Objective of maintaining the landing rate close to achieved in calm/light headwind conditions
- Benefit impact to over 200,000 arrival movements per annum at Heathrow (EUROBEN CBA Study 2006)

TBS Landing Rate Resilience Proposal

- Apply time-based separation minima instead of distance-based separation minima on final approach
- Separation minima time intervals derived from the employment of distance-based separation minima in calm/light headwind conditions employing nominal/standard approach speeds
- ATC, airline and cockpit procedures and practices changes & runway improvements to manage WVE, MAC & RC/RI risks
- Suitable support systems to facilitate controller/pilot visualisation of time-based separations and consistent and accurate delivery to time-based separation minima

ICAO Radar Separation Minima

Three WV Categories

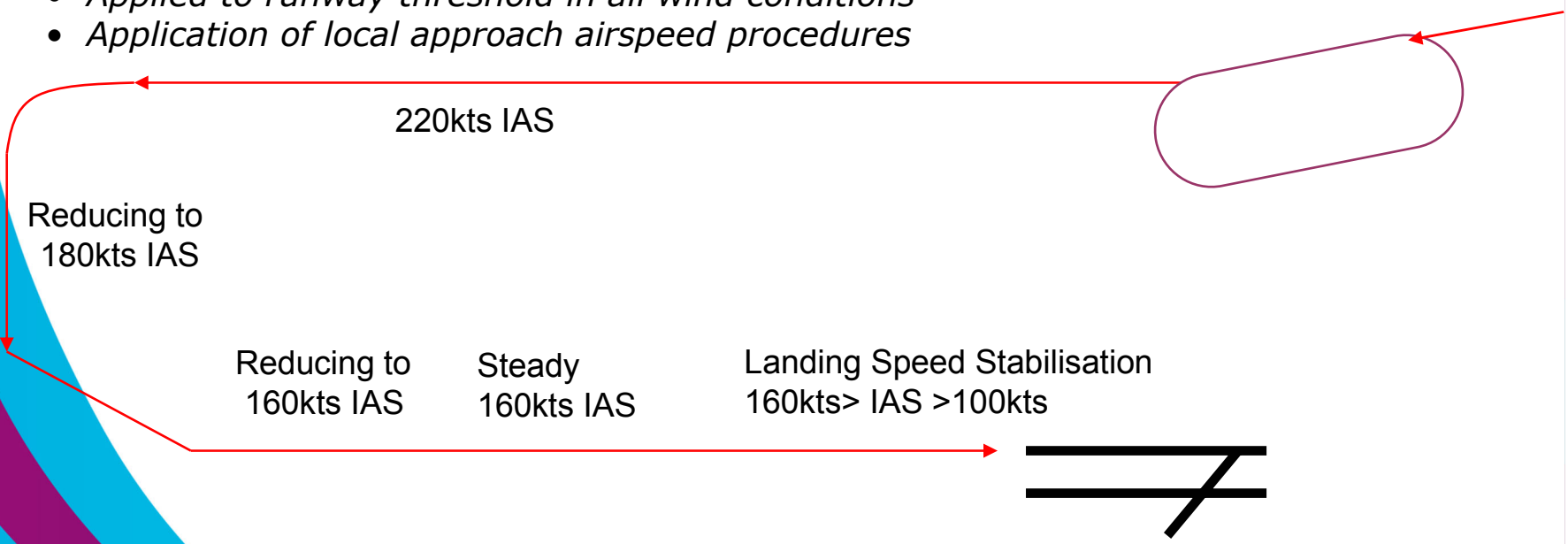
- *Heavy (H) >136,000kg*
- *Medium (M) >7,000kg*
- *Light (L) <7,000kg*

** = radar separation minimum*

- *3NM when radar capabilities permit*
- *2.5NM on final approach within 10NM of threshold under specific PANS-ATM criteria*

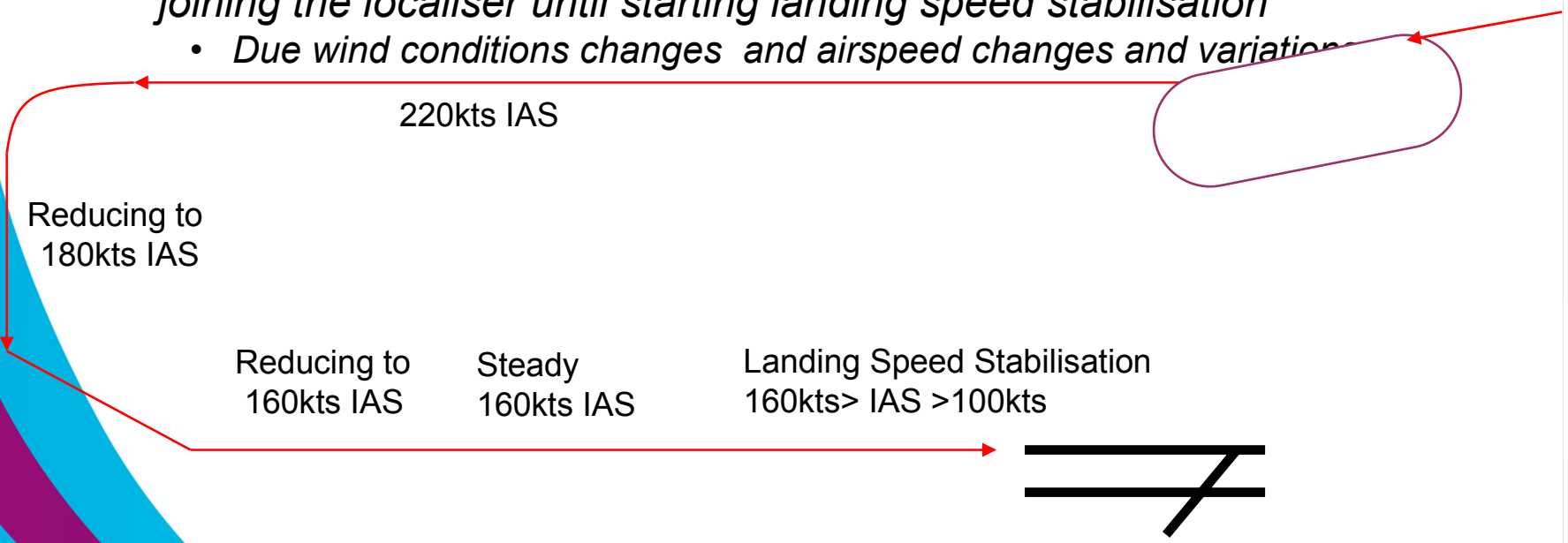
- *Applied to runway threshold in all wind conditions*
- *Application of local approach airspeed procedures*

