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Delay Impacts onto Turnaround Performance

Optimal Time Buffering for Minimizing Delay Propagation

ATM2009

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Structure

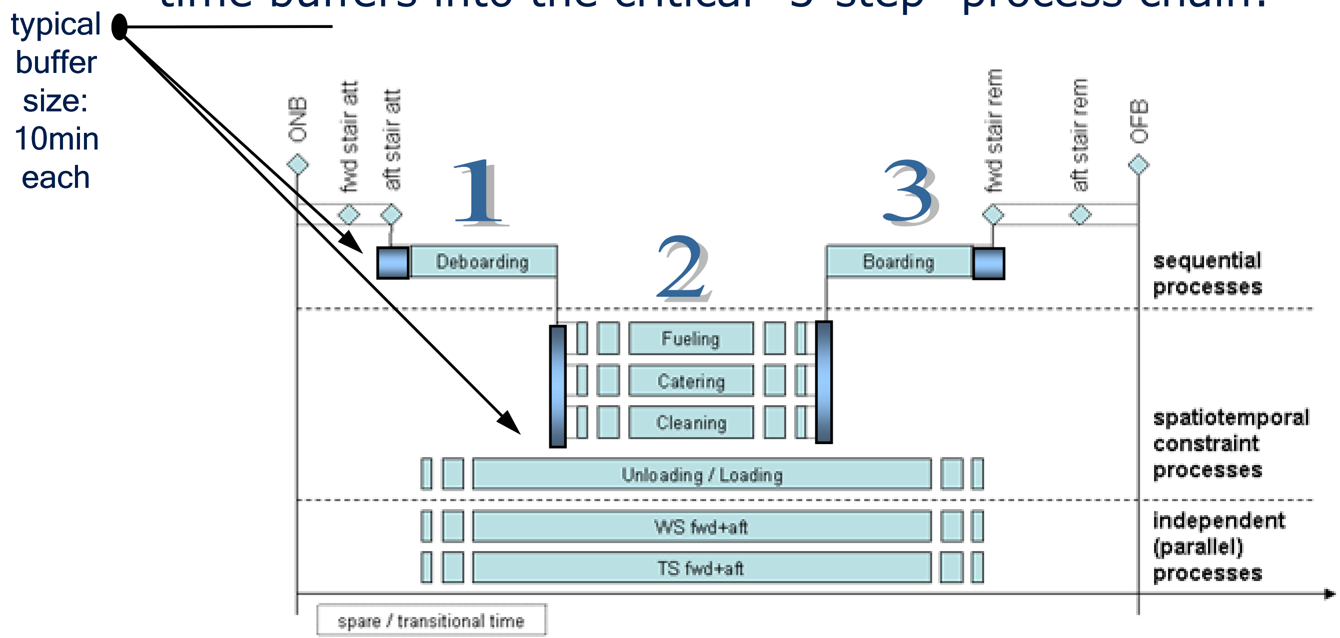
1. Motivation and Need for Investigation
2. Factors to Turnaround Reliability
3. Aircraft Delay acting on Turnaround processes: A large Data Collection
4. Delay to performance Measurement – static buffers are present
5. Potential of Dynamic Time Buffers
6. Conclusion: A dynamic Turnaround Process handler

Why high Turnaround Reliability is crucial

- Ground Operations deliver high percentage to aircraft delay statistics reaching 19% *late* flights in Europe in 2007. Airline punctuality standards are not met.
- Ground Operation is a multi-actor activity – Need for Negotiation & cooperation is pressing, claim for “A-CDM”.
- Process Optimization is a multi constraint problem:
  - Technical, legal and operational dependencies are given
  - High Transparency for optimization strategies is required to convince the local CDM community to contribute, and act accordingly: EBIT figures are small and reduce further.
- Ground Ops processes are stochastic, *dynamic* time buffering promises potential for increased reliability and productivity compared to *static* buffering currently applied in Ground Handling (A-CDM) decision support systems.

