WakeNet Workshop 5-7 February 2007
As it was heard report

SWOT (Strengths, Weaknesses, Opportunities, Threats) for 3 operational concepts

Time Based Separation for arrivals (TBS)
Closely Spaced Parallel Runways (CSPR)
CREDOS

This report documents the post-it notes and categorizations written by participants during the facilitated session on 6 February 2007. Any clarifications are written in square brackets[]. Results of Pareto voting, i.e. number of dots highlighted.

Facilitators:
Garfield Dean
Lawrence Brom
Dirk Schaefer
Nigel Sylvester-Thorne

Time Based Separation for arrivals (TBS)

Strengths

Simplicity: *6*
Conditions when concept can be applied are rather obvious in contrast to many of the proposed crosswind based concepts
Relatively simple concept
Simplicity
Concept can be generalised
Relatively easy to implement
Easy to implement
Straight-forward solution for controllers and pilots

Capacity and Delay: *23*
Help to maintain flight schedule also at adverse headwind
Obvious ops gains => more constant throughput possible
Recovery of lost capacity
Keep capacity constant during head wind
Maintenance of traffic flow during strong headwinds, less disruption
Allows recovering of lost capacity
Delay mitigation in headwind conditions
Is a good system to prevent delays in strong headwind conditions
Using “obvious” free capacity
Potential gain in capacity
Improve and make use in arrivals (increase capacity on approach)

Good CBA: *4*
High payoff
Advocay abounds
Once established probably little costs

Technical concepts: *31*
Wakes decay after certain time not distance so this approach is backed by physics
TBS is in principle the (only!) right separation criterion
Considers vortex age
Distance based – large variations; time based – small variations.
Physically reaslistic, related to the physical nature of WV propagation/ dissipation
WVE risk is time-based (for trajectory, WV decay)
LIDAR can make this feasible and bring big gains

Regulations: *17*
Could be relevant in studies about separation minima foundations
Reducing ICAO WTC-Separations
Useful due to the orientation of the majorith of airports (mainly orients with headwind)
......
Starts transition to control by time rather than by distance.

Weaknesses

Complexity: *11*
Complex concept
Solution not obvious
Concept too complex to be easily introduced in ATM
Difficult to implement.
Less intuitive visualisation to controllers
Concept more difficult to understand and less evident
Has been told to me but not fully understood.

A/C Behaviour: *4*
Individual Deviations from "standard data" are unpredicable.
45s separation at 140 kts is OK

WVE Safety: *38*
Can it guarantee less severe (or no worse than) WV encounters than current operations
ILS interception is an area of wake encounters. Sensors should be used to monitor WV bechaviour in all weather conditions
Need a wake turbulence encounter advisory capability as part of ground based safety nets. (ILS interception).
Safety may be compromised by reducing time interval between generating and following a/c
WV volume and decay not taken into account
Need understanding of WV transport and decay in headwind conditions
Base/intercept phase – uncertainty of the nature of vertical transport of WV.

ATCO: *18*
Requires some extra workload from controllers. They should be facilitated with proper tools
ATCO acceptance of HMI tools (Human Factors)
New controller tools required
What is the main control tool: Radar screen or stopwatch?
Doesn't fit easily within connventional radar picture
ATCO Performance
When and how to change operation modes for ATC controller.

Benefits: *9*
Capacity increase might be marginal
Does not generate capacity
Benefit not widely recognised

Operational Concept Procedure: *13*
Non consideration of visual separations
Guideslope only
Compatibilty with aircraft flying procedures
Changing approach procedures (CDA in particular)
Specific measurement objectives need to be refined relative to the key obstacles or challenges of the desired procedure.

Weather dependent: *16*
Weather dependent
Required strong headwind from GND to GS intercept
Need to understand atmospheric personalities and rate of change in microstructure
Wind monitoring along glide slope
You don't know how the wind will evolve during landing - risk of wake vortex encounter.
Only actual groundspeed is used. Prognosis?

