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UNDERSTANDING THE IMPACT OF AIRCRAFT INFORMATION DATA

FROM NEW GENERATION AIRCRAFT ON THE ACARS NETWORK

Expanding traditional aviation communications networks to accommodate the intelligent aircraft

Collins Aerospace

INTRODUCTION

For decades, Aircraft Communications Addressing and Reporting System (ACARS) has been reliably delivering operational and safety critical information to airline's aircraft globally. Many ACARS applications have become mission-critical to airlines – meaning flight delays or cancellations occur if ACARS information is not received. With the advent — and increasing acceptance — of intelligent airplanes, aircraft and engine performance/health monitoring data have grown over time and now represent up to 80% of a new generation aircraft's ACARS data volume. This significant increase is threatening to overcome the ability of VHF and HF networks to meet capacity requirements.

ACARS over IP and broadband connectivity present an opportunity for aircraft and engine data to be moved away from traditional ACARS VHF, HF, and safety SATCOM connectivity. This will help preserve the limited bandwidth of traditional networks so they can continue to provide highly reliable communications services for operational and safety critical airline information.

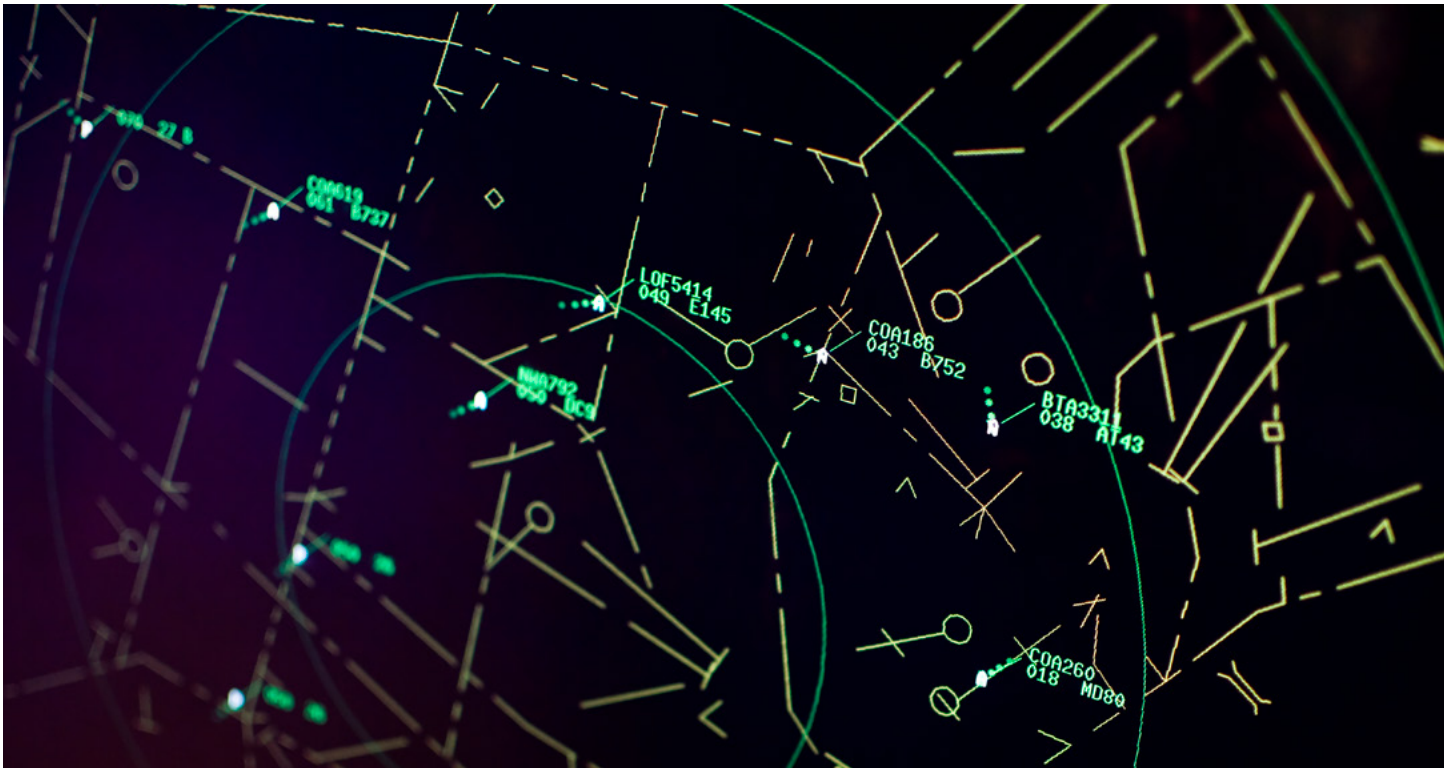
ACARS has existed as a service to airlines globally for over 40 years. Traditionally ACARS leveraged VHF, High Frequency Data Link (HFDL), and more recently L-band satellite connectivity for ACARS communication, with the vast majority of ACARS data being carried over VHF. Aircraft can send and receive ACARS data during any phase of flight, at any time, and almost anywhere an aircraft is located world-wide. This capability is enabled through ACARS networks - private aviation networks dedicated to support airline operations. The networks leverage a limited set of reserved and protected Very High Frequency (VHF) and High Frequency (HF) aviation Radio Frequency (RF) spectrum dedicated exclusively to aviation use worldwide.

