Project CLAIRE Demonstration Report

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Abstract

This document describes the Project CLAIRE RPAS demonstration approach and methodologies, aimed at addressing key issues associated with the routine and safe integration of RPAS into a mixed traffic, non-segregated environment. The partners decided to adopt a challenging yet very realistic approach to air traffic insertion by utilising an unmanned tactical UAV operating within the existing airspace structure and ATM operating procedures. A series of incremental Modelling, Simulation & Synthetic Environment (MS&SE) exercises were conducted with external stakeholders to reduce risks, raise awareness and build knowledge. This was followed by live flights of an unmanned RPAS in non-segregated airspace.

Document History

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Executive summary

This document is the Project CLAIRE Demonstration Report co-authored by Thales, NATS and Netherlands Aerospace Centre (NLR). The report describes the overall approach adopted by CLAIRE to investigate how UAS may be safely inserted into non-segregated, controlled airspace. The selected unmanned aerial system (often referred to as RPAS or 'drone') was the UK Watchkeeper system which achieved MAA certification in 2013 and subsequent 'release to service' with the British Army in early 2014. The Watchkeeper system has routinely flown in UK segregated airspace since 2010 and currently operates from airfields in West Wales and Southern England.

The scope of Project CLAIRE was intentionally ambitious, designed to 'push the boundaries' with a declared objective to operate a certified unmanned aircraft in controlled and non-segregated airspace. Air traffic controllers successfully interacted with RPAS pilots in a remote ground control station with normal voice communications using standard VHF radio relayed via the air vehicle. It was also a key requirement to integrate the RPAS within controlled airspace which was relatively busy and occupied by manned aircraft under NATS control. An existing airway L9 (or Lima 9), which carries regional and oceanic traffic over South Wales, was used due to its representative traffic density and proximity to the West Wales trials area complex which is one of the normal operating bases for Watchkeeper flights in the UK.

An extensive, and very informative, programme of high-fidelity simulation exercises was undertaken to verify ATM procedures and unexpected behaviours associated with the approach and landing of RPAS in a mixed traffic environment and also flight of RPAS in mixed traffic non-segregated airspace. Scenarios exercised both normal operations and contingency (emergency) situations with findings used to optimise ATC and RPAS operating processes as well as de-risk live RPAS flights.

To ensure that the overarching safety objective ("UAS should be no more hazardous than the equivalent manned aircraft operating in the same airspace") was achieved; a significant amount of effort was expended working with the civil and military regulatory authorities (CAA & MAA). It was necessary to develop an acceptable Safety Case for both Watchkeeper flight in non-segregated airspace as well as for provision of ATC separation assurance services within the airspace itself. NATS were responsible for airspace safety assurance which was applied using the NATS ATC Safety Analysis process as well as issuing Temporary Operating Instructions (TOI) which were approved by the UK CAA. Draft ATM processes and procedures were refined and optimised in the simulation facilities to mitigate any procedural gaps, hazards or risks associated with RPAS operations.

The Thales Flight Operations Organisation (FOO) is responsible for operating Watchkeeper on a Military Flight Test Permit (MFTP) for development purposes. Similarly, a revised Trials Risk & Hazard Assessment (TRHA) process was undertaken (and approved by the Type Airworthiness Authority) to address the additional complexities of flying in non-segregated airspace. The assessment process covered aspects such as ATC interaction; aircrew licensing and platform CNS equipment. The process included the generation of a Waiver (approved by the MAA) to meet Regulatory Articles (RA) associated with the current non-availability of an approved RPAS detect-and-avoid system without recourse to an on-board safety pilot. Flights were authorised subject to:

- Provision of a full ATC service at all times and ATC separation for IFR operation
- No flight in non-segregated uncontrolled airspace, even in the event of catastrophic failure
- Establishment of a Temporary Danger Area, below the airway, with ANSP controlled access to mitigate against air vehicle descending out of Class A airspace in emergency situations

A number of significant challenges were successfully overcome in areas such as securing acceptable insurance premiums for the platform and third-party liability as well as developing new Instrument Rating (IR) approvals for RPAS pilots operating in non-segregated controlled airspace. The flight trials attracted enormous interest on a local, national and European scale. The feedback was extremely encouraging with compelling evidence that that it is indeed possible to safely integrate and control RPAS in non-segregated airspace alongside manned aircraft. There is still work to be completed but there is enormous potential for safe, routine and economically viable unmanned flight using larger and more capable platforms. The project satisfied the primary objectives of the CLAIRE Demonstration Plan with several work opportunities identified to progress the boundaries of RPAS airspace integration in the near-term.

1 Introduction

Project CLAIRE was aimed at examining the issues regarding ATM and flying operations associated with the introduction of RPAS into civil airspace. This was undertaken as a series of complementary and incremental demonstration exercises, which offered the opportunity to validate assumptions and further develop procedures based on their findings:

- Ground and TMA RPAS operations based on a mixed-traffic medium-sized airport
- En-route RPAS operations
- Live RPAS flights in non-segregated airspace

The demonstrations exercises were undertaken using synthetic and live environments and allowed the investigation and assessment of:

- Ability of standard ATM procedures to manage unmanned RPAS operations
- Interaction between RPAS Pilot and ATCOs
- Interaction between ATM sectors for RPAS operations
- Contingency management processes and procedures for RPAS
- RPAS and ATCO workloads

These exercises were complemented with studies related to RPAS operations: safety, capacity, efficiency, airport integration & terminal airspace throughput, security, regulatory and collision avoidance.

1.1 Glossary of Terms

GCS Handover: A handover from one ground control station to a second physically remote ground control station. This is done to ensure continuous radio contact with the associated command and control requirements as the air vehicle transits the airspace. The handover follows a formal procedure which ensures that one GCS is in control of the air vehicle at all times.

Hybrid Rig: A very high fidelity hardware-in-the-loop real-time system/simulator using real RPAS hardware and providing a highly realistic environment for pilot training and to validate emergency procedures.

Lost Link Route: A route that the air vehicle would automatically adopt if the command and control link between the pilot and the air vehicle is not operational. This can be adopted immediately on detection of a link failure, or after a period allowing for re-establishment of communications.

Regulatory Article: The UK MAA uses a series of Regulatory Articles [1] which aim to:

- Reflect state of the art and global good practice in the field of air operations.
- Take into account worldwide aircraft experience in service, scientific and technical progress.
- Be risk-based and proportionate.

The regulatory articles are divided into 5 series addressing all aspects of flight:

- 1000 series: General Regulations
- 2000 series: Flying Regulations
- 3000 series: Air Traffic Management Regulations
- 4000 series: Continuing Airworthiness Engineering Regulations
- 5000 series: Design and Modification Engineering Regulations

SESAR Programme: The programme which defines the Research and Development activities and Projects for the SJU.

SJU Work Programme: The programme which addresses all activities of the SESAR Joint Undertaking Agency.

1.2 Acronyms and Terminology

Term	Definition
ACAS	Airborne Collision Avoidance System
ACC	Area Control Centre
ACPO	Aircraft Control Position Operator
AFPEx	Aeronautical Flight Planning Exchange (Service)
AIC	Aeronautical Information Circular
ANSP	Air Navigation Service Provider
APP	Approach
APSA	ATC Procedures Safety Analysis
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
ATM	Air Traffic Management
BLOS	Beyond Line-of-Sight
CAA	Civil Aviation Authority (UK)
CAIT	Controlled Airspace Infringement Tool
CANP	Civil Airspace Notification Procedure
CAS	Controlled Airspace
CFAOS	Contractor Flying Approved Organisation Scheme
CIAL	Cardiff International Airport Ltd
CONOPS	Concepts of Operation
CPL	Commercial Pilot License
CRONUS	Call-sign used by the trials RPAS
CTA	Control Area
CTC	Corporate and Technical Centre
CTR	Control Zone
CLAIRE	CiviL Airspace Integration of RPAS in Europe
CONOPS	Concepts of Operation
D&A	Detect & Avoid
iCWP	Integrated Controller Working Position
EGGD	Bristol Airport
EGFF	Cardiff International Airport
EHRD	Rotterdam Airport
ELSS	Emergency Strip Landing Site (soft landing)
ERP	Emergency Recovery Position (hard landing)
ERL	Emergency Recovery Location (can be ELSS or ERP)
ETA	Estimated Time of Arrival
EVLOS	Extended Visual Line-of-Sight
EXE	Exercise
FAB	Functional Airspace Block
FIR	Flight Information Region
FL	Flight Level

