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INTERNATIONAL CIVIL AVIATION ORGANIZATION

A UN SPECIALIZED AGENCY

Definition of Contingency Measures and Response Strategies

Module 3

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Module Objectives

To provide participants with the necessary knowledge to identify, propose, and document operational measures and treatment strategies for contingency situations in air navigation services, thereby strengthening the ATM system's response capacity and resilience to disruptive events.

Module Content

01 Improving the resilience of ANS systems

02 ATFM measures and contingency handling strategies

03 Documentation of responses actions and protocols.

04 Structure and benefits of the contingency matrix.

Contingency Planning

Service Registry	Scenario Identification	Review of current procedures	**Definition of contingency measures**
• Register the units and services of an ANSP • Register the resources used to provide services	• Identify contingency scenarios • Select realistic scenarios	• Do they exist? • Are they effective?	• **Improve system resilience** • **Define operational measures** • **Document actions for contingency management**

Knowing what to do in the event of a contingency (operational actions) is very important.

Knowing how to avoid or minimize the contingency (resilience improvements) is equally important.

Management Commitment

Practical experience shows that there is a contradiction between proposing additional measures to existing ones that enhance operational safety and the cost to ANSPs of implementing new measures that impact organizational costs.

This contradiction must always be analyzed by the management of each ANSP, and a balance must be sought that ensures the safety of air operations at reasonably adequate costs.

Main Technological Issues that can Cause a Significant Reduction in Safety

- Aspects related to the infrastructure of the ATS unit and services provided by third parties.

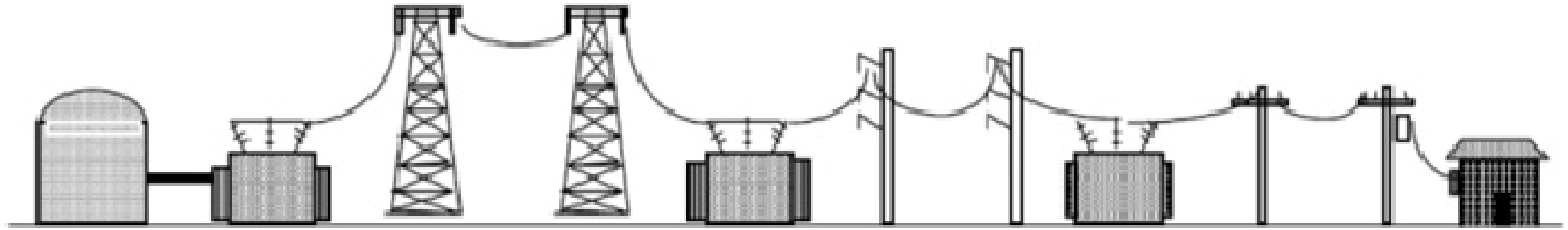
- Aspects related to the provision of the ANSP's CNS services

Power System Failures

Power system failures mean that, even with the most expensive and reliable equipment in the world, ATS services can be affected if the most detailed measures to ensure power supply are not taken.

Without power, there is no ATS service.

Consider whether your supplier can bring power to you from **two independent substations**, or at least two independent paths, including the input transformer.



Plan for two generator sets with automatic changeover and fuel tanks ready for extended events

Is there industrial energy supply?

Si

No

Critical Load Equipment

Generator provides energy when there is not industrial power.

UPS supply backup power for a few minutes while the generator starts up

Plan redundant UPS with sufficient backup capacity, both in terms of power and backup time, to prevent failures in the generator set´s automatic system

Is there industrial energy supply?

Si

No

Critical Load Equipment

Generator provides energy when there is not industrial power.

UPS supply backup power for a few minutes while the generator starts up

Don't rely on a single point of failure, whether it's a cable or a disconnect in the electrical support of the critical load.

Plan your critical active equipment with dual power supplies.

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And yet, just in case something goes wrong, keep your communications equipment on direct battery backup (DC backup).

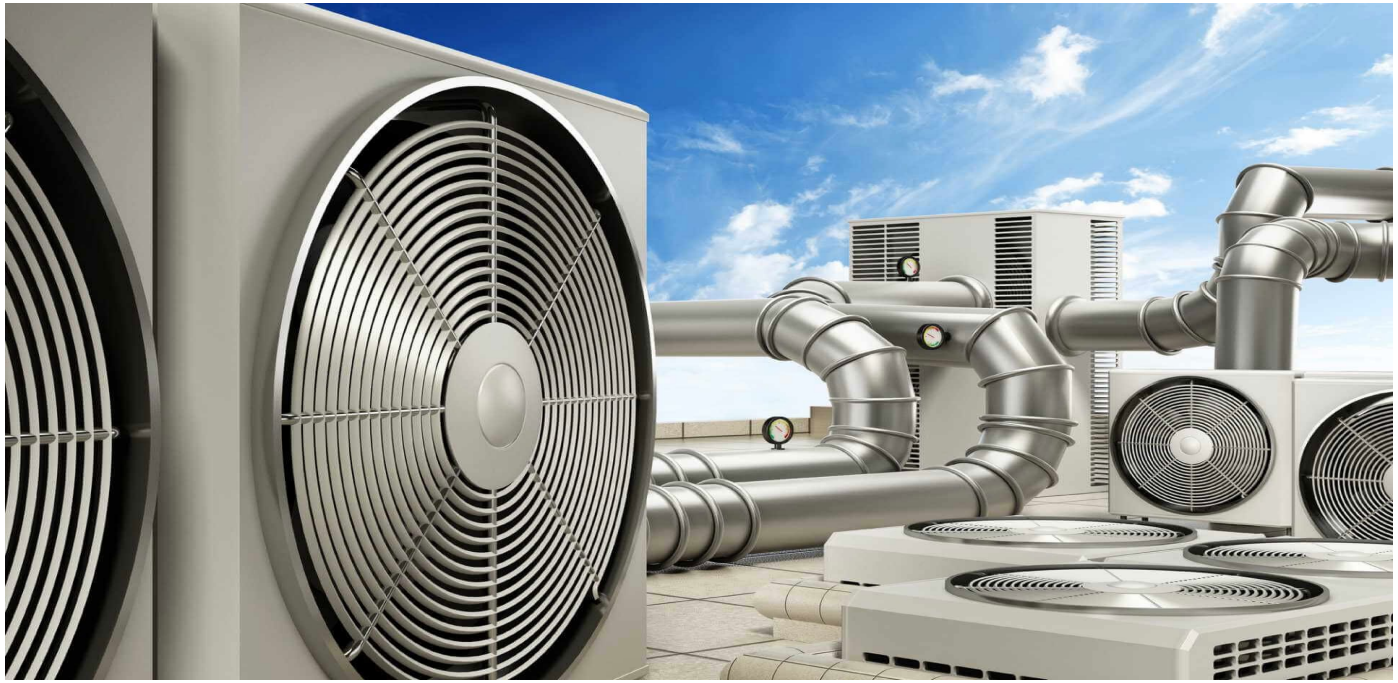
Air Conditioning System Failures

Experience shows that there is a tendency to minimize the criticality of air conditioning or ventilation equipment in ATS control rooms.

Control rooms are closed, windowless, and have relatively low ceilings. They house a large number of people requiring ventilation and technological equipment that dissipates a high heat load, located adjacent to the control room.