ACARS VALUE AND CRITICALITY TO AIRLINE OPERATIONS

As ACARS capability evolved, airlines have grown to rely on ACARS as the primary means to communicate information related to air traffic control (ATC) and airline operational control (AOC) to and from the aircraft. Today, ACARS is essential for airline operations around the world. It is used by hundreds of airlines and over 27,000 aircraft globally to connect airline operation centers, air traffic control, and national aviation centers. Airlines have grown to depend on ACARS information to reliably operate and dispatch aircraft. In fact in most instances, if ACARS information cannot be delivered to an aircraft prior to departure, there is a high likelihood that the aircraft's departure will be delayed, or possibly even cancelled. In summary, ACARS is now 'dispatch-critical' for airline operations.

Capacity limitations

Airline expectations have also evolved; it is widely assumed that the ACARS network is available all of the time, anywhere in the world. Airlines have grown accustomed to sufficient VHF capacity for their dispatch critical information, particularly at the gate prior to departure. Ultimately, it is generally taken for granted by the airlines that ACARS information is successfully delivered to a recipient when the information is required. Because VHF ACARS data is delivered using a limited number of protected, dedicated, aviation-specific spectrum, capacity increases are not endless. The increase in airline data requirements is beginning to strain traditional transmission media. This strain will lead to challenges, including frequency saturation, potential performance constraints, and in areas where additional capacity may be available, the related incremental costs of such expansion.



TRADITIONAL GROWTH IN ACARS TRAFFIC

Initially, the primary driver of ACARS growth was adoption by almost every airline in the world, as well as the expansion of airline's fleets in response to increased global travel demand. The increase in aircraft operations has driven airlines to seek improvements in operational efficiencies and ACARS information has contributed to increased flight operations tempo. As a result, Datalink Service Providers (DSPs) who operate the private ACARS VHF and HF networks increased capacity and coverage world-wide.

Growth has also been fueled by the development of new ACARS applications to serve the needs of the airlines and aviation stakeholders. Hundreds of applications that utilize ACARS exist today to serve not only airline operations and air traffic services, but also to support in-flight passenger services. In addition, aircraft increasingly send a wide range of performance data from aircraft systems; the growth of aircraft operations data caused the next jump in the need for capacity.

To support the need for additional capacity, DSPs added additional VHF frequencies, however those frequencies are limited in availability. As a result, in the late 1990s and early 2000s the industry adopted VHF High Frequency Data Link Mode 2 (VDLM2) ACARS over AVLC (AoA). This technology enabled DSPs to support larger data throughput on the same set of frequencies, adding significantly more capacity to meet the growing demand.

VDLM2 AoA is now the predominant connectivity service supporting ACARS, accounting for the majority of ACARS traffic on the networks. The migration to VDLM2 didn't happen overnight; often airlines waited for new aircraft to come with the appropriate radios rather than perform large-scale retrofits.

Imagery courtesy of Airbus

ACARS DATA TRENDS ASSOCIATED WITH THE EMERGENCE OF NEW GENERATION AIRCRAFT

The newest generation of aircraft, such as the Airbus A320neo and Boeing B737 MAX have the capability (with broadband IP included) to deliver aircraft operations ACARS data at a rate that is multiples of earlier generation A320 and B737 aircraft types. These aircraft and other newer generation aircraft collectively are demanding more and more ACARS capacity to support the growing volume of aircraft operations ACARS messages.

