

Improved Flexibility and Equity for Airspace Users During Demand-capacity Imbalance

An introduction to the User Driven Prioritisation
Process (UDPP)

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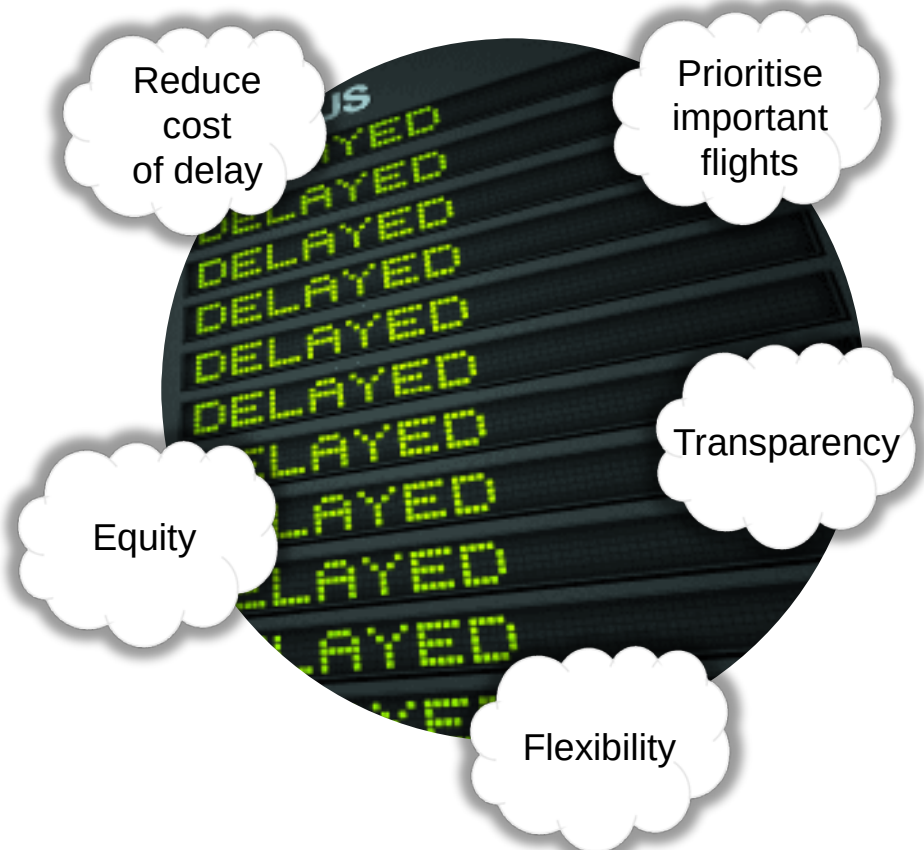
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Problem statement

In order to maintain safety, the **European** Network ATFM Function at Airports or En-Route impose delays or other measures on certain flights before departure

→ limitations on AUs operations

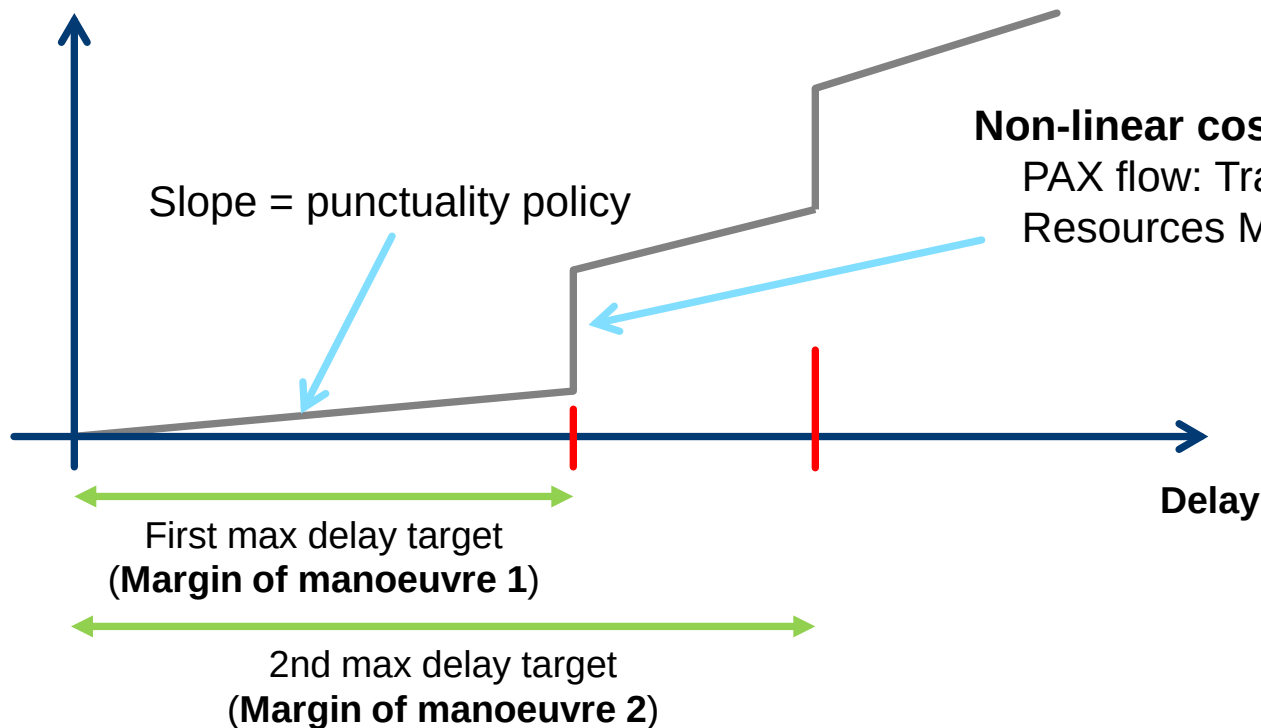
- For ATFM, all flights are equal
- For AUs, every flight is unique
- Reasons:
 - Passenger experience
 - Limitations:
Airport/Crew/Aircraft
 - Schedule Integrity



Cost of Delay for Airspace Users ?