All systems require fresh air exchange with the outside.

- No HVAC system in HVAC units should be simple.
- In technology facilities, HVAC systems must have independent backup power from the central system.
- HVAC systems must be sufficiently connected to backup power systems.



Failures in the Infrastructure of Communications Systems

This point refers to failures in the communications infrastructure that an external company is providing to the ANSP.

There's no point in having the best and most expensive equipment in the world if we're left without communication with the outside world.

To achieve this, several measures can be taken from the planning stage:

Failures in the Infrastructure of Communications Systems

- Consider whether you can contract communications services with more than one local communications provider or whether they can provide services using different technologies.
- Bring communications services to the ATS unit via underground cables, fiber optic cables, or copper cables, or even better, both.
- Bring communications services to the ATS unit via more than one underground communications system.
- Bring communications services via radio link or fiber optic, that is, via more than one communications medium.
- Bring communications via analog and digital links.
- Consider installing communications masts with antennas, if space is available near the ATS unit or on the roof. This will allow you to have equipment for VHF radio communications or ADS-B receivers, which will provide an added advantage for the vitality of your unit. Or locate these resources in a nearby facility with direct line of sight and manage these communications with your own radio link.

Failures in the Infrastructure of Communications Systems

Finally, having a commercial, standard telephone service, whether landline, cellular, or satellite, and a public Internet service can be an inexpensive solution that can solve a serious problem in the face of total communications failures in your ATS unit.

This is a measure that can help you mitigate the effects of a serious contingency.

Aspects Related to the Provision of ANSP CNS Services

- Redundancy in CNS equipment is vital for the proper provision of ATS services.
- Redundant equipment significantly reduces the likelihood of disruption to the services it provides. However, providing ATS services is not just about having redundant equipment. As we are talking about critical services, redundant services must also be provided, in order to minimize the likelihood of contingencies due to equipment failures.

Aspects Related to the Provision of ANSP CNS Services

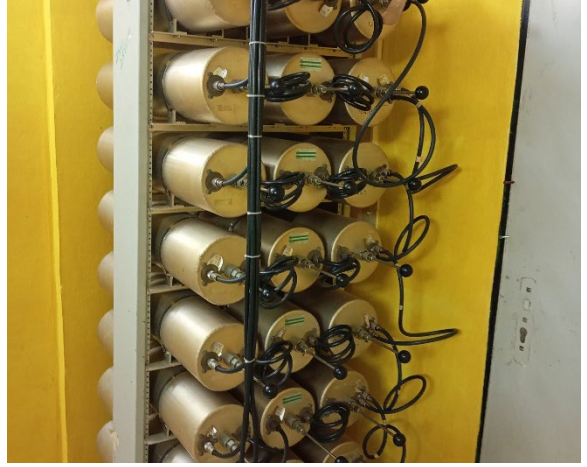
- Multiple sites from which CNS services are provided. This prevents a failure at one site from causing a total failure, as the service can be provided from another site, either fully or in a degraded manner, depending on the service in question.

- Multiple power sources for each facility.

- Multiple communication channels, especially for Communications and Surveillance services, which must be available to controllers.

- Based on these concepts, and of course, on economic valuation criteria, CNS systems are designed, always assuming that there must be redundant and simple fail-safe CNS services to improve the resilience of the ATS service.

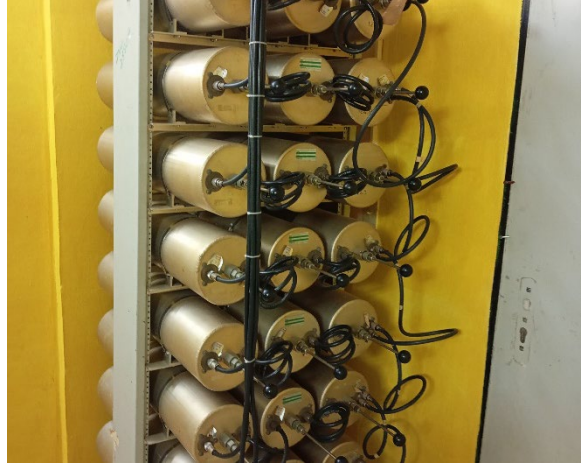





Aspects to maintain the vitality of ground-air communications for ATC

- Radio stations for a sector area or TMA must be located in more than one facility and must have adequate coverage, allowing service to be maintained even if there is a communications failure at one of the facilities.
- Backup or secondary frequencies must be provided for a sector area or TMA to be used when the primary operating frequency is unavailable.
- The selection of the location for the installation of VHF radio equipment must take into account the site's power facilities, including AC and DC backup power and the facilities available from the local communications provider.






Aspects to maintain the vitality of ground-air communications for ATC

- The radio equipment must be able to work with both analog communications technologies and radios that support the new VoIP communication standards (ED-137). This makes it possible to contract with the local communications provider more than one independent communications system (analog and digital).

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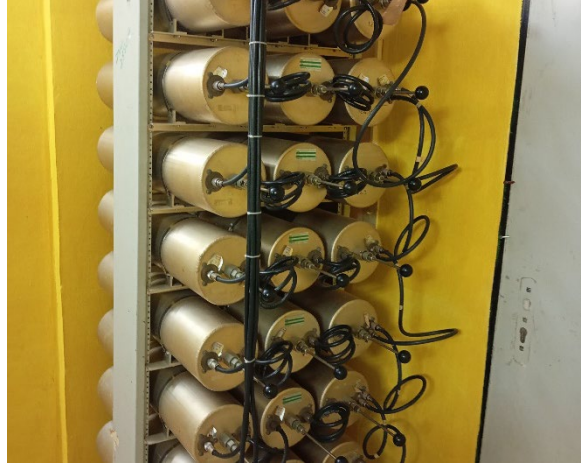


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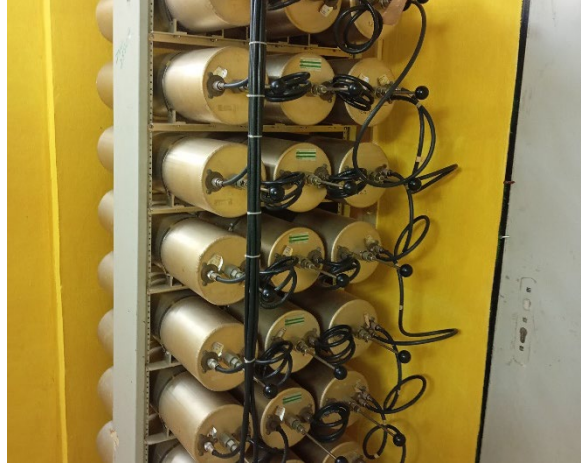


