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N2130: A NEW REGIONAL AIRLINER FOR THE 21st CENTURY

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Abstract:

Forecast of air traffic growth indicates a requirement for a means of transport capable of providing optimum regional service. In the past, major aircraft manufacturers many times offered a shortened derivative of their design to meet this requirement which tends to unnecessarily increase the operating cost. IPTN is directing the N2130 to be an optimal solution for the future requirement of a 'true' 100 seats regional class airliner. The N2130 is incorporating some new technologies in order to achieve an optimal solution, delivering low ownership and operating cost while at the same time alleviating the environmental concerns through the use of an appropriate propulsion system.

Within a life span of an aircraft type, which is over roughly 40 years, the development phase is the crucial one. During this period, the program is defined technically and thus most of its operating cost determined. This paper will discuss some of the design consideration and the technology features, which have been matured during the conceptual and preliminary design phases.

Introduction

The N2130 programme was formally launched by the President of the Republic of Indonesia on 10th August 1995 on the occasion of the N250 maiden flight, the 64-passenger turboprop airliner. The N2130 programme is scheduled to be IPTN's next vehicle in developing a mature strategic aerospace industry into the next century. IPTN's experiences gained during the last three major aircraft programmes will be used to establish an integrated design and manufacturing process to produce an aircraft that is hoped to be the best solution for regional requirements, the N2130 airliner for the 21st century.

The Asian crisis, which was initiated from Thailand, has also reached Indonesia and to some extent caused some disturbance to the N2130 programme. However, there is a strong believe that Indonesia could stand on against this economic turbulence. Several months have passed, the crisis seemed to have reached the bottom, and with the reformation acts by the governments within the region, the economic recovery is underway. The Asian economics once again will be even stronger shortly beyond the year of 2000. As the business is predicted to be booming again, the market of the N2130 will gain momentum. Acknowledging this vision, PT. DSTP, the private funding company has decided that the programme should progress with only some minor adjustments.

Motivation and Objectives of N2130 Programme

Indonesia as an island nation stretches as much as 3000 miles from the most western to the most eastern point embracing more than 17000 islands, requires a reliable system in supporting communication and transportation need. Without an appropriate means of transportation, a nation of the size and geographical situation like Indonesia will be very difficult to manage its daily socio-economic life. The increasing activities in initiating and managing new businesses and ventures combined with the interest to discover and explore the rich different cultures for tourists across Indonesia have caused air traffic to grow both for passengers and airfreight. In addition to that, the need of the nation to defend the country should obviously be supported by an appropriate air supply such as logistic transportation and maritime patrol. These facts generate strong confidence for the nation in embarking upon a national aircraft industry, which will prospect from the domestic market as a basis to enter the world market.

Since the establishment of PT IPTN in 1976, three major turboprop aircraft programmes i.e. NC212, CN235 and N250 were successfully completed within the strategy drawn for transformation of technology, aiming to develop the nation technological capability and transforming Indonesia from an agricultural based to an industrially based country. The production of NC212 was under licence, marked the phase of technology acquisition through a progressive manufacturing plan. The technology integration, aircraft concept design and production of the CN235 within an international co-operation formed between CASA-Spain and IPTN marked the second phase. The third phase, the own development of existing and new technology into a new design and production, was accomplished during the N250 programme, which has made its successful maiden flight in August 1995 and its international debut at the Paris International Air-show 1997. The initiation of programme N2130, the new regional turbofan aircraft, beside of completing the industrial transformation of Indonesia is also strongly driven by the market requirement for regional airliner which is needed by the 21st century.

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Having the clear indication of the strong domestic market prospect, the next task is to forecast the size of the passenger traffic in the first decades of 21st century and to identify what size of aircraft would be appropriate in order to have an optimum load factor. Extensive studies conducted by IPTN have identified requirements for a sizeable number of aircraft with 100-130 seats in the next 20 years as shown in the figure 1 below. The market analysis for regional jet 100-130 seat is showing the requirement of about 3237 aircraft. It consists of 2181 aircraft with 100 seats and 1056 aircraft for 130 seat. Regarding those numbers, 170 aircraft are requirement for domestic market.

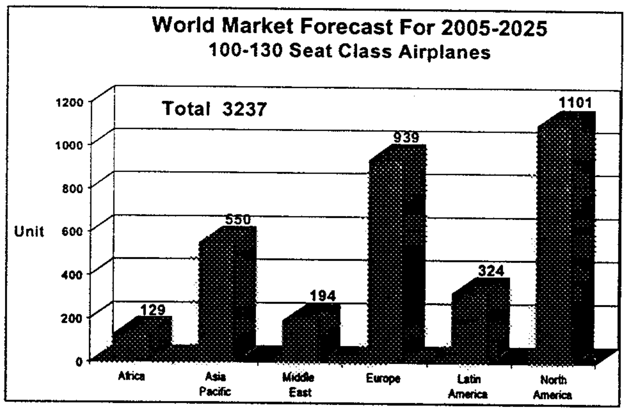

Figure 1

This requirement of dedicated 100-130 seat aircraft seems to be long ignored by major aircraft manufacturers, as figure 2 shows a vacant niche for typical aircraft of 100-130 seats. There are only several aircraft were built in this class, such as B737-200, DC9 and Fokker 100. These aircraft however are shortened derivative of their design to meet this requirement which tends to unnecessarily increase the operating cost. With Fokker have already out of business the niche is even look promising. Currently, there are three companies involve in production of aircraft to fulfil the market of this class. They are Boeing with B737-500/600 and MD87, Avro Aerospace with RJ-85 and RJ-100 and marginally Airbus with A-319. By assuming an equal share of market available of 3237 aircraft, IPTN will obtain about 808 aircraft which is look bright since 170 of them are domestic use.