No way to Act on Delay -> Act on Cost of the Delay

Cost of delay (example on 1 flight)

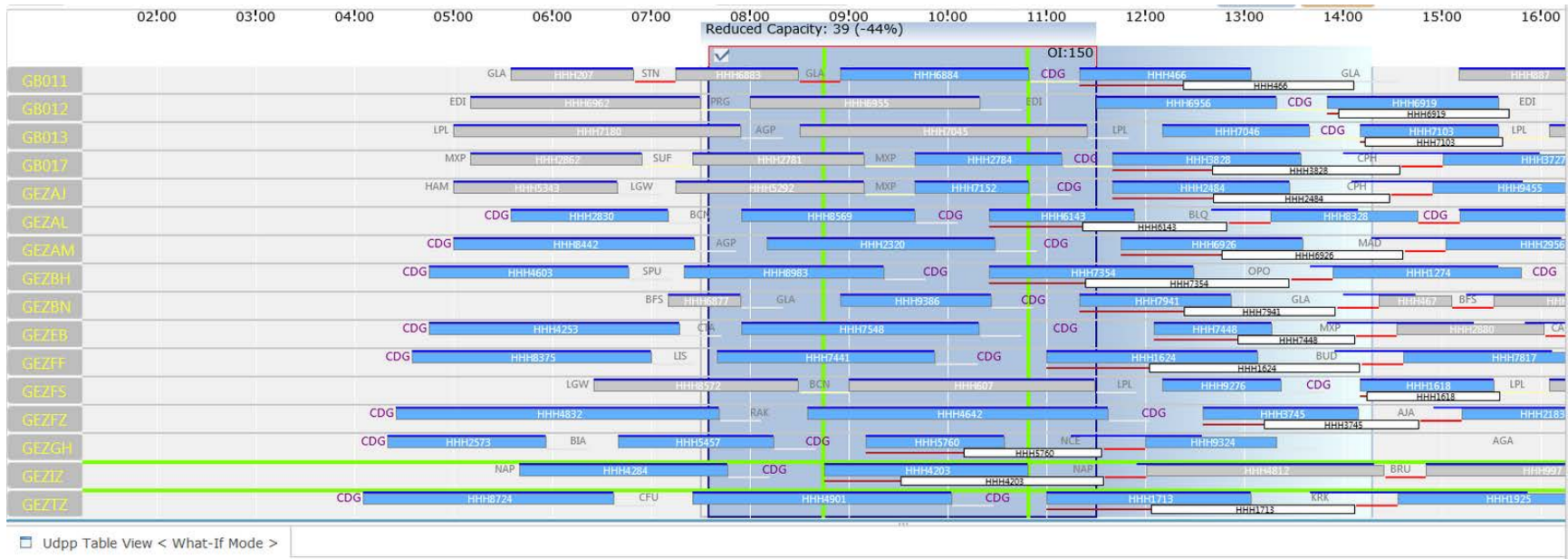


Non-linear cost structure due to :
PAX flow: Transit, VIP, Rotations, ...
Resources Mgt : CREW constraints,
pilots constraints,
Maintenance,
Curfew

Each flight has its own particular complex cost structure (not easy to manage)

Delay propagation (knock-on effect)

AU goal: Decrease the Cost of the delay in a hotspot, taking into account the knock-on effect in the along-day schedule



Registration	Status	Type	Pax	Callsign	Bas. Delay	Delay	From	Dep. Prio	SFP Status	Dep. OC	SOBT	TOBT	UOBT	To	Arr. Prio	SFP Status	Arr. OC	SIBT	TIBT	UIBT
GB010	SCH	319	156 / 133	HHH4811	45	45	CDG			100	08:45	08:45	09:30	NAP			100	11:00	11:00	-
GEZIZ	SCH	319	156 / 137	HHH4203	46	46	CDG			100	08:45	08:45	09:31	NAP			100	10:49	10:49	-
GB007	SCH	320	180 / 135	HHH3794	51	51	CDG			100	08:55	08:55	09:46	VCE			100	10:35	10:35	-
GEZWW	SCH	320	180 / 177	HHH64	53	53	CDG			100	08:55	08:55	09:48	VCE			100	10:27	10:27	-
GB001	SCH	319	156 / 147	HHH3986	58	58	CDG			100	09:10	09:10	10:08	NCE			100	10:45	10:45	-
GEZGH	SCH	319	156 / 146	HHH5760	59	59	CDG			100	09:10	09:10	10:09	NCE			100	10:35	10:35	-
GB004	SCH	319	156 / 140	HHH3774	53	53	CDG			100	10:25	10:25	11:18	OPO			100	12:35	12:35	-
GB008	SCH	319	156 / 119	HHH3840	55	55	CDG			100	10:25	10:25	11:20	BLQ			100	12:10	12:10	-

Principles of the UDPP concept

- AUs have the possibility to **reduce their cost of delays** by re-arranging their own flights' sequence
- Respect **all** stakeholders' needs



