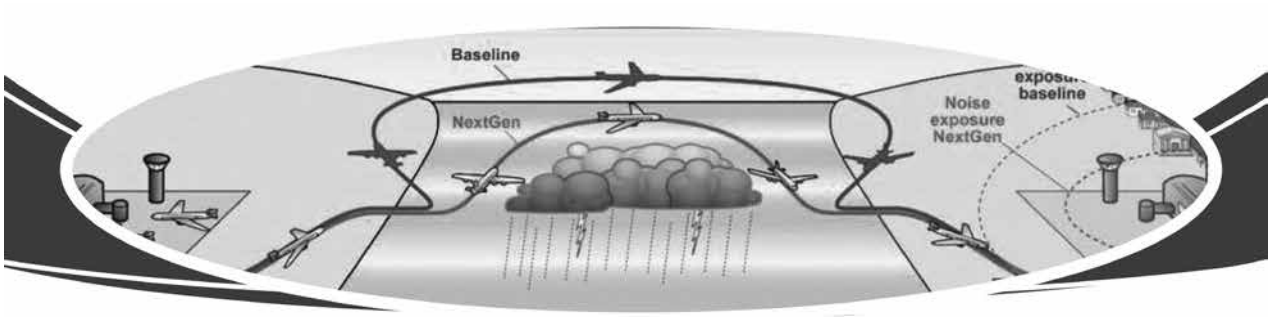
使用下一代航空運輸系統(NEXTGEN)改善航空器導航

為了使航空器能更有效率地利用航行空域，設備製造商、系統整合業者、飛行員、飛航管制員及航空公司正著手合作導入星基導航程序(Satellite-based Navigation Procedures)。這是基於地形上的挑戰、水域的環繞、錯綜的機場系統及其他因素，導致增加了在全球最繁忙的空域中引導航空器的複雜性，因而對於空域提出的改善。

黃昱瑞 譯



美國幾座最繁忙的機場每天都應證了有效率地引導航空器這件事，在實際運作上是相當具有挑戰性的。如亞特蘭大的哈茨菲爾德-傑克國際機場(Hartsfield-Jackson International Airport)擁有多條平行跑道及存在多種航空器機型，而各種機型皆有其特殊的空域使用需求。紐約繁忙的拉瓜地亞國際機場(La Guardia Airport)則是另一個例子，由於其交錯的跑道及受限的滑行道，使得航空器調度更顯困難；同時，該機場四周皆為水域所環繞，且與臨近的甘迺迪國際機場(John F.Kennedy International Airport)和紐華克自由國際機場(Newark Liberty International Airport)共同形成了世界最大的機場系統之一，因此也面臨了擴展上的限制。

美國FAA面對這些種種的限制的處理方式之一，即依據NextGen之大都會區空域及程序的最佳化(Optimization of Airspace and Procedures in the Metroplex, OAPM)計畫，重新規劃這些受限機場周遭空域的航行路徑。該計畫係針對一個包含數座機場服務數個大都會，且彼此之間為航空利害攸關方的地理範圍，為其重新劃設航線，並允許航空器使用飛行管理電腦(Flight Management Computers, FMC)及兩種基於性能導航(Performance Based Navigation, PBN)的先進導航方式，亦即區域航行(Area Navigation, RNAV)以及導航性能需求(Required Navigation Performance, RNP)。

NowGen導航

2014年底前，美國FAA為休士頓及北德克薩斯州機場系統設計了下降程序最佳化(Optimized Profile Descent, OPD)，使該兩座機場系統現代化了；它建立了新的離、到場路徑，使航空器能依屬意的路徑航行，並允許其以平行進場方式進入休士頓George Bush洲際機場。在休士頓與北德州大都會區專案中，美國FAA與業界合作共實現了141組新的星基導航程序，使航空器得以展現其機載飛行管理系統的優越能力。

「結合美國FAA用來隔離航空器的計算工具和飛行管理電腦規劃下降路徑能力，我們可以減少滑降過程中平飛路徑，也減少了使用無線電語音指引進場程序。」聯合航空公司的航空技術主任飛行員Ron Renk接著說：「如我們所預期的，於休士頓的進場程序中，確實減少了航空器燃料的使用及廢氣的排放。但對於北德州而言，仍尚屬初步階段，我們還正在收集足夠的資料及數據來作分析。」