Collins Aerospace recently conducted an analysis of traffic on its ACARS network, GLOBALink, to compare aircraft operations data (in this case the OEM/Engine Digital Flight Data (DFD) application) among aircraft types. Figure 1 shows the difference in DFD ACARS volume among older and newer generations of aircraft. Newer generation aircraft clearly generate significantly more DFD data than older generation aircraft.

AIRCRAFT OPERATIONS DATA ASSESSMENT

General findings of per aircraft/per day volumes:

- Older widebodies ~ 100 Kbits
- Newer widebodies ~ 550 Kbits
- Older single aisles ~ 100 Kbits
- Newer single aisles ~ 500-1000 Kbits
- Regionals (small s.a. <120 pax) ~ 200 Kbits

Avg OEM/engine (DFD) kilobits per aircraft per type per day

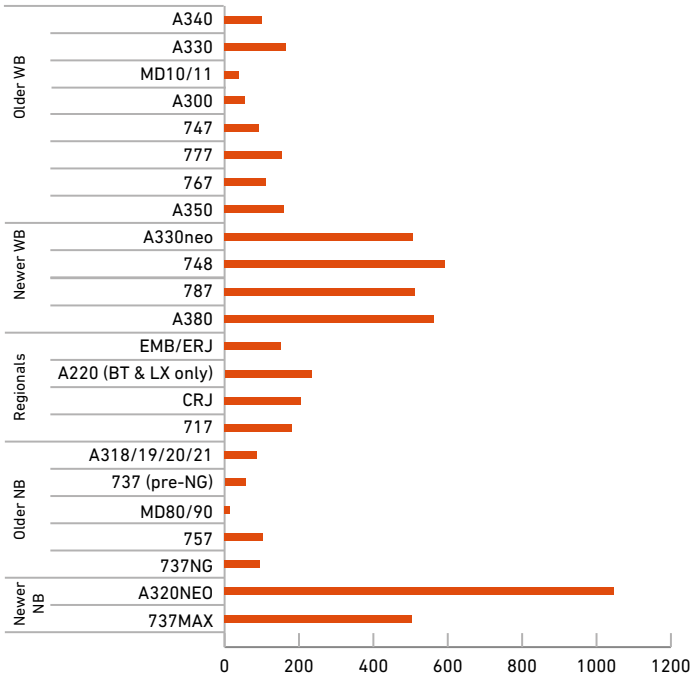


Figure 1. aircraft operations ACARS data assessment

New generation aircraft – aircraft and engine information data is driving ACARS usage growth

