

Prioritisation mechanisms and future potential

Insights into current ATM slot prioritisation mechanisms and how they may be developed

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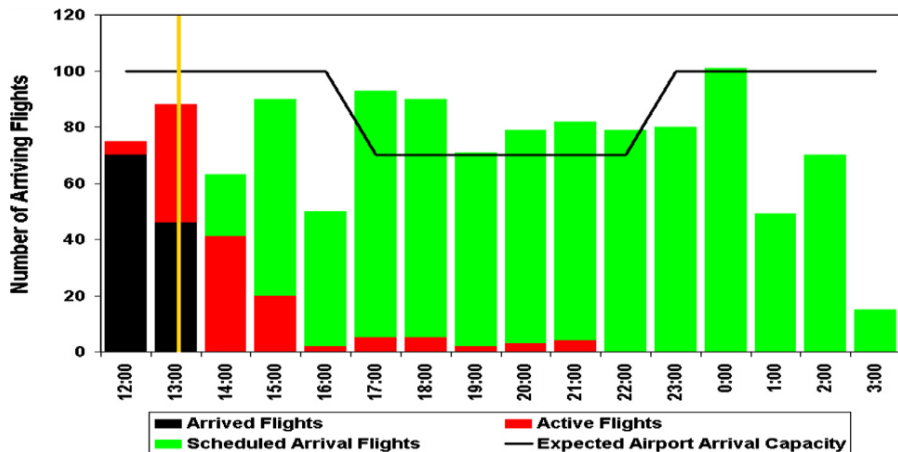
Outline

1. Flight Prioritisation in air traffic flow management (ATFM)
2. What is at stake when Airlines exchange their slots ?
 - When and why ?
 - What are the constraints ?
3. How could behavioural economics help ?

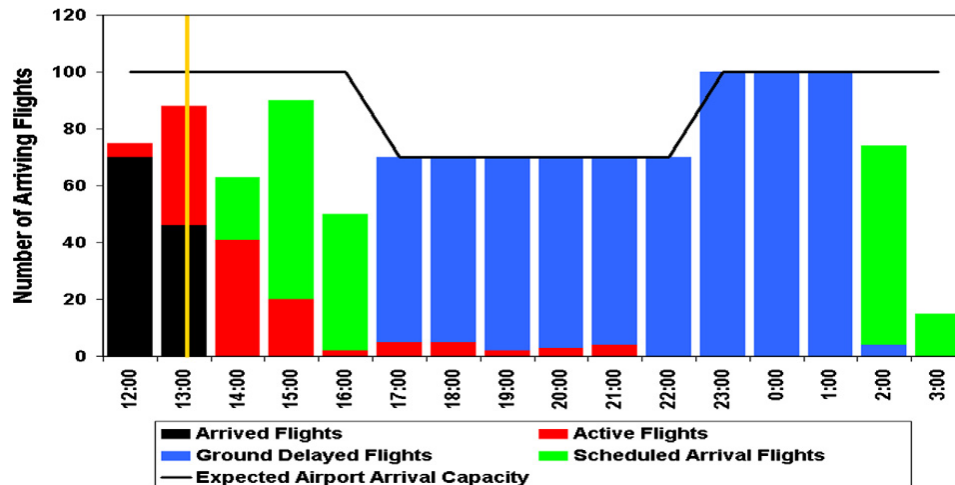
ATFM regulations

- To maintain safety when there is a congestion problem at sectors or at airports, the European Air Traffic Flow Management (ATFM) service may impose ATFM regulations: delays on certain flights before their departure.

