Time-Based Separations for Arrivals

Charles Morris

Technical Leader

Department of Research & Development

NATS Hurn

+44 (0) 1202 472143

charles.morris@nats.co.uk

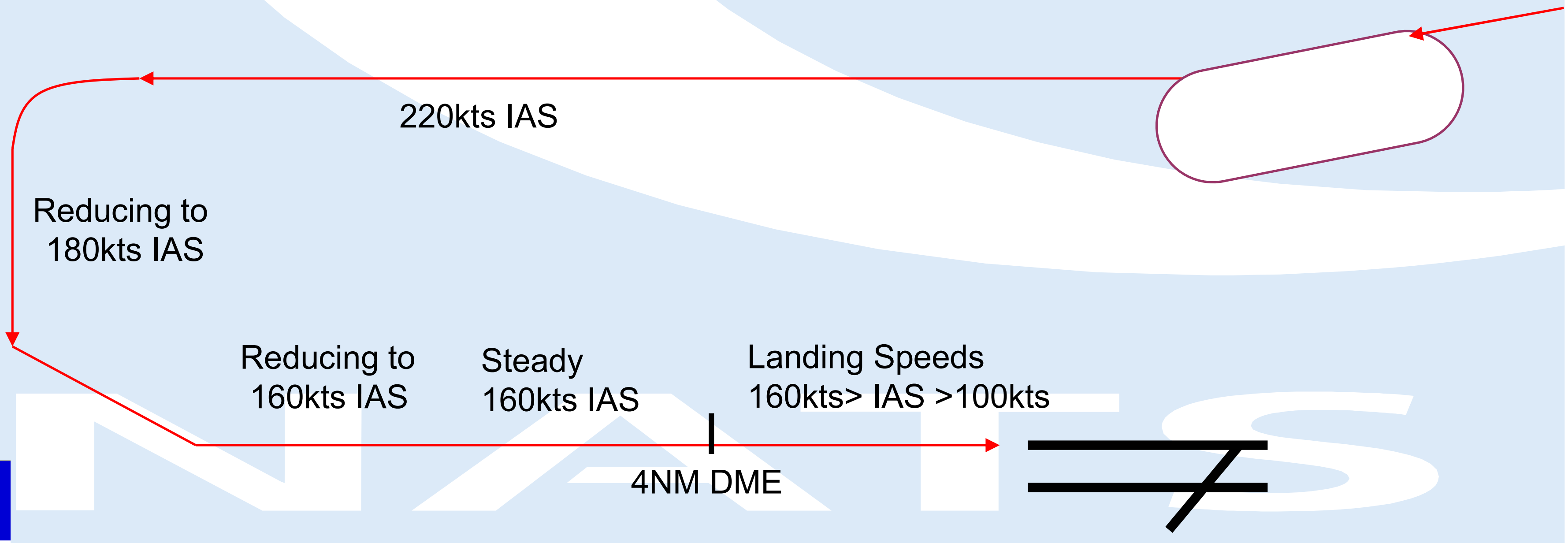
TBS-Arrivals - Overview

- Background
  - NATS arrival separation criteria
  - Landing rate resilience requirements for challenging wind conditions
  - Wind conditions impact on the landing rate
  - Landing speed issues
- TBS-Arrivals
  - Proposed TBS separation criteria for addressing landing rate resilience
  - Impact on distance separations and wake vortex encounter separations
  - Wake vortex encounter mitigation issues
  - Strategy for deployment and strategic priorities
- Key Points
  - Impacts the whole of the common approach path
  - Impacted by the amount of variation and uncertainty in arrivals behaviour
  - Potentially significant wake vortex encounter mitigation issues
  - Safety arguments with supporting evidence are key to operational deployment

NATS Arrival Wake Vortex Separation Criteria

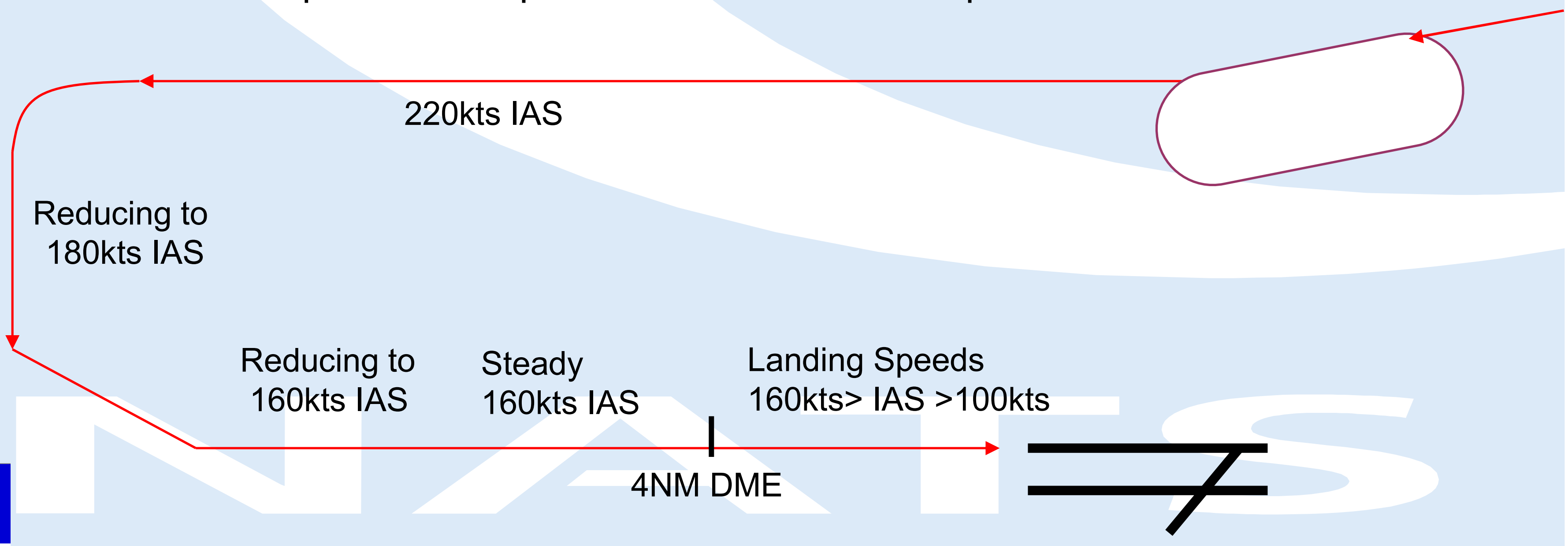
- Five Wake Vortex Categories
  - Heavy (HH), Upper Medium (UM), Lower Medium (LM), Small (SS), Light (LL)
  - * = spacing minimum; 3NM (2.5NM in restricted conditions)
- Applied across 4NM DME
- Standard procedural airspeeds