Term	Definition
FOO	Flight Operations Organisation
GCS	Ground Control Station
HALE	High Altitude, Long Endurance
HMI	Human-Machine Interface
iFACTS	Interim Future Area Controls Tools Support
IFR	Instrument Flight Rules
KPA	Key Performance Area
LACC	London Area Control Centre
LAS	Local Area Supervisor
LLR	Lost Link Route
LTMA	London Terminal Manoeuvring Area
MAA	Military Aviation Authority (UK)
MALE	Medium Altitude, Long Endurance
MASPS	Minimum Aviation System Performance Standard
MCA	Maritime & Coastguard Agency (UK)
MDAL	Master Data assumption List
MFOC	Manual of Flying Orders for Contractors
MFTP	Military Flight Test Permit
MoD	Ministry of Defence (UK)
MOPS	Minimum Operational Performance Standard
MUST	Multi-UA Supervision Testbed
NARSIM	NLR ATC Research Simulator
OAT	Operational Air Traffic
OFA	Operational Focus Areas
R/T	Radiotelephony
RA	Regulatory Article (see Glossary of Terms)
RA(T)	Restricted Airspace (Temporary)
RAC	Range Area Control
RCF	Radio Communications Failure
RLOS	Radio Line-of-Sight
ROC	Rate of Climb
RPA	Remotely Piloted Aircraft
RPAS	Remotely Piloted Aircraft System
RTF	Radio Telephony
S06	Sector 06 (ATC Sector)
S08	Sector 08 (ATC Sector)
SATCOM	Satellite Communications
SESAR	Single European Sky ATM Research Programme
SID	Standard Instrument Departure
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SSR	Secondary Surveillance Radar

Term	Definition
STAR	Standard Terminal Arrival Route
TAA	Type Airworthiness Authority (UK Military)
TDA	Temporary Danger Area
TOI	Temporary Operating Instruction
TMA	Terminal Manoeuvring Area/Terminal Control Area
TRHA	Trials Risk & Hazard Analysis
TWR	Tower
UAS	Unmanned Aerial System
UAST	Unmanned Aerial Systems Team (UK MoD)
UAV	Unmanned Aerial Vehicle
UKFDB	UK Flight Database
VFR	Visual Flight Rules
VHF	Very High Frequency
VLOS	Visual Line-of-Sight
WWA	West Wales Airport
Wx	Weather/Meteorological Conditions
XPDR	Transponder

2 Context of the Demonstrations

2.1 Scope of the Demonstration and Complementarity with the SESAR Programme

The demonstrations described in this document were designed to address the key issues identified with the flight of RPAS through civil airspace in accordance with the agreed demonstration plan [2]. They were based upon the project requirements and the collective experience of the partners and utilised a series of tools and demonstration media in order to demonstrate RPAS issues and possible approaches in the most appropriate, efficient and safe manner.

In particular, the following areas were examined in relation to RPAS operations:

- SESAR Compliance: All the demonstrations were conducted in cognisance of the SESAR ATM methodology, and focussed on the specific issues raised by the introduction of RPAS.
- Regulatory & Safety: The project addressed regulatory and safety issues associated with the flight of RPAS in civil airspace through the continuation of on-going dialogue with the UK CAA. This dialogue identified the nature and scope of activities or processes required in order to achieve safe and fully regulatory compliant flight trials.
- Network Integration: This addressed the effect of potentially lower performance RPAS on the Air Traffic Management service and developed procedures for use in all flight phases. This included the exchange of 4-D trajectory information between the ATCO, RPAS air vehicle and the Ground Control Station (GCS).
- Human Factors: The demonstrations allowed an analysis of the effects of RPAS in a mixed traffic environment on the work load of ATCOs, together with an assessment of terminology and phraseology.
- Command Control and Communications: This addressed the requirements to rebroadcast ATC instructions between the air vehicle and the GCS. It also addressed communications required for command and control of the air vehicle considering aspects such as timeliness; throughput; and RPAS operations in the absence of an operational control link.
- Detect & Avoid: This considered the impact of both human-in-the-loop and automated avoidance systems and the effect this may have on the Air Traffic Management system.
- Contingency Planning & Management: The operational aspects of RPAS require significant levels of contingency planning to accommodate the potential for communications or system failures where the RPAS air vehicle itself may be required to determine a course of predictable actions. This exercise addressed how contingencies could be planned and how they could be shared with the Air Traffic Management System. The demonstrations included lost-link scenarios specifically to address the effect on the Air Traffic Management system and other airspace users.
- Security: This addressed requirements for physical security such as access to the ground control station, and electronic security in terms of the potential for control of RPAS to be denied, or spoofed.

The project conducted three demonstration exercises as described in tables below.

Demonstration Exercise ID and Title	EXE-RPAS.07-001: Ground & TMA Operations 1
Leading organization	NLR
Demonstration exercise objectives	To simulate in real-time RPAS operation in and out from a medium size airport and in terminal airspace during transition from/to en-route airspace. High level CONOPS for RPAS flight in controlled airspace incorporating: • Contingency Procedures for Lost Link; • Radio Comms Failure Procedures; • Transponder Failure Procedures; • Emergency Procedures. RPAS operation in non-segregated controlled airspace Handover procedures from one ATC agency to another. Take-off and landing procedures, including go-around/missed approach Impact on other VFR/IFR traffic The exercise was carried out in two stages. The scenarios assessed and demonstrated in the second iteration took into account the lessons learned and feedback from controllers and RPAS pilots involved in the initial iteration.
OFA addressed	The following OFAs were addressed: • OFA03.01.01 Trajectory Management Framework; • OFA03.01.04 Business and Mission Trajectory; • OFA03.03.01 Conflict Detection, resolution and Monitoring; • OFA06.02.01 iCWP en-route & TMA.
Applicable Operational Context	RPAS operations in TMA and Airport environments. The exercise replicated a medium sized European Airport with a mix of IFR and VFR traffic from which the RPAS could operate. The RPAS also transited controlled terminal airspace towards en-route with realistic IFR traffic.
Demonstration Technique	Interactive, high fidelity real-time simulation
Number of flight trials	Two iterations of multi-run simulations run over a series of days.

Table 2-1: Exercise 1 Overview

Demonstration Exercise ID and Title	EXE-RPAS07-002 : En-route Analysis & Simulations
Leading organization	NATS
Demonstration exercise objectives	To simulate the flight of RPAS in multi-agency, mixed traffic non-segregated environment: • RPAS flight in Class A airspace; • RPAS flight over Class G airspace; • RPAS handover from one ATC agency or unit to another; • RPAS demonstration of lost-link behaviour; • Lost comms procedure tested in controlled environment; • RPAS operation without SSR. Identification of security threats to RPAS ground operations: • Lost link behaviour demonstrated; • Lost comms procedure demonstrated; Impact definition and assessment of RPAS lost-link procedures in airspace management procedures, safety and controller workload: • RPAS lost-link procedures defined and impact assessment carried out. Assessment and demonstration of RPAS trajectory exchange with ATC for optimising inbound traffic flow: • RPAS-ATC trajectory exchange assessed. Impact assessment of RPAS re-routing procedures to avoid bad weather on airspace management, safety, and controller workload: • Impact assessment of RPAS TMA re-routing procedures established. Raise awareness regarding SESAR activities and objectives to stakeholders: • Demonstration sessions to stakeholders given. Successful take off, transit and landing of a MALE/HALE platform from one country to the next: • Successful take off of the RPAS from a non-segregated airport; • Successful transit of RPAS in Class A airspace; • Successful demonstration of the benefit of at least one other SESAR project. Handover procedure assessment and processing between ATC sectors, FABs and GCS: • Identification of issues and approaches associated with RPAS transit between sectors and FABs; • Identification of issues and approaches associated with handover from one GCS to another. RPAS transition from En-route to TMA operations: • Successful routing the airspace to TMA and subsequent landing.

Demonstration Exercise ID and Title	EXE-RPAS07-002 : En-route Analysis & Simulations
OFA addressed	The following OFAs were addressed: • OFA03.01.01 Trajectory Management Framework; • OFA03.01.04 Business and Mission Trajectory; • OFA03.03.01 Conflict Detection, resolution and Monitoring; • OFA03.03.03 Enhanced Decision Support Tools and Performance Based Navigation;
Applicable Operational Context	En-route RPAS operations including both local and long distance flight. The demonstration replicated the UK airway structure and was able to demonstrate RPAS flight in Class A airspace. The proposed scenarios are discussed in section 4.4 and involve: Within the demonstrations, it was possible to demonstrate lost-link procedures; lost communications procedures; and loss of separation scenarios. The demonstration developed and showed handover operations and procedures between ATC sectors and FIRs. It also examined the interaction between the handover from RPAS GCS to another, if SATCOM is not used.
Demonstration Technique	Interactive, high fidelity real-time simulation
Number of flight trials	13 exercises followed by debriefs over a 4 day period.