Demand & Capacity problem

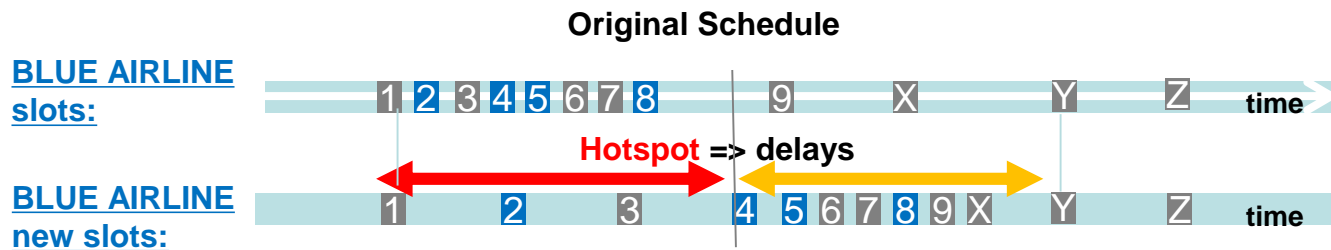


ATFM regulation applied → D&C balanced



What is an ATFM slot ?

- To smooth the traffic at the congested sector/airport, each flight entering into the regulation is allocated to a calculated time of departure with a tolerance window = an ATFM slot
- Slots are allocated on a first-planned-first-served principle (similar to FIFO policy) to preserve ATFM-equity: all flights are blindly considered as **equal** (e.g., equal value) by the slot allocation process



⇒ But the resulting delay may generate big impact on the AUs operations: For AUs, every flight is **unique**

Top 5 Lessons learnt from AUs in SESAR

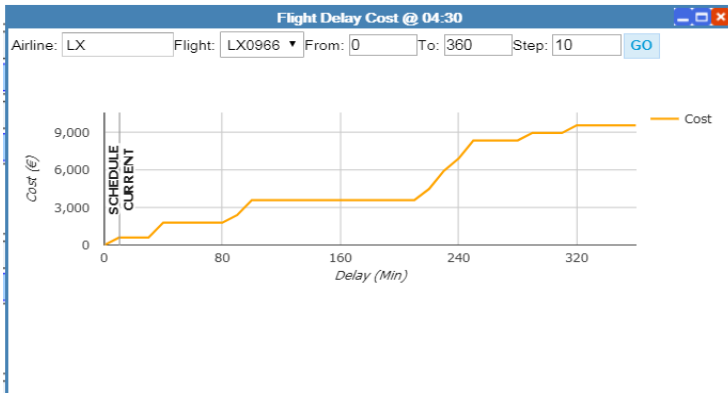
1. Low profitability in air transport → **high sensitivity to cost** (high importance of flexibility for them)
2. Most of the AUs typically operate a '**network of flights**' connected (e.g., connecting passengers, crew & aircraft management, among others) → **Decisions on individual flights are complex**
3. Flight efficiency of individual flights is very important for them, but **schedule disruptions** **typically have much more impact on their costs** (e.g., flight cancellations, crew restrictions, loss of connections, loss of curfew, etc.)
4. Either **capacities or demand are very volatile along the day**, thus they **need to adapt their operations** (**flexibility**) and change their plans in response to changes that come from the ATM.
5. **Equity & access is important** : ATM should not favor one more than others; in addition, any mechanism should require low investment, low effort to operate and give predictable results