Factors to Turnaround Reliability

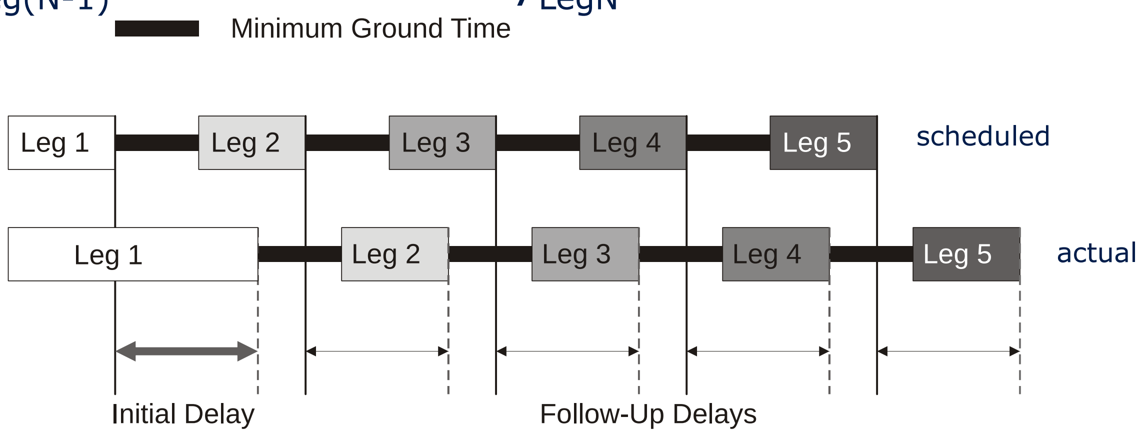
- To push on-time performance on ground, airlines introduce static time buffers into the critical "3-step" process chain:



- Buffer size is found to be static, depending on specifics such as go-to-hub, with-without-belly, MGT, MCT. No inbound delay considered

Aircraft Delay Causes

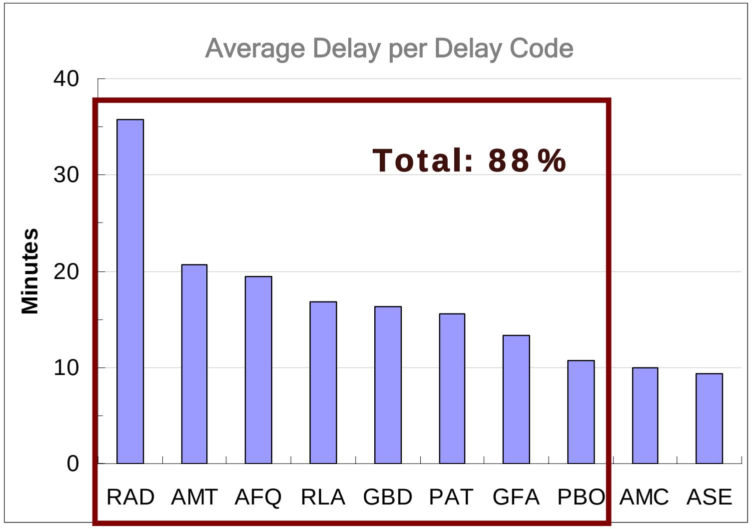
- *Rotation* is heading the causality list (30%), followed by ATFM/ATC; Airport, Handling, summing up in total to 80% !
- Regression Analyses show: Except for ATFM/ATC Delay correlating with Rotation Delay, the categories are highly independent.
- Rotation Delay is increasing per leg, following
  $Delay_{LegN} = Delay_{Leg(N-1)} + Rotation\ Delay_{LegN}$:
- A Delayed Turnaround needs more "time reserve"
- Static buffering seems inadequate

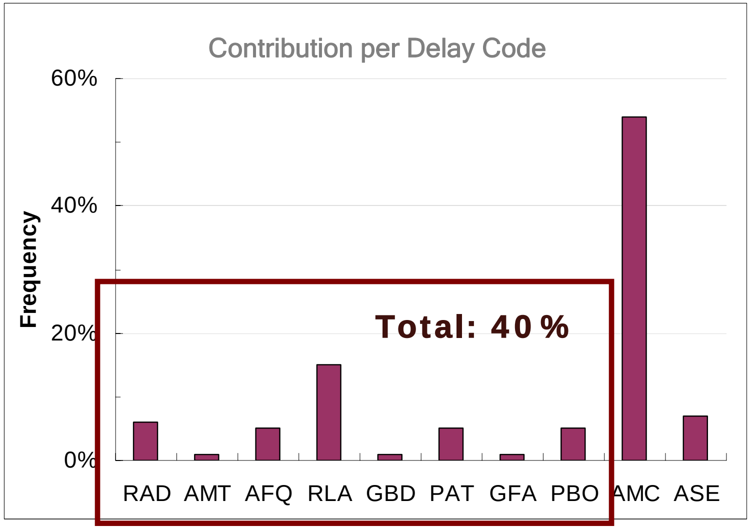


- Only limited compensation in-flight -

Causes are also true for latest a/c types: Sampled A380 Turnaround Data in Dubai

- 6% of all flights (based on 185 Turnarounds from DXB to either SYD/AKL, JFK or LHR) suffered an **inbound delay** of 36min on avg.
- Avg. **Outbound delay** was found at 41.9min for all flights, so that delay obviously increased during Turnaround:





Data Collection Strategy II

- Process structuring used is based on IATA Aircraft Handling Manual (AHM) but appropriately extended to cover the complete Turnaround:
  - Aircraft Servicing (GPU, Water & Toilet Service, Push Back, Stairs supply)
  - Loading & Unloading
  - Boarding & De-boarding
  - Catering Ramp Handling
  - Interior Cleaning (Cabin & Crew rest)
  - Crew Change and Cabin Preparation (cabin crew duties)
  - Fueling (separated in starboard/portside fueling)
- From 2006 until 2009 various Field (Apron) visits were scheduled starting with light (DRS, LEJ) extending to busy traffic environments (STR, MUC, DBX) to get
  - Process Time consumptions using standardized templates
  - Manpower per Process, Equipment type/quantity, Load figures, A/C Layout information, Transfer volumes (esp. required fuel)
  - a sufficient data volume to be representative: +400 Turnarounds observed

Data collection Templates

- To comply with this scope, 3 handy field template types were developed
- Adherence to but extending partly the AHM process structure
- Up to 3 „shadow" observer installed to scan during turn around
- Allowing for post process interviews with personnel
- Allowing for process interruption recording
- Easy transfer into a Webtool Database as potential "A-CDM" Data source

A/C-type:	Stand:	remote / terminal	STA:	Date:
Flight-Nr.:	Routing:	-	STD	

1. Aircraft Servicing		Time	manpwr	types	quantities	notes	a/o	missed
1.1.B	Position wheelchocks = ONBL							
1.2.B	GPU connected			fixed / mob	1 / 2			
1.3.B	Finger/fwd stair attached			finger / stair	single / dual			
1.4.B	Aft stair attached							
1.5.B	WS nozzle connected							
1.5.E	WS nozzle disconnected				[l]			
1.6.B	TS nozzle connected to aft access							
1.6.E	TS nozzle disconnected to aft access				[l]			
1.7.B	TS nozzle connected to fwd access							
1.7.E	TS nozzle disconnected to fwd access				[l]			
1.1.E	Remove wheelchocks							
1.2.E	GPU disconnected							
1.3.E	Finger/fwd stair removed							
1.4.E	Aft stair removed							
1.8.B	P/b equipment on position			towb / lift				
1.8.I	P/b equipment installed							
1.8.E	Leave Parking Stand = OFFBL							

4. Catering ramp handling		Time	manpwr	types	quantities	notes	a/o	missed
4.1.B	Fwd service door open / bridge installed				trolleys:			
4.1.E	Catering bridge (fwd) removed				boxes:			
4.2.B	Mid service door open / bridge installed				trolleys:			
4.2.E	Catering bridge (mid) removed				boxes:			
4.3.B	Aft service door open / bridge installed				trolleys:			
4.3.E	Catering bridge (aft) removed				boxes:			
4.4.B	Belly - Cabin transfer start				trolleys:			
4.4.E	Belly - Cabin transfer end				boxes:			

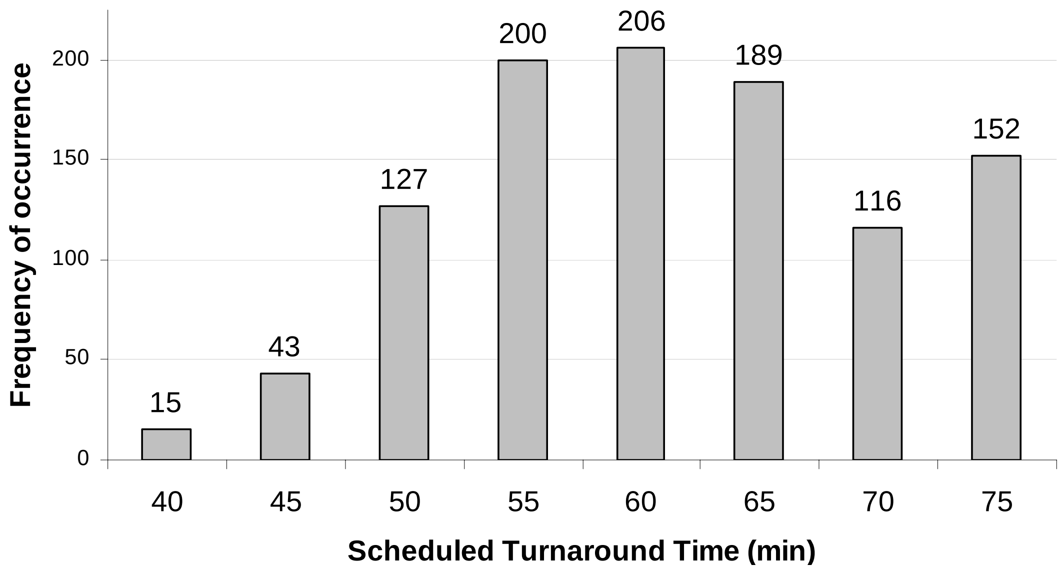
8. Fueling		Time	manpwr	types	quantities	notes	a/o	missed
8.1.1.B	*Equipm. arrived on A/C stand (right)*			tank / disp.				
8.1.2.B	*Fuel nozzle connected*							
8.1.3.B	*Refueling started*							
8.1.3.I	*Blockfuel submitted*							
8.1.3.E	*Refueling finished*				[kg]			
8.1.2.E	*Fuel nozzle disconnected*							
8.1.1.I	*Fuel order deliverd to rep*							
8.1.1.E	*A/C stand left*							
8.2.1.B	*Equipm. arrived on A/C stand (left)*			tank / disp.				
8.2.2.B	*Fuel nozzle connected*							
8.2.3.B	*Refueling started*							
8.2.3.E	*Refueling finished*				[kg]			
8.2.2.E	*Fuel nozzle disconnected*							
8.2.1.E	*A/C stand left*							

