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GENERAL CIVIL AVIATION AUTHORITY

United Arab Emirates

Integrated Airspace Master Plan

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1. BACKGROUND AND SCOPE

The UAE Government published the *UAE Airspace Policy*, demonstrating its commitment to ensuring continuous development and enhancement of airspace infrastructure to support a safe and sustainable civil aviation sector. The purpose of the UAE's airspace policy is to create an effective, efficient, safe, secure, accessible and flexible environment within which the demands for access to national airspace do not constrain reasonable growth within the aviation sector of the national economy. This may be brought about by embracing technological advances, which would support management of the future aircraft demands in the most efficient manner possible, including air traffic flow management processes which favour aircraft better equipped to comply with airspace requirements.

The UAE Government has also identified four specific airspace policy objectives in relation to the administration and use of the UAE-administered airspace, which are as follows:

- Effective cooperation and collaboration between the Air Traffic Management (ATM) community members to achieve agreed expectations in the Key Performance Areas (KPAs);
- Support for International Civil Aviation Organisation's (ICAO's) global Air Traffic Management (ATM) operational concept and Global Air Navigation Plan (GANP) ;
- The adoption of the ICAO Aviation System Block Upgrade (ASBU) programme; and
- Enhanced ATM services for UAE aerodromes served by air services, as determined by the GCAA.

The UAE airspace policy priorities also include achieving the key attributes of the 2030 UAE airspace and ATM system, namely:

- Fair and equitable access to all airspace, airports and ATM services based on best capable – best served approach;
- UAE airspace considered as a 'national asset' with the implementation of Flexible Use Airspace (FUA) for civil and military operations based on real-time needs;
- Seamless Air Navigation Service (ANS) provision throughout the UAE;
- Performance Based Navigation (PBN) route structure throughout the UAE;
- Flight procedures tailored for optimum climb and descent to runways in use;
- Airport infrastructures that maximise throughput and minimise congestion;
- Balancing traffic demands and capacities in a collaborative manner; and
- Interoperability of ATM systems within the UAE and with neighbouring Flight Information Regions (FIRs).

The UAE Government expects that the General Civil Aviation Authority (GCAA) will continue to reform the UAE's airspace and move towards closer alignment with the ICAO GANP and ASBU system, while adopting proven international best practice and reflecting the agreed regional priorities of the MID region.

Under ARP 3, a detailed design was developed by ENAV/Helios, the appointed consultants, to achieve the operational objectives for the period 2016-2020. This was validated, and the performance objectives consolidated, in the IAMP covering the period 2016-2020. This IAMP (this document) is a strategic document that covers the subsequent timeframe and it is built on ARP 3 design and network delivered on 07 December 2017. The IAMP 2020-2035 provides a roadmap for further developments and for supporting traffic growth up to 2040.

The document is organised in three sequential time frames:

- **TF1:** Set in 2020, accommodating traffic demand up to 2025;
- **TF2:** Set in 2025, accommodating traffic demand up to 2035;
- **TF3:** Set in 2035, accommodating traffic demand up to 2040.

The scope of the IAMP 2020-2035 is therefore:

- To lay out the vision of the UAE ARP, i.e. the high-level concept of operations (CONOPS) of a completed airspace restructure and the related technological enablers;
- To utilise 2016-2020 detailed designs, along with other strategic considerations and stakeholder inputs, to develop the master plan phases and infrastructure evolution for the period of 2020-2035;
- To discuss the expectations and requirements of the restructured airspace from a performance perspective in relation to the ICAO's global ATM operational concept, considering factors such as capacity, safety and global interoperability; and
- To develop an airspace implementation strategy covering the defined timeframes and expected CNS/ATM infrastructure evolution, which will support the delivery of the required airspace changes.

1.1 Objectives

The main objective of IAMP 2020-2035 is to provide a clear medium to long-term airspace evolution and implementation strategy for the period of 2020-2035.

The objectives of this IAMP can be further detailed as follows:

- To outline a high-level concept for a UAE's airspace restructuring needs up to 2035;
- To use the airspace solution of 2016-2020 as an input for a clear strategy for airspace development for the period 2020-2035 as well as the identification of the related technology enablers; and
- To refine airspace development and implementation strategies based on future performance requirements, master plan phases and airline/airport business plans.

1.2 Document structure

The remainder of this document is structured as follows:

- **Section 2** outlines the operational requirements of the new airspace, namely the requirement to accommodate forecast traffic growth and a description of the high-level CONOPS requirements. This section also provides a short description of future innovations that should be considered by the UAE stakeholders.
- **Section 3** provides the expectations and KPAs for the new airspace. It lays out the performance expectations of the new airspace once completed, providing the relevant metrics to be used to gauge whether the airspace is performing as designed or expected.
- **Section 4** outlines the concepts of operation that are expected to drive the evolution of airspace delivered within the three timeframes (TF1: 2020-2025, TF2: 2025-2035, and TF3: 2035-2040). This section describes the steps on a conceptual level, that are to be taken to implement the airspace change and restructuring delivered in the UAE's terminal areas and en-route airspace up to 2035.
- **Section 5** summarises the results of the performance assessment activity, which was conducted to evaluate the concepts, procedures and infrastructures defined in Section 4 in relation to the quantifiable KPAs.
- **Section 6** outlines the CNS enablers required to support the changes and performance requirements in the UAE up to 2035.
- **Section 7** outlines the transition roadmap. This section summarises the operational concepts and CNS/ATM enablers defined in the previous sections for each timeframe.

2. OPERATIONAL REQUIREMENTS

This section presents an overview of the operational requirements used as the basis for the development of this IAMP. In establishing the operational requirements, the operational needs of all users have been considered through consultation and as established through Phase 3 of the implementation of the UAE ARP.

The operational requirements are focused on the use of the airspace within the national context by all users and the interactions between the UAE airspace and surrounding States, bearing in mind the requirements for the airspace to be constructed in accordance with the ICAO Standards and Recommended Practices (SARPs) to meet the needs of all users, and in particular, the international community.

2.1 Forecast airspace demand

This section highlights the traffic forecasts in the UAE for the period up to 2040[1]. Developing a forecast is a vital process to achieve a shared understanding of the future with ATM community members and to appropriately derive and define solutions to the airspace operations and ATM/CNS infrastructure. The traffic forecast is provided in Table 1 and shows the volumes for each international airport in the UAE, as well as the total figures assumed for each timeframe of this IAMP.

Traffic forecast	Year 2025 (TF1)		Year 2035 (TF2)		Year 2040 (TF3)	
	Annual	Daily	Annual	Daily	Annual	Daily
OMAA	328,395	900	449,980	1,233	526,735	1,444
OMAD	35,349	97	48,437	133	56,699	156
OMAL	125,269	343	171,649	470	200,927	550
OMBY & OMDL	3,310	9	4,536	13	5,310	15
OMDB	243,048	666	333,035	913	389,842	1,090
OMDW	499,338	1,368	684,214	1,875	800,922	2,173
OMFJ	20,474	56	28,055	77	32,840	90
OMRK	22,642	62	31,026	85	36,318	100

[1] The solutions presented in IAMP 2020-2035 are required to support the traffic up to the 2040 volumes.

OMSJ	138,104	378	189,236	518	221,515	606
Total	***1,415,931***	***3,880***	***1,940,167***	***5,317***	***2,271,107***	***6,224***
Overflights	***248,565***	***681***	***340,594***	***934***	***398,691***	***1,093***

Table 1: Forecasted annual and average daily traffic volumes in the UAE up to 2040

The table above is based on the traffic forecast and extrapolation of the yearly growth rates, as published in the *UAE ATM Strategic Plan*.

The traffic forecasts consider the following input data:

- The increase of traffic demand expected for Dubai airport system (OMDB & OMDW);
- Fleet mix modification arising from future air carriers' marketing and operational plans (e.g. additional flights at OMDW operated with heavy and super heavy aircraft); and
- Evolution of ground infrastructures at OMDW (increase of the number of runways up to five runways).

As such, the resulting split of traffic between OMDB and OMDW is expected to be 33%/67% in favour of OMDW. This approach aligns with the guidance given by the stakeholders and drives the performance assessment documented in Section 5. The resulting fleet mix in each timeframe is shown in Section 5.3.2.2.

The total number of flights in the UAE airspace is estimated to increase from 1,209,605 in 2020 to approximately 2,271,107 in 2040. The average number of daily flights is expected to increase from 3,315 in 2020 to 6,224 in 2040. The cumulative annual average growth rate is estimated to be approximately 3.2% between 2020 and 2040 for total civilian operations in the UAE airspace.

While OMDB is expected to still be the largest airport in terms of the traffic volumes before 2020, this will change in the timeframes recorded in this IAMP, as OMDW takes over significant part of traffic from OMDB from 2020 onwards. OMAA is expected to maintain its position of the second busiest airport in the UAE throughout all the timeframes.

The solutions proposed in IAMP 2020-2035 cover nominal operations. It is therefore advised to conduct ad-hoc analyses, potentially leading to temporary airspace changes, in preparation for events of regional or global importance held in the UAE or in the neighbouring countries, such as the Qatar World Cup in 2022.

2.2 High-level concept

The overarching notion behind the reorganisation of the UAE airspace is the concept of supporting fair and equitable access to all national airspace and airports resources, based on the principle of 'Best Capable – Best Served'. To achieve this aim, a series of iterative design and ATM implementations will be needed between 2020 and 2035 to harmonise the airspace under a consolidated service delivery approach, in which the airspace is treated as a national asset for the benefit of all users, based on their needs.

As such, this will allow the introduction of more efficient flight operations, in which the use of airspace and runways can be optimised to maximise throughput and minimise delays and tactical Air Traffic Control (ATC) vectoring. This will require the introduction of new and interoperable ATM systems and ATC tools to ensure interoperability and harmonisation at an international level with neighbouring units and FIRs.

This overarching goal is consistent with the UAE ARP CONOPS requirements and summarised in Table 2.

CONOPS plan areas	High-level aspects
Objectives and scope	• Capabilities to meet demand within the UAE and region
ATM/CNS assumptions	• ICAO Block 3 capabilities available • Seamless ANS provision
PBN performance criteria	• Advanced Required Navigational Performance (A-RNP) for both en-route and terminal airspace
Integrate national security requirements	• Civil-military airspace management integrated with realtime coordination and use based on need, e.g. Flexible Use of Airspace (FUA)
Safety and performance criteria	• Maintain or improve current high level of safety • Demand accommodated without delays, except for off-nominal situations
Operational requirements	• Common operational requirements across the UAE
Route structure	• Flexible user-preferred point-to-point routing without structure, except in high-density areas where RNP 1 / A-RNP multilane airways are used
Flight procedure integration	• Tailored for runways in use and deconfliction between airports
Prioritisation of possible solutions and input regarding structured implementation path	• Near term – standards and procedures • Mid term – integration with common capabilities • Long term – time-based trajectory operations

Table 2: High-level concept for a completed airspace restructure up to 2035

This document describes the level of performance required to fulfil these long-term CONOPS requirements and lays out the operational and technological enablers on which the long-term goals can be achieved.

2.2.1 Airspace structure and design

The UAE airspace should be organised based on the following principles:

- **Procedure design:**
  - Utilise PBN procedures to achieve predictable and repeatable flight paths;
  - Utilise future procedure design enablers based on need and expected equipage levels; and
  - De-conflict procedures where practical and efficient.
- **Airspace design:**
  - Minimise track distance where practical;
  - Maximise climb/descent efficiency through optimisation of vertical profiles using Optimised Profile Descents (OPDs) and Optimised Profile Climbs (OPCs) where practical;
  - Maximise flow segregation for airspace purposes;
  - Allow optimal airspace for sequencing;
  - Avoid small areas of isolated airspace which cannot be utilised by design;
  - Reduce internal ATC sector boundary complexity (lateral and vertical) wherever possible;
  - Reduce inter-sector coordination complexities wherever possible;
  - Enable the reduction of holding stacks usage;
  - Maximise automation of inter-facility coordination; and
  - Contain complex traffic interactions within an ATC sector where possible.
- **Safety aspects:**
  - Reduce design complexity whenever practical; and
  - Utilise unidirectional routes where practical and efficient.

Flexibility of routings should be supported at all times to facilitate dynamic changes to airspace configurations as required. These should be communicated to all users through the use of initial Collaborative Decision Making (CDM) applications. Such a flexibility should be achieved by the full implementation of Flexible Use of Airspace (FUA) in the UAE. As recommended by the ICAO MIDANPIR, the UAE ANSPs should develop necessary institutional arrangements with the military to foster civil/military cooperation and arrange for the military to be involved in the airspace planning and management process in the UAE.

These developments shall lead to the introduction of pre-tactical and strategic FUA concept of operation in the UAE through strategic civil/military coordination and dynamic interaction in order to open up segregated airspace, when it is not being used for its originally intended purpose, and allow for better airspace management and access for all airspace users.

Within the third timeframe, i.e. beyond 2035, the level of flexibility of the usage of the UAE airspace should be further improved by the introduction of the Free Route Airspace (FRA), subject to wider regional or sub-regional implementation of this concept, e.g. through the Gulf Cooperation Council (GCC) Upper Flight Information Region (UFIR) initiative that assumes the initial implementation of Free Route Airspace (FRA) in Saudi Arabia and southern part of Oman by the end of 2025.

These developments shall be supported by an ATM system able to manage dynamic changes to the airspace from tactical perspectives and capable of presenting a seamless experience for airspace users. The management of the airspace should be delivered through coordination of terminal and en-route airspace structures that enable:

- Integrated regional airspace management; and
- Integrated civil-military airspace management with coordination extending from the strategic through the pre-tactical, to tactical timeframes.

2.2.2 Communication, navigation, surveillance

The deployment of ground-based CNS shall be based on the technical assessment of what is needed to achieve the performance requirements, expected demand and capabilities of the airspace organisation and management between 2020-2035. In the short term, this means the maintenance of sufficient infrastructure to support the deployment of area navigation (RNAV) and RNP instrument flight procedures, in accordance with the *UAE PBN Implementation Plan*.

The UAE's CNS strategy for 2020-2035 is intended to coordinate the future development, procurement and implementation of technical and technological infrastructure systems across government, industry and the wider ATM community. It sets out the agreed strategic direction of the stakeholders and should be subject to ongoing review. The nature of technological development makes it impractical to attempt to prescriptively define the technological base or implementation schedule for infrastructure facilities much beyond 15 years. However, the CNS infrastructure shall deliver sufficient capabilities to support the implementation of ICAO ASBUs up to and including Block 3.

To achieve this, a unified UAE-wide enterprise architecture for the provision of ANS and information, including military, should be established, defining and unifying the capabilities and systems that will be used by each UAE ATM facility. The development and implementation of the UAE's CNS strategy should be coordinated by an appropriate UAE National Airspace Advisory Committee (NASAC) Working Group.

At any time, however, the deployed CNS infrastructure shall be compatible with and exploit the capabilities of modern aircraft and systems. Modern aircraft are already well equipped to meet various implementation mandates in other parts of the world. The airlines operating within the UAE already have a very modern and capable fleet, although with some legacy aircraft that do not have datalink capability or are only capable of utilising older terrestrial navigation facilities – current VHF Data Link (VDL) Mode 2 and VHF 8.33kHz equipage in the UAE is 83% and 100% respectively.

As fleets are replaced over time, it is expected that there will be a much higher proportion of aircraft that will be capable of complying with different PBN specifications and will increasingly be capable of modern datalink communications. For example, the carriage of Automatic Dependent Surveillance – Broadcast

(ADS-B), Mode-S and RNAV 1 capability is already covered by mandate within the UAE. Current ADS-B OUT and ADS – Contract (ADS-C) equipage is 100% and 98% respectively.

2.2.2.1 Communication

The functional needs for communication services are expected to continue over the next 15 years without significant change. Hence, changes to voice communication infrastructure will be predominantly associated with equipment replenishment, modernisation and service improvements. The utilisation of datalink techniques should grow rapidly, enabling improvements to existing air-ground communications, supporting new surveillance services, and progressing towards the more fully integrated communication capabilities proposed under the Aeronautical Telecommunication Network (ATN).

Voice communications should continue to be predominately based on VHF in airspace utilising 25 kHz channel spacing. However, to accommodate traffic density, a move to 8.33 kHz or 12.5 kHz spacing should be adopted if required. Air-ground communications should progressively move from voice services to datalink communications such as Controller Pilot Data Link Communications (CPDLC) and Pre-Departure Clearance (PDC) applications. Aeronautical Message Handling System (AMHS) and ATN datalink communication services should be introduced to eventually replace the existing Future Air Navigation System (FANS-1/A) and Aeronautical Fixed Telecommunication Network (AFTN) systems. Integration of data services towards System Wide Information Management (SWIM) will require suitable data communication services – initial SWIM capability is expected to become available before 2020.

2.2.2.2 Navigation

Today, the en-route airway system and lower routes are predominantly RNAV 1. The GCAA mandated Global Navigation Satellite System (GNSS) RNAV 1 on 07 December 2017. As such, the future UAE navigation infrastructure will be based upon GNSS, inertial and the Instrument Landing System (ILS) navigation systems. This approach is consistent with ICAO *MID Region Air Navigation Strategy*.

This is expected to evolve to a full PBN environment in line with aircraft fleet replacements and evolving airspace capacity requirements. The RNAV/RNP infrastructure is also used in support of terminal procedures and approaches using ILS, which is expected to be retained as today. There are ILS Category (CAT) IIIb capabilities at most runways at major airports across the UAE and CAT II capabilities at most other international airports. The full deployment of PBN capabilities en-route, in the TMA, and at the airports are detailed in the *UAE PBN Implementation Plan*.

The medium to long-term PBN strategy is summarised in Table 3.

	Airspace		Navigation specifications
Medium term (2019-2024)	**En-route**	*Continental*	• RNAV 1
		Remote continental	• RNAV 5 • RNAV 1, where operationally required
	TMA		• Basic RNP 1 • Advanced RNP (A-RNP), where operationally required
	Approach		• Expanded RNP APCH with Baro-VNAV and RNP APCH Authorisation Required (AR), where operationally required • RNP Approach (APCH) Point in Space for helicopter operations • ILS should be gradually replaced by Ground-Based Augmentation System (GBAS)
Long term (2025+)	**All**		• Airspace operations should take advantage of aircraft capabilities, i.e. aircraft equipped with data communications, integrated displays, and Flight Management System (FMS) • Aircraft position and intent information should be directed to automated, ground-based ATM systems, and strategic and tactical flight deck-based separation assurance in selected situations (problem detection and resolution) • Strategic and tactical flow management should improve through the use of integrated airborne and ground information exchange • Ground-based system knowledge of real-time aircraft intent with accurate aircraft position and trajectory information should be available through datalink to ground automation • Real-time sharing of national airspace flight demand and other information should be achieved via ground-based and air-ground communication between ATM and operations planning and dispatch • Overall system responsiveness should be achieved through flexible routing and well-informed, distributed decision-making • The ATM system should be able to adapt rapidly to changing meteorological and airspace conditions, improved meteorological and aircraft intent information shared via datalink • Operations should leverage advanced navigation capabilities such as fixed radius transitions, Radius-to-Fix (RF) legs, and RNP offsets • Increased use of operator-preferred routing and dynamic airspace • Increased collaboration between ANSPs and aircraft operators
	TMA/Approach		• A-RNP based arrival and departure structure for greater predictability • Ground-based tactical merging capabilities in terminal airspace
	Ground		• Integrated capabilities for surface movement optimisation to synchronise aircraft movement on the ground

Table 3: Medium to long-term UAE PBN strategy goals

2.2.2.3 Surveillance

Surveillance within the UAE is based primarily upon radar surveillance, with ADS-B being integrated throughout the UAE and multilateration integrated at OMDB. The radar coverage fully supports en-route and terminal operations at the major airports. However, there is minimal data sharing internally within the UAE ANSPs and also between adjacent FIRs. Further aspects to be addressed in the frame of the evolution of the surveillance system capabilities within the UAE include:

- ADS-B is not integrated into the Raytheon AT3 ATM system, as operated by Dubai Approach;
- The military has ATC radar coverage in the largest training areas, but not the northern area;
- Jeddah has a large boundary area of its FIR with the Emirates FIR without total radar coverage, although Saudi Arabia (KSA) started deploying ADS-B in this area in 2017;
- OMFJ is equipped with MLAT and ADS-B functionalities;
- No ground or airport radar is available at OMSJ;
- Primary and secondary surveillance radar is expected to continue to be used in busy terminal environments and Mode S capability will be a feature of the future ground-based surveillance infrastructure.

2.2.3 ATM automation and standardisation

There are substantial differences in capabilities among the various internal UAE ANSPs and among those of the external facilities that the UAE interfaces with. These differences have resulted in slower-than-desired implementation of new capabilities as well as interoperability limitations between systems. Although the efficient management of planned traffic increases in the UAE is somewhat reliant on the improvement of capabilities in neighbouring FIRs and in the wider Middle East region, there are currently significant manual coordination requirements and a lack of data sharing between neighbouring FIRs reduces efficiency. Therefore, improvements in both ATM and CNS capabilities are needed to meet the expected regional airspace demand and capabilities.

Accommodating future growth in the UAE’s airspace demand and facilitating the proposed airspace design and CNS changes will therefore necessitate also the investments in advanced automation and Air Traffic Flow Management (ATFM) capabilities. The capabilities of ATM systems of all the UAE ANSPs shall be fully standardised to enable improved traffic synchronisation through silent handovers and conflict management harmonisation.

Building on the recommendations of the UAE ARP Phase 2 the separation methods should move from tactical ATC-developed instructions to use of ground and airborne automation decision support. Enhanced system monitoring and alerting of separation and spacing that supports multiple separation modes and standards between aircraft with trend analysis should be implemented. Operational procedures and agreements to provide a positive handoff of aircraft between Air Traffic Controllers (ATCOs) within the UAE airspace and other neighbouring FIRs should be defined.

Arrival Manager (AMAN) capabilities should be enhanced, including tactical adjustments to rates, wake category inclusion (i.e. RECAT), and multiple arrival runways. Aircraft-specific arrival fix times to stakeholders through automation capabilities and to adjacent FIRs should be provided, when they have capabilities to receive such an information. Departure constraint management capabilities should be enhanced by the implementation of Departure Manager (DMAN), including tactical adjustments to flight levels and stakeholder substitution automation capabilities.

To this end, a common situational awareness of airborne aircraft within or destined for the UAE shall be implemented through improved traffic situational display capability to the UAE ANSPs and other stakeholders, including airport operators. This shall be supported by the implementation of the Initial Flight Plan Processing System (IFPS) established either in the UAE or in cooperation with other GCC States on a regional or sub-regional basis. The UAE ANSPs shall therefore implement flight plan and trajectory information capabilities that support both strategic and tactical CDM with application down to the individual flight level.

The establishment of CDM and improved situational awareness, and the implementation of IFPS will be a prerequisite to the introduction of ATFM capability in the UAE. Collaborative constraint analysis processes to understand how projected annual growth will translate to hourly timeframes and airspace sector traffic levels should be established. The UAE ANSPs should:

- Establish CDM processes to determine capacity needed for hourly peaks versus accommodated through scheduling during non-peak times;
- Establish CDM process for exchanging tactical information between the ANSPs and other stakeholders, including airport operators, about projected capacity-demand imbalances;
- Establish CDM processes for making tactical decisions to adjust pre-departure flight trajectories to aid in minimising demand-capacity imbalances; and
- Establish process for the automated substitution of slot times between stakeholders.

ATFM shall become a core function of the UAE ATM system, with dedicated operational personnel at major ANSP facilities in the country. Furthermore, the UAE should foster and lead the creation of regional ATFM, using its ATFM as an example, and in cooperation with multinational initiatives, such as the GCC UFIR, to build a regional ATFM solution.

2.2.4 Civil-military cooperation

The UAE *Civil Military Coordination Plan* is designed to facilitate the requirements of the UAE Airspace Policy with respect to civil/military cooperation. The plan requires the adoption of the ICAO ASBU modules related to civil/military cooperation and the adherence to the timelines incorporated in the various related modules. The plan details enhancing civil/military collaboration and cooperation, which should result in benefits to airspace management and ATM system operations.

Airspace in the UAE is recognised as a national asset which should, except in times of national emergency, be available to all users in an organised and equitable manner. The FUA concept provides an ATM system with the potential to increase capacity achieved by allowing the maximum shared use of airspace through enhanced civil/military coordination. Approximately half (47%) of the UAE airspace is permanently designated for military use and it is therefore essential that this airspace becomes accessible to commercial air traffic during periods of little or no military activity, so as to reduce track miles flown, delays, fuel burn and emissions, and increase the capacity of the airspace for civilian usage.

The basis for the FUA concept is that airspace should no longer be designated as either military or civil, but the UAE airspace should be considered as one continuum and used flexibly on a day-to-day basis. Consequently, any necessary airspace reservation or segregation should be only of a temporary nature. A more effective sharing of airspace and efficient use of airspace by civil and military users, stemming from the application of the FUA concept, would be realised through joint civil/military strategic planning and pre-tactical airspace allocation.

The effective application of the FUA concept requires the establishment of a national high-level airspace policy body, which can be in the UAE context fulfilled through the UAE NASAC. This body would be tasked with the reassessment of national airspace, the progressive establishment of new flexible airspace structures, and the introduction of procedures for the allocation of these airspace structures on a day-by-day basis. The practical application of the FUA concept relies on the daily allocation and promulgation of flexible airspace structures, and on the centralised dissemination of information to aircraft operators through daily airspace utilisation plans that are continuously updated in real time. This requires consolidated network management to implementing centralised real-time civil/military coordination facilities and procedures, if the benefits of the FUA concept are to be fully realised.

Further evolution of the FUA concept has given rise to the Advanced Flexible Use of Airspace (AFUA), which is expected to provide more flexibility based on dynamic airspace configuration (e.g. Variable Profile Areas) and management in all flight phases, from initial planning to execution. AFUA is based on extended, more proactive and performance oriented civil-military cooperation to achieve mission effectiveness and flight efficiency. AFUA is an airspace management concept based on a civil/military partnership to enhance an efficient use of airspace. It is aimed at providing a responsive approach in a more complex environment, such as in the case of the UAE airspace, within which traffic growth needs to be accommodated. It is expected that the implementation of AFUA concept will deliver early benefits including:

- Enhancing synergies in the CDM for a more efficient application of FUA and increasing the Airspace Management (ASM) contribution to the overall network performance;
- Significantly raising the level of harmonisation of ASM processes within the UAE to optimise airspace availability and its utilisation; and

- Improving flight efficiency, fuel efficiency and environmental sustainability.

2.2.5 International agreements

The UAE shall foster its regional leadership through implementation of leading-edge capabilities and establishment of focused ATFM capabilities. To achieve this, the frequency and breadth of communications with adjacent FIRs, focused on improving the capabilities and efficiency of operations within the region, should be increased.

Using the GCC UFIR initiative, the UAE has an opportunity to enter into multilateral agreements with other participating GCC States to improve the level of provided service and establish seamless operation that does not necessarily have to be limited only to the upper airspace of the participating States.

The UAE shall, in cooperation with the ICAO Middle East (ICAO MID), Arab Civil Aviation Commission (ACAC), Civil Air Navigation Services Organization (CANSO), International Air Transport Association (IATA) and other relevant international and regional organisations actively support and lead the regional developments and improvements in the civil aviation domain.

2.3 Assumptions and dependencies

A number of dependencies and enablers have been identified during the UAE ARP Phase 3 that were agreed by the stakeholders to be valid also for the 2020-2035 time and need to be addressed within the airspace deployments to ensure that the goals of the high-level CONOPS can be achieved:

- **Phase 3 airspace design:**
  - UAE airspace must utilise the networks finalised in the Phase 3 integrated design.
- **Adjacent ANSP accommodation ability:**
  - Influence and impact to be contained within the current UAE FIR boundary.
- **Military airspace:**
  - Current FUA procedures are not being implemented (despite being documented), hence this needs to be introduced properly.
- **Fix capacity:**
  - Buffer to separation minima at fix points should be added and maintained – in the case of 3nm minima, 2nm was added as a buffer; in the case of 5nm minima, 3nm was added.
- **FIR boundary spacing:**
  - The location of FIR boundary’s fixes limits location of separated new fixes (7nm) and their corresponding routes that could be developed:
    - <u>West:</u> No availability without total revision of attributions with adjacent ANSPs and the consequent realignment of current fixes;
    - <u>North:</u> Limited availability; however, routes originating from these locations would not be separated due to the route angularity emanating from these fixes;

- East: Two new fixes added (TARDS, MUSAN); and
- South: Unlimited physical availability; however, leveraging this airspace is restricted due to military segregated area (OMR 54), but six new fixes are proposed in the anticipation of the implementation of robust FUA procedures.

- **Meaningful implementation of FUA/AFUA concept:**
  - To provide real-time allocation of airspace based on tactical needs.
  - Requires the establishment of a coordination entity (e.g. civilian-military coordination cell) and a review of airways classification, e.g. Conditional Routes (CDR) concept. The civil-military coordination unit should provide airspace users with the military airspace planned engagement as soon as possible and, in any case, not later than a specific agreed schedule (e.g. 24 hours prior to operation) in order to allow all stakeholders to perform the best planning of flight operations.
- **Centralised national network management:**
  - The FUA concept relies on the daily allocation of flexible airspace structures and on the centralised dissemination of information to aircraft operators through daily airspace utilisation plans that are continuously updated in real-time – this requires consolidated network management to implement centralised real-time civil/military coordination facilities and procedures, if the benefits of the FUA concept are to be fully realised.
- **Implement FRA/published direct routings:**
  - To enable the implementation of FRA, it is required to launch a regional program addressing airspace design and coordination, upgrade ATM systems (e.g. introducing enhanced interoperability and data exchange), implement new ATC tools and operating procedures, and provide adequate training.
- **AIS to AIM to SWIM:**
  - SWIM will enable direct ATM business benefits to be generated by assuring the provision of commonly understood quality information delivered to the right people at the right time. This includes aeronautical, flight trajectory, aerodrome operations, meteorological, air traffic flow, surveillance, and capacity and demand information.
- **Enhanced AMAN/DMAN/XMAN:**
  - Extended AMAN (XMAN) is a new operational procedure to be implemented, which aims to improve and optimise arrival management operations for major airports, but may require cross-boundary coordination and cooperation with neighbouring states in the case of the UAE;
  - The aircraft's holding time at congested airports should be cut by reducing their cruising speed during the final en-route phase of flight, several hundred miles away from the airport. With such approach, flight efficiency will be increased by reducing the overall fuel burn and CO_2 emissions. Lower airborne congestion in terminal areas will contribute to improving operational safety by reducing pilot/ATCO workload.

2.4 Future innovations

The global ATM industry is evolving quickly and is developing new operational concepts and technologies to accommodate new airspace users and operations. Whilst this IAMP is aligned to the current ICAO ASBU roadmap and sets out the requirements for the UAE's airspace and supporting infrastructure to 2035, it is likely that it will continue to be evolved to accommodate new and innovative solutions. These will inevitably take advantage of disruptive technologies from new entrants, to address emerging opportunities and challenges.

This section provides an initial overview of the GCAA's and other UAE stakeholders' priority areas to be addressed in the medium to long term. Each area should be further developed through dedicated NASAC working groups that should provide input to future iterations of this document.

2.4.1 Unnmanned aircraft system traffic management

The use of drones, or Remotely Piloted Aircraft Systems (RPAS), continues to increase, including in the UAE. The future UAE airspace will need to accommodate all airspace users, including the integration of unmanned flights. The IAMP 2020-2035 will evolve to consider both the requirements for accommodating commercial and recreational activities of small drones in very low-level airspace (typically less than 500 ft) and the integration of larger RPAS, including commercial, cargo and military flights in all airspace.

One potential way of addressing this is through the phased approach, as being proposed by the European U-SPACE concept – a SESAR Joint Undertaking's implementation of Unmanned Aircraft System Traffic Management (UTM). U-SPACE proposes moving through a four-phased approach from basic registration services all the way through to full integration. This impacts in the short term on flight planning capabilities and improves the ability of ANSPs and regulators to identify which drone has been used in which part of the airspace. Standardisation activities are also ongoing with some standards covering for example Detect and Avoid (DAA) applications, e-identification, geofencing, spectrum, security and datalink.

The integration of a UTM with traditional ATM will require the development of new interfaces, and potentially new ways of working. It is expected to place a higher demand on the ability to utilise SWIM services for the sharing of data about drone operations and support their deployment in busy aerodrome environments for applications such as Foreign Object Debris (FOD) detection and aerodrome surveys with benefits of increased automation and detection rates and less runway downtime. Particularly from a spectrum impact point of view, the technical solution by which DAA is implemented may require the addition of ground-based infrastructure, depending on peak traffic loads. For example, under high traffic scenarios, it may not be desirable to have all manned aviation as well as the drones squittering ADS-B messages via 1090. It is likely that a mix of new technical solutions based on existing ground-based telecommunication links will be required. This will have implications on ATM, e.g. on Radar Data Processing Systems (RDPS), and regulatory aspects, e.g. use of mobile telephony airborne, from both civil aviation and spectrum licensing perspectives. When applied to a cross-border environment, this implies more coordination at a regional level and an opportunity for the UAE to take a lead in the integration of RPAS within the civil airspace at a regional and perhaps global level.

Additionally, the UTM is likely to be a driving force behind more rapid implementation of ATFM in the UAE and elsewhere in the region. An important aspect of RPAS operations will be the challenge to integrate their four-dimensional trajectories into the current ATM system. This would require the GCAA to carefully balance capacity and demand, for which a comprehensive ATFM solution would be needed that would be deployed on a significantly larger scale, comparing to today's 'traditional' ATFM measures covering manned aircraft operations only. Integration of four-dimensional RPAS operations into the wider ATFM system would also have to tackle specific complexities of such operations, such as ensuring that the drones are geofenced at any point of their flight, i.e. they are kept within or outside certain airspace.

Hence, the future ATFM design would need to be adaptive enough to handle unprecedented variations in magnitude and distribution of traffic over the next decades, not only because of the integration of RPAS, but also commercial space launch vehicles in a more distant future, as further described in the next section.

2.4.2 Space traffic management

Governments and commercial companies are increasingly developing innovative ways to exploit and to access space. The UAE Space Agency was founded in 2014 and is already working on a number of space initiatives, including a mission to Mars in 2020. The UAE is also home to satellite manufacturers and is destined to become the location for the second of Virgin's Spaceport facilities. As such, the GCAA will progressively have to consider how to accommodate near-space and space activities in existing airspace and increasingly in airspace above FL600.

The implications for airspace demand and protection for adjacent air traffic are one of the considerations that will influence the frequency and type of operations within the UAE. For example, considering Virgin Galactic, operations will need to be undertaken within a gliding range of the launch airfield. Therefore, the density of airspace, the selected airfield and the length of time that the runway may have to be closed to support operations would need to be studied and defined. In addition, there are potential requirements for range and mission services covering tracking, and voice and data communications with a platform that is moving at high Mach numbers. Operational procedures and integration of ATCO tools may be developed to help with contingency operations or improve the viability of services for either human orbital flight or Low Earth Orbit (LEO) satellite launch.

2.4.3 Digitisation of service provision

The digitisation of ATM is expected to increase in the next decade. This includes a slow move to virtualisation of services in vast data houses and the use of remote technologies, e.g. to enable single and multiple remote tower deployments. The move to digitisation means an emphasis on cyber security and the need for robust authentication and security, as ATM moves from bespoke communication protocols to IP-based protocols. It applies to SWIM, as well as airport CDM (A-CDM).

The digitisation of ATM is also expected to result in increased cost-efficiency across the UAE ANSPs by sharing some infrastructure. For example, virtual remote towers can be established for the UAE airports, which will be centralised in one or few multi-tower facilities, hence the UAE ANSPs would be sharing the infrastructure, while the staff of the individual ANSPs would still be controlling the airports under their responsibility from such a shared facility.

Going beyond the boundaries of the UAE, ATM services can be provided through the establishment of virtual towers also to other States. For example, during quiet times in one State, the GCAA would be able to provide the service over this State, so that the State's ANSP could save costs on staffing. Such a level of cooperation and bilateral or multilateral agreements in the context of the UAE is most likely to take place within the GCC sub-region, perhaps also fostered by the currently ongoing GCC UFIR initiative.

2.4.4 Space-based CNS

In the future, it is likely that all CNS services will be provided from space. The IAMP 2020-2035 considers the requirements for CNS, but not how these services could be delivered. The move to a space-based solution is likely to result in CNS being provided as a 'service' and the GCAA and other UAE ANSPs no longer owning (or having control of) the physical infrastructure. This may have a profound effect on the ANSPs' cost base and the way they deliver services, including incentives for innovation and wider regional or global cooperation.

From the IAMP perspective, this introduces the concept of rationalisation of the CNS infrastructure beyond what is included within the present ICAO GANP or MID plans. Within the TF2 period, Inmarsat's IRIS service is expected to reach full operational capability. In addition, there are developments such as Smartsky Networks and Swift Broadband-Safety (SB-S) initiatives that will bring broadband on-board data connection. While IRIS is already planned to meet ICAO RCP specifications for the ATM use, this is not the case yet for other alternatives, whether solely satellite-based or combined with terrestrial infrastructure.

In addition, the advent of space-based ADS-B is expected to reach maturity from a number of providers within the next five years. Space-based ADS-B's added value is not only the provision of surveillance service without the need to deploy ground infrastructure, but also the provision of ancillary services, such as data for regional and global ATFM solutions.

In the next ten years, it is expected that multi-frequency multi-constellation GNSS will be available, which will improve integrity, availability and resilience to interference (intentional or otherwise) and ionospheric delay. Both would change the way in which services could be delivered with a rationalisation of ground-based radios, radar, and a minimum required coverage provided by terrestrial infrastructure.

2.4.5 Artificial intelligence and machine learning

The UAE is known for innovation. Combined with the complexity of its airspace, it is likely that the GCAA will become an early adopter of Artificial Intelligence (AI) to support airspace and ATM operations. The concepts for AI and machine learning are at their cusp and the potential adds to the improvements which can be realised through all areas of ATM. At present, AI is predominantly limited to post-data analysis, where it can be applied to identify correlations between events in the data and provide insights to support optimisation of flight profiles under certain traffic conditions, wind conditions, or in the event of contingency procedures. Over time, this could be applied equally to improvements in safety nets and flow management tools, such as AMAN/DMAN. It equally has its place within the heart of an automated UTM system, catering for fleets of delivery drones and coordinating separation assurance between manned aviation and drones. This is perhaps where the techniques could be refined to lead to deployment within manned ATM and supplementing existing ATCO tools to suggest, e.g. speed constraints, flight levels or direct-tos, whilst balancing the requirements of separation with improved cost control through better awareness of wind, actual aircraft weight and kinetic energies, and air carriers' preferences.

It is therefore expected that AI and machine learning, coupled with big data analysis and holistic modelling combining historic data and traffic predictions, would be able to move the data-driven ATM functions from mere post-event analytics to predictive real-time measures that would bring ATCOs advance warnings about, e.g. potential safety events such as airspace infringements or level busts. Hence, decision makers would be able to use such holistic modelling tools and, with suggested corrective actions, avoid a potential issue days or weeks before it might occur.

Hand in hand with the digitisation of ATM and the planned introduction of SWIM, the development of SWIM services and the availability of increasing amounts of data provide an opportunity for AI and machine-learning techniques to look at data in different ways and identify efficiencies that would not be achievable without the ability to process all data in real time, applying lessons learnt of prior data analysis and results of previous decisions made under similar circumstances.

3. EXPECTATIONS AND KEY PERFORMANCE AREAS

The establishment of the new UAE airspace structure and associated changes affecting ATM/CNS capabilities and infrastructure are expected to develop tangible benefits to all users in the timeframe between 2020-2035. It is clear that in implementing the changes within the UAE ARP the expectations of the user community must be met. These needs have been clearly expressed within the context of the Phase 1, Phase 2 and Phase 3 reports. Key expectations of the UAE ATM stakeholders that should be developed by the immediate airspace implementation and its subsequent evolutions out to 2035 (with supporting traffic growth up to 2040) must consider each of these expectations in parallel.

The safety of airspace users and the public being carried in this airspace is of the highest priority. However, the expectations are presented alphabetically as a guide to what should be considered within each implementation timeframe and against which the performance designed and delivered from each iteration should be assessed. Each of these Key Performance Areas (KPAs) and may evolve depending on further inputs from the user community. The ICAO *ATM Global Operational Concept* lists a number of general, high-level ATM community expectations, which are used in performance management as the framework for KPAs. They provide the focus on the overall ATM strategic planning process.

With reference to ICAO's global operational concept, and where the specific KPAs have been quantified, the high-level performance expectations for the UAE airspace during 2020-2035 are summarised in Table 4.

KPA	Performance Expectations
Capacity	• Forecast traffic growth is assumed to increase linearly with capacity. • Between 2020 and 2040, traffic is expected grow by 3.2% each year. • Based on revised 2020 traffic levels (1,209,605 flights per year), capacity will need to increase by: 6.4% by the end of TF1, 16% by the end of timeframe TF2, and 64% by the end of timeframe TF3 (traffic in 2040).
Cost-effectiveness	• The cost of service to airspace users should always be considered when evaluating any proposal to improve ATM service quality or performance. ICAO policies and principles regarding user charges should be followed.
Efficiency	• Airspace design should allow for routes and procedures to be de-conflicted to increase efficiency (e.g. enhanced climb and descent profiles). • Developed concepts should ensure capacity and efficiency that will meet stakeholder expectations.
Environment	• The ATM system should contribute to the protection of the environment by considering noise, gaseous emissions and other environmental issues in the implementation and operation of the global ATM system.
Flexibility	• All airspace users should be able to modify flight trajectories dynamically and adjust departure and arrival times, thereby permitting them to exploit operational opportunities as they occur.

KPA	Performance Expectations
Global interoperability	• The UAE ATM system should be based on global standards and uniform principles to ensure the technical and operational interoperability of ATM systems and facilitate homogenous and non-discriminatory global and regional traffic flows. • All new route structures must not intrude on or hinder any neighbouring State's own airspace or route structure.
Participation	• The ATM community in the UAE should have a continuous involvement in the planning, implementation and operation of the system to ensure that the evolution of the global ATM system meets the expectations of the community.
Predictability	• The UAE ANSPs and airspace users should provide consistent and dependable levels of performance.
Safety	• The maintenance and improvement of safety within the UAE is expected from the improvements provided through the airspace restructuring and ATM/CNS changes and deployments out to the 2035 timeframe. The acceptable level of safety of operations shall be subsequently maintained to accommodate the traffic growth up to 2040. To achieve this, it is expected that safety will be assessed using industry best practice and in accordance with ICAO Annex 19 and UAE regulations. • In addition to the application of safety management processes, operational data to provide common situational awareness between all users should be shared to aid with real-time safety monitoring, alerting and trend analysis. The use of automated tools to analyse the shared data can be assessed for support to air and ground-based decision supporting tools.
Security	• The ATM system should contribute to security, and the ATM system as well as ATM-related information should be protected against security threats. • Security risk management should balance the needs of the members of the ATM community that require access to the system, with the need to protect the ATM system. • In the event of threats to aircraft or threats using aircraft, ATM shall provide the responsible authorities with appropriate assistance and information.

Table 4: KPAs and performance expectations for 2020-2035

4. AIRSPACE AND OPERATIONAL CONCEPTS

The objective of this section is to describe the changes to be introduced in the future terminal and en-route UAE airspace. These new concepts will drive the evolution of CNS/ATM system architecture to ensure full alignment with ICAO regional plans, as described in Section 6. Performance aspects are analysed in a Section 5. Future airspace and operating concepts defined in this section have been organised in three timeframes, i.e. TF1 (2020-2025), TF2 (2025-2035), and TF3 (2035-2040).

The operating concepts proposed for the TF1 represent the logical continuation of those implemented as part of the UAE ARP Phase 3. They predominantly include all the elements discussed, but not mature enough for the implementation within the Phase 3 timeframe. The concepts proposed for the TF2 and TF3 include advanced airspace solutions that require in-depth airspace design studies, ATS regulatory framework enhancements and long-term infrastructure developments prior to their implementation. The solutions provided for the TF3 are expected to support traffic growth up to 2040.

These concepts aim at meeting future traffic demand expected in the UAE, as described in Section 2.1. The resulting airspace and supporting infrastructure will depend on the assumptions related to the traffic growth and traffic distribution between the three main airports (OMDB, OMAA and OMDW).

To support the development of airspace and operational concepts, several design philosophies for the period of 2020-2035 have been identified and consist of the following main aspects:

- Unidirectional route system and parallel route definition will be expanded as far as possible, e.g. through the extension of the ‘highways in the sky’ concept;
- SIDs and STARs structures will be revised according to the latest airspace design standards;
- UAE FIR’s internal routings for departing and overflying traffic will be organised by area of destination, considering the main traffic flows and the links to the key airports in the region;
- The concept of strategic separation between arriving and departing traffic flows will be expanded to reduce the number of tactical actions needed for potential conflicts;
- The review of entry/exit fixes of Dubai and Abu Dhabi CTAs will take into account the evolution of ground infrastructures and traffic demand growth;
- Arrival and departure operations will be compliant with the ICAO Doc 9643, except for those cases that require new regulations which take into account the specific runway spacing and wake turbulence separation model, e.g. RECAT-EU;
- The implementation of multiple approaches and departures will also require the investigation of technological enablers (e.g. GBAS-based operations, AMAN, DMAN, A-CDM), enhanced IFPs design, validation and training exercises (involving ATCOs and pilots);
- Arrival procedures will be based on trombone patterns or Point-Merge System (PMS) for most UAE airports to improve trajectory management and predictability and reduce ATCOs/pilots workload;
- The management of vertical flight profiles will be based on the application of OPD and OPC concepts, as recommended by ICAO Doc 9991 and Doc 9993;

- Subject to the further expansion of national airports, lateral and vertical limits of Dubai and Abu Dhabi CTAs shall be redesigned to enable a more efficient management of traffic flows; because of that redesign, it will be also necessary to integrate the required changes to OMRK and OMFJ CTAs.
- The organisation of ATC control sectors will be based upon a functional approach; and
- Airspace organisation and management will endorse FUA and FRA principles.
- Enhancement of international coordination activities with neighbouring States will allow the UAE to participate in regional ATFM programmes.

The main concepts explored in each timeframe are summarised in Figure 1 and described more in detail in the following sections.

Time Frame 1	Time Frame 2	Time Frame 3
Flexible Use of Airspace within all UAE airspace	Revise of SIDs/STARs from/to OMDW to implement four RWYs operations	Revise of SIDs/STARs from/to OMDW to implement five RWYs operations
Duplication of airway M318 from ATUDO until FIR boundary with Saudi Arabia	Revise of SIDs/STARs from/to OMAA to implement three RWYs operations	Revise of SIDs/STARs from/to OMAA to implement four RWYs operations
Duplication of airway G783 from a TBD waypoint over UM628 up to ALN	Implementation of a regional ATFM service	Rationalization of approach control functions within UAE lower airspace
Revise of interface with Iran over GONVI waypoint		Implementation of Free Route
Revise of SIDs/STARs from/to OMDW to implement three RWYs operations		
Revise of SIDs/STARs from/to OMAL to implement two RWYs operations		

Figure 1: Summary of concepts for each timeframe between 2020 and 2035

4.1 Timeframe – TF1

The proposed changes to the operational concept and organisation of the UAE airspace in TF1 are summarised in the subsequent sections.

4.1.1 Flexible Use of Airspace within the UAE Airspace

Since permanent restrictions related to military activities (e.g. training, air patrolling, etc.) impact large portion of the UAE airspace, its current network may not always accommodate daily traffic flows in the most efficient and cost-effective way. Hence, the current military restrictions may hinder the evolution of national and regional airspace networks.