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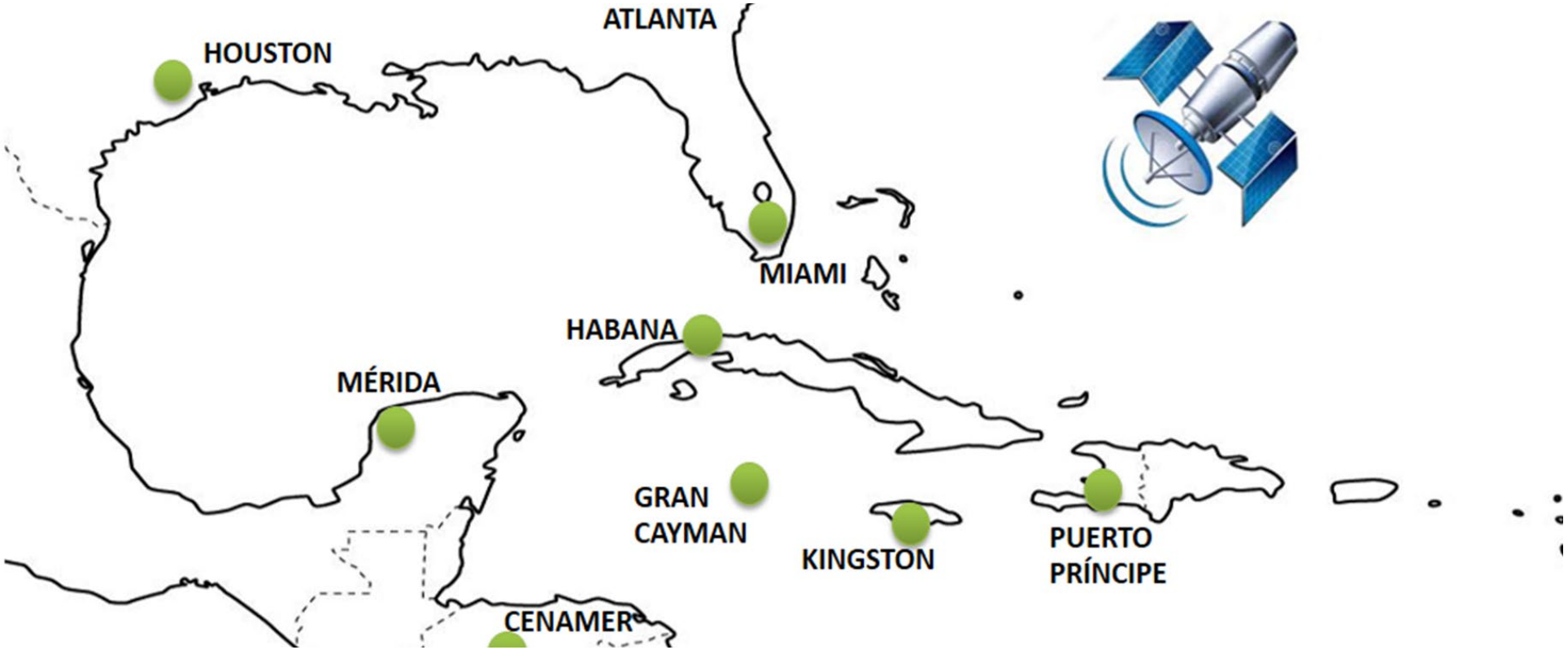
Aspects for Maintaining Vitality in Fixed Oral Communications Systems (Ground-to-ground communication, between ATS units)



Aspects for Maintaining Vitality in Fixed Oral Communications Systems (Ground-to-ground communication, between ATS units)

- An effective measure implemented among the states of the NAM/CAR Region has been the contracting of a VSAT communications system between the ANSPs in the Region, the well-known MEVA project. This has made communications reliable and independent of local communications providers. These VSATs should not be located in facilities far from the ATS units, as they lose their main advantage if communications between the VSAT and the ATS unit are provided by a third party.
- Planning for diverse technologies can be an effective and cost-effective measure. Negotiations can be made with communications providers to establish both analog and digital (VoIP) services without compromising the requirements for communications between ANSPs in terms of signaling methods and response times.
- Plan for commercial telephone communications as a contingency solution. This allows controllers to have a cost-effective way to maintain the vitality of this service, if these communications are available at the controllers' positions.

Aspects to consider when selecting a reliable VCCS

- The selected VCCS must be free of single points of failure that could compromise its operation. **This requires a duplicate design of the central node equipment, from the network to the active equipment, including the IT equipment and the maintenance and configuration station.** The dual network must extend to the workstations.

- The selected VCCS must be capable of operating on both frequencies and fixed communications, both via traditional analog and digital channels.

- The communications network, external to the VCCS, must allow communication between the VCCS and VHF radios that support the ED-137 protocol and between the VCCS and the VoIP telephone switching devices, usually based on the ASTERISK protocols, of the different ATS units.

- The VHF radios, connected to the network via ED-137 digital protocols, must be configured to connect immediately to other ATS units, acting as a contingency in the event of total failures in a given ATS unit. This contingency configuration must be systematically tested to ensure that it can be used when needed.

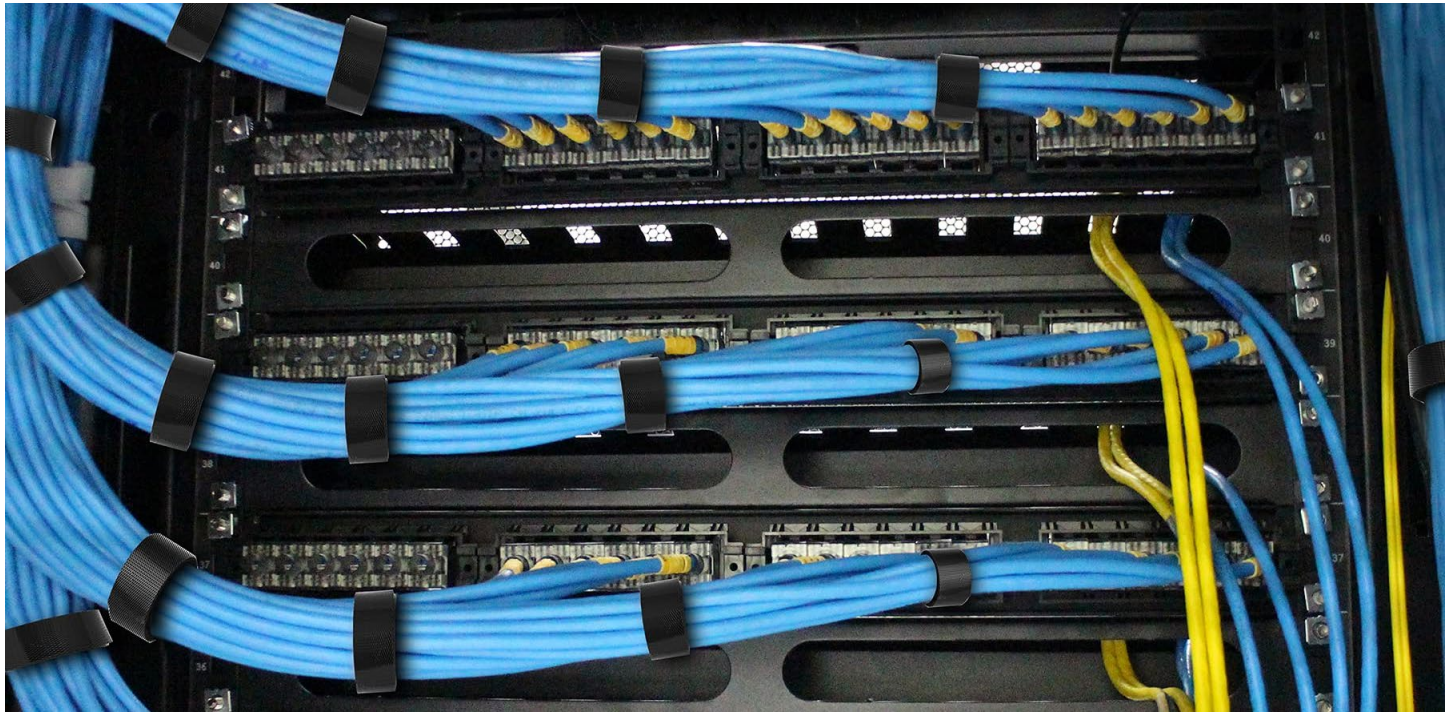
- Active network equipment or servers must have dual power supplies and be connected to a dual network.