Data structure – complete view along the "critical path"

- Process begin, duration and specific rates were collected:
  - Un-/Loading: Bags/min, ULD/min
  - De-/Boarding: PAX/min per door
  - Cleaning: Seats/min*cleaner, lavatory/min, galleys/min
  - Fueling: Fuel flow [l/min]
- Statistical data including mean, min, max and external dependencies for each process in total and for specific data
- Process irregularity analysis: Interruptions, Productivity:
  - Flow interruptions while De-/Boarding or Fueling
- Field data was finally extended with data from the Lufthansa ALLEGRO database for FRA, MUC with 25.000 Turnarounds (For ALLEGRO, static buffer times were known)

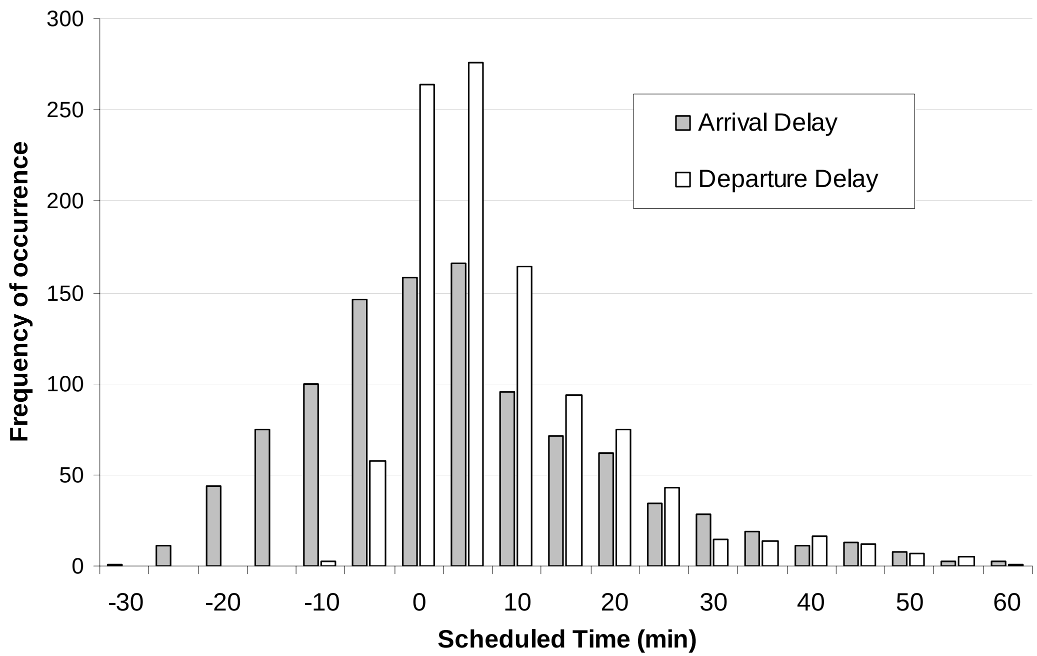
Measured Turnaround Durations

- Only Turnarounds taking less than 75min were considered to be "time restricted" operations, leading to app. 1.000 datasets. The following distribution was found for the most frequent A320 aircraft (μ = 61.1 min, σ = 8.9 min):