(NM)	**H**	**M**	**L**
H	*4*	*5*	*6*
M	*	*	*5*
L	*	*	*

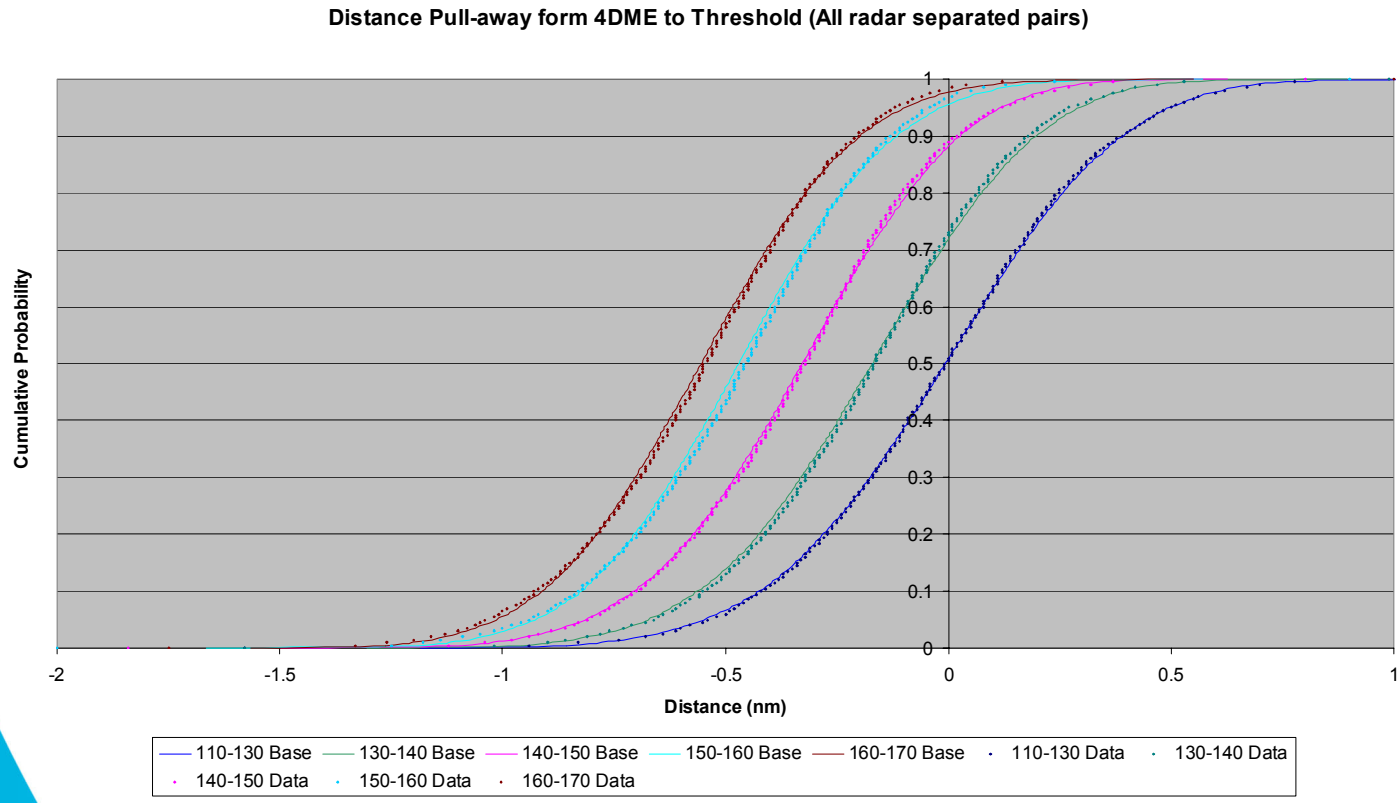


ICAO Arrival Separation Delivery

- *Approach controller determination of distance separation to set up on turning on to join the localiser*
  - *Taking into account observed distance separation compression during the landing speed stabilisation phase of final approach*
    - *Starting from between 6NM and 4NM from the runway threshold*
    - *Due wind conditions changes and airspeed changes and variations*
  - *Taking into account distance separation compression from joining the localiser until starting landing speed stabilisation*
    - *Due wind conditions changes and airspeed changes and variations*

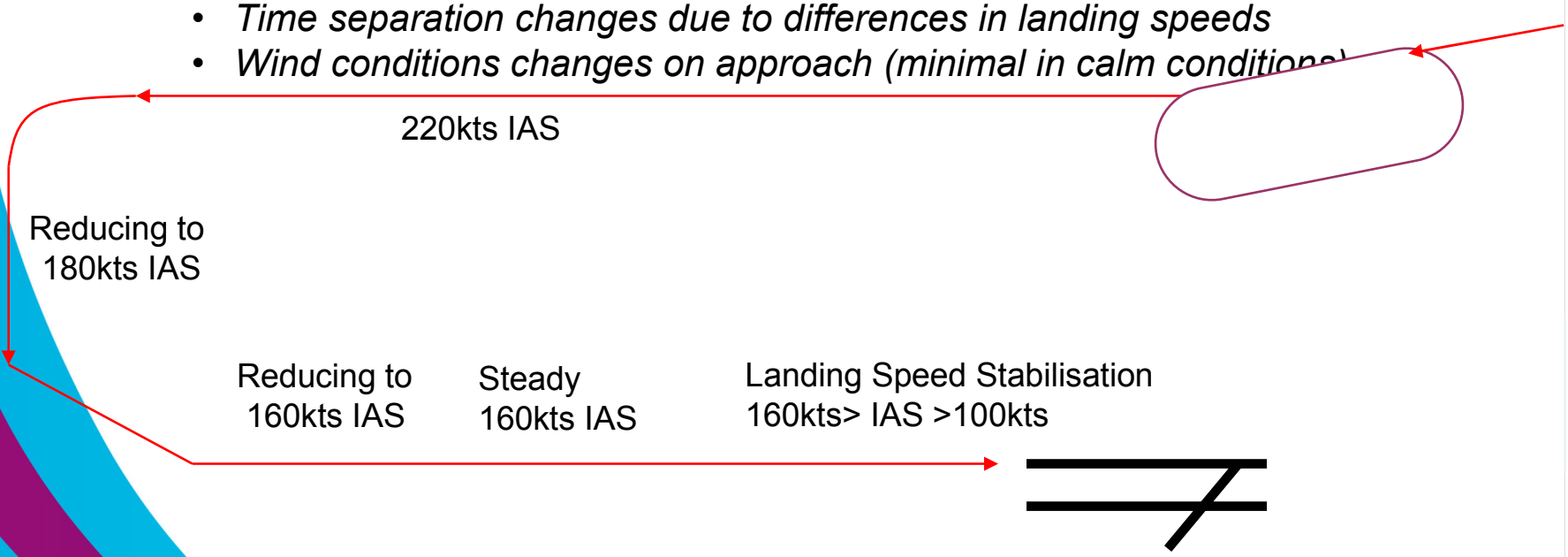


Distance Separation Compression from 4DME

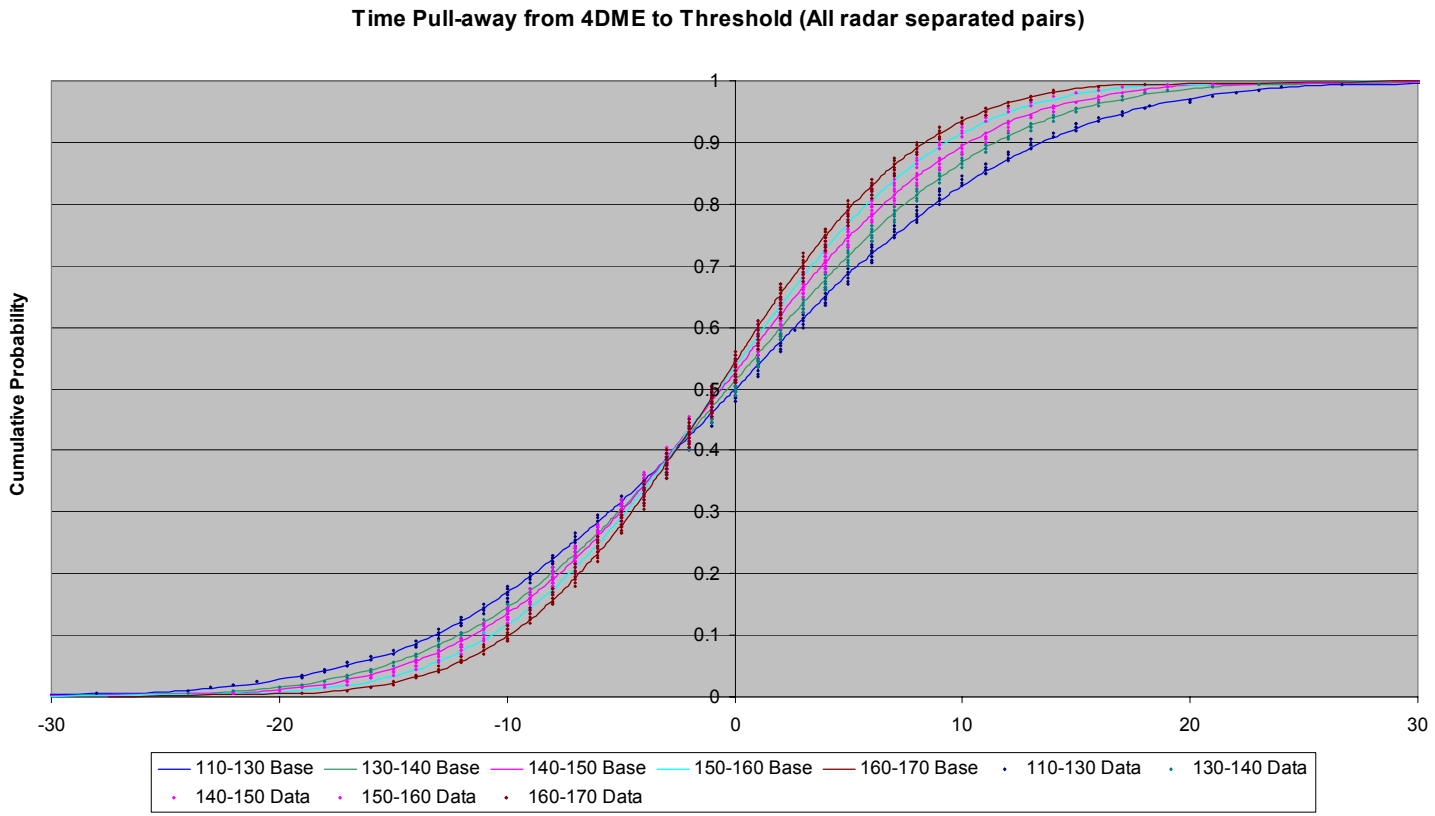


Distance Separation Compression from 4DME

- *In calm/light wind conditions:*
  - *From 1.25NM decrease in distance separation to 0.25NM increase in distance separation*
  - *Cause by a combination of:*
    - *The range of landing stabilisation speeds employed*
    - *IAS reduction from a steady 160kts across 4DME to the landing stabilisation speed by 1000ft to 500ft elevation above runway*
    - *Time separation changes due to differences in landing speeds*
    - *Wind conditions changes on approach (minimal in calm conditions)*