- The external network must be connected to the VCCS through more than one connection point.

- Power must be supplied to the central VCCS equipment through a dual source, through more than one disconnect, from a UPS. Additionally, the VCCS must be connected to a sufficiently sized DC backup source (batteries).

- Evaluate the costs associated with implementing an emergency communications system, independent of the main VCCS, that allows the controller, with a very rapid action, to connect their headset or microphone to a terminal device or junction box, communicating directly with the radios in the event of a VCCS failure.

Data and Messaging Network Systems (AFTN/AMHS) Failures



- The data network that connects your ATS unit to the rest of your organization must have sufficient protection measures, including network equipment, high-availability servers and firewalls, intrusion detection, and other security measures to mitigate cybersecurity risks.

- The ANSP's data network must itself be a closed network, even if it has a broad territorial reach. The points of contact between this closed network and your local communications providers for the extension of the WAN or with the networks of other ANSP organizations must be minimal and subject to ongoing monitoring and supervision.

- The costs and feasibility of having more than one point of contact between your local area network (LAN) and the wide area network (WAN) that connects your ATS unit to the outside world within the ANSP network should be evaluated with your local communications provider.

The reliable way to interconnect their data networks should be evaluated with neighboring ANSPs. A simple failure at an interconnection point deprives them of the ability to exchange information with the outside world, as is currently the case when any ANSP fails to communicate with the Atlanta AMHS Center for aeronautical messaging via the AMHS. The convenience and feasibility of establishing secondary communication for the AMHS, one that does not depend exclusively on Atlanta, should be evaluated with neighboring ANSPs.

The feasibility of having a contingency system for aeronautical messaging via the Internet, such as the FAA's AISR (Aeronautical Information System Replacement), should be evaluated. This system allows access to aeronautical messaging information retained in Atlanta in the event of a failure, thus providing an effective mitigation measure.

AMHS Centers, with their AMHS/AFTN gateways, must be highly available and located as close as possible to the Area Control Centers and the ANSP's regional link.

Failures in surveillance systems that feed into ATS units

Surveillance systems are also the basic support for ATC control.

Without them, ATC is impossible when traffic density is high.

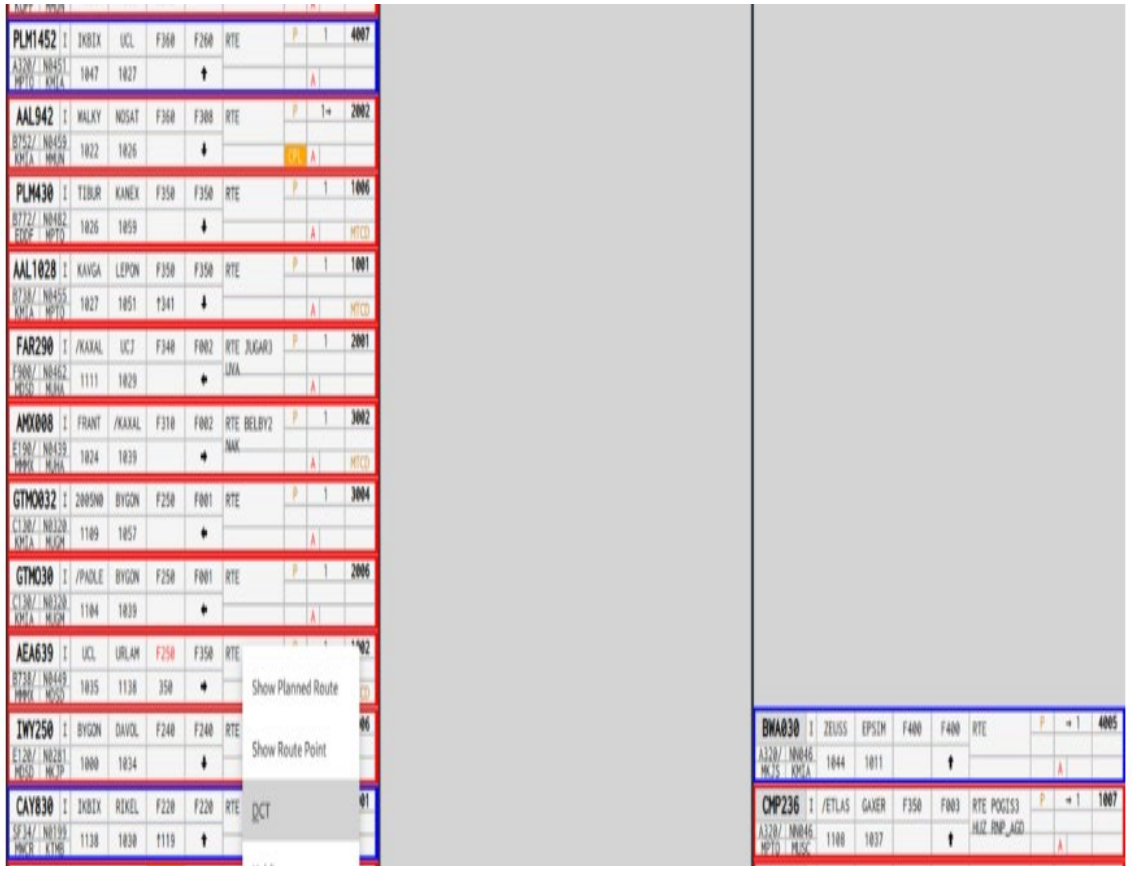
Aspects to take into account to maintain the vitality of surveillance systems

- It must be foreseen that there is more than one surveillance source for a given ATC sector and that they are located in more than one facility and have adequate over-coverage, which allows the service to be maintained, even if there is a failure in one of the facilities.
- It must be foreseen that the main air flows of an ATC sector are monitored by more than one source and that the cone of silence of a radar is well covered by the work of another surveillance source.
- By their very nature, ADS-B and MLAT surveillance sources require reliable digital links with adequate performance. In economic terms, ADS-B and MLAT surveillance sources are lower cost investments than radar, but they have other characteristics that allow us to conclude that the best strategy is to combine the different sources.
- The selection of appropriate locations for the installation of surveillance systems must take into account the power facilities of the site, including AC and DC backup power, communications facilities available with the local communications provider local.

Aspects to take into account to maintain the vitality of surveillance systems

- One aspect to consider when communicating with radars is that surveillance information transmission can be achieved using both analog (using modems) and digital communication technologies.
- The feasibility of having more than one link between the surveillance source and the ATS unit should be evaluated with your communications service provider.
- ADS-B stations are the most economical surveillance sources and generally provide quality data, but they are dependent surveillance sources and, in a surveillance system, must be combined with independent surveillance sources such as radars and MLAT systems.
- In complex surveillance sources (radars, MLAT systems, ADS-B signal concentrators), the equipment must be duplicated, with dual networks and backup power systems.
- The diversity of different surveillance sources in different facilities allows surveillance to be maintained, even during adverse weather conditions that require some surveillance sources to be disconnected during these meteorological events.

