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陳女士：

立法會經濟發展事務委員會
跟進二零一六年三月二十四日的會議

二零一六年四月七日及二零一六年四月十四日來函收悉。來函要求政府提供英國國家航空交通服務有限公司(NATS)於二零一五年十二月以“定照”方式為新航空交通管理系統(航管系統)所作的檢討報告副本。繼我們二零一六年四月二十八日的回覆，我們現提供“定照”方式檢討報告，以及分階段推行新航管系統的第一階段整體過渡準備狀況的最新評估報告。兩份報告載於**附件 A 及 B**(只備英文版)供委員參考。

NATS 就“一次過推行”新航管系統的“定照”方式進行檢討

2. 由運輸及房屋局(運房局)委聘來自英國的獨立顧問公司NATS，根據二零一五年十二月的情況，就“一次過推行”新航管系統的做法，以“定照”方式完成有關系統就技術事宜、運作及訓練文件的檢討。“一次過推行”是指在二零一六年六月一次過全面推行新航管系統的做法。

3. 在二零一五年十二月進行的“定照”方式檢討，在假設新系統“一次過推行”的前提下，NATS的檢討結論認為航管系統在工程方面的表現，與英國及新加坡等其他地區的航空交通管制中心(空管中心)的良好做法看齊。NATS當時(即二零一五年十二月)提出一些意見，當

中大部分是與工程計劃和報告的紀錄，以及長遠的系統維修程序有關。在人員因素方面，NATS認為有若干事宜須予改進，以配合使用者習慣和提升運作效能。委員可留意NATS在行政摘要的第18段的意見：

> *"NATS在二零一五年十二月評估新航管系統若於二零一六年六月開始投入運作時的整體運作準備狀況為黃色級別，這可以理解為整體運作準備狀況於二零一五年十二月時處於中度風險級別。項目於指定時間(經相關持份者同意)內完成有關的改進行動以控制和減低風險是慣常做法。"*

4. NATS在總體評估中指出，以其處理相類空管系統過渡的經驗而言，在該個階段(即二零一五年十二月)提出這些意見及建議的數量及程度，並無不妥。NATS亦在報告中提及："民航處透過成功實施改變，跟進NATS提出的建議後，預期人員因素和整體運作準備狀況會有所改善。" NATS在最新的報告中確認了這一點(見下文第6段)。

5. 根據這項檢討，NATS確認了新航管系統的系統工程安全、穩定且可靠。NATS更建議分階段推行新航管系統，以便空管人員有更多時間分階段熟習系統的功能和運作。再者，考慮到颱風季節會為空管人員帶來額外的工作量和壓力，分階段推行新系統可減少在颱風季節提供全功能服務的風險。分階段推行系統的建議獲民航處接納。民航處考慮了多項因素，包括空管人員對分階段推行系統的支持，才接納NATS的建議，因為這會增強員工信心及減輕其壓力。採納分階段推行系統的做法一事已在二零一六年三月二十四日向立法會經濟發展事務委員會匯報，委員基於安全為先的原則，大致同意分階段推行系統。

<u>NATS就分階段推行系統的第一階段研究</u>

6. 運房局委聘NATS進行進一步評估和籌劃分階段推行新航管系統的顧問研究。工作包括兩個階段：第一階段主要集中評估空管指揮塔在二零一六年六月過渡至新系統的準備情況；而第二階段的評估(目前尚未展開)則涵蓋新空管中心其後的過渡準備。NATS的第一階段評估報告剛完成定稿並獲運房局接納，該報告詳盡而全面檢視了分階段推行新航管系統的最新準備情況。正如NATS在第一階段評估報告中指出，民航處已跟進了NATS為分階段推行計劃第一階段配置編排所作的全部建議，包括工程計劃的紀錄，以及關乎使用者習慣和運作效能的人員因素，如字體大小、不同情況下的聲音警告音效和顯示屏幕的航機標籤重疊等事項。委員可留意NATS在第一階段評估報告的評論：

> *"NATS 早前的分析提出了一些建議讓民航處跟進。NATS 認為民航處一直表現良好，已處理所有與分階段推行計劃第一階段配置編排有關的建議。此外，民航處現正處理餘下的建議，*

而那些建議並不會影響分階段推行的第一階段，並且快將完成。"

換言之，民航處已跟進 NATS 在二零一五年十二月假設 "一次過推行" 新系統的前提下，與分階段推行計劃第一階段有關的建議，而 NATS 亦確認其餘建議亦快將完成。

7. 委員可留意 NATS 的結語：

"NATS 讚賞民航處為分階段推行新系統而作出大量詳細的預備工作，相信民航處已就逐步過渡至新航管系統制訂了整體上穩妥可行的計劃和步驟。從提供予 NATS 的資料顯示，民航處正在務實和全面地跟進分階段推行計劃。由於民航處已按照"論點－論據－證據"的模式就分階段推行系統的整體可行性提交進度報告、論點及證明文件，NATS 信納民航處已準備好由二零一六年六月起使用新系統。"

<u>運房局的意見</u>

8. 運房局接納NATS就分階段推行計劃所擬備的第一階段報告，並知悉民航處正就機場北面指揮塔的初期運作過渡作最後準備。就報告只提出的兩項建議(見報告摘要的第 6 段)，NATS 信納民航處正在跟進，並在二零一六年五月二十五日確認該兩項事宜已處理完畢。至於兩份 "按時更新內容的文件" (參考載於報告 S1.5 及 S1.6)，NATS 留意到這些文件正獲民航處按既有程序妥善處理。NATS 在二零一六年五月二十五日指出預期民航處能在二零一六年六月分階段推行系統開展前，完成處理該兩份 "按時更新內容的文件" 。

9. 請委員留意上述兩份報告和資料。

運輸及房屋局局長

(陳雅思 代行)

連附件

副本送 田北俊議員，GBS，JP (主席)
經濟發展事務委員會委員
民航處處長 (傳真號碼：2501 0640)
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二零一六年五月三十日

Annex A

NATS

Performance
through Innovation

0147-000-2634

Operational Readiness Assessment Of The New Air Traffic Management System

Prepared for the Transport & Housing Bureau, HKSAR Government

D2 Final Report

Issue 1.2

15/03/2016

NATS Private – Commercial in confidence

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Glossary

ARM	Availability, Reliability and Maintainability
AT3	AutoTrac III
ATC	Air Traffic Control
ATCC	Air Traffic Control Centre
ATCO	Air Traffic Control Officer
ATMS	Air Traffic Management System
CAD	Hong Kong Civil Aviation Department
CJS	Controller Jurisdiction
COTS	Commercial Off The Shelf
DB	Data Block
EFS	Electronic Flight Strip
ENG	Engineering
FDL	Flight Data List
HF	Human Factors
HK	Hong Kong
HKSAR	Hong Kong Special Administration Region
HMI	Human Machine Interface
I/B	Inbound
ICAO	International Civil Aviation Organisation
iFACTS	NATS Area Control Toolset (Conflict detection & resolution, task prioritisation, what if analysis)
iTEC	Interoperability Through European Collaboration
ITTF	Implementation and Transition Task Force
MSAW	Minimum Safe Altitude Warning
RAG	Red/Amber/Green Review
RBL	Range and Bearing Line
SA	Situational Awareness
SAF	Safety
SARP	Standards & Recommended Practices
SESAR	Single European Sky ATM Research
SIT	Situational Awareness (display)
SME	Subject Matter Expert
STCA	Short Term Conflict Alert
SUA	Special Use Airspace
TCC	Traffic Condition for Controller

THB	Transport and Housing Bureau
TWR	Tower
UFS	Ultimate Fall-back System

Assumed Knowledge

This document assumes the reader has knowledge of air traffic control and airport operations and is familiar with the project methodology detailed in Reference 1. It also assumes the reader would be familiar with basic terminologies for the subjects involved. Where acronyms are used, they are listed in the glossary or explained in the text.

Table of Contents

Executive Summary

Context

1. CAD is in the process of transitioning their ATC operations onto a new Air Traffic Management System (ATMS). The ATMS supports Tower, Approach/Departure, Terminal and Area operations. CAD have contracted Raytheon to supply, install and commission the system. CAD has been delivering ATC conversion training sessions, as well as fine-tuning/developing the associated ATC and engineering procedures/plans to complete its safety case report and enable operational readiness for transition, currently planned for June 2016.
2. NATS were employed by Transport and Housing Bureau (THB) to undertake an independent (snapshot) assessment of the operational readiness for transition of the new ATMS at December 2015, against the planned date for Day 1 transition of June 2016.
3. In order to achieve successful transition, CAD has to not only ensure that the engineering solution meets safety, integrity, availability, maintainability and usability / Human Machine Interface (HMI) requirements but also ensure that the technical system is fit for purpose in the context of the local specific operational environment. This will include surveillance, airspace and ATC procedures across Tower, Approach/Departure, Terminal and Area operations. This represents a significant and highly complex technology and people change programme.
4. Noting point 3 above, it is common that the engineering functionality / design and that of the local specific operational environment(s) need to be refined through an iterative process before becoming a good match. Accordingly it is both normal and expected that issues regarding the usability (i.e. Human Factors) of the system will be experienced as the engineering system is tested and validated.
5. It is emphasised to the reader that NATS has provided a snapshot of operational readiness at December 2015. Independently of NATS assessment, CAD already had in place planned system updates, training sessions and development of various procedures/plans to further enhance the operational readiness of the system. A comprehensive assessment of these activities and the overall plan between January 2016 and June 2016 was not within the scope of this study.

Method

6. This report provides evidence and commentary on the issues that NATS recommend to be addressed or managed to achieve a successful Day 1 transition.
7. In order to provide a clear status of transition readiness, NATS uses a Red, Amber, Green (RAG) status. The occurrence of Red or Amber status does not imply that the project is not under control, but is often an implication of the relative extent of complexity of the change programme and differences between the engineering setup and the local specific operational environment.
8. In making this assessment, NATS has considered the RAG status for the System Engineering (ENG) and Safety Assurance assessments (SAF) together with the results of the Human Factors (HF) and ATC assessments.

Findings

9. NATS considers the System Engineering and Safety Assurance of ATMS at December 2015 to be **Green** in that, based on the information provided, the control measures are in place and/or plans to implement them are credible (in terms of time, cost and quality). Limited further action is deemed necessary, with only areas of low impact to either Programme delivery, Operational Safety, or Service/Business Continuity having been identified. It should be recognised that these findings do not include those associated with the user display and HMI aspects of the ATMS as these have been considered separately in the HF assessment.