另外，根據業務發展經理Rex Hygate表示，許多搭載

老舊飛行管理系統的傳統航空器正面臨著新儀航程序所帶來的複雜性；「新的進場程序使航空器得以怠速下降，不但節省了航空公司的支出，也使飛航管制更顯容易，因為他們僅需說『you're cleared to land on this approach』飛航管制員除了淨空航道外，直到航空器落地前幾乎不需再與飛行員對話。管制員也允許航空器逕自於進場航線的通道(tube)中航行，因為他們確信航空器不會偏離航線通道。」他接著說：「從舊型飛行管理系統的角度來看，它的問題在於新進場程序變得複雜多了。因為他們包含了10至15個垂直的航點，且每個航點都有最高及最低高度限制，許多傳統的飛行管理系統無法達到此要求。關於這一點，我們正竭盡所能持續地更新飛行管理系統，使航空器得以航行於新的進場程序中，以獲得節省燃料的優點，並使其可以best-equipped, best-served飛行。」

其他如專門從事設備製造與航電系統提升的供應商，也加強了系統的導航性能及可靠度，如Innovative Solutions and Support(IS&S)公司推出了以NextGen為基礎的升級套件，提升各航空公司傳統航空器的導航效率。IS&S NextGen專案副總裁Forrest Colliver說：「我們的波音737駕駛艙的升級套件，係針對傳統航空器的老舊設備與NextGen功能的差異而設計的，如支援RNAV/RNP採用弧形路徑飛行、全球衛星導航系統(GPS/WAAS)、垂直導引定位性能(Localizer Performance with Vertical Guidance, LPV)、管制員與駕駛員資料鏈結通信(Controller Pilot Data Link Communications, CPDLC)及廣播式自動回報監視(Automatic Dependent Surveillance-Broadcast, ADS-B)。」他接續說：「IS&S為波音737經典機型設計的升級套件不但具備彈性，並將升級後的經典機型與新一代B737BG機型於操作上的差異最小化。」

2015年，美國FAA將持續與業界合作，推動更多大都會空域及程序最佳化的專案，以進一步提升航空器進出國家空域系統(NAS)網絡路徑的效率及精確性。實現航空器導航效率的持續提升需仰賴強大的航電系統、PBN飛航程序及有效的支援工具(如有效的隔離及排序系統)的結合，國家空域領航的國家飛航管制員協會(NATCA) Jim Davis如此表示。

他接著說：「假設美國FAA的資金及資源皆如計畫般進行，我們應該會看到所有正在推行中的大都會區的進展；我們將看到設計及評估作業持續在夏洛特(Charlotte)、亞特蘭大、南加州、佛羅里達、克利夫蘭/底特律及鳳凰城等地進行；另外，北加州及華盛頓都會區(D.C. Metro)則有望於未來的幾個月內付諸實現。」

其他航空公司，如聯合航空(United)，也持續與美國FAA及設備製造商合作，共同提升航空器機載航電系統

對於使用NextGen功能的能力。聯合航空的機長Renk說：「目前仍然有一些障礙導致NextGen程序無法百分之百地應用於任何的時間，我們曾預期天氣將是這些因素之一，然而它確實明顯地造成了影響。我們需要持續與美國FAA及航空器製造商合作，研究如何更善用飛行管理電腦來使我們偏離天氣因素。」

NextGen導航

美國FAA持續現代化其以電腦為基礎的空中交通系統，並重新設計其最繁忙空域航線的同時，業界則持續朝著改變原先規則的航空器導航技術發展，以使NextGen的航路更有效率地被使用。舉例來說，業界最新的大型客機－Airbus A350 XWB，業於一月時於卡達航空公司(Qatar Airlines)開始服役。

Rockwell Collins公司設計了A350航空器上大多數的導航技術。「我們對於A350導航技術感到非常興奮！」該公司航空運輸系統的副總裁Steve Timm說：「為A350導入多模式接收機(Multi-Mode Reciever, MMR)最重要的事就是星基增強系統(Satellite-Based Augmentation System, SBAS)，這是第一個獲得SBAS方案的航空運輸平台。當我們進展到NextGen空中交通管理的規劃路線，並迎接歐元區所規劃的歐洲單一天空即將到來，這兩項計劃主要基礎之一皆來自於性能導航，而性能導航仰賴著一個更精確的星基方案。SBAS所須做的是在於導航衛星群中再增添加額外的同步人造衛星。從GPS的角度來看，SBAS使一般航空器改進了導航技術，因為你可使用更多的衛星來定位，另外SBAS衛星提供了一些信息有助於強化航空器的定位。」