Aspects to consider to maintain the vitality of automated air traffic control systems



- Automated air traffic control systems are the technological link available to ATC to enable human-machine interaction (HMI), and their failure causes a significant reduction in service safety, potentially leading to the case of ATC0.
- Automated air traffic control systems must be free of single points of failure that compromise their operation. This requires a high-availability design for central servers, the network, and active equipment.
- The dual network must reach each workstation. All network asset equipment must have duplicate power sources.
- The surveillance source interface server (SIF) must be capable of connecting to the surveillance sources via both digital and low-speed analog links.
- The main systems of an air traffic control system are the surveillance data processors (SDPS) and the flight plan data processors (FDPS). It must be possible to ensure that a failure of the SDPS allows the FDPS to continue operating, and vice versa.

- The system design must provide for the possibility that, in the event of an SDPS server failure, work positions will have direct access to surveillance sources, as selected by the sector controller, to maintain situational awareness during the contingency.
- The system design must provide for the possibility that, in the event of an SDPS server failure, at the discretion of the operational supervisor, the movement of stopped runways may optionally be activated by generating synthetic runway movements, taking into account the latest information stored on the flight plan servers to maintain situational awareness of what was occurring at the time of the event during the contingency.
- When justified by air traffic density and following a prior cost assessment, each work sector must be composed of two control positions with the same characteristics to meet the sector's requirements. This design makes it possible to exclude the simple failure of any position in a work sector from contingencies. The dual positions in each work area must have independent data network cabling and power supply, preferably from separate disconnectors.

- One of the main causes of disruptions to automated air traffic control systems is software updates, which respond to new service requirements or to improvements already addressed in previous versions. These software updates are generally complex and cannot be fully tested in the software manufacturer's environments. Hence, the importance of having an automated test system that receives the same surveillance data and flight plans as the production system and where exercises can be designed to verify the software's adaptation to meet requirements.

- The optimal time for system software updates must be chosen, even if these updates have been sufficiently tested on test systems. Updates should always be performed during times of lower potential impact and on dates not close to weekends, holidays, or commemorative days. The required specialized IT personnel should be available, and secure procedures should be in place to restore the previous version to the current update. Always exercise extreme caution.

Operational Measures

- ATFM Measures in Contingency Situations
- Strategies for Handling a Contingency

Operational Measures - ATFM Measures in Contingency Situations

- ATFM measures are actions implemented to balance the number of flights circulating in airspace, especially when air navigation services (ATS) capacity is limited for some reason (bad weather, airspace closure, staff reduction, etc.).
- These measures are very effective in managing air traffic demand and avoiding congestion that could compromise safety.
- However, they can have negative effects on airspace users (AUs).

Operational Measures - ATFM Measures in Contingency Situations

According to Doc 9971, these measures should be applied according to the following principles:

- Justified Need: They should only be used when strictly necessary, that is, when failure to implement a measure would compromise safety.

- Transparency:
  - They should be based on collaboratively agreed-upon criteria.
  - Decisions must be documented and justified to avoid perceptions of favoritism or arbitrariness.

- Minimizing Operational Impact:
  - Measures should aim to minimize disruption to flight operations.
  - Their impact should be carefully assessed before implementation, and, if possible, less intrusive measures (such as route or altitude changes instead of ground delays) should be preferred.

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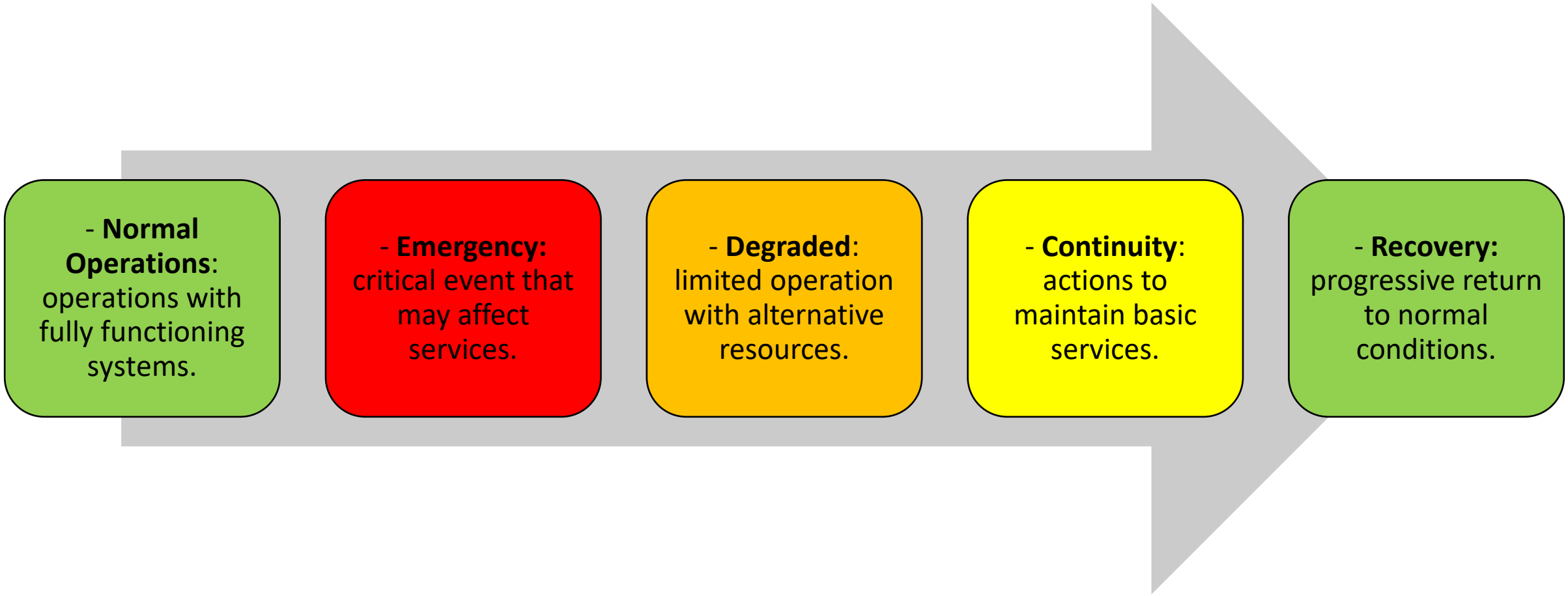
Operational Measures - ATFM Measures in Contingency Situations

According to Doc 9971, these measures should be applied according to the following principles:

- **Collaboration (CDM):**
  - Its design and implementation must be coordinated among all affected parties.
  - A shared decision-making approach is promoted, with effective information sharing and joint analysis.
- **Scalability and temporality:**
  - They must be proportional to the problem identified.
  - They should be applied for the shortest possible time and withdrawn as soon as the situation that caused them has been resolved.

Contingency Life-Cycle



Operational Measures - ATFM Measures in Contingency Situations

Types of ATFM Measures

✈️ **1. Ground Delay Program (GDP)**

- Limits departures from originating airports to an airport with reduced capacity.
- Useful during bad weather, reduced capacity, or special events.

