

**Airbus Pegasus FMS for the
Airbus A330 and A320 Series
Technical Summary**

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1. OVERVIEW AND SYSTEM DESCRIPTION

With its current role in the aircraft, the flight management system becomes a primary player in the current and future CNS/ATM environment. Navigation within PBN/RNP airspace, data-linked clearances and weather, aircraft trajectory-based traffic management, time navigation for aircraft flow control, and seamless low-visibility approach guidance all are enabled through advanced Flight Management System functionalities.

The Flight Management System (FMS) provides the primary navigation, flight planning, and optimized route determination and enroute guidance for the aircraft and is typically comprised of the following interrelated functions: navigation, flight planning, trajectory prediction, performance computations, guidance and AOC/ATC data link functions. To accomplish these functions the flight management system must interface with several other avionics systems from the following generic categories:

- Navigation sensors and radios
 - Inertial/attitude reference systems
 - Navigation radios
 - Air data systems
- Displays
 - Primary flight and navigation
 - Engine
- Flight control system
- Engine and fuel system
- Data link system
- Surveillance systems

The Airbus FMS for the A320 series and A330 aircraft consists of two primary components: flight management computers and Multifunction Control Display Units (MCDU). As shown in figure 1 below which illustrates the A320 series FMS pilot interface, the system consists of two flight management computers that run two identical instances of the FM software and two MCDUs. The configuration of the A330 is similar with the addition of a third standard MCDU to the system.

The FMS on both the A320 series and A330 are Selectable Supplier Furnished Equipment (SSFE) with Airbus standard systems available from two suppliers: Honeywell and Thales. While the core FMS functionality is specified by Airbus, the two offerings from the suppliers do have features and functionalities that differ somewhat. Some differences that exist in the software are attributable to the development programs operating independently and not in lock step, and stem from the fact that one supplier, Honeywell, generally leads FMS innovation activities reflected by the Airbus award of sole source supply to Honeywell for its most recent new aircraft programs (A380, and A350).

The FMS card set hardware (the computer that runs the FMS software), MCDU, and various software components and databases including the Navigation Database used for flight operations with their FMS are unique to the supplier.