Tail wind: *5*
Not woking under tailwind conditions
Increased distances with tailwind?
Tail wind? Sudden changes in wind direction and velocity. Wind Forecast
Completely misses tailwind risks (mis-applies distance based spearation for the tailwind case).

Opportunities

Systems: *20*
Onboard systems that support TBS
Increasing acceptance for wind profilers at airports
New tools needed
Use of X band radar to monitor wake vortex in ILS interception area
Investigate impact of vertical wind measurements/sensors to increase capacity

Benefits: *19*
Prevent delays with strong headwinds
Decreased fuel burn through decrease reliance on holding
Recover movements under strong headwind conditions
Gain lost capacity
TBS = key to optimum runway use
This is the area with greasted potential for improvementsHeadwind operations are the norm. High percentage of posible use
Headwind should be the normal situation on RWY so impact could be significant

Procedures: *12*
Develop and evaluate new ATC procedures in which different aircraft streams using different separation parameters are merged
To base flight plans on possible capacity increase
Close spacial separations under strong headwind
'Close up' excess Δt in some wind conditions
Engaged and enthusiastic operators (Airlines, Pilots, ATC)
Develop new ATC procedures to take different classes of time separation (e.g. 1, 2, ... minutes) into account.

Other Applications: *21*
A study about TBS in departures is possible based on the arrival experience
Study TBS in departures and other flight phases
Links to 4D trajectory
Arrival management with regard to RTA (“Business trajectory”)

Expandable to the general concept of separation
Could become "the" separation criteria (en-route as well).

Local/ Global: 8
If successful a LHR then concept can be transitioned to other airports
Can be applied on every airport.

Threats

WVE Risks: 24
Absolute safety case likely needed. (# of WVE will increase)
WV Risk
Wake vortex encounters in trail aircraft
Study risk of WV encounter in detail
Wake Vortex in ILS interception close to the ground (sensors are needed).

Wind measurement and forecast: 17
Accurate wind measurements and forecast
Unknown met. conditions (wind)
In fairness, if wind effects reduce possible separation with high winds, it should also increase separation during low winds.
Tailwind application?
Loss of capability in tailwind conditions?

Safety Case Issues: 39
Stabilized approaches are with direct relation to flight safety
Safety case may not be favourable for concept
Safety. It may be impossible to demonstrate that applying less than normal separation can actually be done safely
Applying TBA correctly for wakes and forgetting catch up.
Expectation of the LHR stakeholders are extremely high – need to be managed. To prove the safety case
Less space to recover in event of error or incident
projected benefits do not materialise
transition may prove to be too difficult (transition from distance based separation to TBS)
Reduced distance = reduced buffer -> separation violation i.e. Go around
Safety compromised through increased pressure on ATCOs to have reduced separation distances
Buffers (separation) are reduced
Loss of separation due to changes in wind speed and/or direction with time or/and altitude

Pilot and ATCO Acceptance of Procedures and Tools: 37
ATCOs tool too complex and not practicable for the time
Change in working practices depends on weather
It only takes on ore two WVE under reduced separation to alienate pilots and controllers to the concept
A major change from distance (easily seen on radar) to time (how to show to controllers and pilots?)
Difficulty and responsibility (pilot or ATC) in maintaining min Δt.
New approach procedures (CDA)
Acceptability due to complexity of concept

ATCs acceptance of the concept and full implementation
Further research to be preformed to evaluate the uncertainty in pilot behaviour (follower aircraft)
Visualisation and HF issues
Switch forward and backward time to distance based separation.

Concept Viability: 4
Other solutions may be cheaper/ easier
Operational feasibility
Matching of objecxtives with measurement capabilities and logicstics feasibility.