10. In making the Green assessment for ENG and SAF, NATS notes that the system engineering is safe, stable and reliable and in line with good practice. The assessment covers system robustness, cyber security, safety, integrity, stability, reliability, maintainability, availability, expandability, operational sustainability and integration with other sub-systems/systems. A small number of residual observations with potential low/medium impact are raised associated with assurance documentation together with the long-term maintainability and overall system life-cycle beyond Day 1 transition.

11. NATS considers the HF assessment at December 2015 to be **Amber**. An Amber assessment means that collectively the issues have the potential to impact upon delivery of service and need to be managed effectively. Specific areas that require improvement are given in this report. The assessment covers the effectiveness of HMI, such as user friendliness of system/controller functions, ergonomic design of the system.

12. In making the Amber assessment for HF, NATS notes a small number of residual observations with potential medium/high impact associated with specific issues, mitigation for which is provided within the HF high priority recommendations.

13. Details of the findings affecting Day 1 transition are in the main body of report.

Recommendations

14. Recommendations associated with the findings are included in the main body of the report. CAD has responded to reflect their current plans to address these findings.

15. Beyond the assessment scope of system readiness for Day 1 transition, there are some recommendations associated with best practice to further enhance system sustainability and maintenance beyond Day 1 transition. These are not considered to impact the technical readiness of the new ATMS or CAD have plans in place to deliver the assurance and confidence required; however for the overall operational readiness, these findings are recommended as requiring continued focus.

16. NATS has made 4 SAF and 11 HF high priority recommendations that are in progress by CAD at the time of writing. Active monitoring of high priority recommendations is normal.

17. The reader should note that it is NATS established best practice that identified issues can be addressed through a combination of improvements to the Engineered System, Training and/or ATC / Engineering procedures and plans. For instance, it is entirely appropriate and acceptable, subject to safety considerations, to mitigate a high priority HMI design issue through training and procedural changes, such that it can be managed until a system update removes the issue.

Overall assessment

18. NATS has assessed the overall operational readiness of the ATMS system at December 2015 for Day 1 transition in June 2016 as **Amber**. This should be interpreted as the overall operational readiness based on the status of contributing factors at December 2015 is at medium risk. It is normal practice for the project to complete the associated corrective actions within a clearly defined period (to be agreed with relevant stakeholders) to manage and reduce this risk.

19. Whilst no two operational transitions are identical, the number and severity of observations and recommendations raised by NATS is not unusual in relation to our experience of ATC transitions at a similar stage of development.

20. By successfully implementing the changes initiated by CAD and addressing the recommendations raised by NATS, it is expected that the Human Factors and overall operational readiness will be improved. NATS suggests that, following the delivery of this report, consideration be given to:

    a. Proactively monitoring NATS recommendations to validate the timely closure of corrective actions planned and proposed by CAD against defined success criteria; and

b. Continuing the Operational Readiness assessment following the delivery, testing and validation of forthcoming system updates of the ATMS to demonstrate convergence to an operational readiness appropriate for a controlled and successful operation transition. With this further work the consultant would, using established metrics, report progress of operational readiness of ATMS against the December 2015 snapshot and also target levels for operational transition.

21. In completing this report, NATS has compared this significant and complex transition to similar historical NATS transitions, including Heathrow, introduction of iFACTS to the Swanwick Centre, the transition to Prestwick Centre and the current transition at Prestwick to the SESAR iTEC platform. In this context, the scale of change faced by CAD is similar, and parallels exist between the challenges faced by NATS and by CAD. Common across these implementations has been the need to focus on Human Factors assurance across the whole transition period. The Human Factors recommendations raised in this report have parallels with NATS experience of transitions.

22. NATS would like to thank and commend CAD for the openness and support provided in undertaking and delivering this work. It is clear that staff and management are focused on achieving the successful Day 1 transition through their comprehensiveness and thoroughness of documentation, and preparatory work towards transition to the new ATMS.

1 Context and Study Scope

CAD is in the process of transitioning their ATC operations onto a new Air Traffic Management System (ATMS). The ATMS supports both Tower, Approach/Departure, Terminal and Area operations. Raytheon is providing the 'engineering' system under contract to CAD. CAD is installing the system, developing the associated ATC and engineering procedures/plans to enable readiness of operational transition, currently planned for June 2016.

Transport and Housing Bureau (THB) contracted NATS to undertake an independent assessment of the operational readiness of the new ATMS.

The Call for Tender (Reference 1) defined scope for the study. The key requirements are replicated below for convenience:

1. The Service Provider shall conduct on-site assessment (thereafter called "the Assessment") on the operational readiness and user friendliness of the new ATMS installed at CAD Headquarters and North Aerodrome Control Tower as details in paragraph 2.2 to 2.6 below (Section 2.1).
2. The Service Provider shall conduct an operational readiness review of the new ATMS, in terms of system robustness, safety, integrity, stability, reliability, maintainability, availability, and operational sustainability, integration with other sub-systems/systems, to be operated under an uninterrupted air traffic control environment within the designed operational life of the system (Section 2.2).
3. The Service Provider shall assess the effectiveness of Human Machine Interface (HMI) and associated usability, such as user friendliness of system/controller functions, ergonomic design of the system, human factors affecting different usergroups (viz ATC operational staff, system support and engineering staff) in the effective operation and control of the system to support the current air traffic operations of some 1,200 flight movements and 700 overflying flights per day, as well as the projected traffic growth up to 2030 (Section 2.3).
4. The Service Provider shall evaluate the system expansion capability commensurate with projected air traffic growth (Section 2.4).
5. The Service Provider shall conduct the Assessment taking into account the Safety Case Report to be provided by Government to carry out a third party safety assessments with due emphasis to verify if the new ATMS and its software are operationally ready and safe for ATC operations. The Service Provider shall provide findings and practical recommendations to address safety concerns arising from the Assessment (Section 2.5).
6. The Service Provider shall evaluate the system compliance with relevant ICAO SARPS and international software development standard (Section 2.6).
7. The Service Provider shall meet with relevant CAD staff, and co-ordinate with CAD to acquire supporting documents (including the safety case report and safety documents) from the CAD and CAD's contractor(s) concerned during the conduct of the Assessment (Section 2.7).
8. The reports to be submitted by the Service Provider shall include, but not be limited to, the professional conclusion on the operational readiness of the new ATMS and effectiveness of HMI, as well as the pragmatic recommendations, with supporting reasons. All assumptions made in the Assessment shall be discussed and agreed with the Government and stated clearly in the reports (Section 3.5).

This document represents Deliverable D2 for the Operational Readiness Assessment for the New Air Traffic Management system, conducted by NATS Services (Asia Pacific) Pte Ltd for the Transport & Housing Bureau of the HKSAR Government. The project methodology was presented in Deliverable D1 (Reference 1). Section 2 of this report provides a recap of the methodology and analysis employed in the work, Section 3 provides the results of the analysis whilst Section 4 provides a list of recommendations for CAD as control measures for operational transition. Section 5 provides the conclusion of the report and proposes next steps.

2 NATS Methodology

2.1 Data Gathering and Scope

NATS methodology for undertaking this work is detailed in Reference 1. NATS main data gathering was on site in Hong Kong between 30th November and 4th December 2015. NATS provided an engineering SME, Human Factors SME and an ATC Operational SME all with direct and extensive experience of ATC operational transition.

CAD provided open and free access to staff and facilities to support NATS work. To undertake the review, NATS used industry standard criteria for both engineering and Human Factors assessment. NATS analysis focused on:

System Engineering and Safety Assurance;

a. Design assurance and software development compliance;
b. System architecture and integration to sub-systems;
c. Engineering training and procedures, including logistics, supportability and configuration;
d. Acceptance, transition and reversion plans;
e. Safety, ARM (Availability, Reliability and Maintainability);
f. Software assurance review to Eurocae ED109 guidelines; and
g. Readiness demonstrations and transition plans.
h. Cyber security compliance (against ISO 27002)

[Note – The Engineering and Safety Assurance methodology is outlined in Appendix 2].

Impact of Change (ATC)*; and

a. Understanding of change;
b. Understanding of procedures;
c. Overall user friendliness/ease of use; and
d. Perceived system reliability.

Human Factors;

a. Controller situation awareness and controller workload;
b. Teamwork and communications;
c. User acceptance;
d. Training; and
e. HMI design.

[*Note that the results from staff's assessment of impact of change overlap and re-enforce findings reported within the Human Factors analysis. For this reason, they are both reported under Human Factors].

In preparation for the site visit, CAD provided project, engineering (including cyber security), and operational documentation listed in Appendix 1.

The observations arising from the criteria for each of the three areas (System Engineering and Safety Assurance, Impact of Change / ATC Review, and Human Factors) were assessed against their potential impact (High, Medium or Low).

2.2 Overall Analysis

In order to provide an overall assessment of operational readiness NATS also provide a RAG at the Overall Operational Readiness level to reflect the potential impact of the issue, as illustrated in Figure 1 below.

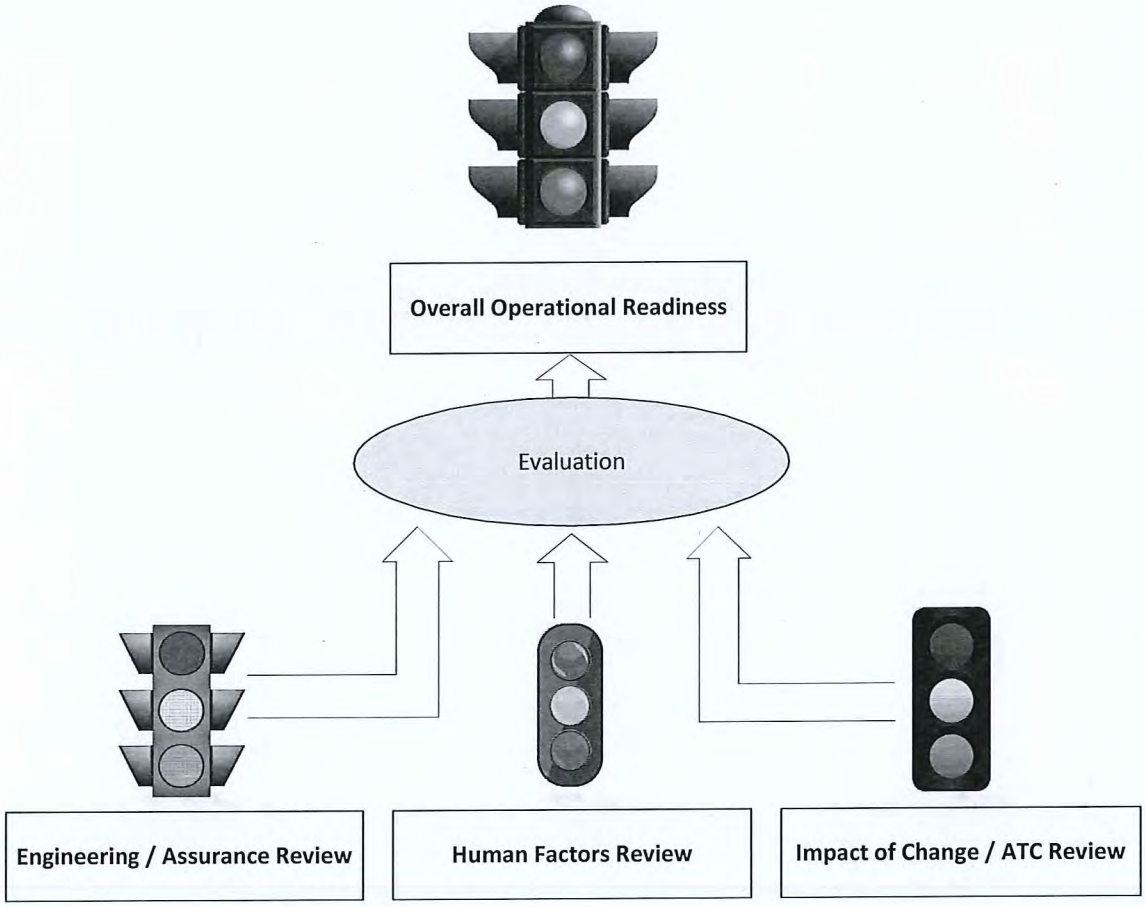


Figure 1 – NATS Assessment Methodology

The Overall Operational Readiness RAG is detailed below.