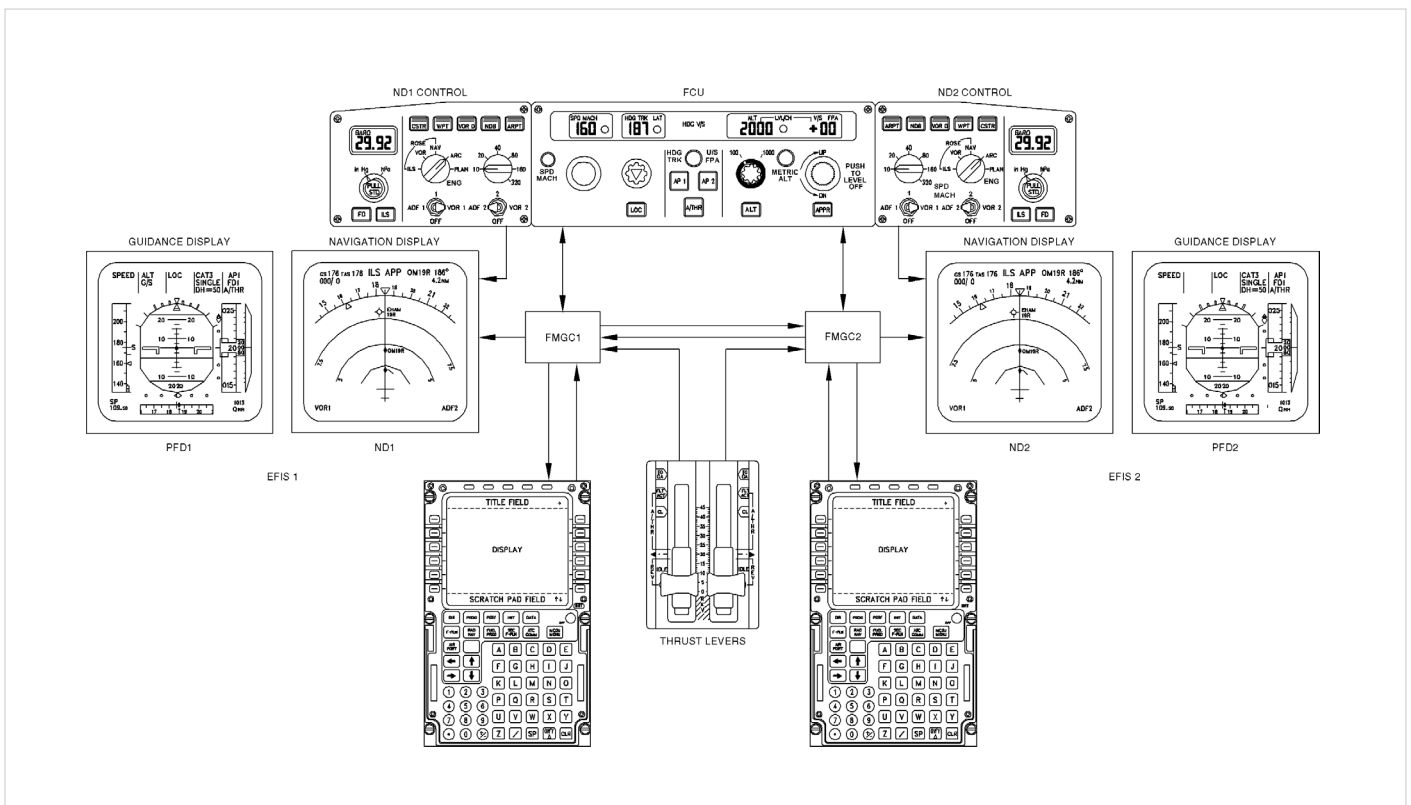


Figure 1: Airbus A320 FMS Pilot Interface

The flight management computers for the Airbus Pegasus FMS for the Airbus A320 Series and A330 are unique among Airline Transport Aircraft in that the FMS is a selectable (as opposed to sole-source). On the A320 Series of aircraft, the Flight Management function is hosted within the Flight Management & Guidance Computer (FMGC), and on the A330 series within the Flight Management Guidance Envelope Computer (FMGEC). On both aircraft types, there are two of these LRUs, each hosting and providing services (e.g., power, cooling, I/O, etc.) to a modular FMS card set that runs the FMS operational software.

The two instances of FMS operate in a redundancy management approach known as dual modular redundancy to provide backup in case of a single FM instance failure as well as providing independent assessment of the lateral and vertical trajectories. When the Honeywell FMS is selected/installed on a given aircraft, the Honeywell Pegasus FM card set is installed in both FMGC/FMGECs along with Honeywell supplied MCDUs. The standard configuration on the A320 series is two MCDUs and on the A330 there are three MCDUs in the standard shipset.

The LCD MCDU provides an interface between the flight crew and the Flight Management System (FMS) subsystem of the Auto Flight System (AFS) as well as up to five other aircraft avionics systems utilizing the ARINC 739 interface protocol. The LCD MCDU acts as a “dumb” terminal when used as an interface to the avionics systems, servicing one system at a time. During preflight, the LCD MCDU provides a means for the flight crew to enter flight plan route information and initialize performance parameters, such as airplane gross weight, fuel loads, and cruise altitudes via the alpha-numeric keyboard. During flight, the crew can call up FMS reference pages to review the airplane performance in terms of progress along the flight plan, fuel utilization, sequencing of waypoints, and time to go information. During normal operation the LCD MCDU communicates with the on-side FMS. In the event of an LCD MCDU failure, either LCD MCDU is capable of communicating with the off-side FMS. As an option, the MCDU can also host a backup navigation function that enables the aircraft to retain the flight plan and basic lateral navigation in the event of a dual FMS failure.

Figure 2 below shows the current version of the Honeywell FMS cardset (Pegasus II) and the LCD MCDU.

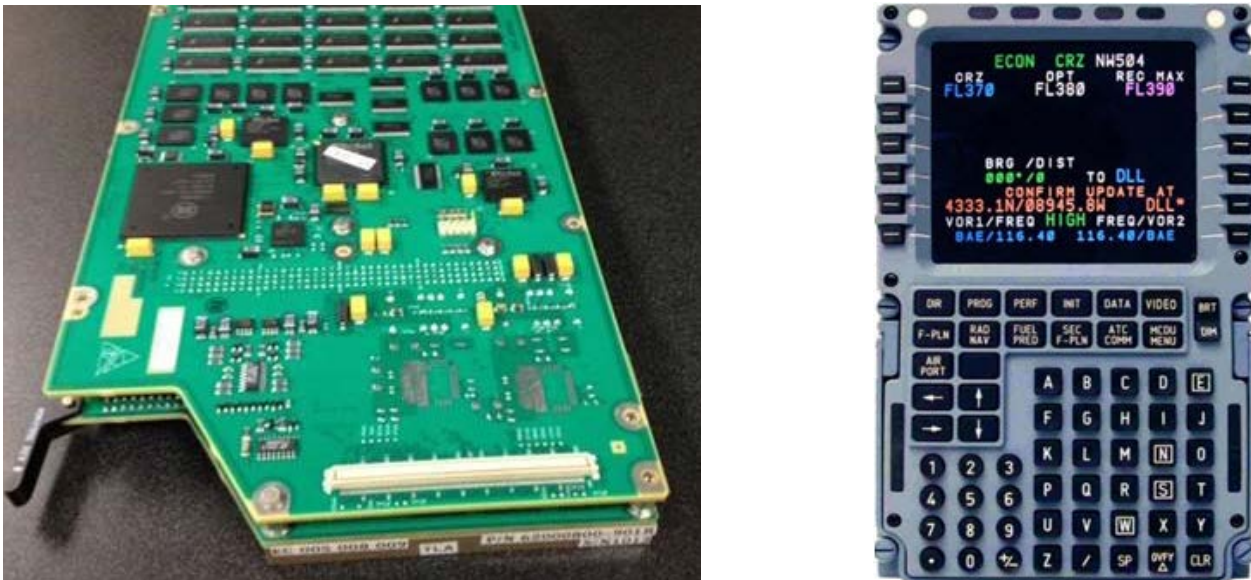


Figure 2: Airbus Pegasus II FMS Cardset and LCD MCDU

2. HONEYWELL PEGASUS II FM CARDSET COMPUTER AND LCD MCDU

Pegasus II FMS Card set Computer

In 2013, initial certification of the second-generation of the Airbus Pegasus FMS card set computer was attained on the A320 Series and subsequently on the A330 aircraft soon after. The Pegasus II is a redesign of the Honeywell FMS card set to provide significant improvements to an already highly reliable computer, as well as increases to processing power and memory to support functionality that will be required as worldwide airspace modernization initiatives transition to the implementation stage at the beginning of the next decade.