Cost of delay

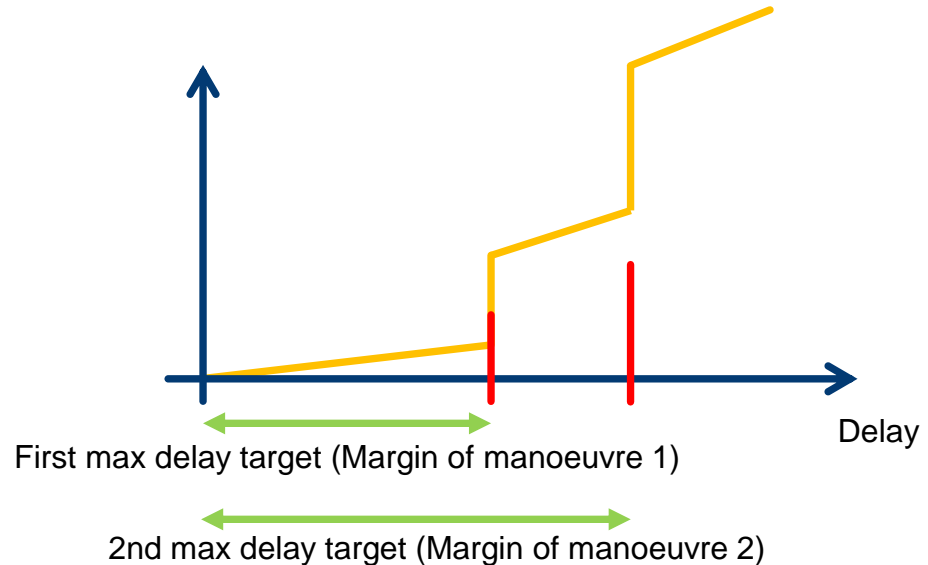
drive AU's prioritisation decisions

The cost of a flight is interrelated to the all-day plan:

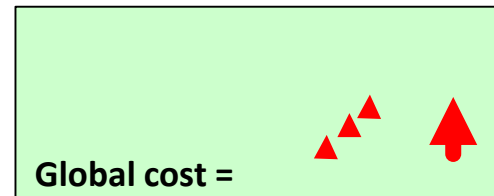
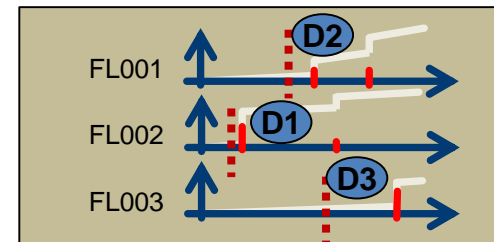
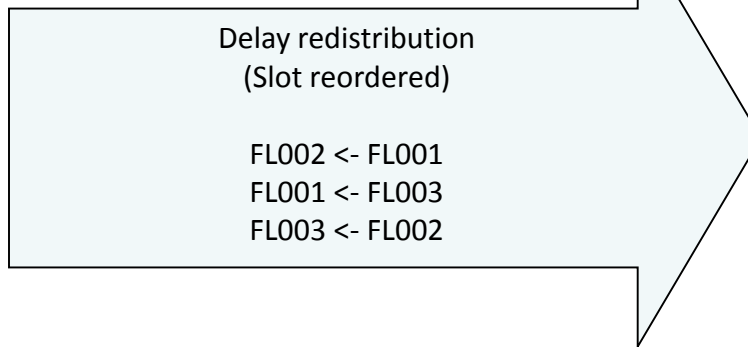
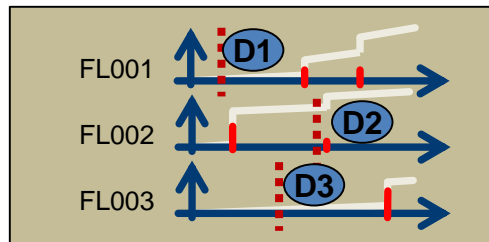
- Schedule time vs Current timings (delay)
- Minimum Turnaround Time at Airport
- PAX Flow : nb of connecting Passengers between flights
- Curfew times
- Staff/crew management



Simplified cost model for 1 flight



User Driven Prioritisation Process - UDPP – brings to Airspace Users the flexibility they need to reduce their impact of delay



AU EQUITY
No impact on other AUs flights
Non participants unaffected

Flights prioritisation in ATM: present and future

Prioritisation of several flights involved in the **same regulation** (congestion problem):

- Enhanced slot swapping (ESS) – deployment started in EUROCONTROL in 2017
- Reordering several own flights (FDR)
- Protecting a few flights pushing delay on other own flights (SFP)
- Margins : not_before – not_after



SESAR
validation
2022

Prioritisation of several flights over **several successive regulation** (1 month, 1 year tbd)

- Flexible Credits for low volume users (FCL)

