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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.

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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 user groups (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.

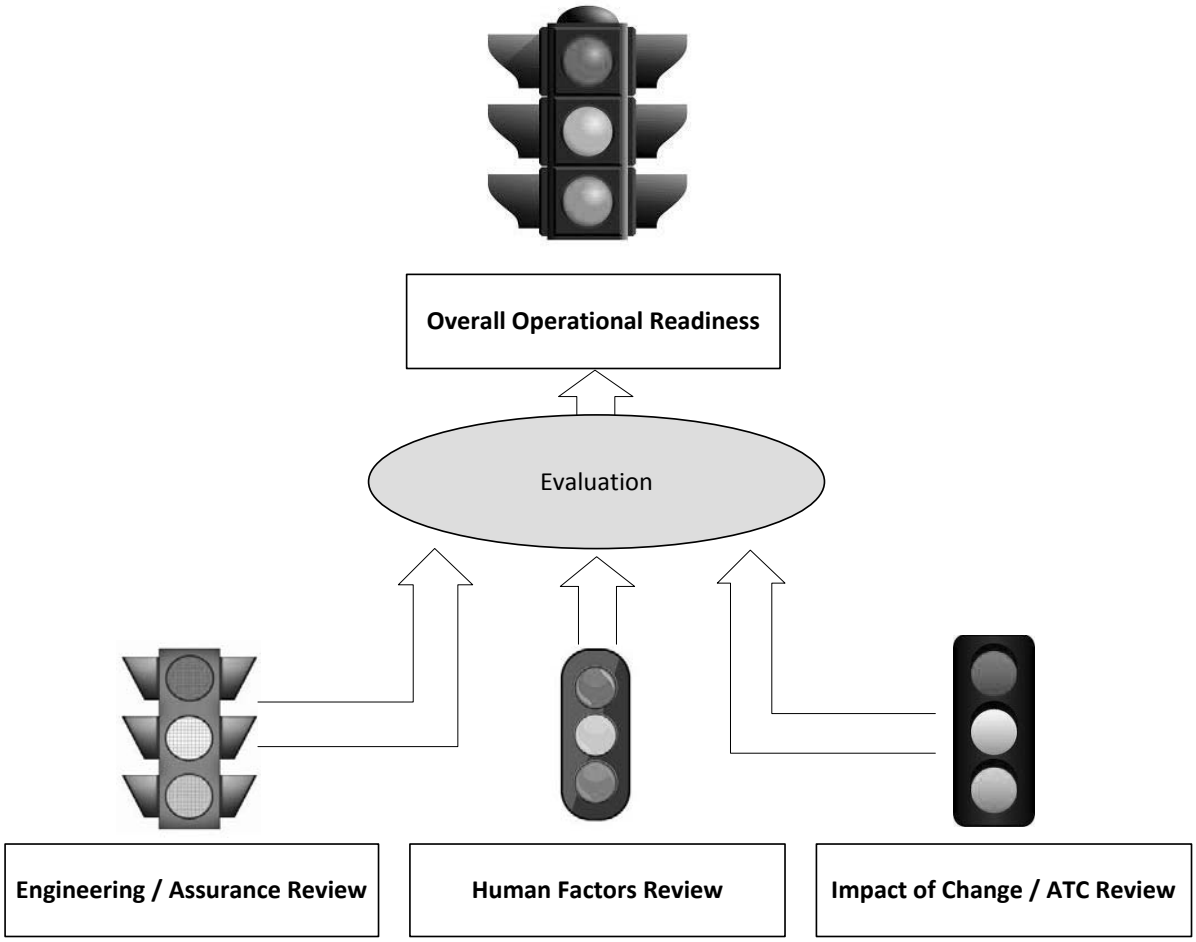

Figure 1 – NATS Assessment Methodology

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	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.	highlight does not exist 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.	**High**	**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.	Medium	**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	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	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	High	**High** **Recommendation Closed**

distance between the aircraft as shown by the RBL fluctuates, controllers will find it difficult to make correct judgements.		reliable.	judgement issues during the last 17 years. The impact of this change will be monitored closely.		
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	High	**High**

			been incorporated in Module 4 training.		
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.	Medium	**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.	Medium	**High**
Crucial information was observed not being transferred during sector handovers between controllers. This should be	REC 20 (HF)	System software fix to resolve the loss of free text during sector handovers	To meet the unique operational setup for CAD, simultaneous inputs/changes to the same aircraft	High	**High**

completely rectified prior to ATC operation under live environment.		or an interim, procedural solution such as leaving this position permanently logged on without user handovers	by different controllers is not accepted by the system in the current 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

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.