The Pegasus II design included the reduction of circuit card assemblies (CCA) from three in the original card, to a two CCA system that combines the processor and memory CCAs into a single circuit card. The elimination of one card improves reliability and reduces weight of each cardset through the reduction of components. The memory architecture, specifically the non-volatile storage on the cardset was modernized and the capacity increased. The Pegasus II card utilizes MRAM (Magnetoresistive Random Access Memory) which utilizes a method of storing data bits using magnetic charges instead of electrical charges which allows for persistent storage without a backup battery resident on the cardset. With the Pegasus I system, by far the most common removal for the card set was that necessitated by replacement of the onboard battery, so this design change with Pegasus II eliminates this source of required scheduled maintenance with the previous generation.

Along with the use of MRAM, the Pegasus II system includes a significant increase in the amount of physical memory to 512 megabytes total flash memory onboard the card. As of the most recent software versions, all FM software and databases consume just under 25MB, leaving 487 MB free, or 95.3% available spare. This spare can be used for increases in Navigation Database driven by the proliferation of RNAV SIDs and STARS, RNP approaches and other increases driven by the worldwide adoption of Performance Based Navigation (PBN). In the current FM software version the Navigation Database capacity is 20MB on both the Pegasus I and Pegasus II FM cardset hardware. In the next version of the software (Release 2) that capacity will be expanded to 64MB as an option. This will provide unparalleled navigation database capacity to support the expected growth in NavDB requirements without having to resort to data compression techniques, and a consistent database format across all the Honeywell Airbus FMS variants. This unique Honeywell capability enables operators of multiple Airbus platforms to reduce recurring navigation database costs through consolidation toward a single, across the Airbus fleet Navigation Database.

The Pegasus II card set also includes a change to the main processor. Keeping with the original and highly efficient single RISC processor design, the Pegasus II processor has been upgraded to the Honeywell 29KII processor. Like all RISC processors the 29KII has fewer transistors in its design, hence it requires less power to operate while generating less heat. The pipelined architecture of the 29KII rapidly executes instructions to provide a fast throughput. Each pipeline consists of independent circuits, and clock cycles synchronize the flow through the pipeline. These pipelines process several instructions simultaneously, where the instruction is at a different stage of completion in each stage. This effectively reduces the number of cycles required to process any instruction. Used in avionics where mathematically intensive calculations are required, this processor provides rapid execution of a wide range of mathematical operations that are particularly important with FMS performance predictions, descent path construction and other processor-intensive calculations.

The Honeywell 29KII is based on the AMD 29050 which was the leader amongst the 29K series of 32 bit microprocessors originally designed to directly compete with the Intel 80960 and Motorola MC68020/030. The AMD 29K series earned a reputation for being faster at most operations (clock for clock) than the competition and were extensively used in demanding applications including real-time avionics. The processor has three separate 32-bit buses for data, addresses and instructions referred to as a "triple bus" architecture.

The Instruction Bus transfers instructions into the processor, the Data Bus transfers data to and from the processor, and the Address Bus provides addresses for both instructions and data accesses. The address bus also doubles its functionality for transferring data to a co-processor. Since both the address and data buses transfer data, the Honeywell 29KII can transfer 64 bits of information to the co-processor in one cycle. A floating-point unit (FPU) provides single-precision and double-precision floating-point operations. There is independent divide and square root circuitry, which enables these functions to proceed in parallel with other operations. By assigning a special address space on the bus channel, a co-processor can attach directly to the processor. This permits the transfer of operands and other information on the address bus without interfering with normal addressing functions.

The Honeywell 29KII is manufactured by Honeywell as an ASIC (Application Specific Integrated Circuit) utilizing technology licensed from AMD. This approach provides not only a high performance processor, but also provides the advantage of protection against obsolescence as Honeywell is not reliant on a semiconductor supplier continuing the line. The Honeywell 29KII processor is utilized in a number of other avionics applications including the Boeing 777 AIMS, Airbus A350 and A380 Flight Management Computers, and the Boeing 737 Cockpit display system. Migration to the 29K2 processor provides the Airbus Pegasus FMS not only additional hardware resources to support next generation software functionality, it also ensures the system can be supplied and supported through the useful life of the platforms on which it is being installed today.

Early measurements of the improvements of the Pegasus II hardware versus the first generation have shown an approximately 30% improvement in FM response time to the user, particularly with the more processor-intensive FM tasks such as Performance Predictions. Flight crews can expect to get updated performance data upon a major flight plan routing change substantially faster with Pegasus II.