Table 2-2: Exercise 2 Overview

Demonstration Exercise ID and Title	EXE-RPAS07-003 : Training & Validation
Leading organization	Thales
Demonstration exercise objectives	Preparation and de-risking of live flight: • No additional risks identified or clear mitigation approach. Clarification of regulatory requirements for RPAS flight in non-segregated airspace: • Training and Assessment Plan complete; • Regulatory approval for live flight granted. Flight of RPAS in multi-agency, mixed traffic non-segregated environment: • Flight of RPAS in class A airspace; • Flight of RPAS over class G airspace; • Handover of RPAS from one ATC agency to another; • Lost comms procedure tested in controlled environment. Assessment and demonstration RPAS trajectory exchange with ATC for optimizing inbound traffic flow: • RPAS – ATC trajectory exchange assessed. Raise awareness regarding SESAR activities and objectives to stakeholders: • Demonstration sessions to stakeholders given. The successful take off, transit and landing of a MALE/HALE platform from one country or FIR to the next: • Successful take off of the RPAS from a non-segregated airport; • Successful transit of RPAS in Class A airspace; • Successful demonstration of the benefit of at least one other SESAR project. • Assessment of handover procedures and processing between ATC sectors, FABs and GCS: • Identification of issues and approaches associated with RPAS transit between sectors and FABs; • Identification of issues and approaches associated with handover from one GCS to another. RPAS transition from En-route to TMA operations: • Successful routing through the airspace to TMA and subsequent landing.
OFA addressed	The following OFAs are addressed: • OFA03.01.01 Trajectory Management Framework; • OFA03.01.04 Business and Mission Trajectory; • OFA03.03.01 Conflict Detection, resolution and Monitoring; • OFA03.03.03 Enhanced Decision Support Tools and Performance Based Navigation; • OFA06.02.01 iCWP en route & TMA.

Demonstration Exercise ID and Title	EXE-RPAS07-003 : Training & Validation

Applicable Operational Context	RPAS operations in TMA and En-route environments
	• RPAS operations at regional airports, in segregated and non-segregated Class A and over Class G airspace.
	• The scenarios are discussed in section 4.1 and involve:
	  • An RPAS routed from West Wales Airport to the Cardiff Control Zone. Following entry into the Cardiff Control Zone the RPAS would make an approach into St.Athan or Cardiff Airport (addressed in EXE-RPAS07-002).
	  • An RPAS taking-off from St.Athan and routing through the Cardiff Control Zone. The RPAS would then join controlled airspace and then route to the South or West in Class A airspace culminating in a handover to Brest FIR or Shannon FIR with the potential to demonstrate flight over the Channel Islands and Cherbourg Peninsula or the Irish Sea (addressed in EXE-RPAS07-002).
	The demonstration developed and showed handover operations and procedures between ATC sectors and FIRs.

Demonstration Technique	Rehearsals in high fidelity simulator followed by live flights
Number of flight trials	2 live flights over 4 planned flight slots

Table 2-3: Exercise 3 Overview

3 Programme Management

The Programme Management activities were completed in accordance with the Demonstration Plan with each partner company providing nominated Project Management and functional staff to direct the overall programme in a co-ordinated and controlled manner.

3.1 Organisation

Project CLAIRE was undertaken by a team comprising Thales, the Netherlands Aerospace Centre (NLR) and NATS. The team provided a complementary mix of technical, regulatory and commercial expertise with roles and responsibilities clearly defined at the onset of the programme. Partners worked closely together throughout the entire programme using formal scheduled meetings, electronic media and telephone conference mechanisms, as well as ad-hoc discussions and information sharing.

- **Thales** acted as consortium coordinator assuming leadership of commercial and programmatic activities as well as acting as primary point of contact with the SJU. Thales provided RPAS technical, operational and regulatory expertise throughout all demonstration exercises including personnel, asset and infrastructure provisioning during the live flying exercises. Thales was also responsible for the development of the platform Safety Case in conjunction with the various regulatory authorities enabling unmanned flight in non-segregated airspace.
- **NATS** is the UK ANSP responsible for the provision of ATM expertise and hosting of the RPAS en-route simulation exercises at the NATS innovation facility, called *SPACE*, which is designed to explore future air traffic concepts. Simulation exercises were undertaken using the *SPACE* infrastructure based at the NATS Corporate and Technical Centre (CTC) at Whiteley, UK. NATS were also responsible for the development and CAA approval of the airspace Safety Case necessary to permit live flight trials. A number of individual ATSUs (air traffic service units) participated in programme exercises, these included Swanwick, Cardiff and Aberporth.
- **NLR** coordinated and hosted the RPAS simulation exercises dealing with airport and terminal airspace operations in both normal and contingency situations. This aspect of the CLAIRE programme was completed in Amsterdam, Netherlands using the NLR ATC research simulation facilities (*NARSIM*) and also the Multi-UAS Simulation Testbed (*MUST*).

Governance was exercised in accordance with the CLAIRE Consortium Teaming Agreement with specific activities decomposed and responsibilities assigned in accordance with the CLAIRE Work Breakdown Structure (WBS).

3.2 Work Breakdown Structure

The programme was structured using three primary work streams:

- **Management & Control:** to provide the overall project management of CLAIRE including technical co-ordination, stakeholder management, internal/external communications and the preparation and delivery of data items and progress reports to the SJU.
- **Research & Analysis:** to undertake research and analysis into specific elements of the project in order to achieve the requirements and outcomes as described in the Demonstration Plan. This work culminated in a successful live trial of an unmanned platform operating in a mixed traffic environment. The elements required to permit RPAS flight in non-segregated airspace have been assessed with outcomes, conclusions and recommendations described in the Demonstration Report (this document), consortium briefings and ancillary documents delivered to the SJU.
- **Experimentation & Trials:** to prepare and conduct high-fidelity and realistic CLAIRE simulation activities using the ATM innovation and experimentation facilities at NLR (airport and terminal operations) and NATS (en-route operations). This work package also includes live flights in order to demonstrate the operation of RPAS in non-segregated, controlled airspace.

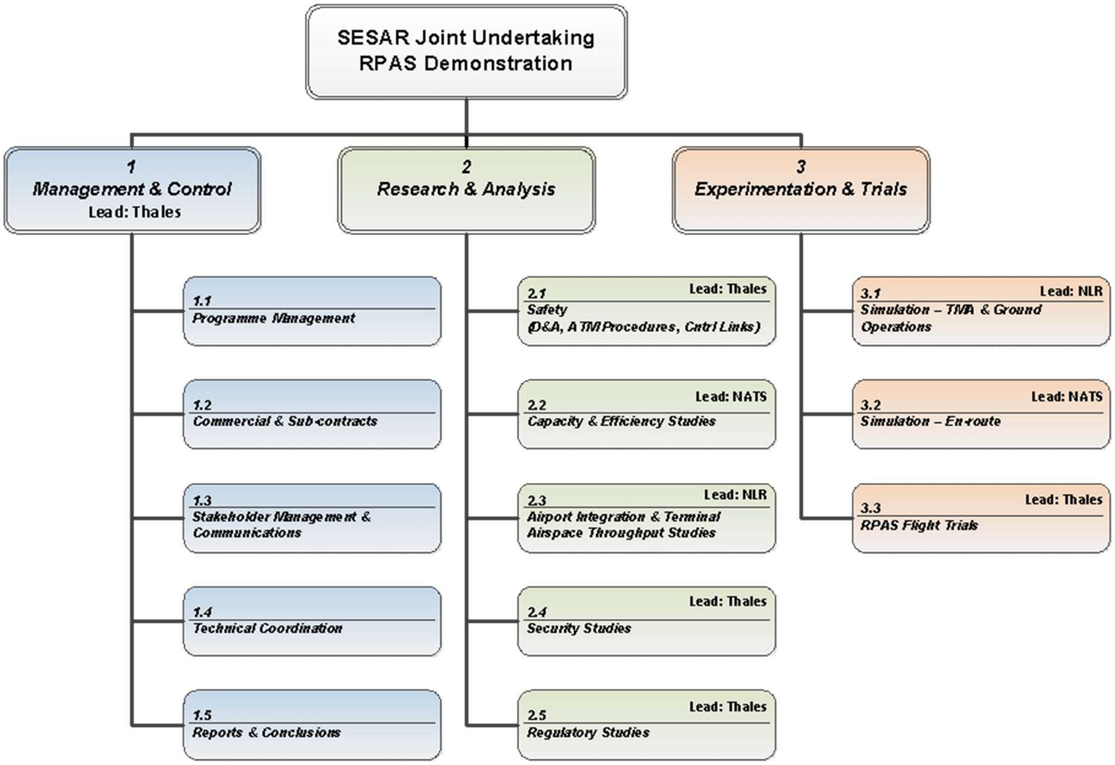

Figure 3-1: Work Breakdown Structure

3.3 Deliverables

The key deliverables may be summarised as:

- CLAIRE Demonstration Plan – version 01.01.00 delivered in December 2013
- CLAIRE Demonstration Report (this document)
- Various communications media, workshop presentations and periodic progress reports. A number of referenced documents containing supplementary information have also been delivered to the SJU.