Network / Airports /
ATC constraints

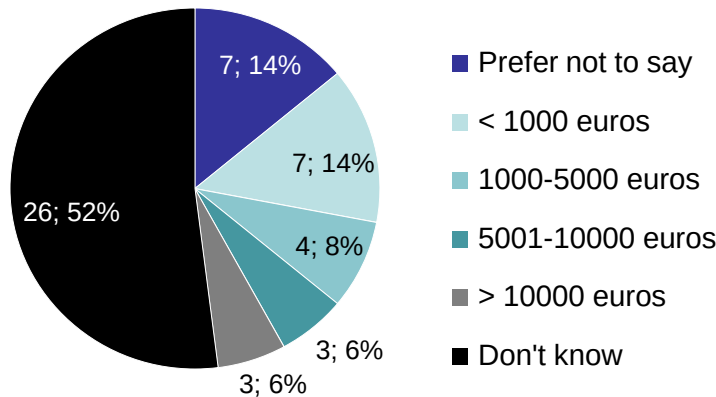


AU
needs

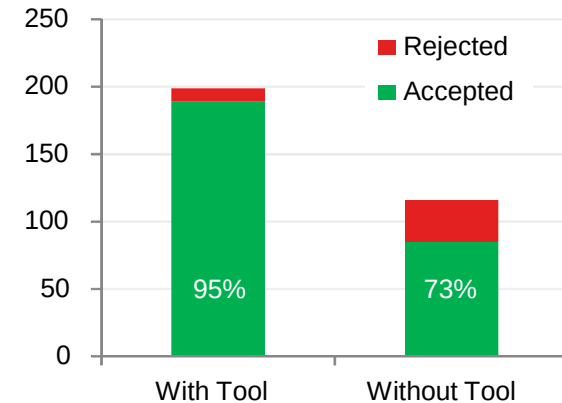


- **Flexibility:** AUs are able to protect most important flights
- **Equity:** no negative impact on other AUs
- **Stable coordination:** high rate of acceptance of requests, coordinated with ATM actors

Achievement: The Enhanced Slot-Swapping



Swap Requests



- EUR 4900– the average cost saved per single ATFM slot swap
- EUR 7-8 million per year saving currently
- 500 M€ estimated over 20 years
- **Deployment in 2017 -----**



Benefits	Airspace Users	Network Manager
More opportunities to swap	✓	
Reduced workload	✓	
Reduced cost of delay	✓	
Higher acceptance of swap requests	✓	✓

UDPP overview

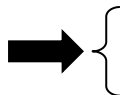
Two prioritisation methods have been validated in SESAR for current operations :

- Enhanced ATFM slot-swapping: more flexible rules and a swap identification tool deployed by NM in 2017
- UDPP departure: AUs can change the priority order of flights in the pre-departure sequence : DFlex at Paris-Charles de Gaulle

New innovative prioritisation approaches are elaborated with AUs to allow AUs' pro-active repositioning for important flights involved

in any Capacity Constrained Situation (Departure – En-route – Arrival), and to share AUs' input in the Network CDM, in a future Trajectory-Based Operations environment :

- Fleet Delay Apportionment
- Selective Flight Protection
- Enhanced Selective Flight Protection



HOP!

FedEx

KLM
Royal Dutch Airlines

AIRFRANCE

BRITISH AIRWAYS

TURKISH AIRLINES

SWISS

airberlin

SAS

Lufthansa

EL AL

Aer Lingus

easyJet

Thomas Cook Group

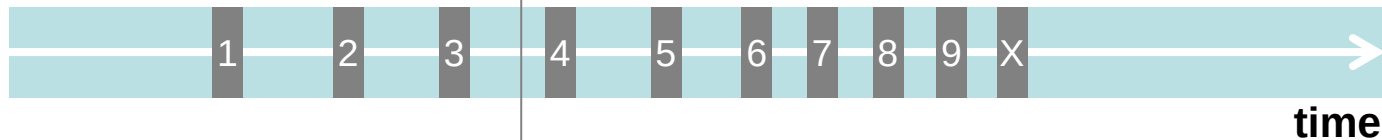
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UDPP Concept : Selective Flight Protection

Original Schedule

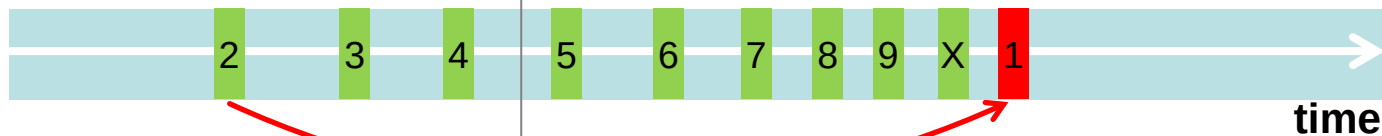


Hotspot (baseline delay)



First Suspend...

