ATM CAPACITY REDUCTION

DUE TO

CNS/ATM Systems and Services disruptions

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This document was developed to study the existing correlation between the ever increasing demand of ATM capacity based on the CNS & ATM systems and services availability and continuity and to highlight the effect of CNS & ATM systems and services degradations or failures and their impact on delays and into the reduction of the airport capacity, as into the consecutive delays, which eventually lead to a propagated reduction of capacity.

This analysis has been conducted using a scientific approach as web analytics combined with data mining techniques on documents from International organizations such as ICAO, Eurocontrol, EASA ,IATA and IFATSEA.

It is also important to study and take into account the role of the Human, in this case the ATSEP who are the personnel directly connected and ensuring the Availability and Continuity of Service of CNS/ATM systems and services increasing Performance, (Fig. 1).

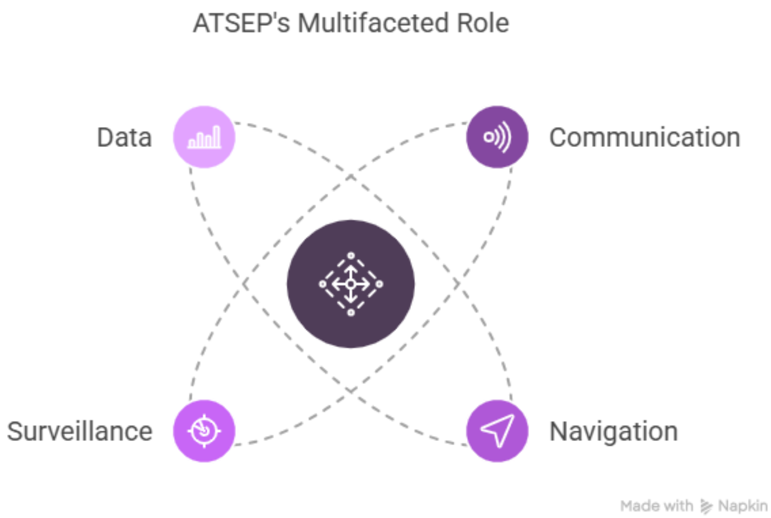

Fig.1 The ATSEP role

I. INTRODUCTION

Aviation is always looking for ways to improve Safety and Performance as well as to reduce cost, leading to a safer, cost effective and best passenger experience. Moreover, the Greening of the Environment through the sustainability of optimum trajectories flown, is directly related to the availability and continuity of CNS services.

The current study has collected and processed information regarding the number of major outages of CNS and ATM systems globally for the last years and highlighted their impact in the domain of ATM capacity reduction and related ATFM Delays.

It is a self-evident conclusion that if these outages are reduced, the benefit in the areas of Safety and Performance, including the environmental impact will be improved. A further study, following the current one may lead to methods and new approaches of reducing these outages.

Additionally, we may also be able to predict and proactively address future delays, using the data given.

For example, if in an ANSP's Contingency plan, every CNS/ATM equipment's or service's failure was stated together with the expected delay and the expected capacity reduction, it would be easier and faster to define the optimum measures to reduce them.

In this way everything will be strategically planned, instead of ad- hoc addressing, avoiding surprises and accumulation of delays.

So the question is

"How can a CNS or ATM equipment and Services failure or degradation affect or impact the capacity in a given airspace e.g. at the number of arrivals-departures at an airport while maintaining acceptable levels of Safety?"

- Is it measurable and how?
- Is it currently taken into consideration by the ANSP strategic and tactical planning providers so it can be mitigated?
- Is it taken into consideration by Airspace users? e.g. in IATA, since the ATC Equipment outages are not clearly or separately identified in the IATA Delay codes.

In order to come to a reasonable and justified conclusion on the impact of CNS/ATM systems and services outages and their impact on Capacity and associated Delays, existing data should be studied. Studies are needed to investigate the impact per se on ATM Performance e.g. Capacity, Delays and possibly Safety regarding the duration of the downtime.

The current study intends to contribute in this direction.

II. FINDINGS

It is currently common that airspace users are taking for granted that CNS/ATM systems and services are available, in full reserve in hot stand by, continuously operating 24/7, unless a NOTAM informs for the opposite.

But it is also a fact that there are CNS/ATM systems degradations and failures e.g. due to a cybersecurity attack, leading to capacity disruptions, even to safety risks not always visible to users at a time when ATSEP are already addressing them.

There is also downtime for preventive maintenance, flight calibration and/or installation or upgrades, not directly known to the airspace users but carefully planned so as not to impact the total Performance.

In those cases of degradations, ATSEP are there to intervene towards restoring and securing CNS/ATM systems and service continuity, without impacting the airspace user or ATC. The ATSEP contribution in extending the availability of CNS/ATM services and restoring the services as soon as possible thus minimizing recovery time is not visible by the airspace user.

As it is depicted in the picture (Fig.2) below, in order to ensure the ATM Continuity and Safety the interwoven continuous operation of Communication, Navigation, Surveillance and ATM systems must be in operation.

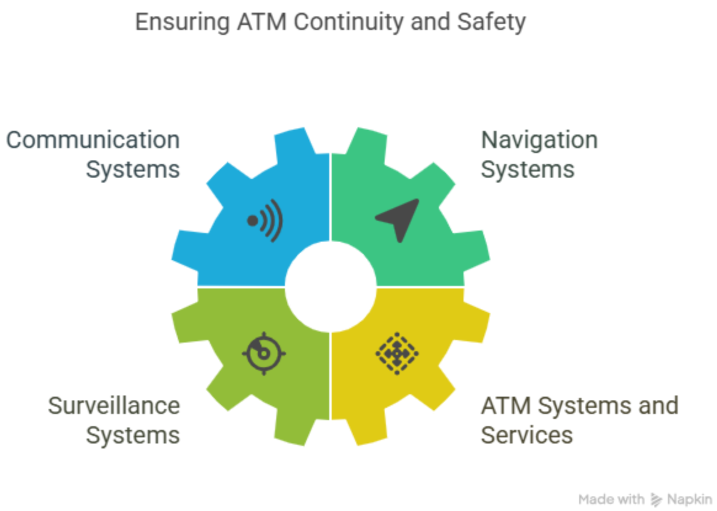

Fig.2 ATM Continuity and Safety

During degradations or failures and in order to secure safety, ATSEP expert decision measures are taken in order to minimize recovery time, and consequently ATM capacity is restored at minimum time with an obvious positive impact on Performance, cost and Safety, without burdening the ATCO workload.

In this study examples of such failures and their impact are provided with a final result on delays to understand how often and how much is ATM capacity dependent on CNS & ATM systems and services availability.

CNS & ATM systems and services

Communication, Navigation, Surveillance and ATM systems and services are the systems and services that continuously provide the needed data input thus enabling Air Traffic

Management. Their continuity of service and availability are the enablers through which ATM continuity and safety is ensured. This includes both Ground based and Space based CNS service provision.

The picture below (Fig. 3) depicts an indicative sample of potential impacts on operations resulting from CNS ground based or space based Services.

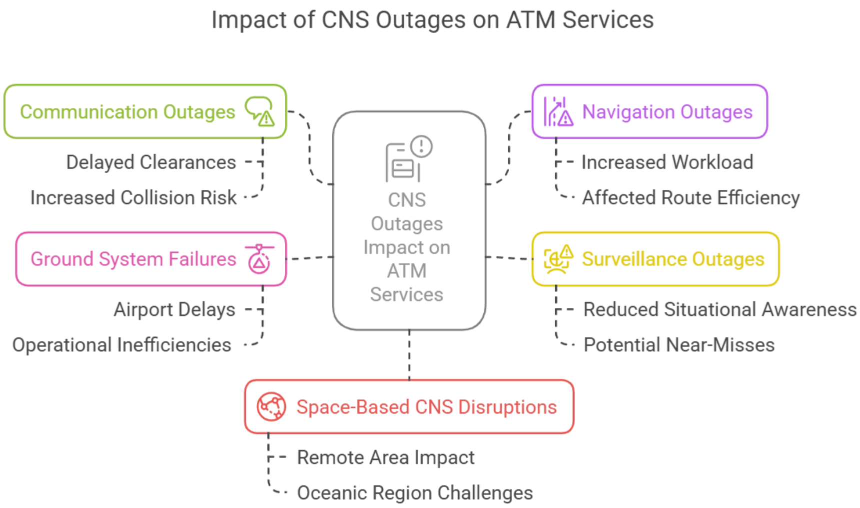

Fig.3 The impact of CNS Outages on ATM Services

III. DATA REPOSITORY: FACTS AND DOCUMENTS

There are data collected in order to analyze and draw some basic conclusions to respond on the question of the impact on ATM Capacity and associated delays.

As seen in the picture below (Fig.4) the delays - only in January 2025 a 3.3% of total delays - were due to CNS infrastructure [1]. This is equal to 25475 minutes in total. It is also clear that this is an area of improvement which should be taken into consideration.