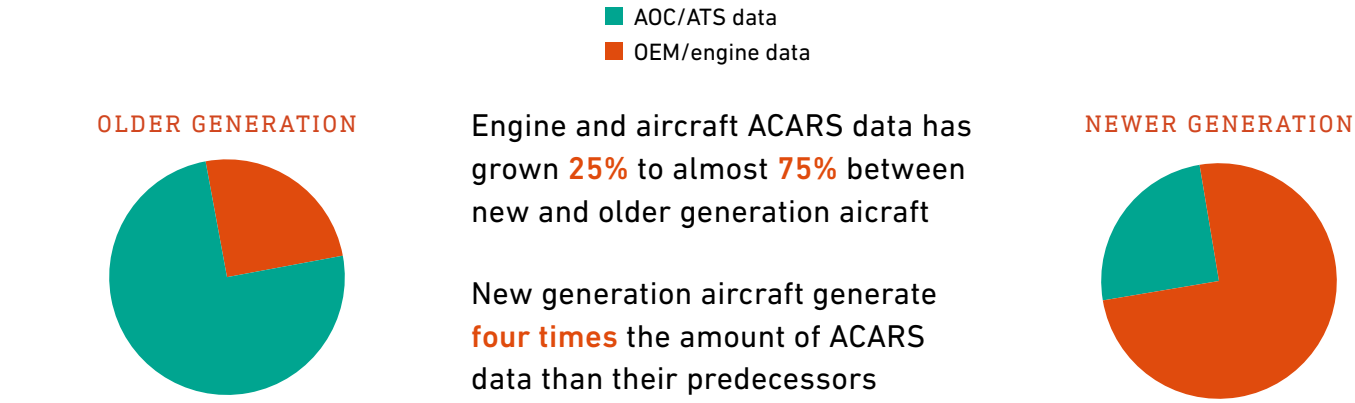


Figure 2. Narrow body aircraft data usage example – A320

It is also revealing to observe the trend among newer generations of the same aircraft type. Figure 2 shows the growth in aircraft and engine information ACARS data compared to Airline Operational Control (AOC) and Air Traffic Services (ATS) data between older and newer generations of narrow body aircraft. Aircraft operations data are shown in orange within the pie charts, green indicates AOC and ATS data, with the size of the pie chart indicating the relative difference in traffic overall. As generations of the same aircraft type evolve, not only does the volume of ACARS data increase but so does the percentage of aircraft operations ACARS data relative to AOC and ATS ACARS data.

The introduction of ACARS over IP (AoIP)

ACARS over IP (AoIP) is the newest option for ACARS communications. AoIP leverages the advantages of ACARS while also utilizing the growing availability and decreasing cost of broadband cellular connectivity on the ground, and IP capable SATCOM connectivity when airborne. The specific mechanisms vary by aircraft and the type of system used, but in general, standard ACARS 618 messages are encapsulated in IP messages between the aircraft and ground based message handlers for processing. When fully integrated with the ACARS avionics, AoIP looks like a new media type in addition to VHF, HF, and Safety Satcom options. Because AoIP uses Broadband IP communications, which have a much higher effective throughput than VHF and HF, it is a highly scalable long term solution. As an additional benefit, Cellular and IP capable SATCOM throughput is so much higher, airlines can also use it to improve other parts of their operations including Electronic Flight Bag (EFB) applications.

The value of ACARS over IP for new generation aircraft

One particular value of AoIP is the ability to offload the growing volume of aircraft operations ACARS information from VHF, HF, and narrow band safety services SATCOM to a broadband connectivity, such as cellular or IP capable SATCOM. These ACARS applications do not have the network performance requirements that dispatch critical or ATS ACARS applications demand; therefore a commercially or publically available broadband alternative connectivity is suitable. Also, airlines that have been experiencing cost increases as a result of growing aircraft operations data volume may realize cost savings by moving aircraft operations ACARS messages to AoIP which is often delivered at a flat rate.

Segregating the use of AoIP for large aircraft operations ACARS applications and VHF, safety services SATCOM, and HFDL for airline operational critical ACARS information will provide airlines with the following capabilities:

- Proven VHF and SATCOM safety services connectivity for operational and safety critical ACARS information
- AoIP and publically available connectivity for large aircraft information ACARS messages that are not operationally critical. An excellent example of this is to “store and forward” some AI data after landing using AoIP with a cellular connection
- It should be noted that AoIP data can be integrated directly into an airline’s existing ACARS infrastructure with no ground side automation changes

Another factor that drives data usage profiles for an airline is the set of AOC ACARS applications that an airline uses. Some airlines have a high volume of ACARS AOC usage while others have a low volume of ACARS AOC usage. Factors that drive AOC usage include frequency of flights and AOC related data needs. These airline specific ACARS usage profiles must be taken into account when analyzing ACARS data trends, with some airlines benefiting from moving AOC traffic to AoIP.

NEW GENERATION AIRCRAFT GROWTH

Collins Aerospace's projection of new generation aircraft growth shows a significant increase in the percentage of new generation aircraft compared to 'legacy' aircraft over the next 15 years. Figure 3 shows this evolution of aircraft mix among legacy, regional (CRJ/ERJ), and new generation aircraft.

> Over the next 15 years, new generation aircraft grow from **9 to 57 percent** of all operational airline aircraft as older aircraft are retired.

Over the next 15 years new generation aircraft grow from 9 to 57 percent of all operational airline aircraft as older aircraft are retired. With these aircraft generating significantly more AI ACARS data, there will be continued stress on VHF ACARS capacity without any change.

The aircraft mix is shifting from legacy to next-generation aircraft over time.