In addition, the changes to the hardware have resulted in significantly increased reliability, particularly with the removal of the battery, that have resulted in marked reduction in total cost of ownership over the aircraft lifecycle. In July of 2015, using data collected since the introduction of Pegasus II drawn from in-service experience from 29 airlines on A320 aircraft, an actual MTBF of the FMGC with Honeywell Pegasus II FMS was calculated at over 195K hours. This compared favorably to the actual MTBF of the A380 FMC on which the Pegasus II FM card set is based. This represents an approximately 10 times improvement over the calculated MTBF for Pegasus I and is truly remarkable performance for equipment subjected to the much higher cycle times encountered in narrow body operations and speaks to the value-add provided by the hardware refresh.

Lastly, the Pegasus II hardware enabled significant reductions in data loading with A615A Ethernet and FMS-to-FMS cross loading times which decreases the amount of maintenance time required to load operational software and databases on aircraft equipped with Honeywell FMS with the Pegasus II hardware, including reduction of Navigation Database load times of up to 80%, and total FMS cross loading duration reduced by 56%. Results of side-by-side testing of data loading performance of the Pegasus I and II cards is illustrated in Figure 3.

	Honeywell Pegasus I			Honeywell Pegasus II		
	Dataloading duration in A615A mode	Dataloading duration in A615-3 mode	Crossloading duration	Dataloading duration in A615A mode	Dataloading duration in A615-3 mode	Crossloading duration
FMS operational software	15 mins	30 to 50 mins	37 to 43 mins	4 mins	20 to 25 mins	12 to 14 mins
Navigation database (NDB)	15 mins	40 mins	15 to 18 mins	3 mins	10 to 15 mins	10 to 12 mins
Performance database (PDB)	N/A	8 mins	4 to 6 mins	N/A	7 mins	4 to 6 mins
Airline Modifiable Information (AMI)	N/A	3 mins	3 mins	N/A	1 min	1 min
Magnetic Variation Database (MAG VAR)	N/A	5 mins	3 mins	N/A	2 mins	2 mins
Operational Program Configuration File (OPC)	N/A	3 mins	3 mins	N/A	1 min	1 min
FIDO	1 min	2 mins	2 mins	1 min	2 mins	2 mins
Total	50 mins		64 mins	20 mins		38 mins

Figure 3: Pegasus II Loading Time Improvements

Airbus MCDUs

Like the FMS computer hardware, the MCDU for the A320 Series and A330/340 has undergone evolution as well. In the initial certification, older CRT MCDUs accompanied the Honeywell FMS standard.

In conjunction with but ahead of the Step 1A FMS software release, a new MCDU employing LCD technology was introduced that became both the forward fit standard (and remains so at the writing of this document), and available for retrofit of the legacy CRT devices with a more capable and reliable user interface device.

The original Honeywell LCD Multi-purpose Control and Display Unit (MCDU) supplied with the Honeywell Pegasus Flight Management System on Single Aisle Airbus A320 Series, and Long Range A330 and A340 aircraft remains a best-in-class product in terms of both functionality and reliability (current calculated MTBUR/MTBF is >50K flight hours / 100K flight hours respectively). That said, Honeywell continues to evolve MCDU technology to further enhance performance and reliability taking advantage of modernized components as well as gains in manufacturing technology.

The technology refresh to the MCDU which will culminate in it becoming the forward fit standard in mid-2017 takes full advantage of modernized components and gains in manufacturing technology while achieving form, fit and function equivalence with the previous LCD MCDU. The new, refreshed MCDU may be intermixed with either the previous generation LCD MCDU or the CRT. Through the technology refresh, the MCDU weight has been reduced by 22% and the power consumption by 15%. Although the current MCDU has achieved best-in-class reliability, it is expected that the technology refresh will result in continued gains in MTBF and MTBUR performance for the Honeywell LCD MCDU in these applications.

3. AIRBUS PEGASUS FMS SOFTWARE EVOLUTIONS

The Honeywell Airbus FMS software has undergone significant evolutions since the first version was certified on the A300/310 in 1986. In the 30 years of joint development of best-in-class FMS on all Airbus airline transport aircraft, many innovations have been incorporated in the baseline that has evolved into the current Pegasus FMS for the A320 series and A330, and the new derivatives that have become the standard (sole source) FMS on the Airbus A380 and A350. The driving force behind the feature and functionality insertions result from both changes within the airspace and innovations that result from Honeywell’s unparalleled breadth of airline transport FMS offerings and industry leadership. Figure 4 below provides a timeline showing the Honeywell Airbus FMS evolutions on the A300/310, A320 Series, A330/340, A380 and A350 covering the entire Airbus fleet, legacy and active model base.



Figure 4: Honeywell Airbus FMS Evolution Timeline

In its 30 years of FMS development partnership with Airbus, Honeywell has achieved a steady track record of achieving industry firsts in the airline transport aircraft industry across the Airbus fleet, establishing its leadership amongst Airbus FMS suppliers:

- First FMS certified on an Airbus Airline Transport Aircraft (A300/A310, 1986)
- First implementation of MCDU-less, graphical user interface with interactive Navigation Display on an airline transport aircraft (A380 2006)
- First implementation of Satellite Landing System (Airbus SLS providing Localizer Performance with Vertical (LPV) approach using SBAS GPS) as a forward-fit option on an airline transport aircraft (A350 2015)
- First implementation of a triplex FMS and Fail-operative RNP AR Approach capability (A350 2015)
- First implementation of FLS – FINAL APP co-existence which enabled Airbus FMS Landing System (FLS) and RNP AR approach capability to be enabled (A350 2015, A330 2016)
- First implementation of Continuous Descent Approaches (A350 2015, A330 2016)

As the A320 entered service in 1988, followed by the A340 and A330 entry into service in 1993 and 1994 respectively, the FMS standard (sole source) was the Honeywell FMS 1 or so-called Honeywell Airbus Legacy which was derived from the A300/310 FMS software. The hardware architecture of the Airbus A320 and A330/A340 Legacy FMS was similar to that of today’s Pegasus in that the FMS software ran on a card set computer that was contained by the legacy FMGC LRU.