Closely Spaced Parallel Runways (CSPR)

Strengths

Capacity gain: 53
Significant potential capacity gain
Heavies in trail (strength relative to risk to loading Large /small) See Weakness Ω
Greatest benefit near and far term
Runway occupancy time is not a limiting factor
Some of the procedures proposed seem to offer increase of declared airport capacity
Once established probably good business case
No significant change in infrastructure
Capacity increase
Capacity gain
Potential for major improvement in rates
Increased capacity with no loss of safety
Much larger potential than on single runways
Capacity increase well defined (for rate change)

Easy concept: 15
If 'rule change' easy to implement.
Clear concept – communication
Clear concept
Simple concept
Concept is easy to understand and is self evident
Clear objectives from operational perspectives
Clear objectives
liklihood of success appears to be good
Improved operations based on limited deployment and wake sensors
Benefits accrue with little or no wake specific equipment remaining at airport

Source knowledge transferable: 23
Learning how to use windtracer
Once accepted easy to implement on other airports
STL can be used to support a National rule change for similar airports (BOS, CLE, ...)
Global applicability
Generation of data
Will data be able to classify WV behaviour for 26L/R at CDG
CDG: non, use or think about better the landing procedures
SOIA: in VMC (no use of vis sep) potentially higher ARR flow
St. Louis: Turn aircraft easily from SID/centerline
CDG: ??? Non!
SOIA: interesting for arrival flow under VMC conditions where no vis separation can be applied

Safe: 4
No incidents reported (CDG)

Independent: 5

Tailored Implementation at specific airport. Local experience/solution

Weaknesses

Concept definition: *5*
Operational concepts on AD may be very different. Sudden change -> operational replanning
Wind dependent concepts: for arrivals a prediction element is needed
There is no generic CSPR concept. Concepts for APR/ Dep and mixed mode are different
Departures: unclear if paired concept or independent
ATCC acceptance of traffic light systematic
STL arrival benefits depend upon arrival mix 757 and heavies leading are excluded

Weather Dependent: *13*
can only be used to cope with possible delays
can not be used to plan a regular schedule
Highly dependent on wind direction
Runway separation is also an issue with Cat II/III ILS. Benefit of reduced WV separation requires different landing system (e.g. GBAS)
CDG: Efficiency, practicability.
St. Louis, SOIA: IMC conditions, Noise abatement.
CDG – Benefits are not quantified in material presented. (Most likely have been quantified but not shown).
Independent operations will only be possible for specific atmospheric conditions
Required meteo conditions fewer times met by northern European airports
wind dependent capacity can be planned only in a statistical sense
To plan with possible capacity increase TACTICAL NOT STRATEGIC.

Feasibility: *9*
Technical feasibility?
Takes a long time to collect data
Departures: a/c trajectory(s) models too simplistic (aircraft do not always fly centerlines)
Lidar sensor cannot detect weather in rainy and fog conditions
We need a methology to know whether or not the wake is present when we are arriving or departing
Data gathering at a number of individual airports required to understand topographic, geographic and demographic effects on WV behaviour before generic implementation.
A survey of results and issues would be useful to avoid repetition and to increase collaboration
Requires major ground changes
Reliability of measuring equipment.

Safety: *33*
Inconclusive safety case
How you are going to treat the uncertainties of measures?
Risk assessment/safety case is very complex
Requires accurate situational awareness in large airspace domain
SOIA:
Safety aspects due to increased wake load
SOIA requires visual ops @MAP may limit times when it can be used
Ignores risk of WVE to lead a/c of second pair

He will be below flight path of trial aircraft of preceding pair
We can not allow a reduction in the target level of safety
poor feedback loop design for WVE reporting (errors)
Crosswind conditions could probably increase WVE
Procedures become more complex.
Improve incident reporting (by use of automatic tools) and their use in the elaboration/ validation of VW concepts.

Airport Specific: *31*
Airport specific
No successful systematic approach (only individual airport solutions/ experiments)
Limited use. Only airports with CSPRs can benefit. (EDDF and LFPG but not EHAM, EGLL, LFPO, LEMD, etc.)
Lack of compatibilty with other airports
Basically a question of aerodrome layout design and runway location
Local procedure are there any common rules for implementation elsewhere?
Work helps onl airports with CSPR
Very sensitive to specific airport layout
No ICAO rule prohibits CDG 8R arrivals with 8L departures. This appears to be just a local concern and not extensible to other airports.