Hotspot

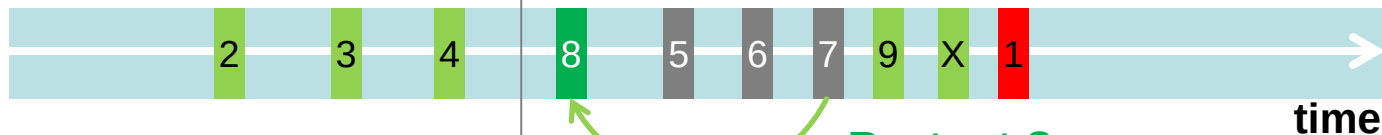


Suspend 1

Positive impact for all others flights

... then Protect

Hotspot



Protect 8



Ration by Effort principle



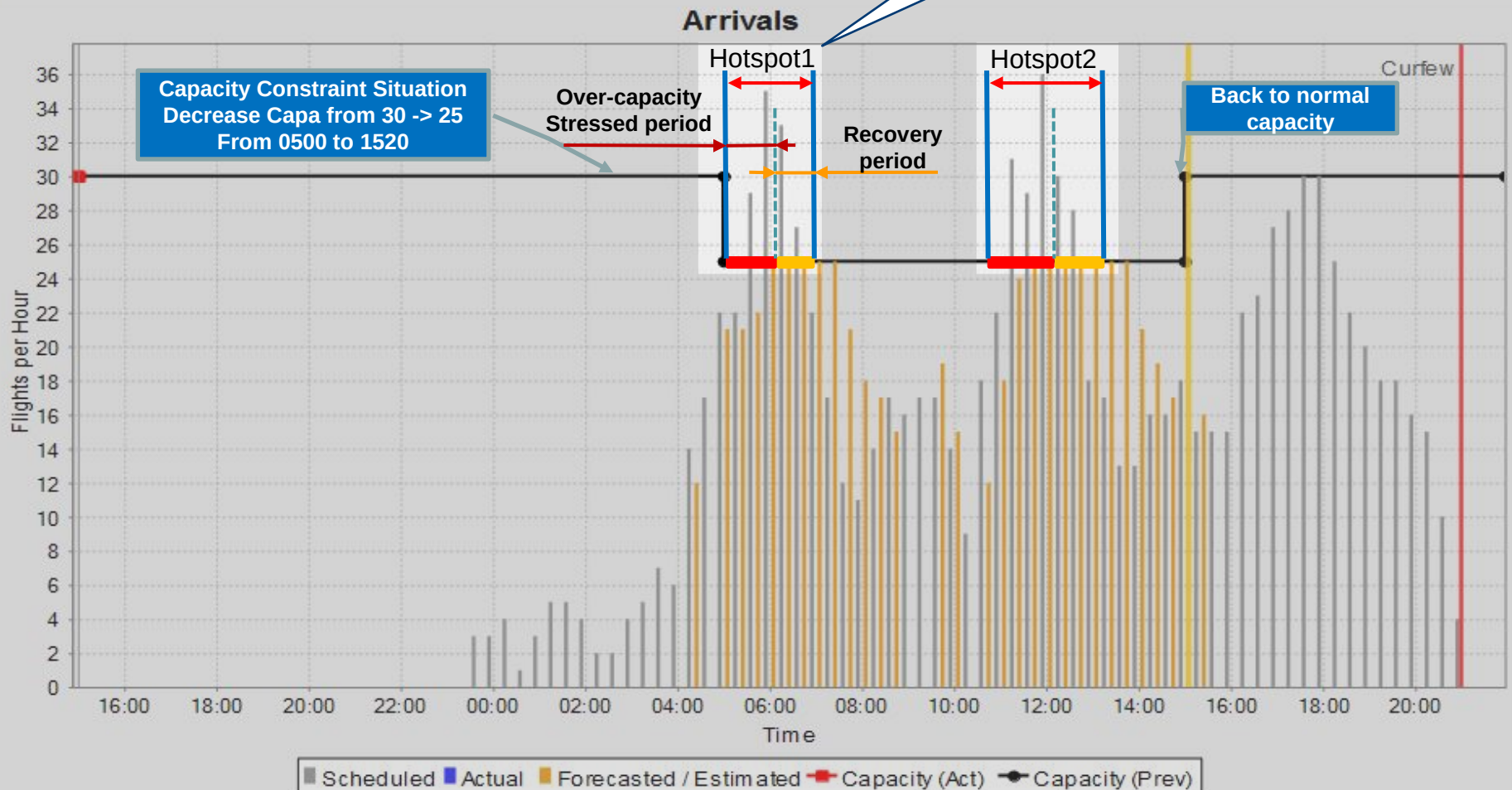
- Neutral impact for flights between Baseline 8 and Original Schedule 8
- Positive impact for all the others