A refresh of the Airbus Flight Management and Guidance System was undertaken in the late 1990s, culminating in the Honeywell FMS 2 or Airbus Pegasus FMS in conjunction with the introduction of the Thales 2G FMGC for the A320 series and the GENEPI FMG(E)C hardware. It was at this juncture that the Airbus decision to make FMS a selectable option began to develop into fruition. The modification of the FMGC/FMG(E)C required to support FM cards and software from two suppliers: Honeywell and Thales was undertaken. Thales developed its own FM card and licensed FMS software from GE, a derivative of the 737 FMS which Thales privately labeled as its TopFlight Flight Management System, an arrangement that continues to the present day for the A320 Series and A330 aircraft.

Upon the certifications of the FMGC/FMG(E)C with Thales FM card set/FMS software which Thales achieved significantly after the Honeywell FMS 2 certifications and second generation FMGC/FMG(E)Cs, FMS became a selectable option on the Airbus A320 series, A330 and A340, or SSFE – Selectable Supplier Furnished Equipment in the Airbus terminology.

The original Honeywell FMS certified as the sole source FMS at EIS is still in service on approximately 500 A320 series aircraft, and 135 A330/A340 at the time of the writing of this summary. The FMS 2, or Honeywell Pegasus FMS is currently in-service on approximately two thousand additional A320 series aircraft worldwide, and over seven hundred A330/A340 aircrafts. Honeywell FMS is being operated on A320 series aircraft at approximately two hundred airlines and other operators, and with approximately seventy five operators of Airbus long range wide-body aircraft.

Step 1 Program

The first Honeywell FMS 2/Pegasus FMS, known as the Step 1 program, certified first on the Long Range A330/A340 in fall of 2000 with subsequent certification on the A320 series in 2002. Along with improvements to the FM card set hardware made in the transition from Legacy to Pegasus and the next generation FMGC/FMG(E)C, there were several new software features and functions added to the common Honeywell Airbus FMS software baseline that is today's Airbus Pegasus for the A320 Series and A330/340. Those features and functions included the following that are part of the aforementioned evolution of the FMS from Airbus Legacy to Airbus Pegasus with the Step 1 Release:

- RNP Improvements including the storage of RNP values for each leg or a procedure in the navigation database and automatic population of those RNP values by the FMS
- Support for Radius-to-Fix (RF) legs to support Fixed Radius Paths (FRPs) used in terminal area approaches, RNAV (RNP) approaches specifically. The RF leg is defined by radius, arc length and fix. RNP systems supporting this leg type provide the same ability to conform to the track-keeping accuracy during the turn as in straight line segments. Bank angle limits for different aircraft types and winds aloft are taken into account in procedure design.
- Increased Navigation Database Capacity (up to 2MB) and improved loading/cross-loading of FM operational software and databases to improve maintainability
- Required Time of Arrival (RTA) functionality for cruise waypoints
- Increased the number of flight plan legs to 200 (165 origin-to-destination plus 35 to alternate airport)
- Added a Closest Airport page to display the 4 closest airports which automatically selected/displayed the 4 closest airports allowing the crew to select a fifth. The system would display the bearing, distance and time to go for each of the five closest airports, allowing effective wind to be entered and computing EFOB at each airport.
- Added IRS monitoring to the FMS which compared the FMS-computed position and the IRS position for each IRS. If the delta in position computation grew to exceed a threshold, the FMS would generate a MCDU scratchpad message to warn the crew that the IRS has abnormally drifted.

Step 1A FMS Software Program

The Step 1A program (referred to by Airbus as Release 1A), a software update to Step 1 to increase functionality of the Honeywell Airbus Pegasus FMS software culminated in certification on the A320 Series in 2009, and then on the A330/A340 in 2012. The Step 1A program included a minor software revision to support the Pegasus 2 FMS card set hardware introduced earlier in the document, after initial certification in the 2013 timeframe before forward fit production transitioned on A320 Series and A330. The A320 Step 1A program provided the initial software baseline for the A380 FMS derivatives that was adapted for A350.

The Step 1A software is the current forward fit standard for the A320 Series. As will be described in the next section, the A330-200 and -300 have very recently moved to the Honeywell Pegasus Step 2 release as the forward-fit standard.