Time Separation Changes from 4DME



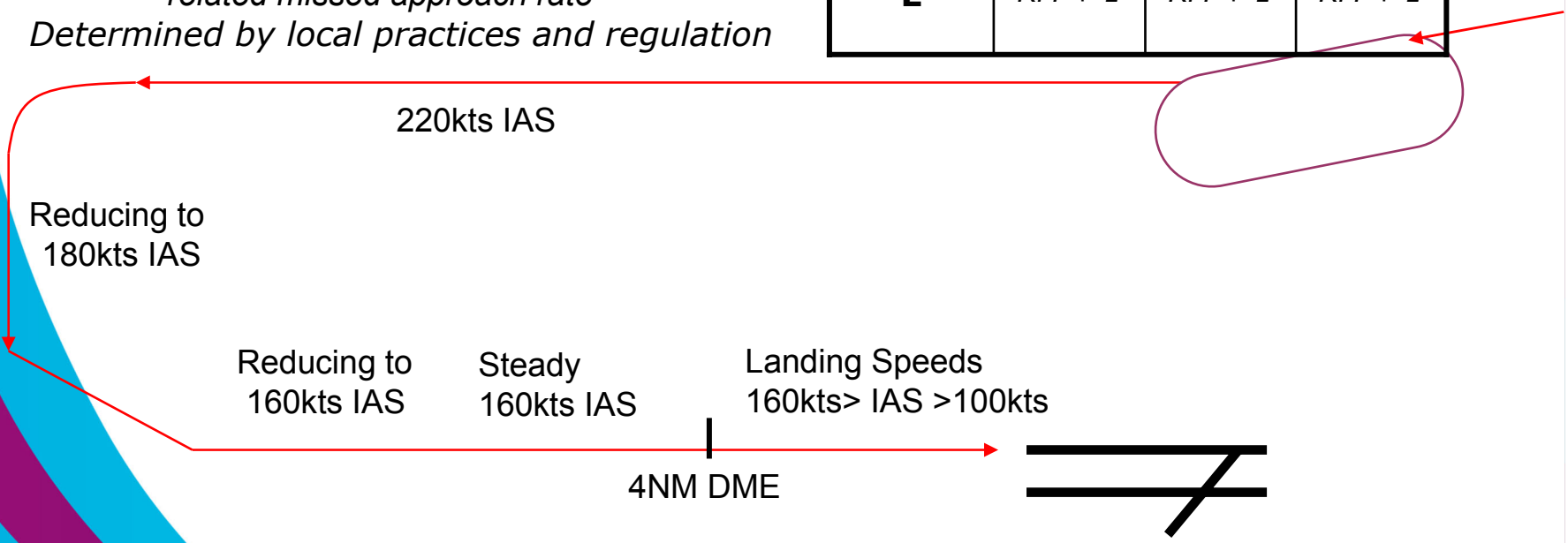
Implications on Required Separation at 4DME

Depends on:

- *Cockpit & controller procedures and practices in place for dealing with arrival pairs with significant time separation reduction inside of 4DME*
- *Procedures for dealing with separation encroachment as the lead aircraft approaches the runway threshold*
- *Acceptability of the resulting separation related missed approach rate*

Determined by local practices and regulation

(NM)	**H**	**M**	**L**
H	*4 + 1*	*5 + 1*	*6 + 1*
M	*RM + 1*	*RM + 1*	*RM + 1*
L	*RM + 1*	*RM + 1*	*RM + 1*



ICAO Time Equivalent at Threshold

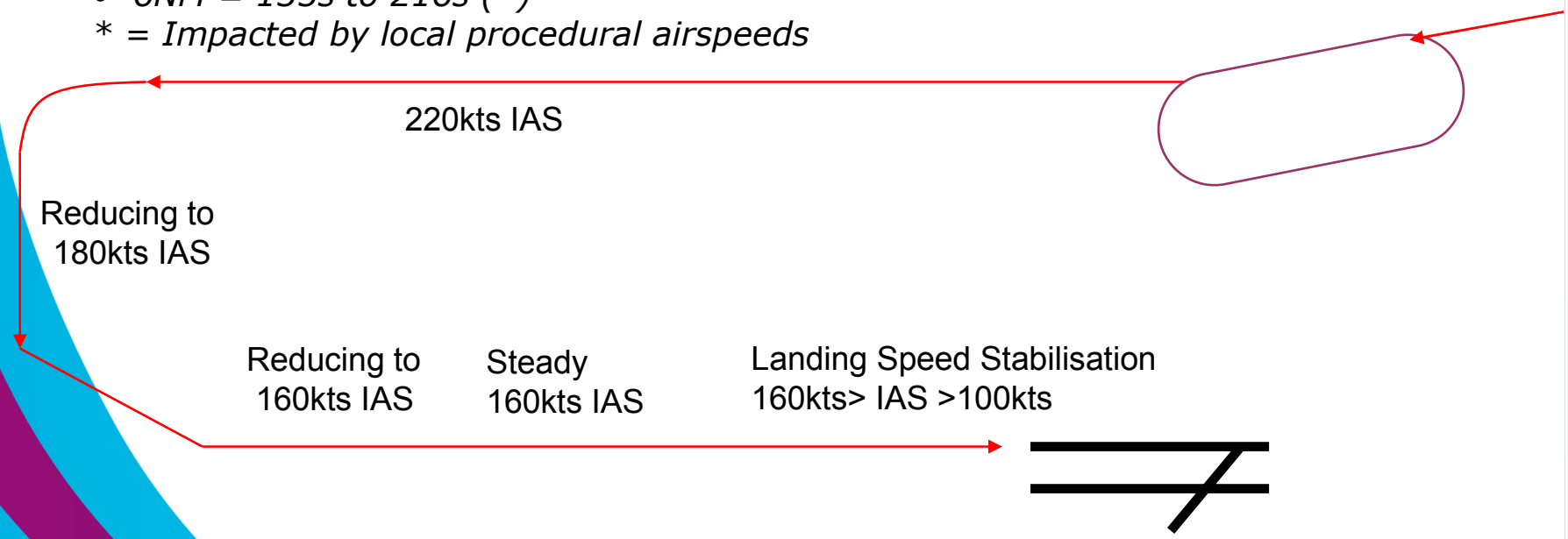
Depends on landing stabilisation speed ranges and where they take effect

- *100ks GS = 36s per NM*
- *160kts GS = 22.5s per NM*

- *2.5NM = 56.25s to 90s*
- *3NM = 67.5s to 108s*
- *4NM = 90s to 144s (*)*
- *5NM = 112.5s to 180s (*)*
- *6NM = 135s to 216s (*)*