Qualitative analysis of traffic flows highlights that the commercial traffic demand in the UAE is mainly concentrated during the 'hub-in' and 'hub-out' rush hours. During some of them, the airspace constraining military activities remain limited or null. For this reason, the introduction of some network flexibility is deemed appropriate to allow for additional airspace availability for commercial traffic, with consequent increased capacity. To this regard, a viable solution to meet airspace users' needs and to balance national airspace exploitation is represented by the implementation of a national FUA concept.

FUA is an airspace management concept based on the principle that airspace should not be designated as purely civil or military, but rather as a continuum in which all users' requirements are accommodated to the greatest possible extent. Airspace is recognised as a finite and valuable resource to both civilians and military. With the global growth of air traffic, States are faced with the challenge of managing their limited airspace that shall accommodate both civil and military requirements.

The implementation of an FUA concept calls for addressing the following steps:

- Prohibited and Dangerous zones will remain unchanged and not made available in the framework of the FUA procedures.
- Restricted zones will be turned into portions of regulated airspace and made available according to the agreed FUA procedures. A new FUA-oriented airspace design will be developed. All ATS routes passing through these areas will always be available to airspace users for flight planning, thus increasing the airspace capacity. Whenever required by the national military authority, these areas will be vacated by civilian airspace users in line with agreed procedures and so used for their original purpose. As a consequence, during the activation periods of restricted zones, the civilian traffic will be rerouted along alternate routings and the airspace capacity will be reverted to the original one.
- According to acknowledged expertise on this domain, the FUA concept is considered as capable of creating more capacity. Demonstration of capacity gains should be proved through employing appropriate fast-time simulation tools.
- The FUA concept implementation requires the establishment of a coordination entity (e.g. civil-military coordination cell) and a review of airways classification (e.g. CDR concept). The civil-military coordination cell shall provide airspace users with the military's planned activities in specified airspace at least 24 hours in advance (according to international best practices) to enable the best possible flight planning by all stakeholders.

- As for the technological enablers, a data sharing system and a reliable communication network for tactical coordination and eventual co-located civil/military operating positions within the main ATS Units shall be adopted.

The implementation of FUA will bring the following benefits:

- Increased flight effectiveness by enabling direct flights or more efficient flight levels across reserved/segregated airspace;
- Increased airspace capacity by providing more ATS routes during defined time periods throughout the day;
- Reduced ATCO workload by enhancing ATS route network and associated sectorisation; and
- More flexible and closely aligned airspace reservation in line with requirements for military operations.

4.1.2 Duplication of M318 – 'highways in the sky' concept

The analysis of destinations in East and South-East Africa served by the main UAE air carriers has resulted in the following main findings:

- Most of the traffic is currently routed via North-West of the UAE airspace, flying additional track miles comparing to other possible shorter routes, thus contributing to the congestion of the area;
- When OMR 54 is made available for civil traffic, airway M318 offers a viable solution for air carriers flying through the UAE to/from the KSA;
- Real-Time Simulation (RTS) carried on during the UAE ARP Phase 3 highlighted the need to improve air traffic management in the ATUDO area; and
- At present, management of air traffic along M318 requires a 30NM spacing and a Flight Level Allocation Scheme (FLAS), thus significantly limiting the capacity of the airway.

A possible solution to mitigate the operational limitations highlighted above consists of the duplication of airway M318 south of ATUDO point. This will permit:

- Full implementation of the 'highways in the sky' concept (two separated traffic patterns), which will improve the overall operational efficiency of the management of traffic flows along the north/south direction;
- Segregation of departures/arrivals to/from OMDB, OMDW, and OMAA airports on separated patterns, which will allow aircraft to fly more efficient profiles enabling OPD/OPC procedures;
- Strategic separation between traffic flows, which will improve the level of safety; and
- ATCO workload will experience an overall balancing in the UAE airspace, as portions of air traffic can be rerouted along the airway M318 – the addition of a parallel airway will allow for simplified flight operations.

To implement the M318 duplication, the following steps shall be undertaken:

- Agree with the military unit to obtain airspace delegation within OMR 54;
- Classify the additional airway M318 as a CDR in line with the national FUA implementing rules;
- Realign SIDs/STARs from/to Abu Dhabi to link the new airways scheme; and
- Review ATC control sectors, as necessary.

To maximise the benefits of the duplication of M318, it is desirable to propose at regional level the implementation of a new waypoint over the boundary and extend the new route into the KSA airspace.

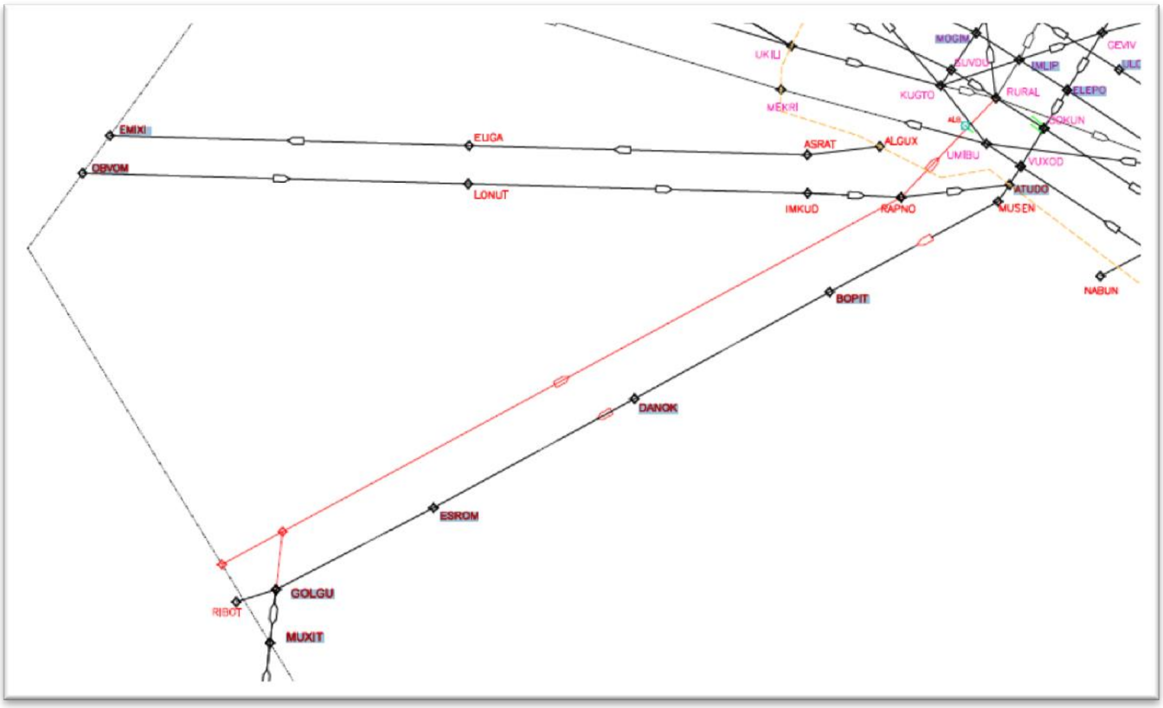


Figure 2: Duplication of M318

4.1.3 Duplication of G783 – 'highways in the sky' concept

The analysis of current traffic flow in the area including the airway G783 and the interface between the UAE and Oman reveals that:

- Traffic departing from Dubai CTA heading south-east (via TARDI) is on vertical movement and it interferes with traffic inbound the UAE within Omani airspace, constraining OPC and OPD procedures;
- Traffic landing at OMAA coming from Muscat FIR is forced to perform a steep descent to meet

FLAS, due to the interaction described above;

- RTS carried on during the UAE ARP Phase 3 highlighted the need to improve air traffic management in the ELUDA area.

This aspect arose during the regional coordination meetings held as part of the UAE ARP Phase 3, Task 1. A possible solution to reduce the operational complexity described above consists of allocating the arrival flow to Abu Dhabi CTA from Muscat FIR over UKRAG point, thus shifting this specific flow south of the congested area. From the point UKRAG, arrivals to OMAA would proceed to CTA entry gates via bidirectional airway G783. Since this airway is used by departures from the UAE's main airports towards Jeddah FIR, it is proposed to duplicate G783 south of point ELUDA, thus reducing traffic density along the mentioned airway. This will enable:

- Strategic separation between traffic flows to improve the level of safety;
- Segregation of departure and arrival flows on separated patterns to allow aircraft to fly more efficient profiles, enabling OPC/OPD procedures;
- Extension of the 'highways in the sky' concept (two separated traffic patterns) to improve the overall operational efficiency of the management of traffic flows along the north/south direction and vice-versa;
- ATCO workload will experience an overall balancing in the UAE airspace, as portions of air traffic can be rerouted along the airway G783 – the addition of a parallel airway will allow for simplified methods of operations.

To implement the duplication of G783, the following actions shall be undertaken:

- Agree with the military unit to obtain airspace delegation within OMR 54;
- Classify the additional airway G783 as a CDR in line with the national FUA implementing rules;
- Establish regional negotiation with Oman aviation authorities.

Figure 3: Duplication of G783

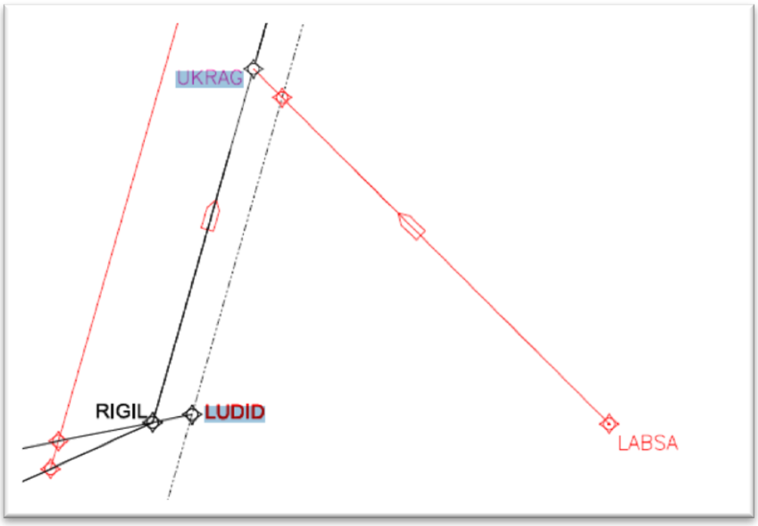


Figure 4: Duplication of G783, detail of routing LABSA-UKRAG

4.1.4 Revision of interface with Iran over ALRAR waypoint

The analysis of traffic routing from the southern UAE airports to Tehran FIR highlights that the availability of only a single exit fix (GABKO) will force air carriers to fly unnecessary extra miles within the UAE airspace. This issue was highlighted during regional coordination meetings as part of the UAE ARP Phase 3, Task 1.

A possible solution to mitigate the aforesaid operational limitations consists of the introduction of a new outbound route from ALRAR to Tehran FIR boundary and the establishment of a new waypoint over the boundary. Creating a new link and a new point between ALRAR and existing airway UP/P574 within Tehran FIR will allow airspace users to plan shorter routings.

This will permit savings in the track miles within the UAE airspace for the traffic departing from OMDW and airports within Abu Dhabi CTA. Airspace users will experience track miles reduction within Iranian airspace as well. In addition, arriving traffic flows to Dubai CTA will not be constrained at all.

This solution shall be implemented subject to regional negotiation with Iranian aviation authorities.

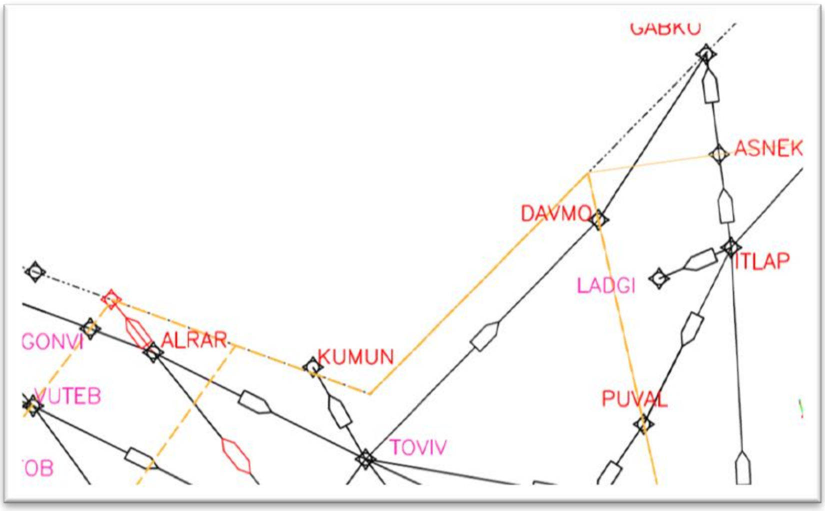


Figure 5: New routing at the ALRAR-FIR boundary

4.1.5 Revision of SIDS/STARS from/to OMDW to implement three-runway operations

In line with the UAE ARP Phase 3 input data and assumptions, the implementation of RWY #2 and #3 at OMDW was confirmed within TF1. Since the structure of current SIDs/STARs was designed for single runway operation, a major review of these linking elements is required to permit simultaneous operations on three runways.

For the given airport ground layout, independent operations on all runways can be implemented in compliance with ICAO Simultaneous Operations on Parallel or Near-Parallel Instrument Runways (SOIR), as the spacing between runways is greater than 1,035 m. This feature shall be considered when performing detailed design of new SIDs/STARs network. Moreover, in-depth design of approach procedures shall consider the technology enablers available by that time (e.g. GBAS).

The following steps shall be undertaken to implement the three-runway system at OMDW:

- Consider a major review of airspace restricted areas (e.g. Skydive Climb Box, D26, etc.) that may have significant impact on the design of IFPs;
- Perform detailed design of SID/STAR procedures to link the three runways with the en-route network;
- Develop operating procedures addressing a three-runway system and review methods of operations;
- Conduct a performance assessment;
- Develop a comprehensive safety case;
- Update the operational documentation for all ATS Units concerned;
- Perform training as necessary; and
- Address transition planning.

The addition of two runways at OMDW will improve the capability of the national ATM system to manage the traffic demand safely and efficiently. Furthermore, the availability of independent operations on three runways properly connected to the route network will permit to satisfy specific airspace users' needs as well as mitigate the impact of contingency events. Quantitative benefits of this system upgrade (runways and ATS network) are described in Section 5.

For each direction of operations (RWY 12 and RWY 30), conceptual proposals to link the three-runway system to the network are illustrated below. This proposal shall be further developed into the PANS-OPS detailed design stage.

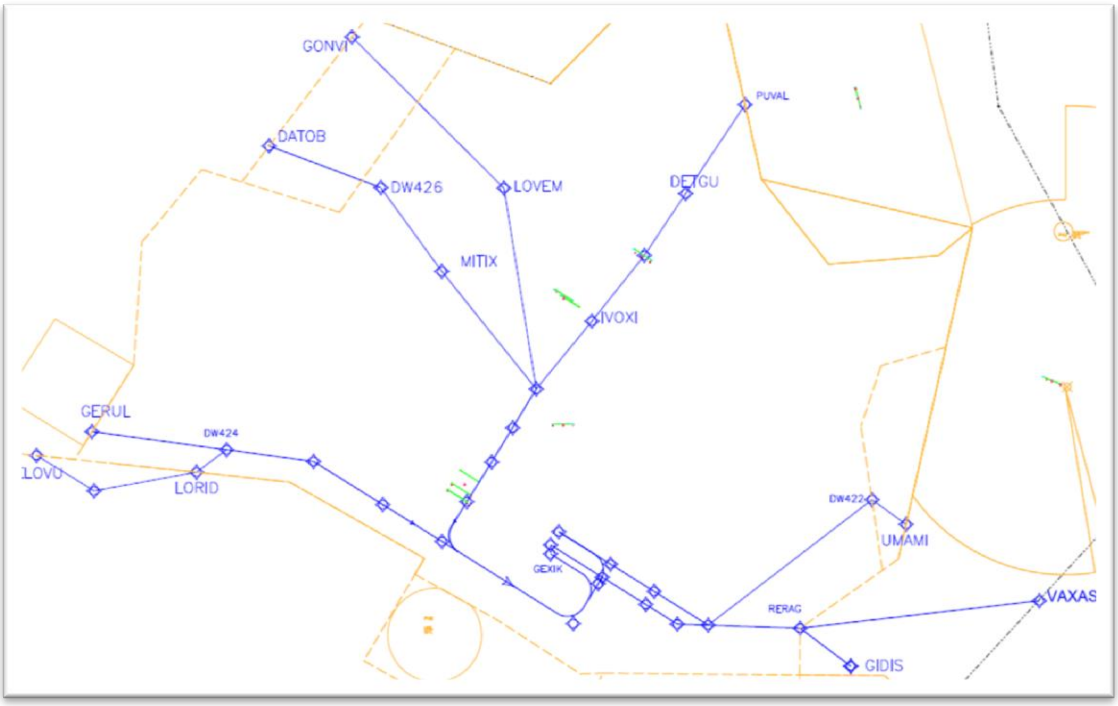


Figure 6: OMDW STAR30

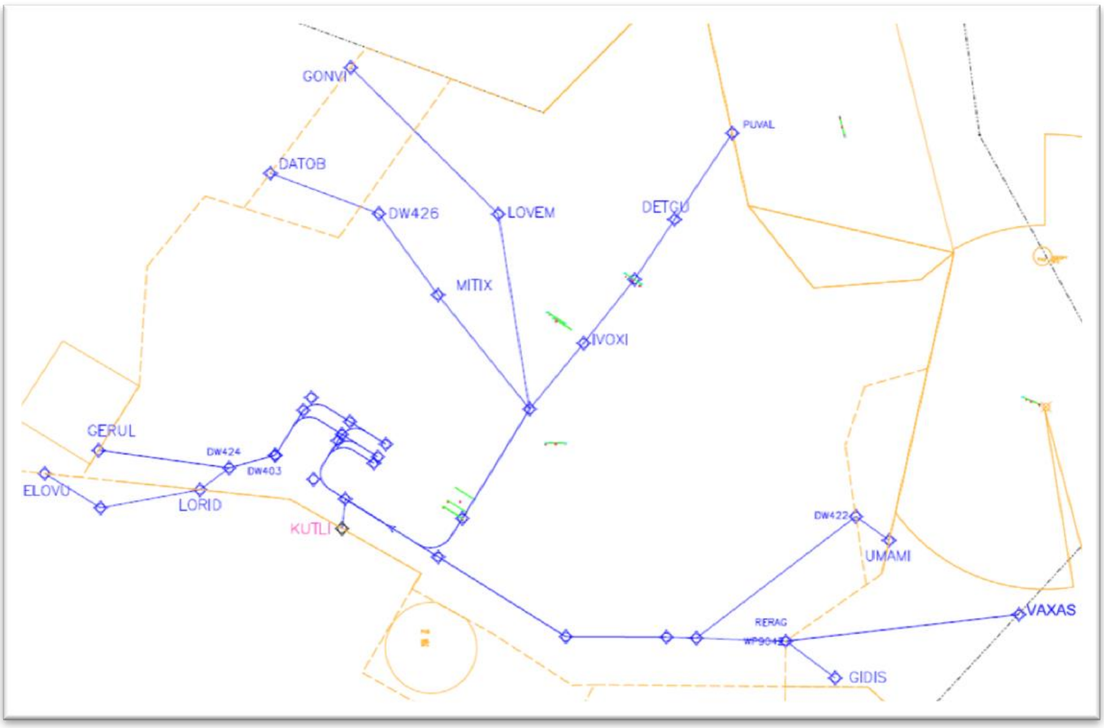


Figure 7: OMDW STAR12

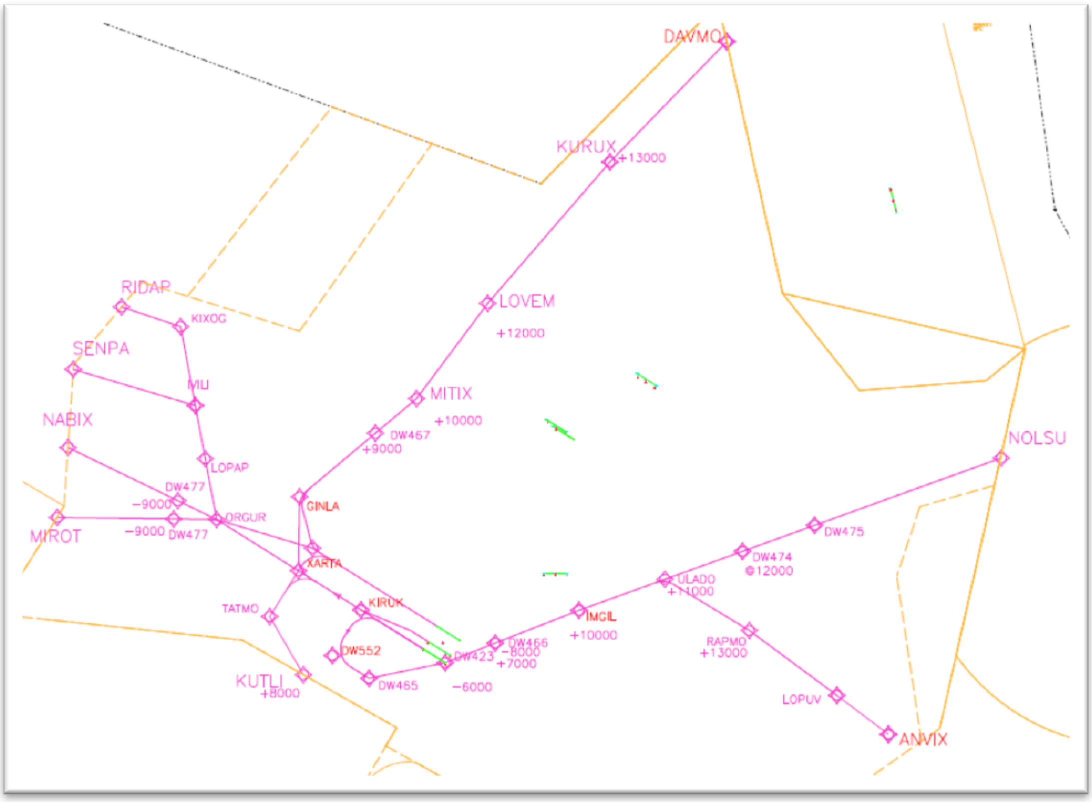


Figure 8: OMDW SID30

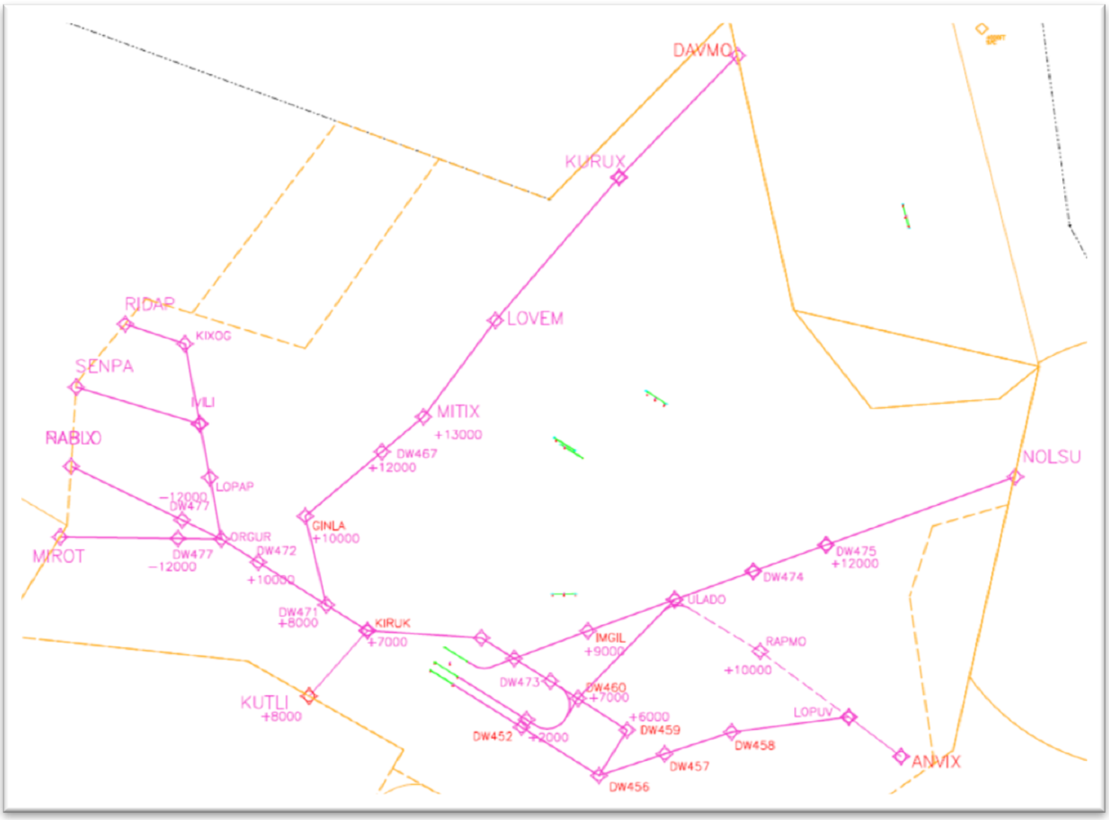


Figure 9: OMDW SID12

4.1.6 Revision of Dubai CTA sectors to manage three runways

The management of three-runway operations at OMDW requires a reshaping of Dubai CTA approach sectors (arrivals and departures) and the implementation of new control sectors (director and final monitors) according to ICAO SOIR provisions. In addition, management of multiple approaches and departures requires an evolution of the current regulatory framework.

Considering the set of SIDs/STARs developed for the three-runway system as input data for this process, a proposal for the review of Dubai CTA control sectors should be developed. The development process will include the following activities:

- Set up an operational model to carry out validation exercises using simulation tools;
- Develop safety case;
- Consolidate ATC operating procedures;
- Update local instructions and regulatory material;
- Perform training as required; and

- Address transition planning.

For the implementation of this new ATC sector organisation, aspects related to the need for additional staffing as well as the upgrade of ATS system for the approach control unit shall be addressed.

Such a revision of ATC sectors will offer additional capacity to better accommodate the traffic demand, whilst the resulting ATCO workload will be kept balanced.

4.1.7 Revision of SIDs/STARs from/to OMAL to implement two-runway operations

In line with the UAE ARP Phase 3 input data and assumptions, the implementation of the second runway at OMAL within TF1 was confirmed. Since SIDs/STARs structure was designed for single runway operations, the linking elements shall be reviewed to permit simultaneous operations on two runways.

For the given airport ground layout, independent operations on all runways can be implemented in compliance with ICAO SOIR, as the spacing between runways is greater than 1,035 m. This feature shall be considered when performing detailed design of new SIDs/STARs network. Moreover, in-depth design of approach procedures shall consider the technology enablers available by that time (e.g. GBAS).

The following steps shall be undertaken to implement the two-runway system at OMAL:

- Consider a major review of airspace restricted areas that may have significant impact on the design of IFPs;
- Perform detailed design of SID/STAR procedures to link the two runways with the en-route network;
- Develop operating procedures addressing a two runway-system and review methods of operations;
- Conduct a performance assessment;
- Develop a comprehensive safety case;
- Update the operational documentation for all ATS Units concerned;
- Perform training as necessary; and
- Address transition planning.

The addition of a second runway at OMAL will improve the capability of the national ATM system to manage the traffic demand safely and efficiently. Furthermore, the availability of independent operations on two runways properly connected to the route network will have the potential to satisfy specific airspace users' needs as well as mitigate the impact of contingency events. Because OMAL is located close to OMAA, such an infrastructure upgrade would potentially enable OMAL to become an alternate airport to OMAA. Stakeholders shall evaluate this option during the implementation stage.

For each direction of operations (RWY 01 and RWY 19), conceptual proposals to link the two-runway system to the network are shown below. This proposal shall be further developed at PANS OPS detailed design stage. Abu Dhabi CTA airspace shall be revised to accommodate the new SIDs/STARs design.

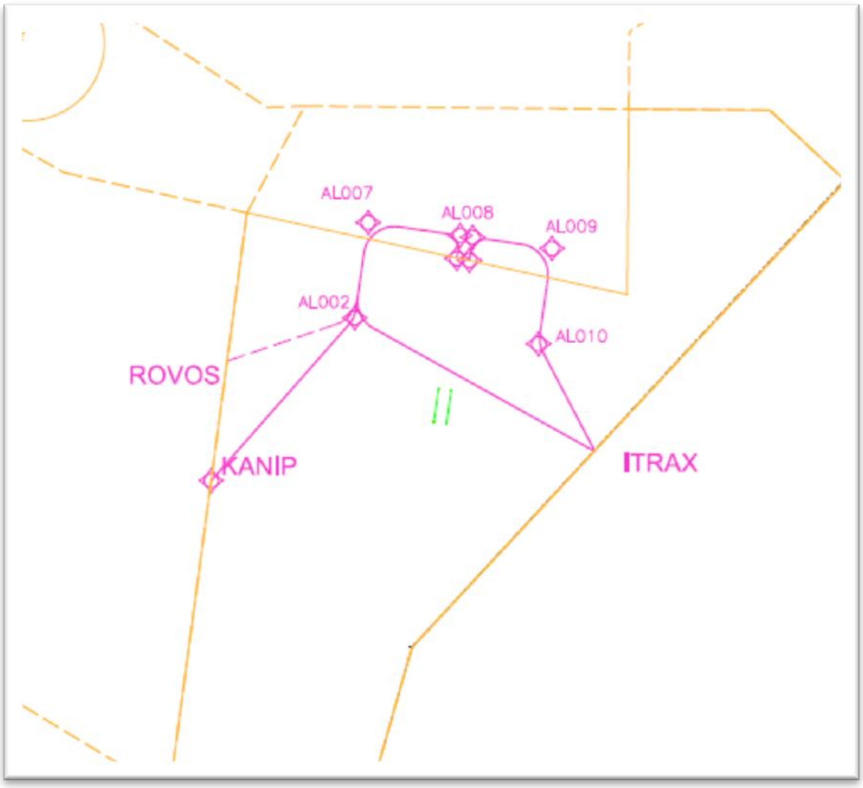


Figure 10: OMAL STAR19

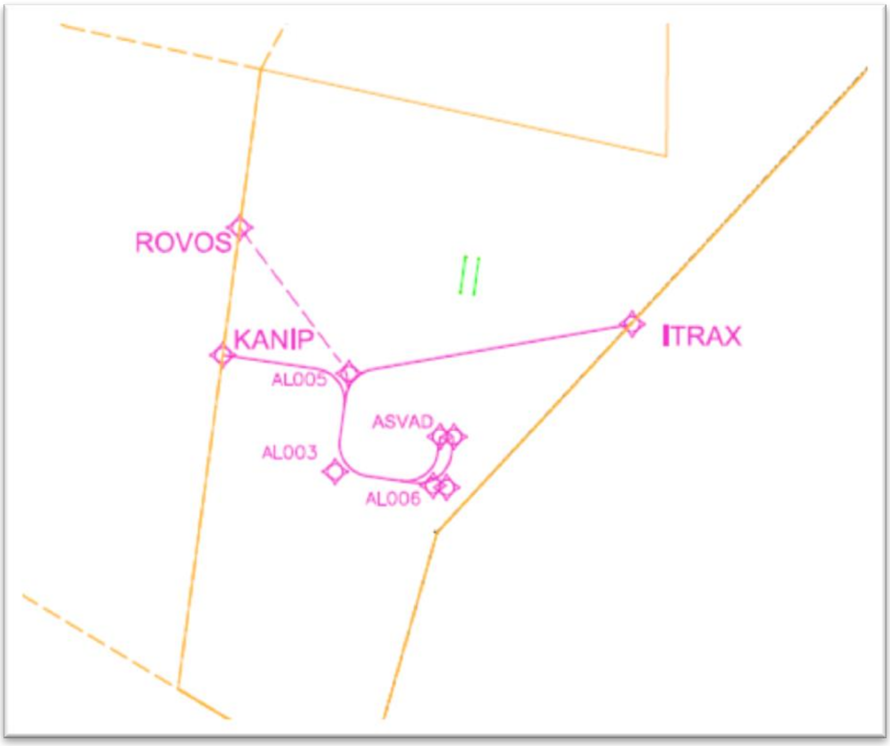


Figure 11: OMAL STAR01

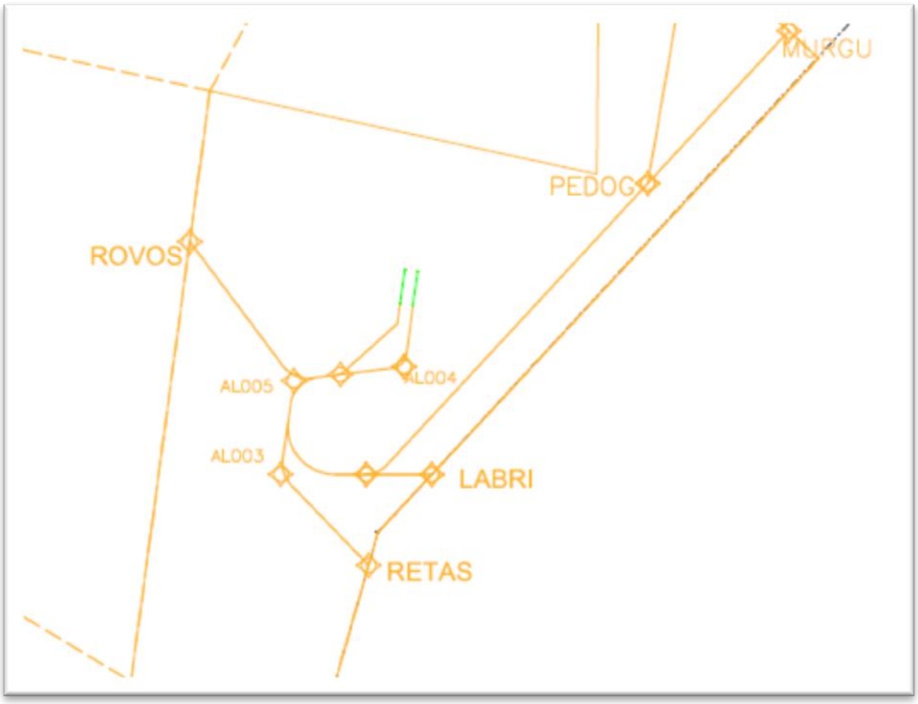


Figure 12: OMAL SID19

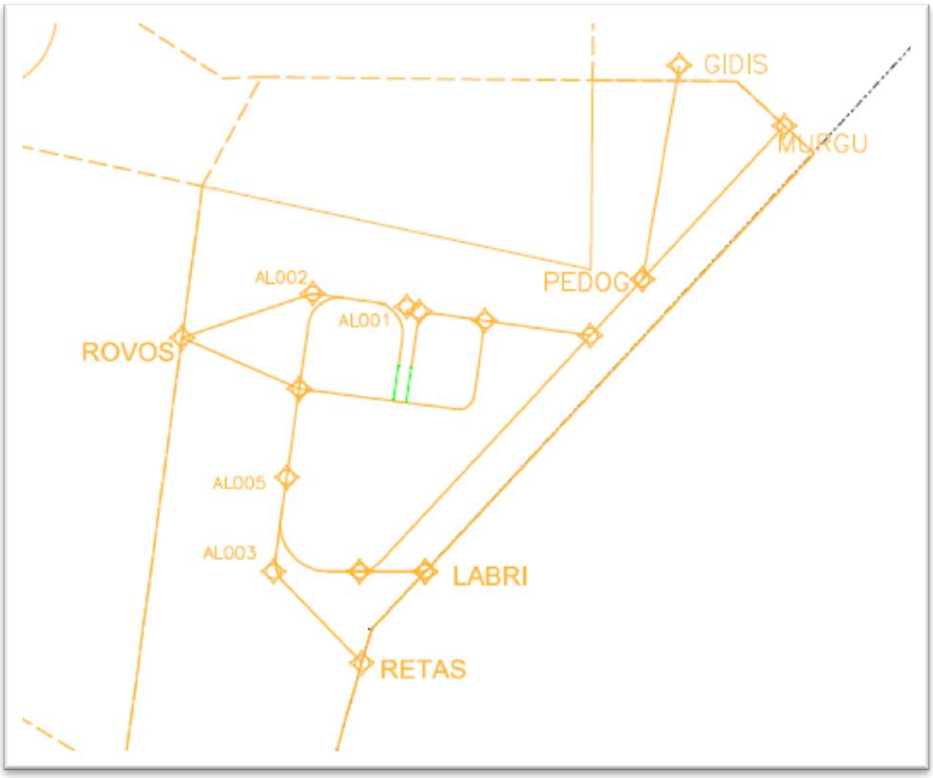


Figure 13: **OMAL SID01**

4.2 Timeframe – TF2

The concepts in this timeframe build on the proposed TF1 changes and represent further enhancement of the overall UAE ATM system with an outlook at regional level aimed at improving the cooperation with nearby States.

4.2.1 Revision of SIDs and STARS from and to OMDW to implement the fourth runway

In line with the UAE ARP Phase 3 input data and assumptions, the implementation of fourth runway at OMDW was confirmed within this timeframe. Although the SIDs/STARs structure for three-runway operation was designed in TF1, to accommodate the fourth runway a further terminal area network revision is required to enable multiple operations on four instrumental runways. Considering the airport layout, the following runway operations should be considered:

- South pair of runways set to independent parallel operations in mixed mode; and
- North pair of runways set to segregated operations, with arrivals on the south runway.

This operational model shall be considered when performing detailed design of new SIDs/STARs network. Moreover, in-depth design of approach procedures shall consider the technology enablers available by that time (e.g. GBAS).

The following steps shall be undertaken to implement the four-runway system at OMDW:

- Consider a major revision of airspace restricted areas (e.g. Skydive Climb Box, D18, etc.) that may have significant impact on the design of IFPs;
- Perform detailed design of SID/STAR procedures to link the four runways with the en-route network;
- Revise Dubai CTA's ATC control sectors;
- If possible, redesign the Dubai CTA, including the portion of airspace above Ras Al Khaimah CTA;
- Develop operating procedures addressing a four-runway system and revise methods of operations;
- Conduct a performance assessment;
- Develop a comprehensive safety case;
- Update the operational documentation for all ATS Units concerned;
- Perform training as necessary; and
- Address transition planning.

The addition of the fourth runway at OMDW will further improve the capability of the national ATM system to manage the traffic demand safely and efficiently. In addition, the proposed mode of operations will optimise the management of hub-in and hub-out traffic flows with a positive impact on air carriers' operations and ground movements. Quantitative benefits of this system upgrade (runways and ATS network) are described in Section 5.

For each direction of operations (RWY 12 and RWY 30), conceptual proposals to link the four-runway system to the network are shown below. This proposal shall be further developed at PANS-OPS detailed design stage.

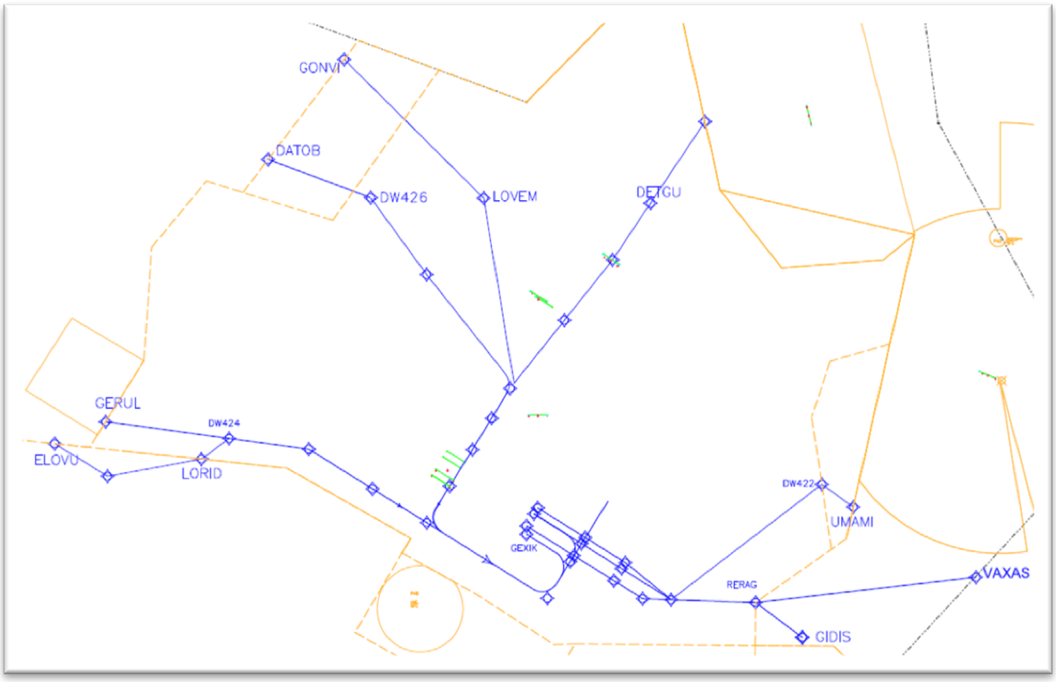


Figure 14: OMDW STAR30

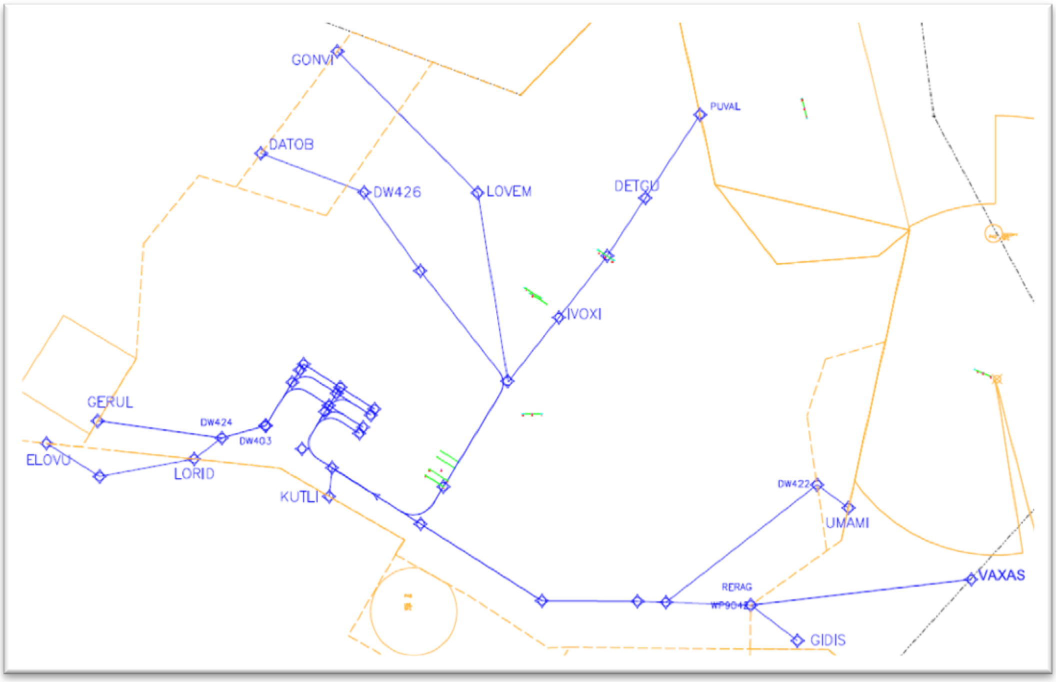


Figure 15: OMDW STAR12

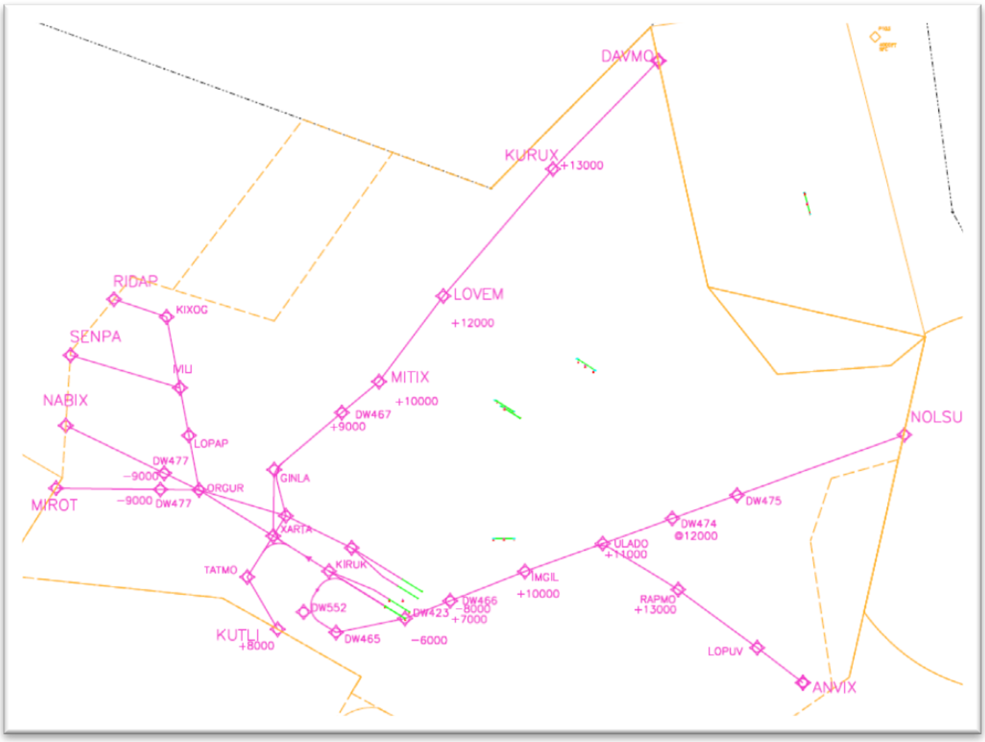


Figure 16: OMDW SID30

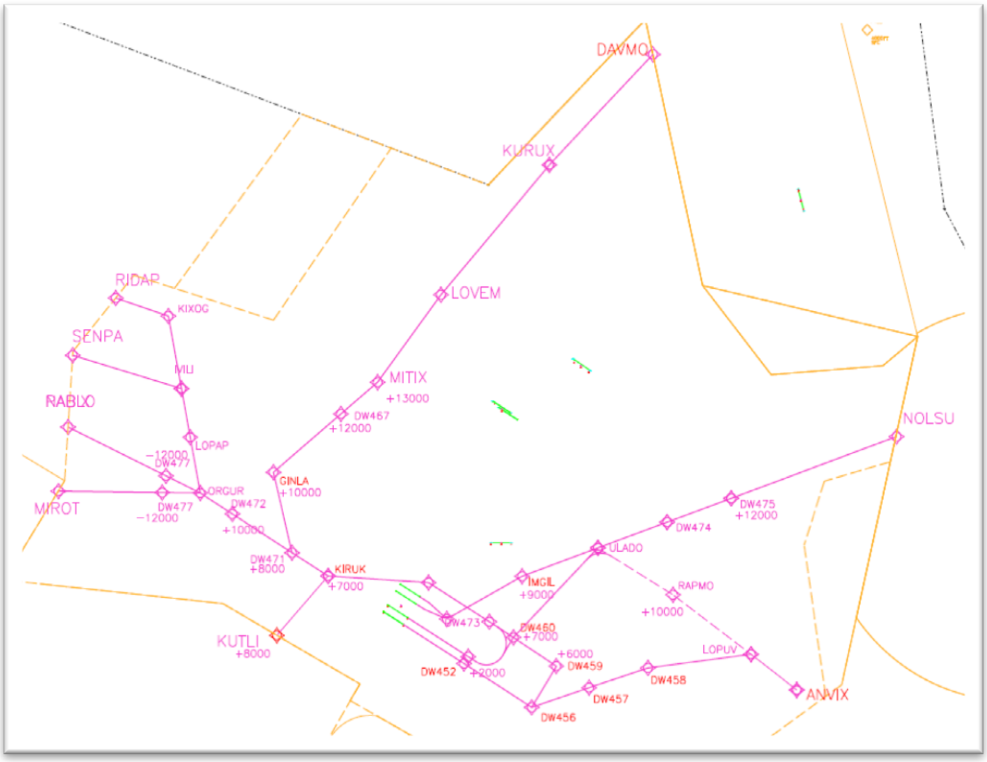


Figure 17: OMDW SID12

4.2.2 Revision of SIDs/STARs from/to OMAA to implement three-runway operations

In line with the UAE ARP Phase 3 input data and assumptions, it has been confirmed that the third runway at OMAA will be implemented within this timeframe. Since SIDs/STARs structure has been designed for two runway operation, a major revision of these linking elements is required to permit simultaneous operations on three runways.