Step 1A introduced a number of new FMS features that significantly added to the functionality and value of the Step 1 Pegasus FMS for both the A320 Series and A330/340 aircraft families:

- Increased the Navigation Database memory from 2MB to 20MB (on both the Pegasus I and II hardware) and transition to the Flex format, compatibility with other (A380/A350 FMS)
- Added required FMS support for RNP AR Approach with operations down to 0.1 RNP on final approach with automatic population of leg-to-leg RNP values from the Navigation Database.
- Added required FMS support for selection of GLS or MLS approaches from the Navigation database and adding them to the flight plan
- Added support for RTCA DO-236 Fixed Radius Transitions (FRTs). FRTs are the second Fixed Radius Path form similar to RF legs. The fixed radius transition (FRT) is intended to be used in en-route procedures. These turns have two possible radii, 22.5 NM for high altitude routes (above FL195) and 15 NM for low altitude routes. Using such path elements in an RNAV route enables improvement in airspace usage through closely spaced parallel routes.
- Added FMS support for multiple RNAV approaches to the same runway at the same airfield, addition of letter designation e.g., RNAV (GPS) Y Rwy 31L and RNAV (GPS) Z Rwy 31L
- IRS alignment on GPS: position entry for IRS alignment was now automatically populated with GPS position, when available. Improved safety and reduces pilot workload through automatic entry of initialization data.
- Improved fuel planning via the addition of the "MIN FUEL AT DEST" parameter on the Fuel Planning/Fuel Prediction pages. This parameter added display and modification of a minimum fuel quantity remaining at destination, with a default value being computed for the flight plan. Informs crew when the fuel on board is not sufficient, with the DEST EFOB BELOW MIN message when computed estimated fuel on board at destination is below default or pilot-entered minimum fuel.
- ARINC 615A Ethernet data loading
- Improved Offset entry and display for more deterministic flight path planning support for lateral offsets
- First stage in Take-Off Securization with Take-Off speed consistency checks and warnings if take-off speeds are lower than minimum speeds
- Separately-loadable (e.g., no longer embedded in the Operational Software) FMS Magnetic Variation database allowing future updates to Magnetic Variation table to be independently loadable/upgradeable without Operational Software updating.
- Added support for the LCD MCDU (replacement for original CRT)

Pegasus II hardware support was added after the initial certification in the 2013 timeframe as Pegasus II became the forward-fit standard on both A320 Series and A330, prior to the A330 transitioning to the Release 2 in early summer of 2016.

Release 2 FMS Software Program

Release 2 is the latest update program for the Airbus Pegasus FMS, with certification attained on the A330 aircraft in the second quarter of 2016 followed soon after by it replacing Step 1A as the Honeywell forward fit standard for the A330-200/330. The Release 2 software for A320 Series has been underway as well and will certify in the second quarter of 2018 and replace Step 1A as the Honeywell forward fit standard for the Airbus narrow body.

The Release 2 program is the evolution of the Honeywell Pegasus FMS for the Airbus A320 Series and A330 aircraft, being the third major Airbus Pegasus FMS software release and taking full advantage of FMS innovations that have been accomplished in partnership with Airbus on the other platforms, the A380 and most recently the A350. As outlined previously, the unique FMS supplier position that Honeywell established with the certification of the first FMS on an Airbus air transport platform with A300/310 in the mid-eighties continues to the present with Honeywell alone providing the FMS on A380 and A350, while sharing an FMS supplier position on the A320 Series and A330 today, as well as providing the first FMS certified on A340 as well.

Honeywell fully leverages that unique position by sharing innovative FMS software features and functions amongst the platforms, consistently chosen by Airbus for the leadership role in the development of new FMS capabilities that deliver significant value to airline operators.

There are two tangible examples of this principle that are clearly evident in the Release 2 program with Honeywell certifying both the FLS-FINAL APP co-existence and Managed Continuous Descent Approach (CDA) features, originally certified on the A350 at entry into service, in the Release 2 FMS certification attained on the A330 in March of 2016, and becoming the forward fit standard in June of the same year.

Coexistence of FINAL APP and FLS solved a crucial problem with the FMS having the capability to support the Airbus FMS Landing System (FLS) and RNP AR (which requires FINAL APP mode) approach selection. In Release 2, modifications to the APPR (Approach) page is modified to allow the crew, upon selection of an RNAV final approach, to designate whether the aircraft will fly the FLS mode (straight-in only), or FINAL APP mode which is required for flying the RF legs frequently present in RNAV (RNP) procedures. In Release 2, Honeywell added full support for Airbus FLS option (functionality activated by OPC option) and mixed LOC/VNAV – which enables flying an ILS localizer with glide slope out, using the barometric VNAV provided by the FMS for vertical guidance but through the FINAL APP and FLS coexistence capability originally developed for A350, allows full support of both FLS and RNP AR through the FLS/FINAL APP selection option on the APPR page.

With the managed CDA feature enabled (functionality activated by OPC option) in Release 2, the deceleration and configuration extensions towards the landing configuration are performed along a descending segment using idle thrust while avoiding decelerations in level flight. This strategy allows reducing both fuel burn and noise which can be significant in level decelerations at lower altitudes. This new construction is applied on all approach types: precision, non-precision and APV (e.g., LNAV/VNAV). The addition of a Managed CDA capability is in preparation for ongoing airspace modernization efforts such as SESAR in Europe and NextGEN in the US both of which intend to increase the usage of CDA procedures.