Overall Operational Readiness RAG Definitions	
Red	This means the overall operational readiness is at High risk. The project requires urgent support and attention from senior staff and stakeholders to achieve successful implementation. This is based on an evaluation of the contributing factors from the sub-ordinate reviews.
Amber	This means the overall operational readiness based on the contributing factors is at Medium risk. The project must complete corrective actions within a defined period (to be agreed and monitored with relevant stakeholders).
Green	This means the overall operational readiness based on the contributing factors is at Low risk. This means that any actions placed on the project (as agreed and monitored with relevant stakeholders) will be completed by dates agreed between the relevant parties of the Project.

2.3 Recommendations

In order to facilitate CAD's follow-up to this report, NATS has supplemented the observations with a set of prioritised recommendations as follows:

- **High** – a recommendation to be addressed prior to Day 1 (Operational transition) in response to an observation that has a high impact and/or occurs frequently. Active monitoring of High priority recommendations is normal;

- **Medium** – a recommendation to address an observation that can be managed in the short term but should be addressed after Day 1. For medium recommendations, plans should be developed and agreed before Day 1. Active monitoring of Medium priority recommendations is normal;
- **Low** – a recommendation that is intended to provide additional benefits, provides additional mitigation to another issue or is considered best / good practice. A low priority recommendation can be adopted either prior to or following initial transition.

3 Results

3.1 Understanding Operational Readiness Analysis

It is important to put the operational readiness results into context, specifically for an organisation such as CAD who are deploying Commercial Off the Shelf (COTS) engineering systems into a specific operation environment.

In order to achieve successful transition CAD has to not only ensure that the COTS solution meets safety, integrity, availability, maintainability and usability requirements but also has to ensure that the technical system is fit for purpose in the context of the local specific operational environment (which will include surveillance, airspace and ATC procedures). It is quite common that the COTS functionality and design and the demands of the local specific operational environment need to be refined before becoming a good match.

It is therefore normal and expected that issues regarding the usability (human factors) of the system will be experienced as the COTS system is tested and validated.

3.2 System Engineering and Safety Assurance Observations and Assessment (ENG/SAF)

Note – Grey shaded recommendations indicate those closed in the period between Dec 15 and the publication of the report (Feb 16).

REC Id	Recommendation	CAD Additional Remarks[1]	Assessed Potential Impact	Day 1 Priority
REC 1 (SAF)	Ensure the plans and schedules to complete the safety case documentation is aligned with the delivery of the dependent evidence artefacts needed to support the assurance arguments and claims (Goals) being made.	The documentation as referenced in the ATMS Safety Case Report is either available or "work in progress" due to on-going or scheduled activities that have not reached their target completion dates. The respective SMEs (engineering and operational) would ensure the on-time delivery of outstanding documentation required in the Report, which itself is to be agreed before Day 1.	Low (Plans for documentation completion are credible – hence considered Low impact)	High (noting the impact of the availability of the safety case on transition timescales and requirement for active monitoring)
REC 2 (SAF)	Ensure the ATC and Engineering Fall-back procedures are completed and subject to verification, validation and training to ensure their effectiveness.	Fall-back procedures would tally with the Contingency Plan, the formulation of which includes the analysis / assessment of the engineering and operational aspects and is "work in progress" to be completed before Day 1. Consolidated Maintenance Training held in Jan 2016 has covered the fall-back procedures and drills to validate effectiveness of procedures. Fall-back procedures are standing tasks (Items B1-5 and B1-6) to be in place prior to Day 1 under CAD's Implementation and Transition Task Force (ITTF) which was established in July 2011.	Low	High (noting the impact on the safety case and transition timescales)

REC 3 (SAF)	The Safety assessment and safety case reporting for Fall-backs is built into the +Project schedule.	CAD have identified to NATS that contingency plan and arrangements are standing work items under CAD's ITTF to be in place prior to Day 1. The safety case of the fall-back procedures is covered under the ATMS Safety Case, which is being developed jointly with another external consultant. The developed ATMS Safety Case would be agreed before Day 1 with outstanding items (actions and documentation) completed, inclusive therefore of the fall-back procedure case.	Medium	High (noting the impact on the safety case and transition timescales)
REC 4 (SAF)	To ensure the predicted reliability and availability analysis that supports the ATMS Safety Case Report is developed in line with good practice and is technically accurate, the supporting analysis and data associated with dependent failure scenarios should be reviewed.	The ATMS has been designed to have Main and Fallback Systems, operating in full redundancy; Sys 1 and Sys 2 can interchange their roles of Main and Fallback. There are fallback operating modes within Main and within Fallback Systems to support ATC operations. To guard against common mode failure, ATMS is also equipped with an Ultimate Fallback System (UFS) provided by another company as a sub-contractor to Raytheon. UFS is a constantly running and readily available system to eliminate common mode failure. As an on-going practice, CAD monitors system performance against the RMA analysis figures, via for instance, Safety Performance Target (SPT) and Safety Performance Index (SPI) and makes practicable and corresponding enhancements in any areas that require attention. CAD is in the process of fine tuning the SPT and SPI for the new system with dedication meetings and workshops, attended by all stakeholders.	Medium	High (noting the potential impact to the validity of the safety case) **Recommendation Closed**

REC 5 (SAF)	CAD to complete the Software assurance for builds since Build 1 as identified in the preliminary version of ATMS Safety Case Report.	CAD have identified to NATS the current software assurance practices followed by CAD are supported by those listed below. These will continue for subsequent software builds to provide "integrity assurance for new ATMS software builds subsequent to build 1". These practices include the following elements aside from verification of planned items: • additional test; • stop-n-go during build verification • and ad-hoc and system performance by engineering and staff on self-verification at each build release, • small to large scale Normal ATC Operations (which is a form of shadowing) involving a sizable number of operational and engineering staff • training courses on Simulator (with same build deployed) • internal testing at factory by Contractor; • dry-runs at site and test readiness review with CAD • Planned Shadowing in first half of 2016 for the operational build.	Low	High (noting the impact on the safety case and transition timescales)

3.3 Human Factor Observations and Assessment

Note – Grey shaded recommendations indicate those closed in the period between Dec 15 and the publication of the report (Feb 16).

HF Issue	REC Id	Recommendation	CAD Additional Remarks[2]	Assessed Potential Impact	Day 1 Priority
When the AutoDB function moves the DB, it does not take into account the relative positions of the aircraft/TPS when moving the DB to new locations. It appears to locate empty space regardless of the position and order of the aircraft, resulting in frequent transposition of DBs and crossing of leaderlines.	REC 6 (HF).	Consideration should be given to significant re-design of the auto-de-conflict function of Data Blocks so that: (i) it recognises other elements on the SIT display and does not overlap with these elements; (ii) the label position does not transpose with adjacent Data Blocks; (iii) it preserves the relative position and order of the Data Blocks so that it remains consistent with the relative position and order of the actual aircraft.	This observation was reported to Raytheon during system acceptance tests and the project team handled it under a higher priority. Improvement made in phases with a recent on-site demonstration made during Build 3 verification period in Dec 2015 to fine-tune the exact implementation. Agreement made with Raytheon in August 2015 to have the leader line de-conflict algorithm delivered in Build 4 in March 2016. Part of the recommendation has been addressed in Build 2A, while the rest will be addressed in Build 4.	High	**High**
The timely availability of TCC indicator and critical ATC information is critical to maintain situational awareness and minimize potential human error. The observed operational practice required the controllers to copy all TCC, ActRq and Emphasis Indicator data entered into the	REC 7 (HF).	Rectify the loss of TCC green highlight and information on other controller-directed input fields when sector is handed over or combined and de-combined or an	This observation was drawn to the CAD's attention during Module 3 conversion training. The project team handled it under a higher priority. Recently, the system database has been adapted to move the TCC field to page 1 of FDL. The loss of TCC green highlight does not exist	High	**High** **Recommendation Closed**