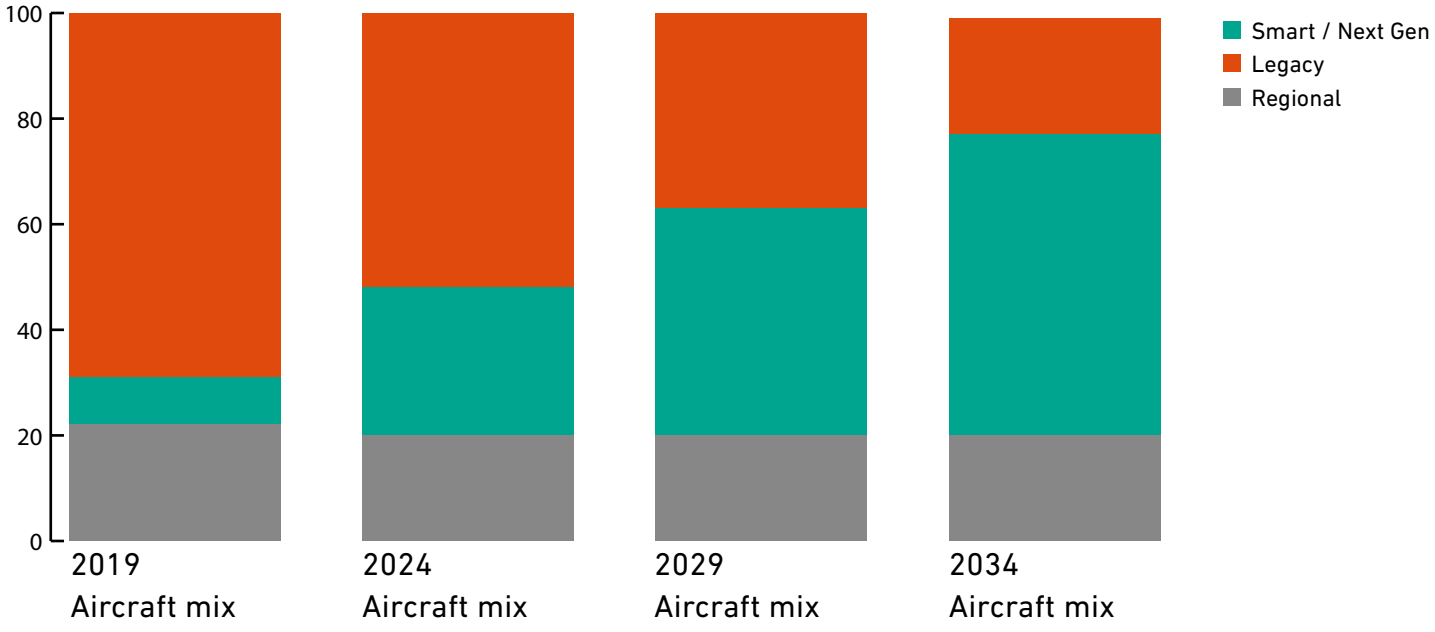


Figure 3. Commercial aircraft forecast over 15 years

ACARS OVER IP IMPACT ON VHF TRAFFIC GROWTH PROJECTIONS

To examine the stress the growth of new generation aircraft might have on VHF capacity, Collins Aerospace conducted an assessment of VHF traffic growth over the next 15 years using the new generation aircraft growth estimate. The assessment considered projected new aircraft deliveries and aircraft retirements over this timeframe. Two scenarios were considered:

- ACARS growth without AoIP for aircraft operations ACARS information
- ACARS growth with AoIP for aircraft operations ACARS information

Figure 4 shows the results of the assessment.