For the given airport ground layout, it is possible to implement independent operations on all runways – ICAO SOIR requirements are met, as the spacing between runways is greater than 1,035 m. This feature shall be considered when performing detailed design of new SIDs/STARs network. Moreover, detailed design of approach procedures shall consider the technology enablers available by that time (e.g. GBAS).

The following steps shall be undertaken to implement the three-runway system at OMAA:

- Perform detailed design of SID/STAR procedures to link the three runways with the en-route network;
- Develop operating procedures addressing a three-runway system and revise methods of operations;

- Conduct a performance assessment;
- Develop a comprehensive safety case;
- Update the operational documentation for all ATS Units concerned;
- Perform training as necessary; and
- Address transition planning.

The addition of one runway at OMAA will improve the capability of the national ATM system to manage the traffic demand safely and efficiently. Furthermore, the availability of independent operations on three runways properly connected to the route network will permit to meet specific airspace users' needs as well as to mitigate the impact of contingency events. Quantitative benefits of this system upgrade (runways and ATS network) are described in Section 5.

For each direction of operations (RWY 13 and RWY 31), conceptual proposals to link the three-runway system to the network are shown below. This proposal shall be further developed at PANS-OPS detailed design stage.

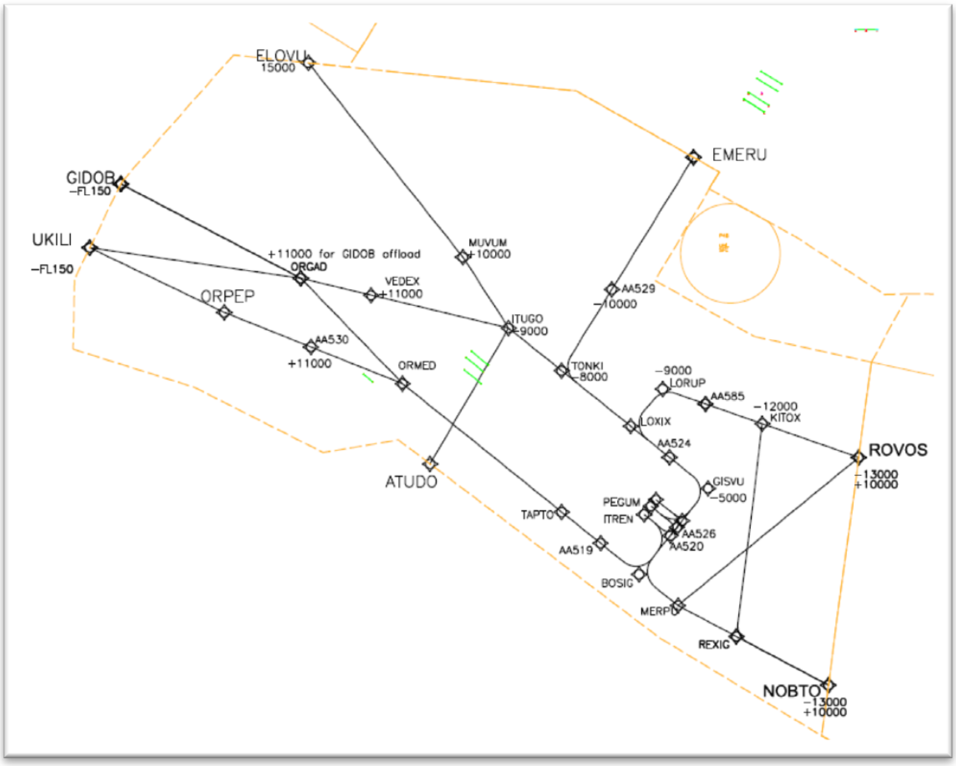


Figure 18: OMAA STAR31

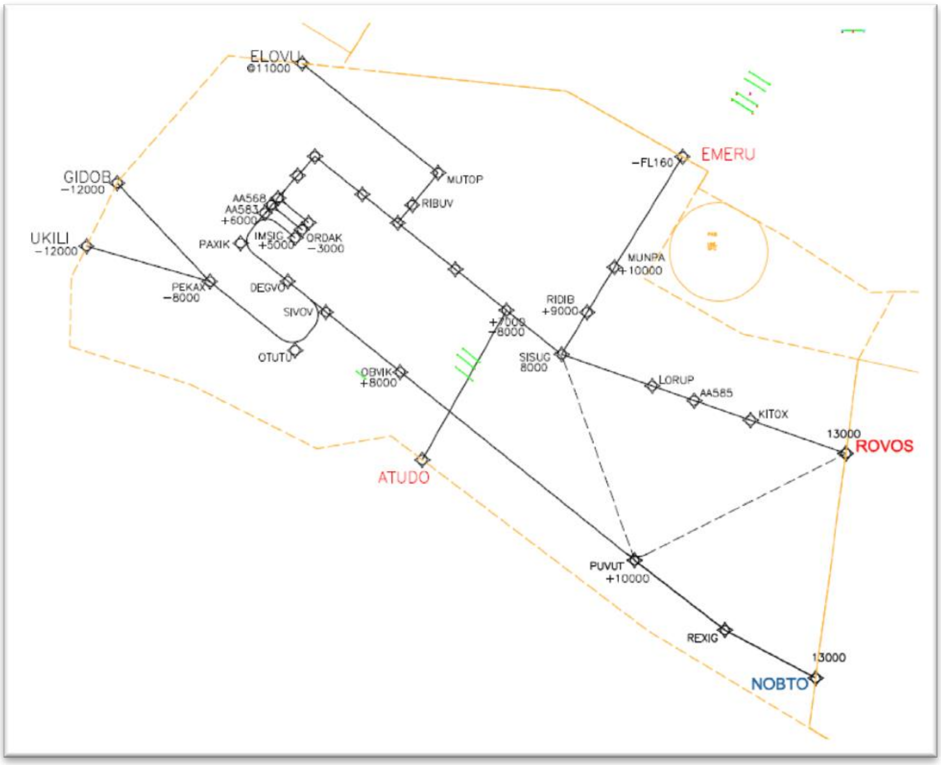


Figure 19: OMAA STAR13

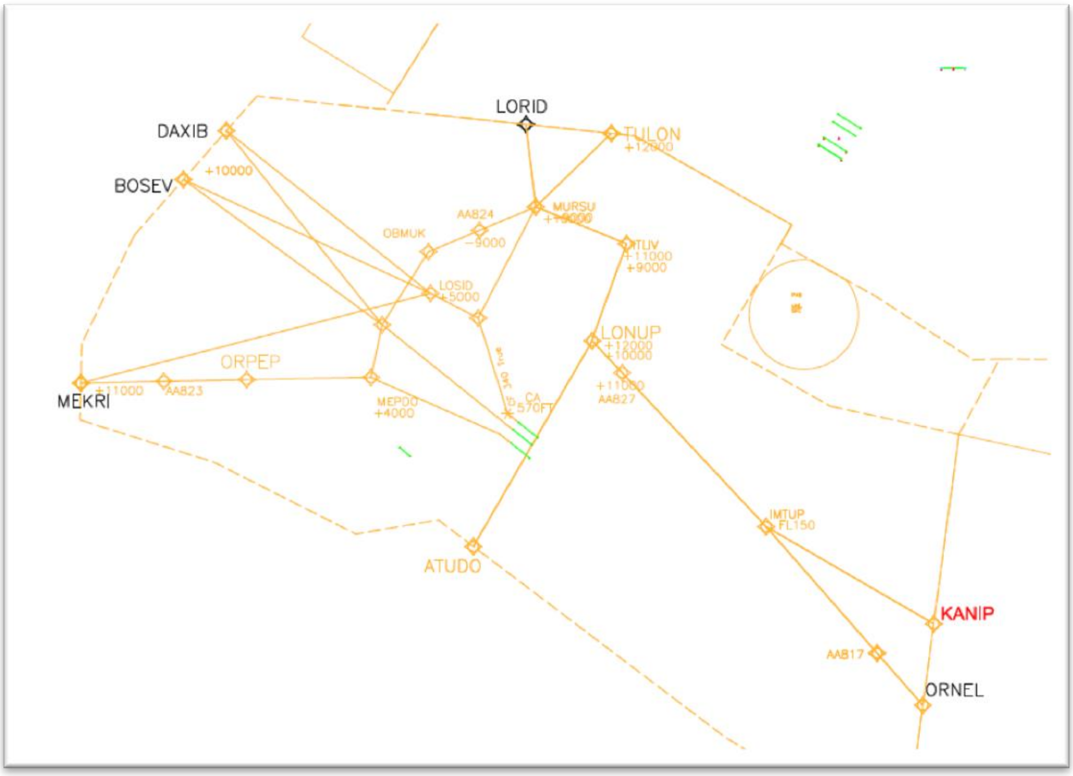


Figure 20: OMAA SID31

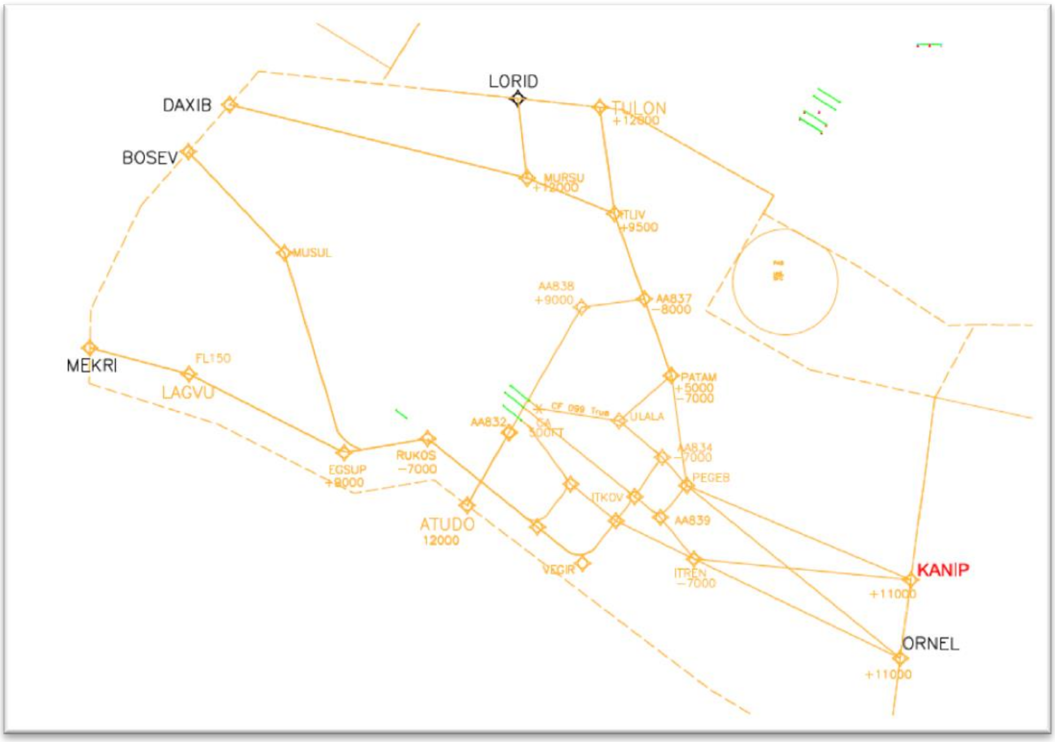


Figure 21: OMAA SID13

4.2.3 Revision of the organisation of Abu Dhabi CTA sectors

The organisation of Abu Dhabi CTA control sectors should be revised for both arrival and departure flows to accommodate three-runway operations at OMAA.

Development of appropriate operating procedures, safety case and training modules will be required. A key enabler of airspace evolution would be a major revision of airspace restrictions (e.g. OMR54, etc.) affecting the design of IFPs. Additional staffing and upgrade of ATM system may be required for the approach control unit, as well.

4.2.4 The implementation of a regional ATFM service

The management of traffic growth forecasted at regional level requires a higher degree of cooperation among the States in the ICAO MID area. According to the foreseen ICAO airspace harmonisation and interoperability plan, it is highly recommended that the UAE and nearby States consider the implementation of an ATFM service. ATFM provides a wide range of benefits to all stakeholders in terms of enhanced safety, reduced greenhouse gas emissions; decrease of fuel burnt and lower operational costs. In fact, ATFM system benefits provide an outstanding return on investment when compared to deployment costs.

It is recommended that the UAE Authorities undertake all necessary actions to establish an international coordination aimed at launching a regional programme of an integrated ATFM service, as limiting the implementation to the UAE airspace will only bring fewer benefits. One of the options is to implement the sub-regional GCC ATFM service as part of the GCC UFIR initiative.

As with any other commodity, airspace is a valuable resource particularly when subject to high demand. Since airspace is a finite resource, airspace management is a vital activity involving the planning, sector definition, use and management of airspace to satisfy users' needs in the most efficient and equitable way. An integrated regional ATFM service will ensure a safe, efficient, predictable and collaborative flow of traffic across all the phases of operations, i.e. from gate to gate.

In this sense, ATFM endeavours to make airspace and airports meet traffic demand. The latter part may result in flow measures, which imply the allocation of individual aircraft departure times (slots) to combat bottlenecks in the airspace and reduce safety risks as much as possible. Throughout all this activity, there should be continuous communication and exchange of information with all ANSPs and aircraft operators.

Embedded in ATFM, CDM process provides additional improvements. CDM is a process which allows decisions to be taken by stakeholders based on the most comprehensive and up-to-date accurate information. The structure of the CDM process in the ATFM service is designed to guarantee that stakeholders, ANSPs and airspace users can discuss ATS route network, areas, traffic demand and flight efficiency issues through regular meetings in order to share pertinent aspects and points of view.

The following steps shall be undertaken to implement a regional or sub-regional ATFM system:

- Potentially in coordination with the GCC, promote at ICAO regional level a comprehensive programme for the establishment of an integrated ATFM infrastructure;
- Conduct a feasibility study addressing the needs of all aviation stakeholders and the benefits achievable at regional and national level;
- Reach agreement and launch the implementation programme;
- Identify all organisational, regulatory, technical, staffing, training and logistics enablers.

ATFM implementation improves airspace use and, jointly with the CDM process, increases the overall operational efficiency of commercial air traffic. Moreover, the establishment of a regional ATFM service may act as one of the enablers for the implementation of FRA concept in TF3.

The implementing solution will offer similar services and functionalities to those provided in other parts of the world (e.g. EUROCONTROL). Given the degree of advancement of the UAE aviation industry and the air traffic volumes managed by the UAE ANSPs, UAE aviation authorities may lead the implementation of a regional ATFM service, proposing Sheikh Zayed Air Navigation Centre (SZC) as a hosting facility.

An ATFM organisation aims to assign to each participating State the responsibility for collecting, disseminating, monitoring and surveillance of ATFM activities within its respective FIR(s). This will ensure that all stakeholders have timely and efficient access to applicable ATFM information.

The airspace users participate in the ATFM process by providing and updating flight plan information as well as participating in CDM processes, e.g. through the discussion about ATFM strategies to improve flight efficiency and participation in user-driven prioritisation processes.

The purpose of this proposed integrated regional structure is to establish a protocol for each level of the organisation to be informed of ATFM information in a timely and accurate manner. The following organisational model can be tailored to meet the needs of each State/ANSP. It is desirable that letters of agreement (LoAs) or other appropriate documentation are developed in order to attain the necessary standardisation.

Each State will ensure that the ATFM organisational structure addresses the management of:

- The ATFM service;
- Coordination and exchange of information, both internally and externally;
- A line of authority for the implementation of decisions; and
- Compliance with mission requirements.

A clear management line to support the integrated ATFM service is required. This may include the following:

- Manager of the ATFM service;
- A Flow Management Unit (FMU) that provides ATFM service for all ATS units inside the regional ATFM airspace;
- Flow Management Positions (FMPs) at specific ATS units responsible for the day-to-day ATFM activities.

FMU and FMP roles and responsibilities imply that the ATS units monitor and balance traffic flows within their areas of responsibility in accordance with air traffic management directives. FMUs/FMPs direct the traffic flows and implement approved traffic management measures jointly with relevant authorities.

All stakeholders involved in the ATFM system shall be given the training required to allow for an efficient ATFM service. ATS personnel, as well as airspace users, must have the knowledge required to carry out their respective responsibilities.

At the ATS level, the ATFM service should be structured as follows:

- The aerodrome control tower is served by an FMP. The control tower's FMP coordinates with the FMP at the approach control unit.
- The approach control unit is served by an FMP. Given the complexity and the workload inside the CTAs, this duty should be assigned to a dedicated position. The approach control unit's FMP coordinates with the FMP at an Area Control Centre (ACC).
- Each ACC within the regional integrated ATFM service area should be served by an FMU. This ATFM structure is more complex and may consist of a number of traffic management coordinator positions to meet the needs of the ACC and its subordinate units. The typical organisation of the ACC FMU requires dedicated staff to provide:
    - Approach control coordination;
    - Departure control coordination;
    - En-route coordination;

- Meteorological briefing/forecasting coordination;
    - Airspace user liaison;
    - Military liaison;
    - Airport coordination; and
    - Additional support functions, e.g. administrative support, crisis management coordinator and post-operations analyst may also be required, as applicable.
- All the ACC FMUs shall be served by a regional ATFM centre. This is a complex ATFM structure that includes multiple functions. Each function may require dedicated staff or it may be combined, depending on workload. The role of a regional ATFM centre covers:
    - Traffic management coordination;
    - Traffic planning;
    - Meteorological briefing/forecasting coordination;
    - NOTAM/messaging coordination;
    - Flight calibration / flight check coordination;
    - Airspace user liaison;
    - Military liaison;
    - Information technology coordination and operational data management;
    - Technical operations coordination (concerning infrastructure and systems such as NAVAIDs, radar, VHF communication sites, etc.);
    - Crisis management coordination; and
    - Operations analysis.

  Depending on traffic demands and complexity, some of the above functions may be combined.

4.3 Timeframe – TF3

In the TF3, traffic demand to/from the UAE as well as the number of overflights is still expected to increase. In this long-term vision, OMAA and OMDW represent the main gateways for the flights in and out of the UAE. The evolution of respective ground infrastructure will drivee the development of the lower UAE airspace structure. The introduction of FRA concept will drive the overall organisation of the upper airspace in coordination with the neighbouring States.

4.3.1 Revision of SIDs and STARS from and to OMDW to implement the fifth runway

In line with the UAE ARP Phase 3 input data and assumptions, the implementation of the fifth runway at OMDW was confirmed to take place within this timeframe, to reach the expected target airport layout. The terminal area network will therefore require an additional revision to enable multiple operations on five instrumental runways. The inclusion of the fifth runway at OMDW will most likely require the introduction of a new approach structure – the Point Merge System (PMS).

PMS is a procedure based on a structure of RNAV 1 routes for managing the inbound traffic flow. This innovative technique improves the efficiency of operational management in the arrival terminal areas with high traffic density by reducing the workload of ATCOs / flight crews and allowing performing OPDs with a high number of arrivals.

The PMS concept is aimed at increasing ATC capacity and improved sequencing through smoother and more harmonised management of arriving traffic. The objective of PMS is to have a smoother and more harmonised management of arriving traffic, providing the following benefits to:

- Sustain expected airport capacity, but at the same time to make it possible to deal with any future capacity increase;
- Increase safety as a result of a more structured airspace, with positive impacts on ATCOs' and flight crews' situational awareness;
- Slightly reduce flight time due to better and more efficient application of delay actions;
- Increase flight efficiency due to the augmented use of the Flight Management System (FMS) and improved environmental sustainability by using OPD, ensuring that the longest track miles distance remains within a pre-set limit;
- Improve predictability as a result of standardised ATCO methodologies, as well as improved trajectory prediction and reduction in the number of open loops; and
- Build a constructive relationship from earlier stages of the project with the Regulator, ANSPs, airline operators, FMS manufacturers and data houses to identify any potential fuel issues (fuel planning) and to find the associated feasible solutions.

By using linear holding, aircraft are always a fixed distance from the runway and this permits more efficient sequencing of the landing aircraft, because they are just one turn from a direct approach to the runway at all times. Hence, PMS will almost eradicate the need to put aircraft into traditional circular holding patterns, providing environmental benefits by reducing fuel burn and carbon emissions, as well as improving flight predictability. The latter will permit a better synchronisation of airport operators and air carrier processes, e.g. aircraft turnaround process. PMS design balances ATC and airspace users' requirements.

The PMS is expected to be the main feature of the new terminal area network, as it will feed all runways used for arrivals. Considering the new OMDW airport layout, runways should be grouped as follows:

- South group of three runways set to deliver dependent parallel operations in mixed mode; and
- North group of two runways set to provide segregated operations, with arrivals on south runway.

The implementation should be addressed in the following steps:

- Perform a major revision of existing SIDs/STARs at OMDW;
- Revise SIDs/STARs of nearby airports as necessary;
- Revise Dubai CTA's ATC sectors;

- Develop operating procedures addressing the five-runways system and revise the methods of operation;
- Conduct a performance assessment;
- Develop a comprehensive safety case;
- Update the operational documentation for all ATS Units concerned;
- Perform training as necessary; and
- Address transition planning.

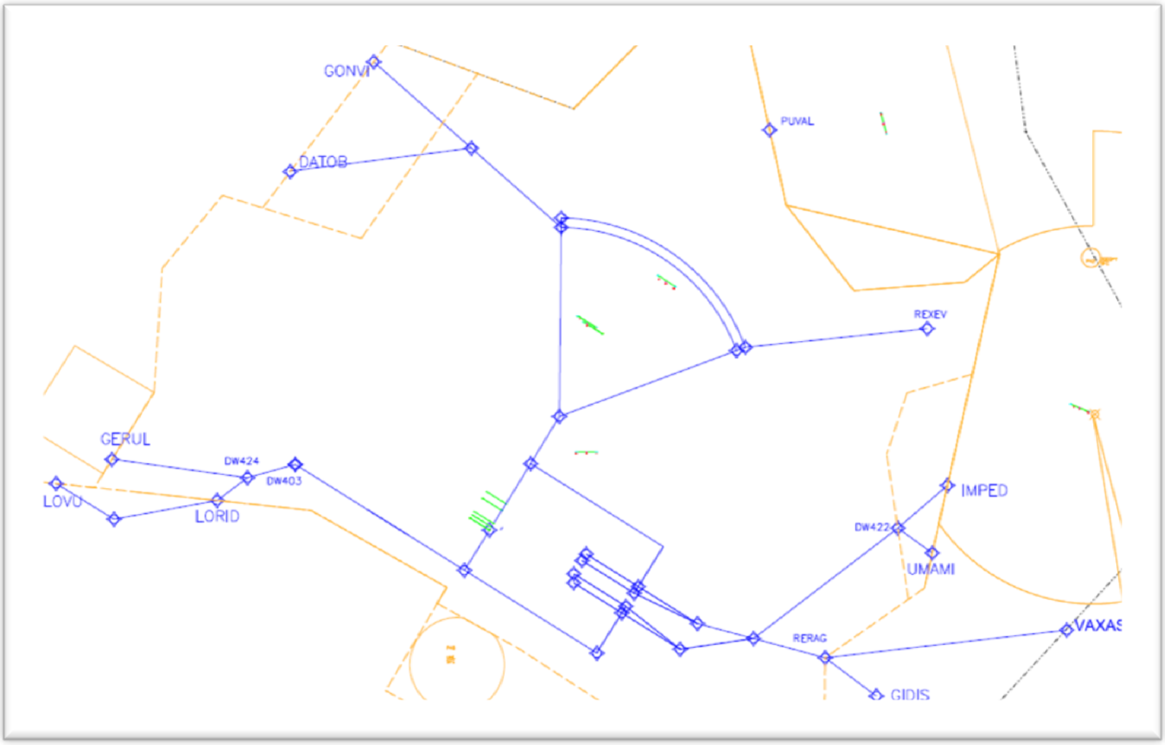


Figure 22: OMDW STAR30 PMS

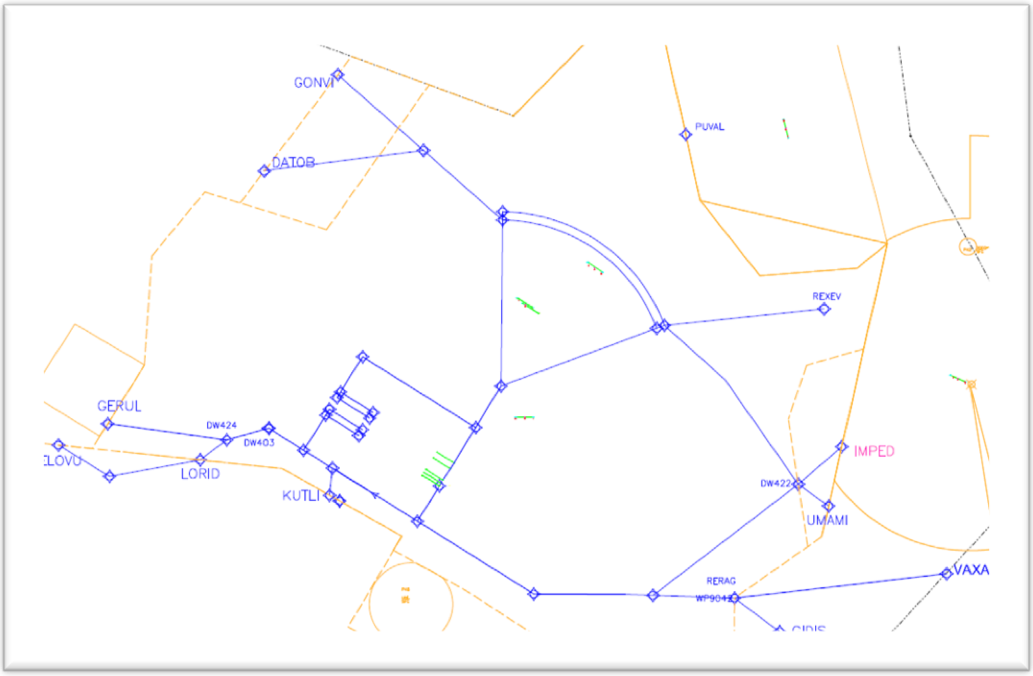


Figure 23: OMDW STAR12 PMS

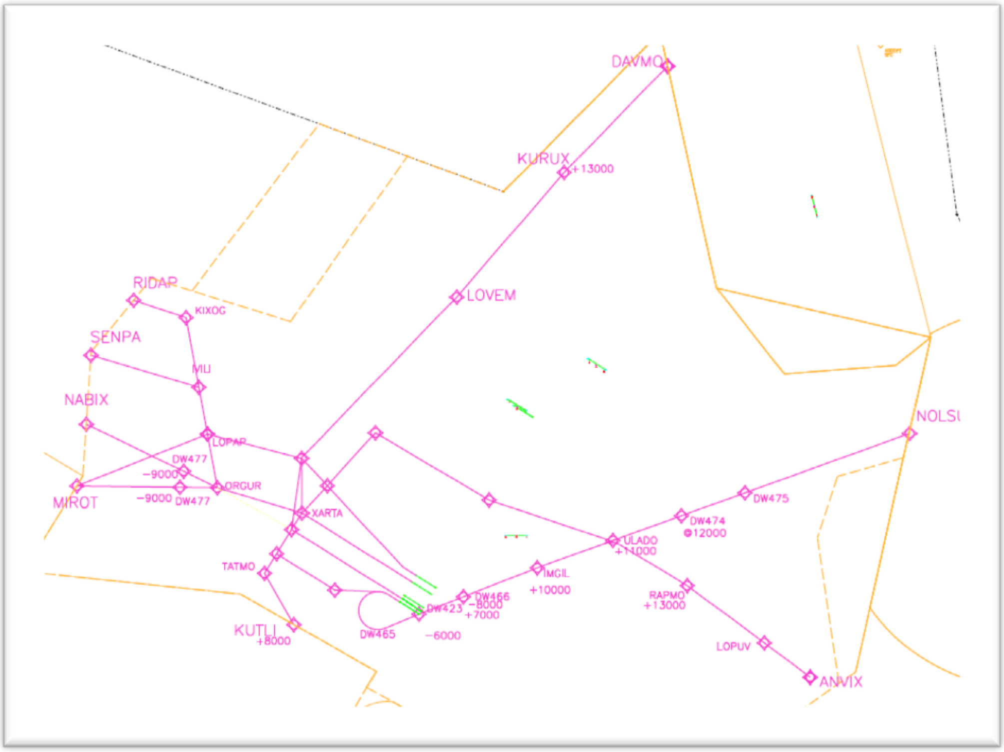


Figure 24: OMDW SID30

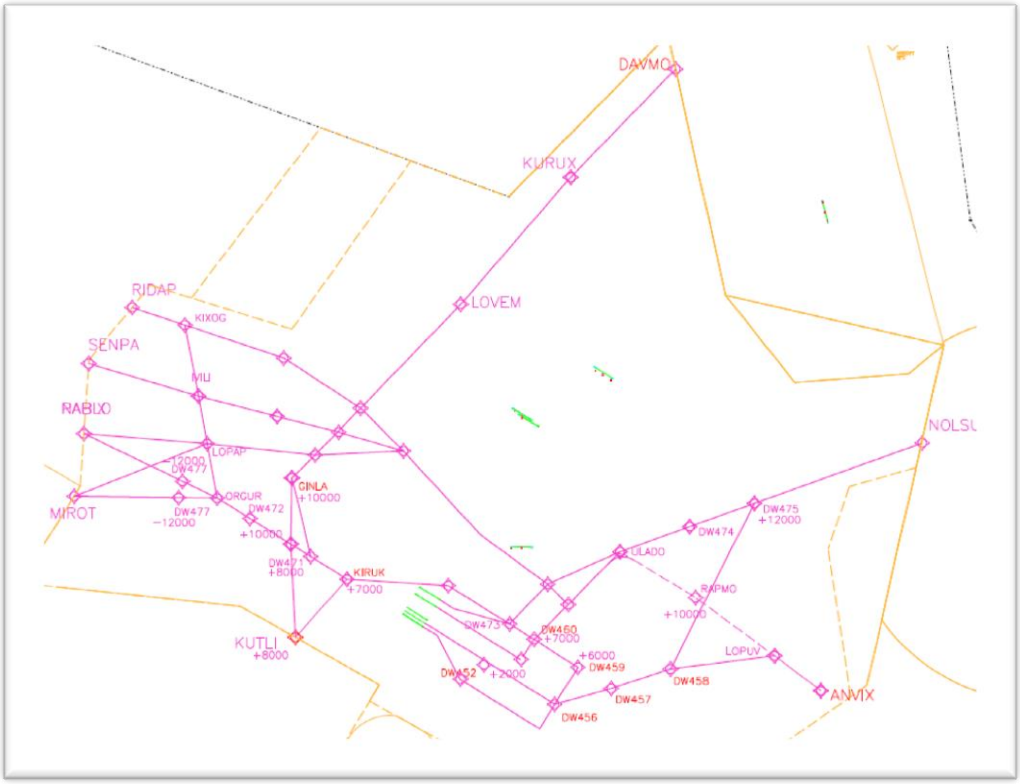


Figure 25: OMDW SID12

4.3.2 Revision of SIDs/STARs from/to OMAA to implement four-runway operations

In line with the UAE ARP Phase 3 input data and assumption, the implementation of the fourth runway at OMAA was confirmed within this timeframe, to reach the expected target airport layout. The terminal area network will therefore require an additional review to enable multiple operations on four instrumental runways.

The implementation should address the following steps:

- SIDs/STARs will be revised as necessary to permit simultaneous operations on four runways;
- Abu Dhabi CTA will be revised to accommodate the new SIDs/STARs design;
- The new infrastructure will require the reshaping/revising of nearby airspace under the responsibility of the military authority;
- Abu Dhabi CTA operational sectors will be reviewed;
- Operating procedures addressing a four-runway system and revision methods of operations will be developed;
- A performance assessment will be conducted;

- A comprehensive safety case will be developed;
- The operational documentation for all ATS Units concerned will be updated;
- Training will be performed as necessary; and
- Transition planning will be addressed.

The addition of one runway at OMAA will improve the capability of the national ATM system to manage the traffic demand safely and efficiently. Furthermore, the availability of independent operations on four runways properly connected to the route network will enable to meet specific airspace users' needs as well as mitigate the impact of contingency events. Quantitative benefits of this system upgrade (runways and ATS network) are described in Section 5.

For each direction of operations (RWY 13 and RWY 31), conceptual proposals to link the four-runway system to the network are depicted below. This design considers the airspace available at the time of writing of this masterplan. Should additional portions of airspace become available, a different link to these four runways may be investigated (e.g. implementation of a PMS pattern similar to the one proposed for OMDW). This solution shall be further developed at PANS-OPS detailed design stage.

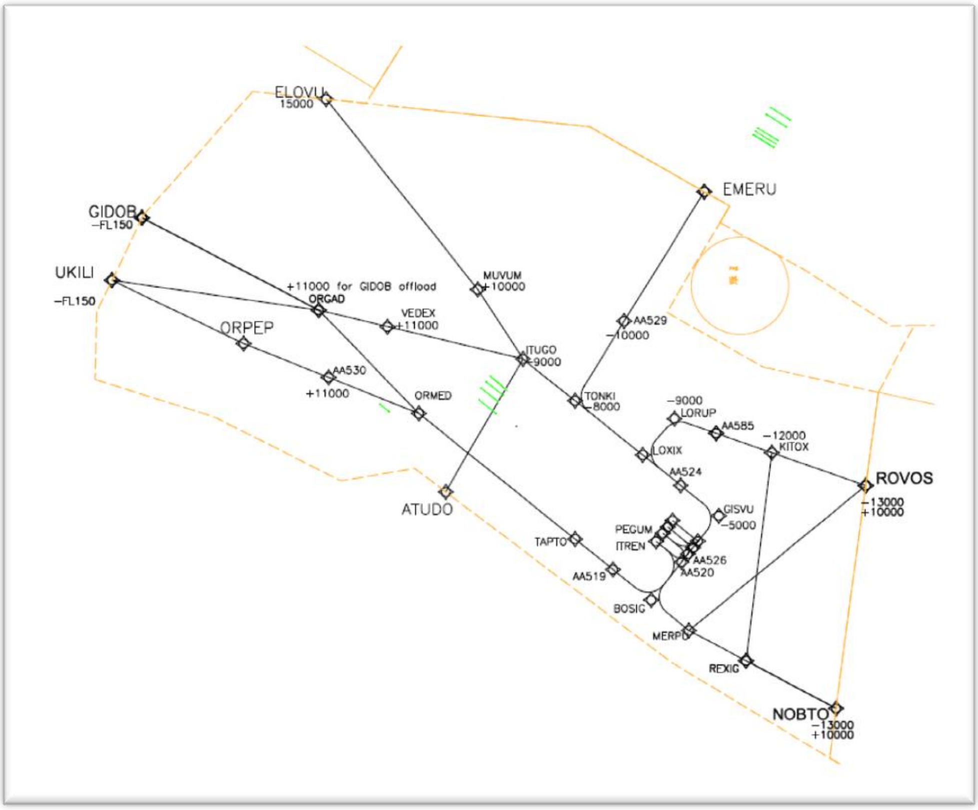


Figure 26 : OMAA STAR31

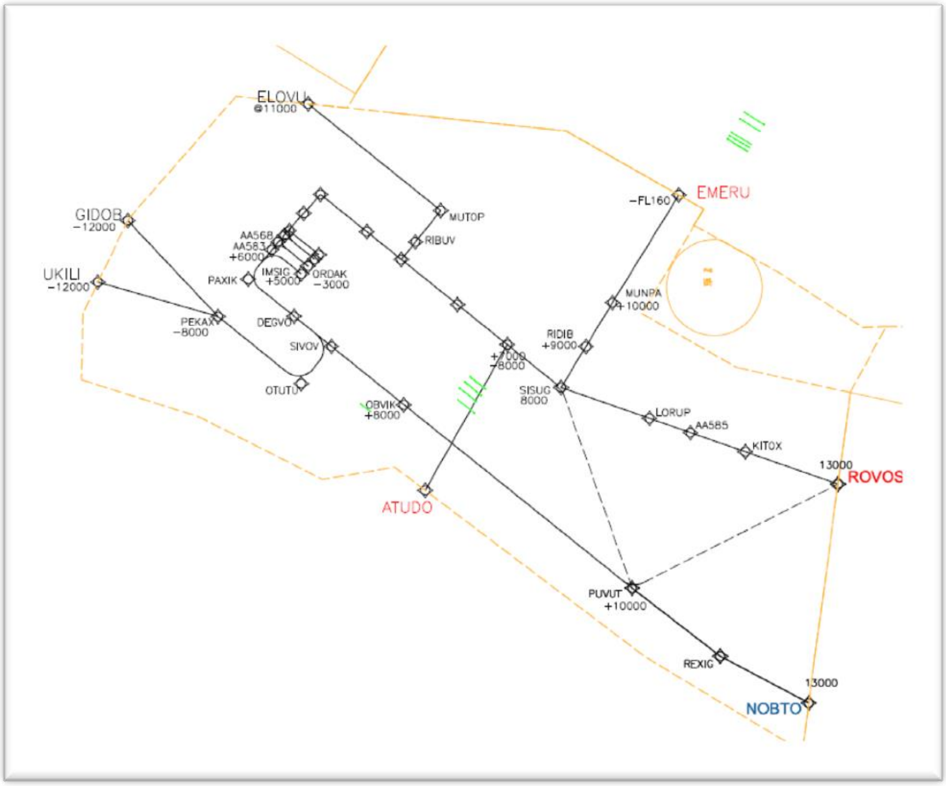


Figure 27 : OMAA STAR13

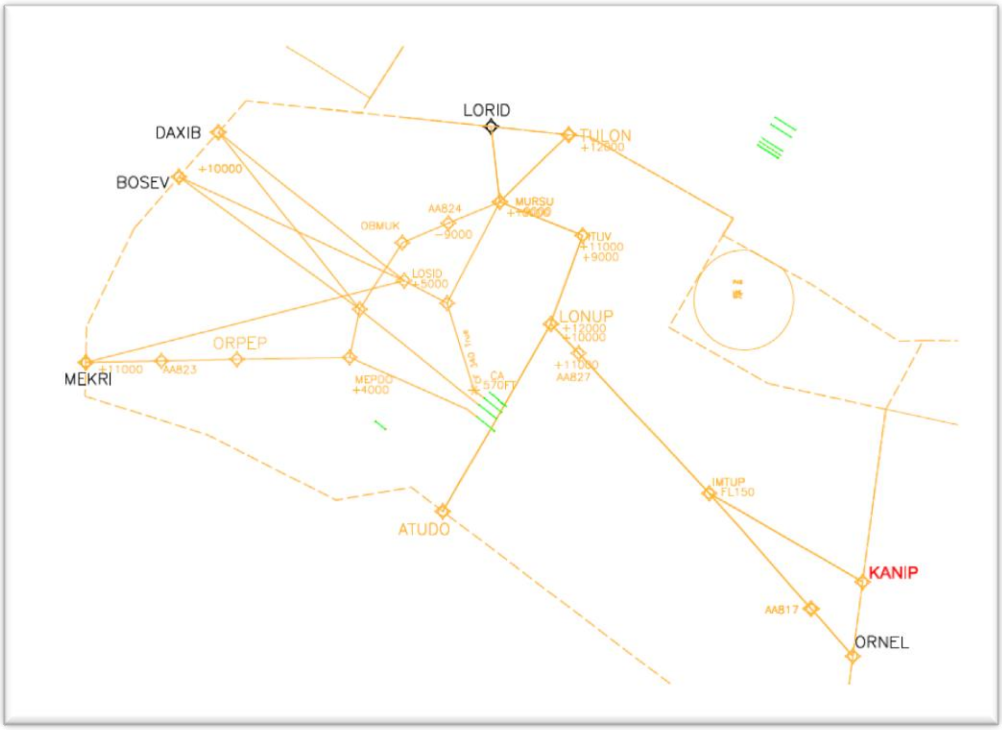


Figure 28 : OMAA SID31

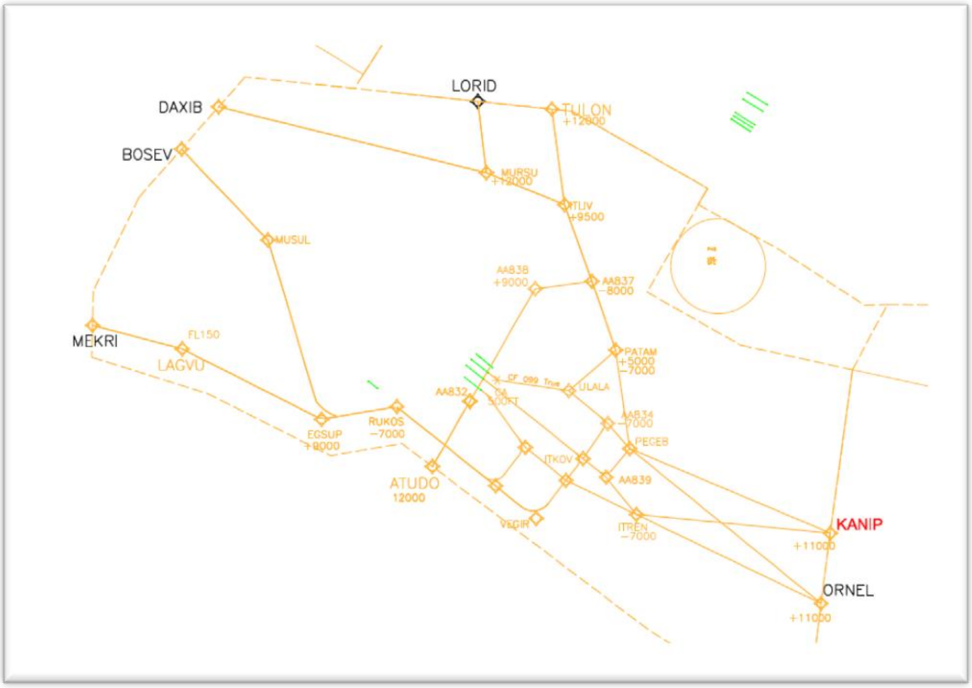


Figure 29 : OMAA SID13

4.3.3 Rationalisation of approach control functions within the UAE lower airspace

The close interaction among SID/STAR sets linking all the aerodromes within the UAE airspace along with the proximity of major hub airports with multiple runways (OMDW and OMAA) makes the circulation of air traffic complex, as limited airspace is available for the ATC management in that area. Keeping the current CTA boundary configurations and methods of operations will introduce unnecessary complexity into CTA operations, resulting in additional coordination requirements, difficulties in the management and restrictions to the network access.

The efficiency of airspace operations may benefit from the different allocation of responsibility in the provision of ANS among all ANSPs (overtaking the limits placed by ATS units/boundaries). This objective could be achieved through an integration and harmonisation process involving airspace design, systems and procedures.

The establishment of a centralised approach control service using the CTAs airspace on a functional basis is a potential solution to be explored. It is highly recommended to start a widespread process aiming at establishing a seamless and centralised approach service within the main CTAs. The acceptance of this principle will enable developing new and more efficient ATC operating procedures and IFPs independently from the existing CTAs boundaries in the UAE.

4.3.4 The implementation of Free Route Airspace

In line with the ICAO airspace harmonisation and interoperability plans foreseen for this timeframe, it is desirable that the UAE stakeholders consider the implementation of FRA concept in the upper airspace. Given the dimensions of the UAE airspace, the major benefit could be achieved only if neighbouring States participate in the FRA programme.

Building on the experience gained in the framework of the regional ATFM programme, the implementation of the FRA concepts will include the following steps:

- The UAE FRA design (FRA airspace boundaries, route availability, no planning area, entry/exit/intermediate points);
- Airspace organisation and management (FRA operations and contingency planning);
- Impact on ATC (vertical connection between FRA and fixed ATS route network within the UAE FIR);
- Elaboration of a risk assessment report;
- Civil-military coordination for airspace availability and reservation management;
- Interface with adjacent States for ATS delegation and LoA review;
- AIS procedures for ANS and airspace users;
- Regulatory framework and AIP updates;
- Changes to Flight Data Processing System (FDPS);
- Traffic flow statistics (eligible flights) and benchmarking; and
- Benefit analysis.

The benefits of FRA for the UAE are mainly the following:

- Removal of the constraints imposed by the fixed route structure and optimisation of the usage of the entire airspace, obtaining advantages in terms of capacity, flexibility, flight efficiency and cost savings; and
- Addressing the requests made by aircraft operators who are always looking for enhancements and new possibilities to provide more flexibility in the airspace.

From the technical point of view, many of the existing systems and management tools already implemented in the UAE are capable of supporting FRA operations. The following identified technical tools could have a significant contribution in further facilitating the implementation of FRA in the UAE airspace:

- Updated FDPS;
- Updated CWP systems;
- Short Term Conflict Alerts (STCAs);
- Flight leg;
- Medium Term Conflict Detection (MTCD);
- Area Proximity Warning (APW); and

- Flight plan tracking.

5. PERFORMANCE ASSESSMENT

This section provides a performance assessment of the airspace and operational concepts defined in Section 4 through a comprehensive description of assessment objectives, assumptions, characteristics of scenarios, analysis methodology, and results.

5.1 Objectives

The main objective of this analysis is to evaluate how the UAE integrated system (airports and airspace) improve by utilising the new operational concepts and infrastructure, such as procedures and runways, in response to potential traffic demand up to 2040.

The assessment is conducted through three simulations (*Stream* 1, *Stream* 2, and *Stream* 3), each varying according to the different objectives and consequently to the introduced and measured variables.

5.2 Methodology

Model-based simulations are selected as a technique to conduct analyses related to the impact of changes occurring in a defined operational context. This is possible thanks to the fast-time simulator's features to model all aspects of the operational environment in terms of ATS geography (airspace, procedures, and runways), while considering all air traffic management rules.

To measure the performances of an ATM system successfully and in coherence with the identified objectives, it is necessary to select a precise set of scenarios in which the changes (operational concepts and ATS infrastructure) and relevant effects are detected in detail. The three timeframes in which this IAMP is composed of correspond to the scenarios. To measure the aforementioned effects, proper indicators shall be chosen in accordance with the performance areas of the analysed system, which can be affected by the said changes. The following section describes the various elements of the simulations.

5.2.1 Tool

AirTOp is a gate-to-gate fast time simulator that is able to model detailed airport and airspace scenarios. The tool assesses changes in infrastructure, operations, procedures, and operational concepts to support planning, analyses, and fit-for-purpose decision-making.

Many hypotheses can be evaluated by AirTOp studies to select the best solution in all ATC applications. Airspace and airport performances can be assessed in Capacity, Safety and Flight Efficiency KPAs.

5.2.2 Measured Key Performance Areas

The following key performance areas were chosen to be assessed for the purposes of this document:

- Capacity;
- Efficiency; and
- Environmental Sustainability.

This categorisation aims at analysing the system behaviour in accordance with the objectives of the airspace/ground improvements foreseen up to 2040.

To measure these performances, a set of Key Performance Indicators (KPIs), specific for each area, as well as the related metrics have been chosen, based on the system features which are potentially affected by the introduced changes. These are listed below

KPA	KPI
Capacity	Throughput
Efficiency	Delay
Environmental Sustainability	Distance Flown
	Fuel Burnt
	Duration Flown

Table 5: KPAs and KPIs

Throughput: This KPI measures the total number of flights in a given timeframe (e.g. hourly, daily) passing through a defined element, which corresponds to the number of flights that are accommodated after having been managed by the system in accordance to the separation rules. It may be measured at runway/waypoints/holding levels and sorted by arrival/departure flows. Therefore, it is the traffic demand affected by the delay.