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



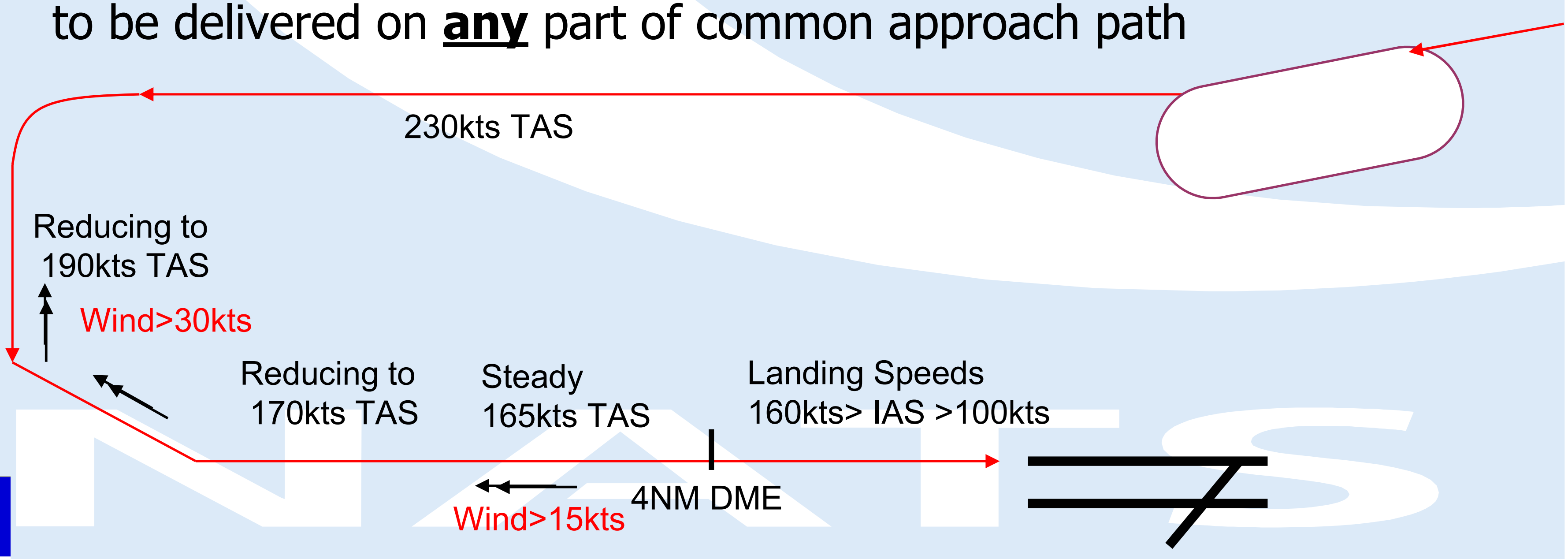
NATS Arrival Wake Vortex Separation Criteria

- Approach controller adjustments made for:
  - Employment of exceptional landing speeds
  - Unacceptable distance separation compression inside of 4NM DME
  - To preserve clearance to land margins for SM*, 3NM, and 4NM HH-HH pairs
- Approach controller additional spacing margin provision for:
  - Airframe/pilot behaviour uncertainties in the prevailing wind; blocked RT
  - Distance separation compression from time catch-up risk inside of 4NM DME



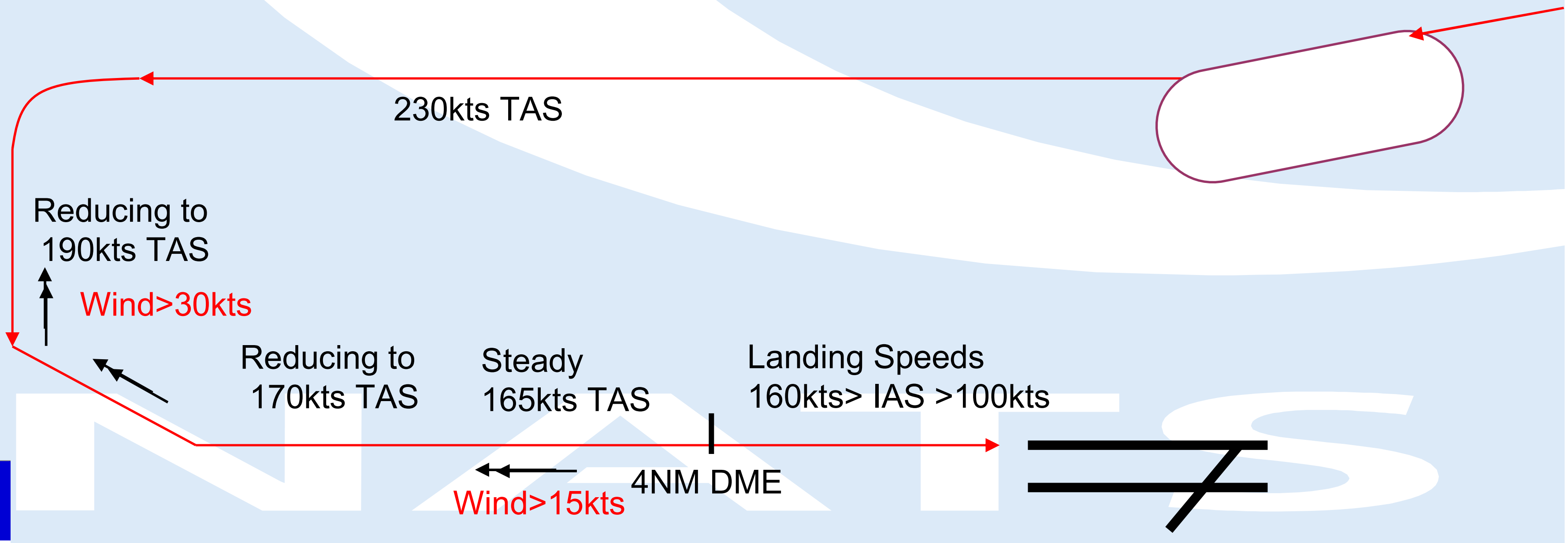
Landing Rate Resilience Requirements

- Amount of spacing to be delivered across 4NM DME
  - Arrival separation criteria: 25LM/15HH = 137NM to 144NM per hour
  - Additional spacing margin provision: Mean of 0.2NM = 8NM per hour
- Amount of spacing to be delivered on turning on to join the localiser
  - Additional spacing margin provision: Mean of 0.5NM = 20NM per hour
- Landing rate falls when ground speed falls below amount of spacing to be delivered on **any** part of common approach path