Definitions and terminology

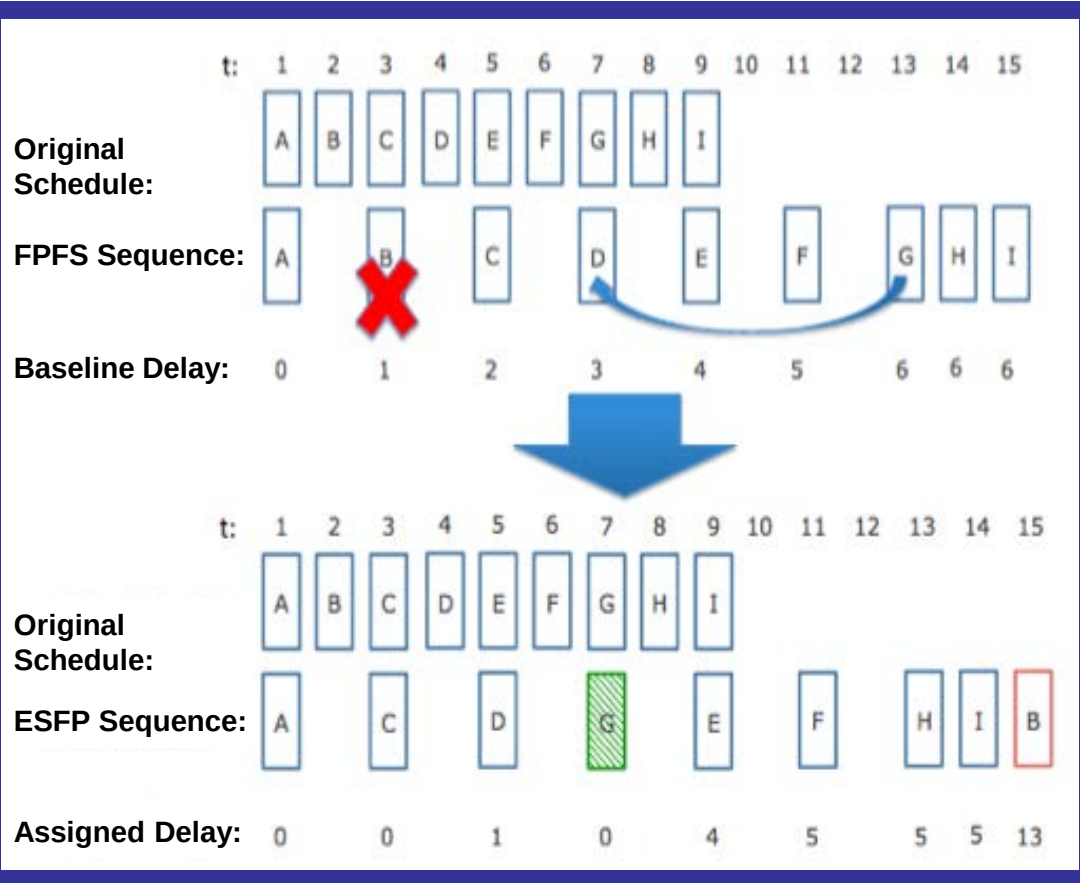
Operating Index (OI) measures the imbalance severity: demand vs. capacity for the hotspot

$$OI = 100 \frac{D}{C}$$

Arrivals Chart



Equity in Selective Flight Protection

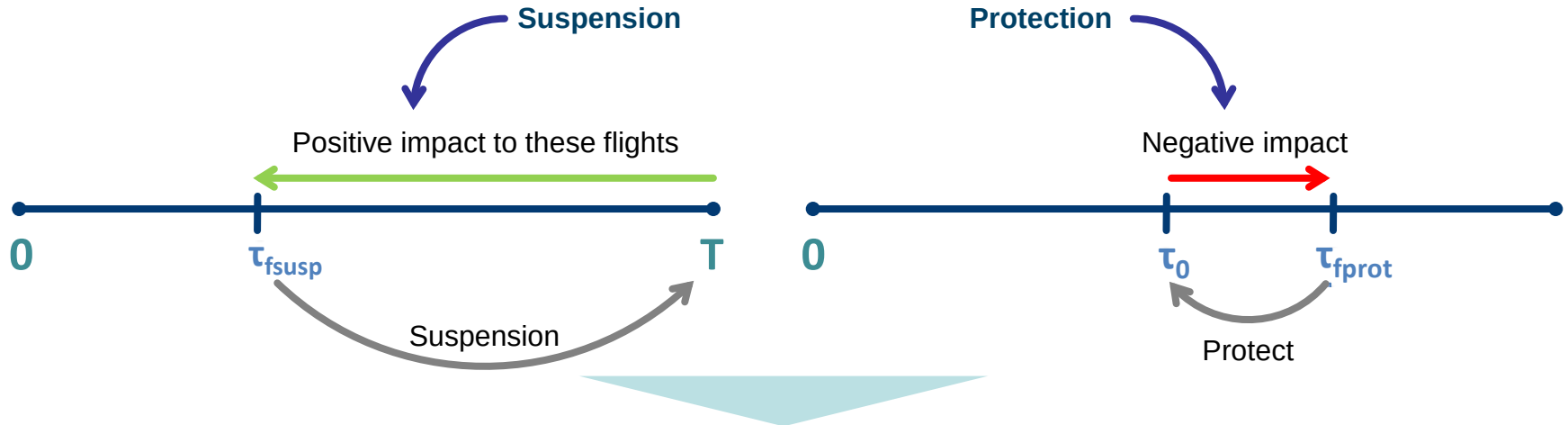


Flights	Baseline Delay	Assign. Delay	Diff.
A	0	0	0
B	1	13	+12
C	2	0	-2
D	3	1	-2
E	4	4	0
F	5	5	0
G	6	0	-6
H	6	5	-1
I	6	5	-1
Sum	33	33	0

The new assigned delay is equitable because no one is worse off

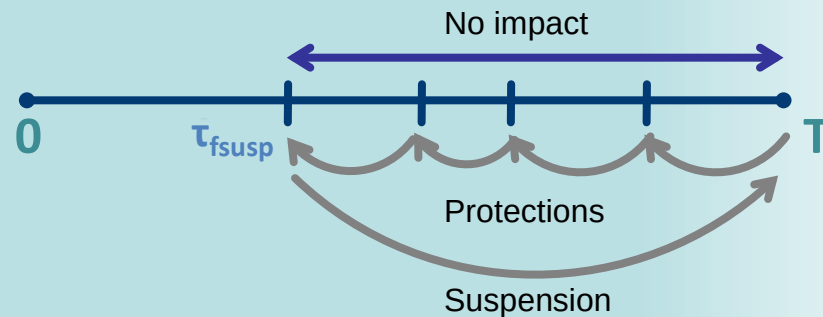
Equity in suspension – protection

Expected impact to other AUs caused by



Since $NI < PI$, many protections can be neutralised by one suspension

1 Flight suspension
&
4 Flight protections



Condition of equity: **$MFP \times NI \leq PI$**

→ Win-win or win-neutral situation

Selective Flight Protection mechanism

- The UDPP Selective Flight Protection (SFP) values are represented by **Operating Credits (OC)**
- The **Operating Index (OI)** provides a means to indicate the severity of a hotspot
- The OI value determines the **Maximum number of Flights that can be Protected (MFP)** in the hotspot in exchange for a suspended flight:

$$MFP = \frac{100}{OI - 100}$$

SFP rules for prioritising a flight:

1. Suspend lower priority flights to liberate the 100 OCs of those flights (effort must be done always first).
2. Move the available credits to flights that are to be protected by raising the OC for these flights to the OI level
3. Protected flights must have new positions in the sequence which are always after or equal to the original scheduled times of the suspended flights

$$Cr_{in} = 100 \times S - [OI - 100] \times P$$

Credits requirement

Enhancements for the SFP method

- **AUs asked for enhancement** of the SFP to extend the validity of the credits to other hotspots, so the non-used leftover credits in a hotspot are not lost



- Specially relevant for the **Low Volume User in Constraint (LVUCs)**, as they usually have fewer chances to take advantage of the flexibility provided by UDPP



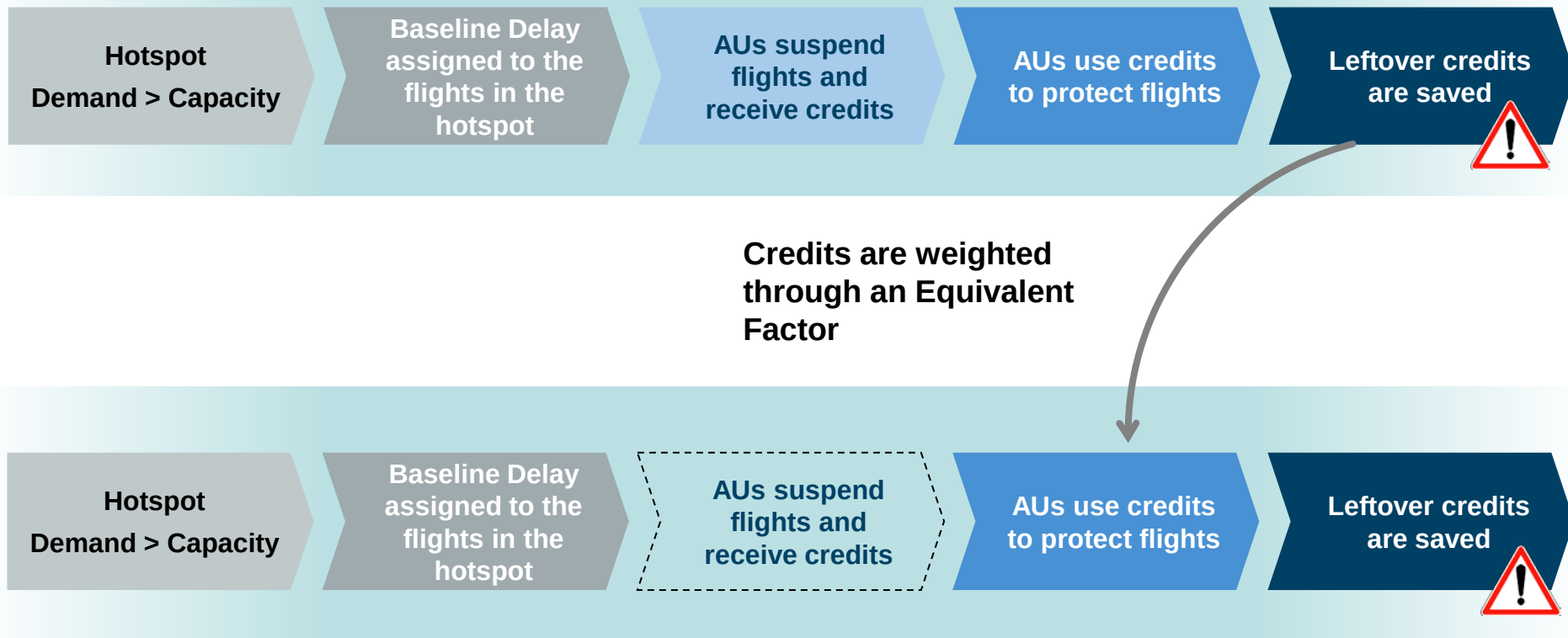
- E.g., LVUC with 1 flights in a hotspot (never can protect that flight)
- E.g.: LVUC with 3 flights Hotspot with $OI=125 \rightarrow MFP = 4$
1 suspension ($Cr = +100$), 2 protections ($Cr = -2 \times 25$) $\rightarrow Cr = 50$ (leftover credits)