Delay: This KPI is normally used to measure the capability of the system to handle traffic demand through its ATS geography infrastructure and air traffic management rules. This efficiency aspect is calculated by measuring the difference between the estimated time at which a flight is expected to be somewhere in air or at ground as well as the estimated time of changing its status (e.g. landing, take-off, etc.) with respect to the actual time when it occurs. The delay is measured because it highlights any system bottlenecks (caused by an exceeding amount of flights passing a defined point) or the effect of the flow management due to the separation requirements acted by, e.g. holding, vectoring, speed reduction, etc. The phase affected by the delay is measured accurately according to the specific focus of the analysis in progress. The delay is then graphically represented on a daily and hourly scale as an average value with respect to the number of flights passing the specific portion of airspace.

Distance flown, Flight duration and Fuel burnt: These KPIs are commonly interlinked because the effects on the distance and/or time affect the fuel burnt, which impacts the environmental sustainability and the cost efficiency of any infrastructure optimization in air and at ground. It is noteworthy that the distance flown as well as the flight duration do not only depend on the route network, but also on the air traffic flow management.

5.3 Models

Three types of simulations were conducted and are referenced as *Stream* 1, *Stream* 2, and *Stream* 3. Each *Stream* analyses the UAE system from three viewpoints, meaning that no relation exists among them, apart from the items below:

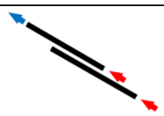
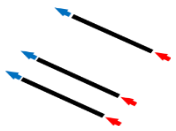
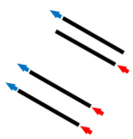
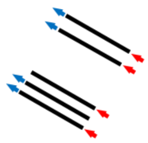
- Timeframe;
- Reference traffic sample;
- Operational concept set (en-route, approach, ground); and
- Assumptions.

5.3.1 Timeframe

Each simulation is divided into three scenarios, which correspond to the timeframes in which this IAMP is organised, i.e. TF1 (2020), TF2 (2022-25), TF3 (2035). The detailed description of operational concepts is provided in Section 4. The table below summarises the major items considered in each timeframe, in terms of:

- Airport runway availability and usage for various TFs;
- Fleet mix for different TFs;
- 2020 traffic level as reference;
- 2040 traffic level as target; and
- RECAT-based wake turbulence separation rules.

SCENARIOS	**TF1 Scenario 2020**	**TF2 Scenario 2022-25**	**TF3 Scenario 2035**
TRAFFIC	up to 2022-25	up to 2035	up to 2040
ATS/ATM CONFIGURATIONS	Duplication of airway M318 from ATUDO until FIR boundary with Saudi Arabia	Revision of SIDs/STARs from/to DWC to implement four RWYs operations	Revision of SIDs/STARs from/to DWC to implement five RWYs operations
	Duplication of airway G783 from	Revision of SIDs/STARs from/to	Revision of SIDs/STARs from/to

SCENARIOS		**TF1** **Scenario 2020**	**TF2** **Scenario 2022-25**	**TF3** **Scenario 2035**
TRAFFIC		up to 2022-25	up to 2035	up to 2040
		a TBD waypoint over UM628 up to ALN	OMAA to implement three RWYs operations	OMAA to implement four RWYs operations
		Revision of interface with Iran over GONVI waypoint	Implementation of a regional ATFM service	Rationalisation of approach control functions within the UAE lower airspace
		Revision of SIDs/STARs from/to DWC to implement three RWYs operations		
		Revision of SIDs/STARs from/to OMAL to implement two RWYs operations		
APT RWY CONFIGURATION	**OMDB** Dubai International	 ARRs segregated arrivals on runway 30L/R. Parallel approach (DPA) procedure. DEPs segregated departures on runway 30R.	 ARRs segregated arrivals on runway 30L/R. Parallel approach (DPA) procedure. DEPs segregated departures on runway 30R.	 ARRs segregated arrivals on runway 30L/R. Parallel approach (DPA) procedure. DEPs segregated departures on runway 30R.
	OMDW Dubai Al Maktoum	 ARRs Simultaneous Parallel Approach on RWY 30L/30R/31 (IPA). DEPs Simultaneous Departures on RWY 30L/30R/31L (IPA)	 ARRs Simultaneous Parallel Approach on RWY 30L/30R/31L (IPA). DEPs Simultaneous Departures on RWY 30L/30R/31R (IPA)	 ARRs Simultaneous Parallel Approach on RWY 30L/30R/31L/31R (IPA). DEPs Simultaneous Departures on RWY 30L/30C/31L/31R (IPA)

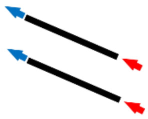
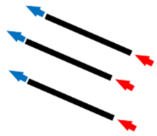
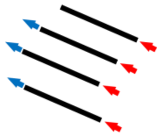
SCENARIOS	TF1 **Scenario 2020**	TF2 **Scenario 2022-25**	TF3 **Scenario 2035**
TRAFFIC	up to 2022-25	up to 2035	up to 2040
OMAA Abu Dhabi	 ARRs Simultaneous Parallel Approach, Independent Parallel Approach (IPA) procedure. DEPs Simultaneous departures.	 ARRs Simultaneous Parallel Approach, Independent Parallel Approach (IPA) procedure. DEPs Simultaneous departures.	 ARRs Simultaneous Parallel Approach, Independent Parallel Approach (IPA) procedure. DEPs Simultaneous departures.
OMSJ Sharjah	 Single runway operation.	 ARRs single arrivals runway operation. DEPs single departures runway operations.	 ARRs single arrivals runway operation. DEPs single departures runway operations.

Table 6: Runway scenarios for each timeframe

5.3.2 Traffic sample

5.3.2.1 Reference

The traffic demand used as a reference for the three simulations is the one resulting from UAE ARP Phase 3 FTS3, identified as *Reference 2020*. This sample is composed only of the movements related to the following airports (arrivals/departures), excluding overflights:

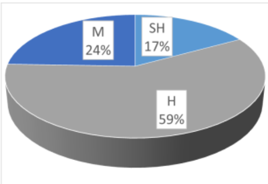
Traffic forecast	Year 2020 (reference)	
	Annual	**Daily**
OMAA	280,542	769
OMAD	30,198	83
OMAL	107,015	293
OMBY & OMDL	2,828	8
OMDB	424,919	1,164
OMDW	209,289	574
OMFJ	17,491	48
OMRK	19,343	53
OMSJ	117,980	323
Total	***1,209,605***	***3,315***

Table 7: 2020 reference traffic sample

This sample was differently elaborated and developed to serve the objectives of the simulations identified as *Stream* 1 and *Stream* 3, in terms of fleet mix and increase in traffic demand as described in the following sections.

5.3.2.2 Fleet mix

Based on the stakeholder requirements, as already reported in the *UAE ARP Phase 1 – Constrained and Hybrid Terminal Airspace Concepts* document, the fleet mix of the traffic arriving/departing to/from the UAE airports is expected to vary throughout the three timeframes, as shown in the following diagrams.

<table>
<tr><td colspan="4">OMDB</td></tr>
<tr><td>REFERENCE</td><td>TF1</td><td>TF2</td><td>TF3</td></tr>
<tr>
<td>
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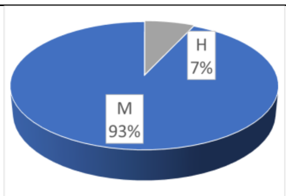
<td>
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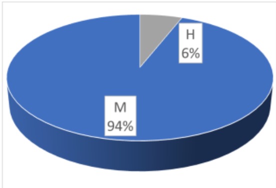
<td>
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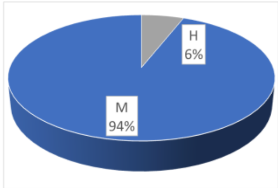
<td>
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</tr>
<tr><td colspan="4">OMDW</td></tr>
<tr><td>REFERENCE</td><td>TF1</td><td>TF2</td><td>TF3</td></tr>
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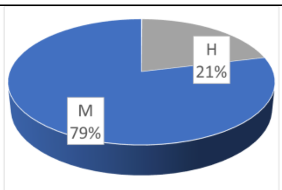
<td>
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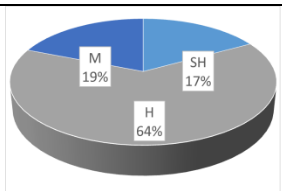
<td>
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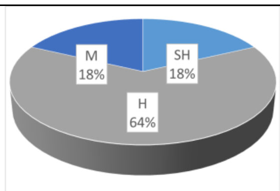
<td>
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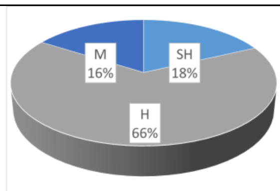
<td>
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<tr><td>REFERENCE</td><td>TF1</td><td>TF2</td><td>TF3</td></tr>
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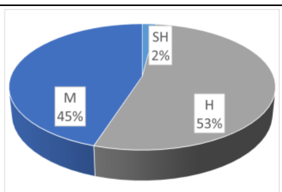
<td>
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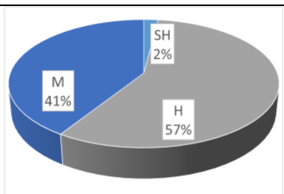
<td>
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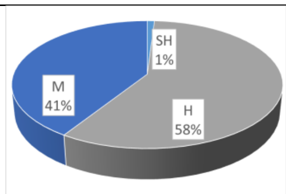
<td>
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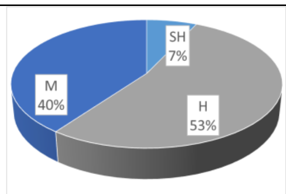
<td>
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<tr><td colspan="4">OMAL</td></tr>
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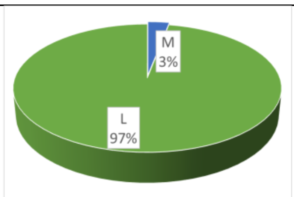
<td>
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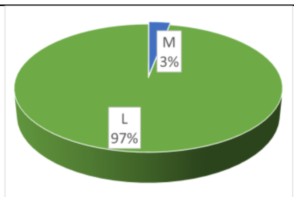
<td>
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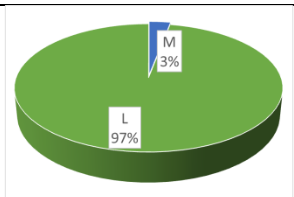
<td>
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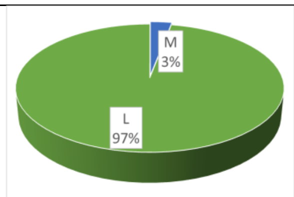
<td>
</td>
</tr>
<tr><td colspan="4">OMFJ</td></tr>
<tr><td>REFERENCE</td><td>TF1</td><td>TF2</td><td>TF3</td></tr>
</table>

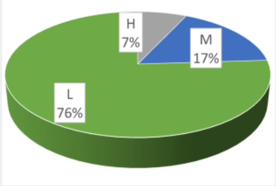
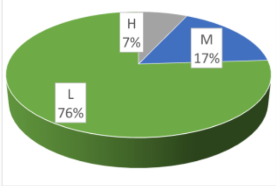
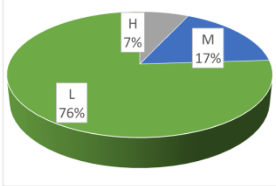
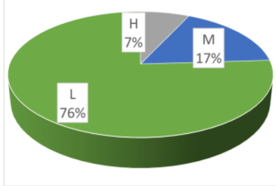
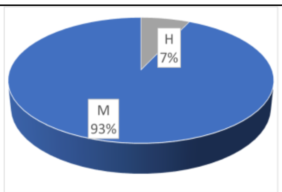
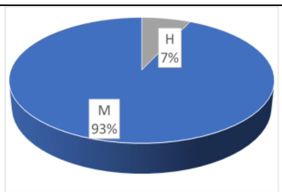
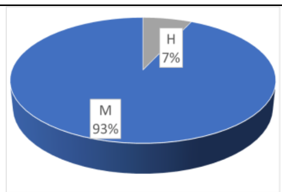
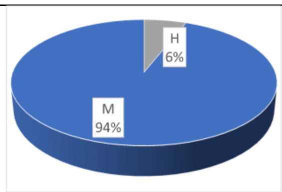
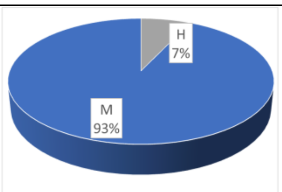
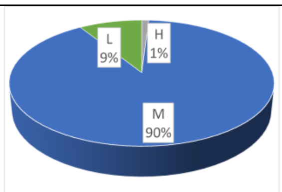
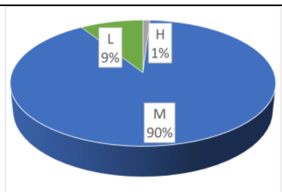
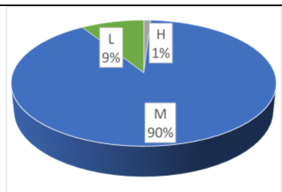
			
OMSJ			
REFERENCE	TF1	TF2	TF3
			
OMRK			
REFERENCE	TF1	TF2	TF3
			

Figure 30: Fleet mix for each timeframe

As reported in Section 2.1, the major impact is on Dubai's airports, where the majority of traffic is expected to relocate to OMDW, leaving OMDB with 33% of the total traffic into and out of Dubai's airports and OMDW with 67% of total traffic. Consequently, specific attention was paid for the creation of the traffic sample serving the two airports in both simulations, *Streams* 1 & 3.

The relevant arrival/departure traffic from/to OMDB was rerouted in order to be allocated to OMDW. The reassignment was conducted by choosing those flights within the *Reference 2020* traffic sample that due to their wake turbulence category were to be moved from OMDB to OMDW, namely the super heavy aircraft. The flight plans of the reassigned flights were changed in accordance to the new implemented route network.

5.3.2.3 Stream 1

The traffic sample taken as reference for this simulation corresponds to the *Reference 2020* and is unchanged for the three timeframes in terms of demand, i.e. the number of flights is kept the same throughout 2020-2040.

However, the fleet mix varies in the three timeframes (TF1, TF2 and TF3) in accordance with what is reported above. The following tables show the changes in fleet mix for the only airports involved in the simulation affected by the said changes.

OMDB	TOT	SH	H	M	L
BL	1164	199	684	286	0
TF1	1164	0	81	1083	0
TF2	1164	0	70	1094	0
TF3	1164	0	70	1094	0

OMDW	TOT	SH	H	M	L
BL	574	1	120	448	0
TF1	574	98	367	109	0
TF2	574	103	367	103	0
TF3	574	103	379	92	0

OMAA	TOT	SH	H	M	L
BL	769	15	408	346	0
TF1	769	15	438	315	0
TF2	769	8	446	315	0
TF3	769	54	408	308	0

OMAL	TOT	SH	H	M	L
BL	293	0	0	9	284
TF1	293	0	0	9	284
TF2	293	0	0	9	284
TF3	293	0	0	9	284

OMFJ	TOT	SH	H	M	L
BL	48	0	3	8	36
TF1	48	0	3	8	36
TF2	48	0	3	8	36
TF3	48	0	3	8	36

OMSJ	TOT	SH	H	M	L
BL	323	0	23	300	0
TF1	323	0	23	300	0
TF2	323	0	23	300	0

TF3	323	0	19	304	0

OMRK	TOT	SH	H	M	L
BL	53	0	4	49	0
TF1	53	0	1	48	5
TF2	53	0	1	48	5
TF3	53	0	1	48	5

Table 8: Stream 1 traffic level and fleet mix for each timeframe

As for the Dubai's airports, the elaboration of the traffic sample was conducted to strictly respect both the total number of flights of *Reference 2020* and the fleet mix percentage estimated for each timeframe. Consequently, some flights were moved from OMDB to OMDW until the defined number of flights was reached (heavy and super-heavy aircraft) for OMDW, while in the same time lapse the exceeding heavy and super-heavy flights were removed from OMDB.

5.3.2.4 Stream 2

Contrary to the *Stream* 1 and 3, *Stream* 2 is not based on a predefined traffic sample, since the aim is to assess a maximum level of sustainable throughput. By doing so, the sample can be considered as generated by the tool (as further described in Section 5.3.5.2).

5.3.2.5 Stream 3

As opposed to the *Stream* 1, in *Stream* 3 each timeframe runs in the simulation with different growing traffic demands. The *Reference 2020* traffic sample was modified in terms of fleet mix as reported in Section 5.3.1 and increased by 3.2% yearly. This led to:

1. TF1: *Reference 2020* increased up to 2025;
2. TF2: *Reference 2020* increased up to 2035;
3. TF3: *Reference 2020* increased up to 2040.

To increase the traffic volumes according to the forecast, the *Reference 2020* traffic sample, modified in line with the new OMDB/OMDW traffic split, was processed by cloning flights to create a new traffic demand. The cloning was performed with the aim to maintain the same daily flights distribution (based on the origin-destination pairs) as for the initial demand in *Reference 2020*. To do so, a temporary window of thirty minutes ahead and thirty minutes behind the time of the original flight was taken into account by the simulator to randomly generate flight times of cloned flights.

As to the traffic split between OMDB and OMDW, the increased volume of traffic foreseen in this simulation made it possible to relocate all the super-heavy aircraft from OMDB to OMDW. The tables below report this in more detail:

OMDB	TOT	SH	H	M	L
BL	1164	199	684	286	0
TF1	666	0	47	619	0
TF2	913	0	55	858	0
TF3	1090	0	65	1025	0

OMDW	TOT	SH	H	M	L
BL	574	1	120	448	0
TF1	1368	233	876	260	0
TF2	1875	338	1200	338	0
TF3	2173	391	1434	348	0

OMAA	TOT	SH	H	M	L
BL	769	15	408	346	0
TF1	900	18	513	369	0
TF2	1233	12	715	506	0
TF3	1444	101	765	578	0

OMAL	TOT	SH	H	M	L
BL	293	0	0	9	284
TF1	343	0	0	10	333
TF2	470	0	0	14	456
TF3	550	0	0	17	534

OMFJ	TOT	SH	H	M	L
BL	48	0	3	8	36
TF1	56	0	4	10	43
TF2	77	0	5	13	59
TF3	90	0	6	15	68

OMSJ	TOT	SH	H	M	L
BL	323	0	23	300	0
TF1	378	0	26	352	0
TF2	518	0	36	482	0
TF3	606	0	36	570	0

OMRK	TOT	SH	H	M	L
BL	53	0	4	49	0
TF1	62	0	1	56	6

TF2	85	0	1	77	8
TF3	100	0	1	90	9

Table 9: Stream 3 traffic level and fleet mix for each timeframe

5.3.3 En-route assumptions

In addition to the operational changes described in Section 4, the en-route scenario modelled in the simulations reflects the following assumptions:

- The ATC rules will not change, except for the rerouting necessary to properly assign the traffic demand between OMDB and OMDW accordingly to the changes in the fleet mix;
- ATC sector reorganisation at ACC level is not assessed;
- Free route concept is not assessed and is postponed to the future implementation programme; and
- The modelling of FIR entry/exit separation rules over the boundary points is performed using the inputs listed in the table below.

Adjacent ACC	entry point	Separation
Bahrain	DEGSO TOMSO RESAR ORSIS ASTOG NAMLA BUNDU	10 NM
Tehran	ORSAR PATAT	20 NM
Muscat	PASOV SOLUD TAPRA MUSAP ITRAX SODEX UKRAG	10 NM
Jeddah	MUXIT TANSU	50 NM

Adjacent ACC	exit point	Separation
Bahrain	TUMAK ALPOB ORMID TOSNA GETID	10 NM
Tehran	DAPER GABKO	20 NM
Muscat	LALDO GOMTA TARDI LABRI RETAS	10 NM
Jeddah	MUXIT TANSU	50 NM

Table 10: Entry/exit separations

5.3.4 RECAT

The separations of arriving and departing aircraft applied in all simulations and related timeframes are based on the RECAT-EU wake turbulence categorisation.

5.3.5 Simulations

To assess the integration of the UAE airspace within the scope of this document, an ad-hoc methodology of fast-time simulations was adopted to measure the identified operational solutions.

A step-wise approach composed by three subsequent streams was adopted to deliver a comprehensive analysis, encompassing the specific goals of each stream described in more details in the following sections. Each of the three streams focusses on the evaluation of specific outputs, as listed below:

- *Stream 1*: The analysis of expected benefits of the introduced operational concepts;
- *Stream 2*: The analysis of the maximum airport runway capacity of the main four international airports in the UAE; and
- *Stream 3*: The analysis of the sustainability of the proposed changes to meet the expected traffic demand forecasted for the time period of 2025-2040.

5.3.5.1 Stream 1 - The evolution of the Airspace Concept Assessment

In the first simulation, a comparative study was preformed to analyse the system performance following the changes introduced throughout the three TFs. To this end, a single traffic demand is used as a reference for all TFs, i.e. the *Reference 2020*, whilst the fleet mix changes accordingly, as defined in Section 5.3.2.2. Therefore, this stream focuses on the behaviour of the 2020 traffic sample compared to the progress of the planned changes described in Section 4 of this document.

The KPIs measured in this stream are mainly related to the efficiency and environment. These were categorised into two groups – KPIs related to the UAE ACC and KPIs related to the Dubai and Abu Dhabi CTAs.

5.3.5.1.1 *UAE ACC*

Average daily delay by entry/exit UAE ACC traffic to/from adjacent ACCs

The objective of this KPI is to analyse air traffic management at ACC level by measuring one of the main indicators of efficiency, i.e. the delay caused by the need to separate the incoming and outgoing traffic to/from the ACC accordingly to the applicable ATC rules. The simulator measures the ATC delay accumulated at the entry/exit points along the boundaries of the UAE ACC. To identify the delay managed inside and outside the UAE ACC, the average daily value is provided by filtering the data based on the incoming/outgoing traffic from/to the adjacent ACCs (Bahrain, Teheran, Muscat, Jeddah).

The delay will be represented in the following example where the horizontal axes are the adjacent ACCs and the vertical ones the minutes of delay.

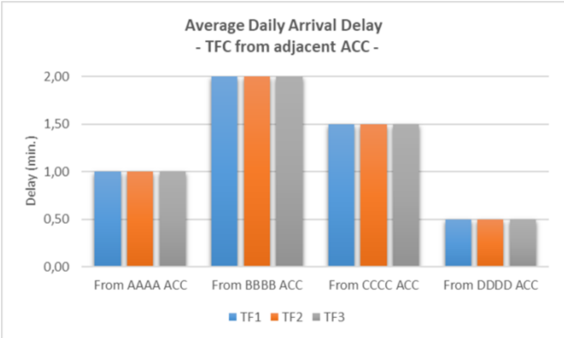


Figure 31: Average daily delay for UAE ACC entry traffic from near ACCs (arrivals)

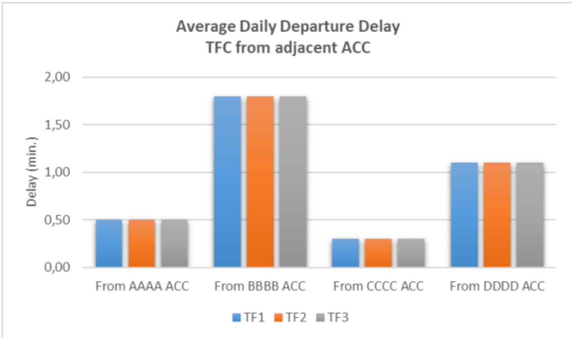


Figure 32: Average daily delay for UAE ACC entry traffic from near ACCs (arrivals)

Average daily delay by exit UAE ACC traffic to CTAs

The other component of the delay managed by the ACC is the one caused by the CTA entry separation rules. This delay depends on the capability of the CTAs to receive incoming traffic directed to their airports. The data are presented with CTA of destination on the horizontal axes and minutes of delay on vertical axes.

Average daily distance flown, average daily flight duration, and average daily fuel burnt

The ACC network and ATC operations can influence the flight distance flown and flight duration, so that they influence the amount of fuel burnt. These metrics are measured relatively to the portion of the flight inside the UAE ACC and provided as the average values of all the flights registered. The results are presented separately for arriving and departing traffic to/from the UAE ACC.

5.3.5.1.2 *Dubai & Abu Dhabi CTA*

Average daily delay within CTAs

The delay within CTAs is generated by all actions required to manage the arriving and departing flights to/from airports within the CTAs. As for the arrival flows, the average daily delay represents the effects on the CTA from all tactical actions (e.g. speed reduction, vectoring, holding) undertaken to manage the traffic arriving to airports.

Average daily distance flown, average daily flight duration, and average daily fuel burnt

The effects of the air traffic management on flight duration, distance flown and consequently on fuel burnt are evaluated too. The results, in terms of daily average values, are sorted by airport destination (i.e. OMDB, OMDW, OMSJ, and OMAA) and presented separately for arrivals and departures.

No analysis of throughput was performed, as traffic volume changes were not considered in the three timeframes in this stream.

5.3.5.2 Stream 2 – Airport Runways Configuration Capacity

The objective of this simulation is to estimate the hourly maximum sustainable runway throughput provided by the airport runway system, where:

- ‘Maximum’ refers to a constant heavy demand assumption of traffic, so that a continuous flow of aircraft is ready to utilise any available capacity; and
- ‘Sustainable’ means that variability in the performance of various system components is accounted for.

The data provided refer to balanced arrival/departure values that represent the best mix of both kinds of operations that the airport runway system can sustainably handle.

In accordance with the objective, the variables of this simulation model reflect the development of airport runway configurations through the TFs, the changes in fleet mix, and consequently the wake turbulence category separation rules (RECAT). This type of airport runway capacity is measured independently of constraints in the en-route or terminal airspaces (arrival and departure procedures) and does not consider any constraints of the airports’ ground infrastructure apart from the runways.

To calculate this type of capacity, the analyser integrated in the FTS tool simulates arriving and departing traffic at the specific airport, the decisions taken regarding runway assignment and sequencing and the flight operations themselves. A randomized traffic sample is generated to keep the airport loaded as much as possible. The traffic sample reflects an airport mix of aircraft types (fleet mix percentage for each individual TF), which differ in their performance parameters. The assignment of the runways (where more than one runway is available) and the sequencing of the traffic are automatically done to balance efficiency and delays, while respecting separation requirements (i.e. RECAT) and runway eligibilities. The tool generates traffic, so as there is constant demand on the runway system and for various arrival-departure mixes.

The ‘sustainability’ of a traffic throughput is then reported by using a capacity curve, which can visualize the relationship between arrivals and departures, as shown in the figure below.

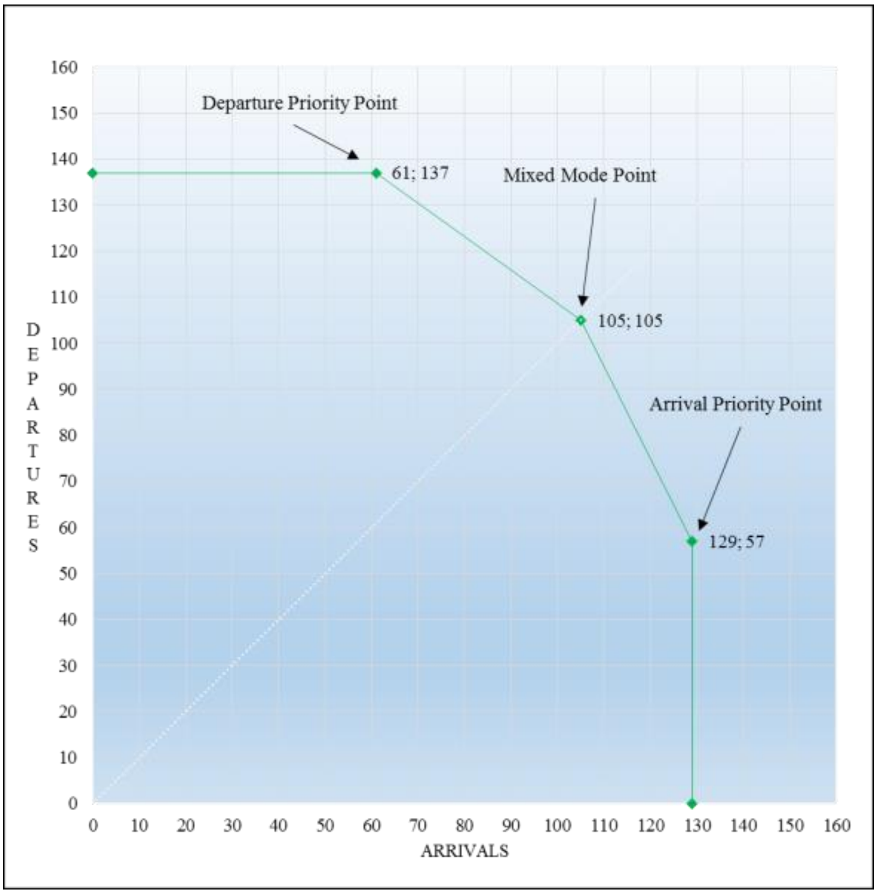


Figure 33: Throughput capacity curve example

By moving along the curve, this graph illustrates the dependency of the throughput on the proportions of arrivals and departures. In fact, as each point in the graph represents a specific number of arrivals and departures, a peak in favour of one of them shows the remaining system capability to accommodate the other. The balanced value is the one in which the same number of arrivals and departures can be allocated on an hourly basis.

The results are presented for each airport by showing on the same graph the evolution of this capacity during the three TFs and the information of the related traffic demand estimated up to 2040. This output then shows whether the planned new runways can accommodate the envisaged traffic demand in each timeframe. For instance:

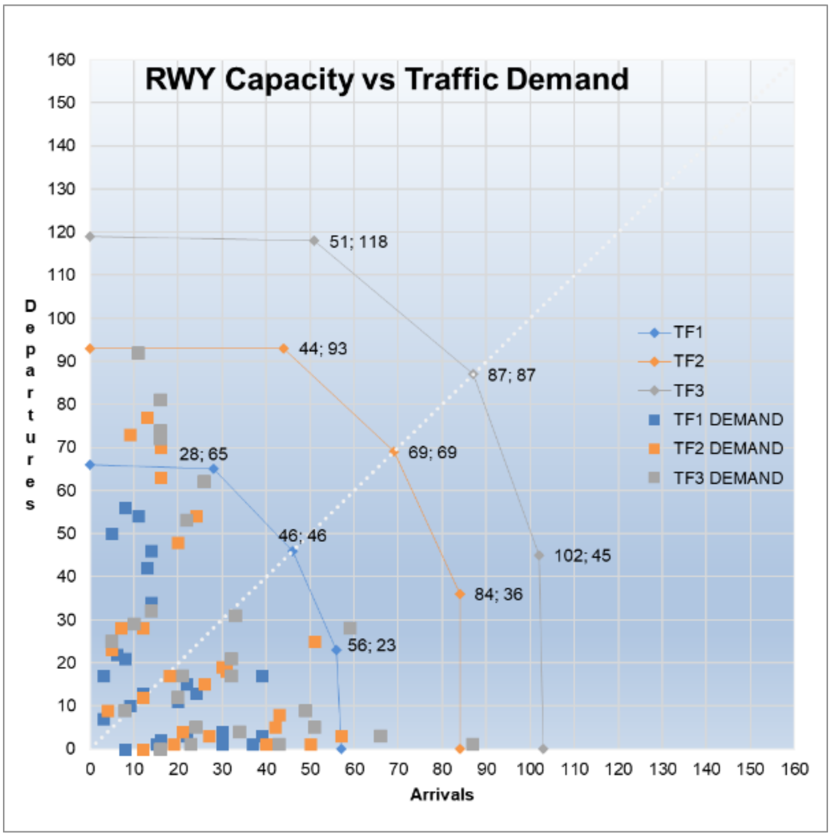


Figure 34: Runway capacity / traffic demand capacity curve

5.3.5.3 Stream 3 – Analysis of Integrated ACC/CTA Concept Performances

The analysis conducted in this stream is focused on the behaviour of the integrated ACC/CTA system, with the operational concepts and ground infrastructures implementations defined in each TF, in relation to the future increased traffic demand up to 2040.

In addition to what has been described above for the model simulated in *Streams* 1 and 2, this stream considers also the growth of the traffic volumes as per the forecasts for each timeframe. The metrics used to assess the system performances are the same as presented in *Stream* 1, except for the throughput indicator, which is described below.

5.3.5.3.1 *UAE ACC*

Avg Delay by entry/exit UAE ACC traffic from/to adjacent ACCs due to the application of boundary separation rules (ref paragraph 5.3.3). It is measured at the boundary and sorted by the main flows (to/from adjacent ACCs: Bahrain, Teheran, Muscat, Jeddah); in this *Stream,* the data will be presented both from a daily and hourly perspectives.

The following figures show an example of **Avg Hourly Delay** related to arrival flights entering UAE ACC from adjacent ACCs (arrivals) and one related to flights directed to adjacent ACCs (departures):

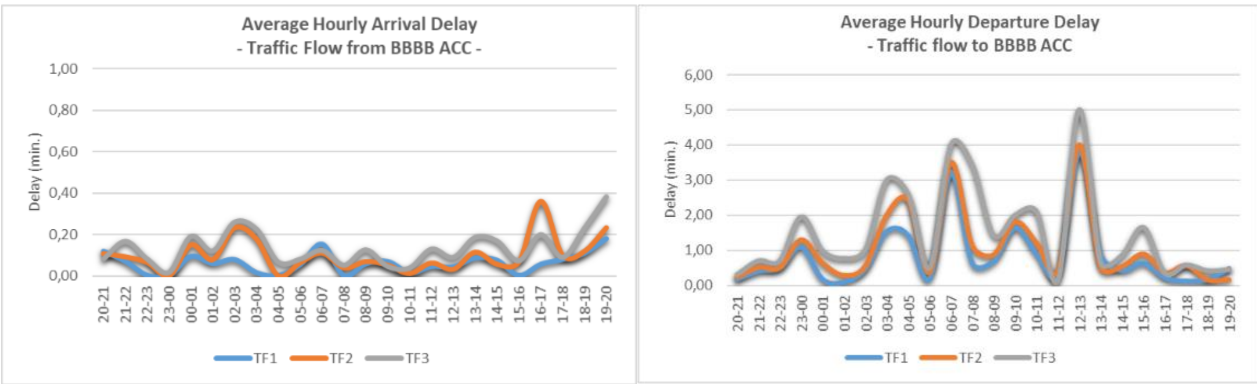


Figure 35: Example of Avg Hourly Delay entering UAE FIR

Differently from the daily delay, each of these diagrams refers to one single traffic flow from/to specific adjacent ACC; therefore, the horizontal axes refer to the hours observed, while the vertical ones refer to the minutes of delay: the lines in different colours show the behaviour of the average delay hour by hour for each timeframe.

Avg Delay by exit UAE ACC traffic to CTAs: it is generated owing to CTA entry separation rules and managed by UAE ACC. Data set is sorted by CTA of destination (Dubai or Abu Dhabi). Output are presented both from a daily and hourly perspectives and by CTA of destination. For instance:

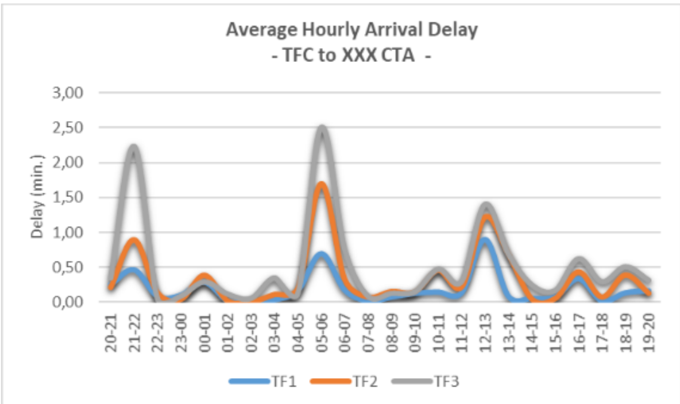


Figure 36: Example of Avg Delay by exit UAE ACC traffic to CTAs

Throughput

This KPI shows the number of flights entering and leaving the ACC in compliance with the entry/exit separation rules. It is used to compare the behaviour of the ACC between the individual timeframes. The values are presented by adjacent ACCs separately for arrivals and departures. The example below is related to arrival flights: on vertical axis the number of flights, on the horizontal one the hours:

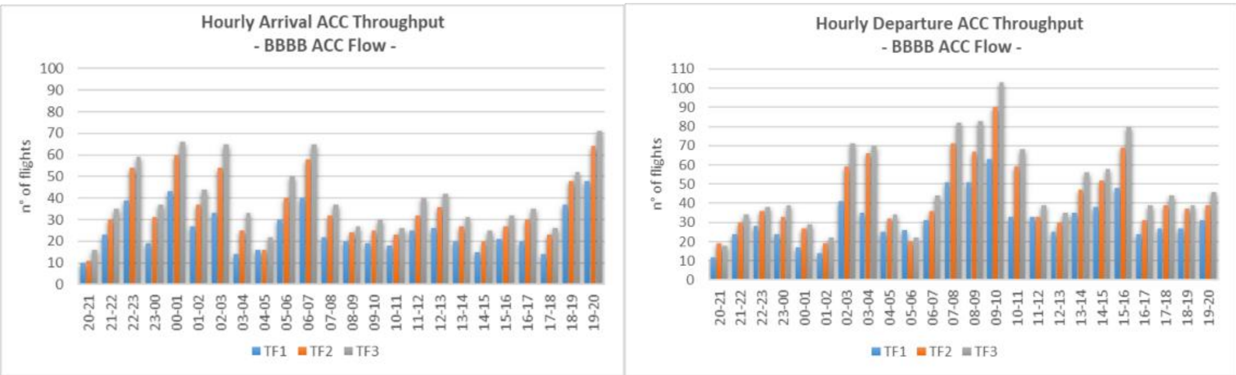


Figure 37: Example of measured Throughput

5.3.5.3.2 *Dubai & Abu Dhabi CTA*

Throughput KPI is explained below, as the others have been described in Section 5.3.5.1.2.

- **Avg Daily Delay within CTA:** it is generated by all the actions required to manage arriving and departing flights to/from airports within the CTAs; the output is presented both on an daily and hourly perspectives.

Throughput

As for UAE ACC**,** this KPI refers to the total number of flights that enter/exit the UAE CTAs in each individual timeframe. Outputs are shown for each airport separately., just as in the following example related to arriving to OMDB, where the vertical axis is the value of delay and the horizontal one the hours:

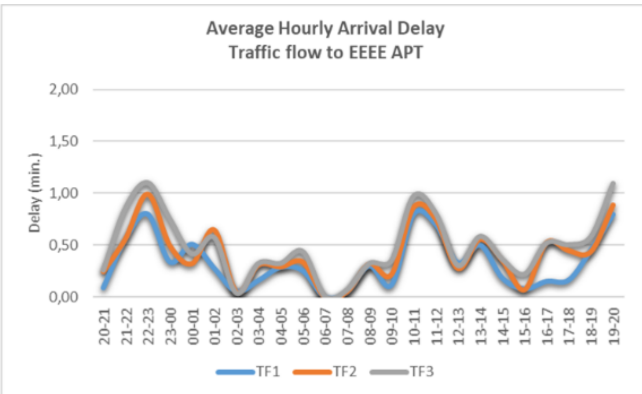


Figure 38: Example of measured Throughput

5.4 RESULTS

The results of the simulations are presented for each stream in the subsequent sections.

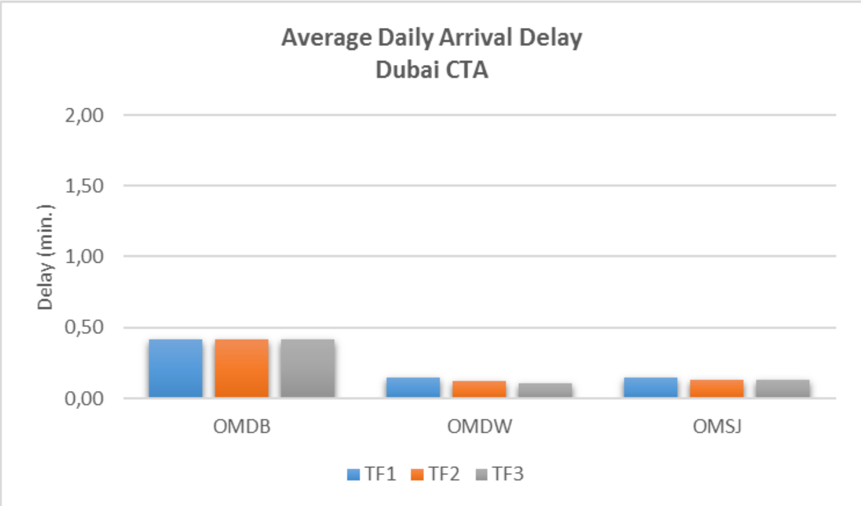
5.4.1 Stream 1

As for *Stream 1*, this section includes only the graphs showing a significant change in the system performances, the remaining results are presented in Appendix B.

The analysis related to the UAE ACC shows no considerable changes in terms of average delay, distance flown, time duration and fuel burnt since the operational concepts which might impact the performances have been already introduced in TF1 (see Section 5.3.1) and kept unchanged until TF3. In addition, no change in traffic demand is recorded for this simulation that might modify quantity-wise the performance assessment. The only change introduced in this stream refers to the fleet mix which impact on fuel burnt. As previously mentioned, this is due to the introduction of fleet mix implying an augmented heavy and super-heavy aircraft. In particular, an increase in fuel burnt is observed on the flows from Jeddah ACC, as aircraft fly longer distances within the UAE ACC area.

Contrary to the ACC, the analysis of CTA has highlighted some changes in performances. These changes are, however, of a minor significance due to the overdesigned infrastructure compared to the traffic demand modelled in this stream.

The following graphs show the average daily delay for arrivals to OMDB, OMDW, and OMSJ (i.e. Dubai CTA) and to OMAA (i.e. Abu Dhabi CTA), generated by all actions required to manage the arrival flights to respective airports within the CTAs.



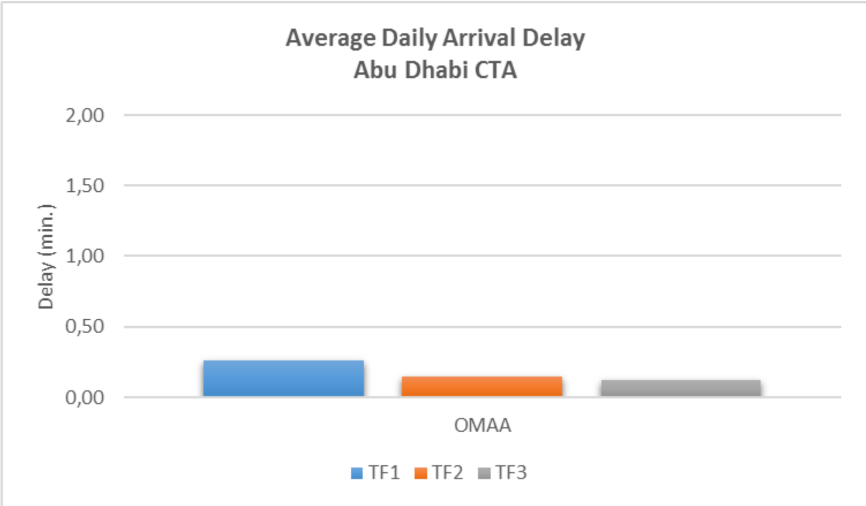


Figure 39: UAE CTAs arrivals – average daily delay

The graphs indicate that the airports' capacity is positively impacted by the introduction of operational concepts in the individual timeframes. These reductions in delay are, however, very limited since the potential benefits stemming from new operational scenarios are spread out over a low and steady traffic demand.

The only airport having an improved environmental footprint is OMDW, whose IFPs' system has undergone the most significant changes. In fact, thanks to the reduction of distances and time as well as the optimised vertical profile due to the introduction of PMS, the airport records a decrease in fuel burnt internally within the Dubai CTA, as shown in the following graph.

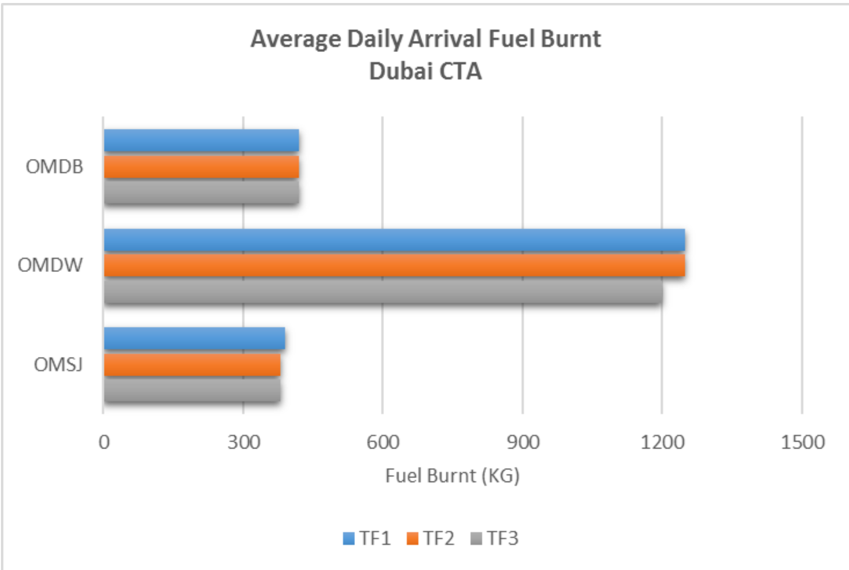
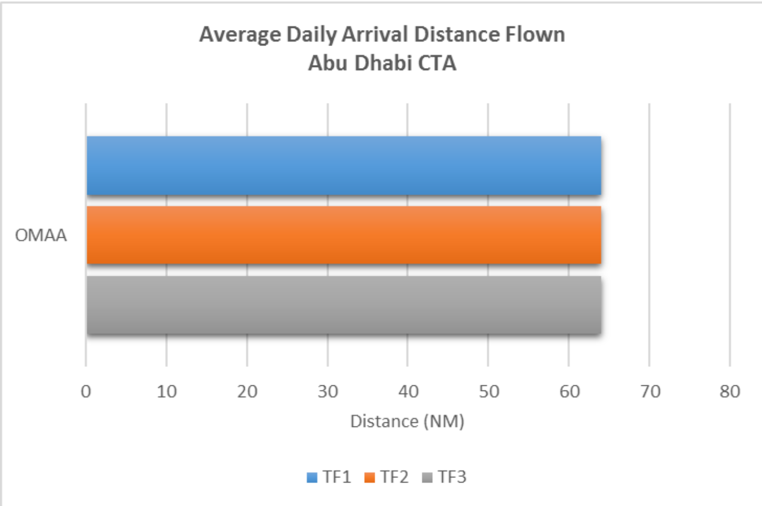
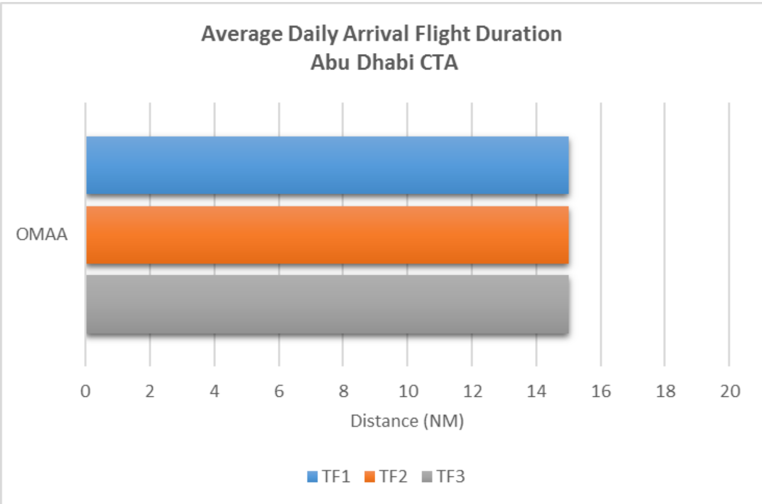


Figure 40: Dubai CTA arrivals – fuel burnt

A slight increase in fuel burnt is recorded in the Abu Dhabi CTA, even though the distance flown and the flight duration of arrivals to OMAA do not change. This is related to the effect of fleet mix changes for OMAA, which sees an increase of super-heavy aircraft.