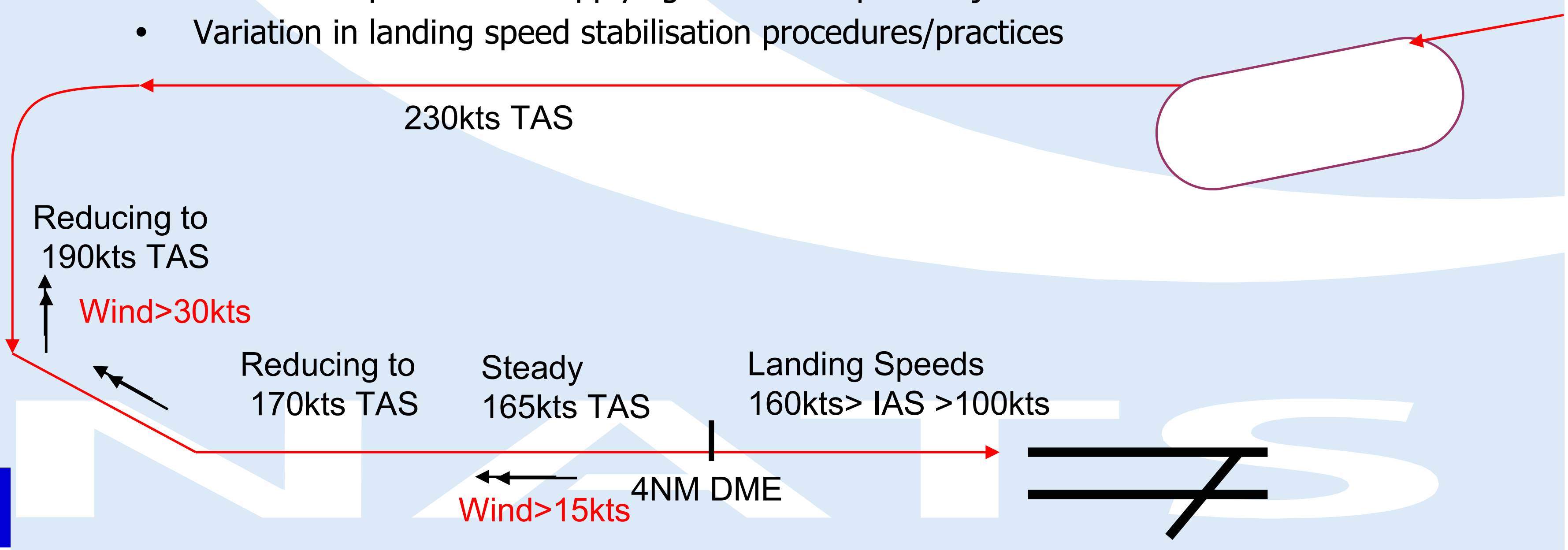
Wind Conditions Impact on the Landing Rate

- 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



Landing Speed Issues

- Challenges when delivering to the wake vortex separation criteria:
  - Aircraft Type
    - Variation in Vref depending on landing weight/flap setting (~25kts)
  - Across Aircraft Types
    - Variation in Vref requirements; variation in adjustments for surface wind conditions
    - Variation in landing speed stabilisation practices: airspeed v ground speed
  - Across Airline Operators/Pilots
    - Variation in practices for applying additional speed adjustment above Vref
    - Variation in landing speed stabilisation procedures/practices