Example: If the destination ACC experiences a technical failure, departures from originating airports are delayed to avoid congestion.

✈️ **2. Ground Stop (GSt)**

- Temporary suspension of departures to a specific destination.

Example: Complete closure of the FIR due to loss of surveillance forces takeoffs to that airspace to be halted.

✈️ **3. Minutes in Trail (MINIT) / Miles in Trail (MIT)**

- Aircraft separation by delaying in minutes or miles before entering an affected sector.
- Useful if the airspace is degraded.

Example: Aircraft must maintain a 20 NM separation to enter an ACC operating in degraded mode.

Operational Measures - ATFM Measures in Contingency Situations

Types of ATFM Measures

✈️ 4. Minimum Departure Intervals (MDI)

- Increased time between takeoffs to avoid route or sector congestion.

Example: A minimum interval of 10 minutes is established between takeoffs from origin airports to an ACC with reduced capacity.

✈️ 5. Change of Route

- Traffic redirection to alternative routes, avoiding affected areas.

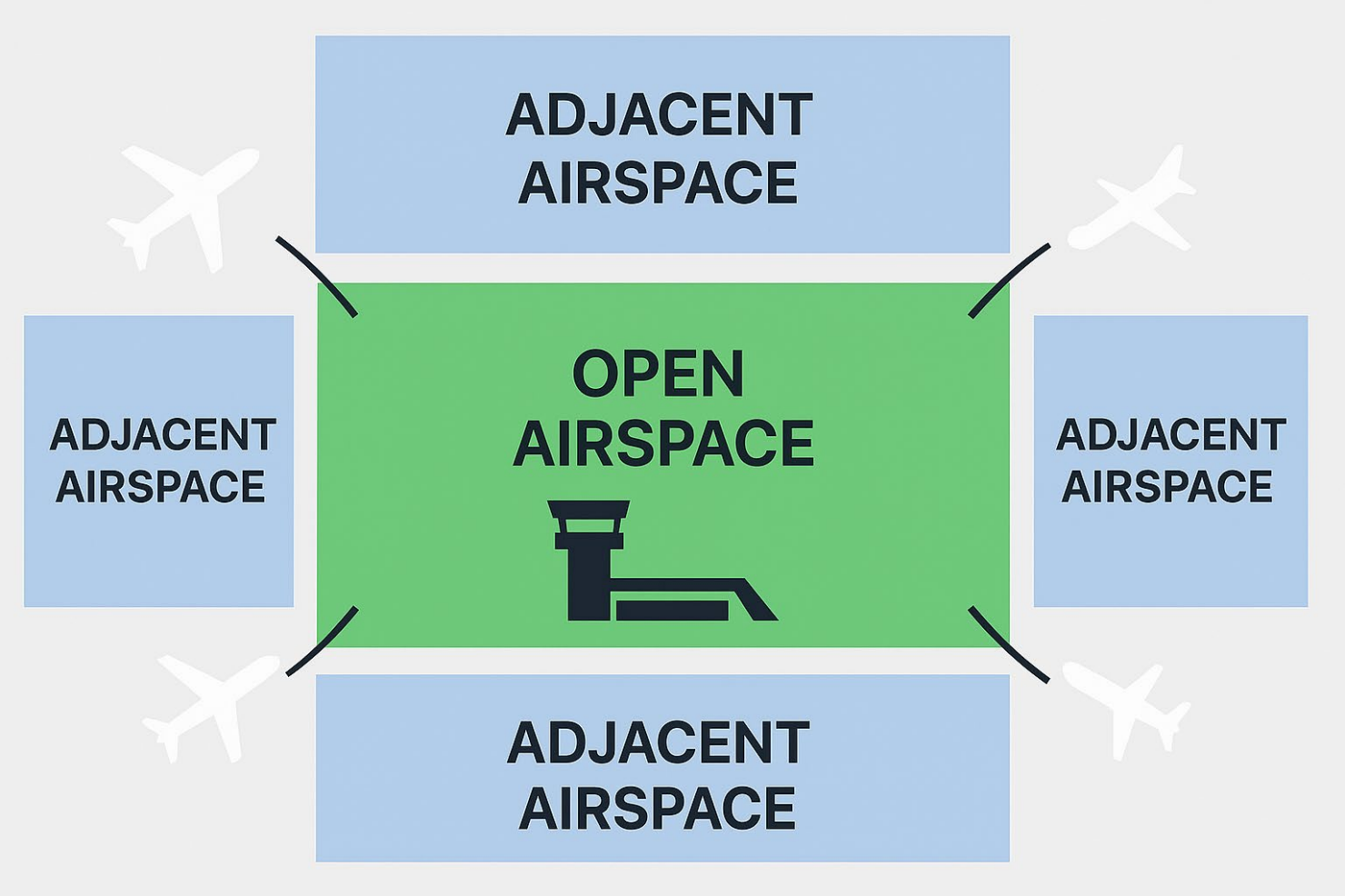
Example: Traffic that usually flies over an affected FIR is diverted to coastal routes or via neighboring FIRs.

✈️ 6. Scenarios of alternative or proposed routes

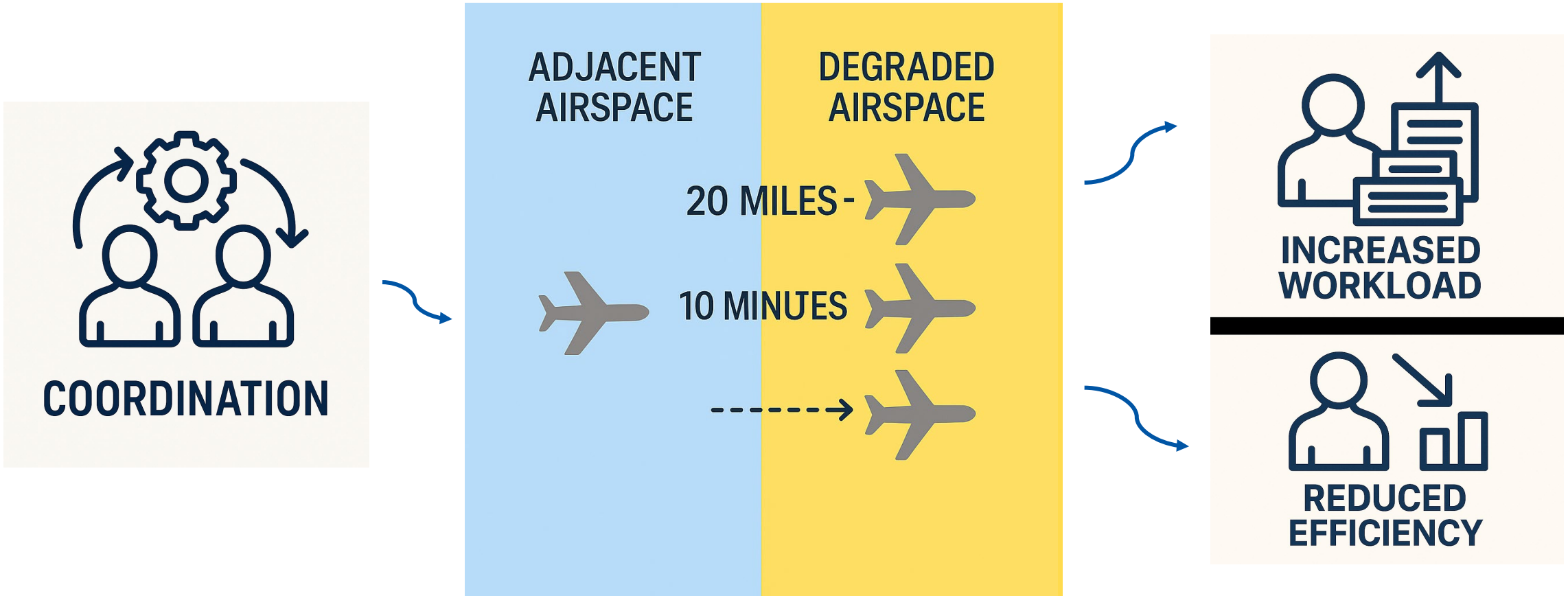
- Design and pre-publication of contingency routes for use in specific events.