It should be noted that the regional airline's capability to continue and expand its route coverage is heavily based on increasing the efficiency of its transports, hence any replacement aircraft must have low ownership and operating costs. These cost requirements can only be met by a new aircraft design optimised for a particular passenger configuration. IPTN, with a skilled work force at very competitive costs compared to other manufacturers, will obviously be in a position to deliver these.

The launching of the N2130 programme at this decade will undoubtedly benefit from the advancement in technology. Many applications of the best available technologies in the aircraft can bring an optimal solution of configuration and better performance. The requirement of cleaner and greener aircraft for example will support the future environmental regulation which will be more stringent in the next century. This requirement has made the future of some aircraft less bright since their design is still based on old technology, which might fail to meet the future challenge. For example, engine manufacturers are currently investing a lot of their resources in order to produce an engine that will suit the future requirement. Recognising this fact, the N2130 is benefiting from the advancement of technology and allowing to integrate a state of the art power plant which has low noise and clean emission that meets the anticipated 'Stage 4' requirements. The application of better technologies in the N2130 is also taking place in aircraft system, avionics etc.

Driven by those motivations, the main objectives of the program N2130 was then drawn, i.e. to design and produce aircraft to satisfy current and future requirement for 100-130 seat class turbo fan powered regional aircraft. In summary: the new aircraft will incorporate best technologies for the optimal configuration, delivering low ownership and low operational cost while alleviating environmental concerns using an appropriate propulsion system. It shall serve for the purpose of passenger and cargo transportation.

Program Development and Implementation

As mentioned earlier, the N2130 programme was formally launched on 10th August 1995, however the actual programme have started in September 1994, starting with the N2130 Technology Programme (see figure 3). Currently the programme is on its course to complete the preliminary design. Detail design is also already commenced which will be followed by design part manufacturing in 1998. Some tests for development have also already commenced, starting from aerodynamic tests, e.g. testing of configurations in high-speed wind tunnels and some structural tests e.g. wing box etc., are also underway. In general the programme is well on its way with several results that were also delivered.

During the N2130 Technology Programme, feasibility studies, market survey and high level of advanced technologies were studied to ensure the N2130 will be a state-of-the art aircraft when it is operational in the year 2004. In the feasibility studies, the N2130 programme is justified from several factors such as market analysis, existing competitor, production capability, environment impact on production, as well as financial matter. Positive outcome was drawn from feasibility studies, brought a firm determination to pursue the programme