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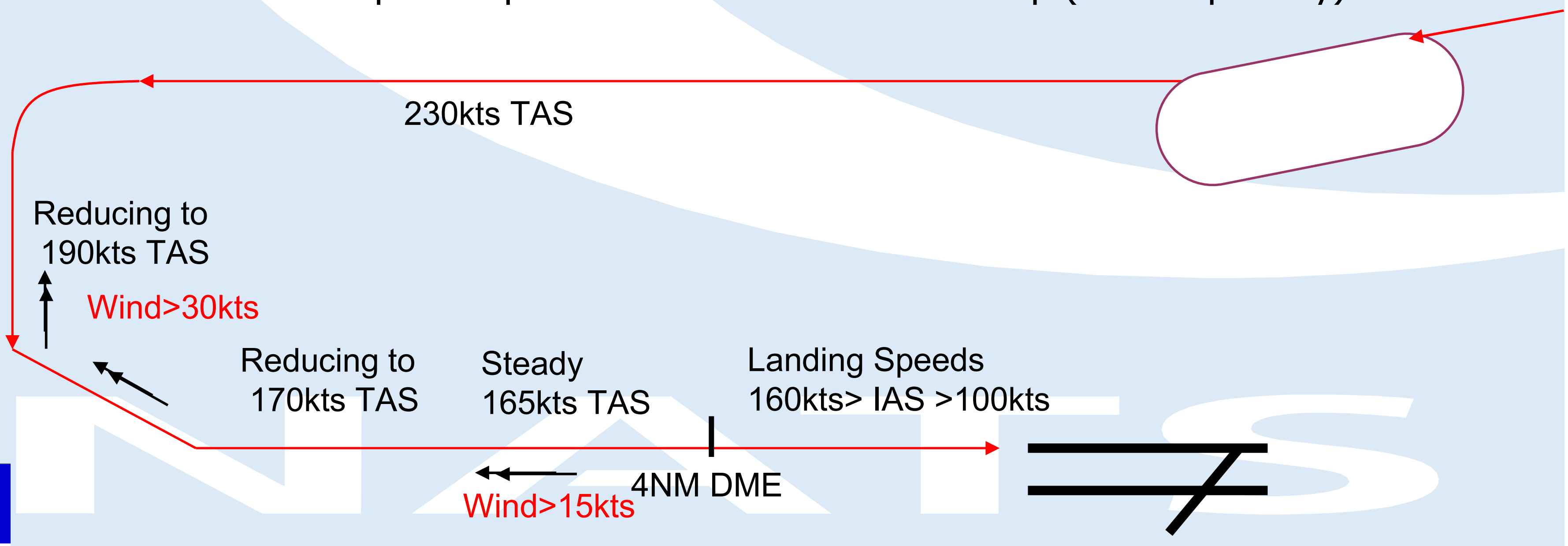
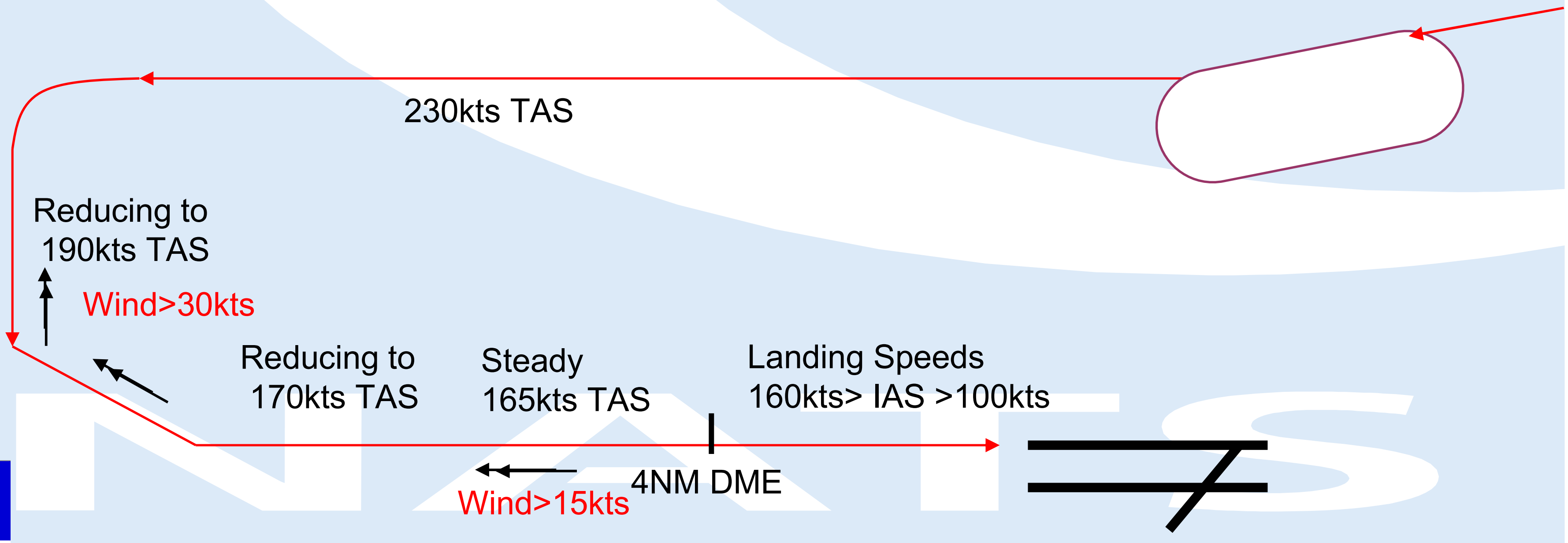
Landing Speed Issues

- Approach controllers are not informed of the selected landing speeds employed
- Wide range of time separation catch-up/pull-away experienced
  - Normal distribution with a mean of no catch-up/pull-away
  - 1 in 6 arrival pairs experience more than 10s catch-up (~ once per 10 minutes)
  - 1 in 40 arrival pairs experience more than 20s catch-up (~ once per hour)
  - 1 in 670 arrival pairs experience more than 30s catch-up (~ once per day)



Landing Speed Issues

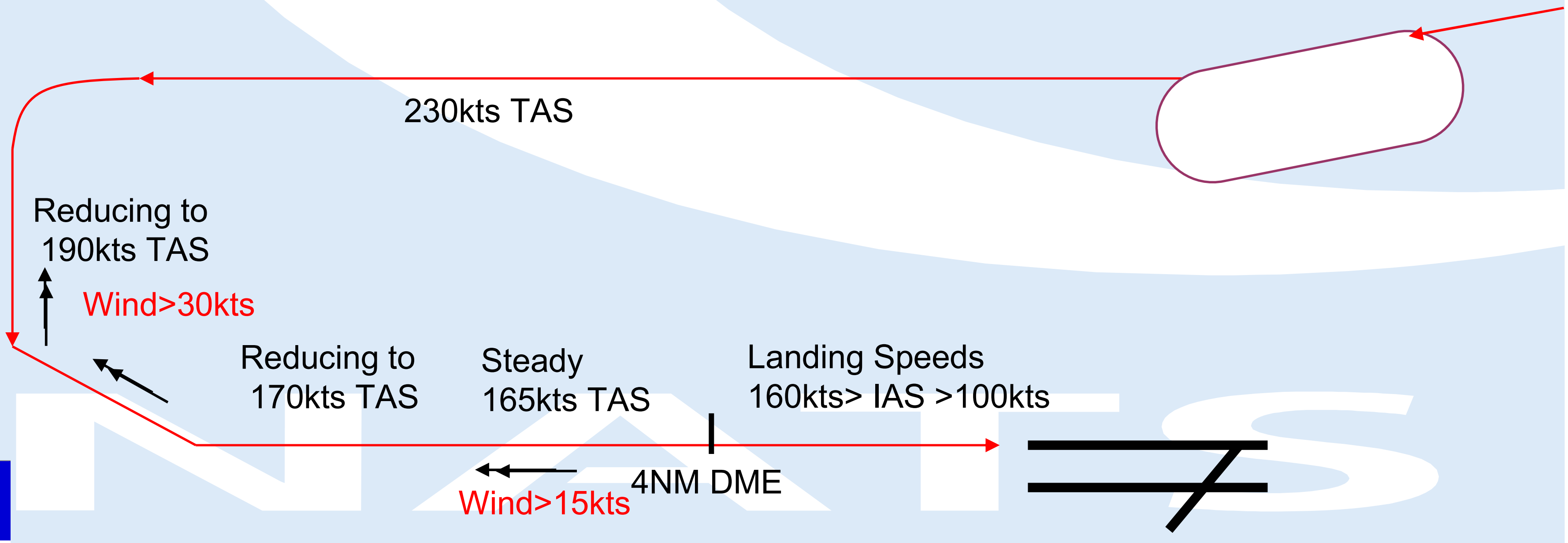
- Wide range of distance separation compression experienced between 4NM DME and the runway threshold
- Increasing distance separation compression
  - Increasing headwinds, time separation catch-up, slow landing speeds
- Decreasing distance separation compression
  - Decreasing headwinds, time separation pull-away, fast landing speeds