The milestones for Project CLAIRE, including quarterly reports, project reviews, internal reports and completion of demonstration milestones, are listed below. All milestones will have been completed during 2015 with the final workshop and presentation scheduled for mid-December.

- M.1 Safety Management Plan
- M.2 Procedural Gap Analysis
- M.3 Hazard Identification Report
- M.4 Quarterly Progress Report
- M.5 En-Route Synthetic Demonstration Plan
- M.6 Airport Ground/TMA Operations Demonstration Plan
- M.7 Simulation Exercise (Airport Ground/TMA Operations Pt.1)
- M.8 Detect & Avoid Studies Report
- M.9 Simulation Exercise en-route Operations
- M.10 Detailed Live Trial Plan
- M.11 Procedural Analysis for RPAS Operations
- M.12 Quarterly Progress Report
- M.13 Decision Point Milestone

- M.14 En-Route Synthetic Demonstration Report
- M.15 RPAS Flight CONOPS
- M.16 Safety Case
- M.17 Simulation Exercise (Airport Ground/TMA Operations Pt.2)
- M.18 Critical Project Review
- M.19 Exercise #3a Complete
- M.20 Quarterly Progress Report
- M.21 Exercise #3b Complete
- M.22 Live Trial Report
- M.23 Airport Ground/TMA Demonstration Report
- M.24 Security Studies Report
- M.25 Regulatory Studies Report
- M.26 Demonstration Report Draft
- M.27 Quarterly Progress Report
- M.28 Final Presentation
- M.29 Quarterly Progress Report
- M.30 Demonstration Report Final

3.4 Risk Management

The management of risk was undertaken in accordance with partners approved processes and company standards with risk reviews forming an integral part of team reporting and review cycles. Periodic progress meetings were held with all partners to ensure risks and mitigation approaches were discussed, shared and understood especially when potential impact may adversely affect overall project milestones, budgets or outcomes. Project risks were provided to the SJU as part of the quarterly reporting cycle using standard identification, analysis, mitigation and monitoring approach to ensure that:

- Project risks were identified, categorised, recorded and monitored in a timely manner;
- Risks were assessed in terms of probability and impact using agreed criteria;
- Any complex risk issues were analysed using qualitative and quantitative methods;
- Appropriate risk reduction measures and mitigation plans were agreed amongst partners and implemented as necessary;
- Risks were monitored and managed to ensure each risk was minimised and (or) removed;
- Risks were each assigned an appropriate 'owner' who assumed overall responsibility for the implementation, monitoring and reporting of mitigation actions.

The table below details the status of risks at the end of the demonstration phase with all the risks closed as demonstration activities are concluded and outcomes captured in the final report. The majority of risks relate to potential difficulties in understanding how regulations would be interpreted or varied against a backdrop of general regulatory development. There was a significant level of dependencies on third-parties which required concerted efforts to keep all stakeholders fully informed and agree 'best practice' approaches beforehand.

Risk No.	Description of Risk	Owned By	Agreed Mitigation Action	Impact if Risk Realised	Status	Sev-erity
R0001 (CLOSED)	Demonstration requirements creep may cause the scope of the project activities to be extended	Thales (flight trials)	Ensure work requests and feedback remain within original scope of work or seek additional funding and/or extensions with the SJU	Potential delays, increase in costs, or a reduction in scope within a particular project area.	CLOSED – Demonstrations undertaken in accordance with budget and time constraints (baseline)	Medium
R0002 (CLOSED)	The initial flight programme has been developed on the basis of restricted operations in NATS controlled airspace without an approved Detect & Avoid capability at this stage.	Thales (flight trials)	Early and continuous engagement with the regulatory authorities to ensure segregated flight is achieved. Ensure Safety Case is supported by robust contingency measures including a 'buffer zone' below the airway	Flights will not occur if Safety Case (potentially underpinned by waivers) cannot be agreed with the regulatory authorities	CLOSED – flight trials completed in accordance with authorised MFTP/TOI for platform and airspace respectively	High
R0003 (CLOSED)	Limited availability of RPAS Pilot for planned simulation exercises	Thales (flight trials)	Early engagement with the Thales flight trials team to secure suitable RPAS pilot with airmanship skills and RPAS IR rating	Simulations will still go ahead although there would be no feedback provided by RPAS pilots which would dilute the outcomes of the programme	CLOSED – RPAS pilots identified & completed independently approved RPAS IR qualification for non-segregated airspace	Low
R0004 (CLOSED)	Insufficient funding for NLR to complete all internal *MUST* simulation facility enhancements necessary to integrate RPAS flight models for airport operations	NLR (simulation)	Use existing *MUST* RPAS simulation capabilities Use *NARSIM* pseudo-pilot position for complex scenarios	Inconclusive demonstration outputs which may require additional effort to determine conclusions and recommendations	CLOSED – *MUST* simulation activities all completed with key stakeholder approval	Medium
R0005 (CLOSED)	Availability of RPAS loan assets may not be secured until midway through the Implementation Phase for 'real-world' RPAS flight trials in late 2015.	Thales (flight trials)	Continuous high-level briefings to key MoD stakeholders (including the MAA) to secure assets under normal UK Form 650 loan agreement' action. Appraise SJU of progress.	Flight trials may be delayed if RPAS loan assets are not secured until the final Decision Point	CLOSED – MOD approvals secured with RPAS loan agreements in place for the duration of flight trials	Medium
R0006 (CLOSED)	Non-agreement by UK MoD to make Watchkeeper assets available to support flight trials.	Thales (flight trials)	Continuous high-level briefings to key MoD stakeholders (including the MAA). Scheduling flying to avoid conflict with primary WKPR programme. Inform SJU of progress.	Conduct additional high-fidelity SE demonstrations, expanded to include transit within French airspace and participation of Fr regulators.	CLOSED – MOD approvals secured with RPAS loan agreements in place for the duration of flight trials	High

Risk No.	Description of Risk	Owned By	Agreed Mitigation Action	Impact if Risk Realised	Status	Sev-erity
R0007 (CLOSED)	Authorisation to fly in suitable airspace is not granted by regulatory authorities	Thales (flight trials)	Ensure continuous engagement between NATS, Thales, UK CAA and MAA to validate flight scenarios and agree Waivers	Inability to undertake flight trials as planned in the Demonstration Plan, undertaking of additional SE demonstration as described in R0006	CLOSED – flight trials completed in accordance with authorised MFTP/TOI for platform and airspace accordingly.	High
R0008 (CLOSED)	Adverse publicity (in the public domain) may harm future RPAS opportunities and damage SJU and consortium reputation.	Thales (flight trials)	Develop a set of overtly 'civilian context messages' such as Search & Rescue and Environmental Monitoring applications to demonstrate benefit. Route trials over the sea, littoral areas & over sparsely populated landscape as far as possible.	The development of RPAS operations in UK non-segregated airspace will be delayed and appetite to invest in future programmes and initiatives will be compromised in the short term.	CLOSED – no adverse publicity arising from flights. Positive feedback from stakeholders to be taken forward by UK government and other key agencies	Medium
R0009 (CLOSED)	Although the live demonstration will be conducted in Class A airspace, the RPAS may need to gain access to that airspace through a small area uncontrolled airspace using a TDA. This may require a lengthy consultation process.	Thales (flight trials)	Engage with CAA to set up TDA for class G airspace as early as possible in the programme using current AIC/NOTAM processes	Additional programme delay if TDA approval takes longer than 90 days. Yankee flight will not be completed if TDA for Class G airspace is not granted in an expedient manner	CLOSED – experimental TDA was established using approved processes as described in this report	Low
R0010 (CLOSED)	Insurance will be prohibitive for initial flight trials in non-segregated airspace. The Insurance community is not yet mature in its understanding of this actuarial issue, this may attract very high (prohibitive) premiums at first.	Thales (flight trials)	Develop detailed discussions with insurance and legal representatives to appraise safety and airworthiness approach and contingency measures to safeguard third-parties and platform	The flight trials will not occur if insurance costs are overly prohibitive	CLOSED – agreements reached with insurance underwriters and sufficient cover purchased for duration of flight trials	High
R0011 (CLOSED)	Overseas authorities will not allow RPAS flights in overseas agency airspace – stretch target for flight trials.	NATS (flight trials)	Initiate exploratory discussions between ANSP and potential overseas agencies to gauge appetite for cross border trials and knowledge sharing	Flight trials will not cross FAB boundaries nor occupy overseas agency airspace - stretch target for flight trials.	CLOSED – exploratory discussions held at onset of programme, excluded from scope of flight trials	Medium