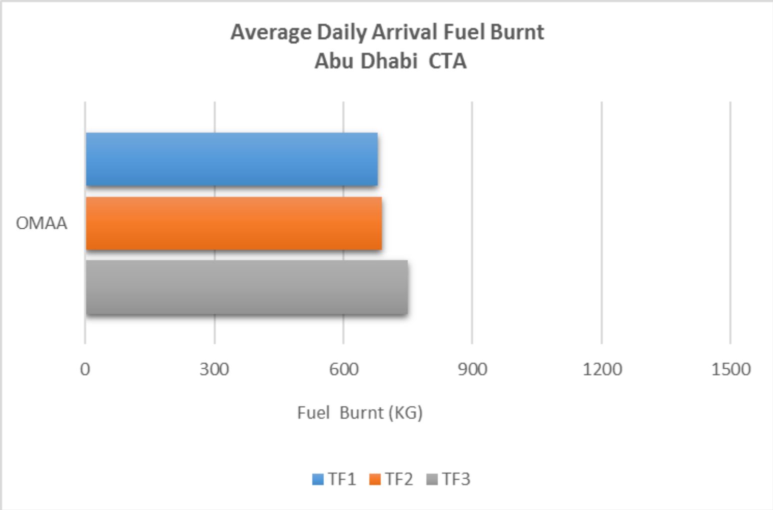


Figure 41: Abu Dhabi CTA arrivals – distance flown, flight duration, fuel burnt

The analysis of departures has shown that despite the increase in the fleet mix of heavy and super-heavy aircraft in OMDW, the new runway configurations reduce the average daily departure delays, as in the case of OMSJ where the fleet mix remains essentially unchanged, but from TF2 onwards a new runway is expected to be added.

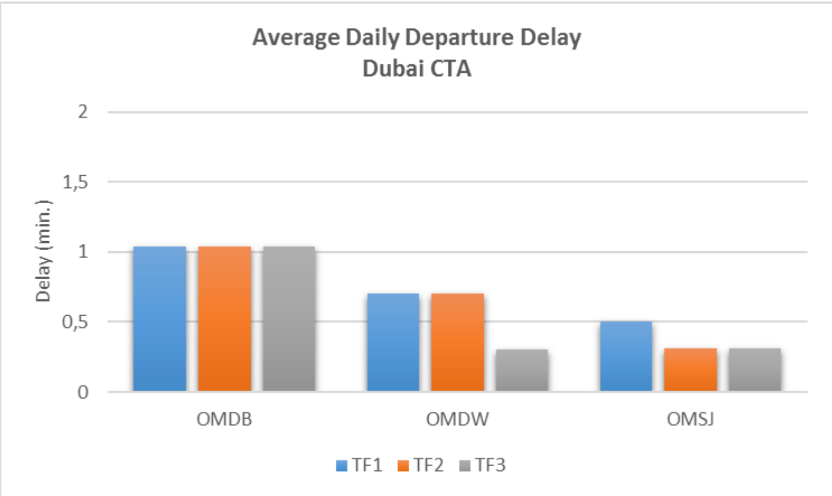


Figure 42: Dubai CTA departures – average daily delay

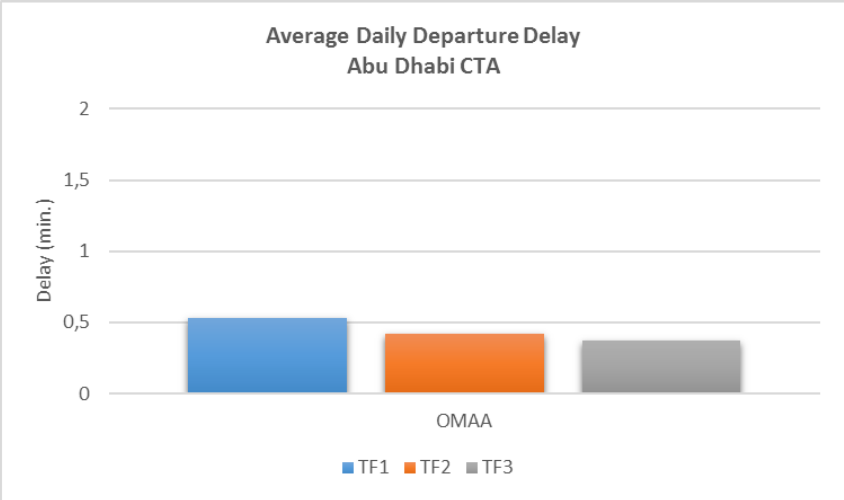


Figure 43: Abu Dhabi CTA departures – average daily delay

The same considerations related to arrivals apply also to departures, which see a decrease in fuel burnt with respect to OMDW due to the new IFPs introduced in TF3.

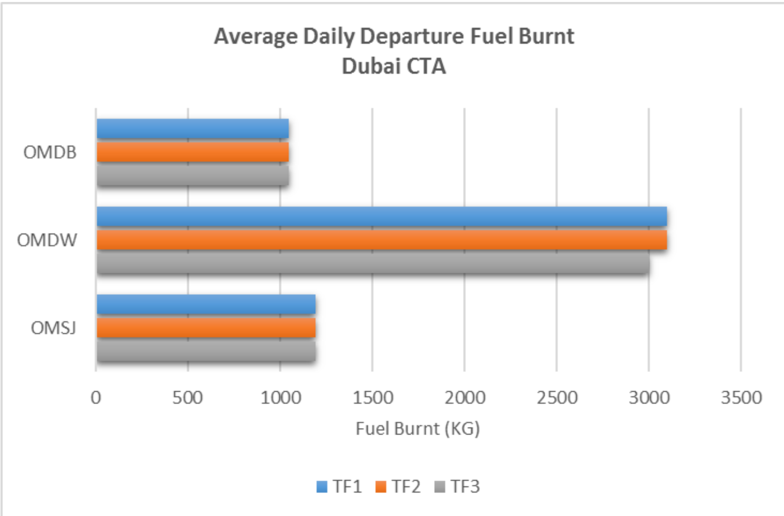
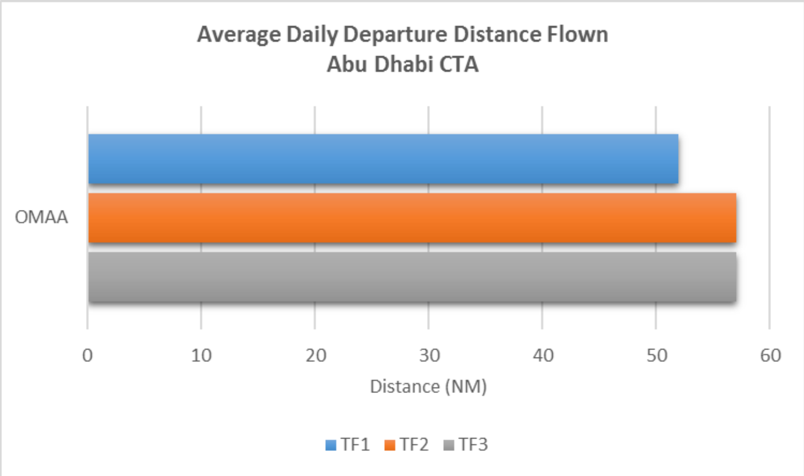
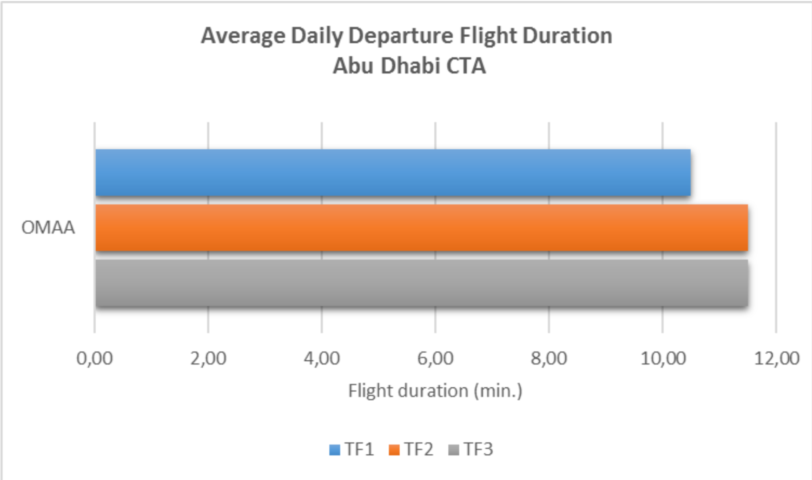


Figure 44: Dubai CTA departures – average daily fuel burnt

The analysis of the Abu Dhabi CTA has revealed slightly worst environmental performances, which bring about an increase in fuel consumption. This is due to the modelling of departures designed to assign runways randomly to reduce as much as possible potential delays as long as the availability of runways is increased throughout the timeframes. Hence, the use of SIDs may not be coherent with traffic flows, sometimes resulting in longer distances to fly.





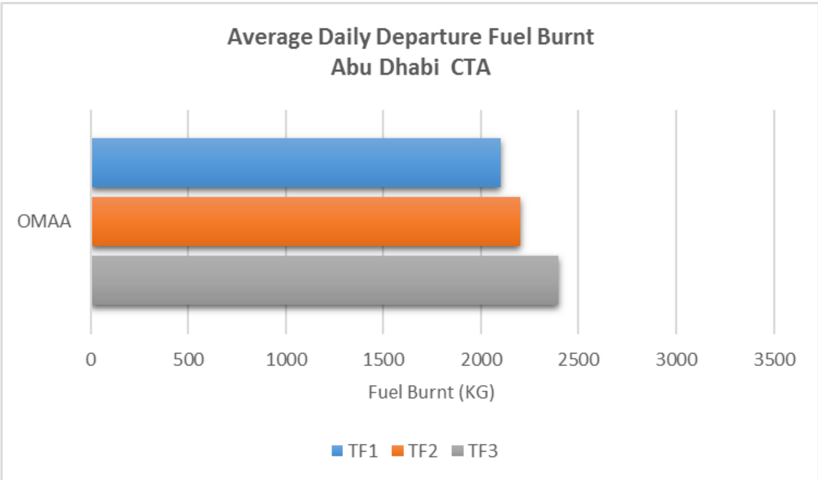
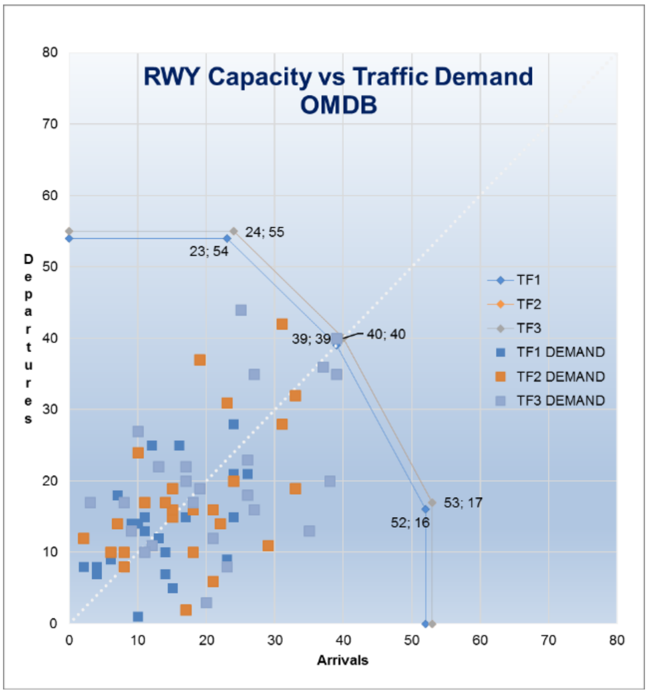


Figure 45: Abu Dhabi CTA departures – distance flown, flight duration and fuel burnt

5.4.2 Stream 2

As previously described (see Section 5.3.5.2), this simulation has the objective to calculate the hourly maximum sustainable runway throughput provided by the UAE airports' runway system. The assessment only considers the runways and does not take into account airport layouts or the airspace organisation in terms of IFPs and traffic management. Therefore, the operational concepts defined in Section 4 of this document will not affect the results.

The following graphs show the outcome of the runway capacity analysis with two-fold information, i.e. the capacity developed by the runway system of a particular airport along the three timeframes and the traffic demand, as expected in *Stream 3*, sorted by TF1, TF2 and TF3.



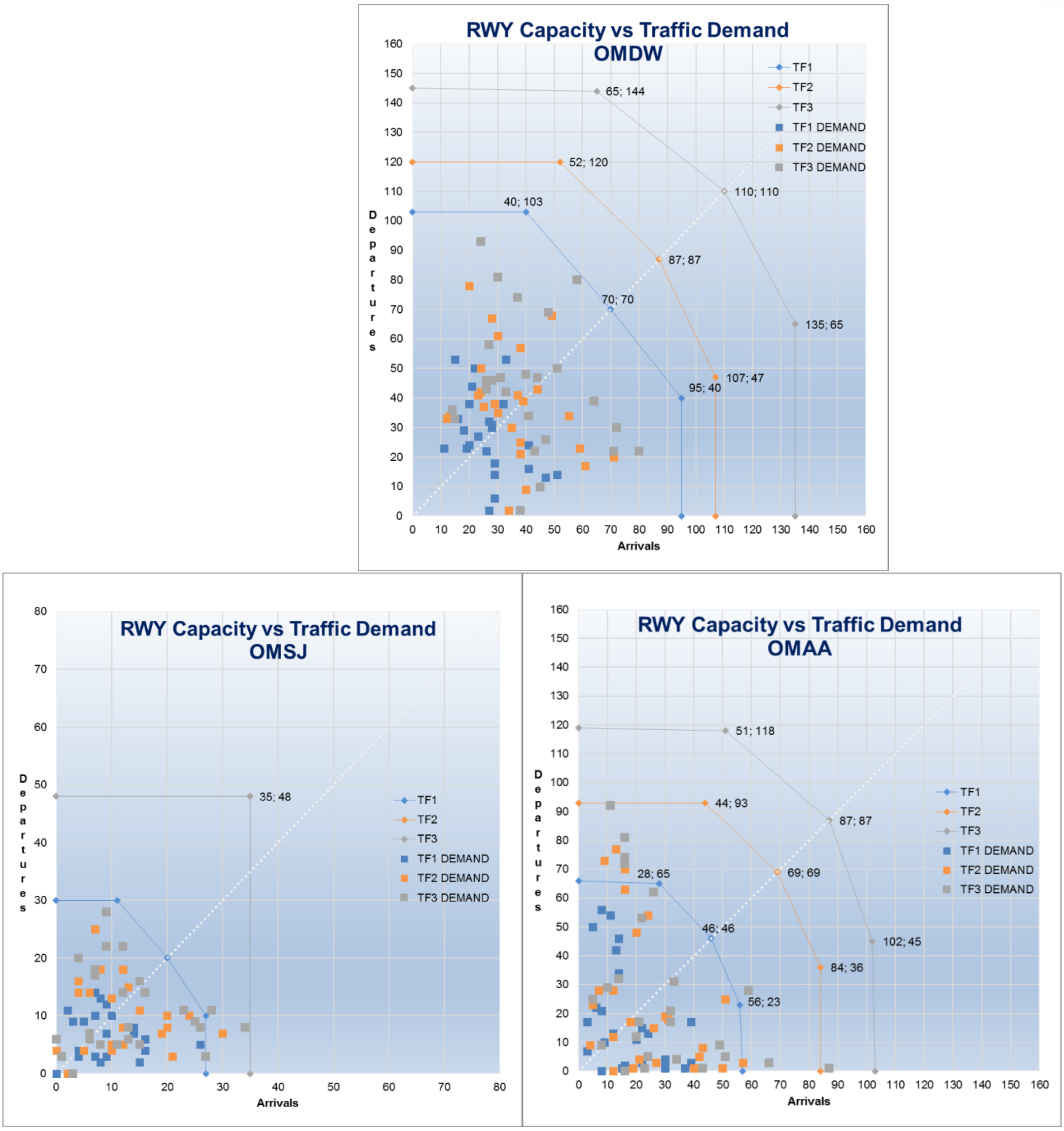


Figure 46: Runway capacity curves

The graphs above show the two sets of information – the coloured lines linking the dots represent the capacity assessment for each TF, the coloured squares show the arrival/departure couples registered based on the traffic demand forecasted for 2025, 2035, and 2040. Namely:

- **OMDB:** The runway capacity does not vary considerably among the three timeframes since the number of runways is not expected to change. The minor variation detected is due to the change in fleet mix. This improves the sequencing of arrivals and departures allowing for increased runway capacity. In addition, it should be noted that the expected traffic demand on the three timeframes is always below the tracked capacity area (i.e. the pareto frontiers).

Configuration	**OMDB – TF1**		
	ARR	***DEP***	***TOT***
Departure Priority Point	23	54	77
Mixed Mode Point	39	39	78
Arrival Priority Point	52	16	68

Table 11: Maximum theoretical sustainable capacity – OMDB, TF1 Scenario

Configuration	**OMDB – TF2**		
	ARR	***DEP***	***TOT***
Departure Priority Point	24	55	79
Mixed Mode Point	40	40	80
Arrival Priority Point	53	17	70

Table 12: Maximum theoretical sustainable capacity – OMDB, TF2 Scenario

Configuration	**OMDB – TF3**		
	ARR	***DEP***	***TOT***
Departure Priority Point	24	55	79
Mixed Mode Point	40	40	80
Arrival Priority Point	53	17	70

Table 13: Maximum theoretical sustainable capacity – OMDB, TF3 Scenario

- **OMDW:** As expected, the capacity of runways has considerably increased because of the new runways introduced in each TF. The expected traffic demand is below the runway capacity in each

TF – the runway capacity developed within TF1 is already sufficient to accommodate traffic demand for 2040 (TF3).

Configuration	**OMDW– TF1**		
	ARR	***DEP***	***TOT***
Departure Priority Point	40	103	143
Mixed Mode Point	70	70	140
Arrival Priority Point	95	40	135

Table 14: Maximum theoretical sustainable capacity – OMDW, TF1 Scenario

Configuration	**OMDW – TF2**		
	ARR	***DEP***	***TOT***
Departure Priority Point	52	120	172
Mixed Mode Point	87	87	174
Arrival Priority Point	107	47	154

Table 15: Maximum theoretical sustainable capacity – OMDW, TF2 Scenario

Configuration	**OMDW – TF3**		
	ARR	***DEP***	***TOT***
Departure Priority Point	65	144	209
Mixed Mode Point	110	110	220
Arrival Priority Point	135	65	200

Table 16: Maximum theoretical sustainable capacity – OMDW, TF3 Scenario

- **OMSJ:** this airport records an improvement of runway capacity thanks to the introduction of a new runway. It is worth considering that the curve related to TF2 and TF3 are coincident because the number of runways is unchanged.

Configuration	OMSJ – TF1		
	ARR	*DEP*	*TOT*
Departure Priority Point	11	30	41
Mixed Mode Point	20	20	40
Arrival Priority Point	27	10	37

Table 17: Maximum theoretical sustainable capacity – OMSJ, TF1 Scenario

Consequently, the values reported in the graph related to TF2 and TF3 show the highest sustainable capacity of the runway used for arrivals (35) and the other for departures (48). The traffic demand expected for each timeframe is less than the maximum runway capacity.

Configuration	OMSJ – TF2		
	ARR	*DEP*	*TOT*
Departure, Arrival Priority Point	35	48	83

Table 18: Maximum theoretical sustainable capacity – OMSJ, TF2 Scenario

Configuration	OMSJ – TF3		
	ARR	*DEP*	*TOT*
Departure, Arrival Priority Point	35	48	83

Table 19: Maximum theoretical sustainable capacity – OMSJ, TF3 Scenario

- **OMAA:** The increase in the number of available runways at OMAA from 2 to 4 ensures an increased overall runway capacity, as illustrated on the chart above. Again, the comparison between the expected traffic demand and runway capacity for each timeframe highlights that the improved runway configurations allow for the accommodation of the forecast traffic.

Configuration	OMAA – TF1		
	ARR	*DEP*	*TOT*
Departure Priority Point	28	65	93

Mixed Mode Point	46	46	92
Arrival Priority Point	56	23	79

Table 20: Maximum theoretical sustainable capacity – OMAA, TF1 Scenario

Configuration	**OMAA – TF2**		
	ARR	***DEP***	***TOT***
Departure Priority Point	44	93	137
Mixed Mode Point	69	69	138
Arrival Priority Point	84	36	120

Table 21: Maximum theoretical sustainable capacity – OMAA, TF2 Scenario

Configuration	**OMAA – TF3**		
	ARR	***DEP***	***TOT***
Departure Priority Point	51	118	169
Mixed Mode Point	87	87	174
Arrival Priority Point	102	45	147

Table 22: Maximum theoretical sustainable capacity – OMAA, TF3 Scenario

5.4.3 Stream 3

The objective of *Stream 3* is to assess the response of the concept of operations proposed in the three TFs against the forecast traffic demand. At the ACC level, since boundary separation rules with adjacent ACCs remain unchanged, whereas the volume of traffic was increasing, the ACC-specific performances have slightly deteriorated throughout the TFs.

At the CTA level, the introduction of new operational concepts such as PMS as well as new entry points in these areas have resulted in improved performances across the TFs. Hence, thanks to the introduction of new ACC routes and the overall improved throughput of the UAE's CTAs, the overall performances improve in all TFs.

Similarly to *Stream 1*, the full list of results are reported in Appendix 0, while the main indicators are described in the sections below.

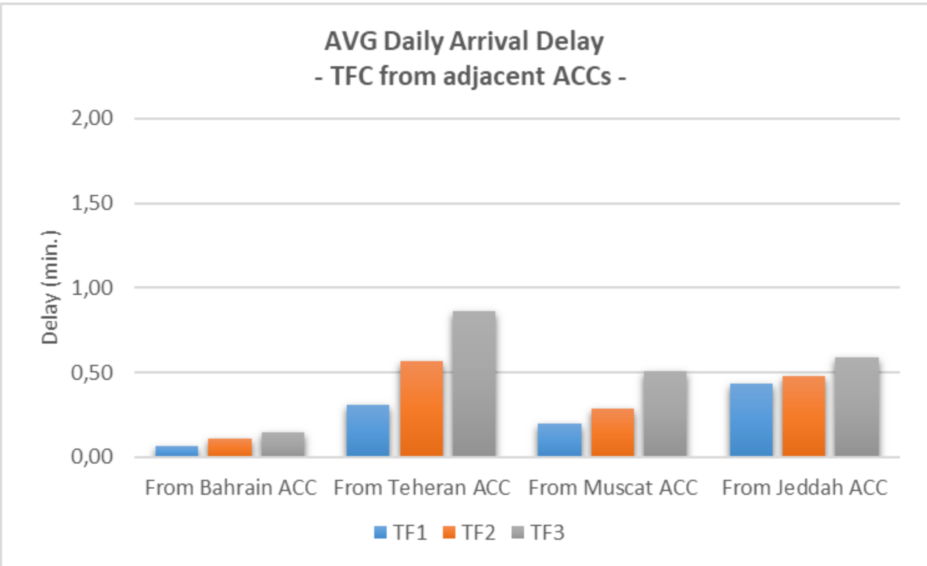
5.4.3.1 UAE ACC results

The following graphs below show the average daily delay of the traffic to/from adjacent ACCs. As anticipated, the charts indicate the delay originated by the entry/exit separations to/from the UAE ACC. Such a delay is managed by adjacent ACCs for the inbound traffic and by the UAE ACC for the outbound traffic flows.

The average daily delay has increased throughout the three timeframes due to the unchanged boundary separation rules and the increase in the traffic demand. Namely:

- Flights to/from Bahrain and Muscat ACCs, although representing the highest traffic flows, are only slightly delayed on average thanks to a 10NM entry/exit separation rule. To be noted thatthe availability of additional entry/exit points has a positive impact on delay performance.
- Flights to/from Teheran and Jeddah ACCs have a 20NM and 50NM entry/exit separations, respectively. These separation rules cause daily higher delay on average than the in the case of Bahrain and Muscat ACCs, although the number of flights to/from Teheran and Jeddah ACC is significantly lower.

Despite the introduction of new entry/exit points in the UAE ACC, the increase in the average daily delay is caused by the gradual increase in traffic volumes throughout the three timeframes.



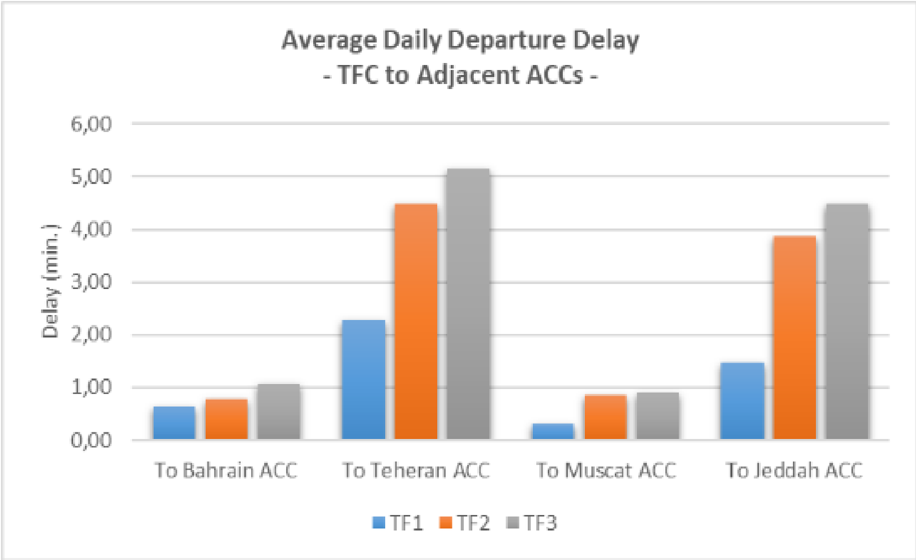


Figure 47: UAE ACC – average daily delay, traffic to/from adjacent ACCs

More details on the average delay on an hourly basis can be found in Appendix 0, along with hourly throughput values.

The average daily delay for traffic exiting the UAE ACC into UAE's CTAs is managed by the UAE ACC, but caused by the CTA entry separation rules. This delay depends on the capability of the CTAs to receive incoming traffic directly to their airports, as shown in the chart below.

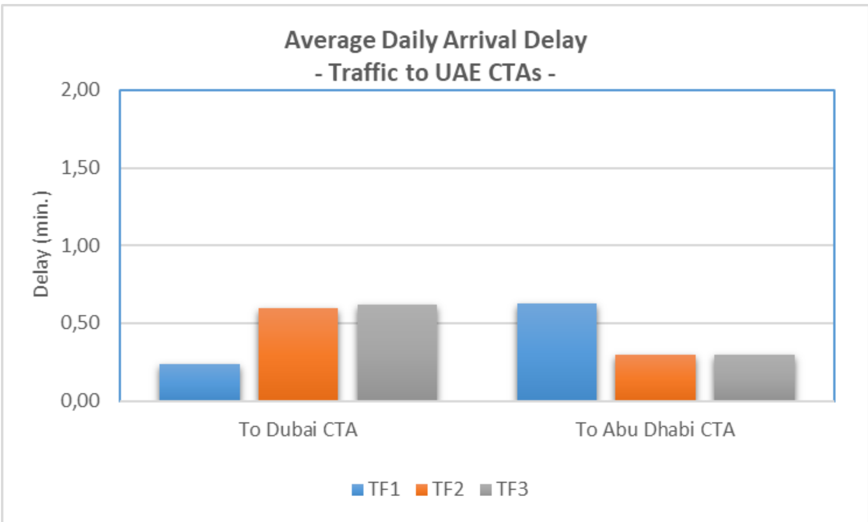


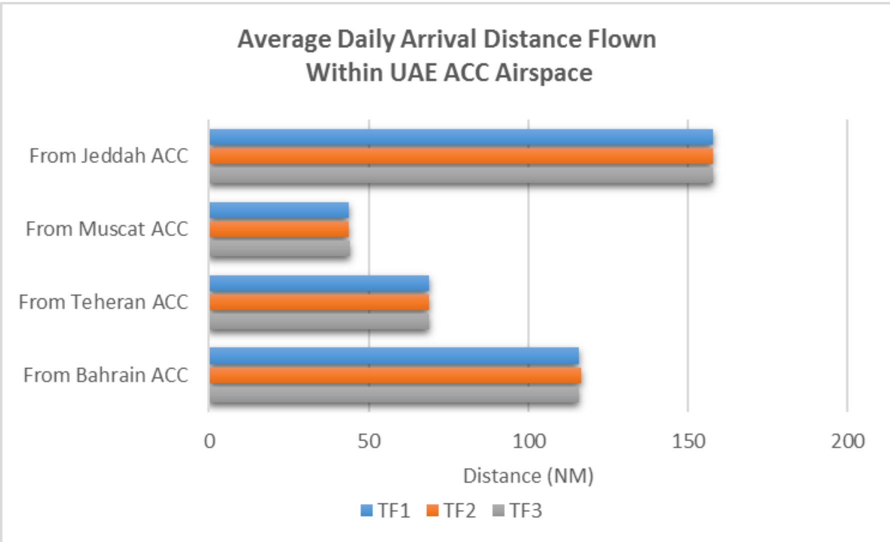
Figure 48: UAE ACC – average daily arrival delay, traffic to the UAE's CTAs

Overall, the results are positive. However, it should be noted that the delay increases for the traffic flow into Dubai CTA between TF1 and TF2, while it is basically constant between TF2 and TF3. The main reason for the increase between TF1 and TF2 is mostly due to the low traffic levels at OMDB in TF1. Approximately half of the current 1,200 flights is assumed to be directed to OMDW in TF1. As a consequence, further to OMDB flights decrease, the associated delay is around 0. In TF2, the traffic to OMDB airport turns to current standard values, so as the delay increases accordingly.

Note: If the number of OMDB flights remained unchanged in TF1 (i.e. approximately 1,200), the delay of flights directed to Dubai CTA throughout the three timeframes would have the same decreasing trend of the flights directed to Abu Dhabi CTA due to the introduction of the new operational concepts.

The graphs below show the results of the Environmental Sustainability KPA, both for incoming and outcoming flights to/from the UAE ACC.

From a flight duration and distance flown perspective, no variation between the timeframes has been observed, because all new operational concepts for the UAE ACC are introduced already in TF1. The only variation assessed relates to the average fuel burnt due to the increase of heavy and super-heavy aircraft throughout the three timeframes.



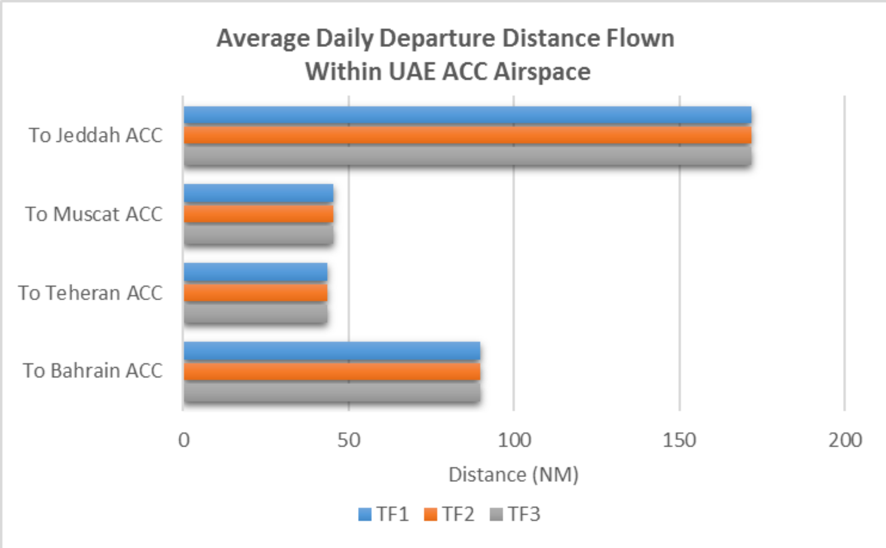
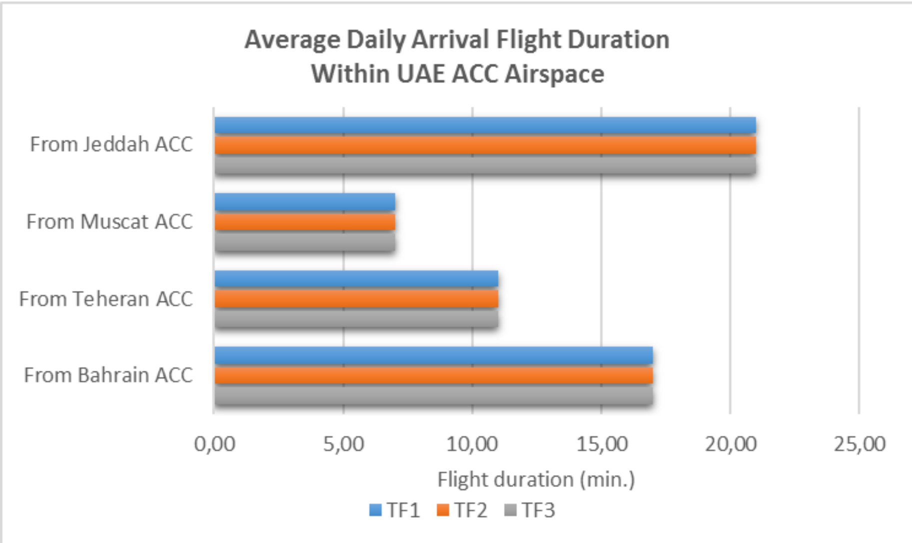


Figure 49: UAE ACC – average daily arrival/departure distance flown within the UAE ACC airspace



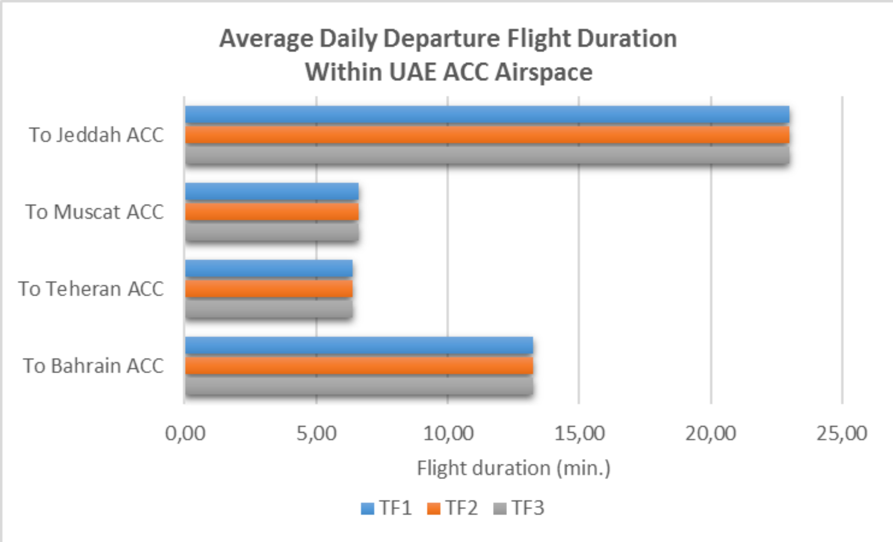
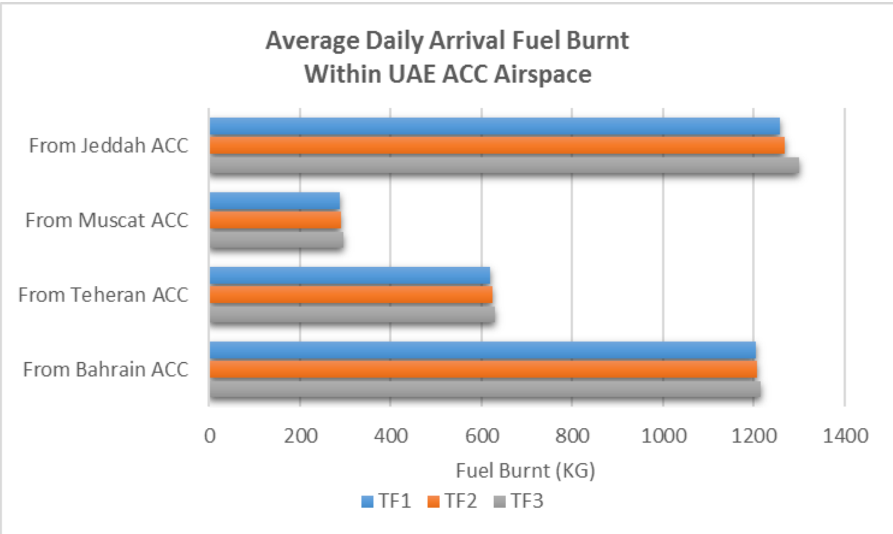


Figure 50: UAE ACC – average daily arrival/departure flight duration within the UAE ACC airspace



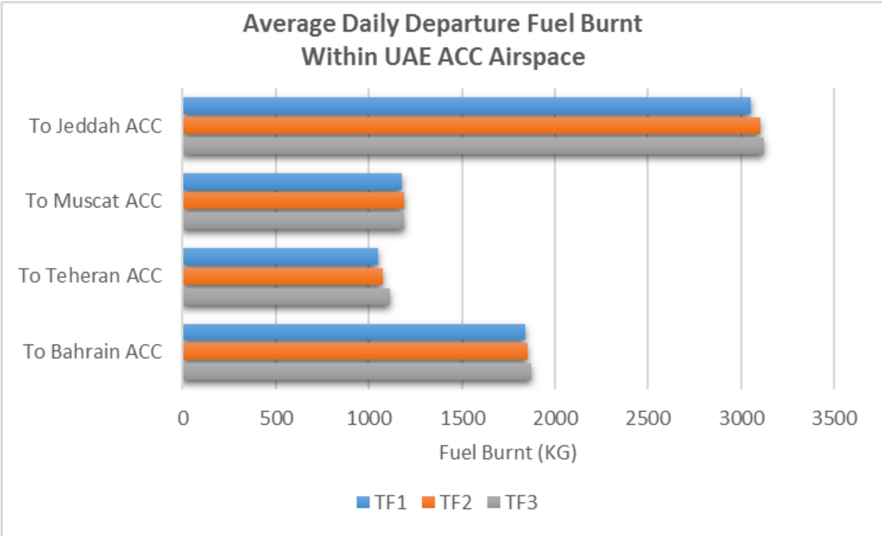
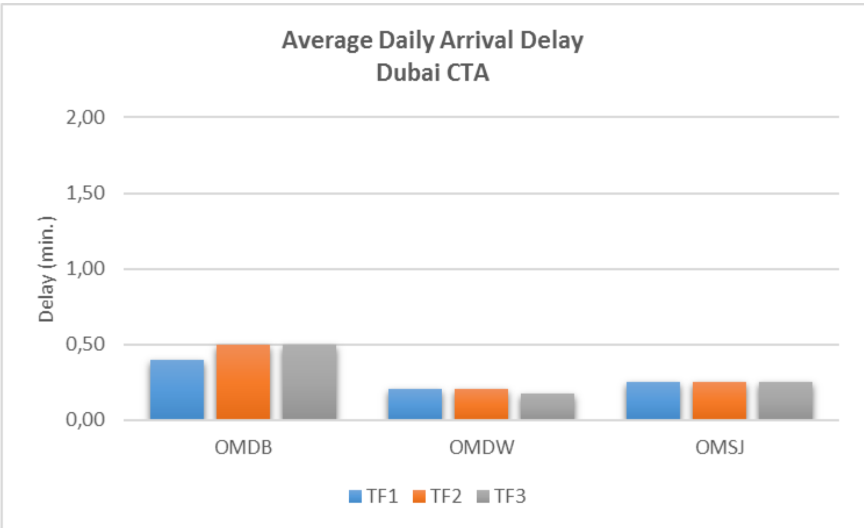


Figure 51: UAE ACC – average daily arrival/departure fuel burnt within the UAE ACC airspace

5.4.3.2 Dubai CTA & Abu Dhabi CTA results

The graphs below illustrate the average daily delay within Dubai and Abu Dhabi CTAs sorted by arrivals and departures, and subsequently by arriving and departing airports across the three timeframes. This delay is caused by actions deviating from nominal trajectories necessary to sequence flights (both arriving and departing), managed by the CTAs.



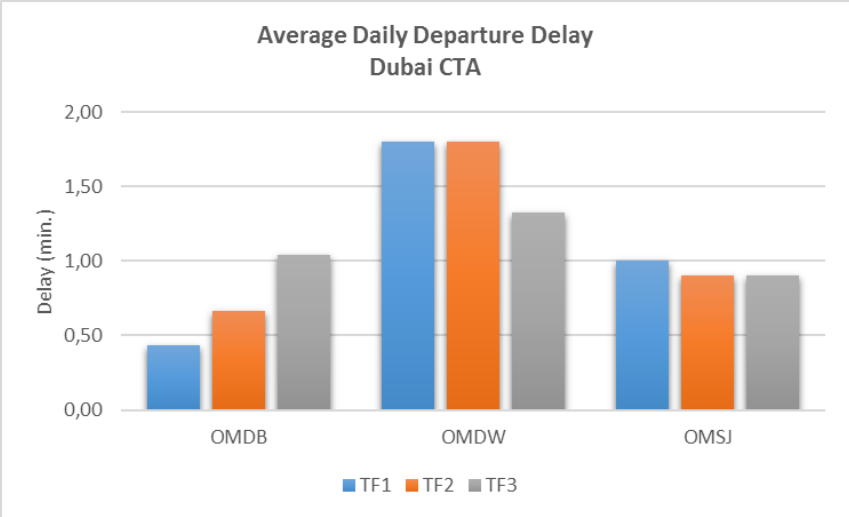
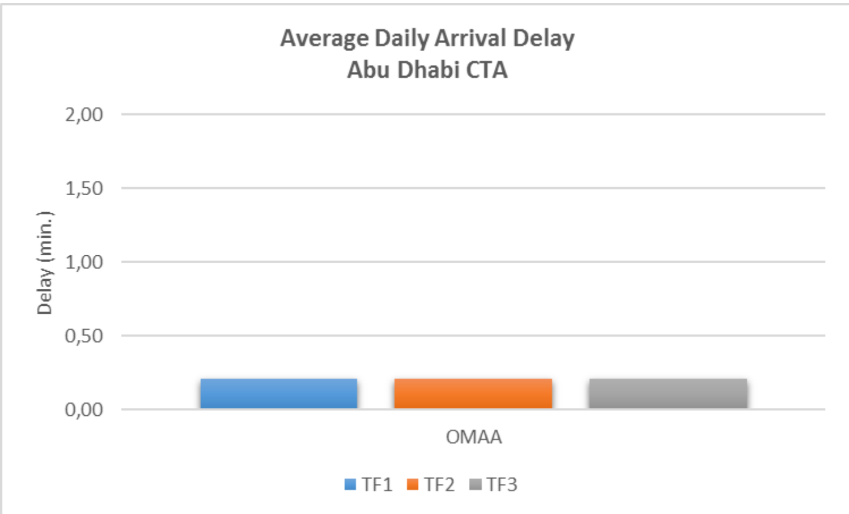


Figure 52: Dubai CTA – average daily arrival/departure delay

The graphs confirm that the traffic flow directed to OMDB is very low in Timeframe 1, and as such, in this Timeframe the average daily delay is very low, with an increasing trend in the subsequent timeframes. This applies to both arrivals and departures.

The traffic flow to/from OMDW and OMSJ has a decreased average daily delay thanks to the introduction of new operational concepts and runways. The graphs indicate that the airports involved in the infrastructural up-grade (increase the number of runways: OMDW, OMAA and OMSJ) experience an improvement in the delay performance on departures.



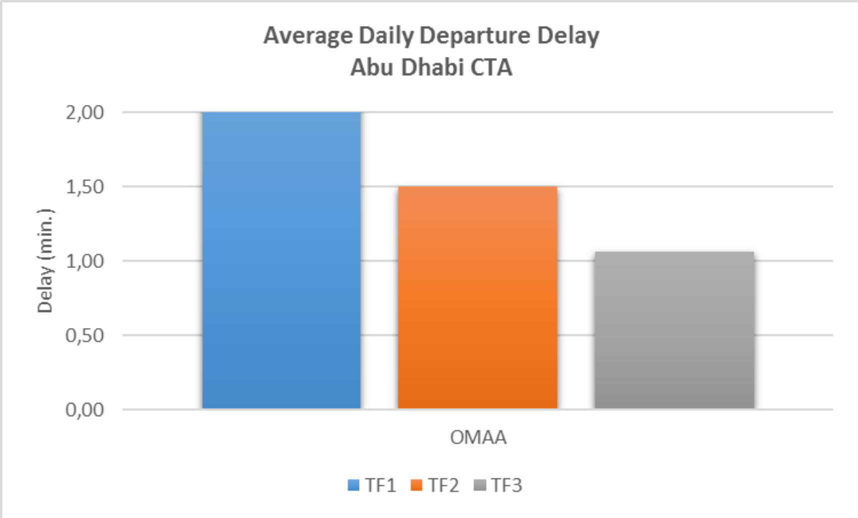
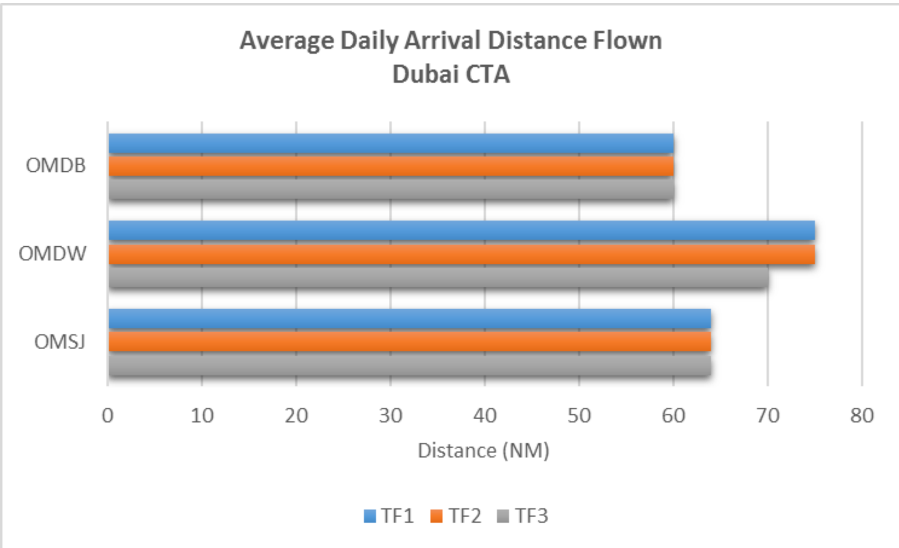


Figure 53: Abu Dhabi CTA – average daily arrival/departure delay

More details on the average hourly delay figures can be found in Appendix 0, along with hourly throughput values.

The graphs below show the results of the Environmental Sustainability KPA, both for inbound and outbound flights to/from the Dubai CTA.