Landing Speed Issues – Catch-up/Pull-away

Time Separation Change per NM				
(s)	***160***	***140***	***120***	***100***
160	0	3.2	7.5	13.5
140	-3.2	0	4.3	10.3
120	-7.5	-4.3	0	6
100	-13.5	-10.3	-6	0

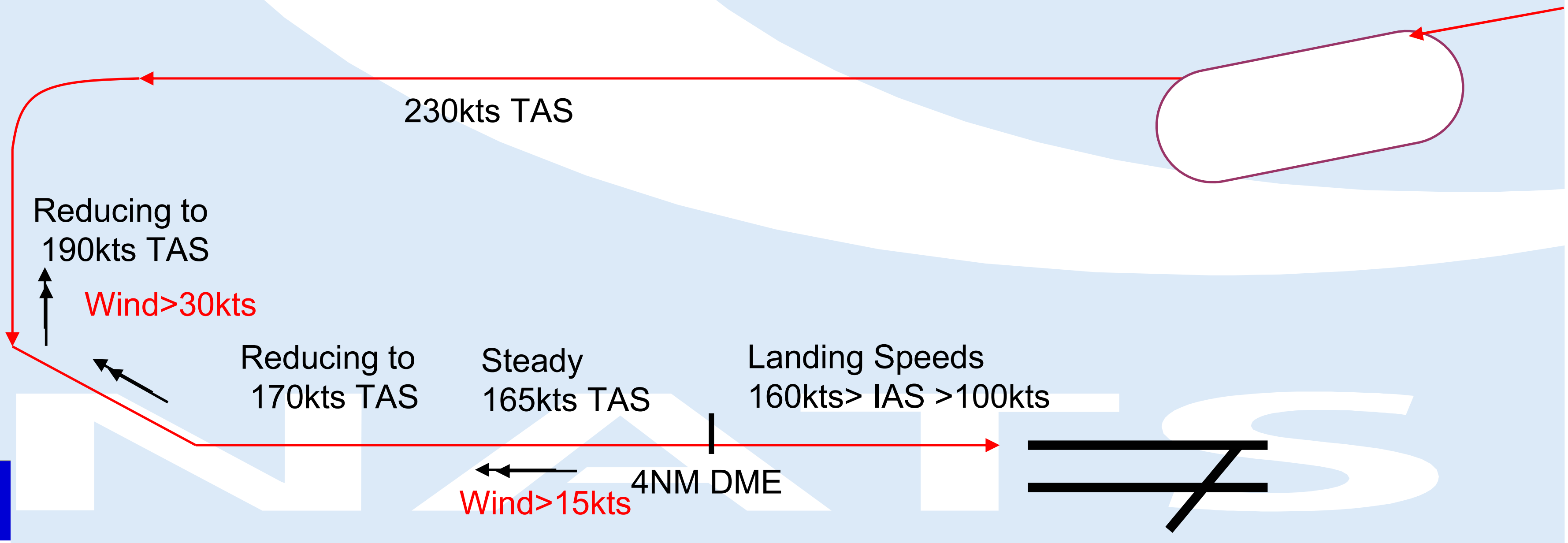
Catch-up/Pull-away (2.5 x NM)				
(s)	***160***	***140***	***120***	***100***
160	0	8	18.8	33.8
140	-8	0	10.8	25.8
120	-18.8	-10.8	0	15
100	-33.8	-25.8	-15	0



Landing Speed Issues – Distance Compression

4NM DME Separation Minima				
(NM)	***68s***	***90s***	***113s***	***135s***
160	3	4	5	6
140	2.6	3.5	4.4	5.3
120	2.3	3	3.8	4.5
100	1.9	2.5	3.1	3.8

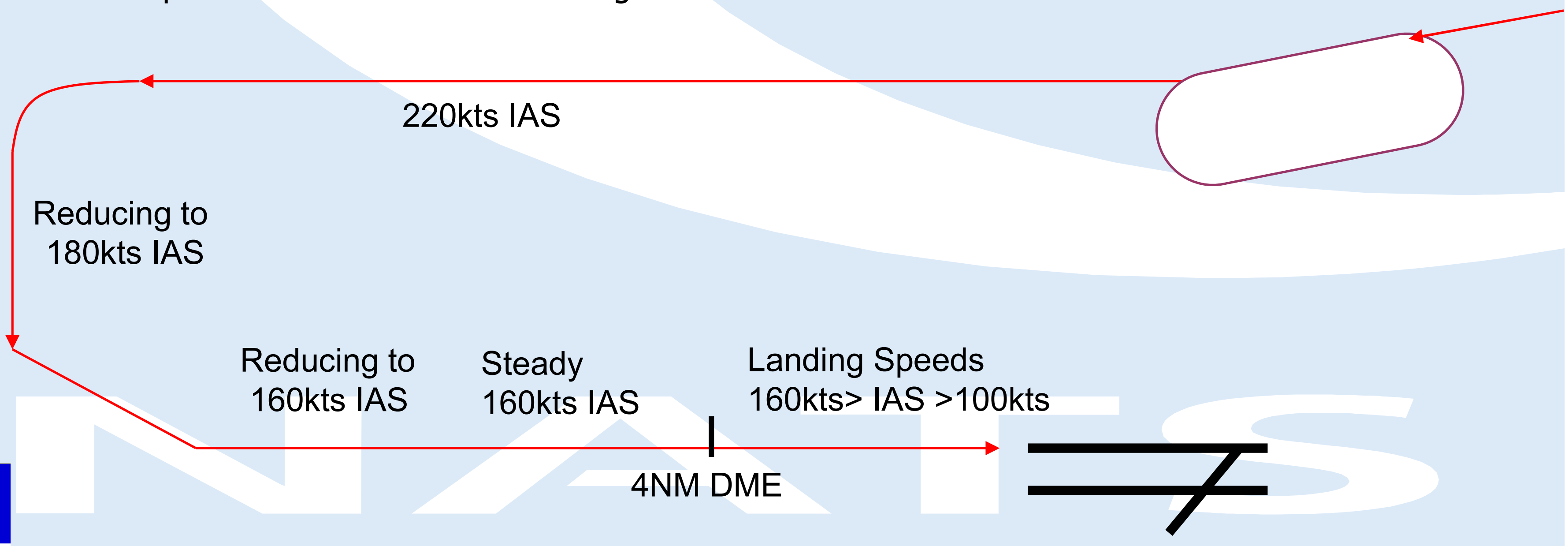
Runway Separation Minima				
(NM)	***60s***	***80s***	***100s***	***120s***
160	2.7	3.6	4.4	5.3
140	2.3	3.1	3.9	4.7
120	2	2.7	3.3	4
100	1.7	2.2	2.8	3.3