Some attributes of the CDA strategy are outlined below:

- The approach profile is built without level segments, except if required by published altitude constraints
- Starting points of configuration extension (CONF1 and CONF2 pseudo waypoints) are computed and displayed on MCDU and ND
- Aircraft energy at pseudo waypoints CONF1 and CONF2 is monitored with additional queues provided to the crew to provide timely response to maintain the aircraft on path and on speed
- Vertical guidance is improved to fit with the Continuous Descent Profile

The CDA implementation includes the creation of new pseudo-waypoints that assist the crew in optimal deployment of high-lift devices during the descent. Two new pseudo-waypoints are defined: CONF1 and CONF2. They are displayed on FPLN page of MCDU and ND to provide queues to the crew. MCDU scratchpad messages are also utilized during the Managed CDA to provide the crew with timely information to make necessary adjustments when necessary to manage energy on the computed path.

Other content in Release 2 certified on A330 at the time of the update of this summary:

- SWAP of Active and Secondary Flight Plans. A new option was added to the SEC (Secondary) page which allows copy of the active flight plan to the Secondary and vice versa. This enhancement changes the previous behavior that would result in the loss of the active flight plan upon promoting the Secondary to Active.
- Modification of descent managed speed. In response to operator feedback requesting this feature, Release 2 modified the behavior in DESCENT mode with respect to the Managed speed. In previous standards, once in DESCENT mode the Managed MACH/CAS could not be modified. ATC will often assign speeds to aircraft during descent to manage separation, and adding the ability to adjust managed speed in accordance with ATC instructions without leaving DESCENT mode was a common request. Release 2 add the ability to modify managed MACH/CAS in Descent.
- (Direct To clearance) DIRTO Improvements. In Release 2, during DIRTO with Abeam operations, constraints that were assigned to the actual waypoints are applied to the abeam waypoints as well and display of the real TO WPT on ND upper right corner and not the next Abeam'ed waypoint which is a pseudo waypoint created by the FMS and not in the Navigation Database. With Release 2, DIRTO temporary flight plan vectors are displayed on both NDs versus in previous versions where the temporary flight plan vector was displayed only on the ND of the crewman that entered the DIRTO (captain or first officer)
- Restrict QNH format in PERF APPR page to avoid erroneous entries of temperature values within the QNH range in the QNH field.
- Larger Navigation Database Size Allocation (up to 64MB Minimum) – Optional functionality. For aircraft with Pegasus II FMS cardsets (with expanded physical media) Release 2 added the ability to increase the Navigation Database from the standard 20MB to an optional 64MB to enable a worldwide navigation database with no constraints to be accessed by the FMS. Targeted to freight and VIP operators that may operate the aircraft on a worldwide basis to allow loading of one navigation database at each cycle and operate the aircraft worldwide with no restrictions. With this option enabled, the Navigation Database capacity on A320 Series and A330 with the Pegasus II FM Cards would match that of the A350/A380, enabling operators to move to a single Honeywell navigation database for the entire Airbus fleet.
- Improvements to the accuracy of the Take-Off Securitization functionality calculations

As the Release 2 program for the A320 series progresses, in addition to the features outlined above that have already certified on the A330 several additional new features and functionalities will be added to the A320 series release and certified as currently planned for the second quarter of 2018.

First and foremost, the A320 series Release 2 certification will include a certified Initial 4-Dimensional Trajectory Based Operation (i4D TBO) capability that will enable Honeywell FMS-equipped aircraft to participate in the SESAR Very Large Scale Demonstrations (VLSD) expected to begin in late 2018 within EUROCONTROL airspace. The initial 4D TBO functionality combines a very accurate full-phase RTA (e.g., Required Time of Arrival constraint in climb, cruise or descent), with the FMS able to consistently achieve arrival at a waypoint within +/- 10 seconds to safely reduce a/c spacing, increase airspace capacity and optimize inbound arrivals to the busiest airports. Honeywell has been a participant in the SESAR i4D development program, the only US-based avionics supplier with full membership in the SESAR Joint Undertaking which commenced in 2007. Honeywell has developed prototype FMS solutions on the Airbus Pegasus FMS that very successfully completed demonstration flights of the i4D capability allowing the program to progress to the VLSD stage with aircraft equipped with certified FMS and datalink capability required to demonstrate the SESAR 4D TBO in operations of scale. The VLSDs of i4D are a critical step in realization of one of the lynchpins in the SESAR airspace modernization effort.

In addition to the i4D functionality, Honeywell will be including three additional enhancements to the Release 2 certification on the A320 series. The decision to add these features to Release 2 was driven by Honeywell Airbus Pegasus FMS operator input and in some cases, to attain parity with the newer Honeywell A350/A380 FMS baselines. The addition of these features based on Airline input while leveraging functionality developed in other baselines which again are a Honeywell Airbus FMS differentiator. The remaining features to be added to the A320 series FMS in the Release 2 program are outlined below:

- Increase number of active flight plan legs to 250 total (215 to destination, 35 to alternate). This is in response to increasing number of waypoints in the flight plan with RNAV departures and arrivals and the increasing mission profiles of the A321 variant.
- Increase the number of down-path transitions displayed on the ND. Current Pegasus releases are constrained to displaying the “next two” transitions on the ND map. Release 2 enhances that to include all down path transitions to assist the crew in visualizing increasingly complex terminal area procedures.
- Entry of temperatures at four flight levels at each cruise waypoint, instead of the current single temperature entry for each waypoint. This improves the atmospheric model used by the FMS performance predictions in accounting for real-world temperature variations that occur, in some cases lowering the tropopause below the ISA standard of 36,000 feet.