Example: The CAR/SAM Regional ATM Plan includes alternate routes ready to be activated in the event of a primary ACC failure.

Operational Measures - ATFM Measures in Contingency Situations



Operational Measures - ATFM Measures in Contingency Situations



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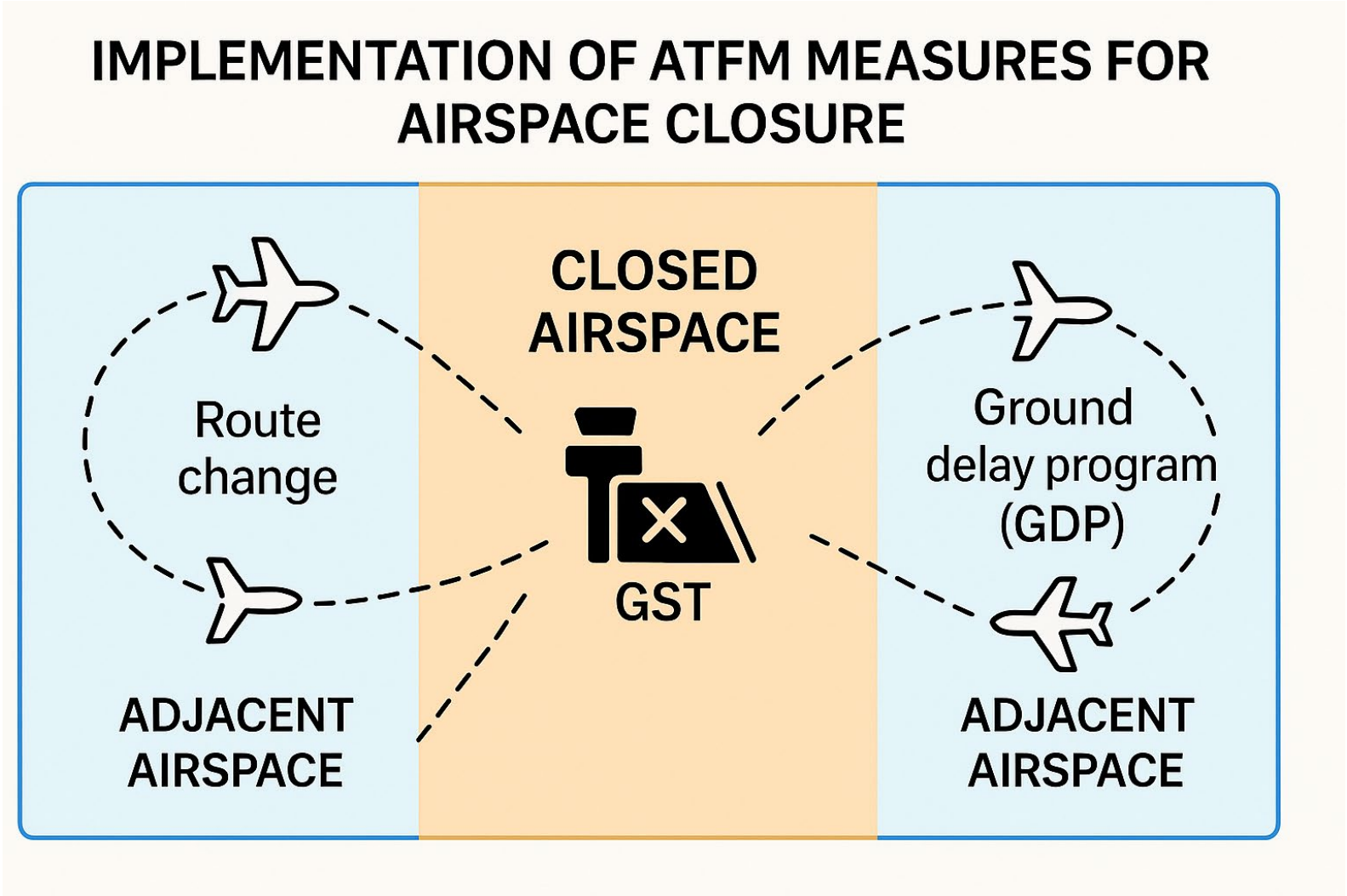


Strategies for the treatment of a Contingency

Strategic response options:

1. **Co-located/shared/joint facilities:** Using shared or training sites as a backup.
2. **Centralized facilities:** A single national contingency site.
3. **Common/shared systems (International) - (Contingency Centers/other Centers in Adjacent States):** Agreements with neighboring states for cross-support.
4. **ATS delegation:** Temporary transfer of control responsibility.
5. **Hybrid models:** Combination of strategies, depending on the type of unit affected (ACC, APP, TWR).

1. Strategy – Co-located/shared/joint facilities

What does it consist of?
It involves using existing areas within the same site (control centers, simulators, training or testing rooms) to provide services in the event of an outage.

Practical applications:
- Simulation rooms that can be quickly converted into operational rooms.
- Shared infrastructure with military installations or other civilian entities.
- Use of legacy systems as operational backup in critical cases.

Advantages:
- Efficient use of already available resources.
- Minimizes transition time.
- Does not require personnel transfer.

Considerations:
- Constant maintenance of backup systems.
- Specific training to operate in alternative environments.

2. Strategy – Centralized facilities

What does it consist of?
Create a single national center (e.g., at a training school) to assume all ATM service operations temporarily or permanently during contingencies.

Practical applications:
- Alternate center located off-site.
- It uses simulation infrastructure adapted for real-life operations.

Advantages:
- Optimizes resources in a single location.
- Enables continuity in major contingencies.
- Can provide coverage to multiple units.

Considerations:
- Requires national coordination and political support.
- Possible resistance from local staff to total centralization.
- Requires solid logistical and operational plans.

3. Strategy – Common/shared systems (International) - (Contingency Centers/other Centers in Adjacent States)

What does it consist of?

Several states share a common facility that can be activated when one of them loses operational capability.