Risk No.	Description of Risk	Owned By	Agreed Mitigation Action	Impact if Risk Realised	Status	Sev-erity
R0012 (CLOSED)	The requisite level of Instrument Rating (IR) type pilot qualification is uncertain for RPAS IFR flight in non-segregated airspace.	Thales (flight trials)	Agree qualification and licensing requirements with regulators and the trials team by holding an early workshop. Use suitable experienced RPAS pilots with requisite airmanship skills	Agree revised scenarios with the regulatory authorities which may restrict which airspace the pilots can access, but which will still allow flights to be undertaken	CLOSED – IR qualification agreed with regulator, pilots completed both classroom and simulator exams with independent assessor	Medium
R0013 (CLOSED)	Lack of availability of ATC controllers for simulation exercises	NATS/ NLR (flight trials)	Ensure resource is requested and commitment secured early	Simulation exercises will be moved to times when ATC controllers are available	CLOSED – ATCOs provisioned from each participating ATSU	Low
R0014 (CLOSED)	Non-agreement by UK MoD to make Watchkeeper assets available to support Zulu flight trial due to potential conflict with ES2 flights.	Thales (simulation)	Continuous high-level meetings with key MoD decision makers. Viability of Black/Zulu flight to be discussed with SJU as early as possible	Black/Zulu flight in more complex airspace with remotely deployed infrastructure will be restricted to simulation exercises	CLOSED – Black/Zulu flights limited to simulation exercises	Low
R0015 (CLOSED)	CAA has advised that TDAs are required for the Class G airspace below the flight paths as an additional contingency measure to access emergency recovery points. This new process may take several iterations	Thales (flight trials)	Develop and apply for required TDAs outside (below) Controlled Airspace for consideration and acceptance by the regulatory authorities.	Potential delay to flight trials pending acceptance of TDA application by the CAA	CLOSED – TDA application accepted by regulator enabling Aeronautical Information Circular (AIC) to be published	High
R0016 (CLOSED)	Thales has been advised that a formal approach to the UK Maritime & Coastguard Agency (MCA) is required to ensure emergency recovery points are acceptable.	Thales (flight trials)	Meetings and briefing papers (including Safety Case) provided to MCA to ensure no additional hazards resulted from ERP approach	ERP approach will have to be reconsidered with potential cost and timescale impact.	CLOSED – acceptance of ERP designation and methodology provided by MCA	Low
R0017 (CLOSED)	Thales will be subject to MAA CFAOS accreditation during 2015, it is assumed that compliance with this latest scheme will be required to support flight approvals process and associated documentation/evidence.	Thales (flight trials)	Maintain continuous dialogue with MAA and Thales CFAOS team to ensure requirements are fully understood and accommodated within CLAIRE schedule. Agree changes to data-items and update as necessary.	Potential cancellation of CLAIRE flight trials if compliance to CFAOS standards is not demonstrated and accepted by regulatory authorities.	CLOSED – CFAOS accreditation achieved and CLAIRE data-items amended to the satisfaction of the MAA	Medium

Table 3-1: Risk Management

4 Conduct of Demonstration Exercises

4.1 Exercises Preparation

4.1.1 Approach

4.1.1.1 General

The project partners constructed a set of coherent demonstrations which allowed issues to be identified and addressed at an early stage to allow additional processes and procedures to be developed before planning a live flight in non-segregated airspace. Each demonstration activity provided the opportunity to engage with the appropriate stakeholders both before and during the demonstration exercise.

Since some of the partners had experience of operating a high end tactical RPAS, it was agreed that all the demonstration exercises should be largely based on such a platform as this type of platform is likely to be one of the first to seek access to non-segregated airspace. This common approach provided consistency across all the exercises. This was reinforced by ensuring that all partners were invited to participate in all exercises.

A set of representative scenarios was developed and used as the basis for the exercises. However, ongoing study and analysis work identified that some scenarios were more relevant than others and as the exercises were developed, some scenarios were expanded in more detail, whilst others were used to a lesser degree, or subsumed into other scenarios.

The final demonstration exercise was to plan for and undertake live flights using a high-end tactical unmanned RPAS to demonstrate the processes and procedures that had been developed. In order to examine the regulatory issues associated with live RPAS flight in non-segregated airspace with the potential to undertake live validation flights, it was important that the RPAS was truly unmanned and the Safety Case could not be augmented by the inclusion of an on-board pilot in an oversight role.

4.1.1.2 Scenarios

In preparation for the exercises, the partners developed a set of scenarios which could be used across the project. These were designed to exercise specific aspects of RPAS flight in current and future airspace in particular:

- Safely push the boundary for RPAS operations beyond what is currently achievable
- Access non-segregated airspace using current ATC processes and procedures
- Examine the impact of workload on ATCOs
- Examine impact of pre-planning contingency management and information sharing
- Determine R/T phraseology differences between manned and unmanned aviation
- Assess the procedures, processes and clearances required to achieve live RPAS flight in non-segregated airspace

The scenarios are described in detail in the following sections. The yellow (route X)[1], green (route Y) and black (route Z) are all based in the region of south west Wales. This area was chosen due to its proximity to the existing area of operations, the experience of operating and managing RPAS in this area, and its suitability to support live flights. References are made to the existing segregated airspace currently in use in West Wales and these are depicted in Figure 4-1

[1] Initially, the routes were known by colours, but in order to be compatible with the AIC format, the routes were renamed to letters and their associated NATO phonetic identifier. See section 4.1.4.5.1 for more details.