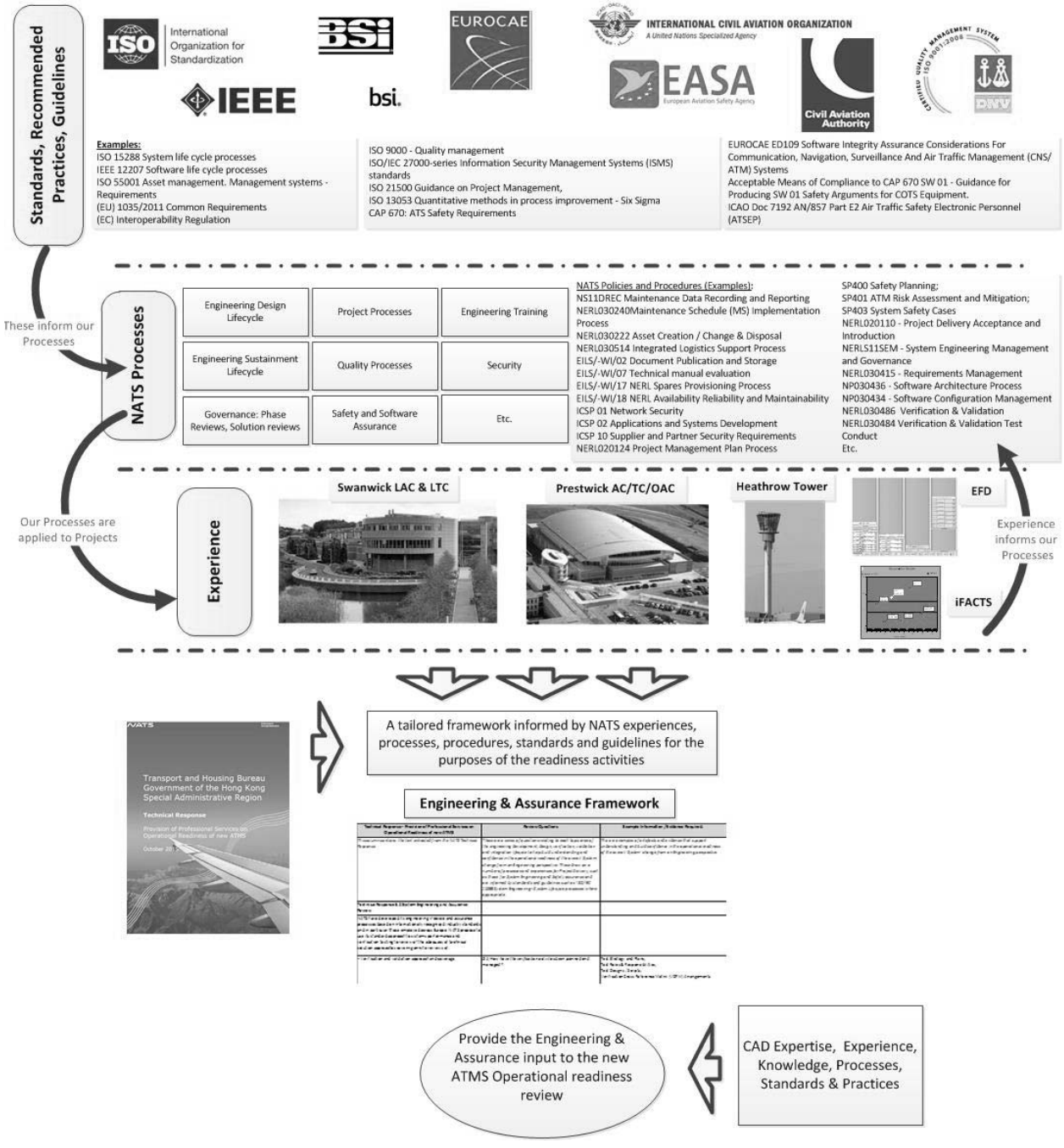

Figure 2- NATS Engineering and Safety Assurance Methodology