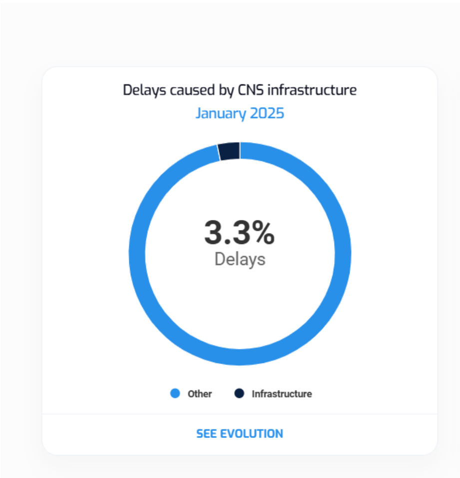

Fig.4 Delays caused by CNS Infrastructure for January 2025

Cost of Delay

According to EUROCONTROL's economic analyses [2], the cost of delay varies by flight phase:

At Gate: €166 per minute

Taxiing: €182 per minute

En-Route (Airborne): €212 per minute

Arrival Management: €206 per minute

From the above it results that only for January 2025 CNS infrastructure caused a massive amount of cost, since delay affects all flight phases.

Source of delays

COMMUNICATION EQUIPMENT PROBLEMS

There are sources of information with regard to the loss of ATC Communication globally. For example:

In the EUROCONTROL report [3] with regard to the Loss of Communication has identified and categorized that the most common factors contributing to communication equipment problems were:

- Sleeping VHF receivers 53%
- Radio equipment malfunction – air 17%
- Radio equipment malfunction – ground 15%
- Stuck microphones 6%

In the **EUROCONTROL EVAIR Bulletin No 25** for the Years 2018-2022A [4] it is mentioned:

"a breakdown of the explanatory factors for loss of communication shows that radio availability problems (software, hardware or other issues) represent the highest percentage (42%) and go-around, at 48%, is the event most frequently associated with loss of communication. Usually, this happens during the final approach when landing clearances are not provided due to loss of communication."

These all lead to significant delays, while it must be noted that the final approach is the most demanding phase of flight and with the highest number of accidents globally.

NAVIGATION (Ground space based)

As stated in the description in **EASA Safety Information Bulletin SIB No.: 2022-02R3 Issued on the 05 July 2024 with the Subject: Global Navigation Satellite System Outage and Alterations Leading to Communication / Navigation / Surveillance Degradation** [5] *“since February 2022, there has been an increase in jamming and/or spoofing of Global Navigation Satellite Systems (GNSS) ..and has shown further increase in the severity of its impact, as well as an overall growth of intensity and sophistication of these events”*

And further down in page 2:

“The following non-exhaustive list provides observed symptoms of suspected GNSS spoofing:

• Incoherence in navigation position, such as GNSS/FMS position disagree alerts;

• Abnormal differences between Ground Speed and True Airspeed;

• Time and date shift;

• Spurious Terrain Awareness and Warning System (TAWS) alerts;

• Potential deviation of hybrid position (IRS/GNSS).”

All leading to the inability to use GNSS for navigation by airspace users.

In the same EASA Bulletin and in order to address the above issues, EASA recommends the implementation of the following mitigating measures where it is clearly stated (page 3) that

“that existing non-GNSS based navigation infrastructure, particularly Instrument Landing Systems (ILS), Distance Measuring Equipment (DME) stations and Very High Frequency Omnidirectional Range (VOR) stations are made available and kept operational as required;”

and that *“ATM/ANS providers should consider keeping a ground navigation infrastructure operational such as ILS, DME, and/or VOR in support of conventional and performance-based navigation procedures;”*

In order to address the failures of CNS service delivery of GNSS the MON concept was developed.

«In the event of CNS degradations, the infrastructure must remain safe, robust, and resilient. This requires thorough evaluation of reversion and contingency scenarios to ensure target performance levels… The document defines the concept of a European civil CNS Minimum Operational Network (MON), aimed at enhancing the cost-effectiveness of the CNS infrastructure through optimization» [6]

SURVEILLANCE

Surveillance in all its forms SSR, PSR Multilateration, ADS-B ground and space based are crucial to aviation.

As FAA states in their **Aeronautical Information Manual** [7]**:**

“The controller's ability to advise a pilot flying on instruments or in visual conditions of the aircraft's proximity to another aircraft will be limited if the unknown aircraft is not observed on radar”

And “The controller's first priority is given to establishing vertical, lateral, or longitudinal separation between aircraft” also “performance is monitored by maintenance personnel rather than ATC”.

Maintenance personnel in this case are the ATSEP.

RADAR plays a major role in the ATM and any failure could lead to severe compromise of safety. [8]

SOFTWARE in CNS/ATM - CYBER-ATTACKS

Cybersecurity plays a crucial role in ATM operations as it ensures the confidentiality, integrity, Continuity and Availability of critical systems and data.

The introduction of new concepts like Remote Towers, ADSPs and Virtual centers as well as Cloud services requires proactively addressing Cybersecurity issues.

ATSEP are the designated personnel exclusively authorized to access and manage ATM/CNS systems, serving as the primary responders to cyber-attacks targeting these systems. Their duties include detecting and containing the incident, preserving evidence for forensic investigation, and ensuring the restoration of service delivery. Upon identifying a malfunction caused by a suspected cyber-attack, compromised processes or servers must be disconnected from the functional system. The on-duty ATSEP holds the responsibility to determine the most suitable ATM/CNS configuration, prioritizing the safest approach to maintain optimal or maximum service delivery, even if operating at a reduced capacity in order to address or mitigate a Cyberattack (as stated in EGHD document at www.atsep.eu/file-list/).

Here is an example of a Cybersecurity incident:

IN 2018 EUROCONTROL's Enhanced Tactical Flow Management System (ETFMS) failed on a Tuesday morning. The outage of the system, which helps controllers by keeping them abreast of the demand on and capacity in different areas under the organization's oversight, meant that any flight plans filed before 10.26 UTC were lost and aircraft operators were asked to refile their flight plans for all aircraft that had not yet departed.

EUROCONTROL reverted on its contingency plan which had the effect of **reducing the capacity of the European network by 10 per cent.**

More than **29,000 flights** were expected to travel through the network and approximately half of them faced delays. [9]

In EUROCONTROL Think Paper 12, using exclusive EUROCONTROL data from the Agency's EATM-CERT (European Air Traffic Management Computer Emergency Response Team) service reveals that on top of a "big 3" crimewave of fake websites, data theft, and phishing attacks, **every week a ransomware attack hits an aviation actor somewhere across the globe**, disrupting business continuity and capable of bringing operations to a grinding halt. [10]

EUROCONTROL DATA on CNS&ATM systems and services outages

CNS&ATM outages Data is collected by EUROCONTROL and summaries are made available. EUROCONTROL publishes its **Monthly Network Operations Report** where, at chapter **4.4 Significant events**, one can see the events due to **Technical** reasons.

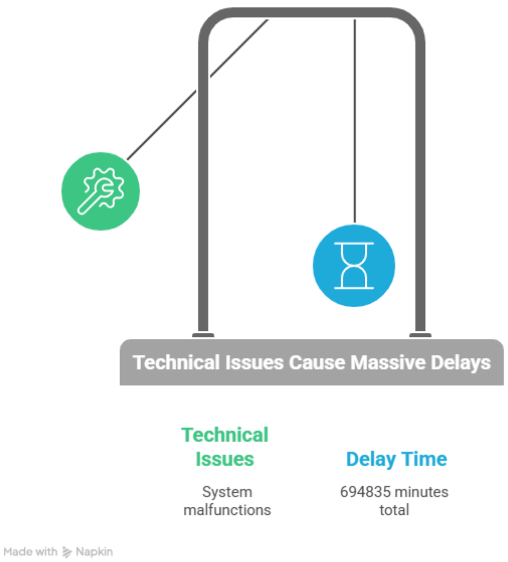

Fig. 5

Below is data from the past year when the total in delay in minutes due to technical reasons was 694835 minutes published at https://www.eurocontrol.int/communications-navigation-and-surveillance