Measured In-/Outbound Delays on Ground

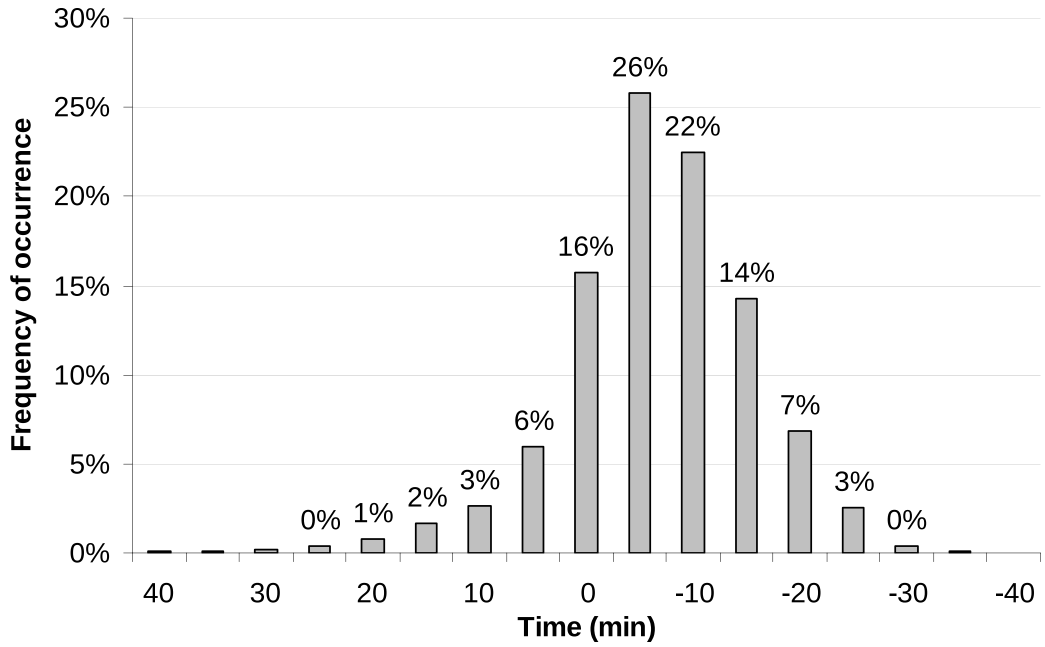
- The delay distribution in this data set was found with the following distribution (avg. arrival delay of μ_{ARR} = 2.4min and an average departure delay μ_{DEP} = 8.4min):



Measured Delay Compensation in-flight

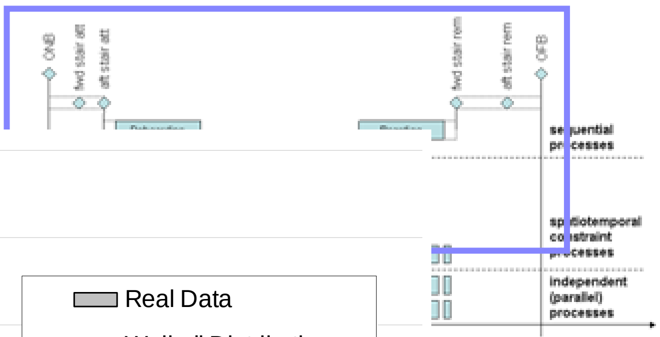
- By linking Out- and Inbound datasets, delay compensation achieved during the flight phase (μ_{Flight} =78.6min, σ=19.9min) was found at μ=-4.5 min only with σ=9.5min :

Medium Haul Aircraft considered

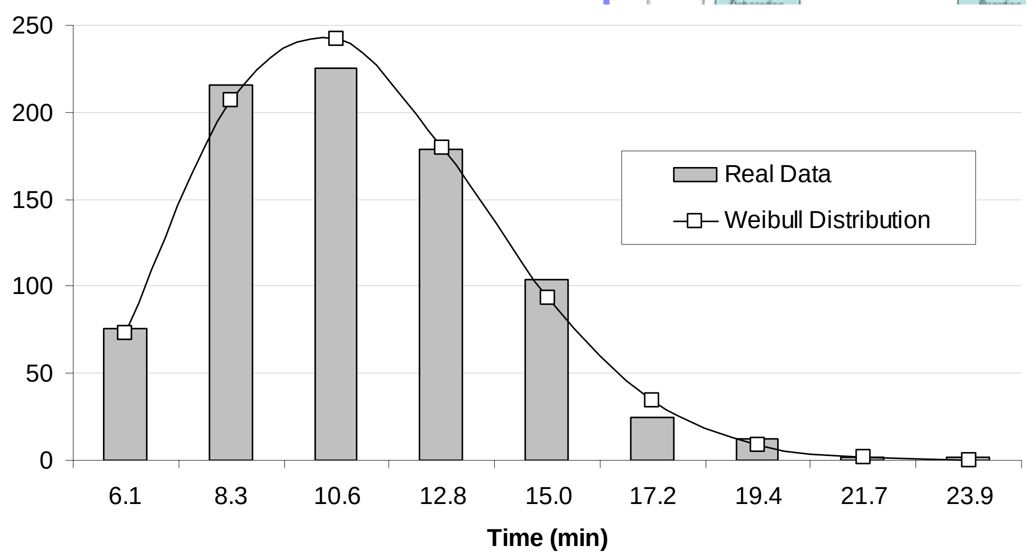


Correlation Of Delay To Process Reliability

- For 6 delay categories (5 to 30min, 5min frame), probability density functions for all critical path related process durations were derived: Weibull, Gamma, or Normal characters were found with a “5 log N” clustering:

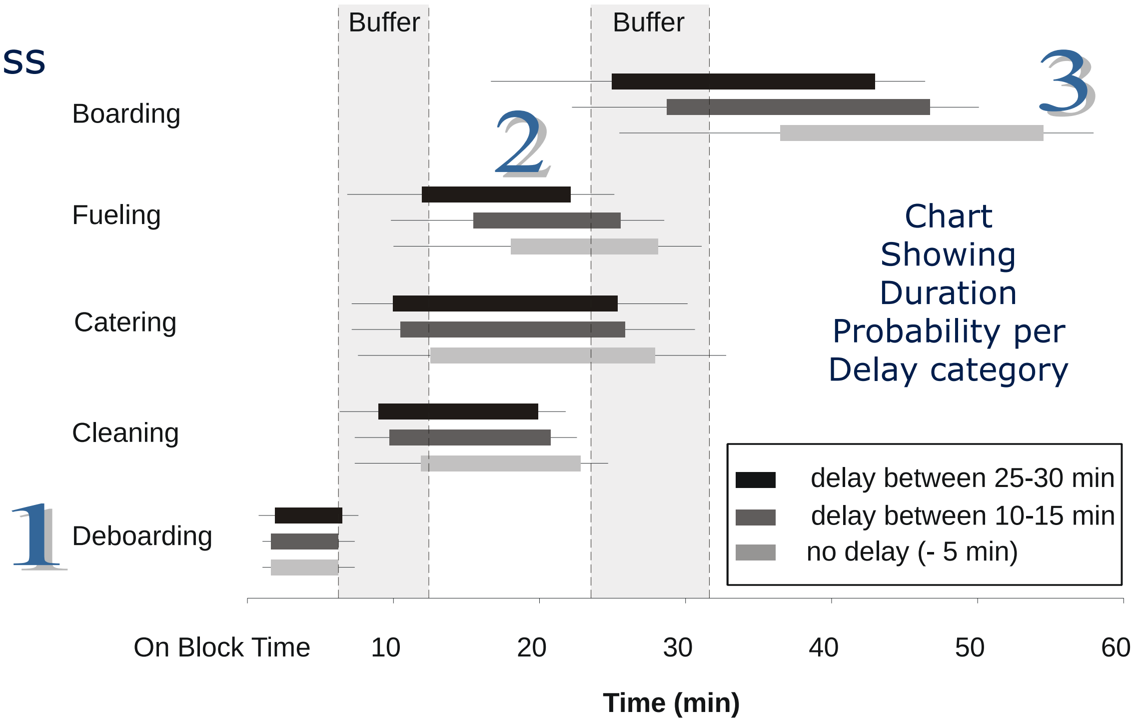


Sample for the Aircraft Cleaning Process



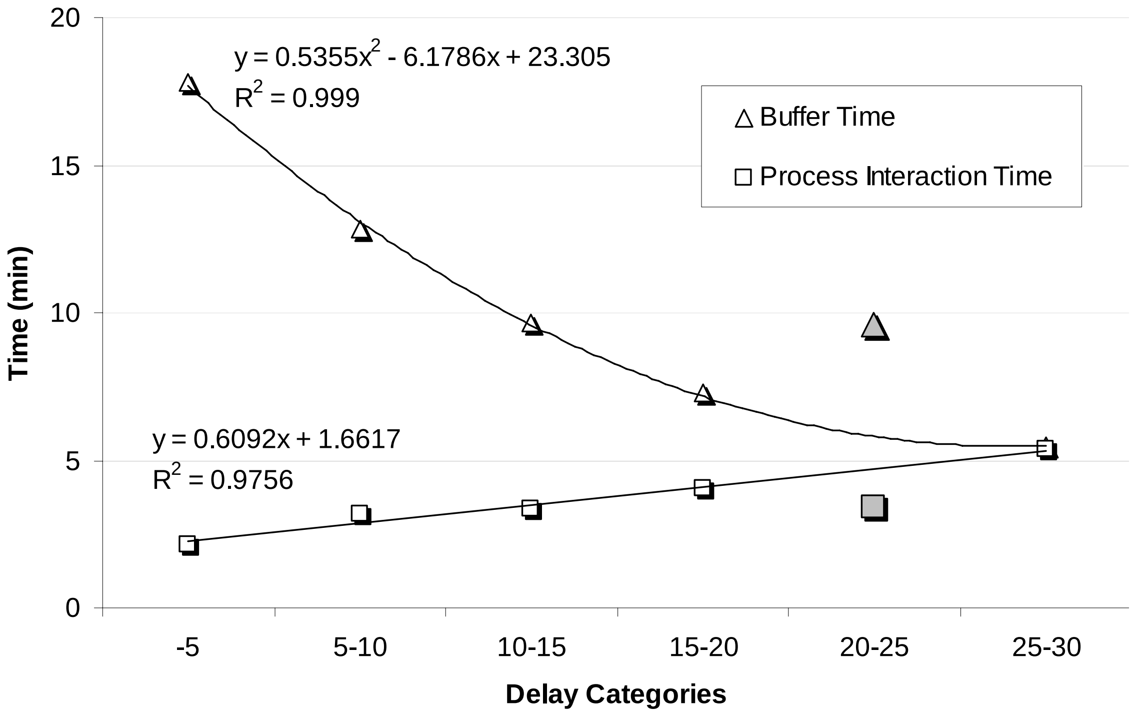
Correlation Of Delay and Process Behavior (1)