system on paper and then re-enter into system. The consequence of this mitigation created additional workload for the controllers. In addition, this mitigation introduces risk of controller errors in transcription errors on paper and data re-entering errors into the system The recent adaptation to move TCC field to page 1 of the FDL and the proposed enhancement in Build 4 (to be delivered in March 2016) which allows the Emphasis Indicators to be retained after sectors combine should resolve the issue. The adaptation and proposed Build 4 enhancements should be evaluated after implementation for assurance.		interim procedural solution.	anymore.		
	REC 8 (HF).	Re-assess the suitability of the mitigation requiring the controllers to copy all TCC, ActRq and Emphasis Indicator data entered into the system on paper and then re-enter into system for sector handover and sector combine and de-combine.	This observation was reported to Raytheon during system acceptance tests and the project team handled it under a higher priority. Agreement has been made with Raytheon to implement enhancement in Build 4 to be delivered in March 2016. The enhancement allows the Emphasis Indicators to be retained after sectors combine/de-combine. ATC procedure will also be fine-tuned to eliminate the need to use paper.	**Hig h**	**High**
EFS can be sorted by user preferences. There are about 20 different information categories. There are no operational rules or recommendations on how the ATCOs in each position should set the sort preference. It will be prudent to provide the controllers with guidance on best practice for the settings on sort preferences for the EFS; to make the presentation of EFS and EFS display consistent between controllers on the same sector groups as well as achieve consistent practice in management of EFS between ATCOs.	REC 9 (HF).	Provide controllers with guidance on specific EFS sort settings to standardise the EFS strip display parameters between relevant positions.	The need to define default settings was raised during a review of conversion training in Q3 2015. It is our plan to finalise the default settings after delivery of Build 4 in March 2016. CAD will take this recommendation into consideration when determining the default settings. Guidance on preferred settings will also be included in the Manual of ATC.	Med ium	**High**
During the site visit (Dec 15) the distance displayed was seen to change erratically because of the SIT display update algorithm and have impact on controller's situation awareness and decision making. For example, the Finals Director and the Area South controllers use the RBL to sequence arrivals and I/B respectively and make critical judgements on the separation between the aircraft using the RBL. If the distance between the aircraft as shown by	REC 10 (HF)	CAD are asked to assure that that the distance and bearing information in RBL label has been corrected and that the solution will be monitored to ensure that it is sufficiently accurate and reliable.	The CAD project team has been well aware of the issue which has been fixed in Build 3 in December 2015, which was not available at the time of the NATS visit. Subsequent to the fix, the distance information becomes much more reliable than the existing system, in which the behaviour did not trigger any decision or judgement issues during the last 17 years. The impact of this change will be monitored closely.	High	**High** **Recommendation Closed**

the RBL fluctuates, controllers will find it difficult to make correct judgements.					
The "small" setting equates to 10 minutes of arc subtended at the eye for a viewing distance of 600mm, which is approximately 38% smaller than the minimum acceptable character height in HMI Standards.	REC 11 (HF)	Provide controllers with a recommended setting for font size for the critical ATC information to ensure consistency in legibility requirements. Currently, the "small" setting should be avoided where possible for safety critical ATC information.	CAD will provide controllers with recommended settings and this information will be included in the Manual of ATC.	Medium	**High**
Controllers and project team members report that the audio alerts for Safety net and Flight plan error alerts perceptually sound the same, even though in the software the alerts use different audio files. HMI standard for safety net requires that the audio alerts for such alerts should be distinct from alert functions with audio means. System error alerts are cautionary or advisory messages. The repeated audio for system errors should correspond with the criticality of the event. It should not be distracting and cause impacts on mental workload. There is a hotkey on the keyboard which is a "Cancel" audio alerts key and cancels all audio alerts with a suppression period of 10 seconds, including STCA and all safety net alerts. New safety events triggered during the suspension period will over-ride the suspension and trigger a safety alert.	REC 12 (HF)	Audio alerts for alarms in the Safety Net category, especially STCA, MSAW and SUA should be distinctly different from the audio alerts for flight planning error warnings.	This is relating to alert management requirements, which was reported to Raytheon during system acceptance tests, and the CAD project team handled it under a higher priority. Agreement made with Raytheon in July 2015 to have the enhanced function in Build 4. Different audio alerts will be used.	High	**High**
	REC 13 (HF)	CAD are asked to assure that the Audio alerts for alarms in the Safety Net category will be triggered when the hot key function which cancels all audio alerts is pressed, especially if the safety net event occurs immediately before, at the same time or immediately after the hot key is pressed.	CAD advised that the hot key function will only suppress the alarm for 10 seconds whenever it is pressed. New alerts will trigger the alarm despite hotkey being pressed to keep operational controllers alerted.	High	**High** **Recommendation Closed**

The Training Effectiveness mean scores in the Human Factors were low, reflecting that controllers require more training to improve their familiarity and ability to use the new system to carry out the current procedures. The controllers reported that they had forgotten a lot of what their learnt in previous modules. In addition, previous training modules were based on a previous build of ATMS and some of the knowledge from previous training modules were no longer applicable.	REC 14 (HF)	A unit training plan should be produced, specifying: (i) the training objectives based on the difference between Build 2 and Build 3 and; (ii) training objectives based on the difference between Build 3 and Build 4 and implement the training module.	During previous modules of conversion training, controllers were briefed of the new functions/behaviours of latest software build. CAD have advised that they will incorporate the recommendation into future conversion training plans.	Medium	**High** **Recommendation Closed**
Training tasks in the Human Factors Review which showed relatively lower scores were Combining / de-combining sectors and CJS absorption and handling traffic deviations due to weather. During the Module 3 simulation training, the fidelity of the traffic situation and scenarios were lower than expected compared to reality, in terms of: (i) traffic levels, (ii) complexity, (iii) weather severity, (iv) absence of practice in night-time operations and (v) unexpected events	REC 15 (HF)	Additional training modules should be included in the training programme, which include simulation exercises to ensure controller performance in high traffic levels and at least at sector capacity and complexity.	In response to feedbacks raised during Module 3 training, CAD has critically reviewed the training plan to ensure sufficient hands-on practice for controllers. Subsequent to the review in December 2015, Module 3A and Module 4 are planned to be included before transition activities.	High	**High**
	REC 16 (HF)	A unit training plan should be produced, specifying the training objectives for a variety of critical ATC events and emergencies, including severe weather, night-time operations and system failure, and implement the training module.	In response to feedback raised during Module 3 training, CAD has critically reviewed the training plan to ensure sufficient hands-on practice for controllers. Subsequent to the review in December 2015, the forthcoming Module 3A and Module 4 are planned to be included before transition activities. It is an established practice for ATC training to cover unusual situations and emergency training. Weather deviation scenario has been covered in Module 3 training and will also be included in Module 4 training to reinforce the skills of controllers. The other critical events have been incorporated in Module 4 training.	High	**High**

Majority of the training tasks received a low response.	REC 17 (HF)	Controller performance should be measured and evaluated during all training modules to monitor training effectiveness and validate readiness and confidence.	Evaluation of controller performance against training objectives was incorporated in Module 3 training. Evaluation of staff readiness and confidence will be included in future training modules.	High	**High**
ATC manpower has been strained with officers deployed to work Replacement ATC system project related duties. The Project, Procedures and Training teams appear too small to effectively prepare for a transition of this size within the current transition timescales, The tight manpower situation of operational ATCOs has made it difficult to release staff from their operational roster for conversion training resulting in long intervals between training modules.	REC 18 (HF)	Consider alternative methods of increasing resource through rostering methods in current operation or increased supply through overtime agreement. Delaying the transition date would assist in the resolution of the issues stated above.	2 new controllers, 1 for each of Approach and Area streams have joined the CAD Project Team to assist in preparation of Module 4 training and subsequent transition activities. Adequate training and hands-on practice will be arranged for all operational controllers.	Med ium	**High**
It is clear that system functionality issues have affected the Area ATC function to a much larger extent than the Tower or Approach functions.	REC 19 (HF)	Although it is understood that this approach would bring a number of new issues into the transition plan, consideration could be given to a phased transition with Tower followed by Approach / Area at a later date.	CAD is considering the phased transition of Tower operations first followed by the more complex Approach and Area operations. A transition plan has been developed to implement this approach in a controlled and progressive manner. Related safety assessment will be conducted to ensure identified risks be properly managed.	Med ium	**High**
Crucial information was observed not being transferred during sector handovers between controllers. This should be completely rectified prior to ATC operation	REC 20 (HF)	System software fix to resolve the loss of free text during sector handovers or an interim, procedural	To meet the unique operational setup for CAD, simultaneous inputs/changes to the same aircraft by different controllers is not accepted by the system in the current	High	**High**

under live environment.		solution such as leaving this position permanently logged on without user handovers	design so as to maintain the data integrity., The CAD Project Team has been working with Raytheon to address several related issues. The proposed enhancements are under joint review and it is targeted to implement these changes in Build 4 in March 2016.		

3.4 Readiness of ATMS - System Engineering and Safety Assurance Results

NATS considers the System Engineering and Safety Assurance of ATMS at December 2015 to be **Green** in that, based on the information provided, the control measures are in place and/or plans to implement them are credible (in terms of time, cost and quality). Limited or no need for further action is deemed necessary, with only areas of low impact to either Programme delivery, Operational Safety or Service/Business Continuity have been identified. It should be recognised that these findings do not include those associated with the user display and HMI aspects of the ATMS as these have been considered separately in the HMI / Human Factors / ATC assessments.

In making the overall Green assessment for System Engineering and Safety Assurance NATS notes that the system engineering is safe, stable and reliable and in line with good practice. The assessment covers system robustness, safety, integrity, stability, reliability, maintainability, availability, and operational sustainability, integration with other sub-systems/systems. A small number of observations are raised associated with assurance documentation together with the long-term maintainability and overall system life-cycle beyond Day 1 transition. These are not considered to impact the technical readiness of the new ATMS or they have plans in place to deliver the assurance and confidence required; however for the overall operational readiness, these findings are recommended as requiring continued focus.

The assessment of the ATMS capacity and capability to cope with projected traffic growth for the Three Runway System for the HKIA was demonstrated during the Site Acceptance Testing of the ATMS, with additional room for equipment expansion to handle further increase of traffic. On this basis the system load tests correlate to predicted traffic growth.

NATS assessment of the ATMS cyber security policies, processes and technical controls measures focused on documentation provided by CAD (see Appendix 1) against ISO 27002 and ICAO requirements. Overall, the analysis indicates a good commitment to establishing an effective Information Security Management System, with a sound and broad list of activities supporting the implementation of security requirements. NATS suggest CAD further evidence and validate the documentation review to ensure that the people using and supporting the ATMS are working consistently in line with the documented processes.

3.5 Human Factor and HF Results

In order to achieve successful transition CAD has to not only ensure that the engineering solution meets safety, integrity, availability, maintainability and usability / Human Machine Interface (HMI) requirements but also has to ensure that the technical system is fit for purpose in the context of the local specific operational environment. This will include surveillance, airspace and ATC procedures across Tower, Approach/Departure, Terminal and Area operations. This represents a significant and highly complex technology and people change programme.

It is quite common that the engineering functionality / design and that of the operational environment(s) need to be refined before becoming a good match. Accordingly it is both normal and expected that issues regarding the usability (i.e. Human Factors) of the system will be experienced as the engineering system is tested and used for training.

NATS considers the Human Factors assessment as **Amber**. Noting the above, it is expected that issues of the type identified may be encountered prior to the implementation of an operational change, however unless they are addressed, the issues have the potential to impact upon delivery of service unless managed effectively. In making the Amber assessment for Human Factors NATS notes a small number of residual medium/high priority observations associated with specific issues, mitigation for which is

provided within the HF high priority recommendations. The assessment covers the effectiveness of HMI, such as user friendliness of system/controller functions, and ergonomic design of the system.