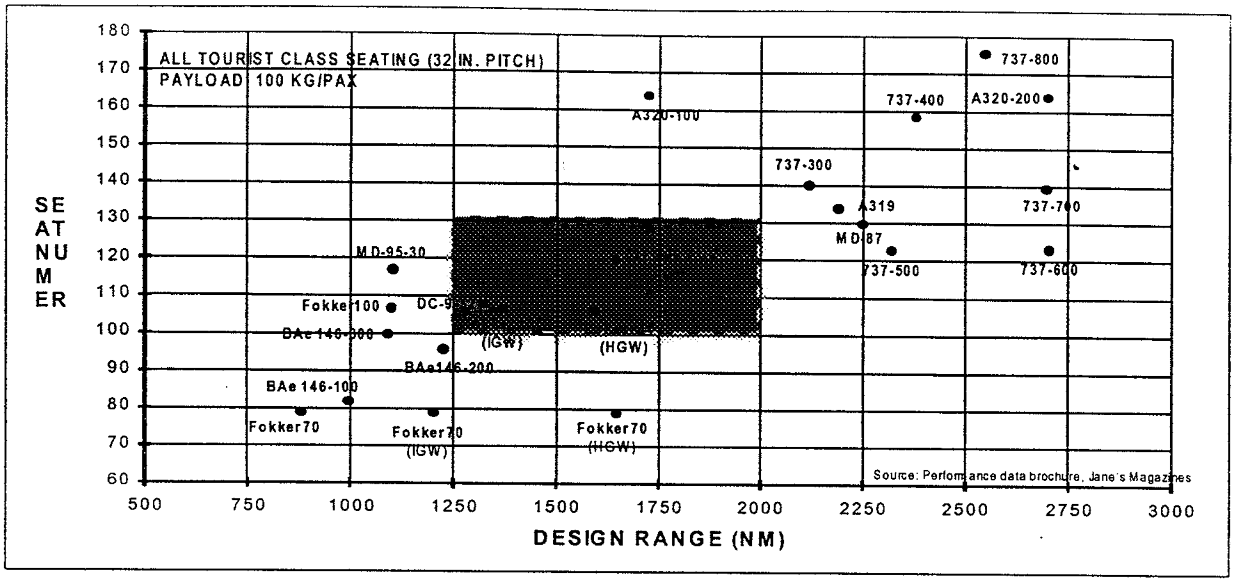

Figure 2

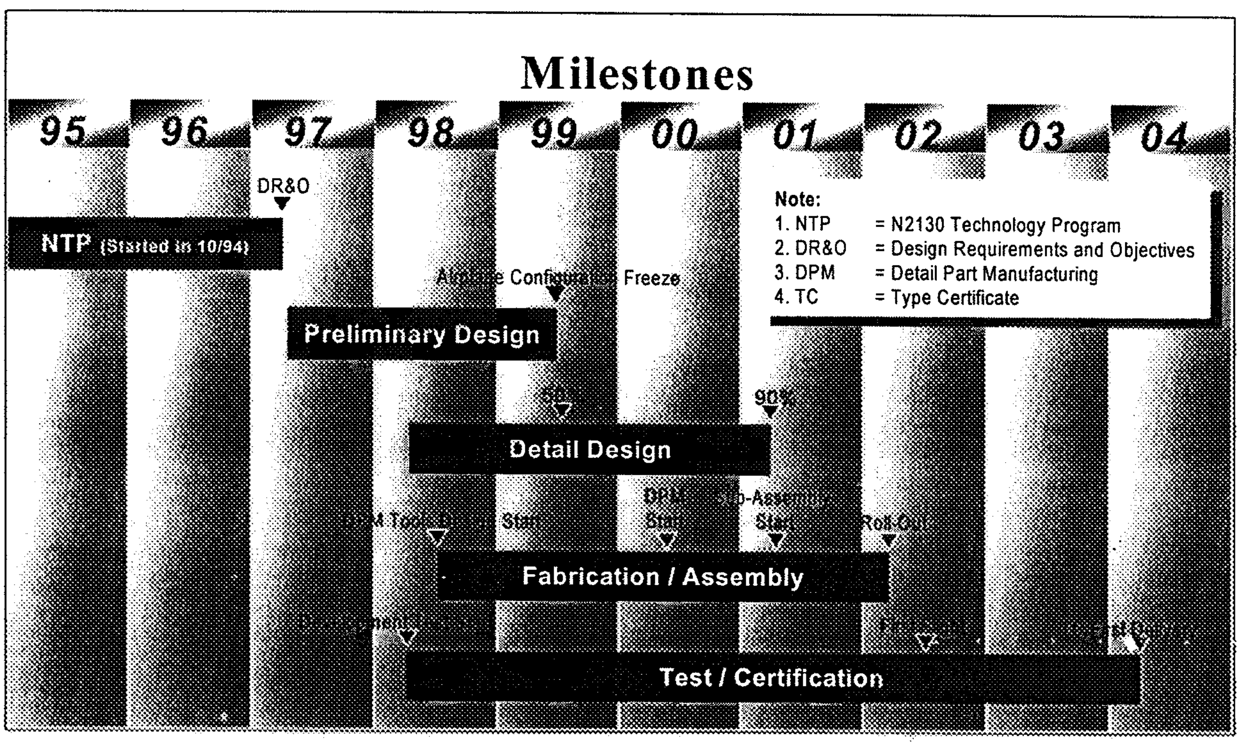

Figure 3.

Many advanced systems that are still in the developmental stages were examined to analyse their benefits on the development of advanced technologies applied in N2130's design. As a result of these extensive studies, Design Requirement and Objectives were drawn, at the end of the Technology Programme in April 1997. Some basic features of the DR&O are presented in the table 1.

The preliminary design stage is currently underway to translate the DR&O into a product. The N2130 design team, which consists of engineering, production and computing support are collocated in the N2130 design centre working in a product oriented environment coordinated and controlled by a Chief Engineer.

Product definition of the aircraft will be stored in the form of 3D digital data. This will allow a virtual pre-assembly of design parts and hence all interference and interfaces can be checked and modified accordingly in an early design phase. Moreover, a single source digital database will be used as a common interface to engineering analysis, design software, production and program management.

The processes of product definition are carried out concurrently on the N2130 design centre, where key person from engineering, manufacturing, material finance and customer services are collocated.

	N2130-100	N2130-200
Payload	114 ATC @ 32" seat pitch	132 ATC @ 32" seat pitch
	At 100 kg/pax with baggage	
Max Payload	114pax+2500kg	132pax+ 3000kg
Seating Layout	6 abreast	
Crew	2 pilots 4 cabin attendants At 100 kg/pax with baggage	
Range	1600 nm	
Altitude	35000 ft	33000 ft
Speed	0.8 Mach	
Climb	Direct climb to 35000 ft at MTOW	Direct climb to 33000 ft at MTOW
Take off & Landing	1750 m S/L ISA + 18°C (wet)	1750 m S/L ISA + 18° C (dry)
Power plant	Two turbofan engines	
Pressure	8000 ft cabin at 39000 ft	

Table 1

Design Philosophy

To ensure that the requirements and objectives discussed previously are satisfied, there are several design development processes adopted for N2130. The first of which concerns the continuous monitoring of customers' requirements, which are collated into an extensive database. An Airline Working Group for N2130 has been formed to forge information that can be used to optimise various design parameters and performance definitions. IPTN is a firm believer that early and on-going communication with potential customers is a key to a successful N2130 programme. Thus, during the conceptual design phase, inputs from industry combined with results from trade-off studies have been integrated into the early configuration. Upon the successful completion of the conceptual design phase in March 1997, the N2130 program plans to further enhance the communication through having established the N2130 Airlines Working Group (AWG).