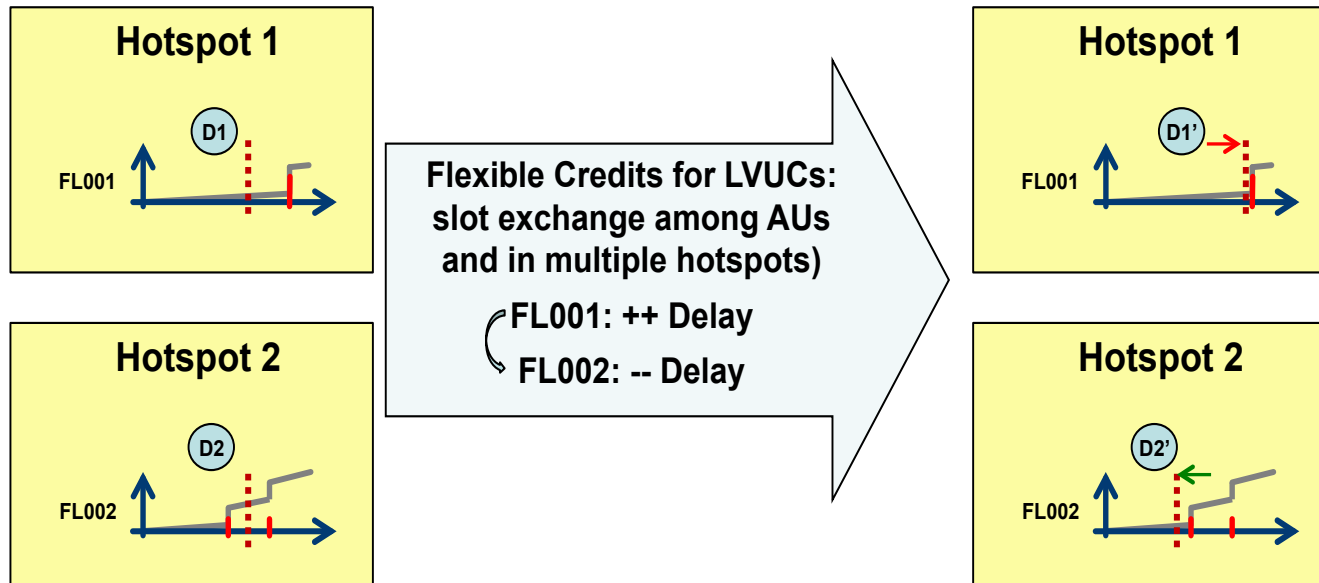


Exploratory

Future developments – UDPP as a market mechanism

Delay management across multiple hotspots

Advanced UDPP features are needed to give access to LVUCs



What is at stake when Airlines exchange their slots ?

- When ?
 - Today, with UDPP Enhanced Slot Swapping (ESS)
- Why ?
 - In order to protect very important flights
- What are the constraints ?
 - Slot swapping only allowed between 2 flights only at each step
 - Very limited understanding of best swaps : human experience of OCC managers and dispatchers, limited awareness of actual costs (specially in real time)
 - Delays imposed on important flights may strongly impact the AUs' schedule integrity
 - The more flights, the more flexibility => in practice, most usage by 'big' airlines

What is at stake when Airlines exchange their slots (2)?

- When ?
 - Tomorrow with FCL (several flights involved, a market of credits at each airport)
- Why ?
 - In order to optimise impact of delays on operations over time while respecting equity
 - The more flights, the more flexibility => over the time, most AUs have a volume of flights
 - UDPP mechanism supporting long-term optimisation (1 month, 1 year tbd)
- What are the constraints ?
 - Automation (complex to operate by human for real-time optimisation)
 - Memory of credits (how to implement an accountability system?)
 - Agreements (important paradigm shift from current system)