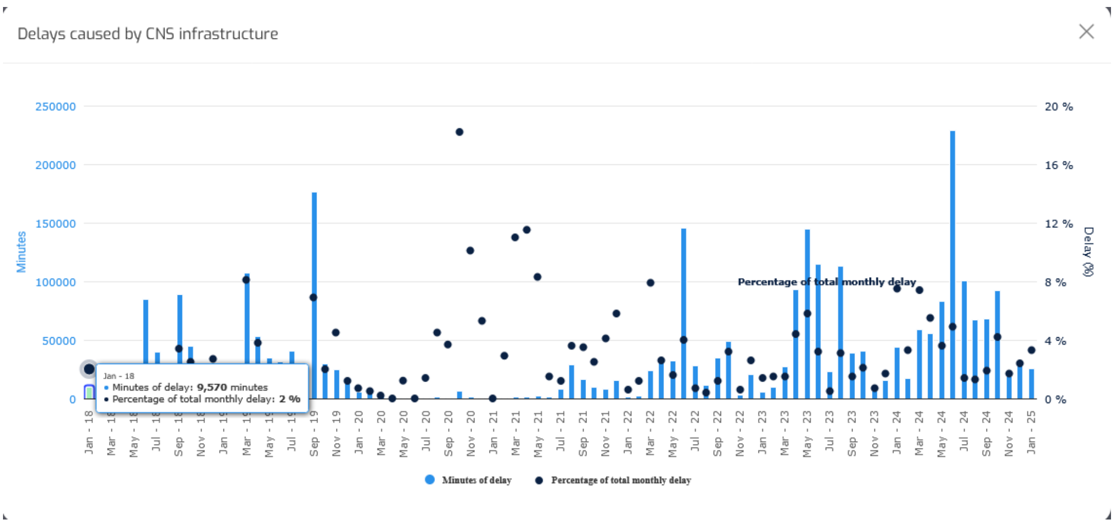

Fig.6

CNS& ATM system failures and associated disruptions

Below is Eurocontrol Data on CNS & ATM system failures and associated disruptions on delay from previous months [11]:

Eurocontrol network operations report January 2025

- Tower radio communication issues at Frankfurt airport from 02 to 15 January generated 10,219 minutes of ATFM delay.
- Local radar issues in Valencia TMA throughout the month generated 4,843 minutes of ATFM delay in Barcelona ACC.
- Technical problem with the Air Traffic Management System in Brussels ACC on 30 January led to a zero rate until early evening and generated 7,254 minutes of ATFM delay. 10 flights diverted to alternate destinations.

Eurocontrol network operations report December 2024

- Due to the unavailability of radio antennas, the number of available sectors provided by Brest ACC in the Bay of Biscay was limited, prompting 6,645 minutes of ATFM delay.
- Local radar issues in Valencia TMA throughout the month generated 11,537 minutes of ATFM delay in Barcelona ACC.

Eurocontrol network operations report November 2024

- Due to the unavailability of a radio antenna located on the Cantabrian coastline, the number of available sectors provided by Brest ACC in the Bay of Biscay was limited, prompting 3,245 minutes of ATFM delay.
- Frequency issues at Porto airport from 01 to 05 November generated 6,024 minutes of ATFM delay.
- FDPS instability in Karlsruhe UAC on 22 November generated 4,152 minutes of ATFM delay.
- Datalink system issues on 23 November prompted capacity measures in Maastricht UAC and Bordeaux ACC generating 1,523 minutes of ATFM delay.

Eurocontrol network operations report October 2024

- Due to the unavailability of a radio antenna located on the Cantabrian coastline, the number of available sectors provided by Brest ACC in the Bay of Biscay was limited, prompting 11,868 minutes of ATFM delay;
- DFS control Center experienced technical issue on 04 October which led to capacity reduction in several German such as Karlsruhe UAC, Munich ACC and Bremen ACC. It also impacted Frankfurt airport and generated a total of 37,747 minutes of ATFM delay;
- Radar issue at Athens airport on 13 October generated 1,169 minutes of ATFM delay;
- Communication system issues in Bremen ACC on 04 and 15 October generated 2,266 minutes of ATFM delay;

• Communication system failure at Amsterdam/Schiphol on 19 October generated 1,582 minutes of ATFM delay;

• Flight Data Processing System issues in Milano ACC on 20 October generated 9,772 minutes of ATFM delay;

• Two days of radar maintenance in Budapest ACC on 28 and 29 October generated 14,465 minutes of ATFM delay;

• Communication system issue at Malaga airport on 29 October generated 2,220 minutes of ATFM delay;

Eurocontrol network operations report September 2024

• Due to the unavailability of a radio antenna located on the Cantabrian coastline, the number of available sectors provided by Brest ACC in the Bay of Biscay was limited, prompting 36,938 minutes of ATFM delay;

• Data Link issue in Reims ACC on 01 September generated 4,870 minutes of ATFM delay;

• Technical issues with Oceanic Center systems in Shanwick OACC on 07 September generated 1,321 minutes of ATFM delay;

• FDP maintenance in Zurich ACC on 10 September generated 2,036 minutes of ATFM delay;

• Electrical failure at Antalya airport on 11 September generated 2,944 minutes of ATFM delay;

• Communication system failure in Zagreb ACC on 23 September generated 1,113 minutes of ATFM delay;

• Communication system failure in Marseille ACC on 24 September generated 6,888 minutes of ATFM delay; additional 1,492 minutes of delay were recorded in Alger ACC due to precautionary measures, 1,345 minutes in Barcelona and 1,408 minutes in Madrid ACC due to traffic unload.

Eurocontrol network operations report August 2024

• 05 August, Athens Airport: issues with ‘MERENDA’ radar.

• 10 August, CPDLC: (4,940 min); technical data link issues attributed as causing limited capacity in Reims ACC (1,727 min), Bordeaux ACC (409 min), Maastricht UAC (1,108 min), Vienna ACC (569 min), and at Lisbon Airport (1,127 min).

• 16 August, Bodo ACC: power issue limiting the ACC's radar surveillance capability, 6,080 min through to Saturday.

• 23 August, Skopje ACC, FDPS limitation issues, week 34, 580 min; Week 35: 2,032 min.

• 24 August, Manchester Airport, FDPS issue, Saturday: 1,052 min

- 28 August, Netherlands Department of Defence IT Network: data exchange affecting some TMAs, notably affecting Eindhoven Airport where operations were severely disrupted before 15:00 UTC, with 78 fewer movements recorded week-on-week.
- August, Brest ACC, ongoing ATC frequencies issues, 3,119 min, 11,771 min

Eurocontrol network operations report July 2024

- Ongoing reduced capacities (since 01-March) in Swiss airspace above FL245 following a series of technical issues that resulted in system instability and generated 19,469 minutes of ATFM delay in Zurich ACC, and 5,698 minutes of ATFM delay at Zurich airport;
- Radar issues in Bordeaux ACC throughout the month generated 12,159 minutes of ATFM delay;
- Frequency issues in Brest ACC throughout the month generated 21,319 minutes of ATFM delay;
- OLDI failure in Roma ACC from 01 July to 05 July generated 8,147 minutes of ATFM delay;
- Communication system failure in Paris ACC on 11 July generated 2,392 minutes of ATFM delay;
- OLDI failure between Zagreb and Brindisi ACCs on 14 July generated 3,359 minutes of ATFM delay in Zagreb ACC;
- OLDI failure between Marseille and Roma ACCs from 16 to 17 July generated 2,713 minutes of ATFM delay in Marseille ACC and 2,079 minutes in Roma ACC;
- Crowdstrike outage on 19 July resulted in delays and cancellations across the network.

EUROCONTROL's systems were not affected.

- IT issues at Venice airport on 20 July generated 3,228 minutes of ATFM delay;
- IT issues at Naples airport on 25 July generated 4,644 minutes of ATFM delay;
- iFMP outage in Maastricht UAC on 30 July generated 1,719 minutes of ATFM delay

Eurocontrol network operations report June 2024

- Ongoing reduced capacities (since 01-March) in Swiss airspace above FL245 following a series of technical issues that resulted in system instability in Zurich ACC and generated 29,538 minutes of ATFM delay;
- Communication system failure in Brest ACC in June generated 22,204 minutes of ATFM delay;
- New software release in Karlsruhe UAC generated 4,615 minutes of ATFM delays from 02 to 13 June;

• Radar failure and following maintenance at Pisa airport from 06 June to 28 June generated 7,161 minutes of ATFM delay;

• OC CASA Trial in London ACC on 10 and 20 June generated 1,988 minutes of ATFM delay;

• ILS25 unavailability at Paris Orly airport from 14 to 27 June generated 1,671 minutes of ATFM delay;

• ILS calibration at Barcelona airport on 18 June generated 1,903 minutes of ATFM delay;

• ATC system upgrade in Tirana ACC on 19 June generated 3,143 minutes of ATFM delay;

• ILS calibration at Paris Le Bourget airport on 26 June generated 2,287 minutes of ATFM delay;

• Flooding in the ops room in Geneva ACC on 25 June and the capacity restriction that followed generated 29,714 minutes of en-route ATFM delay and 3,597 minutes of airport ATFM delay;

• Data exchange system outage in Brindisi ACC on 27 June generated 2,521 minutes of ATFM delay;

• Data exchange system outage in Rome ACC from 26 to 30 June generated 47,962 minutes of ATFM delay;

• FDPS failure in Maastricht UAC from 27 to 28 June generated 52,675 minutes of ATFM delay;

• Radio frequency issue in Marseille ACC on 28 June generated 1,822 minutes of ATFM delay;

Eurocontrol network operations report May 2024

• FDPS failure in Brest ACC on 17 May generated 24,849 minutes of ATFM delay;

• ASMGS system failure at Antalya airport from 01 May to 08 May generated 24,729 minutes of ATFM delay;

• Radar failure at Tel Aviv/Ben Gurion airport on 28 May generated 1,380 minutes of ATFM delay;

• Radar maintenance at Pisa airport from 08 May to 31 May generated 3,517 minutes of ATFM delay;

• FDPS issue in Madrid ACC on 17 May generated 2,207 minutes of ATFM delay

Eurocontrol network operations report April 2024

• In the evening of 15 April, a day already heavily disrupted by thunderstorms, an intervention on an ATM system at Amsterdam/Schiphol resulted in 1,558 minutes of ATFM delay and several diversions;

- A technical issue with the FDPS in Oslo-Stavanger ACC on 25 April resulted in 8,954 minutes of ATFM delay.