Practical applications:

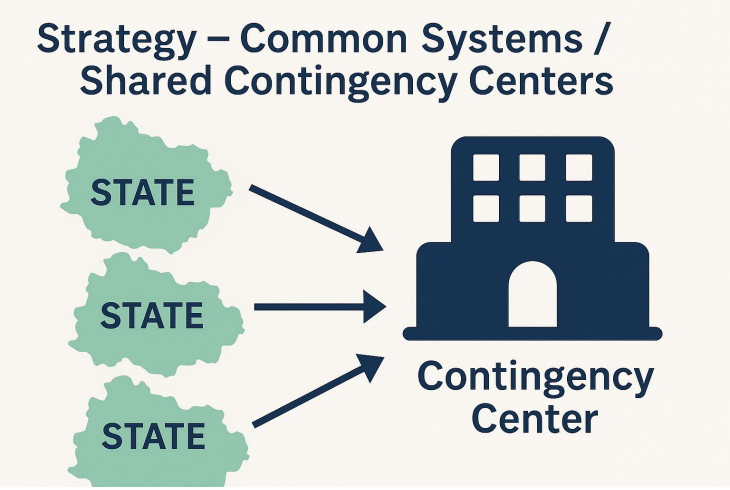
- Regional center that provides services to different FIRs as needed.
- Use of standardized technology and regional agreements.

Advantages:

- Reduction of costs and duplication.
- Increased regional efficiency.
- Promotes interoperability between states.

Considerations:

- It requires legal, technical, and political agreements between states.
- Licenses, procedures, and HMI must be compatible.
- Provision must be made for the repatriation of personnel and services at the end of the contingency.



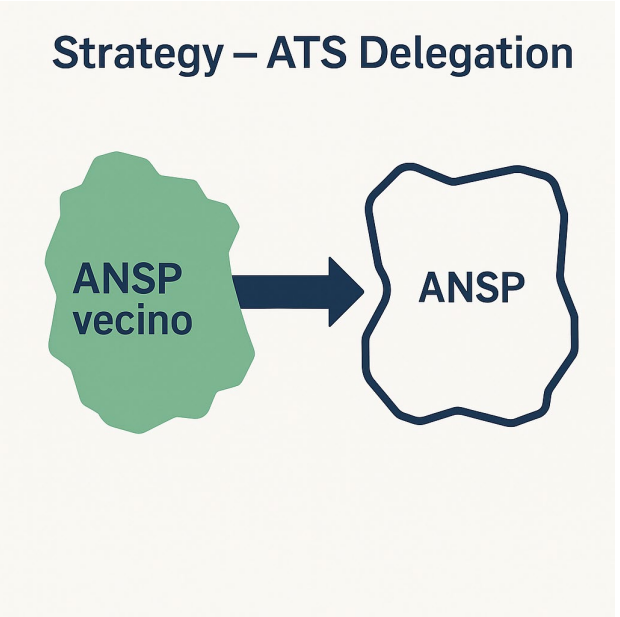
4. Strategy – ATS delegation

What does it consist of?
A neighboring ANSP temporarily assumes full or partial control of the affected airspace, through formal agreements (LoA, bilateral agreements).

Formas de delegación:
- **Horizontal:** Control of entire sectors (FIR/UIR) by the neighboring ANSP.
- **Vertical:** Control from a certain flight level (e.g., FL240 and above).

Advantages:
- Provides continuity when there is no physical backup facility.
- Reduces recovery times.

Considerations:
- Need for clear agreements on roles, licenses, routes, separation, and legal liability.
- Risk of missing traffic notification if not well coordinated.
- Rehearse procedures with drills.



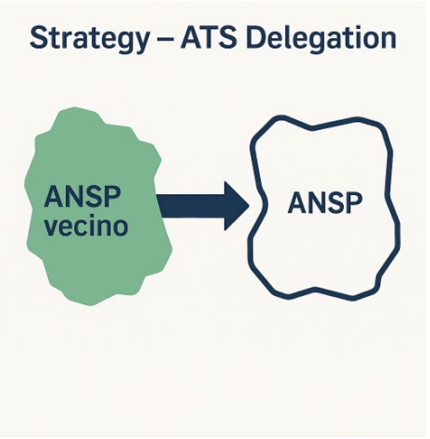
5. Strategy – Hybrid models

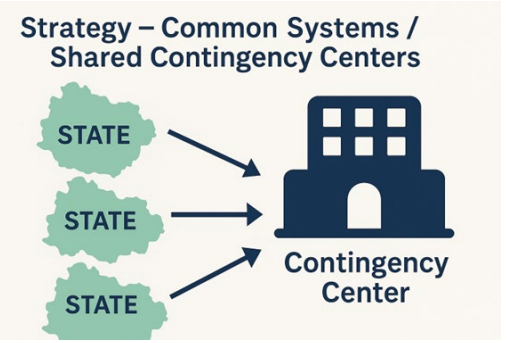
What does it consist of?
A combination of two or more strategies to offer a flexible solution tailored to the ANSP's operational, geographic, and political context.

Examples:
- Co-location + ATS delegation.
- Centralized center + international regional support.

Advantages:
- Maximum adaptability.
- Resource optimization based on changing scenarios.
- Mitigation of weaknesses of a single strategy.

Considerations:
- It requires a higher level of planning and coordination.
- It involves technical and administrative complexity.
- It requires clear protocols for transitioning between strategies.





Document contingency management actions (protocols)

Effective documentation contains:

Clear scenario: Describes the event and context to which the measure responds.

Specific objective: What is sought to be protected or restored.

Sequential steps: Detailed and chronological actions.

Defined responsibilities: Positions or units that execute each action.

Communication methods: Include alternative means.

Required resources: Materials, infrastructure, and personnel.

Completion criteria: Indicators that determine when the contingency is considered over.

Benefit:

Clear and practical documentation facilitates an effective response, minimizes errors, and allows for accountability.

Document contingency management actions (protocols)

What is a contingency matrix?

A tool that organizes the response to critical scenarios, allowing for a quick visualization of actions, those responsible, and resources.

Scenario	Objective	Actions	Responsible	Resources	Completion Criteria
Failure of terrestrial communications	Continue Basic ATS	Activate radio backup, broadcast NOTAM	Head TWR, CNS	Alternating HF/VHF radios, NOTAM template	Traffic Resumed and Links Verified

Utility:

- Quick real-time reference.
- Training base.
- Facilitates audits and technical reviews.

Document contingency management actions (protocols)

Scenario	Objective	Actions	Responsible	Resources	Completion Criteria
Total failure of the surveillance system (Radar, ADS-B, MLAT) in the ACC/TMA Type: Technical -operational degradation Affected Unit: ATS Provider ACC/TMA	Service continuity through capacity reduction	• Apply non-radar procedures (minimum vertical and longitudinal separation) • Limit access to the affected airspace (ATFM regulation) • Coordinate Alternate Routes • Inform ANSP neighbors • Publish NOTAM/AIC • Coordinate with ATFM and Airlines	• Supervisor on Shift • Supervisor on Shift • Supervisor on Shift • Supervisor on Shift • AIS • ATFM Manager	• Operating Procedures Manual, Letters of Agreement, Contingency Plan • ATFM Handbook, Letters of Agreement, Contingency Plan • Contingency Plan • Ground-to-ground communications (ATS channels) • NOTAM XXX format • Regional Group	1. Complete and stable restoration of surveillance systems 2. Functional validation of the system by technical staff 3. Confirmation from drivers that surveillance tools are available in the affected sectors 4. Information to neighboring ANSPs on the restoration of the system 5. Removing or adjusting ATFM measurements 6. Coordination with the ATFM unit for progressive traffic reintegration 7. Event Cancellation NOTAM

Thank You!

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