- Two trends were found for all critical processes with a given (static) time buffer between critical processes when delay increases:
  - Reduced Process duration,
  - earlier Process start
  - with lower variation in start times



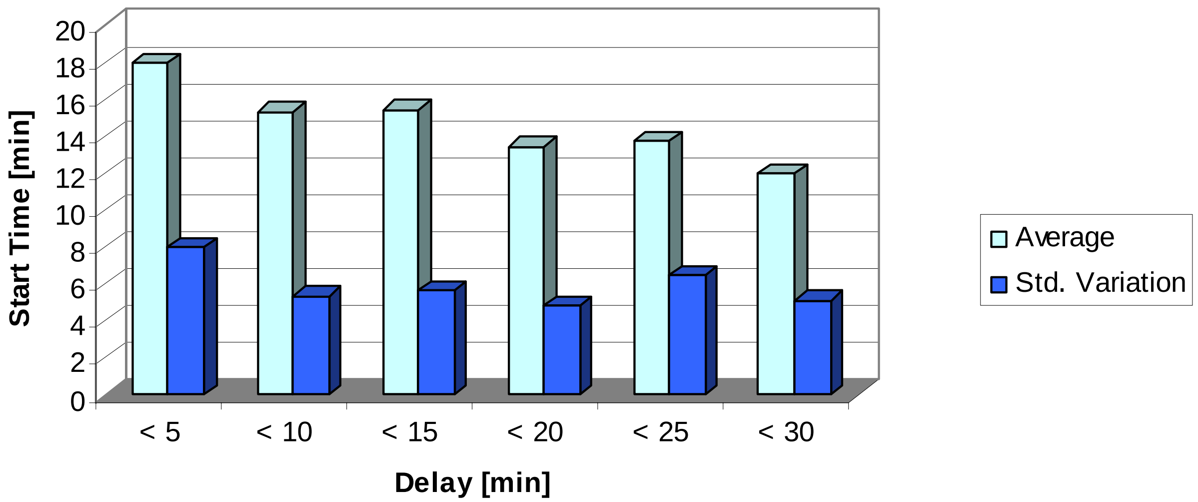
Correlation Of Delay and Process Behavior (2)

- Applying MC Simulations to the measured process behavior data (start time and variance) proves generally these trends:
  - The "idle" time between processes slows down to app. 5min (some "minimum" buffer).
  - The process interferences increase up to 5 min = "waiting" time



Correlation Of Delay and Process Behavior (3)

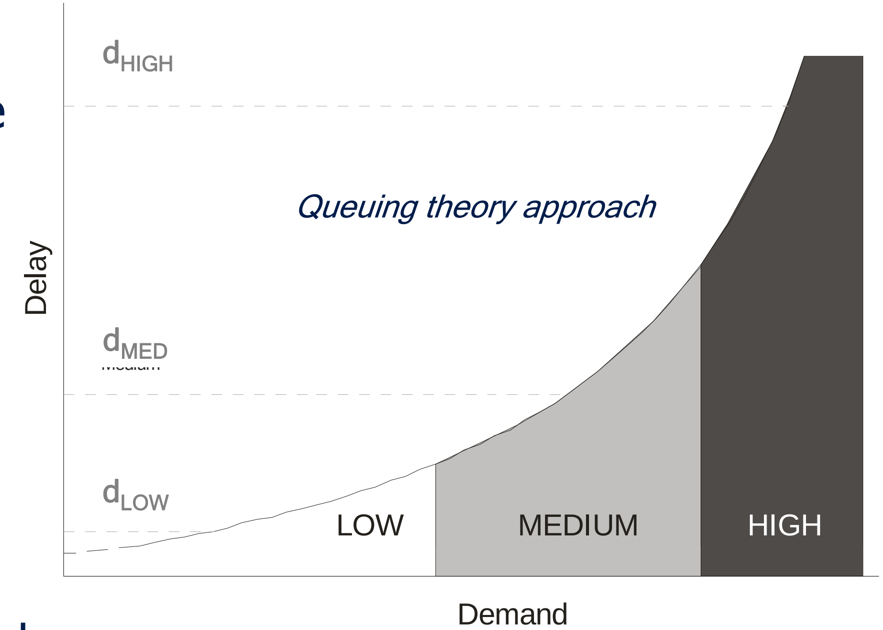
- The Reason for these trends could be verified with the following typical process characteristic (e.g. Fueling process):



- The static buffer found (at typ. 10min each) so far should be replaced by a "dynamic" buffer depending on a given demand.