With the direct participation from potential customers, the N2130 specifications will be further developed. It is planned that the outcomes of the AWG will be a defined e.g. N2130 Standard Configuration, Standard Options and Airlines Specific Options. The Airlines Working Group (AWG) is divided into four groups; the AWG-Flight Deck, the AWG-Payload, the AWG-Systems and the AWG-Propulsion. AWG members are representatives from Airlines, Major Vendors (Engine and Avionics) (Once they are selected) and IPTN.

Periodical updates on airlines' requirements will also provide seasonal inputs for the design process thus enabling the N2130 to be configured in such a way that takes into account, as much as possible, changes in passenger demands.

The "big aircraft in a small plane" design philosophy adopted by IPTN at the outset, drive the N2130 programme to achieve the high functionality and efficiency by integration of advanced technology in aerodynamics, materials and structures, propulsion systems, and aircraft systems. The applications of these technologies are achieved through extensive studies involving their suitability, reliability and their overall level of integrated performance.

Rapid iterations to optimise each structural sub-assembly are made possible through the application of an integrated digital process linking design groups with production and assembly facilities. Design cycles will be reduced by concurrent engineering and minimising the possibilities of future manufacturing, assembly and installation problems through the use of Digital Mock-up and Pre-Assembly. These capabilities are developed using experiences gained during IPTN's previous aircraft programmes and various sub-contract works.

Completing the synergetic relationship between regional airlines and IPTN are the aviation authorities whose stringent requirements ensure a high level of safety. By involving FAA, JAA and Indonesia's own DGAC (Directorate General for Aviation Civil) early in the design stage, the N2130 will be developed along current and future safety requirements and it will provide the authorities with an in-depth assessment on IPTN's capability of designing, developing and producing a quality product. This strategy will also help to ensure that N2130 will be able to obtain type certification in time for its first delivery to the aircraft's launch customer.

One ultimate objective of the N2130 programme is to design to the market. By achieving this primary goal, it will be an optimal solution for future regional airliner requirements and offered with a competitive operational and ownership cost structure.

N2130 Technical Details

Aircraft Configuration

In an effort to cover the varying passenger load specifications for airlines requiring a 'true' 100-pax class aeroplane, the N2130 is being presented with a family concept, covering 100 to 130 passenger specifications.

However, although the N2130 family will be able to cover a range of passenger loads, the efficiency of the designs are guaranteed through choosing a basic configuration (a 100-pax design) that optimally covers the specified range.

Two versions are at the moments being considered to be offered: a Basic Gross Weight (BGW) and an Increased Gross Weight (IGW) version. The basic and extended version of N2130 performance on payload –range diagram is presented in figure 4. It is basically showing the capability of the N2130 using a maximum fuel of 12650kg (no centre tank) performing the optimal configuration for a predefined payload and range. For example, for N2130-100 BGW, with payload of 13200kg will be at the optimum use for a range of 1650nm.

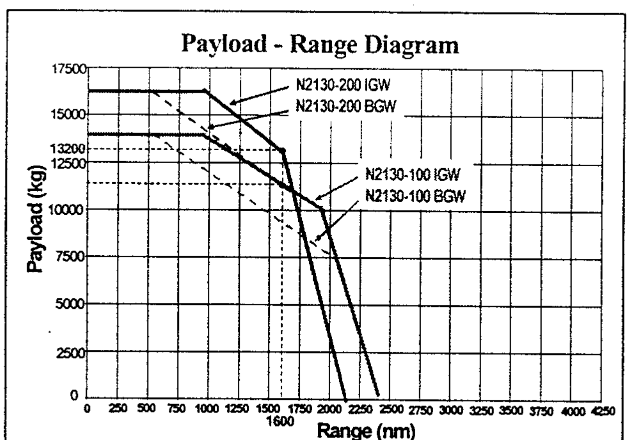

Figure 4

The main performance characteristics for N2130 are defined in such a way that can provide a high degree of operational flexibility for airlines operating in congested skies.

Requirement for speed has been increasing through the years and to anticipate the necessary condition in the 21st century, the N2130 is designed to cruise at 0.8 Mach. The operational implication of the cruise speed is important for the trip time duration and therefore for the aircraft productivity (number of flights per day).

The high cruise speed will also give higher flexibility regarding communality with other aircraft being used for the same routes, figure 5 presents the speed comparison of N2130 to some other aircraft in its class. In addition to that benefit, faster aircraft usually have priority regarding landing/approach queuing compared to slower ones to air traffic control (ATC) in a congested situation.

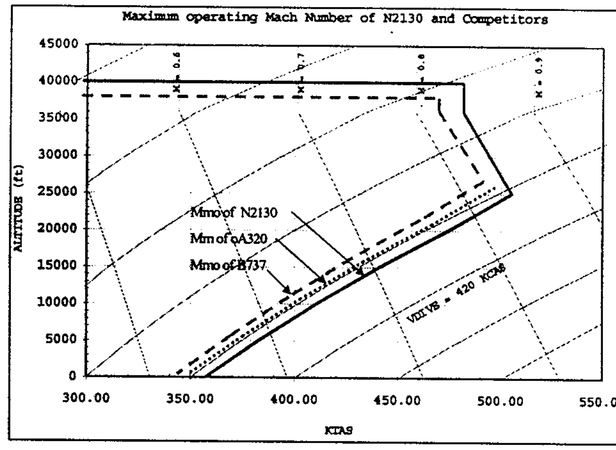

Figure 5

A typical mission profile is given in figure 6 which shows the ability of N2130 in escaping congested sky levels as quick as possible by climbing directly to 35 000 feet