** = Impacted by local procedural airspeeds*

(NM)	**H**	**M**	**L**
H	*4*	*5*	*6*
M	*	*	*5*
L	*	*	*



ICAO Time Equivalent at 4DME

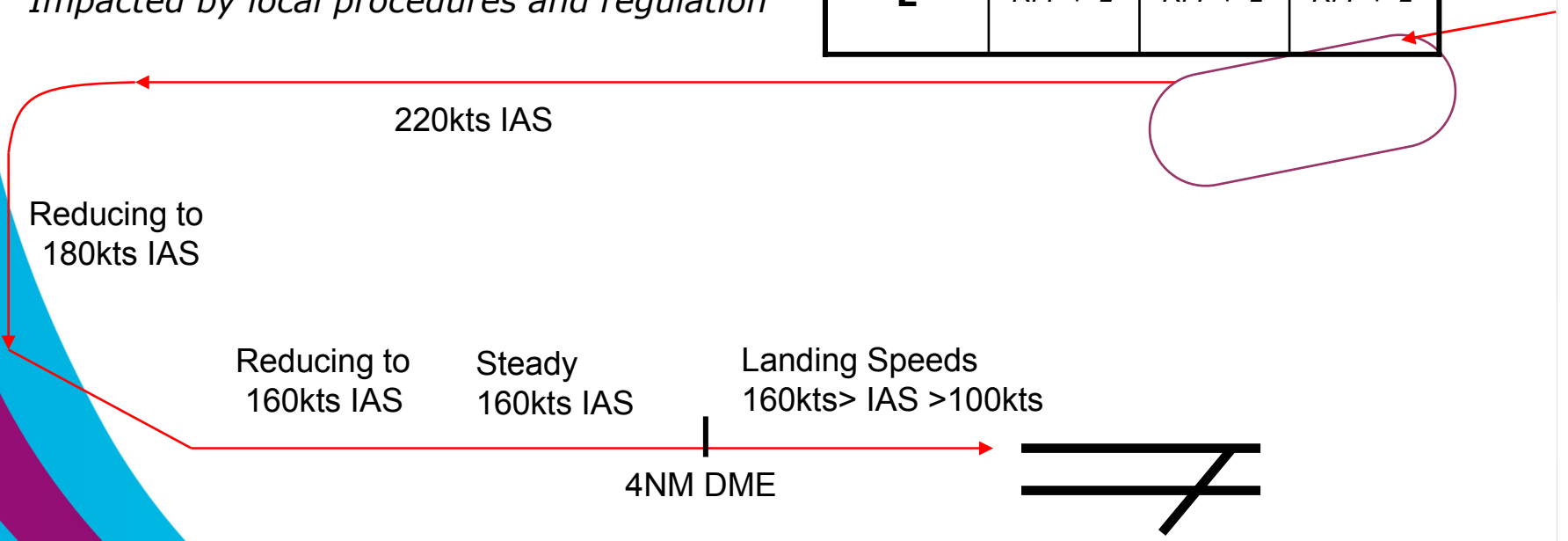
Assuming a steady 160kts IAS to 4DME

- *160kts GS = 22.5s per NM*

- *2.5NM + 1 = 78.25s*
- *3NM + 1 = 90s*
- *4NM + 1 = 112.5s*
- *5NM + 1 = 135s*
- *6NM + 1 = 157.5s*

Impacted by local procedures and regulation

(NM)	**H**	**M**	**L**
H	*4 + 1*	*5 + 1*	*6 + 1*
M	*RM + 1*	*RM + 1*	*RM + 1*
L	*RM + 1*	*RM + 1*	*RM + 1*



ICAO Separation on Joining Localiser

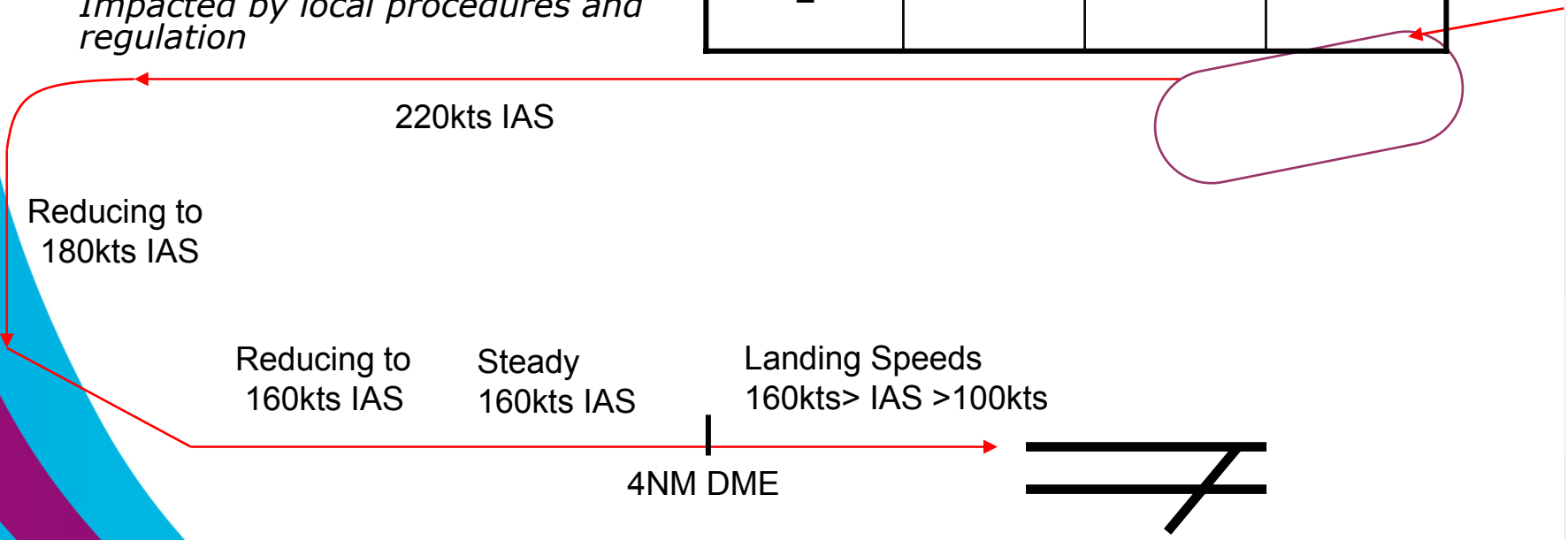
For ICAO time equivalent at 4DME assuming a mean 180kts GS:

180kts = 20s per NM

- *78.25s = 3.9NM*
- *90s = 4.5NM*
- *112.5s = 5.6NM*
- *135s = 6.7NM*
- *157.5s = 7.9NM*

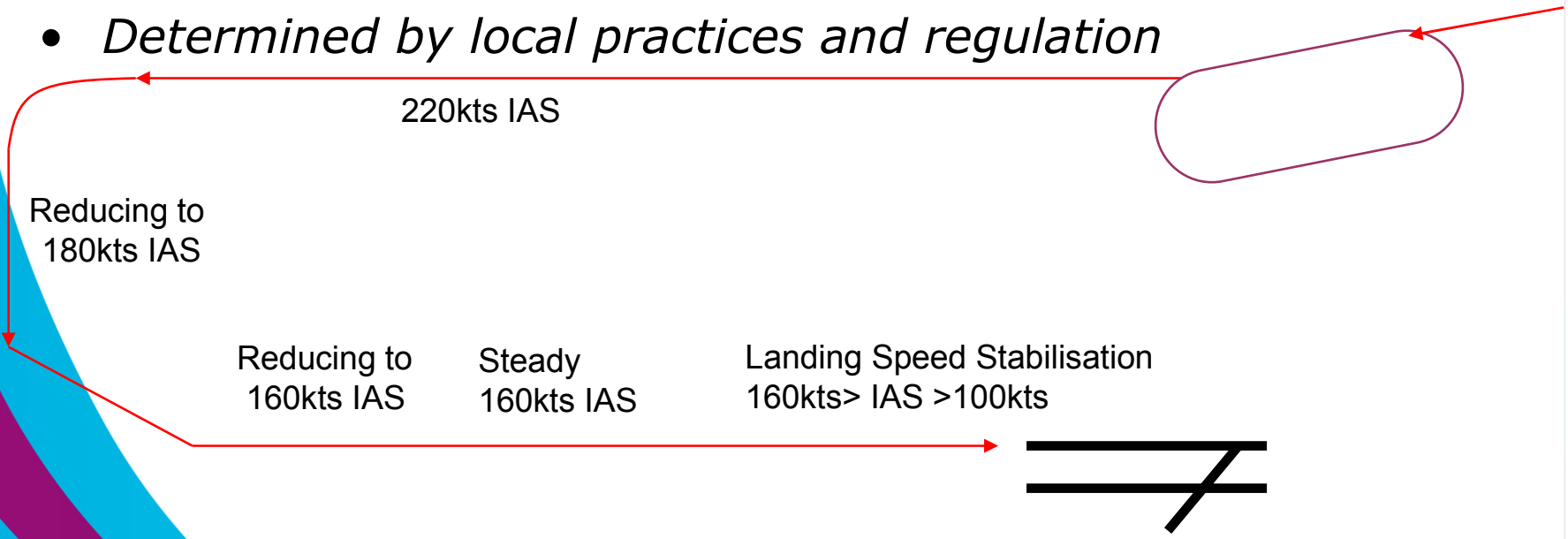
Impacted by local procedures and regulation

(NM)	**H**	**M**	**L**
H	*4 + 1.6*	*5 + 1.7*	*6 + 1.9*
M	*RM + 1.5*	*RM + 1.5*	*RM + 1.5*
L	*RM + 1.5*	*RM + 1.5*	*RM + 1.5*



ICAO Time Equivalent on Joining Localiser

- *Depends on the provision of additional separation for uncertainties in behaviour from follower aircraft joining localiser until lead aircraft crosses 4DME*
  - *Variation in pilot/airframe response to procedural airspeed reduction commands*
  - *Variation in pilot/airframe adherence to the steady 160kts IAS to 4DME*
- *Determined by local practices and regulation*