3.6 Overall Results

NATS has assessed the overall operational readiness of the ATMS system at December 2015 for a Day 1 transition in June 2016 as **Amber**. This should be interpreted as the overall operational readiness based on the contributing factors at December 2015 is at medium risk. It is normal practice for the project to complete the associated corrective actions within a clearly defined period (to be agreed with relevant stakeholders) to manage and reduce this risk.

Whilst no two operational transitions are identical, the number and severity of observations and recommendations raised by NATS is not unusual in relation to our experience of ATC transitions at similar stages of development.

4 Recommendations

Summarising the information presented in Section 3, NATS has made 4 System Assurance and 11 Human Factor high priority recommendations that are in progress by CAD at the time of writing, and are considered high priority to be addressed prior to operational transition.

It is normal practice for the project to complete the associated corrective actions within a defined period (to be agreed with relevant stakeholders) to manage and reduce this risk.

The reader should note that it is NATS established best practice that identified issues can be addressed through a combination of improvements to the Engineering System, Training and/or ATC / Engineering procedures. For instance it can be entirely appropriate and acceptable, subject to safety considerations, to mitigate a high priority HMI design issue through training and procedural changes, such that it can be managed until a system update removes the issue.

NATS understands that CAD had already planned system updates, training sessions and development of various procedures/plans earlier through its various established task force/working groups. By successfully implementing the changes initiated by CAD and addressing the recommendations raised by NATS, it is expected that the Human Factors and over-all operational readiness will be improved.

Beyond the assessment scope of system readiness and Day 1 transition, there are some recommendations associated with best practice to further enhance system sustainability / maintenance beyond Day 1 transition.

5 Conclusions and Next Steps

NATS has undertaken a short focused review of the operational readiness of the ATMS system at December 2015. The planned Day 1 transition date at the time of the study is June 2016.

NATS considers the outcomes of assessment for System Engineering and Safety Assurance of ATMS to be **Green**, whilst the Human Factors of the ATMS to be **Amber**. The overall Operational Readiness is **Amber**.

NATS has made recommendations, predominantly associated with Human Factors, a number of which are High Priority (necessary to be addressed prior to operational transition). By successfully addressing the recommendations raised by NATS it is expected that the Human Factors and over all operational readiness will be improved. NATS suggests that, following the delivery of this report, considerations be given to:

a) Proactively monitoring NATS recommendations to validate the timely closure of corrective actions planned and proposed by CAD against defined success criteria; and

b) Continuing the Operational Readiness assessment following the delivery, testing and validation of forthcoming system updates of the ATMS to demonstrate convergence to an operational readiness appropriate for a controlled and successful operation transition. With this further work the consultant would, using established metrics, report progress of operational readiness of ATMS against the December 2015 snapshot and also target levels for operational transition.

In completing this report, NATS has compared this significant and complex transition to similar historical NATS transitions, including Heathrow, introduction of iFACTS to the Swanwick Centre, the transition to Prestwick Centre and the current transition at Prestwick to the SESAR iTEC platform. In this context, the scale of change faced by CAD is similar, and parallels exist between the challenges faced by NATS and by CAD. Common across these implementations has been the need to focus on Human Factors assurance across the whole transition period. The Human Factors recommendations raised in this report have parallels with NATS experience of transitions.

NATS would like to thank and commend CAD for the openness and support provided in undertaking and delivering this work. It is clear that staff and management are focused on achieving the successful Day 1 transition through their comprehensiveness and thoroughness of documentation, and preparatory work towards transition to the new ATMS.

5.1 Additional Information / Insight

In addition to the Operational Readiness assessment, two specific issues were raised within our work with CAD associated with the programmatic elements of the transition that are reported below for completeness and further consideration.

Timing of Day 1 transition

The current readiness date for a so-called 'Big-Bang' transition is targeted for June 2016, which coincides with the typhoon season. Staff interviewed raised concerns that their ability to safely operate the new system in high levels of traffic, combined with significant weather deviations, would be compromised.

It was raised by two Operational Supervisors that they had concerns regarding their responsibility for managing workload of staff, using new equipment, with the increased complexity of major weather deviations in their airspace. Additional concerns were raised that significant weather over the South China Sea can re-route entire flows of overflying traffic into Hong Kong airspace causing further workload and complexity during this crucial transition period.

Avoidance of inclement weather and peak air traffic periods through suitable scheduling of transition date for an ATMS is common practice to minimize/avoid unnecessary risk.

CAD therefore should review if rescheduling the transition target date until October/November 2016 as this should significantly reduce the safety risk of increased workload and complexity caused by weather.

Irrespective of timing of the ATCC transition, the potential control measure of ATC Flow restrictions in Hong Kong airspace during transition to reduce traffic levels and workload via Tactical ATC flow, as proposed by CAD, are not considered the only means to contain controllers' workload during transition. NATS' suggests that consideration is given to imposing additional proactive measures, such as reduction in slot allocation, to ensure traffic levels and hence workload is managed appropriately.

Phased Transition – operation transition of Aerodrome Control Tower (TWR)

As another option other than the 'Big-Bang' transition, CAD have considered is the feasibility of Phased Transition approach such as the operation transition of TWR first, and subsequently the ATCC transition after an appropriate period of time. The nature of TWR operation is such that its operation is relatively less susceptible to the impact of weather conditions and it is less operationally dependent on/integrated with the ATCC operations. Compared to the Phased Transition of Approach, Area or TMC sectors, Phased Transition of TWR is expected to require less additional manpower resources, seemingly fewer safety risks and at the same time enhancing staff confidence in the new system. Such an option is of course subject to a safety assessment and relevant transition plan to verify its practicability.

Over the course of this study, CAD have developed an ATC Operation Transition Plan for Hong Kong ATC Centre & ADC Tower. NATS has reviewed this together with the Safety Case Assessment and Reporting System (SCARS) report. The Phased Functional Implementation plan is robust with cases of good practice including checklist driven briefings and practice drills prior to both shadowing activity and the live operational trials. Resources have been planned to include good availability of advisors and co-ordinators that are essential to successful outcomes with the PFI plan.

NATS suggest that CAD continue to assess progress through success criteria on and monitoring of handling unusual events that may occur during shadowing and operational trial sessions. Overall, Hong Kong CAD have presented a logical and well planned activity which has sound practice to enable a successful Phased Functional Implementation of the new Tower capability and a firm basis to move forward to full implementation.

References

1. D1 Methodology Report (Operational Readiness Assessment On New Air Traffic Management System for Transport & Housing Bureau, HKSAR Government) Issue 1.2, 2nd December 2015) NATS Private – Commercial in confidence

APPENDIX 1 – CAD Supplied Documentation

Item	Document
1	Organisation Structure (Project and Operational – Eng and ATC)
2	Project Issue Log – including all (i) issues raised, (ii) open and (iii) close, with date, rationale.
3	Project Deliverables list
4	Project High Level Design document
5	Top Level Project Management Plan
6	Contractor's list
7	User feedback
8	Preliminary draft version of Safety Case for Implementation and Transition of Replacement ATC System Project Ed 1 dd 30 Nov 2015
9	Safety Case Report for Air Traffic Management System Edition 1, 31 December 2015.
10	Manual of ATC
11	Divisional Information Circular
12	Communications Staff Meeting records
13	ATS Management Meeting records
14	Records of project progress briefings for operational and engineering staff
15	Airline briefing sessions records
16	Records of interactions with ATMS Contractors
17	Project SMS for Replacement ATCC – Hazard Log, AES/SMS/2110
18	PLN2/12/4 ATC Services/Replacement of ATC System/General
19	Network failure testing results
20	Target load testing results
21	Flight plan loading testing results
22	Airspace Management Manual (ASMM), Ed 1.2 December 2013, Amendment 2 March 2015, CAD
23	ATMS Hazard Log, HKCAD-ATMS-04-039 2.0 Hazard Log.xlsx
24	Monthly Project Report for ATMS – Project Plan, Programmed and Progress Report
25	Raytheon Response to Questions from 24 April Teleconference with CAD and EC Harris
26	Raytheon Response to further questions sent 22 June 2015. Further questions for Raytheon 23 June 2015 + RTN responses.doc
27	Responses from Raytheon to clarification request sent 19 Aug 2015, Safety case request for clarifications from Raytheon 19-08
28	ATMS Safety Case Checklist
29	List of document references in ATMS Safety Case
30	Assessments on System Readiness of the new ATMS Cyber Security Measures V3
31	Cyber Security Manual for Air Traffic Services (ATS) Systems and Services Edition 2.0
32	Cyber Security Handbook for Air Traffic Services (ATS) Systems and Services Edition 2.0
33	CAD ANS Cyber Security Committee (CACSC) V3
34	CAD ANS Cyber Security Working Group (CACSWG) V3

APPENDIX 2 – Engineering and Safety Assurance Methodology

In support of the readiness activity a System Engineering and Assurance methodology has been used based on a number of contributing factors, primarily:-

- **Standards and Processes:** NATS have developed its engineering lifecycle and assurance processes based on internationally recognised industry standards, recommended practices and guidelines, in particular those employed across Europe.
- **Experience:** NATS has also successfully undertaken a number of large scale Programmes introducing significant changes to the UK Air Traffic Management Systems at Swanwick, Prestwick and Heathrow. The experiences from these Projects and Programmes have been used to inform and improve the NATS Processes.

Based on the contributing factors described above, the method for the Engineering and Assurance review has been to develop and apply a tailored framework of questions and queries associated with the engineering lifecycle, governance and assurance processes as applied in NATS for the delivery of major changes. These processes have been reviewed to extract the key elements applicable to this activity.

The methodology is graphically represented in Figure 2 below. As part of this framework NATS has taken its standard approach to systems performance and verification testing to review the adequacy of technical solution approaches covering pre-visit document reviews and on-site reviews of:

- Verification and validation approach and coverage; and
- Performance testing, soak tests, performance tests, functional testing, non-functional testing, fall-back mode testing.

NATS has also undertaken meeting and documentation-based reviews to assess the robustness and resilience of the solution, in particular:

- Design assurance and software development compliance;
- System architecture and integration to sub-systems;
- Engineering training and procedures, including logistics, supportability and configuration;
- Acceptance, transition and reversion plans;
- Safety, ARM (Availability, Reliability and Maintainability);
- Software assurance review to ED109; and
- Readiness demonstrations and transition plans.

Within the scope of this study, NATS cyber security assessment was a paper-based analysis against international standard for information security ISO 27002 and ICAO Doc 9985 requirements. This standard includes a number of areas as summarised below:

- Organization of Information Security;
- Human Resource Security;
- Asset Management;
- Access Control;
- Cryptography;
- Physical and environmental security;
- Operation Security;
- Communication security;
- System acquisition, development and maintenance;
- Supplier relationships;
- Information security incident management; and
- Information security aspects of business continuity management.