Landing Rate Resilience – TBS-Arrivals Proposal

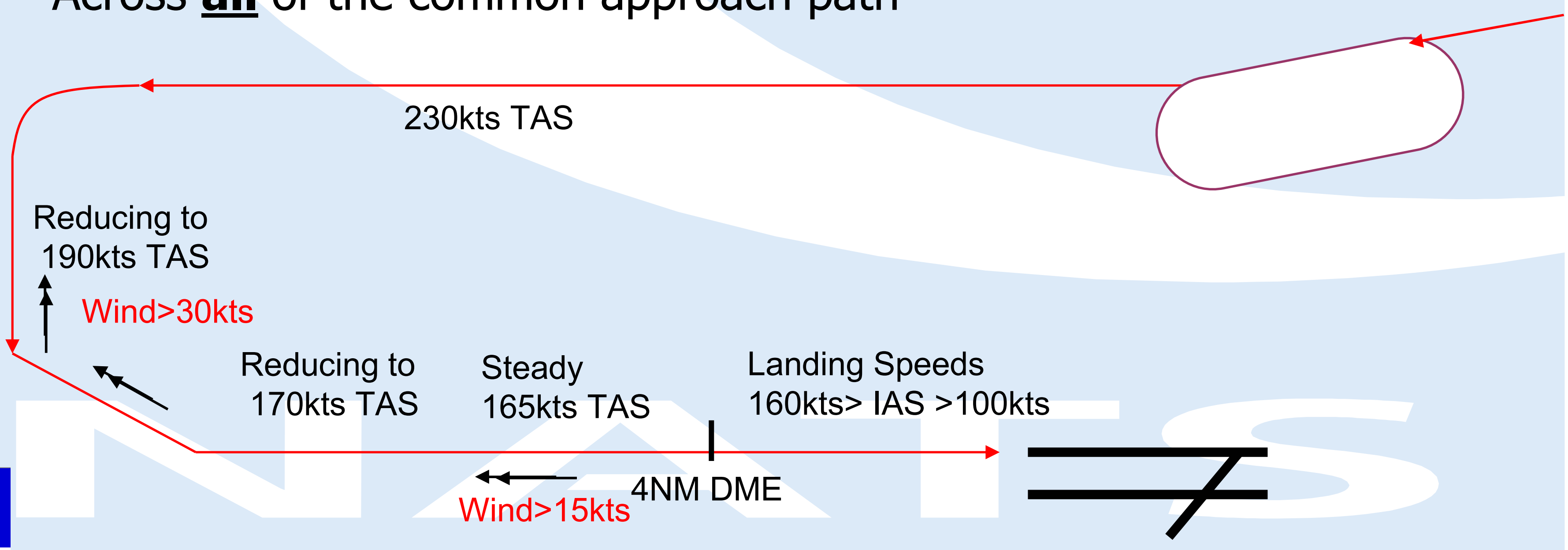
- 160kts ground speed conversion
  - 22.5s per nm, SM*=68s
- Applied across 4NM DME
- Standard procedural airspeeds
- Adjustments made for:
  - Exceptional landing speeds
  - Unacceptable distance compression
  - To preserve clearance to land margins

(s)	***HH***	***UM***	***LM***	***SS***	***LL***
HH	90	113	113	135	158
UM	*	68	90	90	135
LM	*	*	*	68	113
SS	*	*	*	*	68
LL	*	*	*	*	*



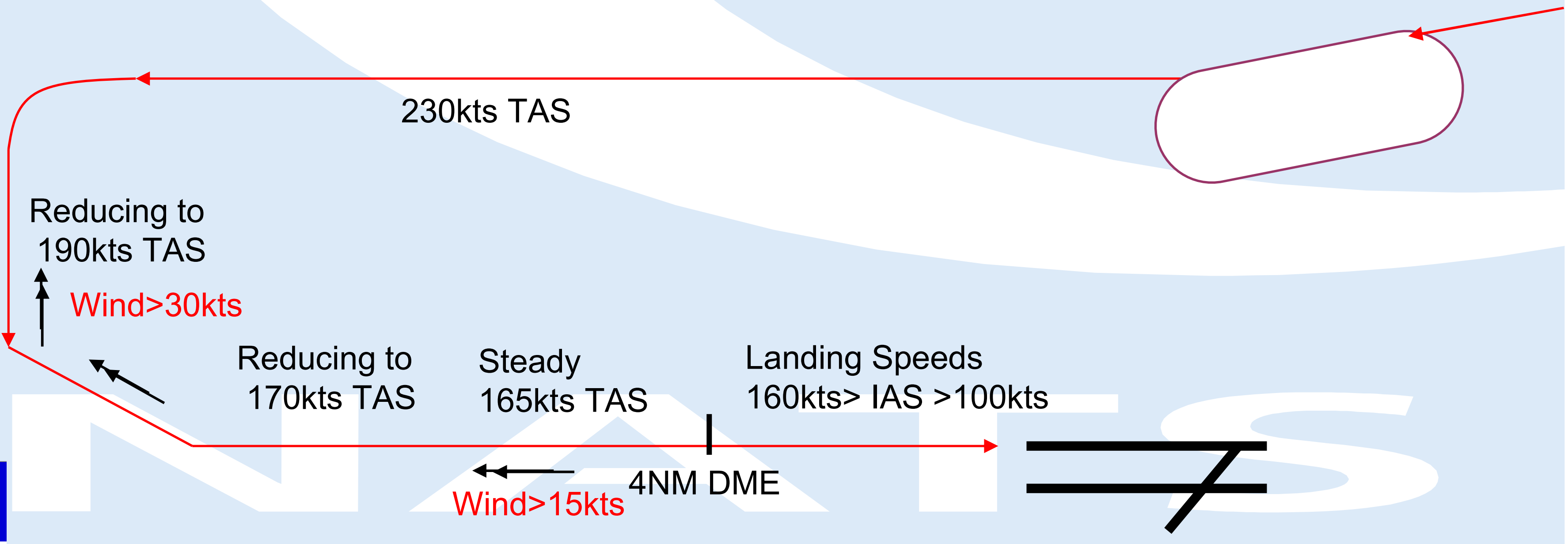
TBS-Arrivals – Impact on Separations

- 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)
- 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
- Across **all** of the common approach path