另一項將來可能被部署於航空器的導航改善技術則是4維導航(4-D Navigation)概念，其係將第4維空間的時間參

數，導入現有被用來計算航行軌跡的3維空間中。航空公司可藉由精確估算兩機場間的航行路徑，更加精確地推估航空器的飛行時間，以幫助航空公司改善到場時間。Timm說：「4維空間航跡(4-D Trajectory)管理的概念，對於我們試圖讓更多航空器進入空域，並推廣於全球的空中交通管理計劃來說，是一個重要的方向。」他接著說：「在A350航空器上，Rockwell Collins公司提供了一個更加精確、高度整合及可用性更高的導航方案，並得以藉由飛行管理系統和機上其他系統提供4維空間航跡管理。」

4維導航雖然看似是一個仍在持續研究的未來概念，但它極可能在未來5至10年就會實現。2013年，美國FAA委託麻省理工學院，研究航空器飛行管理系統對於「風對航空器航行路徑的影響」精確表示的能力。去年，美國NASA和Saab空中交通管理公司達成了一個新的協議，研究使用4維空間航跡方案來協助紓緩高度擁塞的紐約空域。同樣的，歐洲也為其「單一歐盟天空」的願景，進行4維空間航跡管理的研究。2014年3月，空中巴士(Airbus)公司、荷蘭馬斯垂克上層區域管制中心(Maastricht Upper Area Control Centre, MUAC)、北歐及奧地利聯盟(North European and Austrian Consortium, NORACON)執行由法國土魯斯(Toulouse)飛往斯德哥爾摩-阿蘭達(Arlanda)機場航班的第二次4維飛行試驗。Airbus公司系統銷售主管及航太無線電協會(Aeronautical Radio INCorporated, ARINC)工業計劃非盈利標準組織成員Thierry Harquin說：「負責制訂ARINC標準的航空電子技術委員會(The Airlines Electronic Engineering Committee, AEEC)組織，於2014年10月通過了ARINC 702A的更新(先進飛行管理系統)。」他接續說：「這個更新導入了顯著的強化，如風及溫度數據的精確定義，從而將4維空間航跡導航實現於飛行管理系統中。」未來概念的研究如4維空間航跡導航、OAPM新程序的持續運用及部署分析，以及其他空域系統計劃，都將促使仍在持續進展中的NextGen導航系統的啟用。

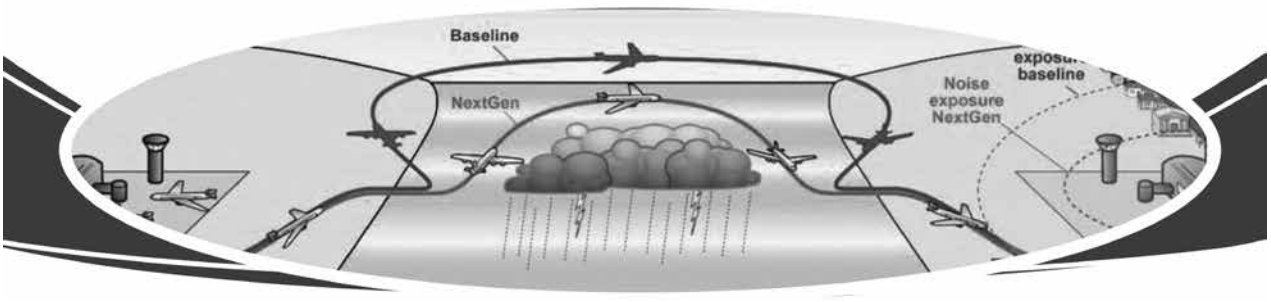
「我相信當所有的相關作為拖廣到了某個程度以後，業界將可獲得真正的整體性利益。我將它比擬作交通運輸部(DOT)正沿著高速公路興建一座新的、更大的橋樑。當他們正在興建這座橋樑時，有許多道路將被封閉或須行駛替代道路，有時造成駕駛員通行更加困難。但一旦完工後，全新的橋樑將全線通車，其所帶來的便利是非常值得去等待的。」聯合航空的機長Renk接著說：「一旦NextGen應用於通信、導航及監視，以及大部分的國家空域系統後，我認為無論對於飛行員或乘客來說都會是一大進步。在達到這一點前，我們看到部分區域的提升，卻也看到還沒為NextGen紮根或缺少要件的地區仍依舊運作著。」

譯自Avionics Today Feb/Mar 2015

USING NEXTGEN TO IMPROVE AIRCRAFT NAVIGATION

OEMs, systems integrators, pilots, air traffic controllers and airlines are all working together to use satellite-based navigation procedures that will allow aircraft to make more efficient use of the airspace.
These spacing improvements are based on terrain challenges, surrounding water, airport systems and other factors that cause complications for efficiently navigating the world's busiest airspace.