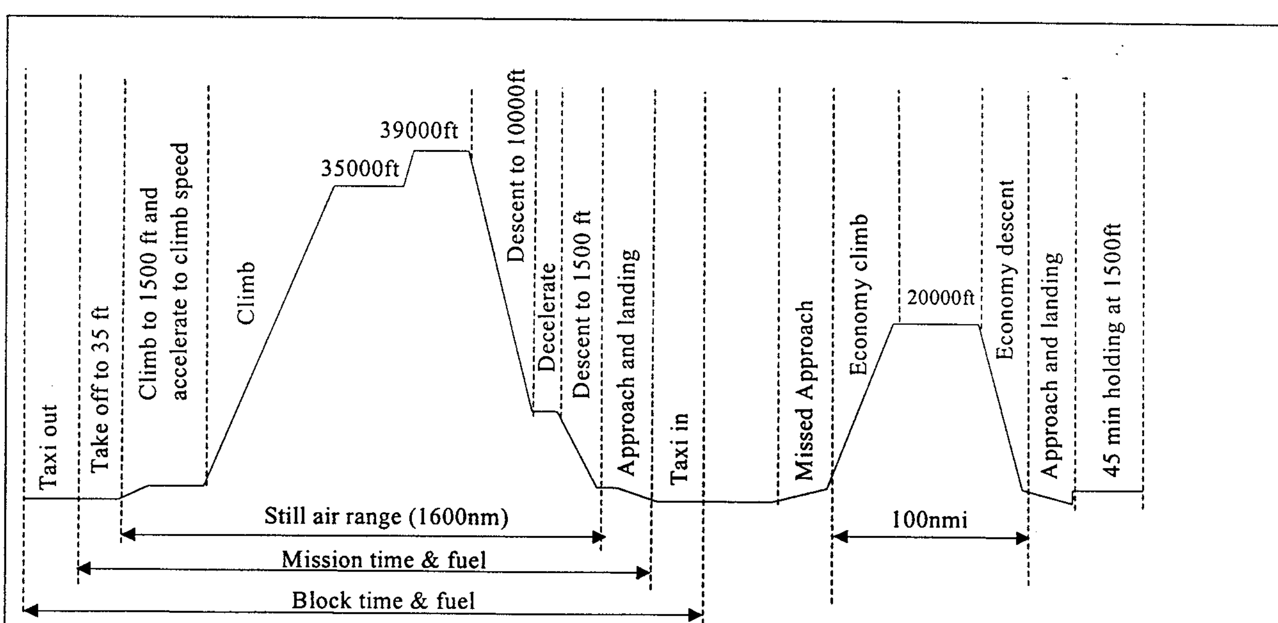

Figure 6

Cabin Interior

As air travel become a more frequent occurrence for many business and tourist passengers, interior comfort features are high on the airlines' list of requirements. Moreover, as general standardisation happens in aircraft design, all aircraft will be more or less looking very similar to any passenger who know little about aircraft. From this angle, the cabin interior is one of the few significant opportunities that allows the airline to differentiate themselves from one another when it comes to visual impressions. The N2130 welcomes this specific situation and because of that, some options on cabin components such as variable geometry/convertible seats, movable class divider, modular PSU, sophisticated entertainment system with liquid crystal displays will be provided to be tailored by the airline.

Recent surveys indicate a preference towards a wide-body level of cabin comfort which offer a certain clearance from the ceiling and sidewall, spacious leg room, minimum curvature lining, and voluminous overhead bins (See Figure 7).

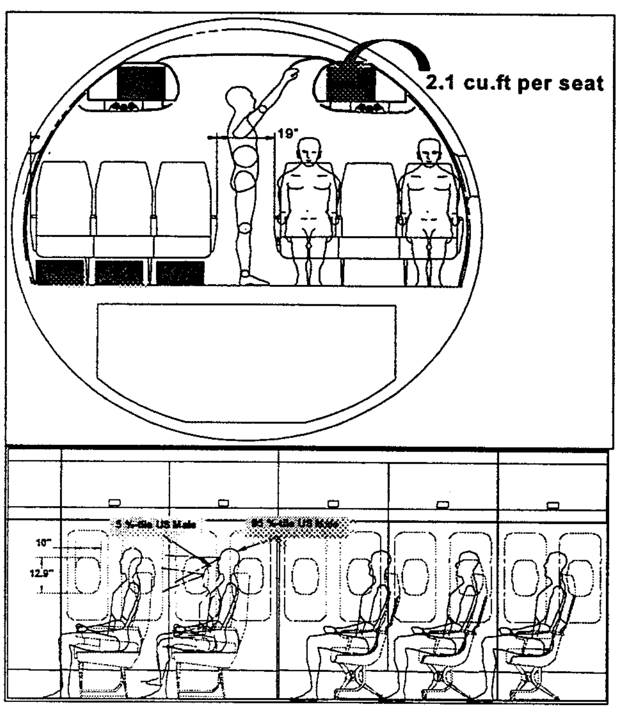

Figure 7

These specifications will provide passengers with a pleasant area to be travelling in; thus avoiding travel fatigue that usually results from cramped and busy surroundings. Passengers may also be offered the option to relax further by being provided an optional in-flight entertainment system that features interactive informational, educational, entertainment and commercial visual shows during the flight, with the latter providing passengers with e.g. in-flight shopping facilities.