A CONCRETE EXAMPLE

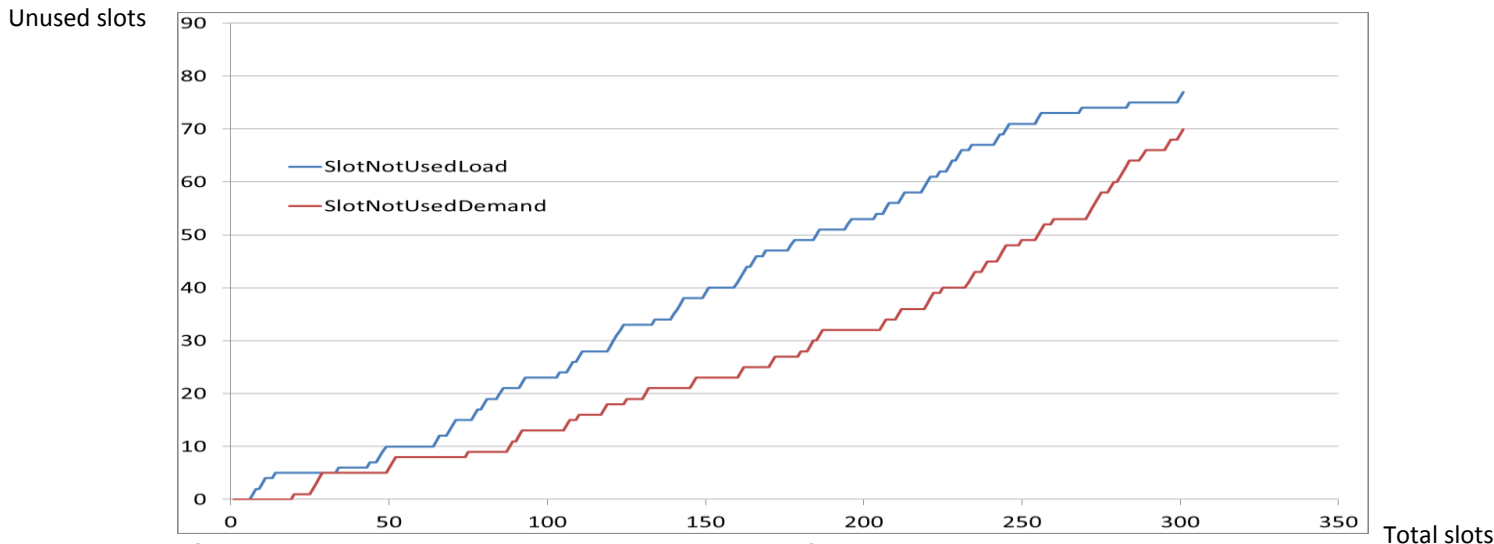
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"WASTED ATM SLOTS" AND POSSIBLE SOLUTION



- - Unused ATM slots not possible to allocate automatic with current software is one reason for "wasted slots" and under delivery of traffic in regulated sectors.
- - Result of a missed slot today is not apparent for AU and not possible to control.
- - Effect is deterioration of slots and more delay for AU.
- - Unused slots are not easy to understand for AU (airline) – could be due to AU own behaviour but also due to the fact that Airport do not accept late change of CTOT while AU may be willing to accept it even until minutes before start-up.
- - Current slot allocation buffers are more suitable for Airport than for AU.
- **How to improve in the future the slot algorithm – how to deal with buffers and current limitations to improve CTOTs very dynamically and minimize number of unused slots?**

UNUSED SLOTS IN A 6H REGULATION (47/60).



- **Conclusions (Post Ops data from several regulations)**
- **a. At the beginning the deterioration is growing quite fast, then stabilises and ends with more slots being used at the end (normal with late filers).**
- **b. The rate of unused slots - taking into account more than 1 flight at the same slot it is probably between 33% and 44%.**
- **c. Current use of 10 min window-width do create more unused slots (red line) but less total delay in a regulation (good statistics for NM + more flights with 0 delay)**

Possible solutions?