Eurocontrol network operations report March 2024

- OPS system instability in Geneva and Zurich ACCs generated 18,729 minutes and 16,711 minutes of ATFM delay throughout the month;
- Radar maintenance at Naples airport from 15 to 19 March generated 11,386 minutes of ATFM delay;
- Communication system failure at Eindhoven airport from 18 to 31 March generated 1,893 minutes of ATFM delay;
- Lack of parking positions at Frankfurt/Main airport on 09 March resulting from two days of Industrial Action taken by Lufthansa Ground Staff generated 1,940 minutes of ATFM delay

Eurocontrol network operations report February 2024

- ILS check at Athens airport on 07 February generated 1,435 minutes of ATFM delay;
- Radar failure at Lyon airport on 07 February generated 1,269 minutes of ATFM delay;
- Computer system failure in Reims ACC from 07 to 08 February generated 1,528 minutes of ATFM delay;
- FDPS failure in Zurich ACC on 18 February led to a short zero-rate regulation in Zurich airspace and generated 1,928 minutes of ATFM delay;
- ILS check at Gran Canaria airport on 19 and 21 February generated 4,837 minutes of ATFM delay;
- Radio system issue in Zurich ACC on 29 February generated 1,860 minutes of ATFM delay

Eurocontrol network operations report January 2024

- Single runway operations at Rome/Fiumicino airport from 23 to 24 January due to ALCMS (Airfield Lightning Control & Monitoring System) upgrade generated 4,492 minutes of ATFM delay;
- Issues with ATCO system in Langen ACC from 02 to 09 January generated 24,448 minutes of ATFM delay.

Eurocontrol network operations report December 2023

- Electrical supply issues in Paris ACC from 11 to 21 December generated 3,291 minutes of ATFM delay;
- Flight plan system issue in at London/Gatwick airport on 12 December generated 1,332 minutes of ATFM delay;
- Communication system issues in Brest ACC on 13 and 15 December generated a total of 3,190 minutes of ATFM delay;
- Communication system issue in Lisbon ACC on 19 December generated 3,239 minutes of ATFM delay;

In the figures below we observe the distribution by category (Fig.7) as well as by month (Fig.8).

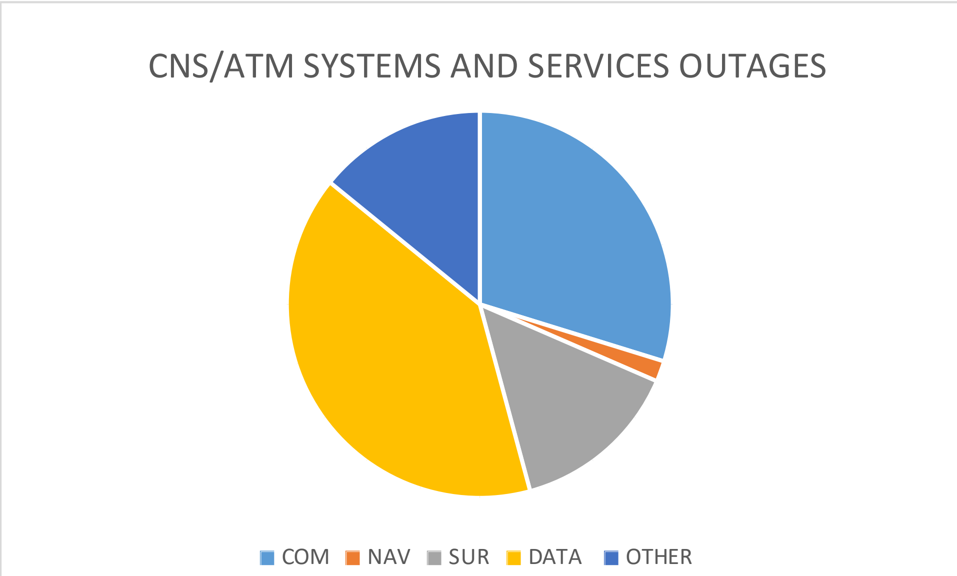

Fig.7

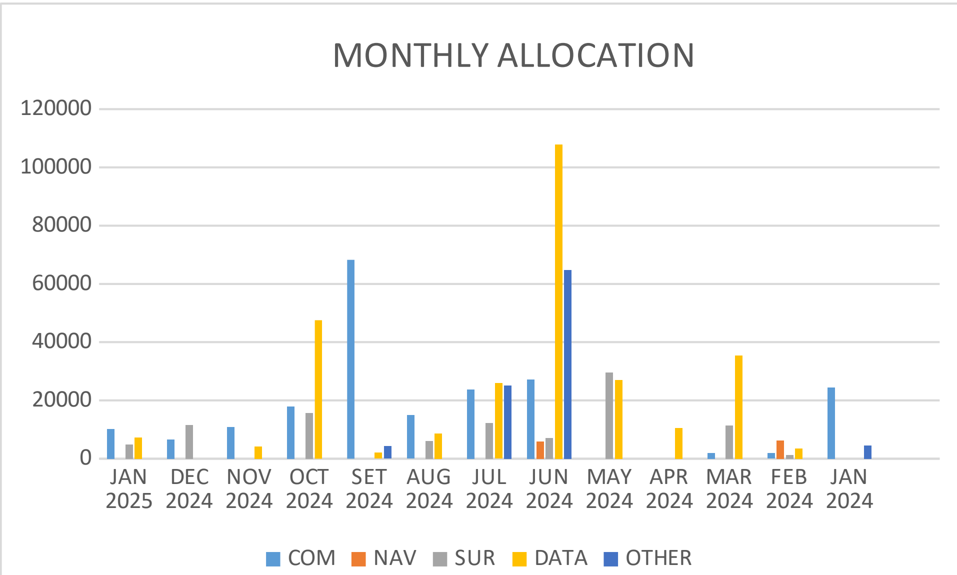

Fig. 8

REST OF THE WORLD

There is also data published in the web that show respective incidents from around the world concerning technical failures in all CNS/ ATM spectrum. The following examples are indicative. (Appendix 1)

Category	Year	Incident	Description	Impact	Source
COMMUNICATION	2004	Radio failure USA	The shutdown led to planes coming too close and caused about 800 flights to be canceled, delayed or diverted.	At least five instances of planes coming too close, cancellation and delays of 800 flights.	https://www.latimes.com/archives/la-xpm-2004-sep-17-me-faa17-story.html
COMMUNICATION	2004	Air Traffic Control Communication Loss	Lost voice communications with 800 planes in flight due to technical problems.	Many flights canceled and delays affected subsequent flights.	https://www.nytimes.com/2004/09/15/politics/air-control-failure-disrupts-traffic.html
COMMUNICATION	2013	VCS Update Failure	Technical Monitoring and Control System servers failed during an update.	90% of flights operated but faced significant delays averaging over 30 minutes.	https://www.nats.aero/wp-content/uploads/2014/08/ATC%20Disruption%207%20Dec%2013%20-%20Report.pdf
COMMUNICATION	2023	Philippine Airspace Closure	Electrical problems offline radios and radars, causing flights to be put on hold or diverted.	282 flights affected and over 56,000 passengers.	https://en.wikipedia.org/wiki/2023_Philippine_airspace_closure
NAVIGATION AND GPS	2006	Low-Visibility Landing System Outage	System down for 40 minutes affecting 13 arrivals at LAX.	Delays for flights landing in low-visibility conditions.	https://www.latimes.com/archives/la-xpm-2006-aug-17-ed-faa17-story.html
NAVIGATION AND GPS	2024	GPS Jamming	Widespread GPS jamming in Eastern Europe impacting 1,600 aircraft.	Disruption over a two-day period.	https://www.gpsworld.com/innovation-recent-gps-jamming-in-regions-of-geopolitical-conflict/
NAVIGATION AND GPS	2024	ILS Non-availability	Non-availability of ILS and bad weather causing diversions and delays at Visakhapatnam.	Frequent flight disruptions.	https://timesofindia.indiatimes.com/city/vijayawada/foggy-weather-non-availability-of-ils-cause-flight-disruptions-at-vizag-airport/articleshow/116512971.cms