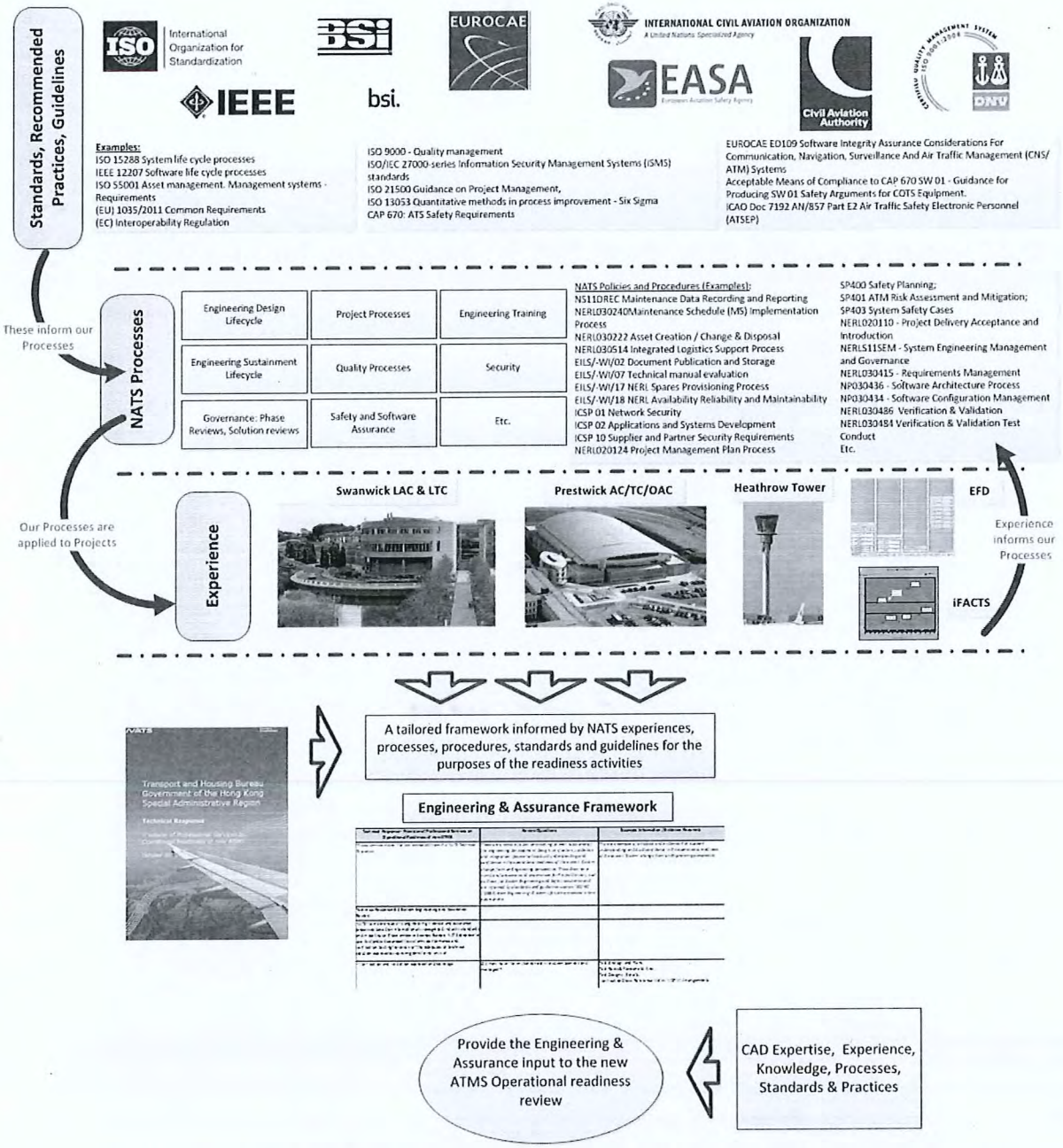


Figure 2- NATS Engineering and Safety Assurance Methodology

Annex B

NATS

Performance through innovation

Transport and Housing Bureau - Hong Kong

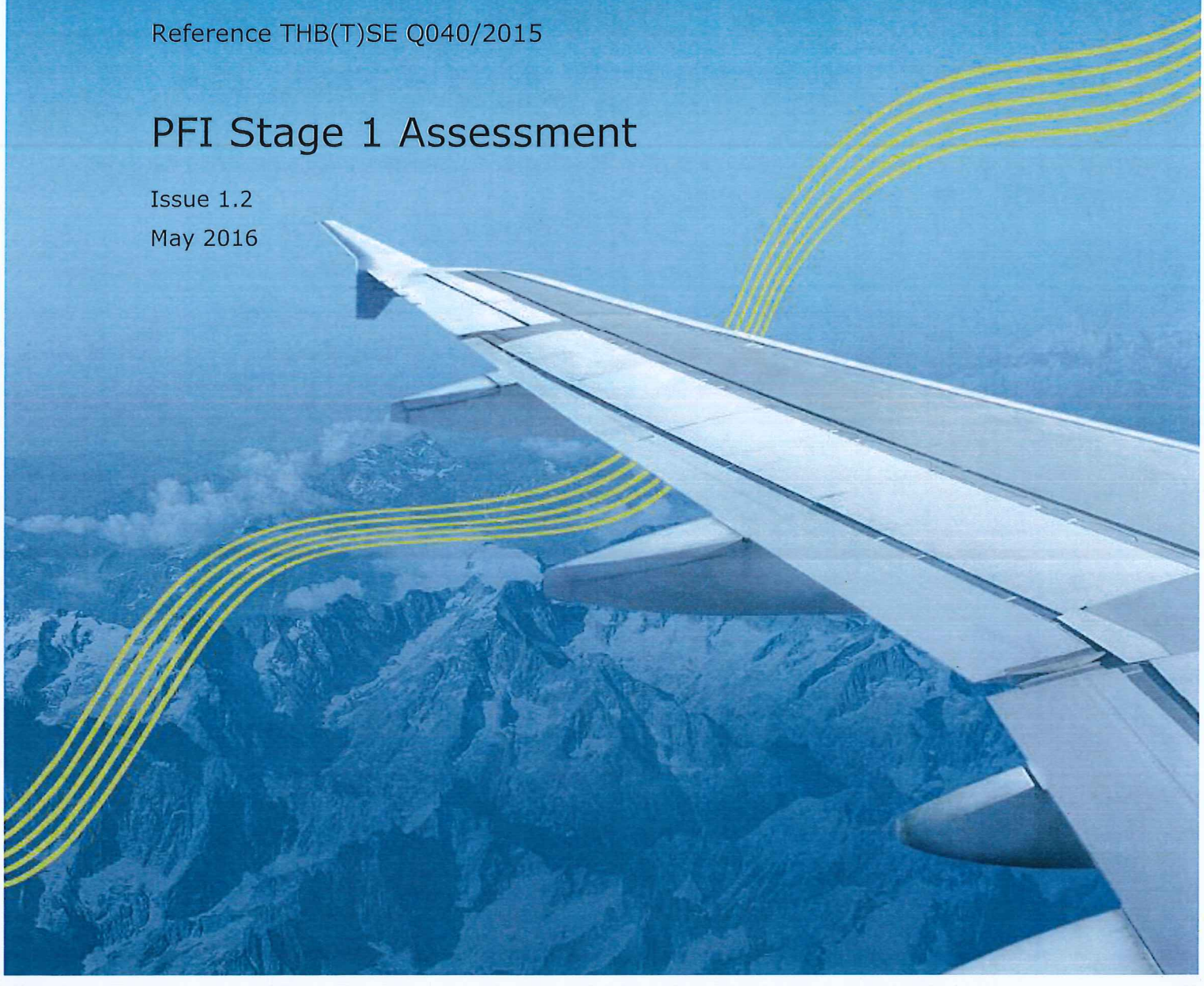
Phased Transition Approach for Air Traffic Management System and Overall Transition Readiness for ATC Replacement System

Reference THB(T)SE Q040/2015

PFI Stage 1 Assessment

Issue 1.2

May 2016



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Executive Summary

1. The Hong Kong Government has commissioned the construction and implementation of a new Air Traffic Management System (ATMS). The new ATMS being installed at the new Air Traffic Control Centre (ATCC) of CAD Headquarters is intended to replace the existing system installed at Air Traffic Control Complex commissioned in 1998.

2. NATS was first engaged by the Transport and Housing Bureau of the Hong Kong Special Administrative Region Government to assess system and staff readiness of the new ATMS based on a "snapshot" review in December 2015 under a "big-bang" implementation. NATS suggested in the study the possibility of a Phased Functional Implementation (PFI) of the new ATMS. CAD accepted NATS' recommended PFI and is using a two-phase transition scheme. Stage 1 of PFI is based on the initial operational transition of the North Aerodrome Control Tower (N-TWR) for limited hours per scheduled day with gradual extension to the remaining positions and adjustment of operational period. This is followed by a similar approach at the new ATCC for various airspace sectors, culminating in the complete transition to full Air Traffic Control (ATC) service with both the N-TWR and the new ATCC covering 24x7 operations (in Stage 2).

3. To support THB and CAD, NATS has been employed to provide independent assessment of the operational readiness of the ATMS system, and also to review and confirm the practicality of the overall PFI scheme and the readiness of the PFI Stage 1 (this report).

4. This study includes an assessment of the overall practicality of the PFI scheme, the readiness of the operational transition of the PFI Stage 1 Configuration, and also an update on the progress made by CAD on NATS' recommendations during the "snapshot" review back in December 2015 (Reference 1). The report is based on documentation made available to NATS between the end of the "snapshot" review up to end April 2016 (with supplementary information provided in early May 2016) and previous documentation and familiarity with the system established in conducting "snapshot" review.

5. Overall, NATS notes that there is a volume of high quality, detailed work providing a significant body of evidence to support all major aspects of the planned PFI. As such NATS believes CAD has an overall robust plan and approach to its ATMS transition. Particular areas of good practice include:

    a. CAD's overall approach to ATC training, planning, and rostering which are thorough and provide a comprehensive body of evidence; and

    b. The ATMS safety case and associated documentation which provide a comprehensive risk assessment and assurance process to undertake the PFI scheme.