4. SELECTION OF HONEYWELL FMS FOR NEW AIRCRAFT DELIVERIES

As outlined in detail throughout this paper, since the FMS 2 program began the FMS on new A320 series and A330 aircraft deliveries is classified as Selectable Supplier Furnished Equipment (SSFE). This means that the operator will designate as part of the Aircraft Selection process its choice for FMS configuration, Honeywell or Thales for each new aircraft delivery.

One common area of confusion regarding this process is how the desired FMS configuration is indicated. Recall that the FMS itself is run on the FM card set from the selected supplier that is hosted in the FMGC (on A320 series) and in the FMGEC on A330. Therefore there is no Honeywell LRU-level PN associated with Honeywell FMS on either aircraft type. It is a subassembly of the FMGC/FMGEC. Therefore as shown in the figure below which is an excerpt from a recent Airbus System Configuration Guide for the A320-200neo, the designation of Honeywell FMS is selected through the appropriate FMGC PN for the selected engine supplier. Note that the MCDU PN however, is the Honeywell LRU PN for the Honeywell LCD MCDU.

22 Auto flight		A320-200neo						
Table 22-2 - Technical solutions description								
TDU	Title (Remarks)	Appl.	Weight (kg) MWE/OWE/APL	Equipment reference	Equipment supplier	Equipment PN	QTY	STS
Std	FM kits (Rel. 1A - FMGC H2BP1XX) / MCDU altern. equip - HONEYWELL assoc. with PW engines	A320-200N		Flight Management Guidance Computer (FMGC)	THALES AVIONICS S.A. / HONEYWELL	C13207DA00	2	SFE
				Multipurpose Control and Display Unit (MCDU)	HONEYWELL INC.	4089740-961	2	SFE
Std	FM kits (Rel. 1A - FMGC H2BPCXX) / MCDU altern. equip - HONEYWELL assoc. with CFM engines	A320-200N		Flight Management Guidance Computer (FMGC)	THALES AVIONICS S.A. / HONEYWELL	C13207CA00	2	SFE
				Multipurpose Control and Display Unit (MCDU)	HONEYWELL INC.	4089740-961	2	SFE

Figure 5: Airbus System Configuration Guide showing FMS Options

5. SUMMARY AND CONCLUSION

Honeywell enjoys a unique position amongst all FMS suppliers in its position of providing the FMS on virtually every airliner that has come into service since the first Honeywell FMS was certified on the Boeing 757/767 in the early 1980s. Since certifying the first FMS on the Airbus 300/310, Honeywell has supplied an FMS on every Airbus airline transport platform with the first certifications on the A320 series, A340 and A330 and attaining sole source FMS supplier positions on the A380 and most recently on the A350.

In the process Honeywell has established itself as the Airbus partner of choice for FMS development and innovation, achieving a series of Airbus aircraft and industry firsts that continues to the present day with several Honeywell-led innovations included in the recently completed Release 2 certification on A330 that will go on to certify on the A320 Series in 2018. Honeywell continues to innovate and invest in the Airbus Pegasus FMS delivering new value-added functionality while continuously improving the reliability of the system preparing it for service well beyond the end of the next decade.

Throughout its thirty years partnering with Airbus on FMS development Honeywell has also continued to invest in not only the FMS software, but also the associated hardware. The recent refresh to the FM card set to the Pegasus II version has significantly increased reliability, performance and capacity, as well as maintainability again leveraging the advanced hardware designs utilized on the A380/A350 Flight Management Computers (FMCs).

In summary, the features, functionality and cost of ownership of the Honeywell Airbus Pegasus FMS for the Airbus A320 and A330 is the best-in-class FMS for airlines worldwide.

Abbreviations

AFCS	Automatic Flight Control System
AOC	Airlines Operational Control
ARINC	Aeronautical Radio Incorporated
ATC	Air Traffic Control
ATM	Air Traffic Management
CNS	Communication, Navigation and Surveillance
GLS/GBAS	Ground Based Augmentation System
FLS	(Airbus) FMS Landing System
FRT	Fixed Radius Transition
GBAS	Ground Based Augmentation System
GPS	Global Positioning System
GNSSU	Global Navigation Sensing System Unit
FMS	Flight Management System
ILS	Instrument Landing System
IRS	Inertial Reference System
LCD	Liquid Crystal Display
LOC	Localizer
LRU	Line-replaceable Unit
MCDU	Multifunction Control Display Unit
MMR	Multi-Mode Receiver
PRAIM	Predictive Receiver Autonomous Integrity Monitor
RF	Radius-to-Fix
RNAV	Area Navigation
RNP	Required Navigation Performance
SBAS	Satellite Based Augmentation System
SSFE	(Airbus) Selectable Supplier Furnished Equipment
VNAV	Vertical Navigation based on barometric altitude

For more information on Honeywell's Airbus Pegasus FMS please contact your Honeywell sales representative or call +1 800 601 3099 or +1 602 365 3099.

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