Opportunities

New Runways: *26*
Build more CSPR without expanding airports.
We can build more runways.
Change of rule for C/L spacing in IMC to <2500' enables construction opportunities for new runways.
STL arrivals – expansion to national rule change. Also enables CSPRs to be build at airport not currently envisioned.

Capacity: *23*
Full utilisation of tarmac (runways & taxiways) at CDG (26L/8R)
Apply CSPR STL deviation to other airports with similar operations
Theoretically very small separations (including parallel landings are possible
If successfully implemented on one airport, further airports may easily make use of the concept
Really needs to be applied or second runway is of little use

Efficiency: *6*
Short term “win”
Reduced delays in peak traffic period.
Adapted/tailored to solve local problem.
To use a huge capacity potential

Co-operation: *29*
Similarity with US FAA/ NASA programmes and existing database => point of leverage
Collaboration between FAA and DGAC/DSNA (Use of collected data and FAA experimention in St. Louis for CDG as a 1st step.)
Improved knowledge on WV movements (Lidar data allows to build a statistic database for

evaluation=> improving the procedures)
Look at ops at airports with similar ops (ATL, STL,) No wake problem for ops there so why the concern for CDG? Leverage lessons leared elsewhere.
Implementation of work done at KSTL, EDDF and LFPG: much data available to support the concept implementation.

Technical Opportunities: *11*
Use of X-band radar to measure wake vortex in rainy and fog conditions

Safety: *18*
Usage of lidar to prove safety
Develop real-time LIDAR WV monitoring and integration into WV-prediction systems.
Can show with lidar data that threat from parallel runways is no greater than risk from in-trail.

Threats

Controllers: *26*
controllers' work becomes too complex in high traffic
pilot acceptance – controller acceptance
change management needed relative to ATC and other 'users'
potential for controller "creativity" to "force" visual separation
departures: "cleared for take-off" – "unable"

Weather: *26*
SOIA increase in workload in changing wx conditions
crosswind direction left/right may vary/varies with altitude
SOIA read ceiling can limit (%) of time procedures are applicable
uses basic WV behavior to increase throughput to airport (provided traffic mix is appropriate)
good weather prediction necessary
identify the 'minimal conditions' for the application of the project
gain only available in x-wind conditions. May not be significant in terms of increased capacity
specific wind conditions
extreme wind conditions in rainy weather, where LIDAR cannot detect wake vortex
could be dangerous in certain wind conditions

Local: *2*
changing demography around CDG possibly (any airport)
specific to local to conditions
is this just to solve a taxi problem (S1 + S2 versus Wa and Wb) can still stage to W's and taxi in position and hold when waiting for arrival to land
unclear whether extensible to other airports without further data collection required
short duration of measurements may not allow for ooperational issues/surprises that appear in the data

Safety: *30*
STL arrivals safety case acceptance is pivoted to success
Go around may disturb the safety of the concept
Vulnerable to mishandled approaches and decision changes like go-around
Forcing runway incursion? Inner needs to be crossed – another EUROCONTROL initiative

Departures: errors more likely catastrophic (more heavy leaders)
Methods for risk assessment (safety case)
CDG safety case may require more data than currently planned. Will likely see some wakes transport to adjacent runway
(applies to many other concepts for ARR too:) wakes generated by missed approaches

CREDOS

Strengths

Data based method: *30*
Ability to predict in certain prevailing wind conditions, therefore procedural can have partial application.
Data driven procedure
Use of actual wind; no forecast
Generation of data.
Results validated using multiple techniques.
Needs little prediction environment
Vortex transfer, vortex decay, engine failure case for the fallover.
Considers vortex transport.

Return/benefits: *17*
Short weather prediction time needed.
Good projected benefits
Makes the most of the weather (wind) to increase (recover) departure capacity.
Meteorological forecasting skills not so demanding as for arrivals.
Small time horizon.
Near term concept.
Realatively quick dealy mitigation gain.
Recovery of delay

Collaboration & Expansion: *15*
Wide support.
Solid base.
Will offer base for implementation.
Excellent collaboration.
To understand industry needs for a more efficient, safer air transport.
Extends work started in Europe & USA.
Considers framework of concept that can be built on for individual airports.