Category	Year	Incident	Description	Impact	Source
NAVIGATION AND GPS	2025	GPS Reliability Issues	Major GPS problems due to geopolitical conflicts.	Unclear impact.	https://www.alphanews.live/cyprus/aerodromio-pafou-chtypithike-apo-keravno-to-vor-me-gps-oi-prosgeioseis-aeroplanon/
SURVEILLANCE	2009	Manila Airport Radar Malfunction	Fixed malfunctioning radar led to normal operations after delays.	Delays or cancellations of flights.	https://www.nbcnews.com/id/wbna32840808
SURVEILLANCE	2015	Rome Radar Failure	Malta International Airport warned of flight delays after radar failure in Rome.	Delays in departures and arrivals.	https://www.maltatoday.com.mt/lifestyle/travel/53008/europebound_flights_delayed_due_to_radar_failure_in_rome
SURVEILLANCE	2017	Sydney Airport Radar Disruption	Total radar failure led to no movements until fixed.	Major disruption and backlog of flights.	https://news.sky.com/story/flight-delays-after-total-radar-failure-at-sydney-airport-11052738
SURVEILLANCE	2019	LAX Ground Control Radar Failure	Ground control radar failure causing major delays.	Delays from 30 minutes to 2 hours on taxiways.	https://abc7.com/lax-radars-safety-collisions/5284724/
SURVEILLANCE	2019	Radar Issue at Swanwick Control Centre	Radar failure leading to fewer aircraft operations at two major airports.	High delays.	https://www.aviation24.be/air-traffic-control/very-high-delays-at-the-two-major-london-airports-due-to-radar-issues-british-airways-a350-1000-welcome-ceremony-cancelled/
SURVEILLANCE	2021	Kuwait International Airport Radar Malfunction	Technical malfunction disrupted navigation for approximately 4 hours.	Significant disruption of air navigation.	https://timeskuwait.com/news/radar-failure-at-kia-paralyzes-the-airport-for-4-hours/

Category	Year	Incident	Description	Impact	Source
SURVEILLANCE	2024	Newark Airport Radar Latency Issue	TELCO line latency caused many delays and cancellations.	456 delays and 64 cancellations.	https://theaircurrent.com/aviation-safety/faa-knew-of-potential-for-radar-issues-before-labor-day-newark-failures/
SURVEILLANCE	2024	Mumbai Airport Radar Automation Fault	Fault in radar automation system causing two-hour delays.	Repeated issues affecting flight schedules.	https://www.livemint.com/news/india/mumbai-news-chhatrapati-shivaji-maharaj-international-airport-facing-delays-2-hours-due-to-air-traffic-radar-system-11710425843307.html
SOFTWARE – CYBERSECURITY EVENTS	2015	ATC Software Malfunction	Major malfunction in ATC software affecting the FAA's Washington Center.	Hundreds of flights delayed or canceled, major impacts on East Coast travel.	https://en.wikipedia.org/wiki/2015_in_aviation
SOFTWARE – CYBERSECURITY EVENTS	2016	Software Issue at LAX	Ground stop due to software issue leading to delays.	145 flights delayed, 7 flights canceled.	https://ktla.com/news/local-news/software-issue-in-san-diego-delays-flights-into-lax/
SOFTWARE – CYBERSECURITY EVENTS	2018	ERAM Channel Failure	Software overload caused air traffic stoppage for over 5 hours.	Significant delays and cancellations impacted travel for days.	https://www.oig.dot.gov/sites/default/files/FAA%20Actions%20to%20Address%20ERAM%20Outages%20Final%20Report%5E11-07-18.pdf

Table 1: Events around the world

IV. Spacing and capacity as mentioned in ICAO

In **lesson 5.1 AIRPORT CAPACITY at the FAA CDM international workshop** [12] it is stated that:

"a TMC's role is to recognize conditions which will impact airport capacity and adjust the flow as necessary"

Conditions that could impact operational capacity include:

#6 Equipment outages Runway lighting, approach lighting, navigational aids (NAVAIDs), radar, etc."

In ICAO (International Civil Aviation Organization) documents**,** aircraft separation is defined as the minimum spacing required to maintain safe distances between aircraft, or between aircraft and obstacles, in controlled airspace, during all phases of flight, to prevent collisions.

This separation is ensured by air traffic control (ATC) and is based on specific criteria outlined in ICAO's **Procedures for Air Navigation Services – Air Traffic Management (PANS-ATM, Doc 4444)** and other related ICAO standards and guidance documents.

Types of Separation:

1. **Vertical Separation**: Ensures aircraft are separated by a specific altitude interval (e.g., 1,000 feet for aircraft at or below FL410, and 2,000 feet above FL410, as per Reduced Vertical Separation Minimums or RVSM).
2. **Horizontal Separation**: Maintains safe distances laterally or longitudinally between aircraft. This can include:
    1. **Lateral Separation**: Ensuring aircraft operate in different geographic locations.
    2. **Longitudinal Separation**: Maintaining a safe time or distance interval along the same route or converging paths.
3. **Radar Separation**: Based on minimum distances between aircraft as detected by radar (e.g., 3–10 nautical miles, depending on the airspace and radar system used).
4. **Wake Turbulence Separation**: Ensures safe distances between aircraft to avoid the impact of wake turbulence generated by larger or heavier aircraft.

These separation standards are critical for ensuring the safety, efficiency, and orderly flow of air traffic globally.

Separation minima are always dependent to the availability of CNS equipment – systems.

Furthermore, their loss or degradation of CNS will lead to the increase of separation, as also stated in **ICAO Doc. 4444**, for example:

5.4.1.1.3 When information is received indicating navigation equipment failure or deterioration below the navigation performance requirements, ATC shall then, as required, apply alternative separation methods or minima.

The importance of CNS systems in aircraft spacing is evident throughout ICAO Doc. 4444 for example in 5.4.2.2.1.1 Aircraft flying on the same track: the spacing is:

a) 15 minutes; or

b) 10 minutes, if navigation aids permit frequent determination of position and speed

also in 5.4.2.2.2.1 Aircraft on the same track. When an aircraft will pass through the level of another aircraft on the same track, the following minimum longitudinal separation shall be provided:

a) 15 minutes while vertical separation does not exist; or

b) 10 minutes while vertical separation does not exist, provided that such separation is authorized only where ground-based navigation aids or GNSS permit frequent determination of position and speed

5.11.1.2 In accordance with regional air navigation agreements when:

a) special electronic, area navigation or other aids enable the aircraft to closely adhere to their current flight plans;

According to FAA regulations/procedures:

*'When radar is employed in the separation of aircraft at the same altitude, a minimum of **3 miles'** separation is provided between aircraft operating within 40 miles of the radar antenna site, and 5 miles between aircraft operating beyond 40 miles from the antenna site."*

[13]

Thus any increase of separation leads in its turn in a reduction of capacity. This can be estimated as follows:

For example, if an airport could land 12 airplanes every hour with an aircraft time spacing of 5 min with all CNS equipment available, in case of a loss of SSR radar, that spacing could increase up to 10 min thus creating a delay. In that case and for that time the capacity of the airport falls to half of the initial capacity.

The need to define, in the ANSP Contingency plan of every airport, a predetermined capacity, in every case of a CNS/ATM failure or degradation, is apparent, so as to prevent the accumulation of major delays.

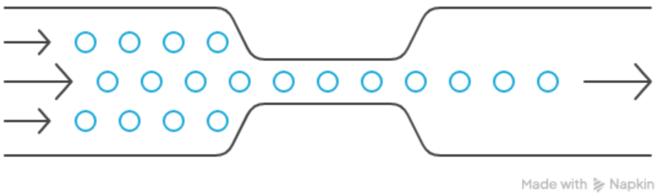

Fig.9 the bottleneck effect

V. Measuring capacity and delay based on time

Measuring capacity based on time in the context of air traffic control, telecommunications, or navigation surveillance, involves assessing how many operations (e.g., flights, communications, data transfers, etc.) can be processed or completed within a specific time frame.

This type of measurement is important for evaluating the efficiency of systems and understanding how various issues or improvements can impact operational performance.

To measure capacity based on time, one could typically focus on the **throughput** (operations per unit of time) and the **processing ability** during a given period.

In air traffic management according to ICAO capacity refers to the maximum number of aircraft that can be managed safely within a defined airspace sector during a specific period such as one hour [14]

$$Capacity = \frac{Number\ of\ aircrafts}{time},$$

"Capacity generally refers to the ability of an airport to handle a given volume of traffic (demand)—i.e., it is a limit that cannot be exceeded without incurring an operational penalty."