Woodrow Bellamy III



Some of the busiest airports in the United States daily demonstrate the operational challenges of navigating an aircraft efficiently.

An example is Atlanta's Hartsfield-Jackson International Airport, which has multiple parallel runways and a complex mixture of aircraft types — all with specific airspace needs. New York's busy international La Guardia Airport is another example, where crossing runways and limited taxiways make it difficult to maneuver an aircraft.

Meanwhile, the New York airport is also in facing expansion limitations due to surrounding water and is sharing one of the largest airport systems in the world with nearby JFK and Newark Liberty International airports.

One of the ways the FAA is tackling these limitations is by redesigning the airspace pathways surrounding these airports, with its Optimization of Airspace and Procedures in the Metroplex (OAPM) NextGen initiative. The initiative takes a geographic area covering several airports that serve major metropolitan areas with a diversity of aviation stakeholders and recreates its skyways to allow aircraft to use their Flight Management Computers (FMC) and advanced navigation systems to fly the two areas of Performance Based Navigation (PBN): Area Navigation (RNAV) and Required Navigation Performance (RNP).

NowGen Navigation

Toward the end of 2014, the FAA modernized the Houston and North Texas airport systems, creating Optimized Profile Descent (OPD) procedures, establishing new departure and arrival routes that align airplanes on their preferred navigational paths, as well as

forming side-by-side arrival routes into George Bush Intercontinental Airport in Houston, Texas. Between the Houston and North Texas metroplex projects, the FAA and industry collaborated to implement 141 new satellite-based navigation procedures that allow aircraft to unlock the advanced capabilities of their FMS.

"Combining the metering tools that the FAA uses to help space aircraft and the FMC's ability to plan the aircraft's descents, we've seen a reduction in the number of level off segments and a reduction in overall vectors off arrival procedures," says Ron Renk, chief technical pilot for navigation at United Airlines. "These have both contributed to a reduction in fuel and emissions, as we predicted, for Houston. North Texas is still relatively new and we are just now starting to collect enough data to do an analysis."

According to Rex Hygate, business development manager, a lot of legacy aircraft have older FMS that face complexities with the new procedures. "What happens is these approaches are idle descents so they save the airline money, they're easier for [Air Traffic Control] ATC because they just say 'you're cleared to land on this approach,' they don't have to say anything else to them until they land, so it clears up the airways. It also allows them to shuffle aircraft below and above the tube of the approach, because they know all of the aircraft will stay within the tube," he says. "The trouble from an older FMS perspective is the approaches are much more complex. They'll have 10 or 15 vertical waypoints each of them with a maximum and minimum altitude.

A lot of older FMS can't take this. This is something where we're contributing for some aircraft in order to continually upgrade the FMS so they can fly the new approaches both to take advantage of the fuel savings and to be able to fly best-equipped, best-served."

Other suppliers that specialize in OEM and retrofit avionics systems that enhance navigation performance and reliability, such as Innovative Solutions and Support (IS&S), have also introduced NextGen-based retrofit packages designed to boost the navigational efficiency of

airlines' legacy aircraft. "Our Boeing 737 Cockpit Upgrade package targets legacy aircraft facing issues of obsolescence of original equipment as well as significant gaps in NextGen functionality, such as support for RNAV/RNP with curved paths, GPS/WAAS, [Localizer Performance with Vertical Guidance] LPV, [Controller Pilot Data Link Communications] CPDLC and [Automatic Dependent Surveillance-Broadcast] ADS-B," says Forrest Colliver, vice president of NextGen programs at IS&S. "The IS&S upgrade package for the Boeing 737 Classic is designed for both flexibility and to minimize operational differences between upgraded Classics and the more modern B737NG aircraft."

In 2015, the FAA will continue to work with the industry to move more OAPM projects forward, further improving the efficiency and accuracy of aircraft paths into and out of the system of networks that makes up the National Airspace System (NAS). The realization of continued improved aircraft navigation efficiency will rely on a combination of strong avionics systems, flying PBN procedures and the availability of supporting tools, such as a "robust and effective spacing and sequencing system," says Jim Davis, national airspace lead for the National Air Traffic Controllers Association (NATCA).