New method ESFP aims at addressing these needs

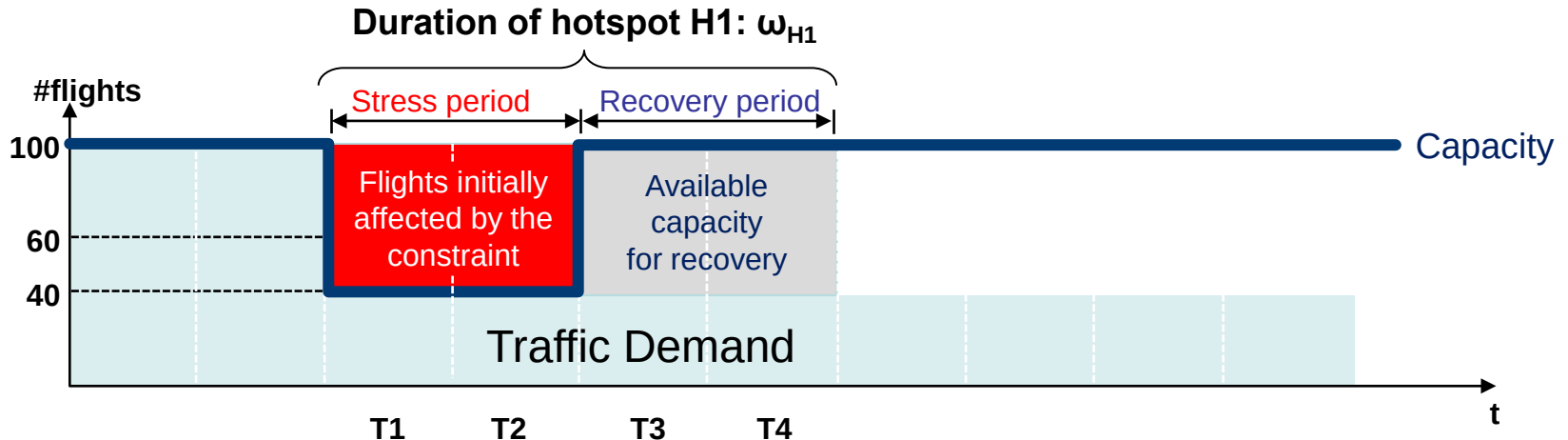
Enhanced Selective Flight Protection

Assign different value for the credits according to the different levels of delay in each hotspot (equivalent factor)



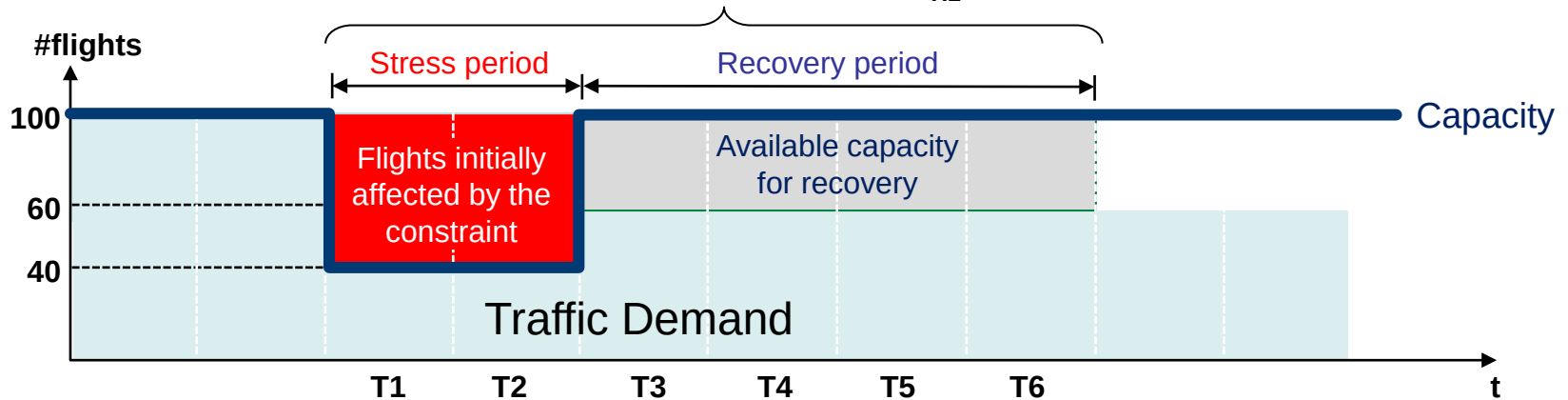
Leftover credits can be accumulated only by AUs with low number of flights affected by the hotspot (Low Volume Users in Constraint)

Enhanced Selective Flight Protection



LVUC' s credits in H1: $Cr_{H1} = 100 \times S - [OI - 100] \times P$

Duration of hotspot H2: ω_{H2}



LVUC' s credits in H2: $Cr_{H2} = 100 \times S_{H2} - [OI_{H2} - 100] \times P_{H2} + \underbrace{Cr_{H1}}_{\text{H1 leftover credits}} \times \underbrace{\frac{\omega_{H1}}{\omega_{H2}}}_{\text{Equivalence Factor}}$

ESFP example

Hotspot	Parameters			
	<i>C</i>	<i>D</i>	<i>OI</i>	<i>ω</i>
H1	20	27	135	300
H2	20	23	115	250

An LVUC in hotspot H1 **suspends** one flight ($S_{H1}=1$) → **+100 OCs**.
 It **protects** only another one ($P_{H1} = 1$) → **-35 OCs**

$$Cr_{H1} = 100 \times 1 - (135 - 100) \times 1 = 65$$

→ Still could protect $65/(135-100) = 4$ flights

$$Cr_{H2} = 65 \times 300/250 = 78$$

→ Now could protect $78/(115-100) = 5$ flights

Hotspot duration determines the number of credits carried to other hotspot, while severity (OI) determines how many flights can be protected

Example (with realistic traffic data)

Hotspot 1

- OI = 128
- Suspended flight: OA1 318 (+100 OC)
- Protected flight: OA1 1714 (-28 OC)