As stated in a study from Princeton University:

"Some amount of delay will be experienced long before capacity is reached, and it grows exponentially as demand increases"

"the probability of simultaneous need for service increases rapidly with traffic density, so that the average delay per aircraft increases exponentially as demand approaches throughput capacity. When demand exceeds capacity, there is an accumulation of aircraft awaiting service that is directly proportional to the excess of demand over capacity" [15]

If an airport can manage up to 80 landings per hour in normal conditions, this is the capacity for that airport's runway system based on full availability of CNS&ATM systems and services.

Consider a radar system can typically track 300 aircraft per hour (capacity = 300 aircraft/hour). However, during a radar technical failure, the system could not operate the entire hour. If it could then track 150 aircrafts, then this would result in 50% of the normal capacity being achieved.

Calculation of the impact:

- Normal Capacity: 300 aircraft/hour.
- Capacity during failure: 150 aircraft/hour.
- Reduction in Capacity: 50%

If a crucial system failure lasts for 1 hour, the delay for aircraft would be proportional to the reduced capacity. The system would have processed 150 fewer aircraft during that hour, potentially leading to longer wait times for aircraft to land or take off.

"For example, if the throughput capacity of an airfield is 60 operations per hour and the demand rate is running at 70 operations per hour, each hour will add 10 aircraft to the queue awaiting service and 10 minutes to the delay for any subsequent aircraft seeking service. Even if demand later drops to 40 operations per hour, delays will persist for some time since the queues can be depleted at a rate of only 20 aircraft per hour"

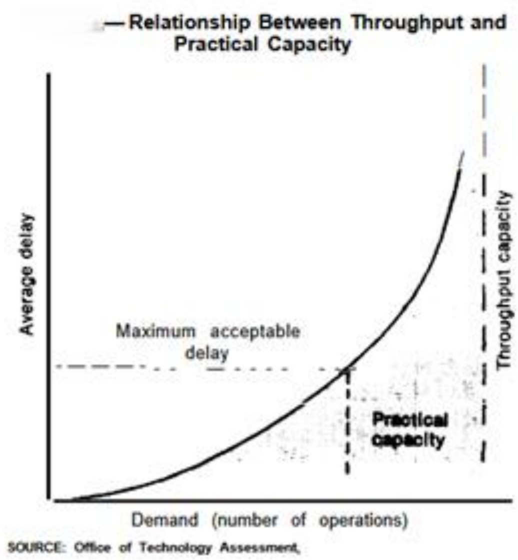

Fig.10 throughput and practical capacity [12]

Capacity and delay time are inherently correlated in systems such as air traffic control, telecommunications, or any system involving operations with limited resources. The relationship between these two factors can be explained as follows:

• Capacity refers to the ability of a system to handle a certain volume of operations or activities (e.g., aircraft, data transmissions, etc.) per unit of time.

• Delay time refers to the additional time required to complete an operation due to factors such as system overload, malfunction, or inefficiency.

Correlation: The greater the delay from a system failure, the more the capacity is reduced.
[16]

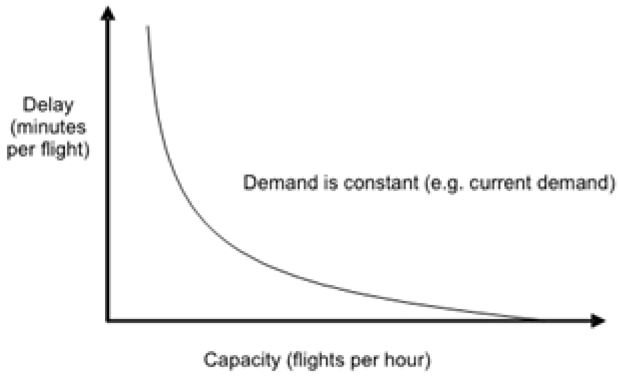

Fig.11 the Capacity versus Delay curve

For instance:

- Normal operation: 50 aircraft per hour.
- After failure: 25 aircraft per hour.
- Delay increase: From negligible to possibly 30 minutes or more, depending on the severity.

We can model the correlation between ATM capacity reduction due to CNS or ATM system and/or service failure and the increase in delays using a simple mathematical approach.

Capacity - Delay Relationship:

The equation relating average delay to airport capacity is presented in the ICAO document titled "PRELIMINARY DELAY ASSESSMENT BASED ON SIMPLE MATHEMATICAL MODEL" (ATFM/SG/5−IP/02), dated 30 March 2015. [17]

$$AvgDelay(min) = 30 * h * \left(\frac{D}{C} - 1\right)$$

where h is the duration of capacity constraint,

D is the demand and

C is capacity.

The maximum delay for the same group of flights is found to be: Max Delay(min)= 2*Avg Delay

Capacity – Availability - Delay Relationship:

An equation incorporating system availability into airport capacity and delay models is not currently published as a standalone formula in publicly available official documents.

Incorporating CNS/ATM Systems' and Services' Availability into the Delay-Capacity Equation, since it can reduce effective capacity when not 100% operational, the capacity can be adjusted as follows:

Ceff=C*A

where

Ceff is the Effective capacity (flights/hour)

A is the Availability of critical systems (as a fraction, e.g., 0.9 for 90% availability)

So the Avg Delay becomes

$$AvgDelay(min) = 30 * h * \left(\frac{D}{C * A} - 1 \right)$$

This simple model illustrates how small reductions in capacity can lead to significant increases in delay over time.

This equation directly accounts for the reduction in operational capacity due to system unavailability. As system availability decreases, effective capacity drops, and delays increase accordingly.

This is an example:

System availability A	Effective capacity Ceff	Average delay (min)
1,0	C	As per base model
0,9	0,9C	increases
0,8	0,8C	Increases further

Table 2: Summary table example

There are several research papers that study the accumulation of delays based on more complex mathematics like Queuing theory, that take into account different factors. The present study is a light approach in order to draw basic conclusions on the impact of CNS/ATM systems and services outages and aims to provide the lead for further studies.

This linear relationship is a simplification. While it provides a useful first-order estimate, it does not capture the nonlinear, often exponential, rise in delays observed as utilization approaches full capacity. More detailed models (such as queuing models or simulation approaches) are used for precise operational analysis, especially near or above capacity limits.

There are a lot of other factors that contribute into that calculation as is the Human Factor, such as the ATCOs performance and the ATSEPs performance stemming from the training, education and immediate response as defined in https://www.icao.int/SAM/Documents/2016-CBT/10057_draft_en.pdf [18]

ATSEP personnel's presence 24/7 fortify and guarantee the immediate response.

Key Factors That Influence ATM Capacity:

1. **Technology or Equipment Availability:** Systems such as radar, communication, navigation and the associated services

2. **Operational Efficiency-Human factor:** The efficiency, readiness and the training of the ATSEP personnel in order to ensure CNS/ATM service Continuity and Availability, plays a critical role in determining the overall airspace/airport capacity, while safety is not compromised**. ICAO Doc. 9868 ensures the training of the ATSEP [19]**

3. **External Conditions:** Factors such as weather conditions, airspace congestion, or other disruptions can reduce operational efficiency.

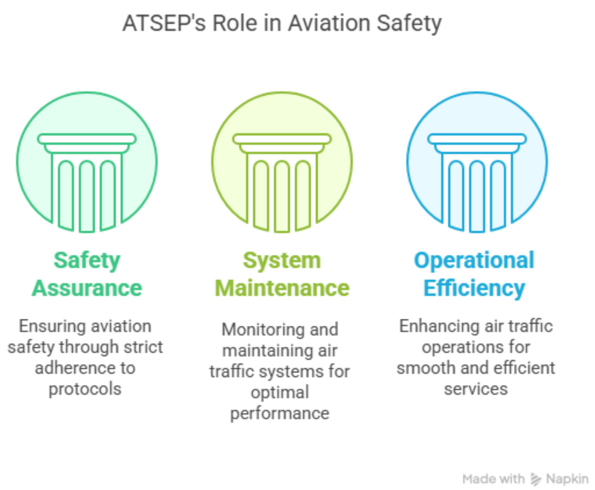

Fig.12 ATSEP's role in Aviation Safety

Measures to minimize delays

Eurocontrol, through its Network Manager, employs a comprehensive set of procedures to manage air traffic flow and capacity, particularly during periods of reduced capacity due to adverse weather or other disruptions. These measures aim to optimize the use of available airspace and minimize delays. [20]

Key Eurocontrol Procedures for Managing Delays

1. **Air Traffic Flow and Capacity Management (ATFCM) Measures**
   When traffic demand exceeds available capacity, Eurocontrol's Network Manager may implement ATFCM measures. These measures include issuing departure slots

and holding some flights on the ground to regulate the flow of traffic into constrained sectors or airports, ensuring safety and minimizing congestion.

2. **Enhanced ATFCM Procedures for Short-Duration Weather Events**
   In March 2022, Eurocontrol introduced a new ATFCM procedure targeting delays caused by short-duration adverse weather at destination airports. This procedure, developed in collaboration with operational stakeholders, aims to reduce delays and related compensation costs by optimizing the management of long-sector flights affected by transient weather conditions.