NATS Arrival WV Separation Criteria

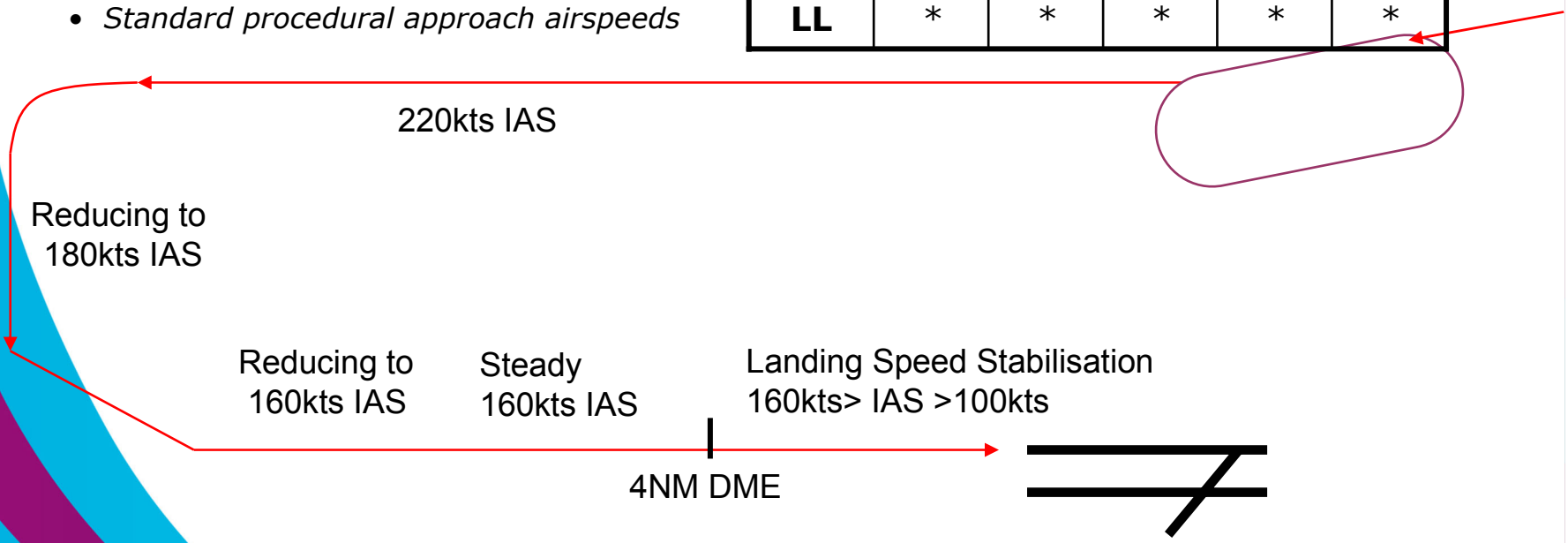
Five Wake Vortex Categories

- *Heavy (HH) >162,000kg*
- *Upper Medium (UM) >104,000kg*
- *Lower Medium (LM) > 40,000kg*
- *Small (SS) > 17,000kg*
- *Light (LL) <17,000kg*

** = spacing minimum; 3NM (2.5NM in restricted conditions)*

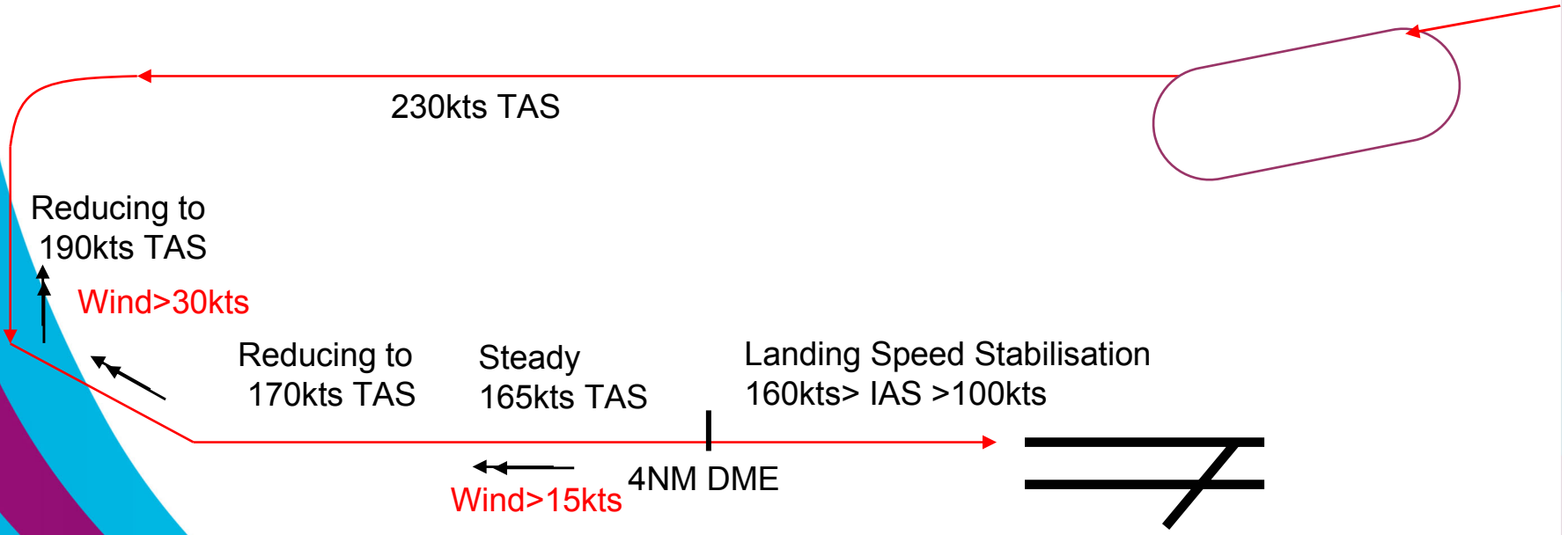
- *Applied across 4NM DME*
- *Standard procedural approach airspeeds*

(NM)	**HH**	**UM**	**LM**	**SS**	**LL**
HH	*4*	*5*	*5*	*6*	*7*
UM	*	*3*	*4*	*4*	*6*
LM	*	*	*	*3*	*5*
SS	*	*	*	*	*3*
LL	*	*	*	*	*



Headwind Conditions Impact on Landing rate

- *10% (~15kts) reduction in ground speed results in 10% (4 aircraft) reduction to the landing rate*
- *Turning on to join the localiser*
  - *45kt headwind = 4 aircraft reduction; 60kts headwind = 8 aircraft reduction*
- *Over the spacing to 4NM DME*
  - *30kts headwind = 4 aircraft reduction; 45kts headwind = 8 aircraft reduction*



NATS Proposed TBS Separation Minima

150kts ground speed conversion when ground speed falls below 150kts

- *24s per NM, SM*=72s*

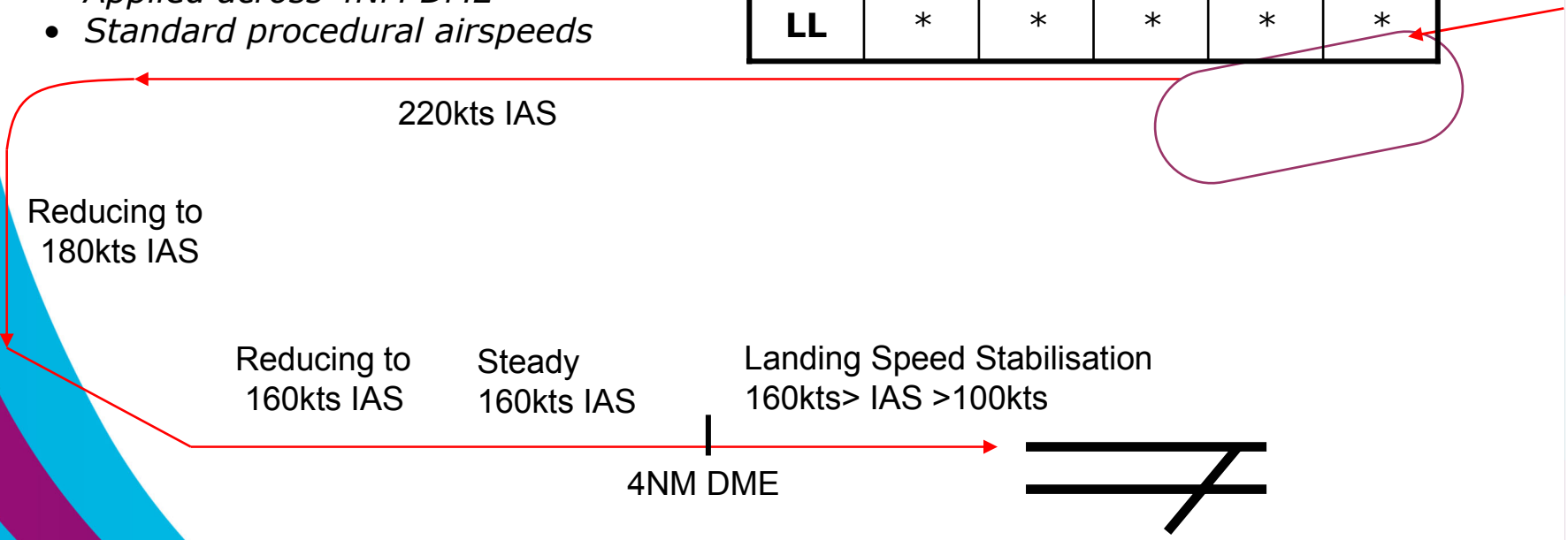
Current distance separation when ground speeds between 150kts & 160kts