The interior design requirements provides also a high degree of flexibility in cabin layout by using convertible seats, variable aisle width, movable class divider, large stowage volume, and flexible seat pitch arrangement. Passenger conveniences and services are enhanced through the use of modular ergonomic lavatories, modular transverse galley, passenger service units (PSU's) and seat-mounted video.

Altogether, the highly functional N2130 cabin integrates simplicity and ease of maintenance thus giving the passengers a comfortable surrounding to travel. In addition to that, many details of the cargo-loading system of N2130 are designed considering a high reliability to promote faster turn around time, reduce ground handling labour cost and reduce cargo handler injuries.

Aerodynamics

The launching of N-2130 program started a new endeavour for IPTN, especially in the aerodynamics area since this would become the first transonic aircraft to be designed, developed and constructed by IPTN. In order to develop the necessary capabilities to design a transonic aircraft, the aerodynamics group of IPTN had engaged in a thorough preparation involving the man power development and tools acquisition, such as supercomputers, software, etc. As important as the quality of the tools to be used is the capabilities of the designers and the understanding of each tool's limitations. In order to generate the experience and knowledge of design and the use of the software, the initial design process has been geared toward software validation and design verification.

Figure 8 shows one of the results of the earlier high speed wind tunnel test as compared to the CFD prediction. The results had provided IPTN with a high degree of confidence in its capability to design a transonic aircraft.

The aerodynamics group of N-2130 is responsible for the design and analysis of the aerodynamics aspect of the entire aircraft. For the wing design for example, the high lift devices have been among the most critical aspects of the design process. The choice of single slotted flaps and slats demands very careful design in order to meet the required maximum lift during take-off and landing.

Computational studies in two and three dimensional unsteady flow analysis (figure 9) have been done extensively along with a number of wind tunnel tests. The nacelle configuration as well as the integration of the engines to the aircraft are some of the major issues the N-2130 aerodynamicists have to handle (Figure 10.) Most of constraints usually come from the configuration point of view, which often have negative effects on the aerodynamics performance. Figure 11 shows the full configuration analysis which becomes the responsibility of the aerodynamics group, including the nose, the wing-body fairing, the empennage, etc. The aerodynamic design of the N2130 is being developed using IPTN's in-house expertise working with the latest CFD analytical methods