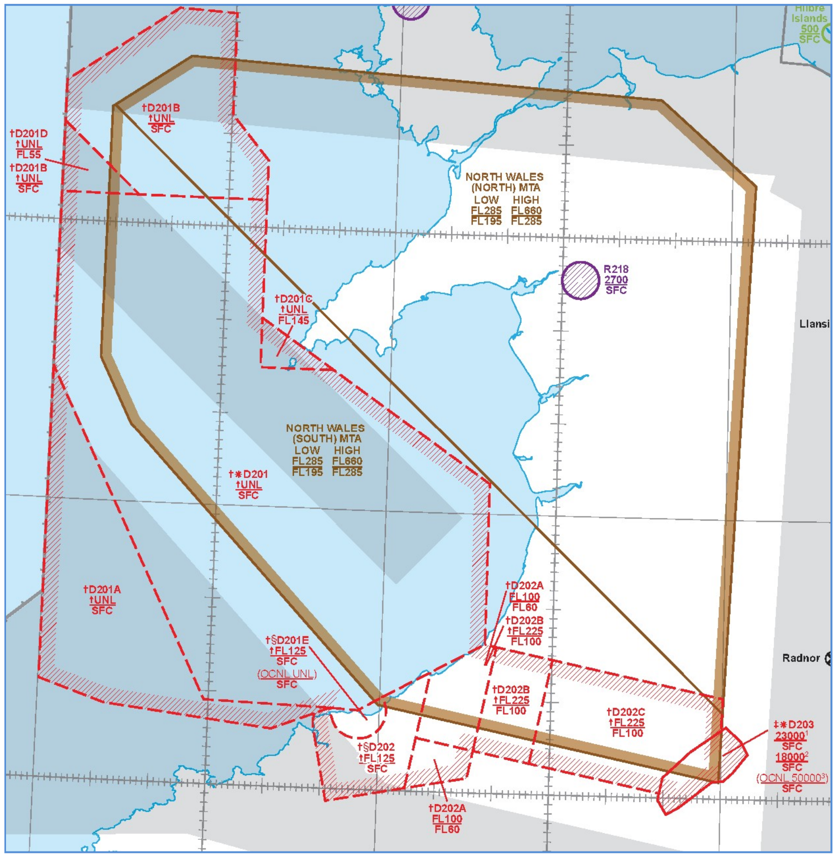

Figure 4-1: D201, D202 & D203 Complexes

Scenario ID	Name	Description
SCN-RPAS-07-001	Yellow/X-Ray	Short excursion into non-segregated airspace
SCN-RPAS-07-002	Green/Yankee	Excursion into non-segregated airspace, flight along airway involving two ATC sectors
SCN-RPAS-07-003	Black/Zulu	Excursion into non-segregated airspace, flight along airway into TMA involving two ATC sectors and terminal control
SCN-RPAS-07-004	Grey	Excursion into non-segregated airspace, flight along airway across FIR/FAB boundary
SCN-RPAS-07-007	RTM Departure	RPAS departure from mixed-traffic airport
SCN-RPAS-07-008	RTM Arrival	RPAS arrival at mixed-traffic airport
SCN-RPAS-07-009	RTM Lost Link	Lost link within TMA
SCN-RPAS-07-010	RTM Lostcomm	Lost Pilot/ATC comms within TMA
SCN-RPAS-07-011	RTM MISAP	Missed approach
SCN-RPAS-07-012	RTM TRAJEX	Approach involving trajectory exchange
SCN-RPAS-07-013	RTM ADVWX	Weather diversion
SCN-RPAS-07-014	RTM noSSR	Failure of transponder

Table 4-1: Scenario Summary

4.1.1.2.1 SCN-RPAS-07-001: Yellow Route/Route X

This route is designed to provide a flight through non-segregated (class A) airspace outside the range area, and involves the transfer of control between air traffic control units. The time inside non-segregated airspace would be typical of an aircraft passing through a sector.

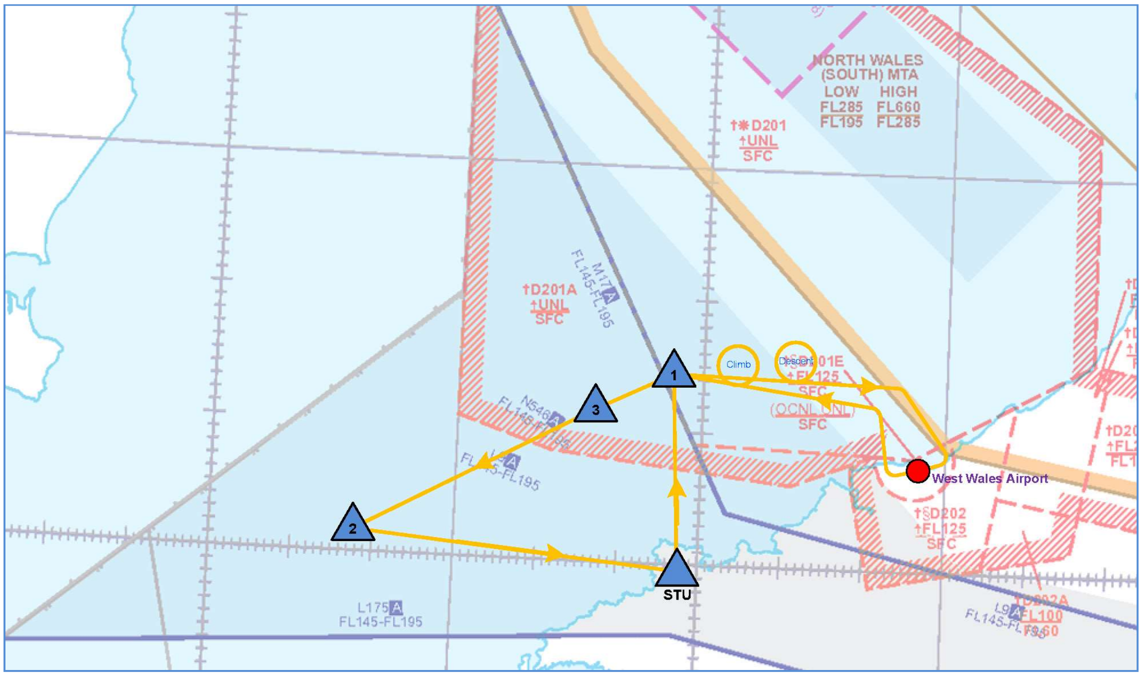

Figure 4-2: Yellow Route/Route X

The route is described as follows:

- Take-off from West Wales Airport (WWA) and climb to FL150 entirely within the D201 complex and head towards waypoint 1.
- Once FL150 is achieved at waypoint 1, pass into M17 and over D201A at waypoint 3, remaining at FL150. On entry into M17, responsibility for air traffic control will be passed from the Aberporth Range Control to London Area Control Centre (LACC) at Swanwick.
- Whilst maintaining FL150, continue through N546 and into L9, heading approximately south-west to waypoint 2.
- At waypoint 2, turn approximately east, heading towards *STU*, remaining at FL150.
- At STU, turn approximately north, return over D201A to reach waypoint 1 in D201, maintaining FL150. During this leg, responsibility for air traffic control will be passed back from LACC to Aberporth RAC.
- From waypoint 1, descend and return to WWA, remaining in D201.

4.1.1.2.2 SCN-RPAS-07-002: Green Route/Route Y

This route is designed to provide a longer excursion into Class A airspace outside the range area and involve the transit of the air vehicle through two non-segregated air traffic control sectors and flight along an airway.

The route built upon the Yellow Route/Route X, involving additional ATC sector handovers and flight over land and is described as follows:

- Take-off from West Wales Airport and climb to FL150 entirely within the D201 complex and head towards waypoint 1.

- Once FL150 is achieved at waypoint 1, pass into M17, over D201A and through N546 to reach waypoint 3, remaining at FL150. On entry into M17, responsibility for air traffic control will be passed from the range head to London Area Control Centre (LACC) at Swanwick.
- At waypoint 3, head approximately south-east to waypoint *STU*, maintaining FL150.
- At STU, turn approximately east-south-east, heading towards *AMMAN*, remaining at FL150.
- On reaching *AMMAN*, the responsibility for separation will transfer from LACC to Cardiff Control. On transfer to Cardiff Control, request descent to reach FL130 at waypoint 4.
- At waypoint 4 turn approximately north towards waypoint 5, maintaining FL130 whilst crossing between L9 and D202C through D198B (see Figure 4-10).
- At waypoint 5, turn approximately west-north-west and descend to land at WWA, remaining in the D201/D202 complex.

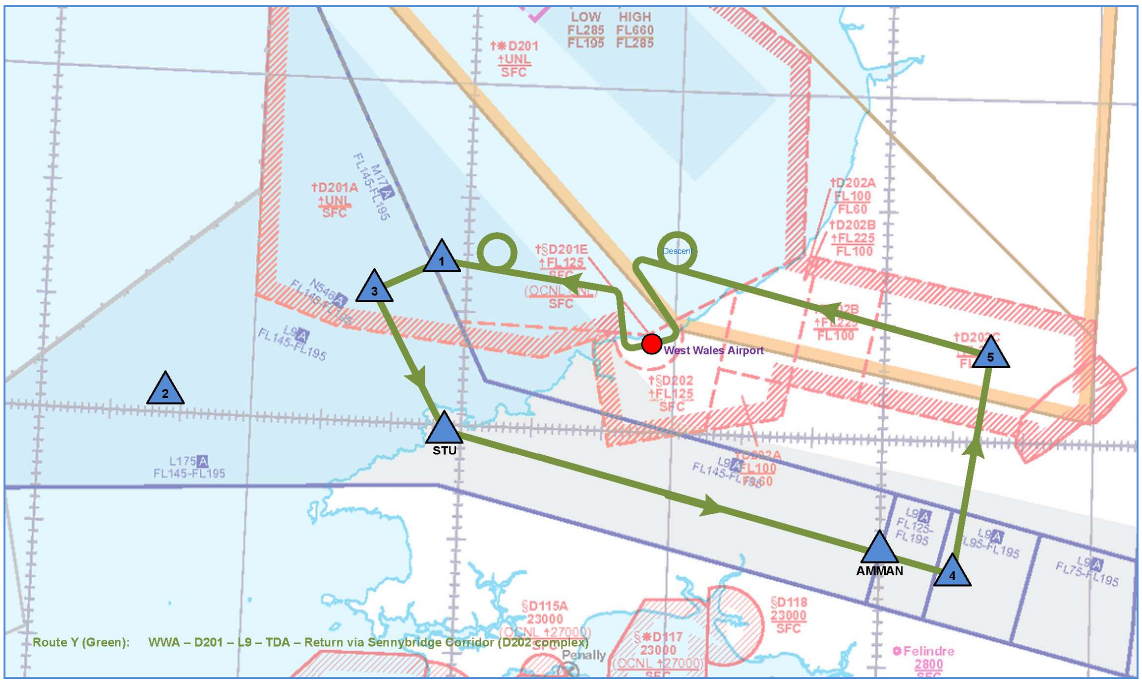

Figure 4-3: Green Route/Route Y

4.1.1.2.3 SCN-RPAS-07-003: Black Route/Route Z

This route is designed to provide a longer excursion into class A and class D airspace outside the range area and involve the transit of the air vehicle through two non-segregated air traffic control sectors together with flight into a TMA.