160kts ground speed conversion when ground speed rises above 160kts

- *22.5s per NM, SM* = 67.5s*

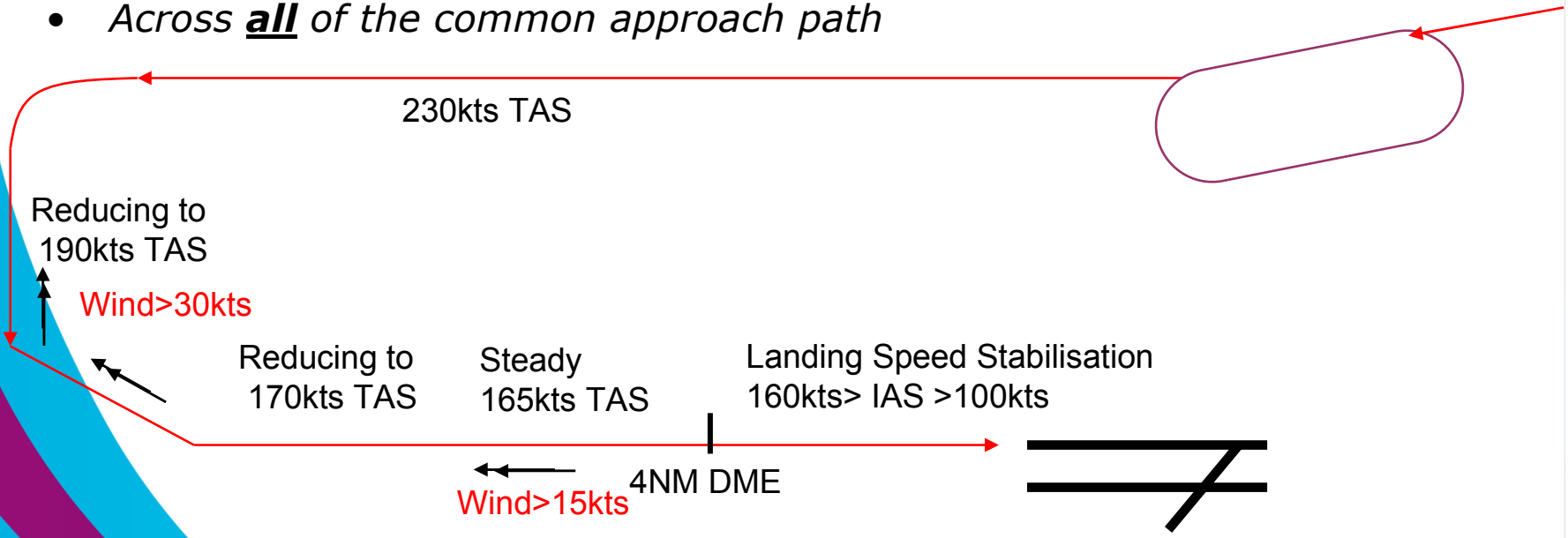
- *Applied across 4NM DME*
- *Standard procedural airspeeds*

(s)	**HH**	**UM**	**LM**	**SS**	**LL**
HH	*96*	*120*	*120*	*144*	*168*
UM	*	*72*	*96*	*96*	*144*
LM	*	*	*	*72*	*120*
SS	*	*	*	*	*72*
LL	*	*	*	*	*



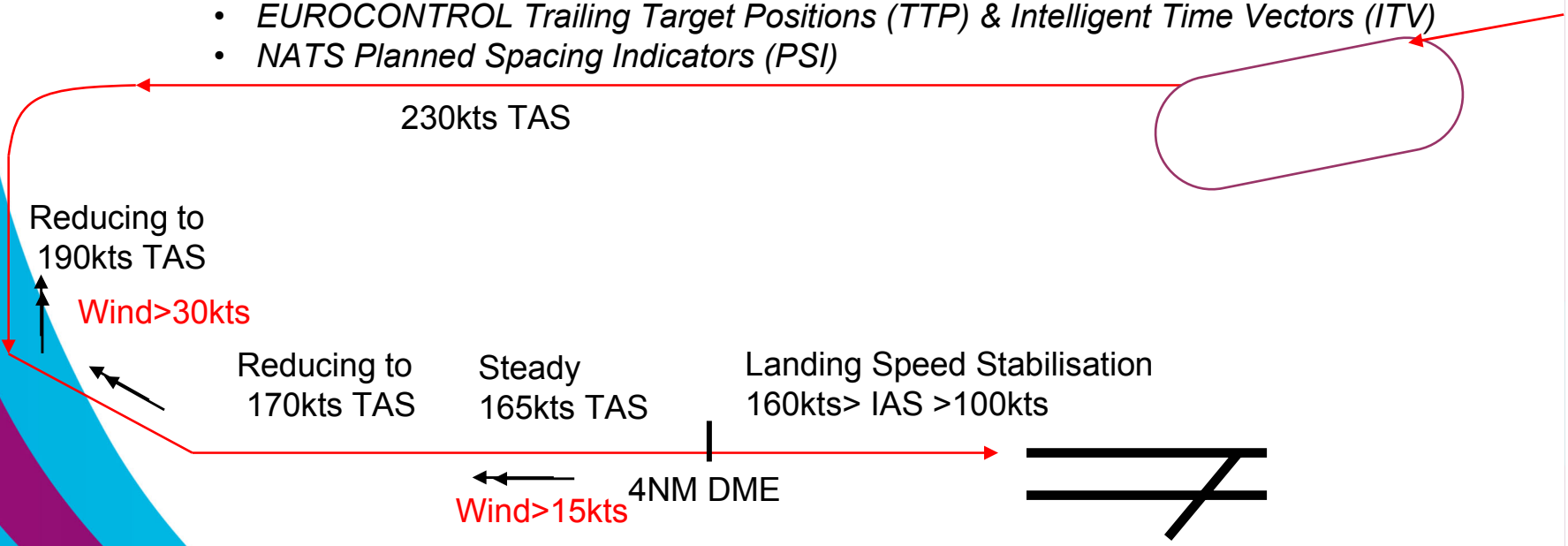
TBS Impact on Distance Separations

- *Distance separation between leader and follower*
  - *10% increase in wind resilience (15kts) requires a 10% reduction in distance separation (e.g. SM* = 2.7NM; HH-HH = 3.6NM; HH-UM, HH-LM = 4.5NM)*
  - *Alternatively a 15kts increase in IAS employed*
- *Time separation to a potential wake vortex encounter*
  - *10% reduction in distance separation results in a 10% reduction in the time separation to a potential wake vortex encounter when employing the same IAS*
- *Across **<u>all</u>** of the common approach path*