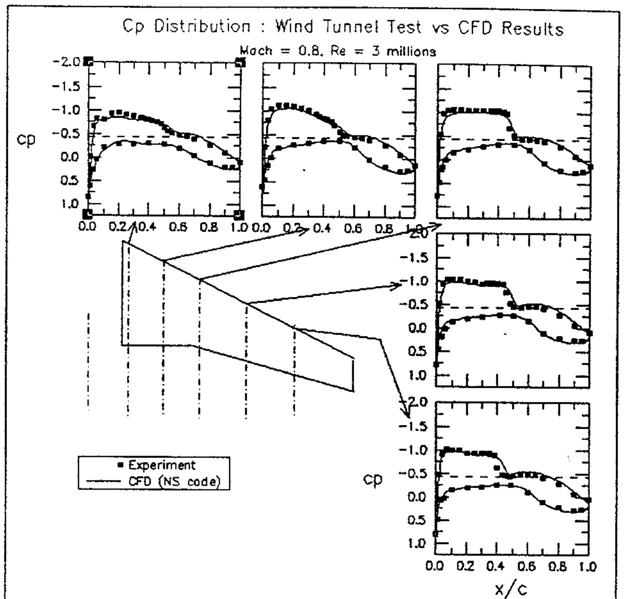

Figure 8

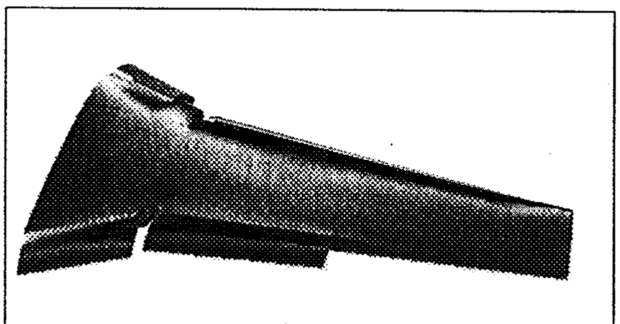
Figure 9

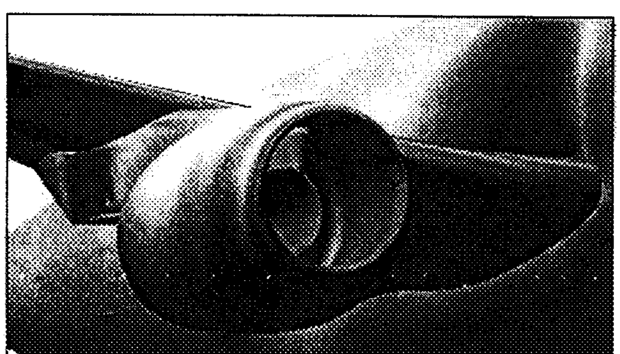
Figure 10

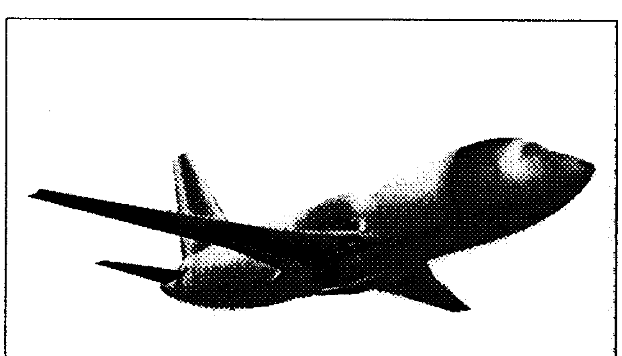
Figure11

Navier-Stokes, Euler with Boundary Layer corrections and Potential flows codes (Panel methods) are some of the codes that currently being used. Design validations and optimisations are conducted using state-of-the-art wind tunnel facilities around the world. At the moment, the N2130 preliminary advanced wing design featured a moderate sweep ($\zeta \approx 25°$) to minimise weight, thickness-to-chord ratio between 14%-12.5%, and an aspect ratio of $\Lambda \approx 8.4$. The high lift devices for the N2130 will be realised through the use of single or, if necessary, double slotted flaps, designed for simplicity whilst having a relatively good performance. Inherent natural stability is optimised against required aircraft performance and the use of full fly-by-wire flight control system to provide a highly efficient design.

Propulsion System

Engine Selection

The propulsion system configuration has to be defined taking into account issues such as maintainability, reliability, and simplicity in the design which all results in lower operating costs for the user. It is important to achieve a configuration that prioritises operational safety while reducing its effect on the environment. This directly translates into low noise and emissions, and, parallel to that, a high degree of fuel-efficiency. The low ownership and operating cost must be achieved by integrating and optimising various design parameters. Thus a green propulsion system is required and shall be realised through under wing mounted high-by-pass ratio turbofan engines that are clean and quiet. Full operational performance of engines shall be accessible through the implementation of Full Authority Digital Control (FADEC) which will bring forward the benefits of reduced fuel burn, longer engine life, and continuous engine condition monitoring.

IPTN invited engine manufacturers to join the program as a partner in an integrated team to provide a complete power plant system. Three engines namely the CFM56-9 from CFMI, BR715-56 from BMW Rolls Royce and PW6000 from Pratt and Whitney are now under study. The thrust required ranges between 19000 lbf to 23500 lbf. The areas that should be given priority to achieve the best-combined aircraft/engine are the following: fuel burn, thrust specific fuel consumption, deterioration, exhaust gas temperature margin, speed margin, thrust growth capability, environmental impact, in-flight shut-down rate, shop visit rate, delay cancellation etc.

Aircraft Systems

The emphasis on aircraft system design is laid on high reliability, maintainability and low operating cost, these factors will be maintained by preserving key parameters such as simplicity through design, modularity, proven technology and integrated approach throughout the design. The integrated design development approach mainly states that the development begins from the basic system function to the certification plan, and that in a concurrent process safety assessment results are integrated into the design. (see figure 12).

A typical N2130 modular system will have distinctive features such as: being based on a single type computer module, simplification of maintenance, reduction of space requirement, usage of a standardised data bus and the ability of loading the software on the field.

Passenger comfort is guaranteed through an environmental control system configured for 8,000 ft at aircraft maximum ceiling altitude. It has the flexibility using various power sources regarding the bleed air, which includes the engine, the APU (Auxiliary Power Unit), and GPU (Ground Power Unit). Two independent air conditioning packs allow to dispatch with one pack being inoperative, with plenty per passenger fresh air supply provides and optimum comfort level.

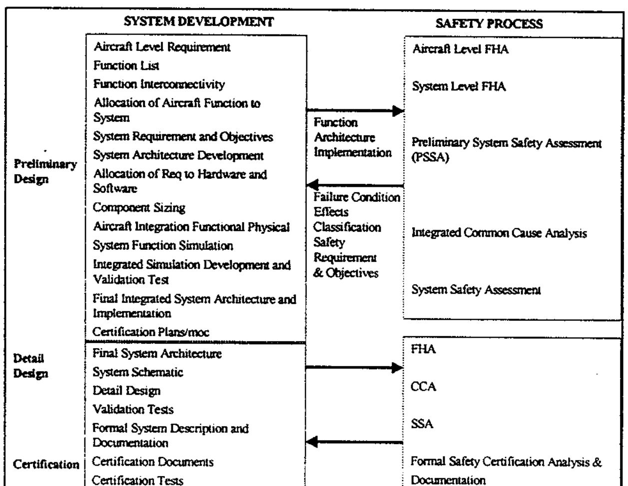

Figure 12

Econo-flow type of controls will allow to obtain maximum thrust from main engine and optimise fuel consumption during low passenger occupancy. The condenser will be sized accordingly to provide the optimal operation even in an extremely humid tropical climate. For a higher comfort level, single or dual cabin zone temperature controller is also another design consideration.

Another very important point regarding the N2130 aircraft systems is the flight control system. Building on experiences gained during the design of N250's fly-by-wire system, the N2130 flight controls will feature an integrated architecture (see figure 13) enabling the flight control computer to provide optimised and co-ordinated flight dynamics and a range of automatic functions. The mission requirement for N2130 flight controls is to induce aerodynamic loads, the reduction of flight crew workload, a higher degree of integration with other aircraft system and the subsequent reduction in maintenance cost.