6. NATS has made two recommendations to support CAD's planning and delivery of the PFI. These two recommendations are made as a result of this report which is accepted by CAD and corresponding actions have been in place to address them:-

    a. **Recommendation 2.1:** To support the senior management team to maintain and manage the overall progress through the PFI scheme, a single graphic of overall progress (reporting progress, successes, risks and issues) across the people, process, technology, communications and safety assurance should be

created and maintained. NATS believes this will accord greater clarity on CAD's overall status of preparedness, as well as being a method of providing oversight to third party auditors. [NATS notes that CAD has accordingly presented the progress, claim and supporting documentation for the overall PFI practicality in the Claim, Argument, and Evidence (CAE) structure in Appendix B.]

b. **Recommendation 2.2:** Previous experience in NATS of running systems in parallel / shadow mode operations has highlighted the importance of maintaining data integrity between two 'live' systems. Discrepancies between the data sets could potentially affect certain functions. NATS believes particular importance should therefore be placed on confirmation that all data supplied to the N-TWR by any 'shadowed function' is in line with the data at S-TWR. To support this, NATS proposes a specific activity and success criterion within the PFI Stage 1 Configuration plan for a shadowing activity prior to the initial PFI session and a specific objective/success criterion of each PFI session to ensure data integrity across the two 'live' systems is continuously monitored. NATS noted and is satisfied that:

   i. CAD has been implementing respective supporting equipment, trained staff, as well as procedures to carry out on-going data integrity checks to monitor and maintain data integrity between the two "live" systems; and

   ii. CAD has consolidated the engineering / technical documentation supporting equipment, staffing, procedures and mechanisms for data checking with defined follow-up actions recorded.

7. Previous analysis raised recommendations for CAD to address. NATS has found that, as a result of the continued good work within the CAD delivery, all recommendations for the purposes of PFI Stage 1 configuration have been addressed. It is also noted that CAD has been addressing the remaining recommendations that do not affect the PFI Stage 1 and are on track for closure. NATS will conduct a further review during Stage 2 assessment as planned.

8. In undertaking this review, NATS has conducted analysis for a total of 12 elements in 4 key aspects listed below (see Section 3.2 for details):

   a) The overall practicality of the PFI Scheme;
   b) Integrity and Validation of Safety Documentation in support of PFI (including the ATMS Safety Case);
   c) ATC / Engineering Procedures and Contingency; and
   d) ATC / Engineering Training.

9. NATS concludes that 10 of these elements have been duly addressed and closed. For the remaining 2 elements, which are considered "living documents", their finalisation depend on the timing of on-going processes and activities. NATS notes that the finalisation process is under control and within the established process of CAD. Accordingly, finalisation, review and closure of these 2 elements are expected prior to commencement of PFI Stage 1.

10. NATS notes that CAD, based on NATS' suggestion and CAD's own assessment on the overall system and operational readiness of the new ATC system, has decided to adopt a PFI approach incrementally from June 2016 onwards. This approach to commence PFI at N-TWR would minimise the impact from weather while allowing more time for ATC staff to familiarise themselves with the system's functions and

operations in phases, and help minimise the risk of providing full functional services in October/November2016.

11. Phased introductions of major system changes are used as standard practice within NATS, utilising 'shadowing' and live 'operational services', within a defined and well-controlled operating environment (COE) under the International Civil Aviation Organisation (ICAO) Safety Management Regime.

12. NATS compliments CAD on the amount of work carried out to a detailed level in preparation for PFI. NATS believes CAD has an overall robust, achievable plan and approach to the phased transition of the new ATMS. The body of evidence provided to NATS has demonstrated that CAD is addressing the PFI scheme in a practical and complete manner. As CAD has presented the progress, claim and supporting documentation for the overall PFI practicality according to the CAE model, NATS is satisfied that CAD is on track to commence in June 2016.

Table of Contents

SECTION 1: Introduction

1.1 Document Scope

The Hong Kong Government has commissioned the construction and implementation of a new Air Traffic Management System (ATMS). The new ATMS being installed at the new Air Traffic Control Centre (ATCC) of CAD Headquarters is intended to replace the existing system installed at Air Traffic Control Complex commissioned in 1998.

CAD's operational readiness and transition strategy has evolved, and as a result CAD is now planning on the basis of a phased transition. The phased transition scheme, hereafter called Phased Functional Implementation (PFI), is based on the initial operational transition of the North Aerodrome Control Tower (N-TWR) for limited hours per scheduled day with gradual extension to the remaining positions and adjustment of operational periods (Stage 1). This is followed by a similar approach at the new ATCC for various airspace sectors, culminating in the complete transition to full Air Traffic Control (ATC) service with both the N-TWR and the new ATCC covering 24x7 operations (Stage 2).

This document assesses the overall readiness and practicality of the operational transition of the N-TWR within the PFI scheme by reviewing, including but not limited to, the aspects of safety, ATC procedures, contingency procedures, training, maintenance and supporting safety documentation covered under the ATMS Safety Case Report and the relevant safety documents supporting transition readiness of PFI.

This document represents the Stage 1 assessment for the Tower Phased Functional Implementation. Section 2 provides the high level description of the PFI Stage 1 Configuration, and Section 3 provides the detailed assessment of the different elements of the Stage 1 configuration. Section 4 concludes the report and provides the outcomes and best practice guidance.

SECTION 2: PFI Configuration

2.1 Stage 1 High Level Description

The phased transition strategy to the new ATMS is based on two Stages. This document focuses on the PFI Stage 1 configuration.

The PFI Stage 1 configuration allows ATC executive control to be provided by the North Tower (N-TWR), whilst the area control executive control is provided by the existing Area Control Centre (ACC). In order to provide the data to the N-TWR, the new ATMS is running in parallel to the current ACC, with ATC staff inputting data to the new ATMS to ensure that the system and staff in the N-TWR have the appropriate data to provide the service. In this configuration the current South-Tower (S-TWR) provides the hot stand-by (contingency) to the N-TWR i.e. S-TWR is on 'shadowing' mode during the designated hours on scheduled days. In order to enter this configuration there are clear entry criteria and exit criteria. This configuration is summarised in Figure 1 below.

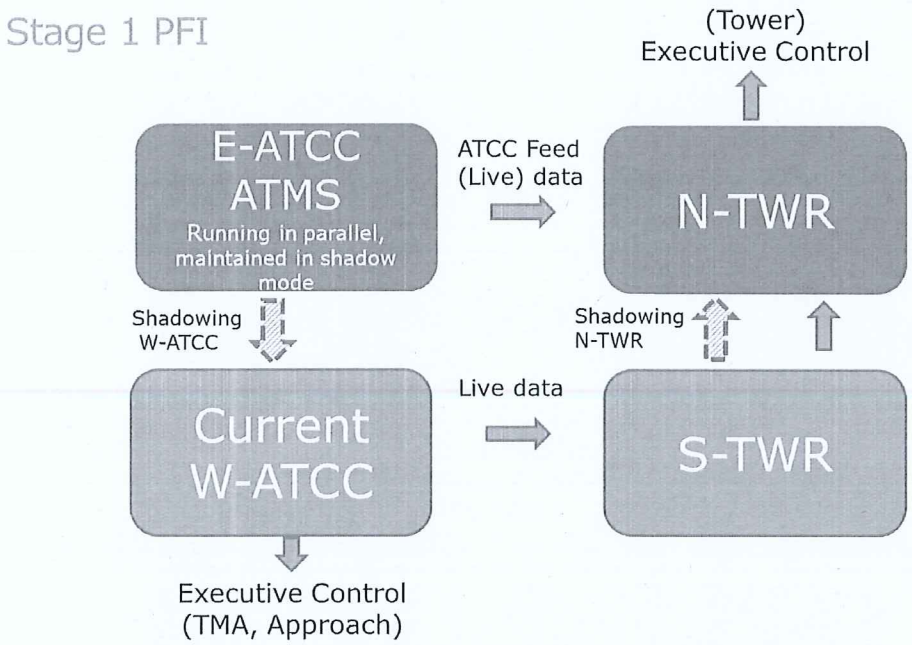

Figure 1

Within the PFI Stage 1 configuration, a number of sessions are planned, with the precise timing and nature of those sessions under active review (depending on the defined entry criteria such as meteorological conditions).

SECTION 3: Analysis of PFI Stage 1 Configuration

3.1 Methodology

The analysis is based on documentation made available to NATS between the end of the "snapshot" review of Phase 1 study in December 2015 and up to end April 2016 (with supplementary information provided in early May 2016) and previous documentation and familiarity with the system established in delivery of Phase 1 study.

Within the analysis NATS was tasked to respond to the following 4 key aspects:

- The overall practicality of the PFI Scheme;
- Integrity and Validation of Safety Documentation in support of PFI (including the ATMS Safety Case);
- ATC / Engineering Procedures and Contingency; and
- ATC / Engineering Training.

Supporting points, in the form of questions, being used to assess these aspects within the study are detailed in Appendix A. Where applicable the review is also supported by information and evidence from previous activities from the Operational Readiness Review of ATMS undertaken in December 2015. Each of these points will be discussed in Section 3.2, highlighting key findings from the documentation review, and associated points that need clarification from CAD as well as CAD's corresponding responses, which include clarification, additional information and/or action from CAD.

The review was achieved through assessing the following:

- Safety and related safety documentation;
- ATC procedures;
- Resourcing Plans;
- Contingency Procedures;
- Training;
- Maintenance and Engineering procedures; and
- Documents supporting transition readiness of PFI.

NATS has assessed the integrity, reasonableness, implementation of CAD's responses and, if outstanding, the potential impact for such items on PFI Stage 1 and the overall PFI scheme. This information is provided under the "Summary of Documentation Review" column. The assessed result of such items is registered under the "Status" column.