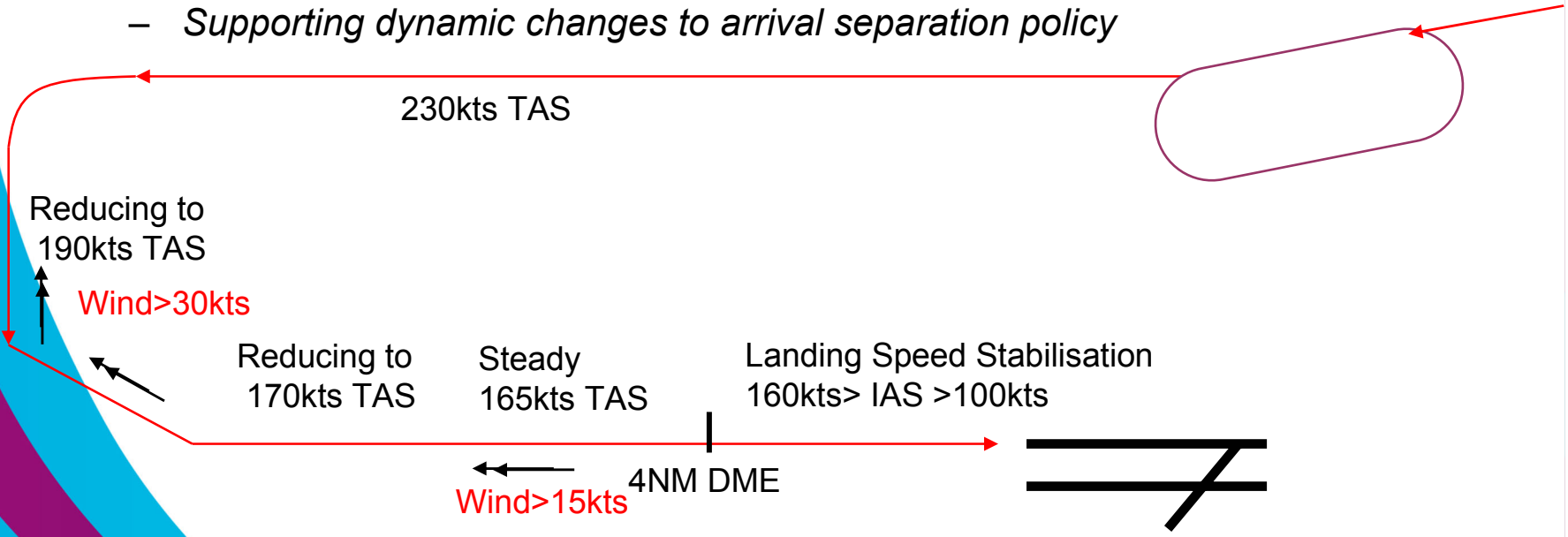
Controller/Pilot TBS System Support

- *Facilitating controller/pilot visualisation of time-based separations and consistent and accurate delivery to time-based separation minima*
  - *Distance-based system visualisation support*
    - *10NM range rings working at a 25NM to 30NM radar display range*
    - *2NM centre line markings*
    - *Limits the accuracy of delivery to around +/-0.2NM to +/-0.3NM*
  - *Time-based system visualisation support*
    - *Requirement for accuracy of delivery to +/-0.1NM*
    - *EUROCONTROL Trailing Target Positions (TTP) & Intelligent Time Vectors (ITV)*
    - *NATS Planned Spacing Indicators (PSI)*



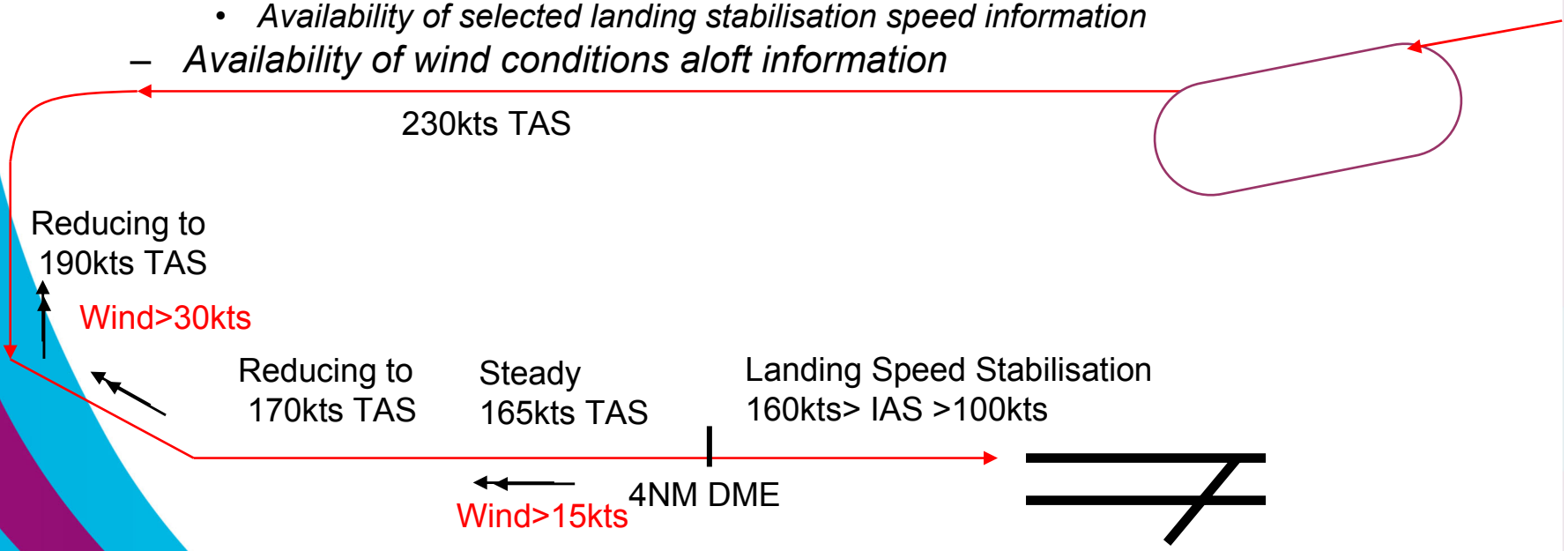
Time-Based System Visualisation Support

- *Challenges in calculating required time-based separations*
  - *High integrity arrival deliver sequence order information*
  - *High integrity aircraft type/WV category information*
  - *Dealing with arrival pairs with excessive time separation reduction on final approach*
    - *Availability of selecting landing stabilisation speed information*
    - *Availability of wind conditions aloft information*
  - *Dealing with arrival pairs employing non-standard approach speeds*
  - *Supporting dynamic changes to arrival separation policy*



Time-Based System Visualisation Support

- *Challenges in providing for visualisation of time-based separations*
  - *Ground speed changes on approach impacts the stability of distance-based separation visualisation along the approach path (e.g. TTP, ITV and PSI)*
  - *Impacts whether to just provide stable visualisation of required separation across 4DME or provide for dynamic visualisation across the whole of the approach path*
  - *Landing stabilisation speed impacts visualisation once lead aircraft inside of 4DME*
    - *Availability of selected landing stabilisation speed information*
  - *Availability of wind conditions aloft information*



ICAO WVE Separation Management

- *PANS ATM 8.7.4 Radar Separation Minima*
  - *Wake turbulence separation radar separation minima applied*
    - *When an aircraft is operating directly behind another aircraft at the same altitude or less than 300m (1000ft) below*
    - *Both aircraft using the same runway, or parallel runways separated by less than 760m*
    - *An aircraft crossing behind another aircraft, at the same altitude or less than 300m (1000ft) below*
  - *Applied across the whole approach path in all wind conditions and the application of all approach speeds*

ICAO WV Separation Management

- *In-trail aircraft on approach*
  - *Time separation to WVE determined by distance separation between aircraft and closing TAS of follower aircraft on the WV*
    - *4NM WV Separation*
      - *230kts TAS = 62s; 190kts TAS = 76s; 160kts TAS = 90s*
    - *5NM WV Separation*
      - *230kts TAS = 78s; 190kts TAS = 95s; 160kts TAS = 112.5s*
  - *As headwind conditions increase difference between time separation between aircraft and time separation to WVE encounter increases*
    - *40kts Headwind & 160kts TAS*
      - *120kts GS: 4NM = 120s time separation between aircraft*
      - *160kts TAS: 4NM = 90s time separation to WVE*

ICAO WV Separation Management

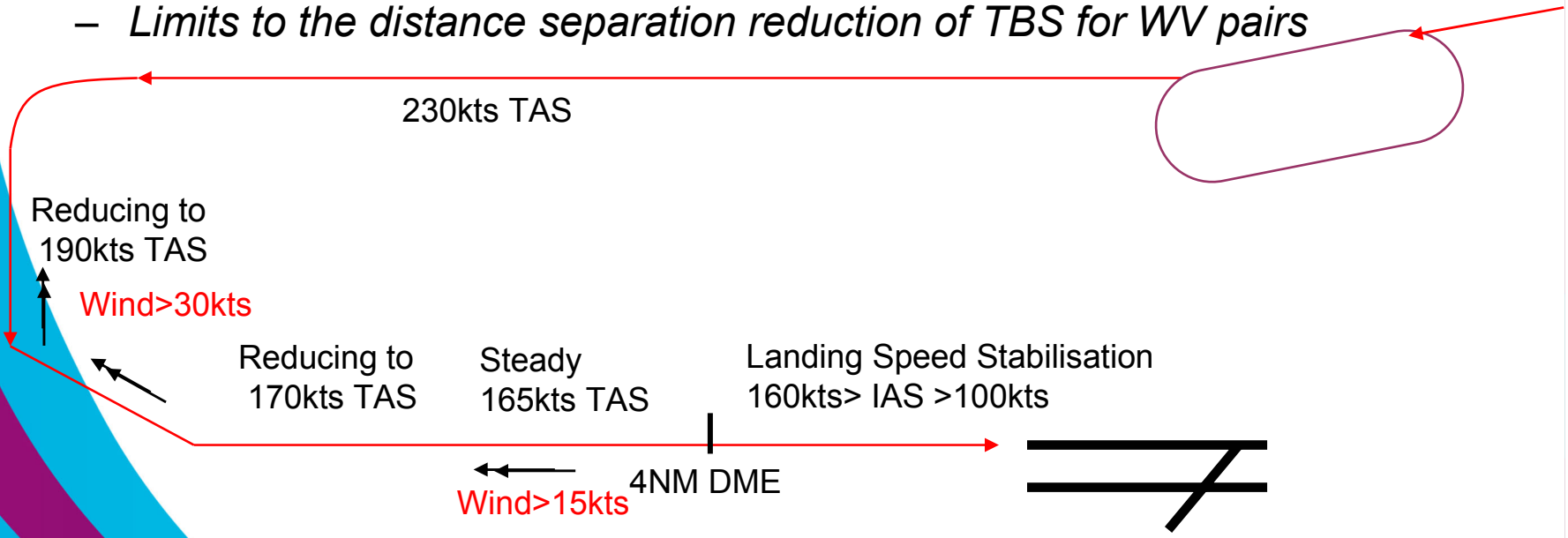
- *Aircraft crossing behind another aircraft on approach*
  - *Time separation to WVE determined by distance separation when crossing behind and TAS of lead aircraft over the separation distance*
    - *4NM WV Separation*
      - *230kts TAS = 62s; 190kts TAS = 76s; 160kts TAS = 90s*
    - *5NM WV Separation*
      - *230kts TAS = 78s; 190kts TAS = 95s; 160kts TAS = 112.5s*
  - *As headwind conditions increase difference between time separation between aircraft and time separation to WVE encounter increases*
    - *40kts Headwind & 160kts TAS*
      - *120kts GS: 4NM = 120s time separation at crossing point*
      - *160kts TAS: 4NM = 90s time separation to WVE at crossing point*