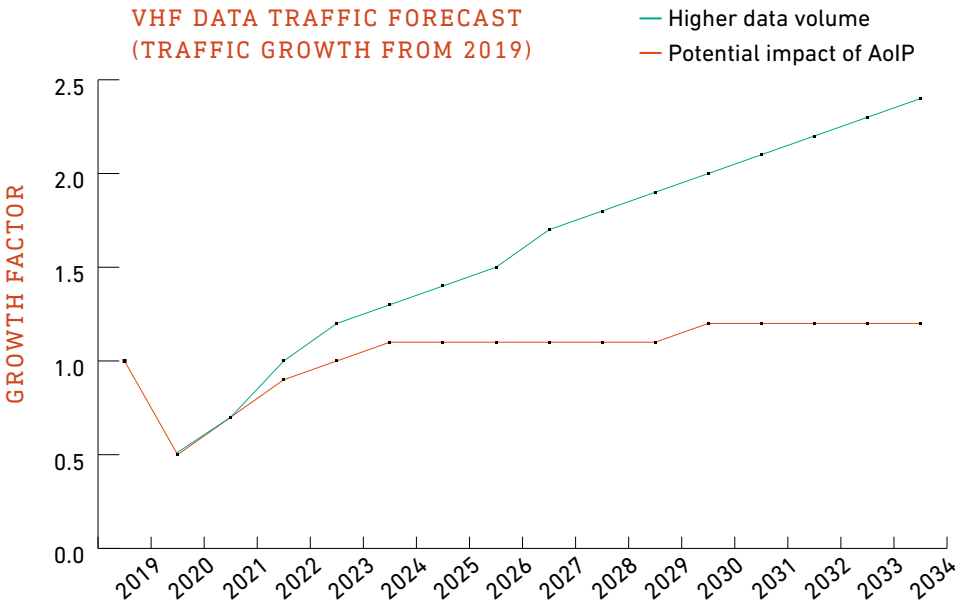


Figure 4. VHF data traffic forecast

The assessment shows a potential growth factor of up to 2.4 times that of 2019, pre-COVID levels of VHF based AI traffic without considering a migration of AI traffic to AoIP. It also shows that AoIP has the capability to preserve VHF capacity for critical airline operations and air traffic services by migrating aircraft operations ACARS applications away from VHF. The forecast shows that strong market adoption of AoIP would result in nearly half the VHF ACARS traffic over the next 15 years. While we expect VHF traffic will grow slightly as new aircraft are introduced, it could be much less dramatic with the use of AoIP. This would equate to improvements of performance to the Datalink network.

AIRCRAFT AOIP CAPABILITIES

An aircraft needs the following to enable AoIP:

- Aircraft Interface Device (AID) integrated with the aircraft's ACARS Avionics
- Software on the AID that is capable of encapsulating ACARS 618 messages into an IP message
- Broadband IP connectivity with a high degree of security, such as an IP Virtual Private Network (VPN). Examples are either a ground cellular capability or IP capable Satcom (Swift BroadBand SBB or Iridium Next)
- A ground requirement is AoIP software with the ability to accept AoIP messages from the aircraft and route the resulting messages over the ACARS ground network

As an example, Airbus A320neo and A330neo aircraft have FOMAX that come linefit and are available for retrofit. FOMAX is an AID that includes integration with the Air Traffic Service Unit (ATSU) and optional broadband cellular and satellite capabilities to enable AoIP. The FOMAX AID is integrated with ground based software that receives and processes AoIP based messages that are fully interoperable with the legacy ACARS network. Other aircraft, such as the Airbus A350 and Boeing 787 have similar linefit capabilities with many more having retrofit options.

It is important to note that a significant volume of aircraft operations ACARS messages are generated en-route. In order to maximize the reduction of VHF ACARS capacity and cost savings, an aircraft must have IP capable SATCOM integration or the capability to store en-route ACARS messages for ground transmission via a cellular connection after landing.

Recommendations and next steps

Airlines will rely on VHF or HF ACARS communications for safe and reliable operations for the foreseeable future and these supporting infrastructure will remain in place for those critical messages by which require VHF/HF media. The need to improve the performance and capacity of traditional ACARS networks will continue as the volume of aircraft operations traffic from next generation aircraft increases. If forecasts become reality, demand will soon outpace VHF and HF capacity. In fact, in some places capacity limitations are already impacting operations. It may not be economical to add enough VHF and HF capacity to handle the projected increase in ACARS traffic over the next 15 years.

AoIP is a proven technology that is capable of off-loading aircraft operations ACARS traffic from VHF/HF, allowing traditional systems to stay focused on ATC and other mission critical traffic. As next generation aircraft are purchased, airlines should invest in both AoIP technology, and the broadband services that support its delivery to the ground. This will ensure capacity of VHF and HF networks will continue to be sufficient. Additionally, airlines can potentially realize cost savings by avoiding charges of typical ACARS traffic while leveraging broadband connectivity for additional operational improvements.

To learn more, go to
collinsaerospace.com/acars-over-ip

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