3.2 Overall Practicality of PFI Scheme

Ref	Question	Summary of Documentation Review	Status
S1.1	Are Resourcing Plans for all (ATC) required positions in place?	**Consideration**: A staffing plan, with detailed arrangements, for PFI sessions has been produced. Detailed plans are in place for PFI Stage 1 sessions. **Assessment**: NATS views that the plans are in place and the ATC staffing plan is robust.	CLOSED
S1.2	Are Resourcing Plans for all (Engineering) required positions in place?	**Consideration**: An Engineering resource plan equivalent to the ATC Resource Plan for PFI has been produced. The information provided for Engineering resource relates to the manpower resources required to support the transition and technical staff needed for PFI sessions in Stage 1. **Assessment**: NATS views that the plans are in place and the ATC staffing plan is robust.	CLOSED
S1.3	Are there problem raising and tracking linked to the appropriate phase of implementation ?	**Consideration**: The CAD Transition Review meeting includes both ATC and engineering representation. NATS also notes that a single database is employed, which CAD manages and prioritises issues associated with PFI for information integrity, timeliness and correctness. **Assessment**: NATS views that such a process is in place and effective.	CLOSED
S1.4	Is there a lesson learning review process in place for each PFI?	**Consideration**: The process is in place to review and manage lessons learnt, if any. This includes high level success criteria and specific success criteria defined for each session. **Assessment**: NATS views that such a process is in place and effective.	CLOSED
S1.5	Does the plan of activity have clear scope, timing and deliverables / success criteria? *(Does the plan of activity have clear equipment and test dependencies, scope, timing and deliverables / success criteria?)*	**Consideration**: There are details of the processes to be used for the PFI Stage 1 – these cover the pre-PFI activities and the processes used to confirm equipment availability and readiness. The processes include Engineering representation via the Responsible Officer (RO) of equipment (AESD/ATMD), the engineers and procedures. In relation to the equipment and test dependencies, the ability of the ATMS to be used for shadowing and provision of feed data is supported by previous shadowing experience. It is recognised that some of these documents are by nature "living documents" and require base lining and/or updates for PFI Stage 1. The confidence in the ATMS to support the Tower EFPS functionality for PFI Stage 1 and other functionality is further improved by subsequent software builds verification, validation evidence and additional test evidence. There are a number of on-going minor technical aspects being tracked and resolved in subsequent build verification tests via regular meetings on the Phased Transition Approach, which are part of the established processes. **Assessment**: CAD is in action to ensure that documents that are "living" by nature are finalised, updated if necessary, and	IN PROGRESS AND ON TRACK FOR PLANNED STAGE 1 PFI

		communicated before commencement of the PFI Stage 1 Configuration, as per normal CAD process. Noting the comprehensive nature and overall readiness of these documents, NATS is satisfied that the item is on course to closure subject to the final review prior to commencement of PFI to be registered in the updated Report.	
S1.6	Does the plan of activity have clear scope, timing and deliverables / success criteria? *(Does the plan of activity have clear scope, timing and deliverables / success criteria for completion of safety assurance)*	**Consideration**: The processes for entering and establishing the PFI Stage 1, which include checks to ensure the required safety management activities, have been satisfactorily completed. It is recognised that some of these documents are by nature "living documents" and require base lining and/or amendment for PFI Stage 1. **Assessment:** CAD is in action to ensure that documents that are "living" by nature are finalised, updated if necessary, and communicated before commencement of the PFI Stage 1 Configuration, as per CAD established process. By the degree of completeness of such documents, NATS is satisfied that the item is on course to closure subject to the final review prior to commencement of PFI.	IN PROGRESS AND ON TRACK FOR PLANNED STAGE 1 PFI

3.3 Integrity and Validation of Safety Documentation in support of PFI (including ATMS Safety Case)

Ref	Question	Summary of Documentation Review	Status
S1.7	Have safety documentation and the relevant supporting documents been reviewed for their integrity and validity?	**Consideration**: Safety Case Assessment Reports (SCARS) have been made available and these follow the CAD Safety Management System process. The SCARS undertaken include the record of the Subject Matter Experts (SMEs) involved. There are a comprehensive set of SCARS made available as part of this review. It is noted that confidence is gained as CAD has identified the requisite areas using the related Project and Transition mechanisms and associated forums. The majority of these elements are available for the PFI Stage 1, though they are spread across a large number of documents, which makes the assessment of completeness and robustness challenging. To address this CAD has now developed a single graphical argument for PFI that shows how each element comes together to form a complete picture of the assurance (see Appendix B). This is reflected in Recommendation 2.1. **Assessment**: With the action taken by CAD in the preceding paragraph, NATS views that this item is closed.	CLOSED

3.4 ATC / Engineering Procedures and Contingency

Ref	Question	Summary of Documentation Review	Status
S1.8	Are Plans for both Transition into and reversion from PFI sessions robust? (ATC)	**Consideration**: The reversion to the normal system is deemed to be the reverse of the transition, either at the planned time or due to a contingency situation. The ability to revert has been considered in the ATC Operational Transition Plan and the SCARS. The advanced publishing of the specific transition and reversion procedures, such as coordination with approach, CDC and use of the speakers are established normal practice in CAD. **Assessment**: NATS views that such plans are in place.	CLOSED
S1.9	Are Plans for both Transition into and reversion from PFI sessions robust? (Engineering)	**Consideration**: The reversion to the normal system is deemed to be the reverse of the transition, either at the planned time or due to a contingency situation. The ability to revert has been considered in the ATC Operational Transition Plan and the SCARS. CAD has reviewed the overall documentation to ensure that roles and titles for those responsible for calling off the PFI and reverting are clearly defined and consistent. **Assessment**: NATS views that this item is closed.	CLOSED
S1.10	Are the ATC Procedures identified for PFI and implemented as required?	**Consideration**: Safety assurance is provided in SCARS Report Operational Trial of the new ATMS in the North Air Traffic Control Tower **Assessment**: NATS views that this item is closed.	CLOSED

3.5 ATC / Engineering Training

Ref	Question	Summary of Documentation Review	Status
S1.11	Are ATC procedures, contingency procedures and ATC training in place?	**Consideration**: OPS Transition procedures will be published in advance to allow controllers to become familiar with them prior to OPS Transition. These procedures will enable controllers to brief themselves, feel comfortable with their ability to perform OPS Transition and have the opportunity to ask questions of the OPS Transition experts prior to the session. Paper copies of these procedures should be provided at all CWPs in case staff need to refer to them during OPS Transition. The Training Plan for the tower controllers has been provided. **Assessment**: NATS views that this item is closed.	CLOSED
S1.12	Are engineering procedures, contingency procedures and engineering training in place?	**Consideration**: Engineering and technical staff have undertaken training courses to maintain and support the systems associated with PFI stage 1; with 21 competent technical staff dedicated to the new ATMS available to support the PFI commencing June 2016. Consideration has been given to providing an Engineering and Technical staff briefing, including PFI Stage 1 specific training or familiarisation for Engineering and Technical staff. CAD has provided the plan for Engineering training (Training Plan 2016 Rev 1 (PFI)) and briefing presentation. Any Temporary Operating Instructions required will be issued and briefed as per CAD established processes. **Assessment**: NATS views that the procedures are in place.	CLOSED

SECTION 4: Conclusion, Outcomes and Best Practice Recommendations

Phased introduction of major system changes is a standard practice within NATS using 'shadowing' and live 'operational services' within defined and constrained operating environments (COE). The approach has been applied to

- iFACTS – the introduction of controller tools and removal of paper flight strips to London Area Control;
- New Prestwick Centre – the transition of Area, Terminal, Oceanic and Military Control Operations;
- Electronic Flight Data (EFD) – the introduction of new controller tools and removal of paper flight strips; and
- Prestwick Upper Airspace – the introduction of new Controller tools and Flight Data Processing.

NATS has completed an assessment of the overall practicality of the PFI scheme, the readiness of the operational transition of the PFI Stage 1 Configuration, and also an update on the progress made by CAD on recommendations made by NATS during the "snapshot" review back in December 2015. The analysis is based on documentation made available to NATS between the end of "snapshot" review up to end April 2016 (with supplementary information provided in early May 2016) and previous documentation and familiarity with the system established in conducting "snapshot" review.

Overall, NATS notes that there is a volume of high quality, detailed work providing a significant body of evidence to support all aspects of the planned PFI. It is also noted that CAD has been addressing the remaining recommendations resulting from the "snapshot" review that do not affect the PFI Stage 1 and are on track for closure. NATS will conduct a further review during Stage 2 assessment as planned. As such, NATS believes CAD has an overall robust plan and approach to their ATMS transition. Particular areas of good practice include:

- CAD's overall approach to ATC training, planning, and rostering which are thorough and provide a comprehensive body of evidence; and
- The ATMS safety case and associated documentation provide a comprehensive risk assessment and assurance process to undertake the PFI scheme.

In noting the areas of good practice NATS has made two recommendations to support CAD's planning and delivery of the PFI.

a. **Recommendation 2.1:** To support the senior management team to maintain and manage the overall progress through the PFI scheme, a single graphic of overall progress (reporting progress, successes, risks and issues) across the people, process, technology, communications and safety assurance should be created and maintained. NATS believes this will accord greater clarity on CAD's overall status of preparedness, as well as being a method of providing oversight to third party auditors. [NATS notes that CAD has accordingly presented the progress, claim and supporting documentation for the overall PFI practicality in the Claim, Argument, and Evidence (CAE) structure, in Appendix B.]

b. **Recommendation 2.2:** Previous experience in NATS of running systems in parallel / shadow mode operations has highlighted the importance of maintaining data integrity between two 'live' systems. Discrepancies between the data sets could potentially affect certain functions. NATS believes particular importance should therefore be placed on confirmation that all data supplied to the N-TWR by any 'shadowed function' is in line with the data at S-TWR. To

support this NATS proposes a specific activity and success criterion within the PFI Stage 1 Configuration plan for a shadowing activity prior to the initial PFI session and a specific objective/success criterion of each PFI session to ensure data integrity across the two 'live' systems is continuously monitored. NATS has noted and is satisfied that:

i. CAD has been implementing respective supporting equipment, trained staff, as well as procedures to carry out on-going data integrity checks to monitor and maintain data integrity between the two "live" systems; and

ii. CAD has consolidated the engineering / technical documentation supporting equipment, staffing, procedures and mechanisms for data checking with defined follow-up actions recorded.

The body of evidence provided to NATS has demonstrated that CAD is addressing the PFI scheme in a practical and complete manner. As CAD has presented the progress, claim, argument and supporting documentation for the overall PFI practicality, NATS is satisfied that CAD is on schedule for the PFI Stage 1.

References

Reference	Title
1.	Operational Readiness Assessment of the New Air Traffic Management System, D2 Final Report (Issue 1.2, 15/03/2016)

Appendix A: Stage 1 Analysis

Required Phase 1 Study Scope	Supporting Questions
Practicality of the Overall PFI Scheme	Are Resourcing Plans for all required positions (ATC and Engineering) in place?
	Are there problems raising and tracking linked to the appropriate phase of implementation?
	Does the plan of activity have clear scope, timing and deliverables / success criteria?
	Is there a lesson learning review process in place for each PFI?
Integrity and Validation of Safety Documentation in support of PFI	Have safety documentation and the relevant supporting documents been reviewed for their integrity and validity?
ATC / Engineering Procedures & Contingency	Are ATC / engineering procedures changes identified for PFI and implemented as required;
	Are Plans for both Transition into and reversion from PFI sessions robust?
ATC / Engineering Training	Are ATC / engineering procedures, contingency procedures, ATC and engineering training in place?

Appendix B: PFI Claim, Argument, Evidence (CAE) Structured Notation

An 'example' generic structure for the PFI Stage 1 N-TWR Operations.