Simplicity & easy to explain: *26*
Easy to test, validate and implement.
Simple concept; single runway, cross wind.
Simple concept.
Easily understood concept &acceptable for pilots & controllers.
Simple concept.
Concept easy to understand & evident.
Simple & easy to explain (simple physics).
Easy to understand & apply, capacity increase possible.
Simple concept easy to implement
Robust easy to visualize/sell to stakeholders.
Easy to implement.
The idea itself looks clever but… Practical implementation?
Wake vortex argument easy to understand.

Global/generic: *12*
More generically applicable than landings because fewer local variations.
Global application.
Generic
Data collection eg Frankfort, St Louis. Two different sources that can corroborate/validate concept.

Other:
Reach for more environmently friendly sky.
To combine deps and arrs in closely spaced runways.

Weaknesses

Weather dependent: *29*
RWYs are normally in main wind direction -> is there sufficient crosswind to operate system most of the time?
The majority of airports are designed to have mainly head-wind -> mainly weak cross-wind
Can only be used if there is sufficient and not too much crosswind
Wind dependent: may vary a lot at certain airports -> on-off
Limited by particular weather conditions
Only applicable to APs with regular x-wind
Only when crosswind conditions
Concept is weather dependent: should only be used to cope with possible delays; should not be used for setting up regular schedule
Concept relies on a certain x-wind component. This is not always available, reducing potential benefits
Existence of a crosswind window: weak crosswind -> not applicable; strong crosswind -> not applicable

Complex Implementation: *2*
Implementation complexity is unknown
Technically complex due to uncertainty in wind forecast
Deceptively simplistic – however complex when considering wind profile forecasting, SID path changes and aircraft performance behavior envelopes

Weather Prediction: *28*
Better be sure and check where Vx are going with radar, LIDAR, Sonar
Reliable determination of meteo parameters possible?
Accurate wind forecast and measurement
Difficulty of prediction of WV in phase 2
What is good x-wind? Kts? - Non identical aircraft tracks, sudden changes in wind speed and direction, focus is just on airports, not on ACC/UAC
Wind monitoring/prediction aloft
Reliable wind statistics needed before establishing a flight schedule with more flights.
Requires good wind prediction: position & time
Prediction of favorable conditions ahead of time not possible
LIDAR cannot detect wake vortices in rain and fog
Crosswind conditions often associated with changing weather/precipitation, which may require

intersecting R/W departures (a/c type – wet R/W x/w limits).

Tactical Capacity Gain Only: 12
No extra airport capacity can be planned
Gains not huge since limited by separations due to direction of departures
Difficulties in exploiting departure rate gains for increasing scheduled capacity
No capacity increase (no long term planning possible)
Does not generate capacity
No advantage at a capacity limited airport unless you can also increase the landing rate (on a daily basis)
No gain for no crosswind (overall ops gain questionable)
Additional hardware for monitoring required (wind tracers, etc.)
Requires agile ATC to take advantage of variable applicability

AC Trajectory Variability: 8
Does not seem to consider a/c trajectories – only uses wake trajectory
Aircraft trajectories are not known beforehand
Single runway departures more difficult than CSPRs
Departure routes must be separated sufficiently and flexibly
Variance on a/c rotation and performance and errors in wind measurements may make concept difficult to realize

Other
Why don't use WA/WB taxiway for line-up
What happens if you operate with the two north or south runways only for arrival/departures?
Only applicable to departures -> marginal capacity increase
The idea to provide x wind operations and to force airport operations in that direction
Vortex decay due to turbulence not taken into account
Identify specific benefits for each party and qnty
No room for benign encounters
Lack of specific objectives
Practicality to users
ATCO acceptance of concept and ease of application
Human Factors: How easy is it to make a mistake if there is variability in application of guidance.