ICAO WV Separation Management

- *Conclusions*
  - *For a particular procedural airspeed*
    - *Distance separation minima provide for a stable time separation to WVE across variations in wind conditions*
  - *For different phases of the approach path where different procedural airspeeds apply*
    - *Increasing time separation to WVE is provided for as the procedural airspeeds reduce*
- *Question*
  - *Why is there a need for the provision of increasing time separation to WVE on final approach as compared to downwind?*
    - *How does this impact the TBS reduction of time separation to WVE on approach in headwind conditions?*

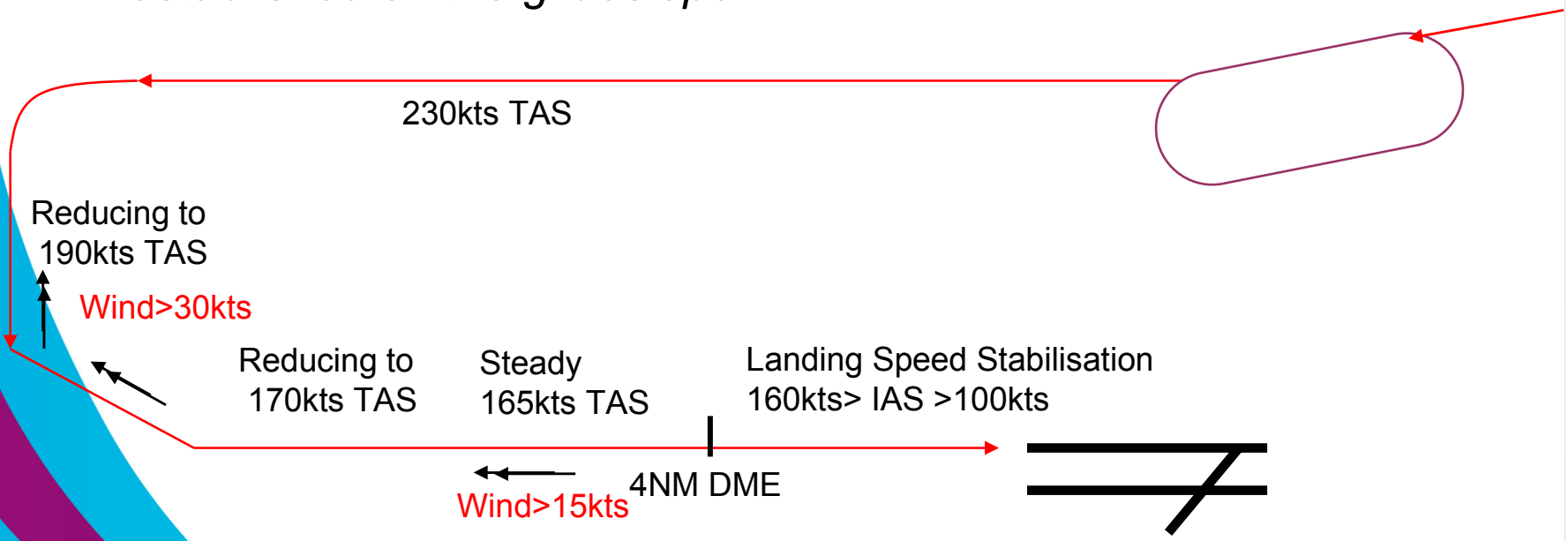
Stakeholder Input Session Issues

- *Management of WVE Risks*
  - *ATC, airline and cockpit procedures and practices changes to reduce uncertainties in behaviour impacting consistent and accurate separation delivery*
  - *Safety mitigation for reducing time separation to WVE*
    - *Transport mitigation when both aircraft established on glideslope*
    - *Procedure/practices mitigation when turning on to localiser*
  - *Limits to the distance separation reduction of TBS for WV pairs*



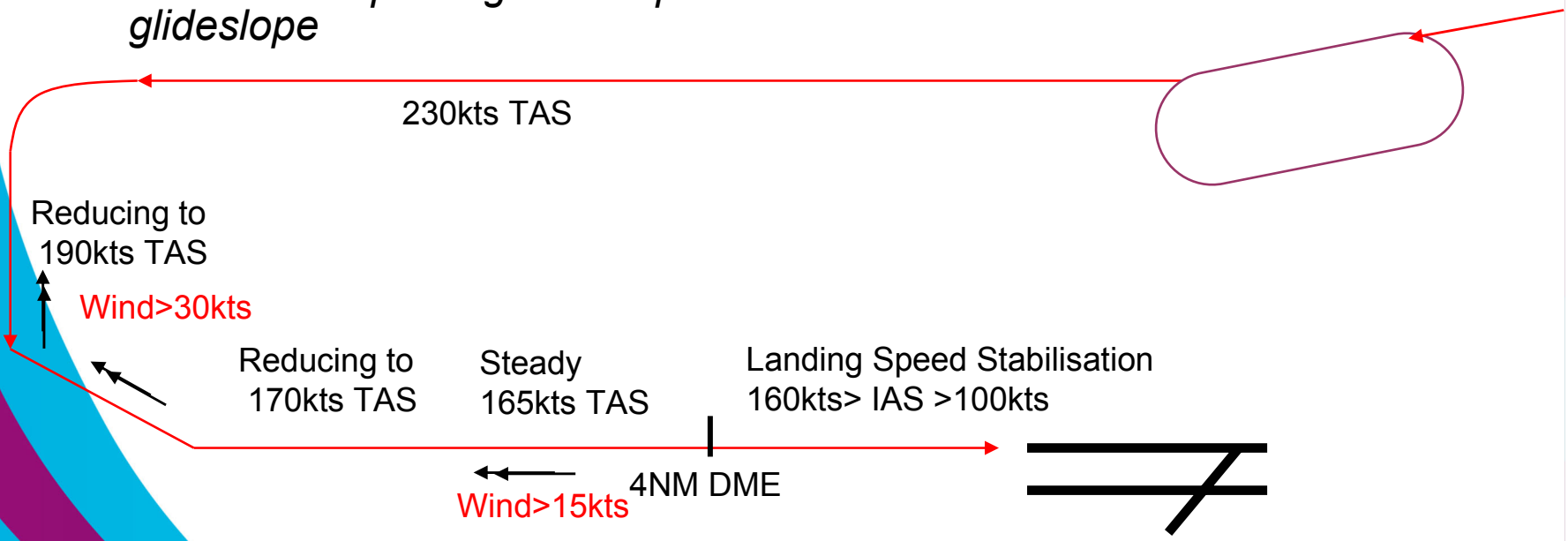
Stakeholder Input Session Issues

- *Management of MAC Risks*
  - *Limits to the distance separation reduction of TBS for radar minimum separated pairs*
  - *ATC, airline and cockpit procedures and practices changes to reduce behaviour impacting time separation reduction once established on the glideslope*



Stakeholder Input Session Issues

- *Management of RC/RI Risks*
  - *Impact of TBS on clearance to land procedures*
  - *Improvements to runway exit taxiways for supporting expedited runway vacation for radar minimum separated pairs lead aircraft*
  - *Improvement to consistency of expedited runway vacation behaviour*
  - *ATC, airline and cockpit procedures and practices changes to reduce behaviour impacting time separation reduction once established on the glideslope*



Stakeholder Input Session Issues

- *How do we facilitate fast-track deployment of TBS?*
  - *Establishing pro-active Local and European stakeholder working groups*
  - *Developing a mature operational concept that all stakeholders are happy with*
  - *Starting long lead time deployment preparation activities*
    - *Improvements to procedures and practices*
    - *Improvements to runway rapid exit taxiways*
    - *Development and deployment of required system support*