3. **Delay Threshold Mechanism**
   Eurocontrol's Delay Threshold Mechanism, introduced in 2015, provides aircraft operators with advance delay information, allowing them to adjust their operations proactively. This mechanism helps prevent unnecessary delays and ensures that flights are not unduly affected by minor disruptions.

4. **Collaboration with Stakeholders**
   Eurocontrol works closely with various stakeholders, including Air Navigation Service Providers (ANSPs), airlines, and airports, to coordinate responses to disruptions. This collaborative approach ensures a unified and efficient response to capacity constraints, minimizing the impact on operations.

5. **Real-Time Monitoring and Communication**
   The Network Operations Portal (NOP) provides real-time information on air traffic operations, allowing stakeholders to monitor the current and expected European air traffic situation. This transparency facilitates informed decision-making and timely responses to emerging issues.

Being able to predict delays that could be caused by CNS/ATM systems and services outages and using the above procedures could help to the minimization of these delays.

VI. RECOMMENDATIONS

It is clear that some of these incidents mentioned above led to brief disruptions, while others caused widespread and prolonged delays causing major disruptions with costs in the area of millions of Euros and huge passenger discomfort. Many of these problems also cause ripple/cascade effects that affect not only direct flights but also connections, with delays compounding across the network.

Especially now that new conditions are changing and evolving aviation, as AI and the CNS Evolution plan.

In the EUROCONTROL **CNS Evolution Plan 2024** [21]**,** where it is mentioned that "*synchronization, coordination and interoperability between ANSPs are needed to build a resilient airspace, there are areas of systematic gaps identified and improvements proposed:*

-CNS interoperability requirements and compliance demonstration have not been fully addressed. The lack of a harmonized compliance framework resulted in additional delays, duplication of efforts, and costs for airspace users and ANSPs (1,1,3 e)

- The current CNS infrastructure provides a robust and resilient service. However, occasionally CNS outages can cause a significant degradation of ATM services (1,1,4,b)

- The shift to Trajectory-Based Operations (TBO) and the wider use of PBN will allow for more flexible and efficient routing, reducing delays, optimizing flight paths, and increasing airspace capacity. However, these approaches depend heavily on CNS technologies for precise aircraft positioning, communications, and surveillance, which will require updates and enhancements to existing systems (3,2).”

Additionally, now that Artificial Intelligence is introduced in aviation, integrated with electronic systems, will play a critical role in ensuring air traffic operations, it becomes clear that the systems must be monitored and maintained effectively and degradations addressed promptly. Prolonging Continuity and Availability and minimizing downtime must be the main objective in terms of Performance and of course Safety.

The variety and complexity of the systems make particularly difficult and time-consuming the distant support due to the safety-critical nature of the aviation environment, while the expertise of Air Traffic Safety Electronic Personnel (ATSEP), who are trained to supervise, calibrate and maintain all these systems in real time and on the spot, ensures the reliable operation of the systems, supporting interoperability and allowing for immediate response, guaranteeing compliance with strict safety standards.

In that scope the following ways and means are recommended:

- More data should be collected and studied in order to understand and measure the exact expected capacity in case of each CNS/ATM equipment failure or in case of a combination of them, depending on the rate of their occurrence and on their causes.

- a KPI Key Performance Indicator should be established so as to measure the contribution of CNS/ATM systems and services outages for the performance scheme.

- an IATA code could be considered to be added for the case of a delay due to CNS/ATM equipment.

- A predefined expected capacity, in every case of a CNS/ATM degradation due to failure or maintenance, should be stated in the respective ANSP Contingency plans, so as to prevent the accumulation of major delays, as a tool, e.g. in across reference table or a protocol. **Predicting the expected delays and proceeding to measures according to Eurocontrol’s network management, can lead to their minimization.**

- It is clear that the ATSEP performance in fulfilling the above objectives directly impact the Total Aviation System performance in order to ensure CNS/ATM service Continuity, Availability and Safety, the ATSEP personnel’s training and availability should be unwavered. The ATSEP professionals’ duty is a major contributor towards minimizing the delays, as their tasks and objectives aim at extending the Continuity and Availability of CNS equipment and Services and minimizing recovery time.

  The **IFATSEA ATSEP SAFETY STUDY** in 2024 is a response to the requirement set by the ICAO Assembly (2016) to investigate the potential positive safety impact from the Inclusion of ATSEP in Annex 10 and their subsequent licensing as well addressing the operational, business and Environmental gains associated.

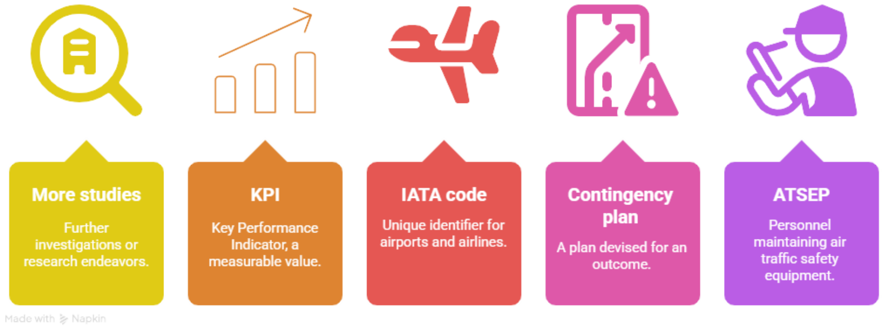

Fig.13 Recommendations

VII. CONCLUSIONS

From the amount of data available, it is clear that CNS/ATM systems and services' outages lead to an increase of aircraft spacing and consequently to an increase of delays and finally to a decrease of airport capacity.

Delays and reduced ATM capacity have serious economic and environmental effects, without overlooking the passenger's discomfort, so it is clear that they have to be minimized and kept close to zero while also minimizing recovery time.

The scope of this study is to acknowledge these effects and, based on prediction, to strategically plan and proactively prepare, with certain measures taken, in order to eliminate delays and their accumulation, maintaining capacity in satisfactory levels.

ATM capacity and flight delays depend on the availability of the CNS/ATM equipment and services and also on the efficiency, readiness and the training and performance of the ATSEP. Since safety is crucial it is obvious from the above facts that the role of the ATSEP is the irreplaceable guarantee, and shall be performed at top performance 24/7, not only for equipment failures and maintenance but also for addressing Cybersecurity related disruptions even if they do not reach the ATCO or the pilot.

In an aviation ecosystem which heavily relies on the technical enablers no gap should be left unmonitored. The fact that capacity falls in case of CNS/ATM degradation must stimulate us to take extra measures and to develop a cross reference table or a protocol in order to be fully in control of the potential faults within the system and help avoid a potential chaotic situation. In case of a default the ATC will benefit from the above, since it will be a useful tool to help them handle the situation with less pressure and anxiety, while ATSEP are already dealing with it.

ACKNOWLEDGMENT

We would like to express our deepest gratitude for the invaluable help and support of Mr. Theodore Kiritsis, former President of the International Federation of Air Traffic Safety Electronic Associations (IFATSEA). His insights, guidance, and expertise have made a significant difference in this study.

We would also like to thank John Rafail Fotiadis and Stella Markia Fotiadi who generously assisted in the writing of this paper and for their support and precious insight.

Appendix 1

List of major failures since 2004

COMMUNICATION

- 2004 Radio failure USA

The shutdown, which lasted more than three hours, led to at least five instances in which planes came too close to one another and caused about 800 flights in and out of Southern California's airports to be canceled, delayed or diverted.
The backup's failure left controllers with no way to communicate with other FAA centers or the high-altitude flights displayed on their radar screens, forcing them to hand flights off to other FAA facilities in the West.
Voice Switching and Control System, is a high-tech touch-screen tool that allows air traffic controllers to quickly communicate with planes in transit

https://www.latimes.com/archives/la-xpm-2004-sep-17-me-faa17-story.html

- 2004

The air traffic control center lost voice communications with 800 planes in flight because of a technical problem …the secondary system also failed..many flights had been cancelled and other planes were so late that their next flights would also be disrupted

https://www.nytimes.com/2004/09/15/politics/air-control-failure-disrupts-traffic.html

- 2013

On the night of 6/7 December 2013, NATS' engineers were carrying out an update of the Voice Communication System (VCS) at Swanwick Area Control (AC) as part of a series of overnight activities on some 20 systems at the Centre.
8. During the VCS update process, the Technical Monitoring and Control System (TMCS) servers (main, standby and back-up) failed.
90% of flights were able to operate albeit with some significant delays averaging more than 30 minutes per flight.
https://www.nats.aero/wp-content/uploads/2014/08/ATC%20Disruption%207%20Dec%2013%20-%20Report.pdf