Referring to Figure 4-4, route Z is described as follows:

- Take-off from West Wales Airport and climb to FL150 entirely within the D201 complex and head towards waypoint 1.
- Once FL150 is achieved at waypoint 1, pass into M17, over D201A and through N546 to reach waypoint 3, remaining at FL150. On entry into M17, responsibility for air traffic control will be passed from the range head to London Area Control Centre (LACC) at Swanwick.
- At waypoint 3, head approximately south-east to waypoint *STU*, maintaining FL150.
- At *STU*, turn approximately east-south-east, heading towards *AMMAN*, remaining at FL150.
- Continue beyond *AMMAN*, passing through waypoint 4 to reach *BCN*, maintaining FL150
- At *BCN* turn approximately south towards *CDF*, descend into class D airspace (Cardiff CTA6, CTA4 and CTR) as agreed with ATC to reach CDF at 9000ft

- Hold at *CDF* until given ATC clearance to return to *BCN*
- Climb to reach *BCN* at FL130, returning to class A airspace (L9/N864)
- At BCN turn approximately west-north-west towards waypoint 4, remaining at FL130
- At waypoint 4 turn approximately north towards waypoint 5, maintaining FL130 whilst crossing between Lima 9 and D202C through D198B (see Figure 4-10).
- At waypoint 5, turn approximately west-north-west and descend to land at West Wales Airport, remaining in the D201/D202 complex.

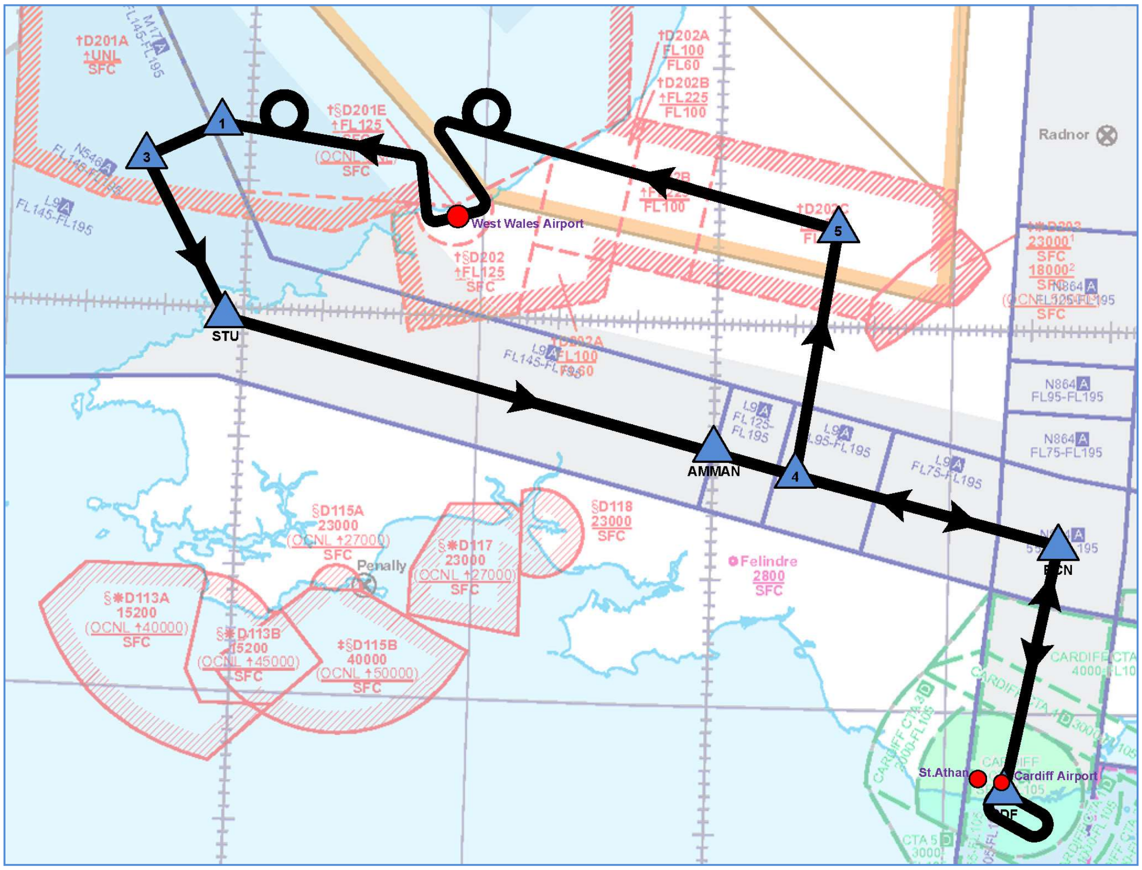

Figure 4-4: Black Route/Route Z

4.1.1.2.4 SCN-RPAS-07-004: Grey Route

The Grey Route is designed to provide extended flight in Class A airspace together with passage across FIR/FAB boundaries. The route is based on a take-off from Cardiff Airport and uses airways N864 and N682 to travel south over the Channel Islands and into French Airspace, before returning on a near reciprocal route.

This scenario is used to examine the effects of longer duration flights, using RPAS similar to Watchkeeper, as well as other RPAS with comparable transit speed and manoeuvrability to commercial airliners.

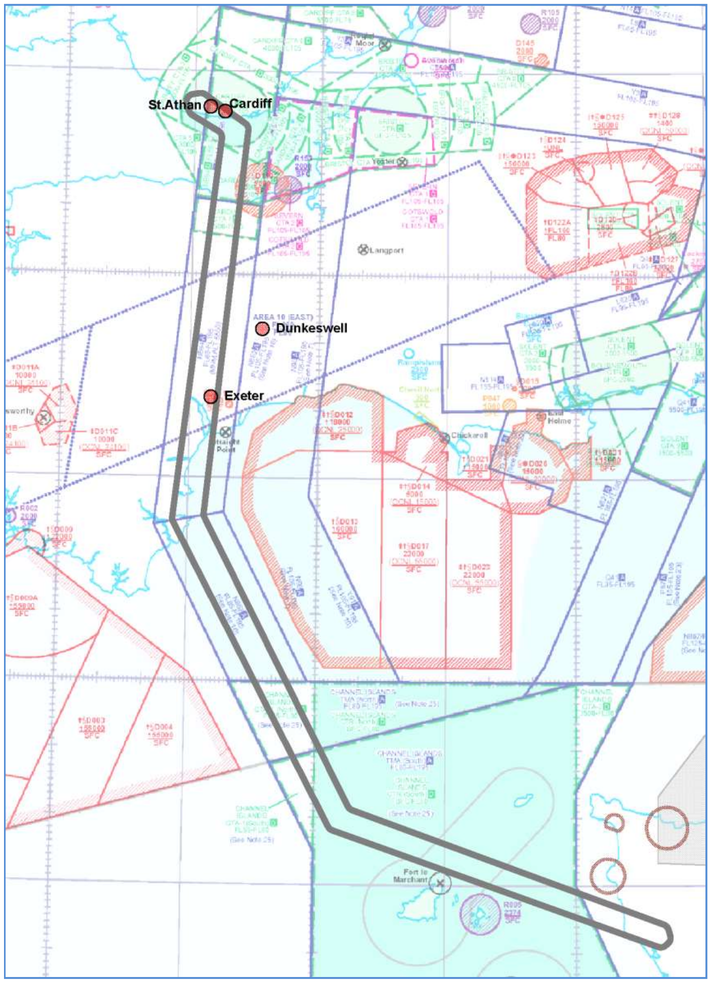

Figure 4-5: Grey Route

4.1.1.2.5 SCN-RPAS-07-007: Rotterdam Departure

This scenario includes IFR/VFR traffic and is used to exercise departure routing for RPAS. The scenario involves:

- Take-off from Rotterdam Airport.
- Climb-out and departure routing through Rotterdam CTR
- Hand-over to approach control into EHRD TMA airspace.