"We should see progress in all of our active metroplexes, assuming FAA funding and resources continue as planned," he says. "We will see design and evaluation activities continuing in Charlotte, Atlanta,

Southern California, Florida, Cleveland/ Detroit and Phoenix. Implementation activities for Northern California and D.C. Metro are expected within the next few months."

Airlines, such as United with Captain Renk, are also going to continue to work with the FAA and OEMs to improve their ability to use the NextGen-enabled usage of their aircraft's avionics systems. "There are still impediments that prevent using the NextGen procedures 100 percent of the time. We already predicted weather would be one of those factors and it definitely has had an effect. We need to continue to work with the FAA and aircraft manufacturers to better utilize the FMC when we need to deviate for weather," says Renk.

NextGen Navigation

While the FAA continues to modernize its computer-based air traffic system and redesign the use of its busiest airspace routes and pathways, the industry continues moving forward with game-changing aircraft navigation technology that can be used to navigate more efficiently under NextGen skyways. Take, for instance, the industry's latest airliner, the Airbus A350 XWB, which entered into service with Qatar Airlines in January.

Rockwell Collins designed most of the navigation technology onboard the A350. "We're pretty excited about the A350, as far as navigation," says Steve Timm vice president of air transport systems at Rockwell Collins.

"The biggest thing that was introduced in the [Multi-Mode Reciever] MMR for the A350 is SBAS, Satellite-Based Augmentation System, and this is the first air transport platform to get an SBAS solution. As we progress into the NextGen air traffic management roadmap and the Single European Sky mandates that are coming for the Eurozone, one of the key drivers in both of those initiatives is performance-based navigation, and PBN relies on a more accurate satellite-based solution. What SBAS does is add additional satellites to the constellation that are stationary above a certain location. From a GPS perspective, SBAS gives aircraft

improved navigation in general because you have more satellites to use in that solution, but also the SBAS satellite gives some information that helps augment the position of the aircraft," Timm says.

Another improvement of aircraft navigation that could be deployed in the future is the concept of 4-D navigation, which adds the fourth dimension of time to the three spatial dimensions that are currently used to calculate an aircraft's navigational trajectory. This helps to improve arrival times for airlines, as they can more accurately project flight arrival times because of a more precise way of estimating the aircraft's navigational path between airports. "The concept of 4-D Trajectory management is another key aspect to some of the air traffic management initiatives that are going on around the world where we're trying to put essentially more aircraft into the airspace," says Timm. On the A350, Rockwell Collins provided a "more accurate, and higher integrity and more availability navigation solution that then gets used by the Flight Management System and other systems on the airplane to provide this overall 4-D trajectory management," he adds.

While 4-D may seem like a futuristic concept, it is a realistic possibility within the next 5 to 10 years, and research continues. In 2013, the FAA commissioned MIT to study the ability of aircraft Flight Management Systems' to represent accurate information about the impact of wind on the aircraft's navigational path. Last year, NASA and air traffic management company Saab formed a new agreement to research the use of 4-D trajectory solutions to help reduce the highly congested

New York airspace system. Europe is also researching 4-D for its Single European Sky program, where in March 2014 Airbus, Maastricht Upper Area Control Centre (MUAC) and North European and Austrian Consortium (NORACON), performed a second 4-D flight trial from Toulouse to Arlanda airports. "The AEEC organization, in charge of producing ARINC standards, adopted in October 2014 an update of the ARINC 702A (Advanced Flight Management System)," says Thierry Harquin, head of systems sales at Airbus, and a member of the ARINC industries activities non-profit standards body. "This update, referred to as Supplement 4, introduces significant updates, such as accurate winds and temperature data definitions, enabling the implementation of 4-D trajectory within the Flight Management System." Research of future concepts such as 4-D trajectory and continued usage and analysis of the deployment of new procedures within the OAPM and other airspace system initiatives will lead to the continued NextGen enablement of navigation systems.

"I believe true utopia comes when all the initiatives have reached a critical mass. I liken it to the DOT building a new, bigger bridge along the highway. While they are building it, there are lots of lane closures or alternate routes to take, sometimes making the driver's commute more difficult. But once it is finished and all the lanes of the new bridge are open, it is well worth the wait," says Renk.

"Once NextGen has applied its work to communications, navigation and surveillance, and a large portion of the National Airspace System is using NextGen, I think it will be a big improvement for pilots and passengers alike.

Getting to that point, we see pockets of improvement but also still see business as usual where NextGen has not taken root or is missing key components."

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