AU name	Total flights	Baseline delay	Assigned delay	Difference
HUB	52	1388	1294	94
LC1	8	250	241	9
LC2	12	461	446	15
OA1	6	227	373	-146
OA2	2	32	29	3
OA3	2	59	59	0
OA4	1	33	30	3
OA5	3	94	91	3
OA6	4	113	101	12
OA7	0	0	0	0
OA8	6	208	201	7
	98	2865	2865	0

Hotspot 2

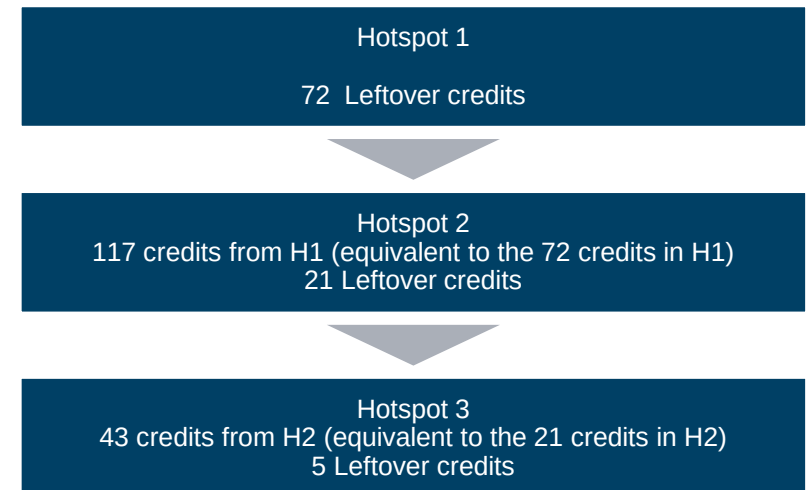
- OI = 132
- Protected flights: OA1 318, 192, 1714
(-32 OC x 3 = -96 OC)

AU name	Total flights	Baseline delay	Assigned delay	Difference
HUB	39	463	481	-18
LC1	6	112	127	-15
LC2	9	196	215	-19
OA1	4	74	4	70
OA2	1	1	1	0
OA3	1	32	37	-5
OA4	0	0	0	0
OA5	2	35	40	-5
OA6	2	13	13	0
OA7	0	0	0	0
OA8	5	88	98	-10
	69	1014	1016	-2

Hotspot 3

- OI = 136
- Protected flight: OA1 1714 (-36 OC)

AU name	Total flights	Baseline delay	Assigned delay	Difference
HUB	22	166	172	-6
LC1	4	41	45	-4
LC2	7	80	82	-2
OA1	3	17	5	12
OA2	0	0	0	0
OA3	1	15	15	0
OA4	0	0	0	0
OA5	1	12	12	0
OA6	0	0	0	0
OA7	0	0	0	0
OA8	3	36	36	0
	41	367	367	0



Positive or almost neutral general impact on the delay distribution

AU name	Total flights	Baseline delay	Assigned delay	Difference	% B.Delay
HUB	113	2017	1947	70	3,47%
LC1	18	403	413	-10	-2,48%
LC2	28	737	743	-6	-0,81%
OA1	13	318	382	-64	-20,13%
OA2	3	33	30	3	9,09%
OA3	4	106	111	-5	-4,72%
OA4	1	33	30	3	9,09%
OA5	6	141	143	-2	-1,42%
OA6	6	126	114	12	9,52%
OA7	0	0	0	0	0,00%
OA8	14	332	335	-3	-0,90%
	208	4246	4248	-2	

AU name	% flights	% B.Delay	% A.Delay	% change	NIT*
HUB	54,85%	47,50%	45,83%	3,47%	-5
LC1	8,74%	9,49%	9,72%	-2,48%	-5
LC2	13,59%	17,36%	17,49%	-0,81%	-5
OA1	6,31%	7,49%	8,99%	-20,13%	0
OA2	1,46%	0,78%	0,71%	9,09%	0
OA3	1,94%	2,50%	2,61%	-4,72%	-5
OA4	0,49%	0,78%	0,71%	9,09%	0
OA5	2,91%	3,32%	3,37%	-1,42%	-5
OA6	2,91%	2,97%	2,68%	9,52%	0
OA7	0,00%	0,00%	0,00%	0,00%	0
OA8	6,80%	7,82%	7,89%	-0,90%	-5

- OA1 is the Airspace Users suspending and protecting flights
- Very low negative impact on some AUs only (**equitable**)
- The LVUC use credits among different hotspots and benefited from **flexibility**

AUs found the impact negligible compared to the number of flights operated, and valued positively the benefits of the extra flexibility given by ESFP

Conclusions

- UDPP bring flexibility to Airspace Users to reduce their cost of delay
- UDPP concept comprises several mechanisms at different levels of E-OCVM maturity: **V3+ maturity** for ESS and D-Flex; early **V2 maturity** for FDA and SFP; **V1 maturity** for ESFP
- **There is still a lot of work to do:**
 - Continued **validation** of assumptions and performance, introducing uncertainty and improving the mechanisms
 - Integrate **prioritisation with other AUs' processes and tools** (pax reaccomodation, ..) to inform decision about costs reduction
 - Integrate UDPP into the other stakeholders's processes for an improved **Collaborative Decision Making in the ATM Network**
- **AUs expressed their interest for further UDPP development**
- Thanks for the contributions to the achievements:



... and Frankfurt, Munich, Heathrow and Paris-CdGaulle Airports



Any Questions ?

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