- **Show/visualise in a Regulation the Entry Target Time list with Free and negotiable slots for easy access to the AU?**
- Create a Webb solution for AU interactions to find and act on possible Target Time changes?
- **Can individual slots be negotiated – can it be based on brokering?** If one AU can allow his “earlier” slot to be used by another AU but gets some compensation for it, the regulation efficiency would increase and flexibility for AU increase.
- **Compensation for AU giving up their slots?**
- **Future upgraded software must better accept negative delay?** (aircraft able to depart earlier than EOBT) when NM allocate a slot approved by AU.
- **Improvement regarding “window-width”?**
- **New algorithm to be developed to meet AU need to find “wasted slots”?**

Snapshot from TV at 11:51

Entry Target Time

14:06C		AEE530	A321	LGTS	EDDF	12:30	15	8		0	N	SAM	KDON121A	N
14:07C		RYR15BH	B738	EDDH	LGTS	13:20	10	8	13:28t	0	N	SAM	KAP2221	Y
14:08A	LF	ENT7014	B738	LPMA	EPKT	09:40	15	8	10:21	27	N	SWM	KDON121A	Y
14:11C	LU	WZZ2YB	A320	LGAV	EGGW	12:00	15	12		3	N	REA	KFUL121M	Y
14:11C		DLH5MA	A20N	LIRF	EDDF	12:55	10	15	13:10t	0	N	SAM	KDON121A	N
14:12A	LF	RWD700	A333	HRYR	EBBR	06:00	15	10	07:12		N			
14:13C	LU	DLH9KV	A321	LGAV	EDDF	11:52	15	12		15	N	SRM	KDON121A	N
14:13C		AZA6BF	E75S	LIRF	EDDF	12:55	10	15	13:10t	0	N	SAM	KDON121A	N
14:18C		WZZ852	A321	LIMC	EYVI	13:30	10	11	13:41t	0	N	SAM	KDON121A	N
14:18C		BAW703	A320	LOWW	EGLL	13:45	15	13		0	N	SAM	KNTM3C21	Y
14:21C		AZA512	A320	LIRF	LKPR	13:05	10	15	13:20t	0	N	SAM	KDON121A	N
14:25C		CFG6FK	A320	EDDL	LBWN	13:40	10	11	13:51t	0	N	SAM	KDON121A	N
14:28A	LF	A6SHJ	A320	OMSJ	EGLF	08:30	15	10	08:51		N			
14:29C	LF	ROT305F	B737	LROP	EDDF	13:00	15	10		0	N	SAM	KDON121A	N
14:31C		SXS6BM	B738	LTAI	EDDL	11:50	15	14		0	N	SAM	KDON121A	N
14:33C		EZY8954	A319	LOWW	EGKK	14:00	15	13		*0*	N		KNTM3C21	Y
14:34C		SXS1	B738	LTAI	EDDF	11:45	15	22		0	N	SAM	KDON121A	N
14:34C		VJT822	GLEK	LFMN	ESSB	13:30	10	17	8	0	N	SRM	KDON121A	Y
14:35C		TCX525	A321	LTAI	EGSS	11:40	15	22		1	N	SRM	KNTM1C21	Y
14:35C		SXD8QR	B738	LBWN	EDDF	12:50	15	11		0	N	SAM	KDON121A	N
14:36C		THY6HS	A332	LTBA	EDDF	12:30	15	20		0	N	SAM	KDON121A	N
14:36C		EWG2TY	A319	LDSP	EDDH	13:35	15	5		7	N	SRM	KAP2221	Y
14:43C		TCX205	A321	LTAI	EGBB	12:00	15	22		0	N	SRM	KNTM3C21	Y
14:45C		RYR18VL	B738	LROP	EGSS	13:05	15	10		9	N	SAM	KNTM3C21	Y
14:46A	LF	ETH3712	B77L	HAAB	EBBR	09:00	15	10	09:10		N			
14:46C		TVS12J	C680	LEMG	LKPR	12:00	10	17		0	N	SAM	KDON121A	N
14:47A	LFU	JAI118	B77W	VABB	EGLL	07:20	15	10	07:41		N			
14:47C		SXS2MC	B738	LTBJ	EDDL	12:30	15	12		0	N	SAM	KDON121A	N

THY6HS EOBT 1230
will be ready to dep
1220 .