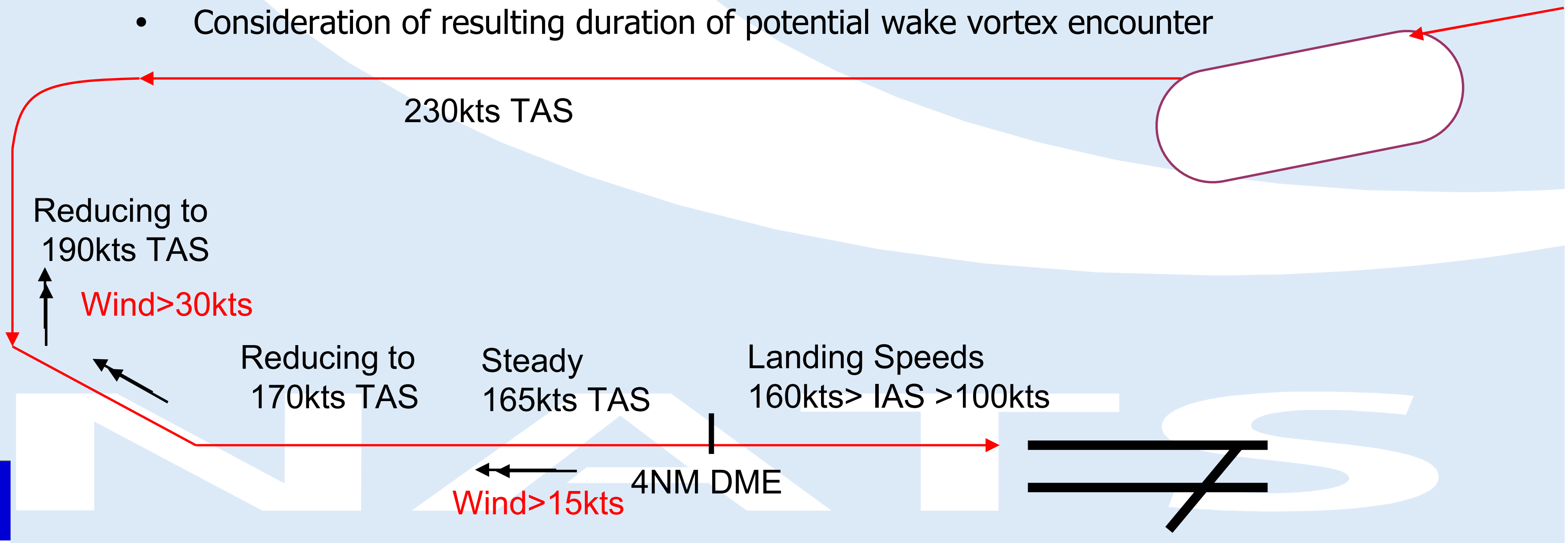
TBS-Arrivals – Wake Vortex Encounter Mitigation

- Turning on to join the localiser & not established on glideslope
  - Reduction in separations: 10% for 30kts; 20% for 45kts; 30% for 60kts resilience
  - Potential severity & duration of any wake vortex encounter
    - Aircraft reactions; alertness of pilot; recovery to continue approach; cabin procedures
  - Wake decay mitigation; no transport mitigation
    - Will transport mitigation be required for TBS-arrivals?



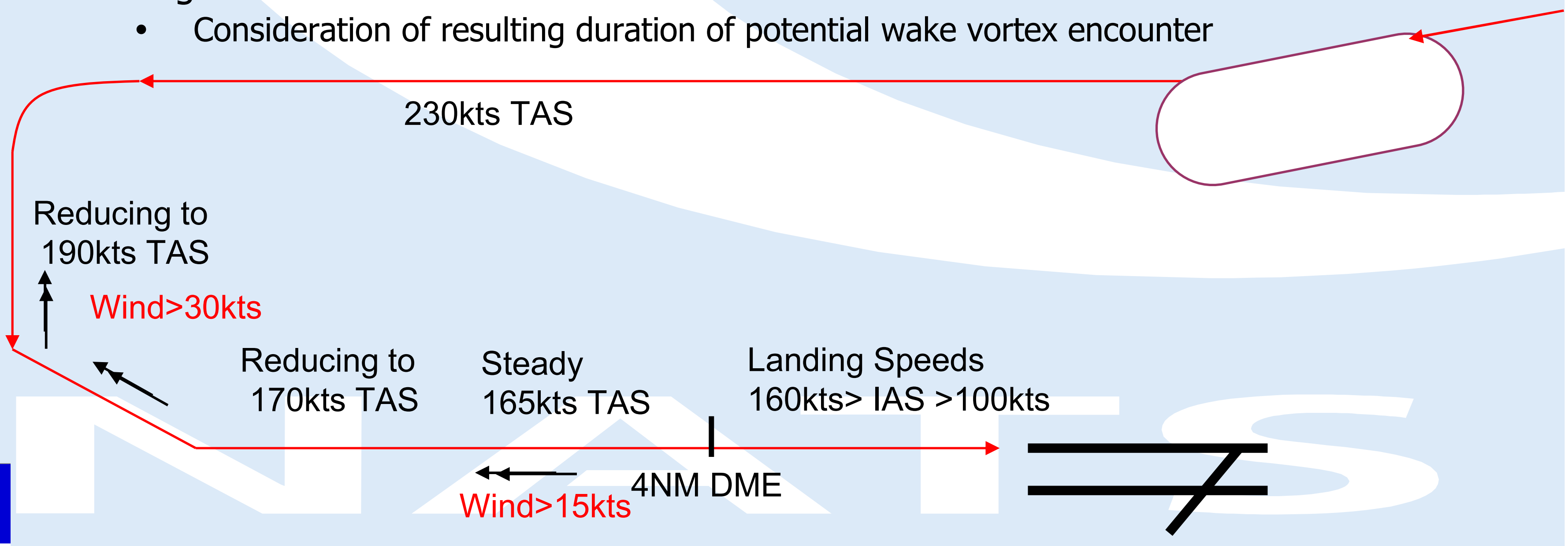
TBS-Arrivals – Wake Vortex Encounter Mitigation