- 2023

electrical problems brought the center's radios and radars offline. Shortly after, nearly all flights towards major airports in the Philippine airspace were put on hold or diverted. Around 282 flights to and from various Philippine airports and over 56,000 passengers, many of whom were travelling to or from the country following the New Year's Day holiday, were affected

https://en.wikipedia.org/wiki/2023_Philippine_airspace_closure

NAVIGATION AND GPS

- 2006

a radio system that helps pilots land in low-visibility conditions went down for 40 minutes, delaying 13 arrivals at LAX. It was the same system that went down Aug. 7 for 3 1/2 hours, delaying 46 flights

https://www.latimes.com/archives/la-xpm-2006-aug-17-ed-faa17-story.html

- 2024

on March 23 to 24, 2024, widespread GPS jamming occurred in Eastern Europe that impacted more than 1,600 aircraft over a period of two days and was widely reported by mass media.

https://www.gpsworld.com/innovation-recent-gps-jamming-in-regions-of-geopolitical-conflict/

- 2024

Non-availability of the Instrument Landing System (ILS), along with bad weather, frequently causes diversions or delays of flights at Visakhapatnam international airport

https://timesofindia.indiatimes.com/city/vijayawada/foggy-weather-non-availability-of-ils-cause-flight-disruptions-at-vizag-airport/articleshow/116512971.cms

- 2025

Major problem since GPS is questionable due to geopolitical conflicts

https://www.alphanews.live/cyprus/aerodromio-pafou-chtypithike-apo-keravno-to-vor-me-gps-oi-prosgeioseis-aeroplanon/

SURVEILLANCE Radar and Surface Movement Radar Issues

A typical procedural approach might allow less aircraft to land than when using instrumental procedures.

Discussion is being made about the age of outdated CNS systems https://www.npr.org/2025/02/06/nx-s1-5286407/air-traffic-control-expert-discusses-the-outdated-technology-behind-u-s-systems

In 2000 FAA experienced 12000 outages a month.

https://isr.umd.edu/NEXTOR/Conferences/200011_NEXTOR_Symposium/Rakas.pdf

- 2009

Manila's airport fixed a malfunctioning radar and brought its operations back to normal Monday after delays or cancellation of more than a dozen domestic and international flights, officials said

https://www.nbcnews.com/id/wbna32840808

- 2015

Malta International Airport warns passengers of flight delays in departures and arrivals following total radar failure in Rome

https://www.maltatoday.com.mt/lifestyle/travel/53008/europebound_flights_delayed_due_to_radar_failure_in_rome

- 2017

Major disruption of Radar in Australias busiest airport

In a recording, one air traffic controller could be heard informing a pilot there had been a "total radar failure" and there would be "no movements" until the system was "reliable" once again, after it went down early on Monday morning (late on Sunday UK time). The fault at Australia's busiest airport was fixed after a few hours but caused "major disruption" in the morning and a backlog of flights left travellers facing delays into the evening.

https://news.sky.com/story/flight-delays-after-total-radar-failure-at-sydney-airport-11052738

- 2019 LAX Ground Control System Failure:

In January 2019, a failure in the ground control radar at Los Angeles International Airport caused major delays for planes on the taxiways, as ground controllers could not track aircraft accurately, leading to congestion and delays on the ground.

Impact: Ground radar failure delayed aircraft on the taxiways.

Delay Time: **30 minutes to 2 hours**.

Details: Loss of radar tracking on the ground caused delays in departures and arrivals as air traffic controllers lost the automation support and had to manually manage surface movements.

Source: Reports from FlightGlobal and The Verge covered the ground control radar failure at LAX, leading to significant delays.

Old, failing ground radars increase risk of collisions at LAX..
..one or both of these radars "was out of service" for 1,627 hours

https://abc7.com/lax-radars-safety-collisions/5284724/

- 2019

the reason for the delays is a radar failure at Swanwick Control Centre. This means fewer aircraft than normal can use the two airports

https://www.aviation24.be/air-traffic-control/very-high-delays-at-the-two-major-london-airports-due-to-radar-issues-british-airways-a350-1000-welcome-ceremony-cancelled/

- 2021

A technical malfunction in the radar of Kuwait International Airport (KIA) disrupted the air navigation for about 4 hours

https://timeskuwait.com/news/radar-failure-at-kia-paralyzes-the-airport-for-4-hours/

- 2024

Newark controllers are no longer located on Long Island …the TELCO line… suffered a latency issue…could cause safety issues

According to Flight Aware, this resulted in at least 456 delays and 64 cancellations of both inbound and outbound flights.

https://theaircurrent.com/aviation-safety/faa-knew-of-potential-for-radar-issues-before-labor-day-newark-failures/

https://theaircurrent.com/feed/dispatches/newark-outages-workplace-trauma/

https://x.com/metropolitanatc/status/1854547214963503172?s=46

https://nypost.com/2024/09/03/lifestyle/passengers-stranded-after-newark-airport-radar-issue-results-in-over-450-flight-delays-60-cancellations-unbelievable/

- 2024

Mumbai: Chhatrapati Shivaji Maharaj International Airport is facing delays of up to 2 hours because of a fault in the air traffic radar automation system

The airport had faced issues more than 70 times in June 2022.

https://www.livemint.com/news/india/mumbai-news-chhatrapati-shivaji-maharaj-international-airport-facing-delays-2-hours-due-to-air-traffic-radar-system-11710425843307.html

SOFTWARE – CYBERSECURITY EVENTS

- 2015

A major air traffic control system software malfunction causes the U.S. Federal Aviation Administration's Washington Air Route Traffic Control Center in Leesburg, Virginia – which controls airspace above an altitude of 20,000 feet (6,100 meters) over a 165,000 sq m(430,000 km2) area centered on Washington, D.C. – to stop functioning for several hours, causing airlines to delay or cancel hundreds of flights and disrupting air travel throughout the United States and especially along the United States East Coast. New York City-area airports experience delays, and at Washington Dulles International Airport in Fairfax County, Virginia, 154 flights are delayed and five percent are cancelled by early evening. The disruption hits Ronald Reagan Washington National Airport in Arlington, Virginia, and Baltimore-Washington International Thurgood Marshall Airport in Baltimore, Maryland, particularly hard; dozens of their flights – about 25 percent – are canceled. Some stranded passengers do not reach their destinations until the next day.[337] Overall, the outage delays 492 flights and prompts the cancellation of 476, cutting traffic at Baltimore-Washington to 70 percent, at Reagan National to 72 percent, and at Washington Dulles to 88 percent of normal, and Washington Dulles continues to experience two-hour delays the following day.

https://en.wikipedia.org/wiki/2015_in_aviation

- 2016

A total of 145 flights were delayed and seven were canceled after a short ground stop was issued at Los Angeles International Airport Thursday morning.

The ground stop stemmed from a software issue

https://ktla.com/news/local-news/software-issue-in-san-diego-delays-flights-into-lax/

- 2018

software tool at controller workstations overloaded the system's memory and caused both of the system's primary and secondary channels2 to fail, leading the Center to declare ATC Zero3 and suspend all air traffic in the facility's airspace. The incident lasted over 5 hours and caused flight delays and cancellations that impacted thousands of flights over several days.

A flight plan for a military aircraft (a surveillance training mission) flying above 60,000 feet caused a sequence of events that resulted in flight data memory overload and the failure of both ERAM channels. According to FAA the event lasted for about 2 hours, but the impact on the traveling public throughout the NAS lasted for over 24 hours.

https://www.oig.dot.gov/sites/default/files/FAA%20Actions%20to%20Address%20ERAM%20Outages%20Final%20Report%5E11-07-18.pdf

A mass IT outage has caused travel chaos all around the world, with many flights grounded, huge queues and delays at airports. Several airports and airlines have reported issues with their IT systems.

Berlin airport posted on X, formerly known as Twitter, that it is experiencing delays to check-ins due to a "technical fault", and in Spain, an "incident" has been reported at all of the country's airports.

Cyber-security firm Crowdstrike says the problem was caused by a "defect" in one of its software updates.

https://www.bbc.com/news/videos/cz7ejpld988o

- 2023

Thousands of flights across the U.S. were canceled or delayed Wednesday after a system that offers safety information to pilots failed, and the government launched an investigation into the breakdown, which grounded some planes for hours…The breakdown showed how much American air travel depends on an antiquated computer system that generates alerts called NOTAMs...the cascading chaos led to more than 1,300 flight cancellations and 9,000 delays by late afternoon, according to flight-tracking website FlightAware

https://www.latimes.com/world-nation/story/2023-01-11/flight-delays-us-after-faa-computer-outage

- 2024

More than 40 flights were delayed at various airports across Japan.. 40% of JA flights were delayed

https://www.nytimes.com/2024/12/25/business/japan-airlines-cyber-attack.html

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[3] EUROCONTROL European action plan for Air Ground Communications Safety

AGC (Air- Ground Communications) Briefing Note 3 - loss of communication

https://www.eurocontrol.int/sites/default/files/2019-05/agc-action-plan.pdf

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