Ask CFG6FK for his
entry slot 1425.
CFG6FK accept to get
11 min delay.



Entry Target Time

Current Time is 0815 UTC

JAF5894 EOBt 0815 and
Entry time in regulation
1024. Need 10 min extra
find 1034 free.

RYR39TB EOBt 0840 and
Entry time in regulation
1054. Will be ready 0830
and find 1045 free.

10:24:00	68 JAF5894	69 SWR2560	####	####	##	##
10:25:00	####	####	####	####	##	##
10:26:00	70 BMS5512	####	####	####	##	##
10:27:00	####	####	####	####	##	##
10:28:00	71 TCX1021	72 KLM1456	73 EIN43R	####	##	##
10:29:00	74 AZA58Y	####	####	####	##	##
10:30:00	####	####	####	####	##	##
10:31:00	75 EZY97VN	76 TOM7FT	####	####	##	##
10:32:00	77 CFG7PE	####	####	####	##	##
10:33:00	78 EZY21QA	79 EZY61LE	####	####	##	##
10:34:00	####	####	####	####	##	##
10:35:00	80 VLG33AG	####	####	####	##	##
10:36:00	81 BAW753	82 EXS24W	####	####	##	##
10:37:00	83 VVV161	####	####	####	##	##
10:38:00	84 BEL22X	####	####	####	##	##
10:39:00	85 BAW62NL	86 ASL51G	87 KLM1302	####	##	##
10:40:00	88 AMC116	####	####	####	##	##
10:41:00	####	####	####	####	##	##
10:42:00	89 IBK1KS	90 KLM86N	91 TOM8PB	92 AFR87UC	##	##
10:43:00	####	####	####	####	##	##
10:44:00	93 BAW2623	94 TAP664A	####	####	##	##
10:45:00	####	####	####	####	##	##
10:46:00	95 CCM2EU	96 BAW75M	97 AFR127X	####	##	##
10:47:00	98 EZY21MW	99 EZY67GR	100 EZY98QG	####	##	##
10:48:00	101 BAW132	####	####	####	##	##
10:49:00	102 EZY57JW	103 EZS53XR	####	####	##	##
10:50:00	104 RYR25EF	####	####	####	##	##
10:51:00	####	####	####	####	##	##
10:52:00	####	####	####	####	##	##
10:53:00	####	####	####	####	##	##
10:54:00	105 BAW27G	106 RYR39TB	####	####	##	##
10:55:00	107 BAW31CE	####	####	####	##	##
10:56:00	108 RYR44AQ	109 AFR15HH	####	####	##	##

HOW COULD BEHAVIOURAL ECONOMICS HELP ?

How to model AUs decision-making to reflect Network evolution ?

- Hyp: The system is economically rational
 - Facts: The users -with their bounded rationality- behave in an economically irrational manner
- Currently we are using an AU cost model to emulate AUs decisions based on a wrong hypothesis (and most likely with a large error)
 - How to make it more “statistical” ?
 - How to better capture the relationship between costs, flexibility and equity to model more accurately the AU behaviours?
 - Having better AUs models may contribute to have better predictions of the states of the ATM Network during operations (more safety & capacity)

How to define equity in a multi-stakeholders environment

- Hyp: The system is equitable in the allocation of ATM resources
 - Facts: The new ATM philosophy is to take into account the cost efficiency when allocating the resources (e.g., introduction of UDPP)
- Users want flexibility with equity (& fairness)
 - Is the outcome of irrational agents using UDPP flexibility acceptable ?
 - What are the limits of flexibility & equity ?
 - How to define Equity & fairness for irrational agents ?

Methodological challenges

- how could we collect evidence ?
- which behavioural insights would be most useful to have in future (e.g. to which extent are costs understood and used in AUs decision-making)?

THANK YOU for your attention !
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