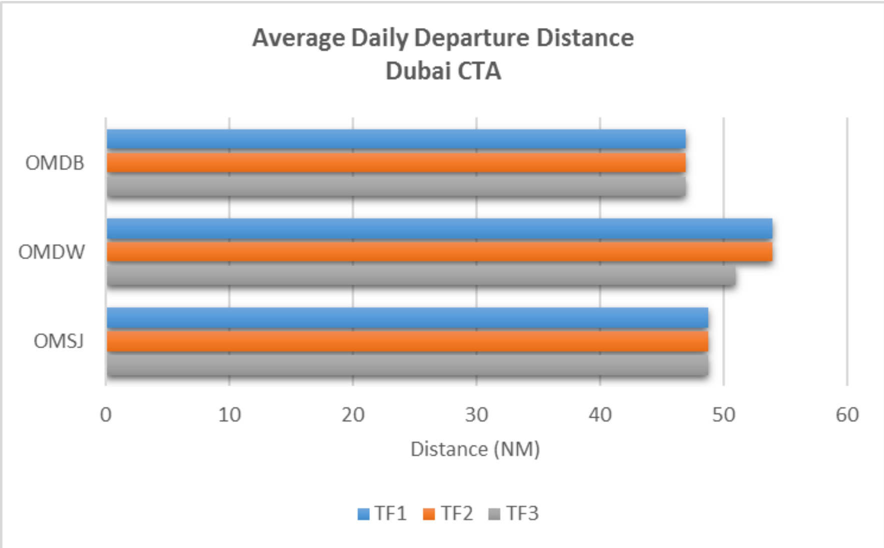
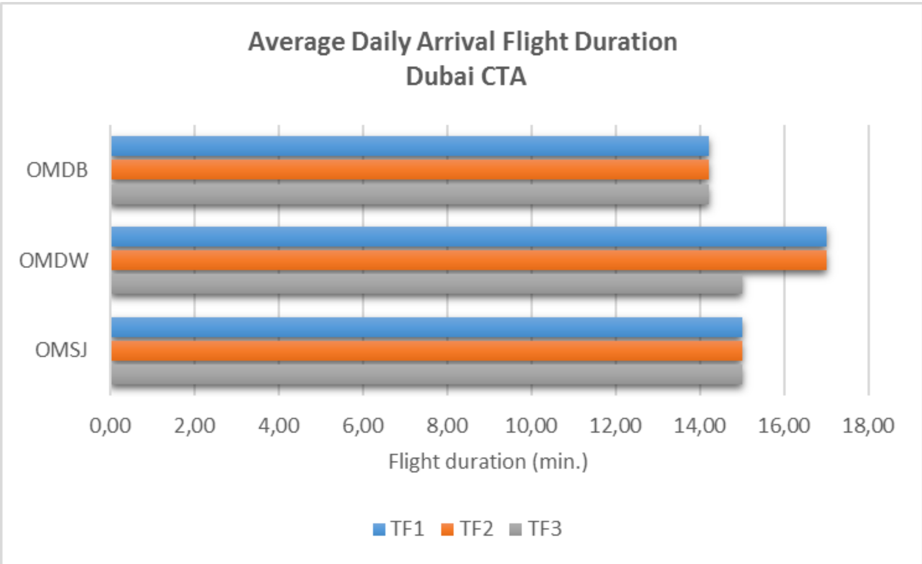


Figure 54: Dubai CTA – average daily arrival/departure distance flown



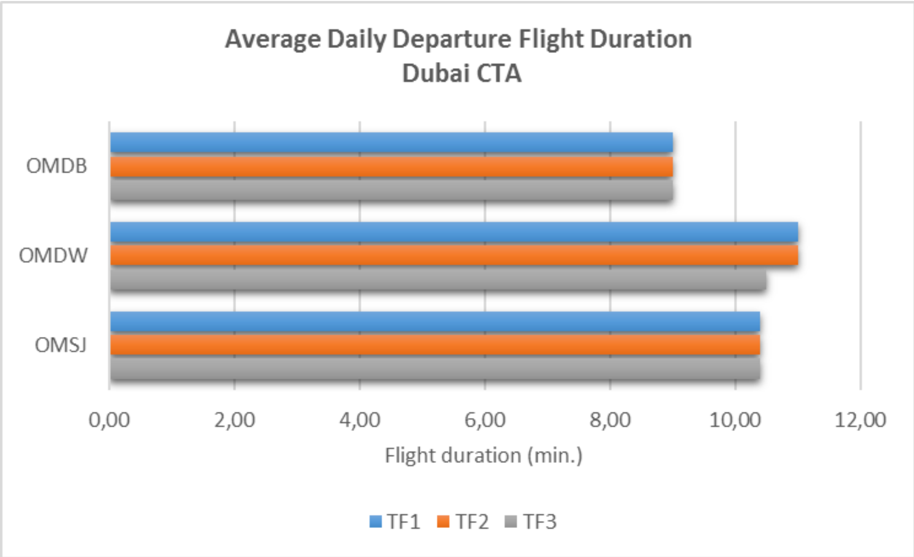
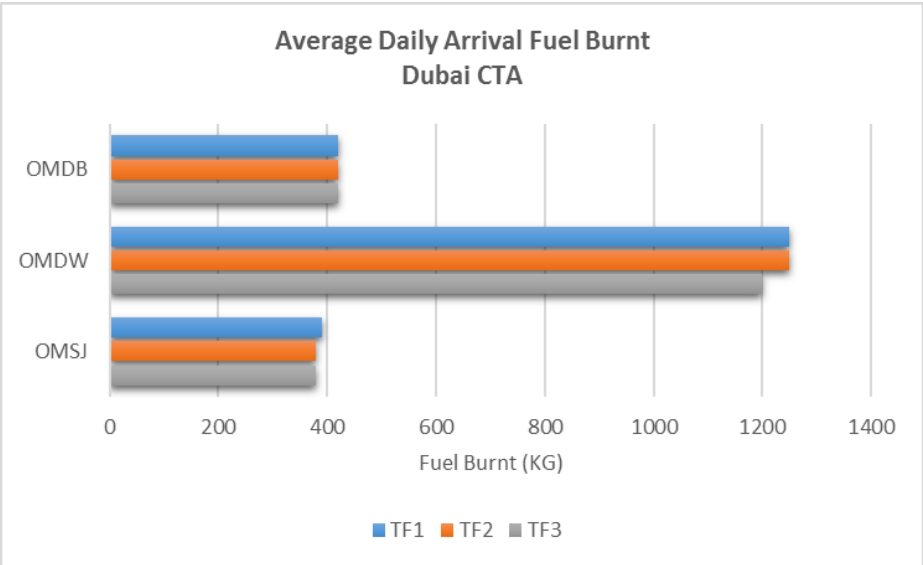


Figure 55 Dubai CTA – Average daily arrival/departure flight duration



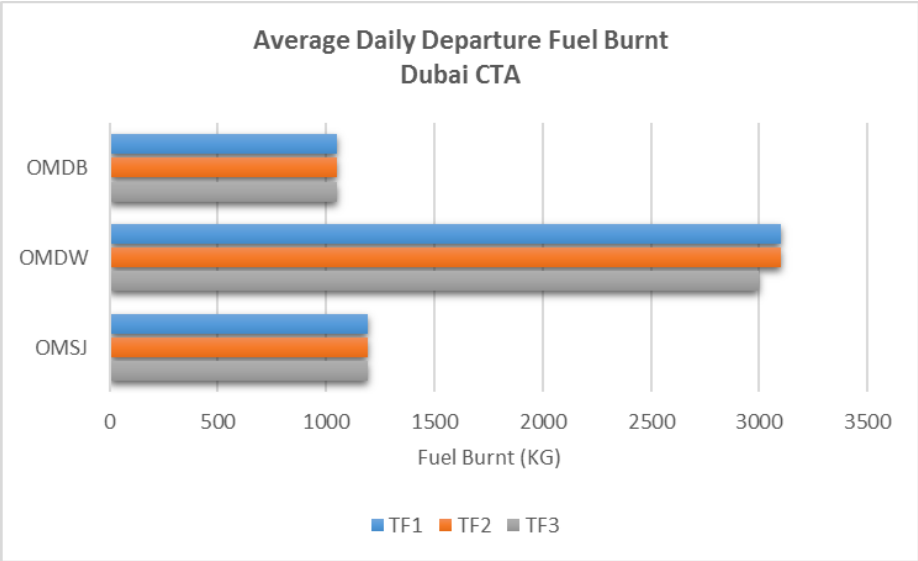


Figure 56: Dubai CTA – Average daily arrival/departure fuel burnt

From a flight duration and distance flown perspective, no variation in the diverse timeframe is assessed since the new operational concepts are introduced since Timeframe 1. The only variation assessed relates to the average fuel burnt due to the increase of heavy and super-heavy aircraft throughout the three timeframes.

The only airport that records an improved environmental footprint is OMDW, whose IFP system is expected to undergo the most significant changes throughout the individual timeframes. In fact, thanks to the reduction of distances and time as well as the optimised vertical profile caused by the introduction of PMS, the airport records a decrease in fuel burnt internally within the Dubai CTA, as shown in the graphs above.

The graphs below show the results of the Environmental Sustainability KPA, both for incoming and outcoming flights to/from the Abu Dhabi CTA.

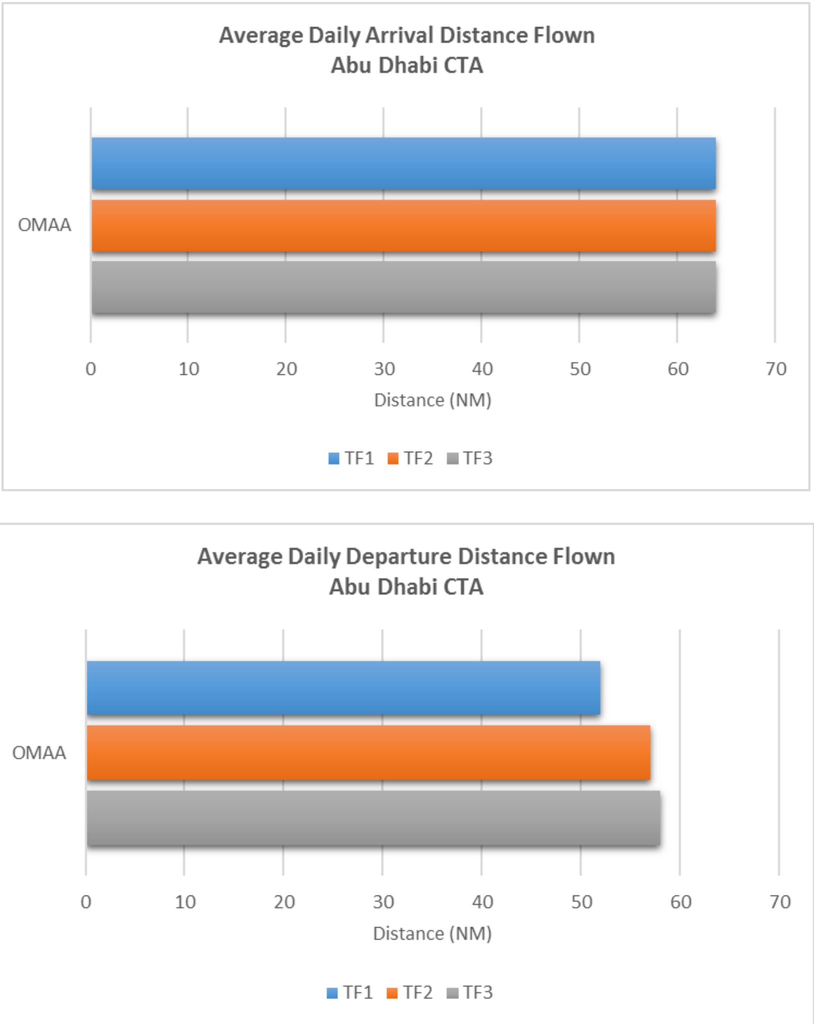
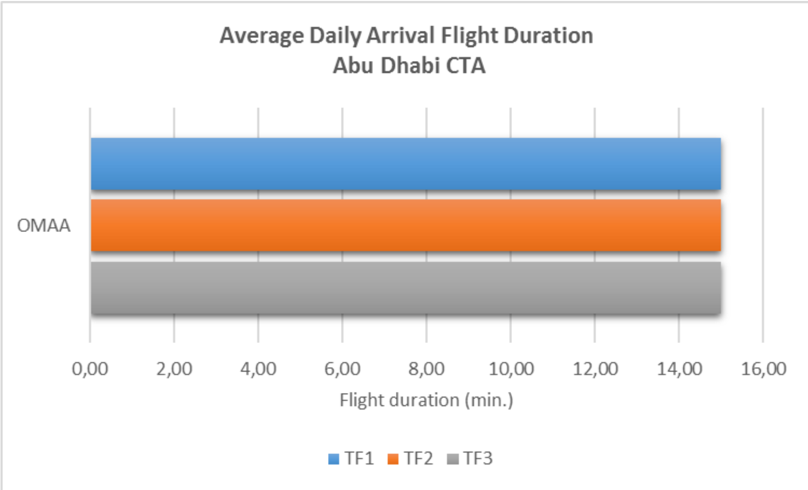


Figure 57: Abu Dhabi CTA – average daily arrival/departure distance flown



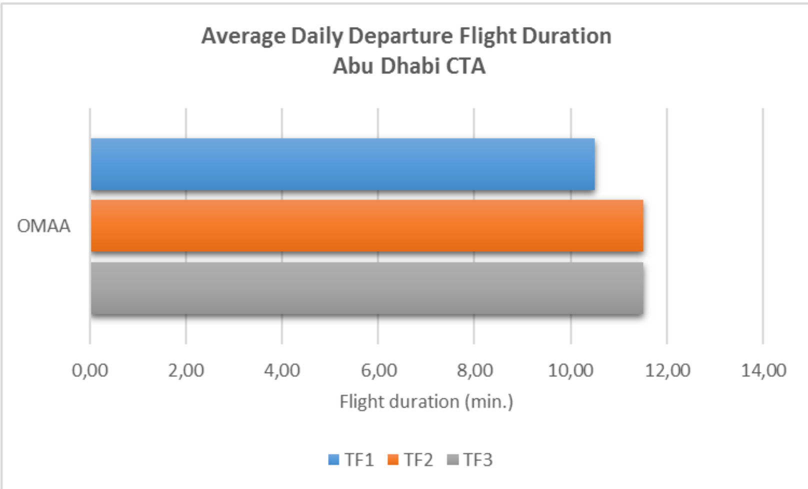
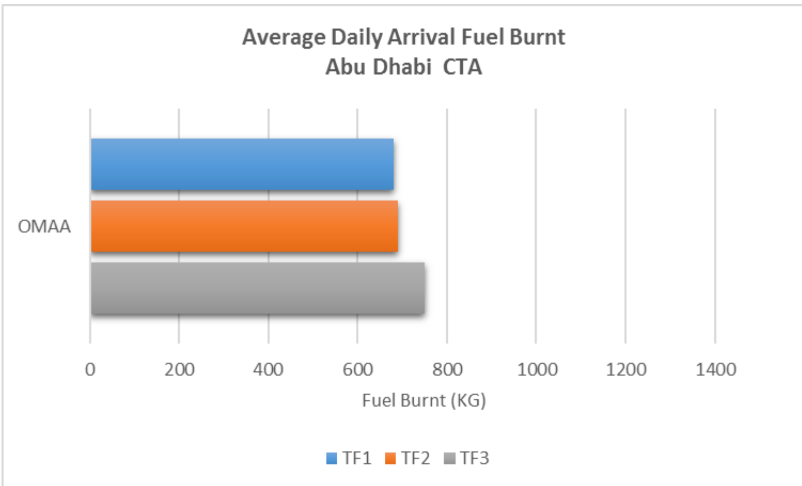


Figure 58: Abu Dhabi CTA – average daily arrival/departure flight duration



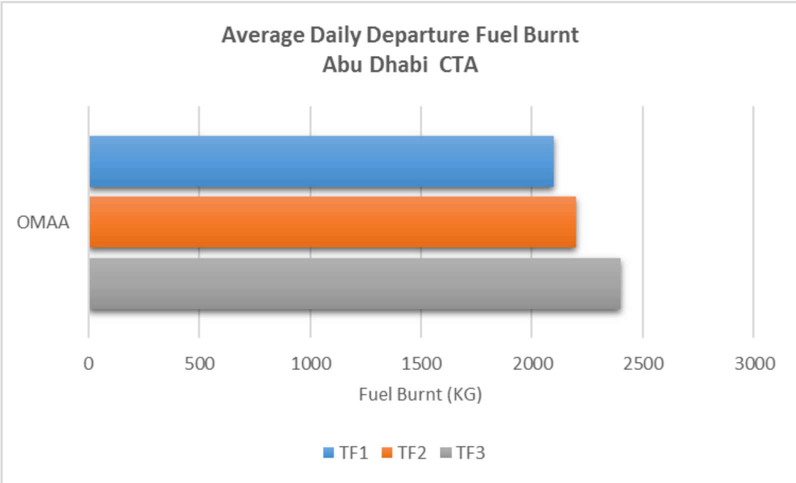


Figure 59: Abu Dhabi CTA – average daily arrival/departure fuel burnt

As for the arrivals, a slight increase in fuel burnt is recorded in Abu Dhabi CTA, even though the distance flown and the flight duration of arrivals to OMAA do not change. This is caused by the fleet mix changes for OMAA, which see an increase in super-heavy aircraft.

As for the departures, the analysis of the Abu Dhabi CTA has revealed slightly worst environmental performances, which result in an increase in fuel consumption. This is due to the modelling of departures designed to assign runways randomly to reduce as much as possible potential delays, as long as the availability of runways is increased throughout the timeframes. Hence, the use of SIDs may not be coherent with traffic flows, which sometimes results in longer distances to fly (similarly to *Stream 1*).

6. ATM/CNS ENABLERS

This section provides at a high level the key updates that will be required to the ATM/CNS infrastructure across the three defined timeframes. These follow the ICAO ASBU framework **Error! Reference source not found.**and the regional ICAO documentation, namely the *MID eANP Volume III* and it's amendment from 2017. However, the regional documents cover only Block 0 ASBUs and therefore information on any further blocks are based on the global ICAO documentation.

In each timeframe, the UAE NASAC should assess and validate the current and future compliance of the UAE against the ICAO ASBU framework and MID priorities, and set the national priorities for further development.

6.1 Timeframe – TF1

The required CNS infrastructure is largely in place because of ARP Phase 1 and 2. The new ATM systems are expected to be implemented before 2020. This means that there is a relatively small number of additional ATM/CNS enablers required to support changes and performance requirements between 2020-2025.

It is understood that most of the ICAO ASBU Block 0 are already or will be fully implemented by the UAE by 2020. However, the information on Block 1 requirements and beyond is largely lacking from the UAE stakeholders (and more widely from the ICAO MID region). Based on the experience with Block 0 targets being implemented with a delay of several years, the assumption used in this IAMP is that Block 1 ASBUs will be implemented by the UAE in the TF1, i.e. by 2025.

6.1.1 Airport operations

6.1.1.1 B1-APTA: Optimised airport accessibility

All the UAE airports except for OMAL and RWY 11 at OMFJ have already optimised their approach procedures, including vertical guidance, through the implementation of Lateral Navigation (LNAV) and Vertical Navigation (VNAV), the objectives of B0-APTA.

To progress further with the universal implementation of PBN and GLS approaches, as per the *UAE PBN Implementation Plan*, PBN and GLS (CAT II/III) procedures should be implemented to enhance the reliability and predictability of approaches to runways, increasing safety, accessibility and efficiency.

Category	Priority	Item	Related ASBU		2020	2021	2022	2023	2024	2025
Arrival	*High*	All	APTA:	B1-						

Category	Priority	Item	Related ASBU		2020	2021	2022	2023	2024	2025
procedure adjustment			Airport accessibility	APTA						
RNAV 1		Beyond major routes to support Middle East		B1-APTA						

6.1.1.2 B1-WAKE: Increased runway throughput through dynamic wake turbulence separation

Although not a priority for the ICAO MID region, it is assumed that increased capacity through the implementation of wake turbulence categorisation for main UAE airports is of an importance to the UAE. Live trials were held at OMDB in 2015-2016 and it is expected that the UAE will implement improved throughput on departure and arrival runways through optimised wake turbulence separation minima, revised aircraft wake turbulence categories and procedures at its major airports by 2020. Hence, fulfilling the requirements of B0-WAKE.

The UAE should subsequently implement improved throughput on departure and arrival runways through the dynamic management of wake turbulence separation minima based on real-time identification of wake turbulence hazards. This entails implementing collaborative Airport Operations Planning (AOP) and, where needed, an Airport Operations Centre (APOC).

Category	Priority	Item	Related ASBU		2020	2021	2022	2023	2024	2025
Separation minima	*Low*	UAE harmonisation and wake separation	WAKE: Wake turbulence separation	B1-WAKE						

6.1.1.3 B1-RSEQ: Improved airport operations through departure, surface and arrival management

Arrival Manager (AMAN) and Departure Manager (DMAN) are currently reported to be operational for the major UAE airports. As the next step, arrival metering should be extended and integrated with surface management for departure sequencing. This will improve runway management and increase airport performance and flight efficiency.

Category	Priority	Item	Related ASBU		2020	2021	2022	2023	2024	2025
Time-based operation	*Low*	Full departure, ground, arrival management	RSEQ: Runway sequencing	B1-RSEQ						

6.1.1.4 B1-SURF: Enhanced safety and efficiency of surface operations

Advanced Surface Movement Guidance and Control Systems (A-SMGCS) provide surveillance and alerting of movements of both aircraft and vehicles on the aerodrome, thus improving runway/aerodrome safety. Automatic Dependent Surveillance-Broadcast (ADS-B) information should be used when available (ADS-B APT). Enhanced Vision System (EVS) should be used for low visibility operations.

A-SMGCS level 1 is currently implemented at three UAE airports (OMAA, OMDB, OMDW). A-SMGCS level 2 is currently implemented at two UAE airports (OMAA, OMDB), OMDW is scheduled for implementation in 2018. However, according to the reported plan, OMAA and OMDB report to have A-SMGCS level 4 functional since 2017, while OMDW should have the A-SMGCS level 4 installed by 2018. Although delayed, it is expected that these will be implemented at the respective airports by 2020.

The UAE should subsequently provide enhancements to surface situational awareness, including both cockpit and ground elements, in the interest of runway and taxiway safety, and surface movement efficiency. Cockpit improvements should include the use of surface moving maps with traffic information for flight crew traffic situational awareness on the taxiways and on the runway.

Category	Priority	Item	Related ASBU		2020	2021	2022	2023	2024	2025
A-SMGCS	*High*	Enhanced safety and efficiency	SURF: Surface operations	B1-SURF						

6.1.1.5 B1-ACDM: Optimised airport operations through A-CDM total airport management

The initial Airport Cooperative Decision Making (A-CDM) applications are understood to be implemented by 2020. The UAE's original plan was to implement apron management, ATM-aerodrome coordination, and define the declared terminal and runway capacities for OMAA, OMDB and OMDW by 2017. It is understood that this work is currently still in progress.

A unified concept of operations is currently being developed by and under the responsibility of NASAC WG 14. The establishment of TTOT and CTOT is coordinated with the initiative for a National Operation Centre (NOC) and ATFM activities, currently under the responsibility of NASAC WG 12. Relevant procedures are currently being developed for Abu Dhabi and A-CDM implementation is ongoing at major UAE international airports.

Building on B0-ACDM, the UAE should enhance the planning and management of airport operations and allow their full integration in the air traffic management, using performance targets compliant with those of the surrounding.

Category	Priority	Item	Related ASBU		2020	2021	2022	2023	2024	2025
CDM	*High*	Total A-CDM (major airports)	ACDM: Airport Collaborative Decision Making	B1-ACDM						
		Total A-CDM (regional airports)		B1-ACDM						

6.1.1.6 B1-RATS: Remotely operated aerodrome control

It is expected that the UAE will join the latest developments of some other leading States in the provision of a safe and cost-effective ATS from a remote facility to one or more aerodromes where dedicated, local ATS are no longer sustainable or cost-effective, but there is a local economic and social benefit from aviation. This can also be applied to contingency situations and depends on enhanced situational awareness of the aerodrome under remote control.

Both leading airport management organisations in the UAE, Dubai Airports and Abu Dhabi Airports Company (ADAC), have already conducted studies into remote airport towers for contingency purposes, but also for the potential provision of ATS for smaller airports (such as the island airports operated by ADAC). It is therefore expected that within the TF1 one or more of such airports may become operated through a remote facility.

Category	Priority	Item	Related ASBU		2020	2021	2022	2023	2024	2025
ANS provision	*Low*	Remote ATS	Remote towers	B1-RATS						

6.1.2 Globally interoperable systems and data

6.1.2.1 B1-FICE: Increased interoperability, efficiency and capacity through FF-ICE, Step 1 application before departure

The UAE ANSPs fully implemented B0-FICE objectives, namely deployed the Aeronautical Message Handling System (AMHS) and provided interconnections. On-Line Data Interchange (OLDI) protocol was also deployed and currently is fully functional and implemented locally between the UAE ANSPs.[2] These technologies improved coordination between the individual ATS units and they are expected to provide the benefit of improved efficiency of the transfer of communication in a datalink environment.

It is, however, understood that the UAE experiences some connectivity issues with neighbouring States. This is assumed to be resolved by 2020. The AMHS capability is currently implemented in four out of eight airports (OMAA, OMDB, OMDW and OMAE). International AMHS connections are currently established from OMAE, OMDB, OMDW to Jeddah, Doha, Muscat, and Amman. Further connections depend on the readiness of partners from the neighbouring States.

OLDI between adjacent ACCs are currently partially implemented for seven out of 13 connections. These are implemented from OMAE to OMAA, OMAL, OMAD, OMDB, OMDW, OMRK, OMSJ, and OTHH. Other connections are currently being tested, namely from OMAE to OMFJ, OBBB. Connections not implemented are from OOMM, OEJD, OIIX. Testing with OOMM have been suspended until OOMM declares readiness following a change of ACC.

In TF1, the UAE should introduce Flight & Flow Information for a Collaborative Environment (FF-ICE), Step 1, providing ground-ground exchanges before departure using common Flight Information Exchange Model (FIXM) and Extensible Mark-up Language (XML) standard formats. FIXM is the pre-requisite to trajectory-based operations, which will allow richer content exchange with the goal to better support user needs.

Category	Priority	Item	Related ASBU		2020	2021	2022	2023	2024	2025
Enhanced system automation and decision support	*High*	Collaborative flight and flow information	FICE: FF-ICE	B1-FICE						

[2] The UAE follows wider regional decision to implement the European standard OLDI as opposed to the Air Traffic Service Interfacility Data Communication (AIDC) developed by ICAO. However, the functionalities are similar, as recognised also by ICAO.

Category	Priority	Item	Related ASBU		2020	2021	2022	2023	2024	2025
tools										

6.1.2.2 B1-DATM: Service improvement through integration of all digital ATM information

It is understood that most of the elements of B0-DATM have already been implemented, namely:

- National Aeronautical Information Management (AIM) Implementation Plan: The UAE has developed a plan for the transition from AIS to AIM in 2011
- Aeronautical Information Exchange Model (AIXM): The UAE currently operates AIXM 5.1, which is fully compatible with all the requirements for the AIXM standards.[3]
- eAIP: The UAE has fully implemented the Integrated Aeronautical Information Database (IAID) driven AIP production.
- Quality Management System (QMS): The UAE has fully implemented QMS for AIS/AIM.
- WGS-84: The UAE has fully implemented WGS-84 for horizontal plan (en-route, terminal, aerodrome, and ground).
- eTOD: The UAE fully integrated required terrain datasets in 2016.
- Digital NOTAM: The UAE will fully implement digital NOTAMs by 2021.

In B1-DATM, the UAE ANSPs should address the need for increased information integration and support a new concept of ATM information exchange, fostering access via internet protocol-based tools. This includes the cross-exchange of common elements with the initial introduction of the ATM Information Reference Model (AIRM), which integrates and consolidates ATM information in a transversal way. Exchange models such as AIXM, FIXM (for flight and flow information, and aircraft performance-related data), IWXXM (for meteorological information) and others relate their concepts to the AIRM fostering convergence, reusable, and collaborative alignment.

Category	Priority	Item	Related ASBU		2020	2021	2022	2023	2024	2025
ANS provision	*High*	Integration of all digital ATM information (UAE)	DATM: Digital ATM information	B1-DATM						

[3] The latest AIXM standard is 5.1.1, released in 2016. It is currently unknown if and when the UAE undergoes the transition to this standard.

6.1.2.3 B1-SWIM: Performance improvement through application of system-wide information management

The implementation of System-Wide Information Management (SWIM) services (applications and infrastructure), creating the aviation intranet based on standard data models and internet-based protocols to maximise interoperability, is a basic prerequisite for an interoperable and efficient future ATM system.

The UAE has already started implementing parts of the SWIM-like infrastructure, e.g. by defining its current and future ATM system requirements that include SWIM capability. In addition, the UAE has currently plans to deploy a SWIM capability for the exchange of consolidated real-time flight information with a target operational date within the UAE in 2018. Hence, it is assumed that an initial SWIM infrastructure and capability in the UAE will be achieved by the end of TF1.

Category	Priority	Item	Related ASBU		2020	2021	2022	2023	2024	2025
Enhanced system automation and decision support tools	*Low*	Initial SWIM applications	SWIM: System Wide Information Management	B1-SWIM						

6.1.2.4 B1-AMET: Enhanced operational decisions through integrated meteorological information

The UAE implemented SADIS 2G and Secure SADIS FTP protocols, and developed an ISO 9001 certified QMS for its meteorological service and information already in 2012. Hence, the B0-AMET requirements are fully addressed.

According to B1-AMET, the UAE should achieve a full ATM-meteorology integration to ensure that meteorological information is included in the logic of a decision process and the impact of the meteorological conditions on the operations are automatically derived, understood and considered. The supported decision time horizons range from minutes, to several hours or days ahead of the ATM operation. This includes optimum flight profile planning and execution, and support to tactical in-flight avoidance of hazardous meteorological conditions (improved in-flight situational awareness) to typical near-term and planning (20 minutes ahead and more) type of decision making.

This will promote the establishment of standards for global exchange of the MET information closely aligned with other data domains and adhering to a single reference (ICAO-AIRM). It will also promote further enhancement of meteorological information on various quality-of-service aspects, including the accuracy and consistency of the data when used in interlinked operational decision-making processes.

Category	Priority	Item	Related ASBU		2020	2021	2022	2023	2024	2025
ANS provision	*High*	Integration of MET data	AMET: Meteorological information	B1-AMET						

6.1.3 Optimum capacity and flexible flights

The OPFL (improved access to optimum flight levels through climb/descent procedures using ADS-B) and ACAS (airborne collision avoidance systems improvements) ASBU modules are not considered within this IAMP, as these are unrelated to the CNS/ATM infrastructure or covered by other modules (such as ASUR).

6.1.3.1 B1-FRTO: Improved operations through optimised ATS routing

The UAE should allow the use of airspace, which would otherwise be segregated, i.e. special use airspace, along with flexible routing adjusted for specific traffic patterns. This will allow greater routing possibilities, reducing potential congestion on trunk routes and busy crossing points, resulting in reduced flight length and fuel burn.

The implementation of the Flexible Use of Airspace (FUA) concept is currently ongoing as per the UAE's civil/military coordination plan. The implementation of flexible routing is also currently ongoing, with 41 total ATS routes, three routes required to be implemented through segregated area, and 4 routes not implemented due to military restrictions. It is, however, expected that these B0-FRTO requirements will be fully addressed in the UAE by 2020. The FUA is reported to be currently partially implemented in the UAE, with some ATS routes not being implemented due to military restrictions in segregated areas.

According to B1-FRTO, the UAE shall provide, through PBN, closer and consistent route spacing, curved approaches, parallel offsets and the reduction of holding area sizes. This will allow the sectorization of airspace to be adjusted more dynamically and reduce potential congestion on trunk routes and busy crossing points, leading to reduced ATCO workload. The main goal is to allow flight plans to be filed with a significant part of the intended route specified by the user-preferred profile. Maximum freedom will be granted within the limits posed by the other traffic flows. The overall benefits would be reduced fuel burn and emissions.

In this context, the application of the B1-FRTO improvements would best benefit from a harmonized wider regional or sub-regional implementation. This can be achieved through the GCC UFIR initiative to increase the intra-GCC State boundary throughput, although separate arrangements would need to be defined for the lower airspace.

Category	Priority	Item	Related ASBU		2020	2021	2022	2023	2024	2025
Flexible and free routing	*High*	Optimised ATS routing (civilian)	FRTO: Flexible and free route operations	B1-FRTO						
		Optimised ATS routing (military)		B1-FRTO						

6.1.3.2 B0-NOPS: Improved flow performance through planning based on a network-wide view

The primary role of Air Traffic Flow Management (ATFM) is to manage the flow of traffic in a way that minimises delays and maximises the use of the entire airspace. Collaborative ATFM can regulate traffic flows involving departure slots, smooth flows, and manage rates of entry into airspace along traffic axes, manage arrival times at waypoints or FIR/sector boundaries and reroute traffic to avoid saturated areas. ATFM may also be used to address system disruptions, including crisis caused by human or natural phenomena.

The airspace capacity of the UAE sectors is currently defined, and their usage monitored. The implementation of a SWIM database system to collect and consolidate all information from national and international sources to provide information sharing to the stakeholders on a national level is currently planned. However, a regional collaborative ATFM has not been established yet. It is expected that this may result from the currently ongoing initiative for the establishment of a common GCC UFIR, which is in its initial form planned to be established by the end of 2020.

Category	Priority	Item	Related ASBU		2020	2021	2022	2023	2024	2025
ATFM	*High*	Regional view	NOPS: Network operations	B0-NOPS						

6.1.3.3 B1-NOPS: Improved flow performance through planning based on a network-wide view

Once a basic ATFM system is deployed in the UAE (and the neighbouring States) through B0-NOPS in the TF1, enhanced processes to manage flows or groups of flights in order to improve overall flow should be introduced. The resulting increased collaboration among stakeholders in real time, regarding user preferences and system capabilities should then result in better use of airspace with positive effects on the overall cost of ATM in the UAE and wider region.

Again, the deployment of an enhanced ATFM solution in the UAE and the GCC sub-region can be facilitated by the deployment of a Target Scenario for the GCC UFIR, which is planned to take place by the end of 2025.

Category	Priority	Item	Related ASBU		2020	2021	2022	2023	2024	2025
ATFM	*High*	Regional view	NOPS: Network operations	B1-NOPS						

6.1.3.4 B0-ASUR: Initial capability for ground surveillance

The UAE should provide initial capability for lower cost ground surveillance supported by new technologies such as Automatic Dependent Surveillance – Broadcast (ADS-B) OUT and wide area multilateration (MLAT) systems. This capability may then be translated into the adjustments and improvements in various ATM services, e.g. traffic information, search and rescue and separation provision.

The UAE has already mandated the ADS-B OUT on-board equipment for all aircraft operators operating in the UAE from 01 January 2020. It is therefore understood that this ASBU module will be fully addressed by 2020.

6.1.3.5 B1-ASEP: Increased capacity and efficiency through interval management

Interval management for en-route and terminal areas will improve the organisation of traffic flows and aircraft spacing. Precise management of intervals between aircraft with common or merging trajectories will maximise airspace throughput while reducing ATCO workload along with more efficient aircraft fuel burn, which will in turn reduce environmental impact.

Category	Priority	Item	Related ASBU	2020	2021	2022	2023	2024	2025

Category	Priority	Item	Related ASBU		2020	2021	2022	2023	2024	2025
ANS provision	*Low*	Interval management	ASEP: Air traffic situational awareness	B1-ASEP						

6.1.3.6 B1-SNET: Ground-based safety nets on approach

The UAE ANSPs already operate their ATC systems with Short-Term Conflict Alerts (STCAs), Area Proximity Warnings (APWs), as well as Minimum Safe Altitude Warnings (MSAW). These ground-based safety nets make an essential contribution to safety and remain required as long as the operational concept remains human centred. They enable monitoring of flights while airborne to provide timely alerts to ATCOs of potential risks to flight safety.

To enhance safety further by reducing the risk of controlled flight into terrain accidents on final approach and the risk of unstable approach, the UAE should implement and use Approach Path Monitor (APM). APM warns the ATCO of an increased risk of controlled flight into terrain during final approaches, or of an approach path above nominal that could lead to unstable approaches. The major benefit is expected to be a significant reduction of the number of major incidents.

Category	Priority	Item	Related ASBU		2020	2021	2022	2023	2024	2025
ANS provision	*Low*	Approach path monitor	SNET: Ground-based safety nets	B1-SNET						

6.1.4 Efficient flight path

6.1.4.1 B1-CDO: Improved flexibility and efficiency in descent profiles using VNAV

The B0-CDO has been to a large extent already achieved in the UAE and it is expected that the full implementation of B0-CDO will take place by 2020. RNAV Standard Terminal Arrival Routes (STARs) have been implemented at all UAE airports except for OMAL, OMJH and OMRK. To use performance-based airspace and arrival procedures will allow an aircraft to fly its optimum profile using Optimised Profile of Descent (OPD) procedures. This will optimise throughput, allow more fuel-efficient descent profiles and increase capacity in terminal areas.

The UAE shall subsequently enhance vertical flight path precision during descent, arrival, and to enable aircraft to fly an arrival procedure not reliant on ground-based equipment for vertical guidance. The main benefit will be higher utilisation of airports, improved fuel efficiency, increased safety through improved flight predictability and reduced radio transmissions, and better utilisation of airspace.

Category	Priority	Item	Related ASBU		2020	2021	2022	2023	2024	2025
CDO	High	CDO with VNAV	CDO	B1-CDO						

6.1.4.2 B0-TBO: Improved safety and efficiency through the initial application of datalink and SATVOICE en-route

It is understood that datalink is not a priority for the ICAO MID region and the UAE, due to its limited airspace size and therefore not a sufficient time to relay messages through datalink (voice is a preferred means of communication by ATCOs in such a case). However, its initial application as per B0-TBO, e.g. for providing route clearances, as identified in the GCC UFIR initiative, will be beneficial and is expected to take in place early in TF1. The initial set of datalink applications will support surveillance and communications in air traffic services, which will lead to flexible routing, reduced separation and improved safety.

Improved safety and efficiency through the initial application of datalink en-route is currently technically ready and it is part of the UAE's ATM modernisation project due to be implemented by 2019. Activation of the capability will be dependent on operational validation and approval.

Category	Priority	Item	Related ASBU		2020	2021	2022	2023	2024	2025
RNP	*Low*	En-route	TBO: Trajectory based operations	B0-TBO						

6.1.4.3 B1-TBO: Improved traffic synchronisation and initial trajectory-based operation

Building on B0-TBO, the synchronisation of traffic flows at en-route merging points should be improved and the approach sequence optimised through the use of 4D Trajectory Datalink (4DTRAD) capability and airport applications, e.g. datalink service for taxiing aircraft (D-TAXI).

Category	Priority	Item	Related ASBU		2020	2021	2022	2023	2024	2025

Category	Priority	Item	Related ASBU		2020	2021	2022	2023	2024	2025
RNP	*Low*	En-route	TBO: Trajectory based operations	B1-TBO						

6.1.4.4 B0-CCO: Improved flexibility and efficiency departure profiles

The UAE has implemented elements of Optimised Profile of Climbs (OPCs) at most of their airports. Their full implementation, in conjunction with PBN, will provide opportunities to optimise throughput, improve flexibility, enable fuel-efficient climb profiles, and increase capacity at congested terminal areas.

RNAV SIDs are currently implemented at all UAE airports since 2017. It is therefore understood that this ASBU module is already fully addressed.

6.1.4.5 B1-RPAS: Initial integration of remotely piloted aircraft into non-segregated airspace

With the advent of Remotely Piloted Aircraft Systems (RPAS), the implementation of basic procedures for their operation in non-segregated airspace has become a necessity. To achieve appropriate integration of RPAS into the wider ATM system, synchronization of the deployment of airborne and ground procedures will be necessary.

The UAE has been leading in this area and the GCAA has already issued the first RPAS-related civil aviation regulation in early 2018 – *Unmanned Aircraft System (UAS) and Operations*. GCAA has also launched its portal for registering RPAS. It is expected that further regulations and adjustments to the current regulation would be required, but the aims of this ASBU module should be fulfilled early in TF1.

Category	Priority	Item	Related ASBU		2020	2021	2022	2023	2024	2025
RPAS	High	Initial RPAS integration	RPAS	B1-RPAS						

6.2 Timeframe – TF2

It is expected that the TF2 will cover mostly the development and implementation of capabilities and systems to address ICAO ASBU Block 2 requirements. These are currently not as mature as Block 0 or 1 modules and therefore also the level of detail in descriptions below differs to the one provided in Section 6.1 .

6.2.1 Airport Operations

6.2.1.1 B2-WAKE: Advanced wake turbulence separation (time-based)

It is expected that the UAE would further refine its wake separation categorisation by the application of time-based aircraft-to-aircraft wake separation minima and changing to the procedures the UAE ANSPs would use to apply these separation minima.

The establishment of time-based separation criteria between pairs of aircraft extends the existing variable distance re-categorization of existing wake turbulence into a conditions-specific time-based interval. This will optimise the inter-operation wait time to the minimum required for wake disassociation and runway occupancy. Runway throughput will be increased as a result.

Category	Priority	Item	Related ASBU		2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Separation minima	*Low*	Conditions-specific time-based separation	WAKE: Wake turbulence separation	B2-WAKE										

6.2.1.2 B2-RSEQ: Linked arrival management and departure management

Integrated AMAN/DMAN will enable dynamic scheduling and runway configuration of the UAE airports to better accommodate arrival/departure patterns and integrate arrival and departure management.

Runways and terminal manoeuvring area at major hub airports, such as OMAA, OMDB, and OMDW are expected to be most in need of these improvements. The infrastructure for RNAV/RNP routes need to be in place as an enabler to this functionality.

Category	Priority	Item	Related ASBU	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035

Category	Priority	Item	Related ASBU		2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Time-based separation	*Low*	Integrated AMAN/ DMAN	RSEQ: Runway sequencing	B2-RSEQ										

6.2.1.3 B2-SURF: Optimized survace routing and safety benefits and enhanced safety and efficiency of surface operations

The UAE airports are expected to improve efficiency and reduce the environmental impact of surface operations, including during periods of low visibility. Queuing for departure runways should be reduced to the minimum necessary to optimise runway use and taxi times should also be minimised. Overall airside airport operations will be improved so that low visibility conditions have only a minor effect on surface movement. These capabilities should be supported by the deployment of A-SMGCS levels 3-4 and Synthetic Vision Systems (SVS), further enhanced through runway safety alerting logic (SURF-IA) provided through on-board aircraft equipment.

These improvements will be most applicable to the main UAE airports, namely OMAA, OMDB, and OMDW, as the upgrades address issues surrounding queuing and management and complex aerodrome operations. As all these airports tend to have high number of days with Low Visibility Operations (LVOs), the priority is set to high.

Category	Priority	Item	Related ASBU		2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
A--SMGCS	*High*	A-SGMCS level 3-4, SVS	SURF: Surface operations	B2-SURF										

6.2.2 Globally interoperable systems and data

6.2.2.1 B2-FICE: Improved coordination through multicentre ground-ground integration

The UAE should implement advanced FF-ICE applications that will support trajectory-based operations through exchange and distribution of information, including execution phase for multi-centre operations using flight object implementation and interoperability (IOP) standards. FF-ICE would be extended to use also after departure, supporting trajectory-based operations. To achieve this, new system interoperability ICAO SARPs would need to be defined to support the sharing of ATM services, involving more than two ATS units.

Category	Priority	Item	Related ASBU		2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Enhanced system automation and decision support tools	*High*	Collaborative flight and flow information	FICE: FF-ICE	B2-FICE										

6.2.2.2 B2-SWIM: Enabling airborne participation in collaborative ATM through SWIM

The airborne participation in collaborative ATM through SWIM would allow aircraft to be fully connected as an information node in SWIM, enabling full participation in collaborative ATM processes with exchange of data, including meteorological information. This enhancement should start with non-safety critical exchanges, supported by commercial datalinks.

Category	Priority	Item	Related ASBU	2026	2027	2028	2029	2030	2031	2032	2033

Category	Priority	Item	Related ASBU		2026	2027	2028	2029	2030	2031	2032	2033
Enhanced system automation and decision support tools	*Low*	Initial SWIM applications	SWIM: System Wide Information Management	B2-SWIM								

6.2.3 Optimum capacity and flexible flights

The ACAS (airborne collision avoidance systems improvements) ASBU module is not considered within this IAMP, as this is unrelated to the CNS/ATM infrastructure.

6.2.3.1 B2-NOPS: Increased user involvement in the dynamic utilization of the network

As part of an enhanced CDM application that would be supported by SWIM, airspace users should be able to manage competition and prioritization of complex ATFM solutions when the network or its nodes (airports, sectors) no longer provide capacity commensurate with user demands. This would further develop the CDM applications by which ATM will be able to offer/delegate to the users the optimisation of solutions to flow problems. Benefits would include an improvement in the use of available capacity and optimised airline operations in degraded situations.

Category	Priority	Item	Related ASBU		2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
ATFM	*High*	Regional view	NOPS: Network operations	B2-NOPS										

6.2.3.2 B2-ASEP: Airborne separation

Airborne separation (ASEP) is defined as a creation of operational benefits through temporary delegation of responsibility to the flight deck for separation provision with suitably equipped designated aircraft. This measure is expected to reduce the need for conflict resolution clearances, while reducing ATCO workload and enabling more efficient flight profiles. The flight crew would ensure separation from suitably equipped designated aircraft as communicated in new clearances, which would relieve the ATCO of the responsibility for separation between these aircraft. However, the ATCO would retain responsibility for separation from those aircraft that are not part of these clearances.

As this concept is not mature enough yet, a comprehensive safety case has not been performed. In addition, the impact on airspace capacity is still to be assessed in case of delegation of separation for a particular situation, implying new regulation on airborne equipment and equipage roles and responsibilities (e.g. to cover new procedures and training). First applications of ASEP are envisaged in Oceanic airspace and in approach for closely-spaced parallel runways, such as the runways at OMDB.

Category	Priority	Item	Related ASBU		2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
ANS provision	*Low*	Interval management	ASEP: Air traffic situational awareness	B2-ASEP										

6.2.4 Efficient flight path

6.2.4.1 B2-CDO: Improved flexibility and efficiency in descent profiles using VNAV, required speed and time at arrival

A key emphasis in further enhancing the OPDs would be on the use of arrival procedures that allow the aircraft to apply little or no throttle in areas where traffic levels would otherwise prohibit this operation. Airspace complexity, air traffic workload, and procedure design would need to be considered to enable optimised arrivals in dense airspace.

Category	Priority	Item	Related ASBU		2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
CDO	High	CDO with VNAV	CDO	B2-CDO										

6.2.4.2 B2-RPAS: Remotely piloted aircraft integration in traffic

The UAE should continue to improve the RPAS' access to non-segregated airspace and continue improving the RPAS approval/certification process. RPAS operational procedures should also be refined to reflect the current and near-future operating environment, including communication performance requirements, standardizing the lost command and control (C2) link procedures, agreeing on a unique squawk code for lost C2 link, and working on detect and avoid technologies. RPAS should include ADS-B to fully integrate into the airspace.

Category	Priority	Item	Related ASBU		2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
RPAS	High	Full RPAS integration	RPAS	B2-RPAS										

6.3 Timeframe – TF3

6.3.1 Airport Operations

6.3.1.1 B3-RSEQ: Integration of AMAN/DMAN/SMAN

The UAE should deploy a fully synchronized network management between departure airports and arrival airports for all aircraft in the air traffic system at any given point in time, namely for the runways and terminal manoeuvring areas of major hub airports in the UAE. This would further support the enhanced ATFM system deployed as part of B3-NOPS.

Category	Priority	Item	Related ASBU		2036	2037	2038	2039	2040
Time-based separation	*Low*	Integrated AMAN/DMAN	RSEQ: Runway sequencing	B3-RSEQ					

6.3.2 Globally interoperable systems and data

6.3.2.1 B3-FICE: Improved operational performance through the introduction of full FF-ICE

Data for all relevant flights should be systematically shared between the air and ground systems using SWIM in support of collaborative ATM and trajectory-based operations.