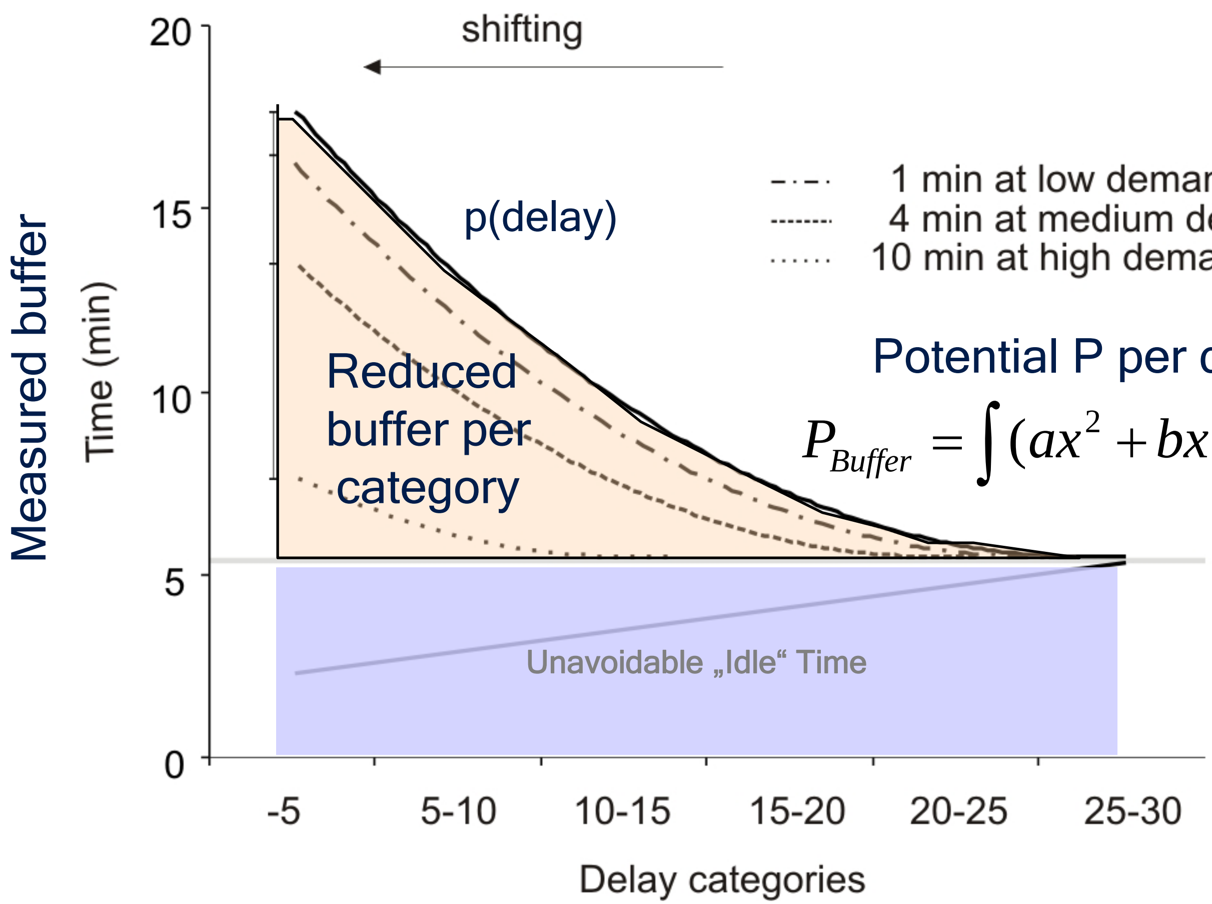
Applying "dynamic" buffering

- Referring to airport capacity correlating with throughput, so with demand and delay:
- To improve ground handling efficiency with less "idle" time while granting a constant Turnaround reliability, the following strategy is pursued:
- Define an appropriate buffer per expected demand (and so delay) category:



Buffersize = f (exp. Delay) so keep
Measured buffer = Buffersize – delay != min.

Conclusion: A dynamic Turnaround Process Handler



Potential P per demand category:

$$P_{Buffer} = \int (ax^2 + bx + c)dx - IdleTime$$

Thank you for your attention

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At

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