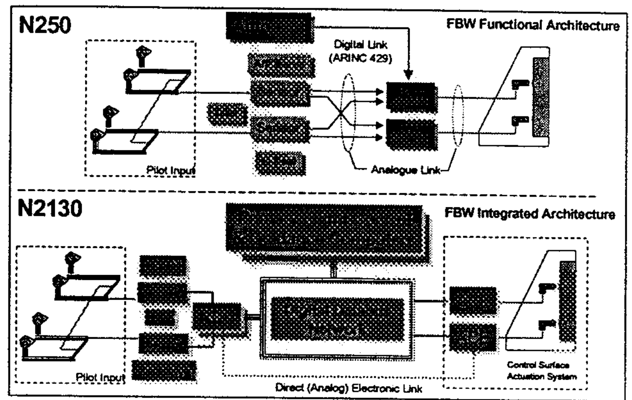

Figure 13

Safety issues are addressed through the application of triple redundancy system concepts, employing dissimilarity logic in the design of the algorithms and software, and through full flight-envelope protection. Many additional functions such as gust load alleviation etc. have been analysed to understand how they could be integrated to enhance the N2130's flight dynamics, increase performance and passenger comfort. Flight crew efficiencies and awareness are enhanced with the use of an integrated Flight Management System enabling the crews to cover the flight routes safely and with reduced workload.

The avionics system of N2130 will be featuring flat panel screens, optional head-up display, and integrated modular avionics. Generally speaking, the N2130 will adhere to the philosophy of the dark cockpit.

Structures/Material

The integrated aircraft structure design is intended to achieve the objective of design to market by reducing the flow time of the design cycles. The entire structure design process is done in digital format and integrated with existing and future manufacturing facilities to increase producibility and optimise the quality of the finished product. Fabricated parts and whole assemblies are further optimised by using the drawings in a digital format (CATIA) of structural parts for digital mock-up and digital pre-assembly scenarios. Structural analysis are optimised through Finite Element Methods (FEM) using a variety of tools, each chosen for its relative usefulness in a specific design case. The integration of every tool within the context of using a common database for all tools and methods is crucial to the reduction of the design process.

Whilst the use of relatively conventional material will dominate the structure design, some composite parts are being studied in an effort to reduce the overall weight.

Experimental activities in order to prove the structural concept, e.g. the wing box have been started already.

The transonic operating region for the N2130 has also posed new challenges in structural dynamics such as transonic flutter etc.. An integrated aeroelastic design analysis process has been initiated to develop and establish the required structural dynamic performance which will allow a potential application of structural load control functions within the N2130 flight control system.

Typical DOC

The N2130 Direct Operation Cost (DOC) per trip will be definitely lower compared to the existing competitor also due to the fact that the N2130 cruises at higher speed therefore having less crew cost per trip. By designing the N2130 to be a 'true' 100 passenger airliner and by incorporating state of the art technology, the N2130 can achieve a better performance and operational cost than the existing aircraft in its class. This can be seen from the Figure 14. which shows a comparison of the N2130 to existing aircraft models. For the same mission of a range of 500 nm, the N2130 has the lower DOC/nm and the lower DOC/Seat/nm compared to all competitors. In comparison to one model (Aircraft F1 Std), the N2130 has a higher DOC/nm of about 1.5%. However, the N2130 being a more efficient aircraft with a bigger size and seat capacity results in a lower DOC/seat/nm of about 5%.The DOC/seat/nm will be inversely proportional with the range. At the design range of 1600 nm, the DOC/seat/nm is 33% cheaper than at 500 nm trip.

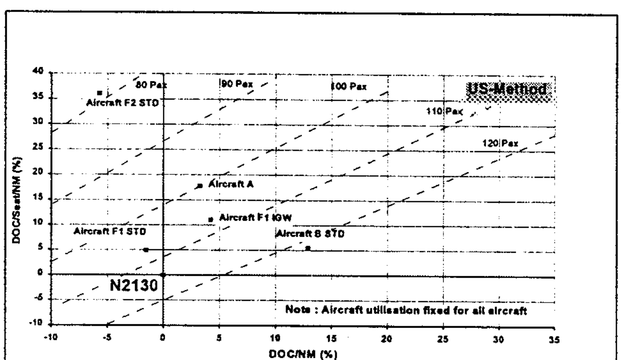

Figure 14

The aircraft price will drive the interest cost, insurance cost and depreciation cost. Maintenance cost is determined by the technical design of the aircraft as well as the fuel cost.

Concluding Remarks

The N2130 programme has been launched at the end of this century to provide an optimised solution for airlines requiring a "true" 100-seat-class regional aeroplane. Feasibility studies indicate that the potential market for this class of aircraft is significant and will be sufficient to justify the investment made. Current and future market requirements are analysed and used to provide a set of design requirements and objectives that are realised through the optimum use of advanced technology. Using experiences gained during the developments of IPTN's capabilities to produce a quality product, the N2130 aircraft design process is conducted through digitised multi-disciplinary integrated analysis and concurrent engineering to achieve an optimal configuration that is designed to the market. Key technologies are investigated and tested to explore their applicapability. Expected to offer exceptional operational performance, reliability and maintainability and tuned for high frequency operating scenarios, the N2130 will enable airlines to reap the maximum benefits from a variety of passenger demands.

Acknowledgement

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The data and figures presented in this paper have been collated from various presentation materials prepared by many N2130 Teams during the Technology Programme and Preliminary Design phases.

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