Category	Priority	Item	Related ASBU		2036	2037	2038	2039	2040
Enhanced system automation and decision support tools	*High*	Collaborative flight and flow information	FICE: FF-ICE	B3-FICE					

6.3.2.2 B3-AMET: Enhanced operational decisions through integrated information (near-term and immediate service)

The UAE should build upon the initial information integration concept and capabilities developed under B1-AMET. Key points to develop are:

- Tactical avoidance of hazardous meteorological conditions, particularly in the 0-20 min. timeframe;
- Greater use of aircraft-based capabilities to detect meteorological parameters (e.g. turbulence, winds, or humidity); and
- Display of meteorological information to enhance situational awareness.

These developments would be applicable to air traffic flow planning, en-route operations, terminal operations (arrival/departure) and ground control. Aircraft equipage is assumed in the areas of ADS-B IN/CDTI, aircraft-based meteorological observations, and meteorological information display capabilities, such as EFBs.

Category	Priority	Item	Related ASBU		2036	2037	2038	2039	2040
ANS provision	*High*	Integration of MET data	AMET: Meteorological information	B3-AMET					

6.3.3 Optimum capacity and flexible flights

6.3.3.1 B3-NOPS: Traffic complexity management

The UAE should introduce complexity management to address events and phenomena that affect traffic flows due to physical limitations, economic reasons or particular events and conditions by exploiting the more accurate and rich information environment of SWIM-based ATM. Benefits will include optimised usage and efficiency of system capacity.

This application would be particularly beneficial to the UAE, as the benefits are expected to be mainly useful in higher density airspace. At the same time, however, the benefits would be largely dependent on the geographical size of the application, which would in this case require regional or, at least GCC sub-regional implementation.

Category	Priority	Item	Related ASBU		2036	2037	2038	2039	2040
ATFM	*High*	Regional view	NOPS: Network operations	B3-NOPS					

6.3.4 Efficient flight path

6.3.4.1 B3-TBO: Full 4D trajectory-based operations

The UAE should implement advanced concepts and technologies, supporting four-dimensional trajectories (i.e. comprising of latitude, longitude, altitude, and time) and velocity to enhance global ATM decision making. A key emphasis will be on integrating all flight information to obtain the most accurate trajectory model for ground automation.

This module would be applicable to air traffic flow planning, en-route operations, terminal operations (approach/departure), and arrival operations. Benefits would accrue to both flows and individual aircraft.

Aircraft equipage is assumed in the areas of ADS-B IN/CDTI, data communication, and advanced navigation capabilities. Benefits from deployment would increase with the size of equipped aircraft population in the area where the services are provided.

Category	Priority	Item	Related ASBU		2036	2037	2038	2039	2040
RNP	*Low*	4D trajectories	TBO: Trajectory based operations	B3-TBO					

6.3.4.2 B3-RPAS: Remotely piloted aircraft transparent management

The UAE should continue to improve the certification process for RPAS in all classes of airspace, working on developing a reliable command and control (C2) link, developing and certifying airborne detect and avoid (ABDAA) algorithms for collision avoidance, and integrating RPAS into aerodrome procedures. This would apply to all RPAS operating in non-segregated airspace and at aerodromes.

Category	Priority	Item	Related ASBU		2036	2037	2038	2039	2040
RPAS	High	Full RPAS integration	RPAS	B3-RPAS					

7. TRANSITION ROADMAP

In the 2020-2040 time, the level of change that needs to be implemented is based on a culmination of the performance requirements of the period and the elements that need to be phased out, upgraded or introduced relative to the changes introduced before 2020. The interdependencies between each ATM or CNS element need to be addressed to ensure changes are made in a consistent, cost-effective manner, and align with the operational requirements of Section 2 and the KPAs of Section 3.

It is apparent that there is a need to move towards a full implementation of the 'highway in the sky' concept and the major changes expected will be related to airspace change, runway additions and optimisation of operating processes, networks and systems. As for the CNS/ATM infrastructure, the implementation and deployment of ATM technologies in the UAE could see potential alignment with the technological pillar of the Single European Sky (SES), the SES ATM Research and Development programme (SESAR), while maintaining full compliance with the ICAO ASBU framework.

Commission Implementing Regulation (EU) No 716/2014 sets out the Pilot Common Project (PCP), which supports the implementation of the European ATM Master Plan up to 2030 in a timely and coordinated manner. The PCP identifies six ATM functionalities, of which four are particularly relevant for the restructuring of UAE airspace from 2020-2040. As such, there is the possibility that the restructuring of UAE airspace during these three timeframes could capitalise on the ATM concepts and implementation timelines set out in the European model. Those ATM functionalities that are particularly relevant in this regard are described in the relevant timeframes in the subsequent sections.

This section summarises the design enablers that drive the transition for each timeframe. The high-level implementation roadmap covering all three timeframes is provided in Appendix A.

7.1 Timeframe – TF1

7.1.1 Airspace structure and design

'Highways in the sky concept' (two separated traffic patterns) to improve overall operational efficiency in traffic management to/from OMDB, OMDW and OMAA airports is proposed to be implemented. This would require agreement with military units to obtain airspace delegation.

SIDs/STARs to and from OMDW to support implementation of new runway should be reviewed. This would requires reshaping/reviewing of nearby airspace under military authority and review of Abu Dhabi CTA airspace to accommodate this new design.

Dubai CTA sectors should also be reviewed to manage three runways. This activity would require reshaping Dubai CTA approach sectors and implementation of new control centres according to ICAO SOIR provisions.

Appropriate operating procedures against ATM regulatory requirements would also need to be developed. The implementation will only be able to go ahead if a well-defined safety case to identify risks, quantify impacts, rank risks and identify possible mitigation strategies is conducted and its outcome is positive. An effective post-implementation monitoring of safety via appropriate methodologies (e.g. potential alignment with the Single European Sky model for setting targets on safety, via Effectiveness of Safety Management, Risk Analysis Tool, and promoting just culture) should be established.

7.1.2 ATM automation and standardisation

The ATM system should be upgraded to support the new approach control unit. Hence, the procurement, staffing and operational costs need to be considered in advance.

The implementation of FUA would result in the following system requirements:

- Implementation of an airspace management support tool will be a prerequisite for the implementation of advanced FUA;
- FUA needs to be published in the UAE AIP;
- Flight data processing systems and flight planning systems will need to be updated; and
- An appropriate training for ATCOs to support these new operational environments would need to take place.

7.1.3 Civil-military cooperation and international agreements

The FUA should be implemented to better use UAE airspace for both military and civilian airspace users' needs. FUA is expected to bring significant benefits to the UAE stakeholders in terms of flight efficiency, capacity and environment up to 2040. Furthermore, the implementation of flexible airspace management will allow operations that require segregation, for example military training, to take place safely and flexibly, with minimum impact on other airspace users.

The implementation of FUA would require civilian-military coordination and a defined contact point between civilian and military entities to disseminate information and procedures clearly and in a timely manner, e.g. 24-hour notice by the military to provide best planning of flight operations. The implementation of FUA will also require a review of airways classification, i.e. the CDR concept, as well as adequate staff training under a national framework agreement.

CDM capabilities and processes should be established for exchanging strategic and tactical information and decision-making between the ANSPs and stakeholders, including airport operators. High-level agreements and plans should be developed that would result in transition to integrated civil-military airspace management.

In addition, the cross-border relations need to be strengthened, e.g. interface with Iran concerning ALRAR waypoint. This would require regional coordination with Iran, i.e. bilateral agreements and defined points of contact between the UAE and Iran, appropriate forms of regulation to ensure standaridsation of interoperability requirements, and improved information sharing and management between the stakeholders.

7.2 Timeframe – TF2

7.2.1 Airspapce structure and design

SIDs and STARs within the Dubai CTA should be reviewed to manage four runways at OMDW. Appropriate operating procedures, safety case and training modules will be required to implement simultaneous operations at OMDW. Additional staffing and upgrade of the ATM system may be required for the approach control unit. The implementation of the concept requires an upgrade of the existing ATM regulatory framework.

Best practices for wake turbulence standards and separation minima for major airports with substantial heavy and super aircraft operations (e.g. OMDB) would also need to be developed. Operational procedures and agreements to allow the transfer of aircraft from operational sectors that have reached traffic saturation levels would need to be revised.

Abu Dhabi CTA sectors organisation should also be reviewed. This would requires the re-shaping/reviewing of nearby airspace under the responsibility of the military authority. To this end, the current airspace and its limitations need to be understood, and opportunities for further improvements in line with performance requirements and infrastructural upgrades within this timeframe recognised.
Transition to full PBN airspace should be accommodated to support increasing traffic demand. Based on SESAR, the European implementation deadline for PBN is 1 January 2024. Therefore, it is likely that full PBN in the UAE will be implemented in the latter part of TF2.

7.2.2 ATM automation and standardisation

It is expected that a regional ATFM service will be implemented – according to the foreseen ICAO airspace harmonization and interoperability plan, it is highly recommended that UAE and nearby States consider the implementation of ATFM, as also recognised by the GCC UFIR initiative for this timeline.

The introduction of an ATFM service would require dedicated operational personnel at major ANSP facilities. Personnel involved in ATFM activities would be required to aware of the relevant provisions and should be adequately trained and competent for their job functions. Staff working methods and operating procedures will need to comply with an appropriate regulatory framework devised by the GCAA.

The UAE with other participating States would need to ensure that all parties with responsibilities for ATFM functions develop and maintain operational manuals containing all necessary instructions and information to operate the ATFM system.

The participating States would need to ensure that a safety assessment, including hazard identification, risk assessment and mitigation, is conducted, before any ATFM systems and procedures are introduced, including an assessment of a safety-management process addressing the complete lifecycle of the ATM and ATFM system.

In addition, extended AMAN should be implemented, together with the PBN in high-density terminal manoeuvring areas. Extended AMAN would aim to improve the precision of the approach trajectory and facilitate air traffic sequencing at an earlier stage. This would include the extension of the planning horizon out to a minimum of 180-200 nautical miles.

PBN in high-density TMAs would cover the development and implementation of fuel efficient and/or environmental-friendly procedures for arrivals and departures, such as RNP 1 SIDs, STARs and RNP APCH. This could be particularly beneficial in airports with high anticipated growth, such as OMDB/OMDW and OMAA. As part of this, the system requirements would include the following:

- Data exchange, data processing, and information display at the relevant ATCO working positions in the ATS units shall support the management of arrival constrains; and
- Data exchange between ATS units may be achieved with existing technology, pending the implementation of SWIM.

SWIM supports the development of services for information exchange and comprises standards, infrastructure and governance that enables the management and its exchange between operational stakeholders via interoperable services. This will be particularly relevant for the airspace restructuring programme in the UAE, given the high degree of cross-border initiatives that will have to take place to support the implementation of new technologies to meet performance requirements across the region. As part of this, the SWIM system requirements would include the following:

- A registry, for publication of information regarding service consumers and providers, business, technical and policy information;
- Public Key Infrastructure (PKI), used for signing, emitting and maintaining certifications, to ensure that information can be securely transferred;
- ATM systems need to be able to use the aeronautical, flight information and meteorological information exchange systems; and
- A centralised system to support operational stakeholders in exchanging data electronically would need to be implemented.

7.2.3 Civil-military cooperation and international agreements

The regional ATFM service should be implemented, which would require regional coordination with surrounding States. It would also require a regulatory framework to lay down the common rules for ATFM implementation, and its interoperability between the participating States and, if possible, also with the neighbouring regions.

7.3 Timeframe – TF3

7.3.1 Airspace structure and design

SIDs and STARs to and from OMDW should be reviewed to enable the implementation of the fifth runway. Therefore, the use of restricted airspace should be revised to optimise airspace operations in the central part of the lower UAE airspace. In this long-term vision, OMDW may usefully represent the main gateway to the UAE, linked to terrestrial transportation networks.

7.3.2 ATM automation and standardisation

The FRA concept should be implemented. This would require a regional programme addressing airspace design and coordination, as well as the upgrade of the ATM systems (e.g. enhanced interoperability and data exchange). Procurement costs for new systems need to be considered in advance.

Procedures for transitioning between free and fixed route operations need to be set. Initial implementation of FRA may be done on a structurally limited basis, for example by restricting the available entry/exit points for certain traffic flows, through the publication of DCTs, which will allow airspace users to file a flight plan on the basis of those published DCTs.

The implementation of FRA may also require new sectorizations to better accommodate new traffic flows. Additional ATCO support tools, e.g. Tactical Controller Tool (TCT), may need to be developed and implemented to reduce ATCO workload.

ATM system requirements for FRA would include the need to review and update flight data processing systems, flight planning systems, and setting up the appropriate Medium-Term Conflict Detection (MTCD) methods, including Conflict Detection Tools (CDT) and Conflict Resolution Assistant (CORA).

Airspace users will need to implement flight planning systems to manage dynamic sector configuration and FRA. In addition, appropriate training for ATCOs to support these new operational environments would need to take place.

The initial trajectory information sharing should be implemented. This would consist of the improved use of target times and trajectory information including, where available, the use of on-board 4D trajectory data by the ground ATC system, thereby implying fewer tactical interventions and improved de-confliction situations.

A datalink regional implementation plan across the UAE does not exist for the short term. However, the airspace capacity issue might bring about the need for datalink communications. There is evidence that ANSPs in the UAE are not willing to implement datalink capabilities on their own, but they would not be against joint, regionally-coordinated implementation (e.g. as part of the GCC UFIR initiative).

Regional airports such as Sharjah, Al Bateen and Al Ain are rapidly expanding, and are expected to continue to do so up until 2040. This may potentially lead to greater communication and surveillance coverage issues. In the UAE, there are plans for the Common Regional VPN (CRV), the regional IP network, to be deployed, which provides the opportunity to introduce datalink services and initial trajectory information sharing capabilities.

7.3.3 Civil-military cooperation and international agreements

The implementation of FRA concept would require the implementation of new ATC tools, operating procedures, and staff training. This needs to be coordinated with the military stakeholders, as the efficiency benefits will only be achieved if FRA is deployed over large areas and appropriated measures are taken so that aerodromes do not become bottlenecks.

FRA would need to be implemented gradually rather than a single act, to reduce safety risks. The UAE might consider starting with limited implementation, e.g. during night hours, before gradually expanding it. Also, if the FRA concept is applied on a regional or sub-regional basis, e.g. as proposed by the GCC UFIR initiative, enhanced (system supported) cross-border coordination between ANSPs would be required.

Detailed analysis of ANSPs' operational needs across the UAE through 2040 would need to be performed and a plan to meet those needs with optimum effectiveness and efficiency developed. The outcomes should be summarised in a plan to manage UAE ANS provision that is seamless from a stakeholder perspective, including requirements, system capabilities, and coordination.

Such studies may also consider the potential for a single ANSP unit across the UAE. Having a single centralised ANSP offers UAE airspace the ability to effectively coordinate movements, with full responsibility for the region, control to execute decisions, and the ability to deploy rapid short-term measures in an unforeseen event. Through seamless communication and tracking, cross-border flight trajectories can be optimised to reduce track distances and network delays.

A review of airspace boundaries and responsibilities within the UAE FIR should also take place. The efficiency of airspace operations may benefit from the different allocation of responsibility in the provision of ANS among all ANSPs. This would require an integration and harmonisation process involving airspace design, systems and procedures.

Category	Item	Related ASBU	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
FUA	FUA within all UAE airspace	B1-FRTO																				
Network evolution	Duplication of airway M318 from ATUDO until FIR boundary with KSA	B1-FRTO																				
	Duplication of airway G783 from a TBD waypoint over UM628 up to ALN	B1-FRTO																				
	Revision of interface with Iran over GONVI waypoint	B1-FRTO																				
	Revision of SIDs/STARs from/to OMDW to implement three RWYs operations	B1-APTA																				

Category	Item	Related ASBU	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
	Revision of SIDs/STARs from/to OMAL to implement two RWYs operations	B1-APTA																				
	Revision of SIDs/STARs from/to OMDW to implement four RWYs operations	B1-APTA																				
	Revision of SIDs/STARs from/to OMAA to implement three RWYs operations	B1-APTA																				
	Revision of SIDs/STARs from/to OMDW to implement five RWYs operations	B1-APTA																				
	Revision of SIDs/STARs from/to OMAA to implement four RWYs operations	B1-APTA																				

Category	Item	Related ASBU	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
APP control evolution	Rationalisation of approach control functions within UAE lower airspace	-																				
PBN	Arrival/departure procedure adjustment	B1-APTA																				
	RNAV 1 beyond major routes to support Middle East	B1-APTA																				
	En-route RNP	B0-TBO																				
	4D trajectory data-link	B1-TBO																				
	4D trajectories integration	B3-TBO																				
Separation minima	UAE harmonisation and wake separation	B1-WAKE																				
	Conditions-specific time-based separation	B2-WAKE																				

Category	Item	Related ASBU	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
	Full departure, ground, arrival management	B1-RSEQ																				
	Integrated AMAN/DMAN	B2-RSEQ																				
	Integrated AMAN/DMAN/SMAN	B3-RSEQ																				
A-SMGCS	Enhanced safety and efficiency	B1-SURF																				
	A-SGMCS level 3-4, SVS	B2-SURF																				
ATFM	Total A-CDM (major airports)	B1-ACDM																				
	Total A-CDM (regional airports)	B1-ACDM																				
	Basic ATFM system	B0-NOPS																				
	Regional view	B1-NOPS																				
	Regional planning	B2-NOPS																				

Category	Item	Related ASBU	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
	Regional integration	B3-NOPS																				
ANS provision	Remote ATS	B1-RATS																				
	Integration of all digital ATM information (UAE)	B1-DATM																				
	Integration of MET data	B1-AMET																				
	Full integration of MET data	B3-AMET																				
	Interval management	B1-ASEP																				
	Advanced interval management	B2-ASEP																				
	Approach path monitor	B1-SNET																				
Enhanced system	Collaborative flight and flow information	B1-FICE																				

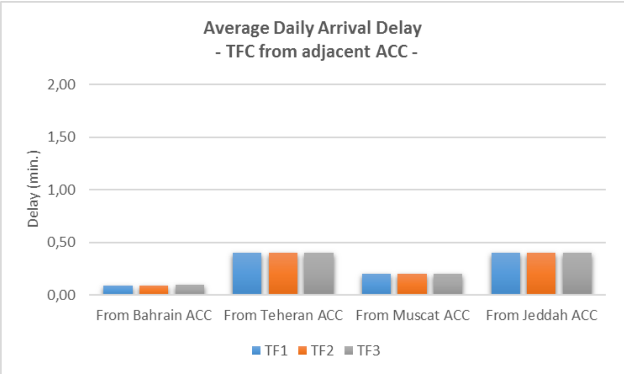
Category	Item	Related ASBU	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
automation and decision support tools	Enhanced collaborative flight and flow information	B2-FICE																				
	Enhanced collaborative flight and flow information	B3-FICE																				
	Initial SWIM applications	B1-SWIM																				
	More advanced SWIM applications	B2-SWIM																				
FRA	Implementation of FRA	B1-FRTO																				
CDO/CCO	CDO with VNAV	B1-CDO																				
	Enhanced CDO with VNAV	B2-CDO																				
RPAS	Initial RPAS integration	B1-RPAS																				
	Enhanced RPAS integration	B2-RPAS																				

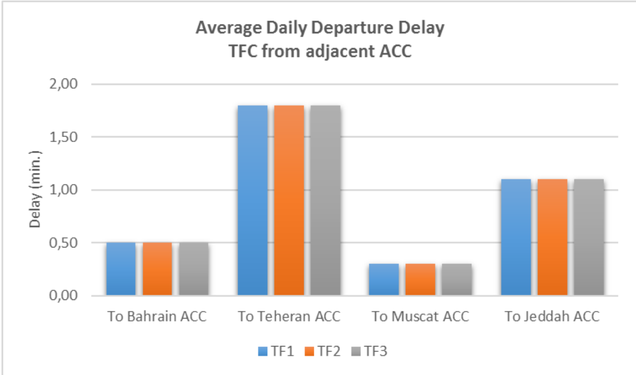
Category	Item	Related ASBU	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
	Full RPAS integration into UTM	B3-RPAS																				

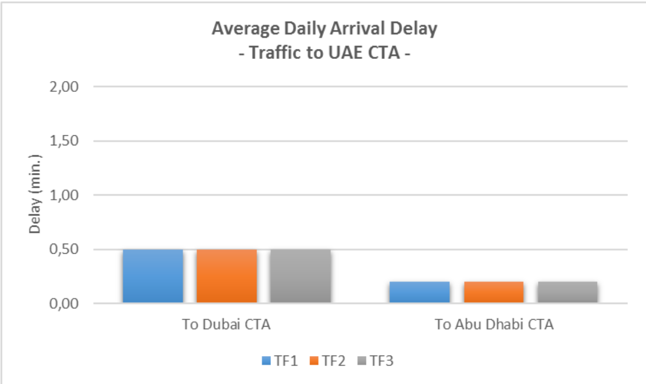
B. APPENDIX B: PERFORMANCE ASSESSMENT RESULTS

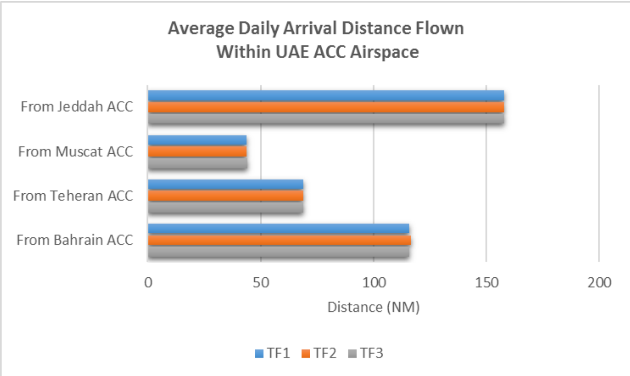
Stream 1: The evolution of the airspace concept assessment

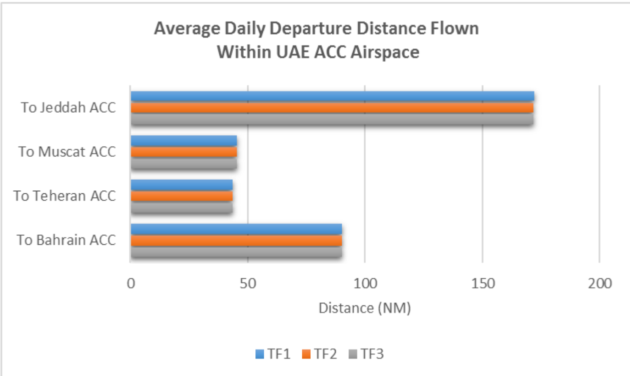
UAE ACC

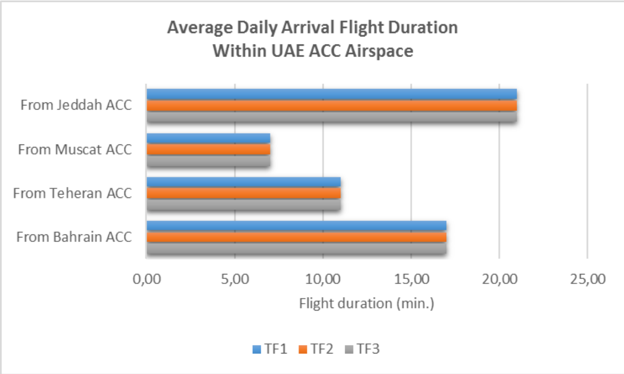


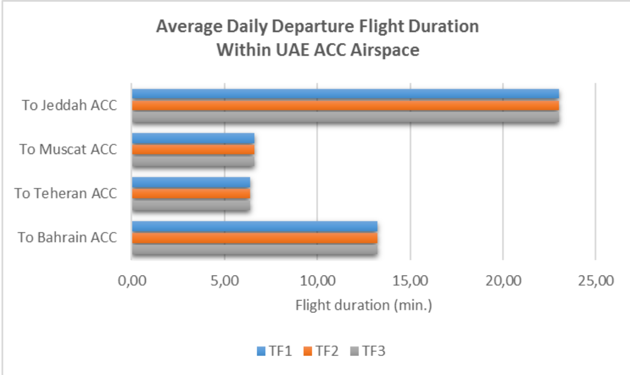


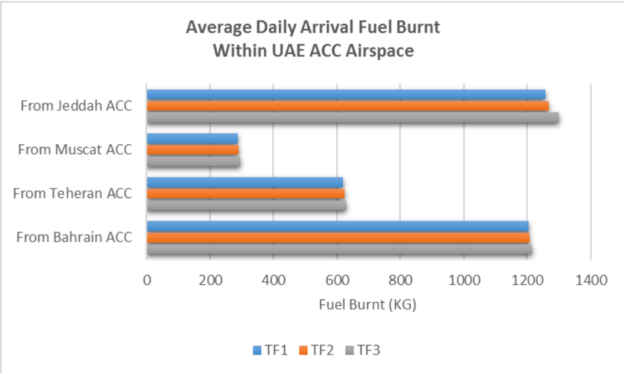


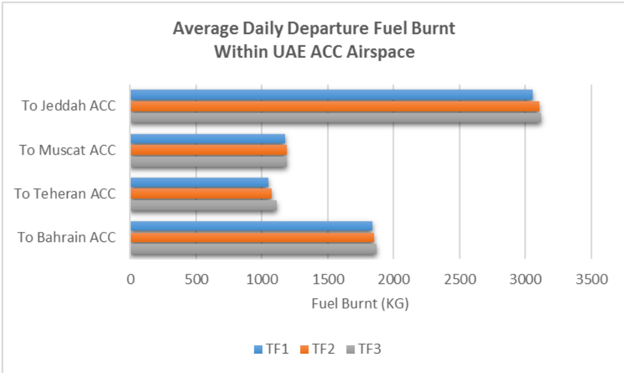




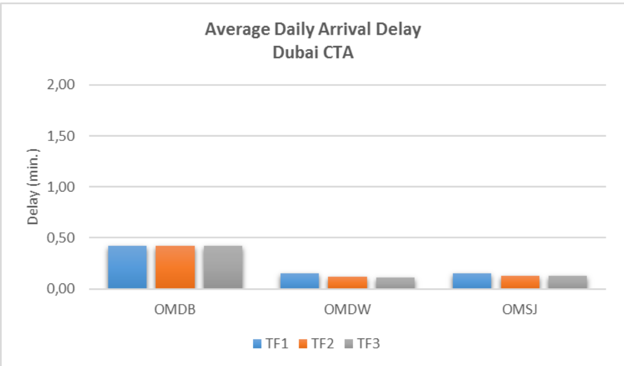


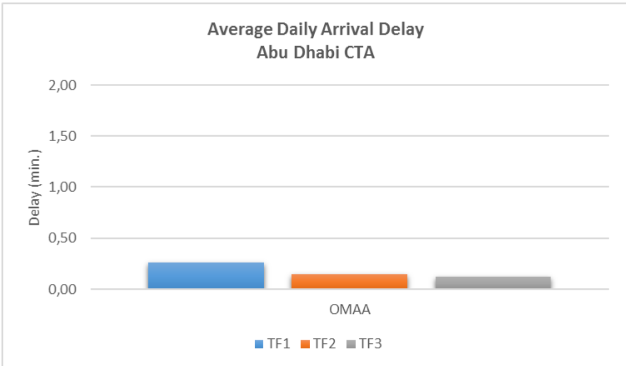


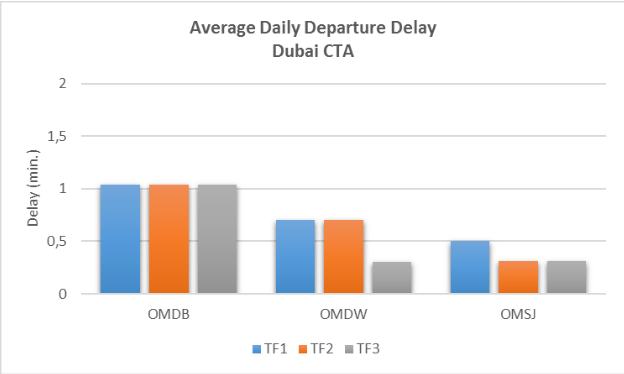


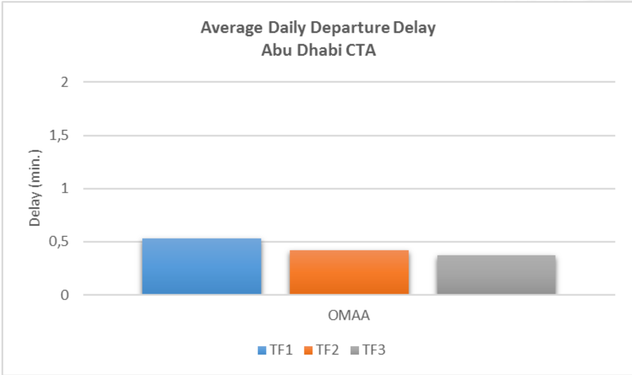


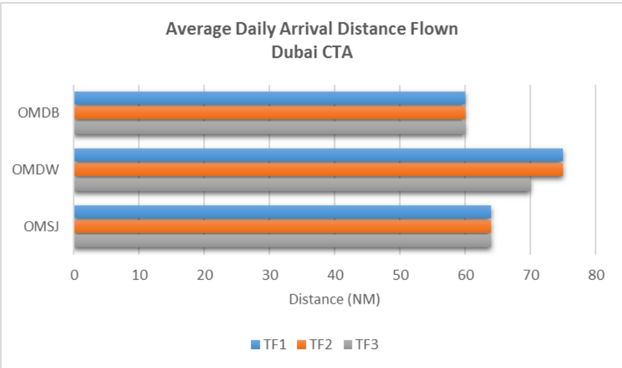
Dubai & Abu Dhabi CTA

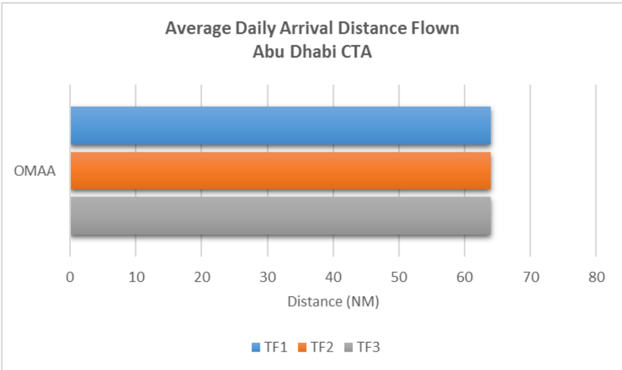


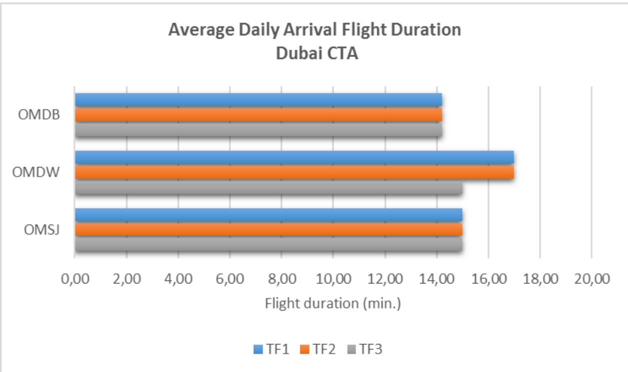


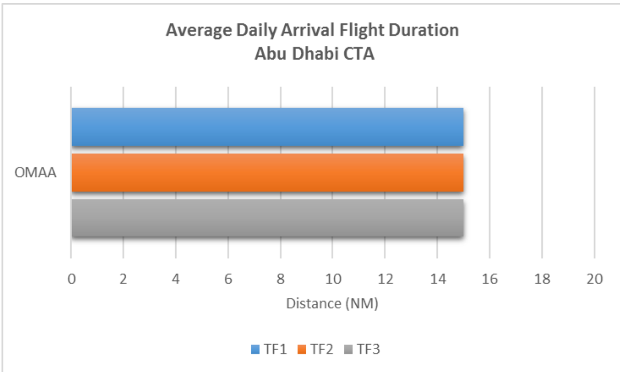

Average Daily Departure Delay
Dubai CTA
Delay (min.)
0
0,5
1
1,5
2
OMDB
OMDW
OMSJ
TF1 TF2 TF3

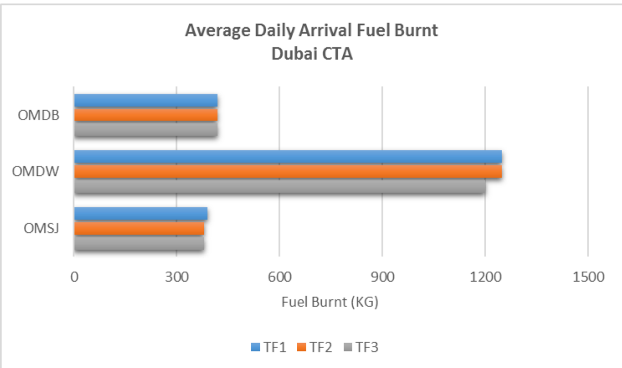

Average Daily Departure Delay
Abu Dhabi CTA
Delay (min.)
0
0,5
1
1,5
2
OMAA
TF1 TF2 TF3

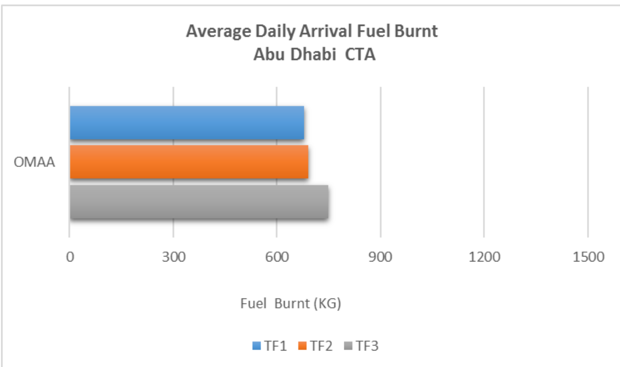

Average Daily Arrival Distance Flown
Dubai CTA
OMDB
OMDW
OMSJ
0 10 20 30 40 50 60 70 80
Distance (NM)
TF1 TF2 TF3

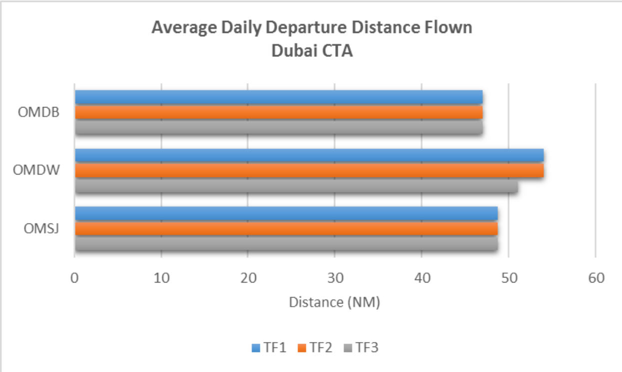

Average Daily Arrival Distance Flown
Abu Dhabi CTA
OMAA
0 10 20 30 40 50 60 70 80
Distance (NM)
TF1 TF2 TF3

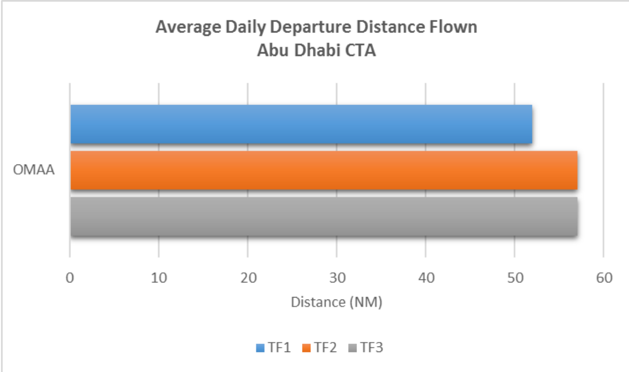

Average Daily Arrival Flight Duration
Dubai CTA
OMDB
OMDW
OMSJ
0,00 2,00 4,00 6,00 8,00 10,00 12,00 14,00 16,00 18,00 20,00
Flight duration (min.)
TF1 TF2 TF3

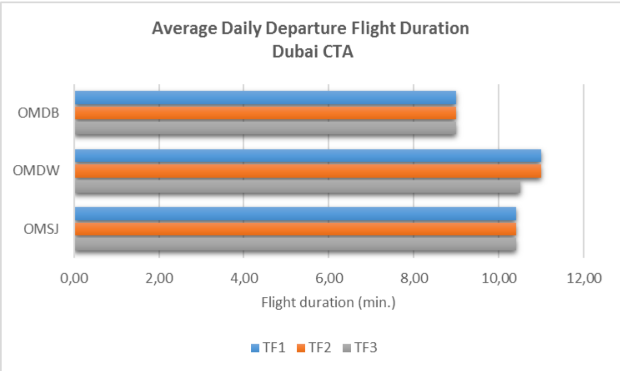

Average Daily Arrival Flight Duration
Abu Dhabi CTA
OMAA
0 2 4 6 8 10 12 14 16 18 20
Distance (NM)
TF1 TF2 TF3

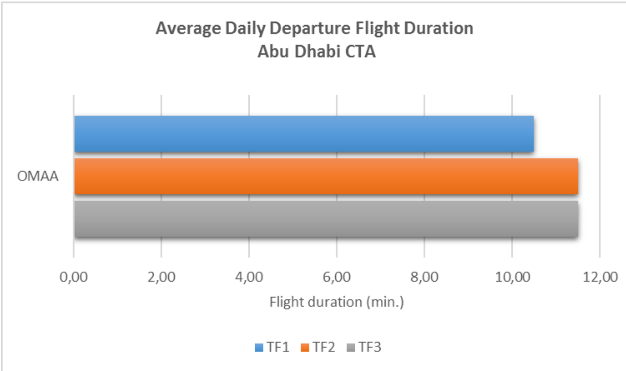

Average Daily Arrival Fuel Burnt
Dubai CTA
OMDB
OMDW
OMSJ
0 300 600 900 1200 1500
Fuel Burnt (KG)
TF1 TF2 TF3

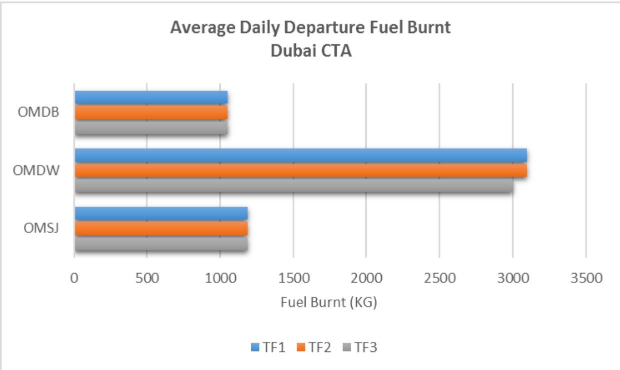

Average Daily Arrival Fuel Burnt
Abu Dhabi CTA
OMAA
0 300 600 900 1200 1500
Fuel Burnt (KG)
TF1 TF2 TF3

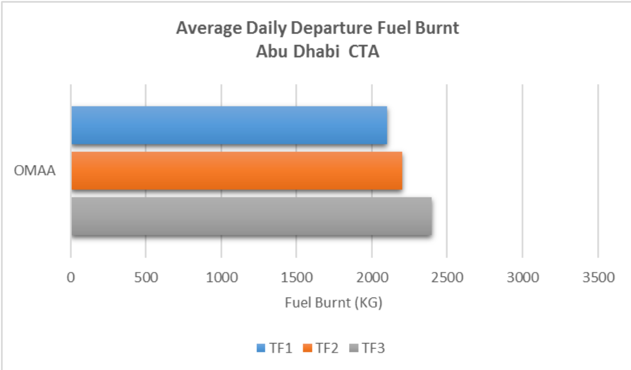






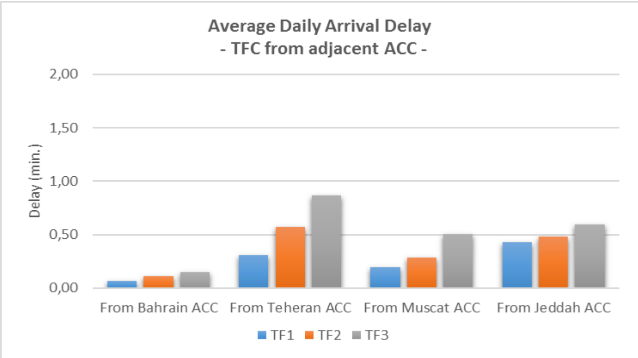


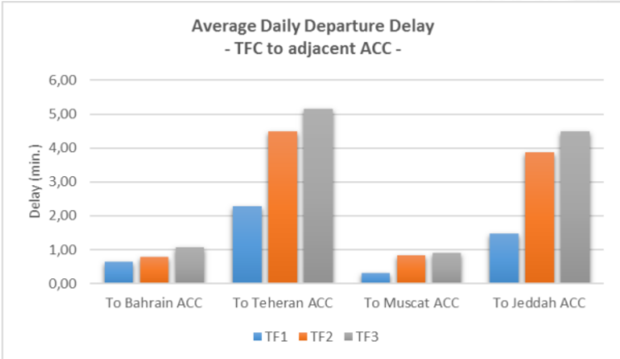


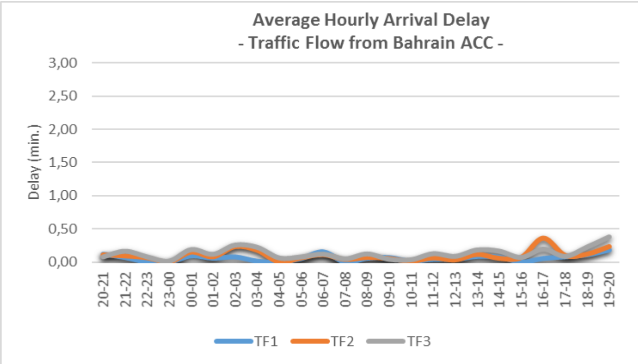


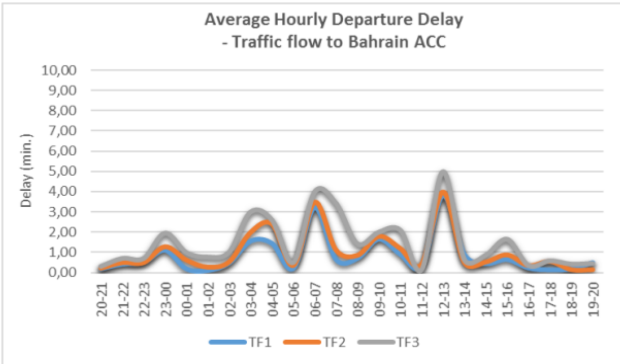
Stream 3: ACC/CTA integrated concept performance analysis

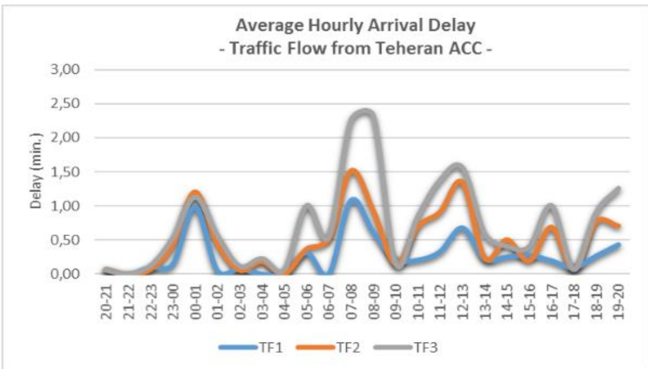
UAE ACC

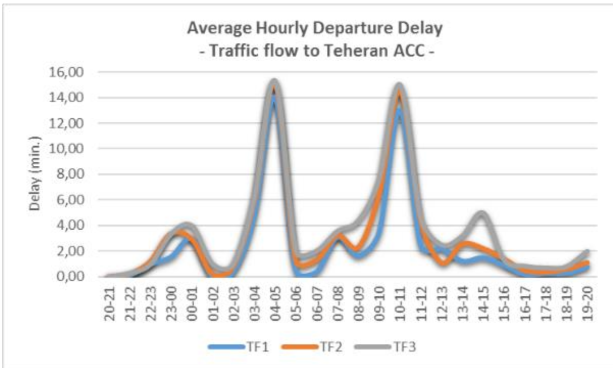

Average Daily Arrival Delay
- TFC from adjacent ACC -
Delay (min.)
From Bahrain ACC
From Teheran ACC
From Muscat ACC
From Jeddah ACC
TF1
TF2
TF3

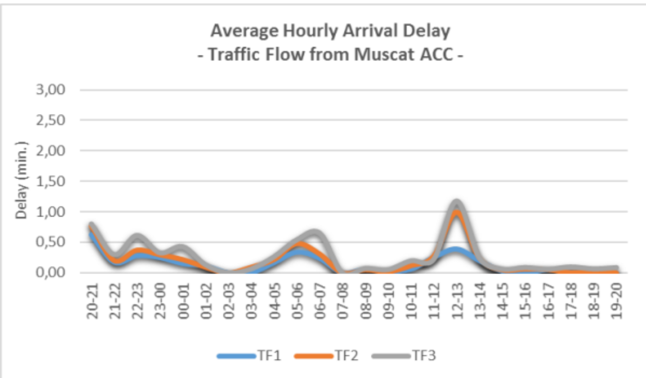

Average Daily Departure Delay
- TFC to adjacent ACC -
Delay (min.)
To Bahrain ACC
To Teheran ACC
To Muscat ACC
To Jeddah ACC
TF1
TF2
TF3

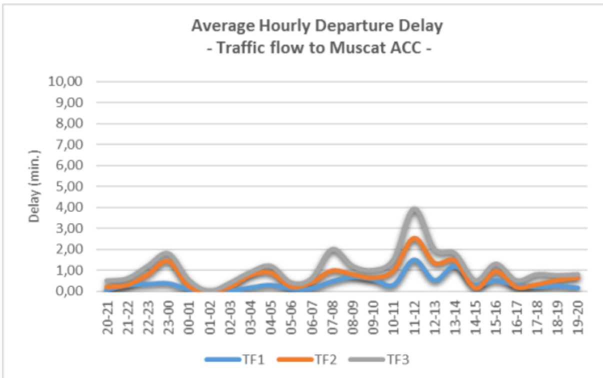

Average Hourly Arrival Delay
- Traffic Flow from Bahrain ACC -
Delay (min.)
TF1
TF2
TF3

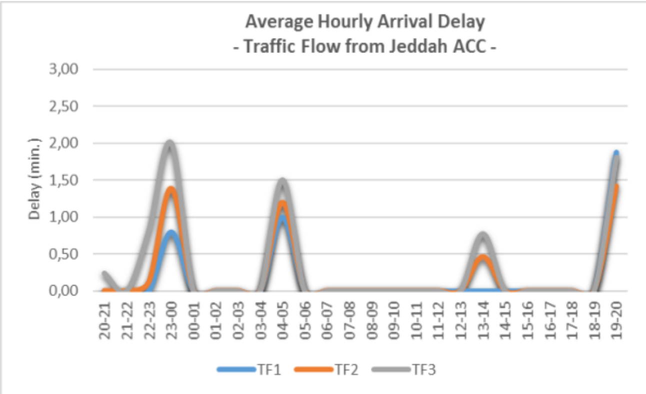

Average Hourly Departure Delay
- Traffic flow to Bahrain ACC
Delay (min.)
TF1
TF2
TF3

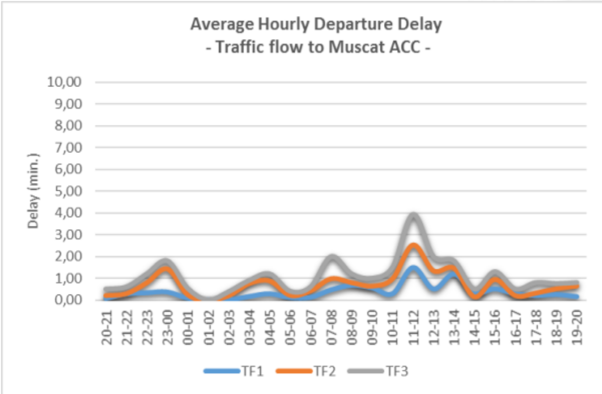

Average Hourly Arrival Delay
- Traffic Flow from Teheran ACC -
Delay (min.)
TF1
TF2
TF3