- Arrival pair both established on glideslope prior to landing phase
  - Reduction in separations: 10% for 15kts; 20% for 30kts; 30% for 45kts resilience
  - Potential severity & duration of any wake vortex encounter
    - Aircraft reactions; alertness of pilot; recovery; missed approach procedure; cabin procedures
  - Wake transport mitigation and wake decay mitigation?
  - Impact of missed approach procedure on the follower wake vortex encounter mitigation
    - Consideration of resulting duration of potential wake vortex encounter



TBS-Arrivals – Wake Vortex Encounter Mitigation

- Arrival pair both established on glideslope on landing phase
  - Reduction in minimum separations: 0.5NM; 1NM; 1.5NM reduction
  - Potential severity & duration of any wake vortex encounter
    - Aircraft reactions; alertness of pilot; recovery; missed approach procedure; cabin procedures
  - Wake transport mitigation and wake decay mitigation?
    - Consideration of ground effects of wake vortex behaviour
  - Impact of missed approach procedure on the follower wake vortex encounter mitigation
    - Consideration of resulting duration of potential wake vortex encounter



TBS-Arrivals – Strategy for Deployment

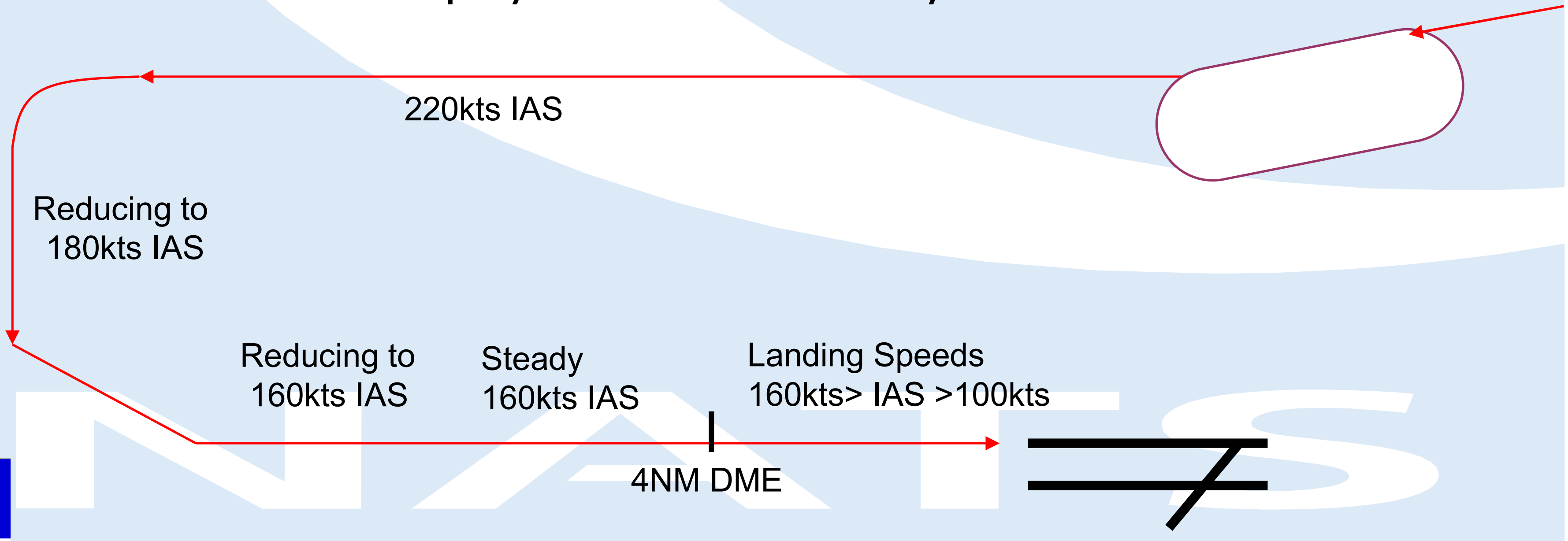
- Immediate improvements to practices and procedures
  - Consistency in airline/airframe/pilot approach procedures/practices behaviour
  - Consistency in approach controller procedures/practices
  - Consistency in aerodrome controller procedures/practices
- Early deployment of TBS-arrivals
  - Establish regulatory approval for TBS-arrivals separations with the list of enabling conditions
  - Within existing capabilities of radar surveillance support for the reduced distance separations of TBS-arrivals
  - Enhancing the approach controller capabilities to enable time-based separation delivery
    - Visualisation of time separation
    - Consistent & accurate delivery to 0.25NM or 0.1NM distance increments
- Enhanced deployment of TBS-arrivals
  - Enhanced surveillance support for reduced distance separations
  - Informing approach controller support tools of the selected landing speeds
  - Involvement of the airframe/pilot in providing transport mitigation on turning on to the localiser and in the consistency & accuracy of separation delivery

TBS-Arrivals – Strategic Priorities

- Establish regulatory approval with the list of enabling conditions
  - Development of the safety arguments (e.g. hazards identification; claims trees)
  - Stakeholder agreement on the sufficiency of the arguments (e.g. scope, correctness, completeness)
  - Stakeholder agreement on the evidence to be collected (e.g. what, how much)
  - Evidence generation and collection (e.g. modelling; measurement)
  - Stakeholder agreement on the enabling conditions
  - Requesting and obtaining regulatory approval
- Investment to address the list of deployment enabling conditions
  - Improved procedures/practice & associated training and validation
  - Approach controller support tools; surveillance support; airframe support
  - Operational safety cases

TBS-Arrivals – Summary of Key Points

- Impacts the whole of the common approach path
- Impacted by the variation and uncertainty in arrivals behaviour
- Potentially significant wake vortex encounter mitigation issues
- Safety arguments with supporting evidence and regulatory approval are key to timely operational deployment
- Identification of deployment conditions key to investment decisions



Questions