Opportunities

Capacity Benefits: 29
Provides for opportunistic increases to the departure rate that can be used to clear departure queues
Possibly higher departure flow
Increased RWY capacity with no loss of safety assurance
Opportunity to increase throughput
Global increase in capacity
Increase departure throughput
Catch up from departure delays
Reasonable approach to first step to reduce separations
Increase capacity while maintaining safety level
Increasing OPS capacity and safety of the ATS

Simplicity: 22
Good application for implementation due to simple concept
Easy application
Can be implemented on many airports
Possibly relatively easy implementation possible (not necessarily a LIDAR-based monitoring tool etc.)
Could probably be applied more quickly than landing separations
If successful CREDOS can be the blue print / role model of how staged benefits in the WV area can be developed
Simple rules – safety studies may be reused
To get started
Large number of possible applications (airports)

Extended Applications: 27
Use of x-band Doppler radar to monitor wake vortex in Rain & Fog
Increase declared slots while accepting more delays to optimize average capacity
Explore synergies with other EU/non-EU initiatives. Data availability,
range of behavior models (NASA, DLR, UCL)
Study WV abefior (???) in parallel runways (not only for closely)
Apply to other flight phases as well (esp. approach)
Study for arrivals
Good studies of controller workload could be developed in parallel
More flights in schedule (only if one can be sure that crosswind is sufficient all over the year

Other:
Can Europe use 4/5 nmi to 2 minute alternative wake separation? Results in 75-100 sec delay vs. 120 sec
Pilots could decide (if they can "see" wake vortex drift)

Threats

Wind Variability: 14
Unreliable wind measurement & prediction
Sudden change of wind direction or speed.
Possibility of compromised safe WV separation in departure phase
Changing orientation and strength of the wind conditions to the SID path due to (1) boundary layers individual changes to wind speed and direction as the aircraft ascends the SID, (2) changes in the SID path direction along the SID
Wind variability and short-term local effects may result in unreliable hazard avoidance

Wind Definition: 11
Appropriate definition of crosswind is not unique
Identify the correct limits for each airport – minimal crosswind, etc.

AC trajectories: 7
Difficulties in application of concept where SID paths diverge: possibility of managing this through vertical separation; however limitation of vertical navigational performance of airframes along SIDs
Limitation on the vertical navigational performance of airframes along SIDs

Safety case too difficult due to variations in the departure routes

Benefits?: 13
Inadequate actual benefits observed
Times when sufficient crosswind exists may be infrequent, may not match up with high demand times
Dependent on increase in arrivals before get departure capacity increase
Implementation funding
Sufficient benefits???.
If tool is required, cost would increase beyond benefit
No business case ROI = could be canned
Delays when additional capacity is scheduled into flight plan – but no x-wind
To plan with crosswind departures -> delays when crosswind insufficient
Delays if insufficient crosswind on certain days

Acceptance: 29
Favoring x-wind operations at busy airports
Insufficient acceptance by pilots
Pilot participation
Acceptance of safety argument by stakeholder community
Pilot participation
Concept relies on a certain x-wind component. Pilot acceptance to use a x-wind runway may be an issue when alternatives are available
Because it is generic, it may not have a specific 'driver' airport to make it happen
Ensure concept validity and applicability for each partner
Pilot simulation experimental design under the concept of 'hazards of certain encounters': pilot factors, experimental design & assumption
wingdrop on rotate if you get it wrong
Observe x-wind limits (certification) and operational application

Wake Vortex: 31
Encounter of younger vortices later on SID
Safety due to x-wind can be annulated if aircraft routes converge
Less predictable IGE (?) vortex behavior
Must be based on WV lateral transport (eng. fail case)
Uncertainty in WV propagation and dissipation

Other technical: 9
Extreme wind conditions in rain and fog: LIDAR cannot provide information in raining conditions
Switch in working procedures if there is no x-wind
What happens in case of engine out?
Runway conditions other than dry need physical treatment of RWY surface
Unknown changing x-winds at higher altitudes
Winds aloft do change directions