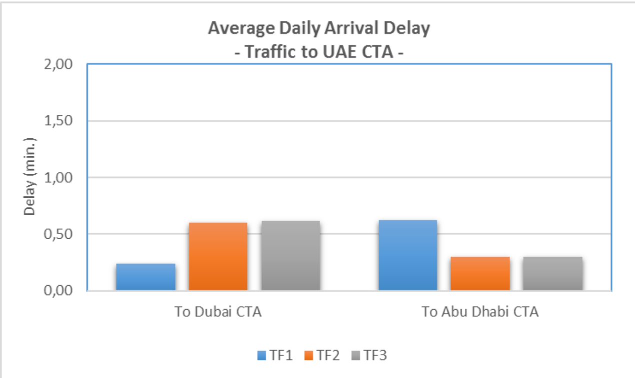

Average Hourly Departure Delay
- Traffic flow to Teheran ACC -
Delay (min.)
TF1
TF2
TF3

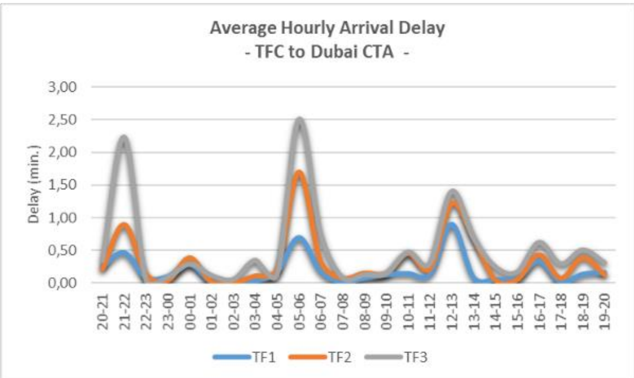

Average Hourly Arrival Delay
- Traffic Flow from Muscat ACC -
Delay (min.)
TF1
TF2
TF3

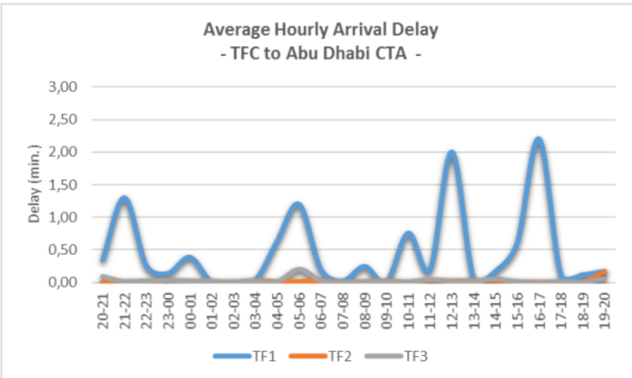

Average Hourly Departure Delay
- Traffic flow to Muscat ACC -
Delay (min.)
TF1
TF2
TF3

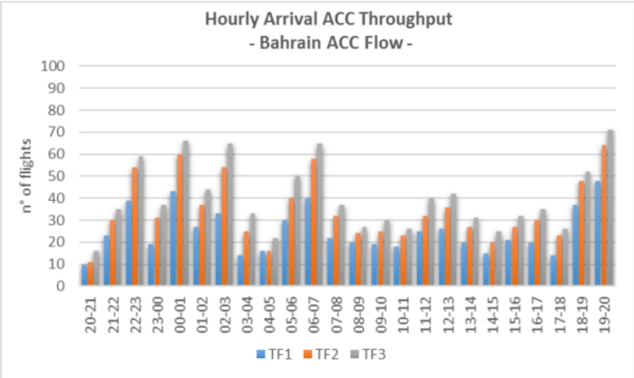

Average Hourly Arrival Delay
- Traffic Flow from Jeddah ACC -
Delay (min.)
3,00
2,50
2,00
1,50
1,00
0,50
0,00
20-21 21-22 22-23 23-00 00-01 01-02 02-03 03-04 04-05 05-06 06-07 07-08 08-09 09-10 10-11 11-12 12-13 13-14 14-15 15-16 16-17 17-18 18-19 19-20
TF1 TF2 TF3

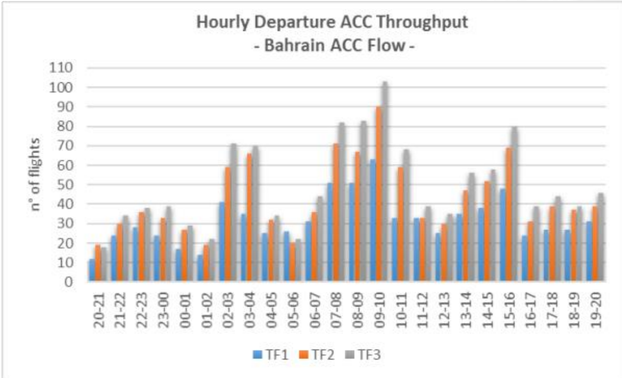

Average Hourly Departure Delay
- Traffic flow to Muscat ACC -
Delay (min.)
10,00
9,00
8,00
7,00
6,00
5,00
4,00
3,00
2,00
1,00
0,00
20-21 21-22 22-23 23-00 00-01 01-02 02-03 03-04 04-05 05-06 06-07 07-08 08-09 09-10 10-11 11-12 12-13 13-14 14-15 15-16 16-17 17-18 18-19 19-20
TF1 TF2 TF3

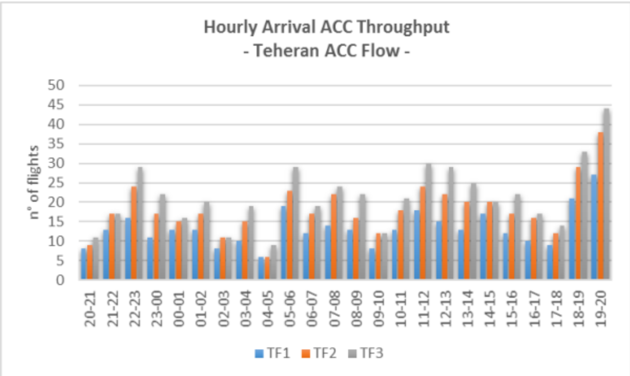

Average Daily Arrival Delay
- Traffic to UAE CTA -
Delay (min.)
2,00
1,50
1,00
0,50
0,00
To Dubai CTA
To Abu Dhabi CTA
TF1 TF2 TF3

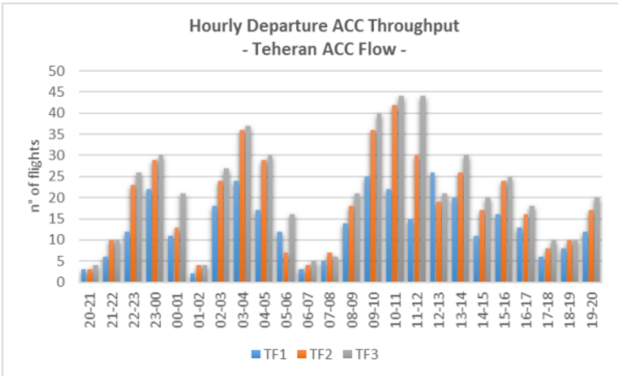

Average Hourly Arrival Delay
- TFC to Dubai CTA -
Delay (min.)
3,00
2,50
2,00
1,50
1,00
0,50
0,00
20-21 21-22 22-23 23-00 00-01 01-02 02-03 03-04 04-05 05-06 06-07 07-08 08-09 09-10 10-11 11-12 12-13 13-14 14-15 15-16 16-17 17-18 18-19 19-20
TF1 TF2 TF3

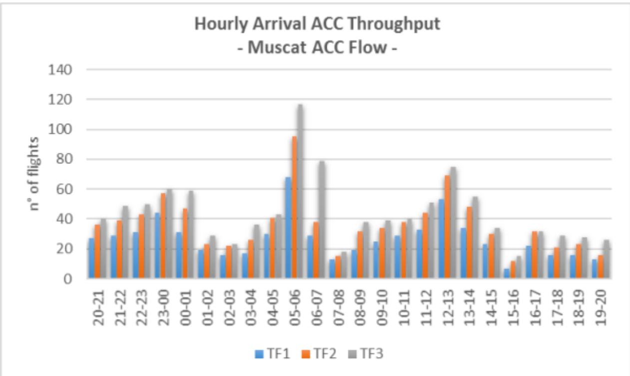

Average Hourly Arrival Delay
- TFC to Abu Dhabi CTA -
Delay (min.)
3,00
2,50
2,00
1,50
1,00
0,50
0,00
20-21 21-22 22-23 23-00 00-01 01-02 02-03 03-04 04-05 05-06 06-07 07-08 08-09 09-10 10-11 11-12 12-13 13-14 14-15 15-16 16-17 17-18 18-19 19-20
TF1 TF2 TF3

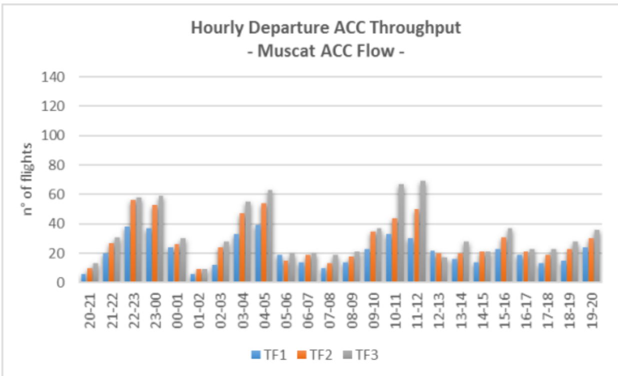

Hourly Arrival ACC Throughput
- Bahrain ACC Flow -
n° of flights
TF1 TF2 TF3

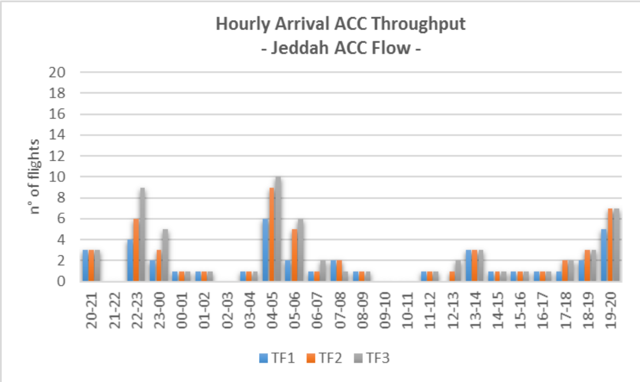

Hourly Departure ACC Throughput
- Bahrain ACC Flow -
n° of flights
TF1 TF2 TF3

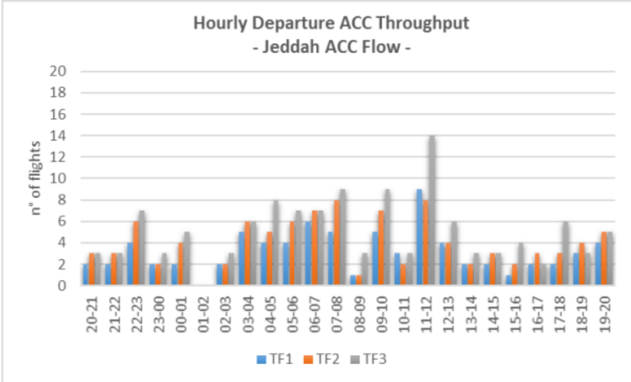

Hourly Arrival ACC Throughput
- Teheran ACC Flow -
n° of flights
TF1 TF2 TF3

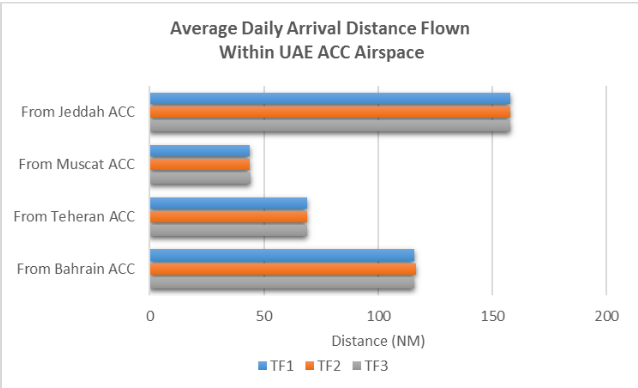

Hourly Departure ACC Throughput
- Teheran ACC Flow -
n° of flights
TF1 TF2 TF3

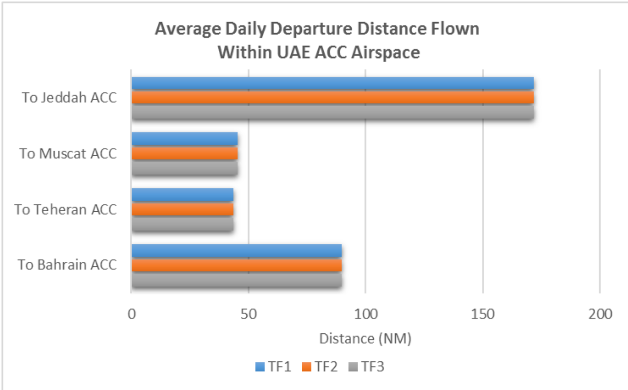

Hourly Arrival ACC Throughput
- Muscat ACC Flow -
n° of flights
TF1 TF2 TF3

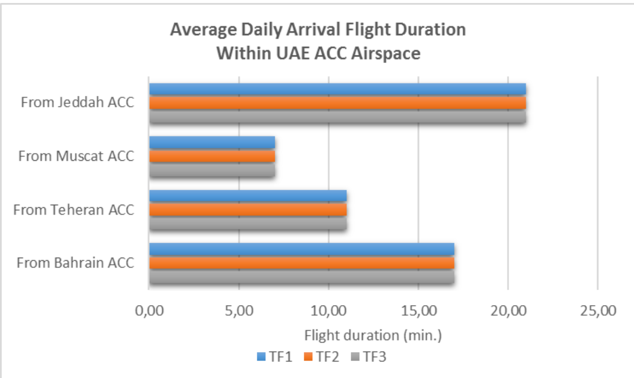

Hourly Departure ACC Throughput
- Muscat ACC Flow -
n° of flights
TF1 TF2 TF3

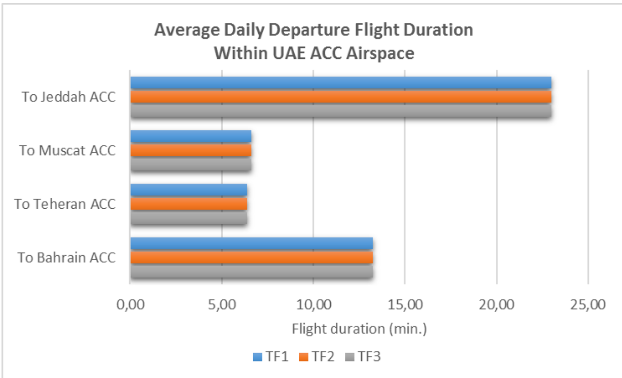

Hourly Arrival ACC Throughput
- Jeddah ACC Flow -
n° of flights
TF1 TF2 TF3

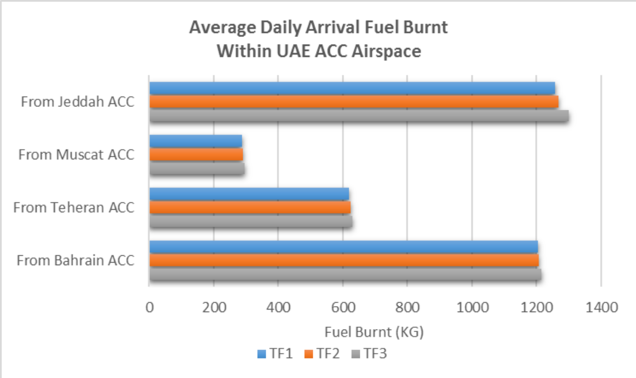

Hourly Departure ACC Throughput
- Jeddah ACC Flow -
n° of flights
TF1 TF2 TF3

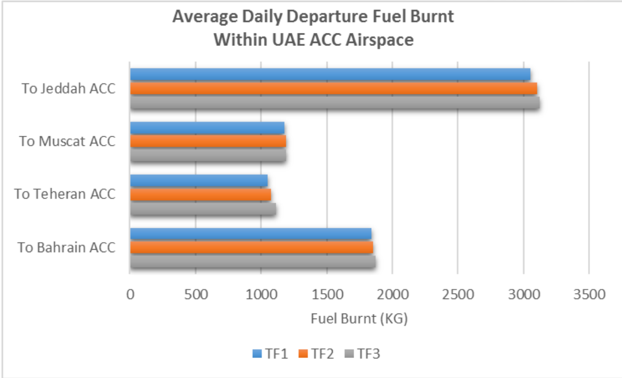

Average Daily Arrival Distance Flown
Within UAE ACC Airspace
From Jeddah ACC
From Muscat ACC
From Teheran ACC
From Bahrain ACC
Distance (NM)
TF1 TF2 TF3


Average Daily Departure Distance Flown
Within UAE ACC Airspace
To Jeddah ACC
To Muscat ACC
To Teheran ACC
To Bahrain ACC
Distance (NM)
TF1 TF2 TF3

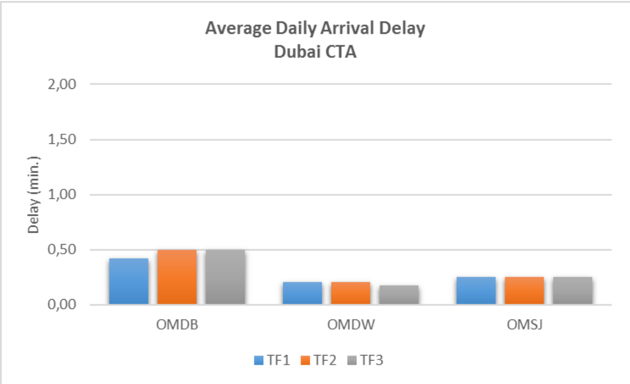

Average Daily Arrival Flight Duration
Within UAE ACC Airspace
From Jeddah ACC
From Muscat ACC
From Teheran ACC
From Bahrain ACC
Flight duration (min.)
TF1 TF2 TF3

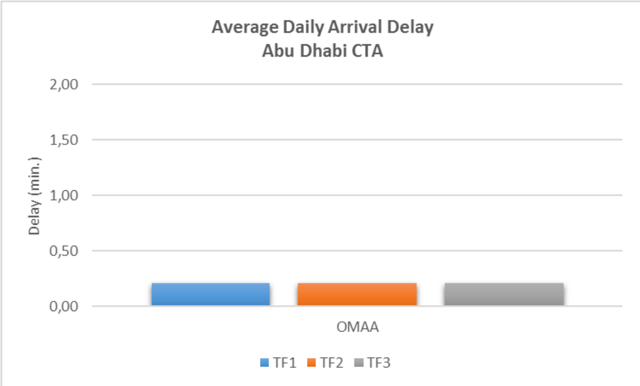

Average Daily Departure Flight Duration
Within UAE ACC Airspace
To Jeddah ACC
To Muscat ACC
To Teheran ACC
To Bahrain ACC
Flight duration (min.)
TF1 TF2 TF3

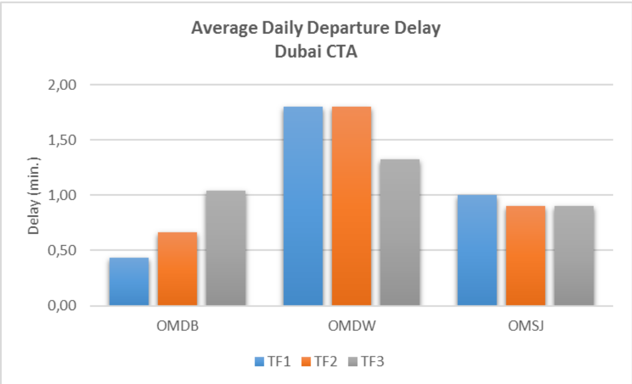


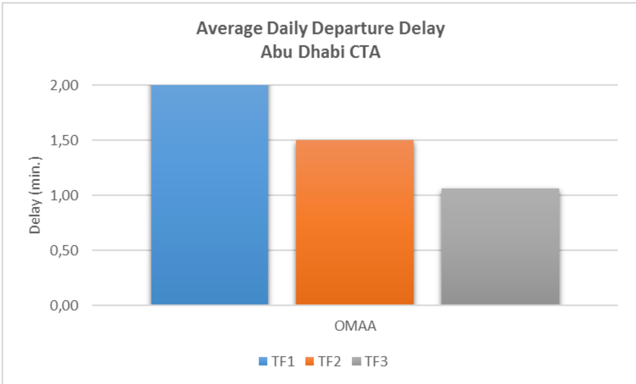


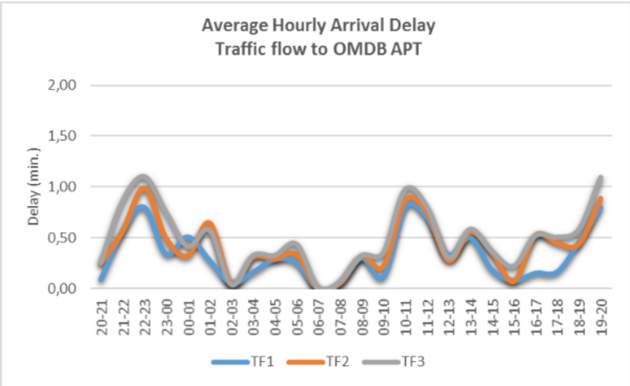
<u>Dubai & Abu Dhabi CTA</u>

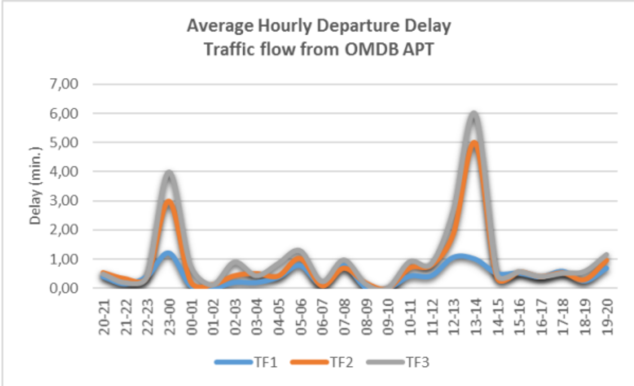


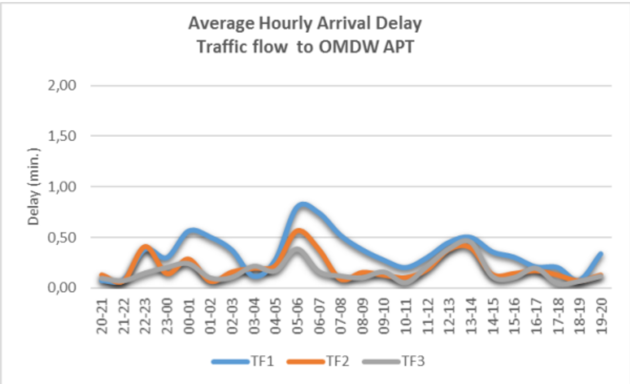


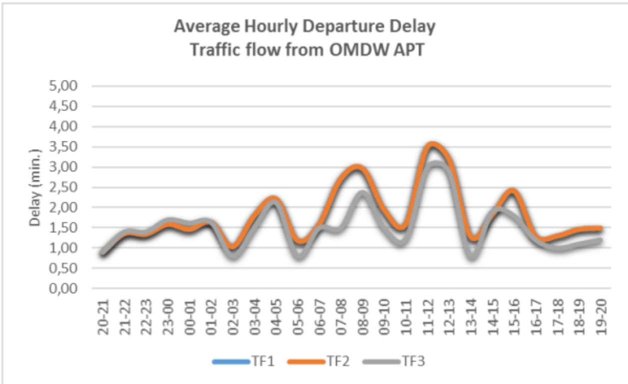


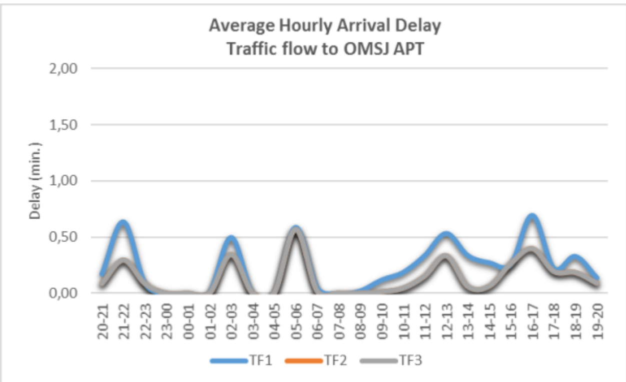


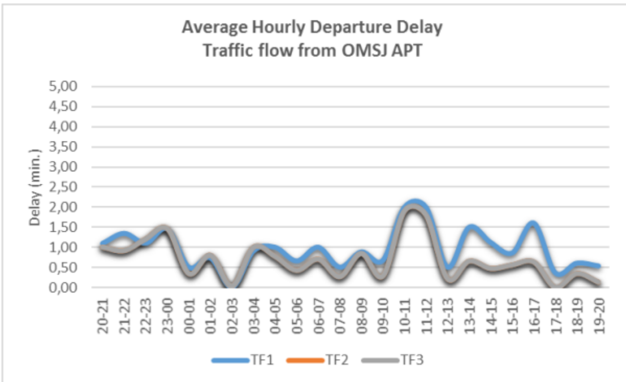

Average Hourly Arrival Delay
Traffic flow to OMDB APT
Delay (min.)
TF1
TF2
TF3

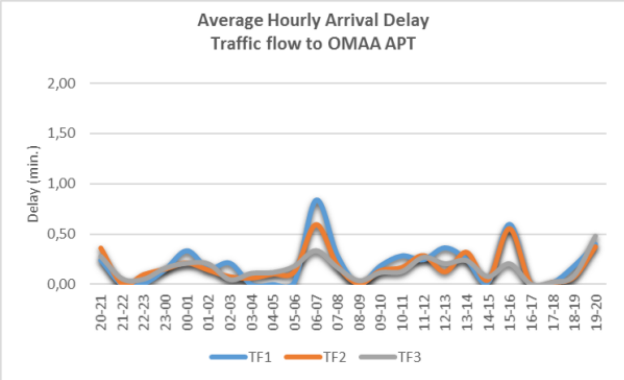

Average Hourly Departure Delay
Traffic flow from OMDB APT
Delay (min.)
TF1
TF2
TF3

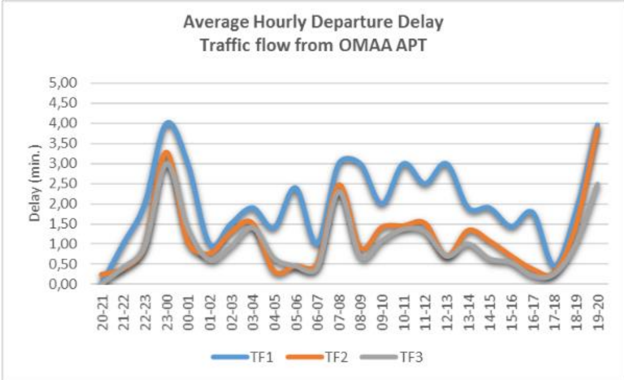

Average Hourly Arrival Delay
Traffic flow to OMDW APT
Delay (min.)
TF1
TF2
TF3

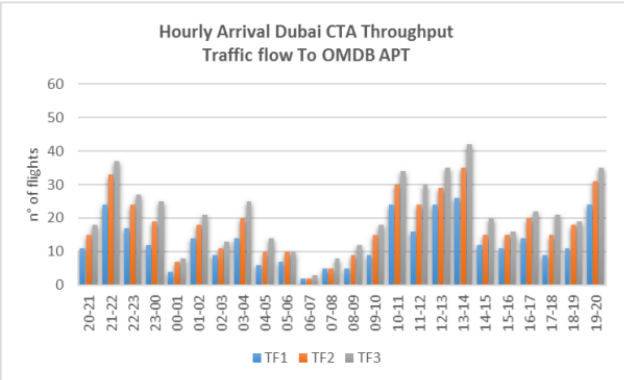

Average Hourly Departure Delay
Traffic flow from OMDW APT
Delay (min.)
TF1
TF2
TF3

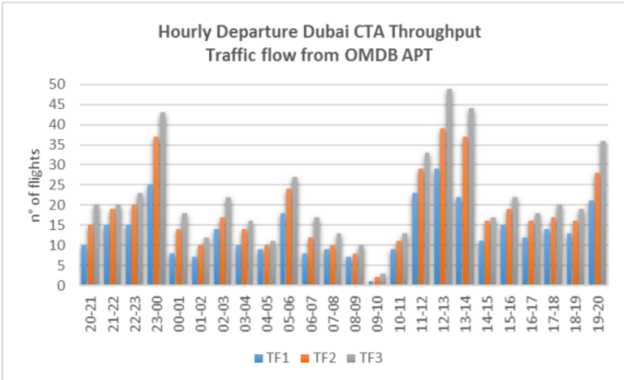

Average Hourly Arrival Delay
Traffic flow to OMSJ APT
Delay (min.)
TF1
TF2
TF3

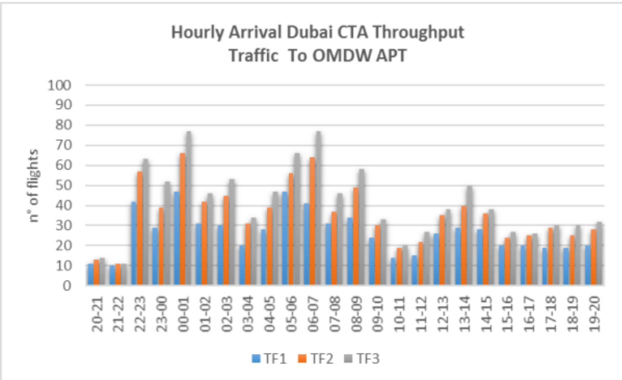

Average Hourly Departure Delay
Traffic flow from OMSJ APT
Delay (min.)
TF1
TF2
TF3

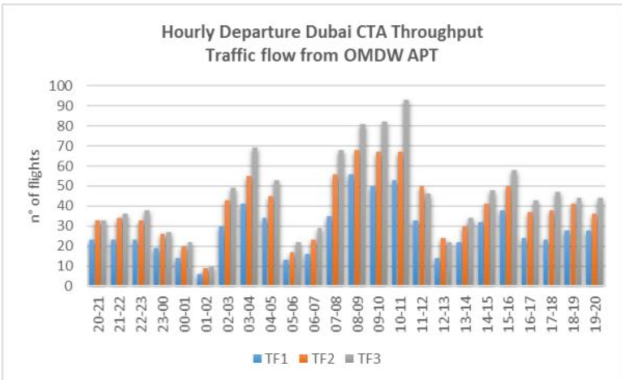

Average Hourly Arrival Delay
Traffic flow to OMAA APT
Delay (min.)
2,00
1,50
1,00
0,50
0,00
20-21 21-22 22-23 23-00 00-01 01-02 02-03 03-04 04-05 05-06 06-07 07-08 08-09 09-10 10-11 11-12 12-13 13-14 14-15 15-16 16-17 17-18 18-19 19-20
TF1 TF2 TF3

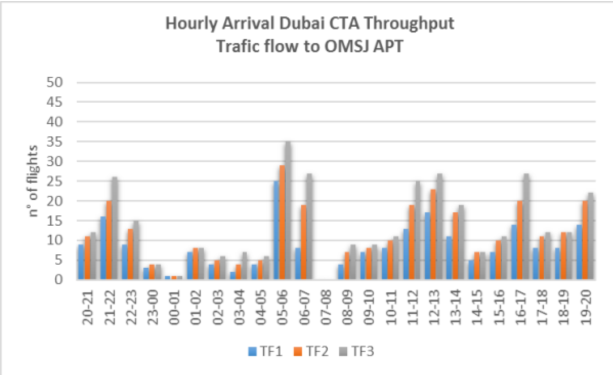

Average Hourly Departure Delay
Traffic flow from OMAA APT
Delay (min.)
5,00
4,50
4,00
3,50
3,00
2,50
2,00
1,50
1,00
0,50
0,00
20-21 21-22 22-23 23-00 00-01 01-02 02-03 03-04 04-05 05-06 06-07 07-08 08-09 09-10 10-11 11-12 12-13 13-14 14-15 15-16 16-17 17-18 18-19 19-20
TF1 TF2 TF3

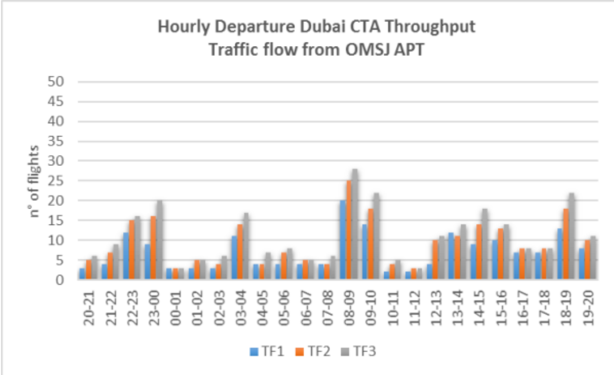

Hourly Arrival Dubai CTA Throughput
Traffic flow To OMDB APT
n° of flights
60
50
40
30
20
10
0
20-21 21-22 22-23 23-00 00-01 01-02 02-03 03-04 04-05 05-06 06-07 07-08 08-09 09-10 10-11 11-12 12-13 13-14 14-15 15-16 16-17 17-18 18-19 19-20
TF1 TF2 TF3

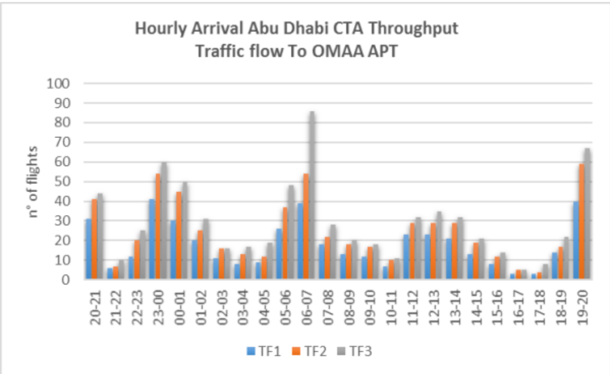

Hourly Departure Dubai CTA Throughput
Traffic flow from OMDB APT
n° of flights
50
45
40
35
30
25
20
15
10
5
0
20-21 21-22 22-23 23-00 00-01 01-02 02-03 03-04 04-05 05-06 06-07 07-08 08-09 09-10 10-11 11-12 12-13 13-14 14-15 15-16 16-17 17-18 18-19 19-20
TF1 TF2 TF3

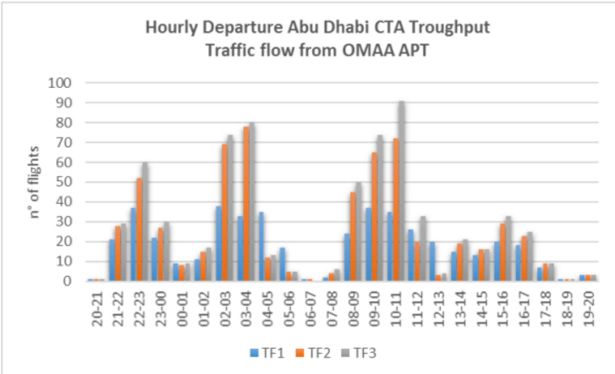

Hourly Arrival Dubai CTA Throughput
Traffic To OMDW APT
n° of flights
100
90
80
70
60
50
40
30
20
10
0
20-21 21-22 22-23 23-00 00-01 01-02 02-03 03-04 04-05 05-06 06-07 07-08 08-09 09-10 10-11 11-12 12-13 13-14 14-15 15-16 16-17 17-18 18-19 19-20
TF1 TF2 TF3

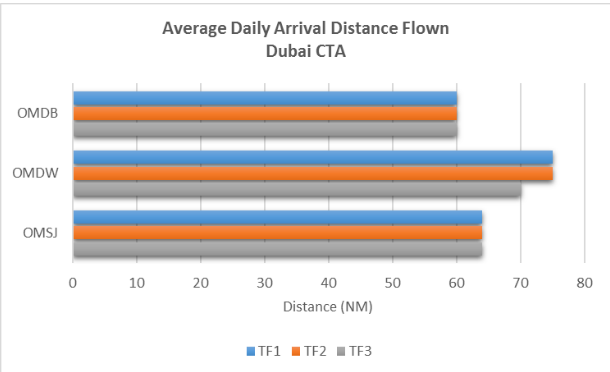

Hourly Departure Dubai CTA Throughput
Traffic flow from OMDW APT
n° of flights
100
90
80
70
60
50
40
30
20
10
0
20-21 21-22 22-23 23-00 00-01 01-02 02-03 03-04 04-05 05-06 06-07 07-08 08-09 09-10 10-11 11-12 12-13 13-14 14-15 15-16 16-17 17-18 18-19 19-20
TF1 TF2 TF3

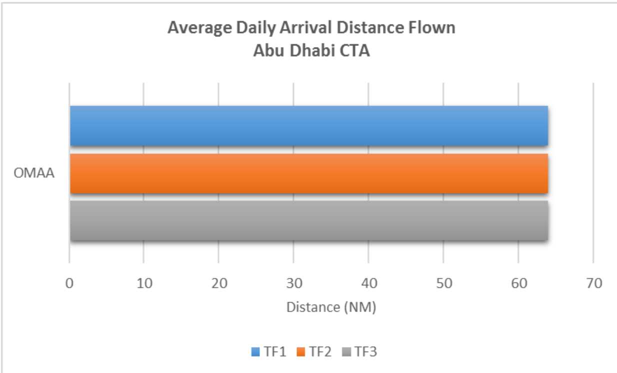

Hourly Arrival Dubai CTA Throughput
Trafic flow to OMSJ APT
n° of flights
TF1 TF2 TF3

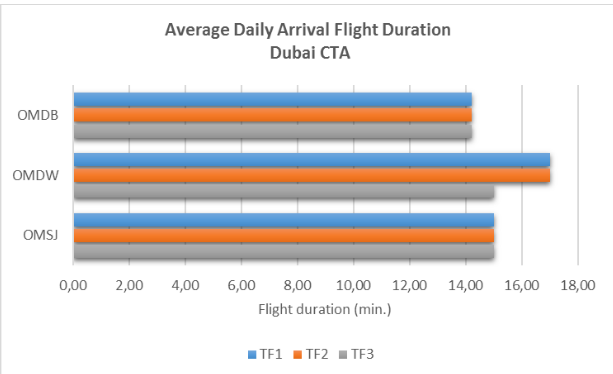

Hourly Departure Dubai CTA Throughput
Traffic flow from OMSJ APT
n° of flights
TF1 TF2 TF3

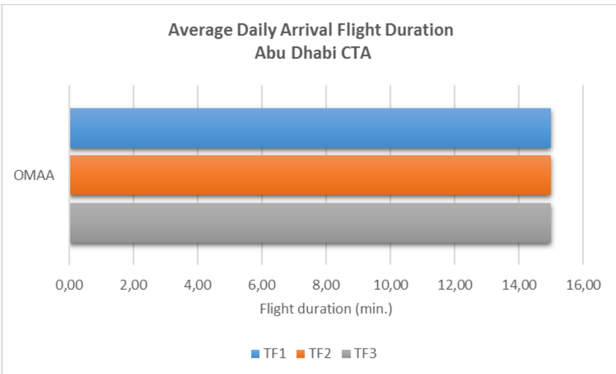

Hourly Arrival Abu Dhabi CTA Throughput
Traffic flow To OMAA APT
n° of flights
TF1 TF2 TF3

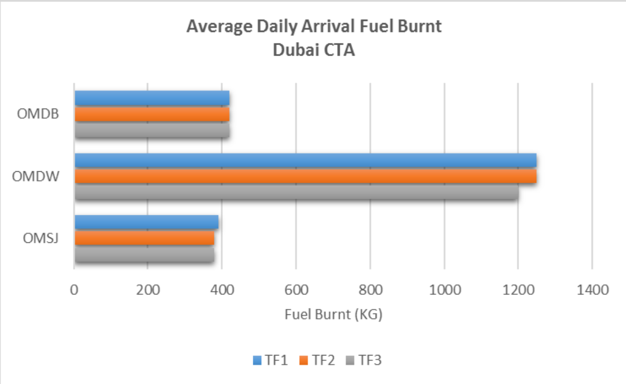

Hourly Departure Abu Dhabi CTA Troughput
Traffic flow from OMAA APT
n° of flights
TF1 TF2 TF3

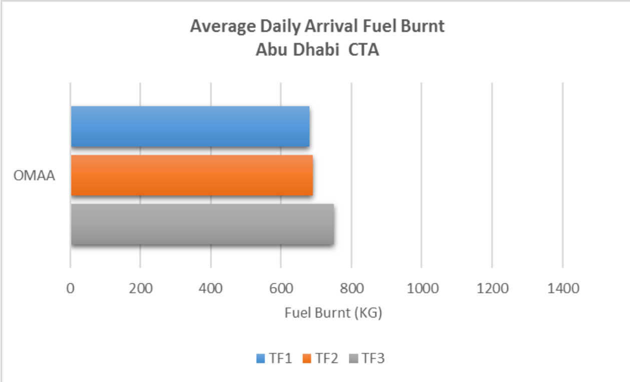

Average Daily Arrival Distance Flown
Dubai CTA
OMDB
OMDW
OMSJ
Distance (NM)
TF1 TF2 TF3

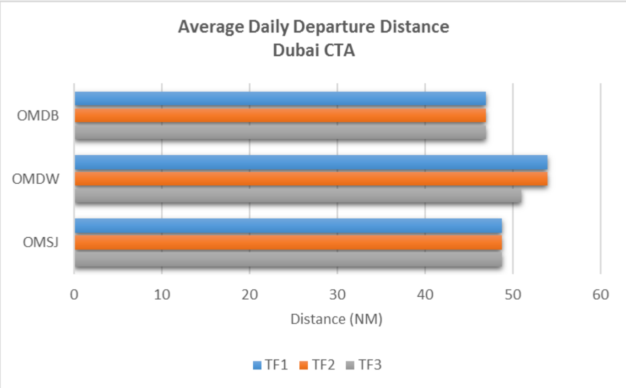

Average Daily Arrival Distance Flown
Abu Dhabi CTA
OMAA
Distance (NM)
TF1 TF2 TF3

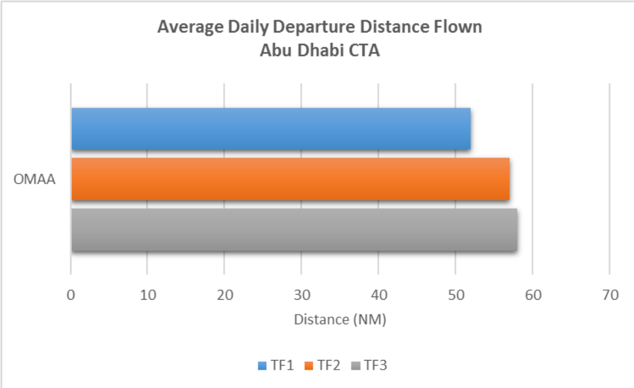

Average Daily Arrival Flight Duration
Dubai CTA
OMDB
OMDW
OMSJ
Flight duration (min.)
TF1 TF2 TF3

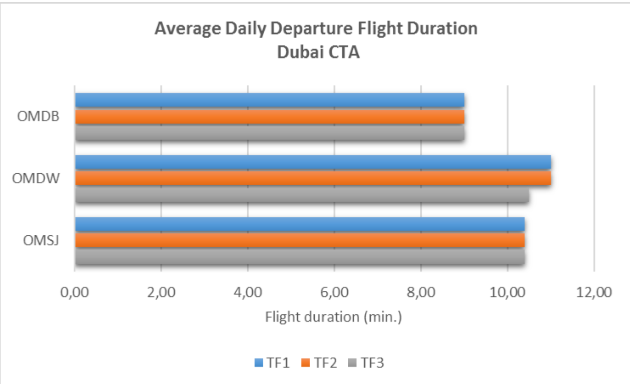

Average Daily Arrival Flight Duration
Abu Dhabi CTA
OMAA
Flight duration (min.)
TF1 TF2 TF3

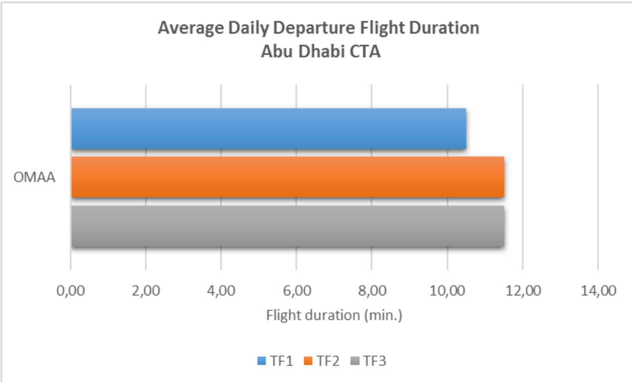

Average Daily Arrival Fuel Burnt
Dubai CTA
OMDB
OMDW
OMSJ
0
200
400
600
800
1000
1200
1400
Fuel Burnt (KG)
TF1
TF2
TF3

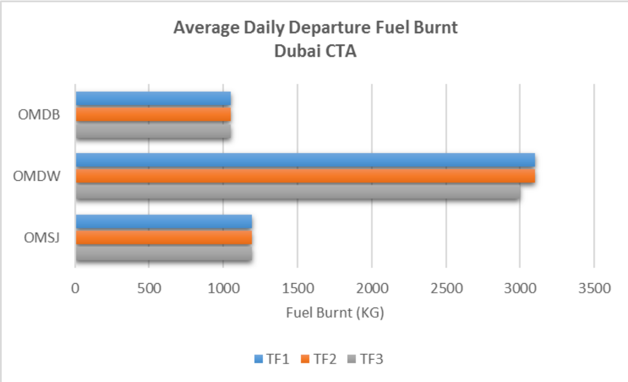

Average Daily Arrival Fuel Burnt
Abu Dhabi CTA
OMAA
0
200
400
600
800
1000
1200
1400
Fuel Burnt (KG)
TF1
TF2
TF3

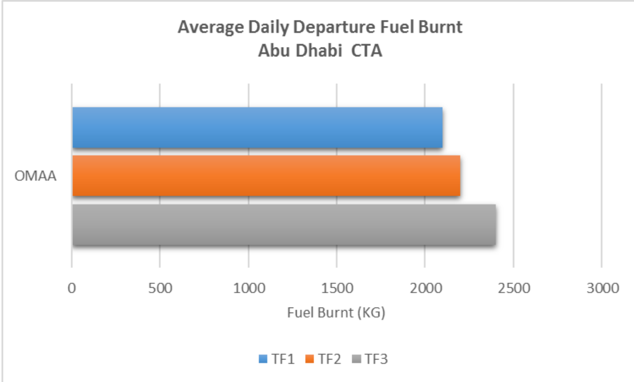

Average Daily Departure Distance
Dubai CTA
OMDB
OMDW
OMSJ
0
10
20
30
40
50
60
Distance (NM)
TF1
TF2
TF3


Average Daily Departure Distance Flown
Abu Dhabi CTA
OMAA
0
10
20
30
40
50
60
70
Distance (NM)
TF1
TF2
TF3


Average Daily Departure Flight Duration
Dubai CTA
OMDB
OMDW
OMSJ
0,00
2,00
4,00
6,00
8,00
10,00
12,00
Flight duration (min.)
TF1
TF2
TF3


Average Daily Departure Flight Duration
Abu Dhabi CTA
OMAA
0,00
2,00
4,00
6,00
8,00
10,00
12,00
14,00
Flight duration (min.)
TF1
TF2
TF3





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