4.1.1.2.6 SCN-RPAS-07-008: Rotterdam Arrival

This scenario includes surrounding traffic (IFR/VFR) and is used to exercise arrival routing and landing for RPAS. The scenario involves:

- Descent and approach within TMA airspace under Rotterdam approach control.
- Hand-over from radar approach control to tower control in vicinity of airfield.
- Landing and runway operations.

4.1.1.2.7 SCN-RPAS-07-009: TMA Lost Link

This scenario includes surrounding traffic (IFR/VFR) and is used to demonstrate how ATC would manage the situation where the RPAS pilot is unable to control the RPAS and the effect this may have on ATC. The scenario involves:

- Take-off and climb from Rotterdam Airport. Departure routing through Rotterdam CTR and hand-over to APP control into TMA airspace
- Following occurrence of loss-of-datalink, automatic return to airfield using pre-programmed return routing.

Figure 4-6: Rotterdam Arrivals & Departures

4.1.1.2.8 SCN-RPAS-07-010: TMA Lost ATC Comms

This scenario is used to demonstrate how ATC would manage the situation where the RPAS pilot is in full control of the RPAS, but is unable to communicate with ATC. The scenario includes surrounding traffic (IFR/VFR) and involves:

- Take-off and climb from Rotterdam Airport.
- Departure routing through Rotterdam CTR and hand-over to APP control into TMA airspace.
- During return flight, failure of communication between RPAS and ATC.
- RPAS returns to airfield using alternative/backup communication procedures.

4.1.1.2.9 SCN-RPAS-07-011: TMA Missed Approach

This scenario is used to demonstrate how ATC would manage the situation where the RPAS pilot is in full control of the RPAS, but is unable to communicate with ATC. The scenario involves:

- Take-off and climb from Rotterdam Airport.
- Departure routing through Rotterdam CTR and hand-over to APP control into TMA airspace.
- During return flight failure of communication between RPAS and ATC.
- RPAS returns to airfield using alternative/backup communication procedures.

4.1.1.2.10 SCN-RPAS-07-012: Trajectory Exchange

This scenario is used to demonstrate how trajectory information could be exchanged between the RPAS and ATC. The scenario involves:

- The RPAS descends into the Rotterdam TMA and is guided towards final approach for landing.
- Prior to descent into the TMA, the RPAS will exchange its planned trajectory with ATC

4.1.1.2.11 SCN-RPAS-07-013: Adverse Weather

This scenario is used to assess how diversions resulting from adverse weather can be accommodated by the RPAS and ATC. The scenario involves:

- The RPAS descends into the Rotterdam TMA and is guided towards final approach for landing.
- Adverse weather causes RPAS and ATC to agree alternative routing.

4.1.1.2.12 SCN-RPAS-07-014: Transponder Failure

This scenario is used to assess RPAS and ATC procedures following a transponder failure. The scenario involves:

- Take-off and climb from Rotterdam Airport.
- Departure routing through Rotterdam CTR and hand-over to APP control into TMA airspace.
- During return flight a failure of SSR transponder occurs. RPAS returns to airfield without indicated position on radar.

4.1.1.2.13 SCN-RPAS-07-015: Taxi

This scenario is used to assess the interaction and with other aircraft and with ATC and involves:

- Taxi from parking position to runway
- Taxi from runway to parking position

As taxi operations to and from the RPAS parking platform were integrated during all simulation runs, no specific separate scenarios were made for this part of the RPAS operation.

4.1.2 Preparation for Exercise 1

The objectives of this activity were to demonstrate airport surface operations capability including:

- Interaction with other traffic on the surface as well as ground vehicles and obstacles
- Demonstrate take-off and landing capability without impacting airport throughput
- Demonstrate D&A for ground operations taking into consideration wake turbulence and metrological conditions and
- Quantify minimum performance requirements for integration in a TMA including speed, climb/descent and turn performance and possible mitigations approaches according to different airport complexity types.

The environment for carrying out the simulations was based on a Rotterdam airport (EHRD) simulation environment acting as a “typical” medium size airport with both VFR and IFR traffic.

The simulations were run using the NLR Air Traffic Control Research Simulator (*NARSIM*) and Multi-UA Supervision Testbed (*MUST*). These platforms comprise modules that work together to form a complete simulation of an ATC environment as well as RPAS ground control station. The following setup was used:

- NLR Air traffic Control Research Simulator (*NARSIM*), with the following components:
  - *NARSIM* Radar, allowing EHRD approach radar simulation.
  - *NARSIM* Tower, for EHRD airport simulation with a 360 degrees visual system.
- Multi-UA Supervision Testbed (*MUST*)

The ATC simulator facility was connected to the *MUST* RPAS simulation and control facility, enabling an integrated demonstration and assessment. The CLAIRE Exercise 1 simulation setup consisted of one approach controller working position, the *NARSIM* tower simulator, 2-3 pseudo-pilot workstations and the *MUST* RPAS ground control station/simulator connected.

In preparation to the simulator evaluations, the following activities were carried out:

- Adaptation of *NARSIM* radar and tower environment for the specific evaluation
- Preparation of *MUST* with RPAS characteristics comparable to Watchkeeper
- Adaptation of connection between *NARSIM* and *MUST* for the particular evaluation
- Development of RPAS arrival and departure routes and drawings
- Preparation of (suitable) air traffic scenarios and traffic samples, representative of a busy medium size airport with both VFR and IFR traffic
- Preparation of normal, contingency and emergency scenarios
- Briefing material for participating ATCOs, pseudo-pilots and RPAS pilot
- Preparation of (web-based) questionnaires for use during debriefing sessions

4.1.3 Preparation for Exercise 2

The activities taking place in the NATS CTC facilities focused around simulation activities looking at the en-route elements under standard and emergency situations of an RPAS flight.

These simulations were mainly intended to inform the ATC Temporary Operating Instruction, but also provided and developed new procedures to address any procedural gaps, hazards and risks, particularly around the emergency situations, which were intensely tested. Within the ATC TOIs development process, Exercise 2 had been preceded by a Procedural Gap Analysis, Hazards ID Workshop, Trials Risk Assessment Workshop, Procedures Workshop and the first group of simulations performed in Exercise 1.

The operational concept of non-segregated RPAS operations was demonstrated in an IFR traffic environment, by replicating a mix of conventional and RPAS flights in the UK airway structure. Handover procedures between different air traffic controllers (APP, ACC) were taken into account. Operations included take-off/landing and arrival/departure routing in control zone and terminal airspace in a realistic traffic situation.

In addition to normal operations, emergency and contingency procedures were demonstrated, including loss-of-link with the RPAS, RPAS communication failure, RPAS SSR transponder failure, RPAS engine and/or control problems or weather/traffic related issues.

A briefing pack was provided to the Air Traffic Controllers at the beginning of each session to present a high level description of Project CLAIRE, the aim of the exercises carried out at NATS CTC facilities, the performance characteristics of the Watchkeeper (speed, rate of climb, rate of descent and max rate of turn), route characteristics and their associated vertical profiles.

The development of the exercises and the consequent debriefing were witnessed and participated by Air Traffic Controllers from the affected sectors, RPAS pilot, UAS, ATM and ATM policy experts, UAS Airspace Regulator and Inspector of ATS (En-Route) Operations. Those roles represented the main stakeholders involved in the exercises: CAA, Thales and NATS.

Debriefing sessions were performed at the end of each run in order to promote discussion and collect good quality feedback. In addition to that, questionnaires were developed to collect subjective, quantitative and qualitative ATC feedback after the end of each run (results shown in Table 6-11). The main question was aimed to rate the overall user acceptance in a scale between 1 and 10, as shown in Figure 4-7.

In addition to this, the ATCOs were presented with four scales to represent their agreement or disagreement with regards to the following statements and space to leave any comments if appropriate:

- I am comfortable with the procedures and policy of use associated with the RPAS.
- I am comfortable with my awareness of RPAS performance.

- I am comfortable with the communications that support the RPAS flight.
- I believe that the ATC system adequately supports the RPAS flight.

The participation of Air Traffic Controllers from each NATS unit and the RPAS Pilot together with replication of Watchkeeper performance characteristics and real airspace conditions met the requirement to replicate live flights conditions. More detail is provided in section 6.2.2.1 regarding the simulation platform, roles involved and environment conditions such as surrounding traffic, airspace structure and ATC sector positions.

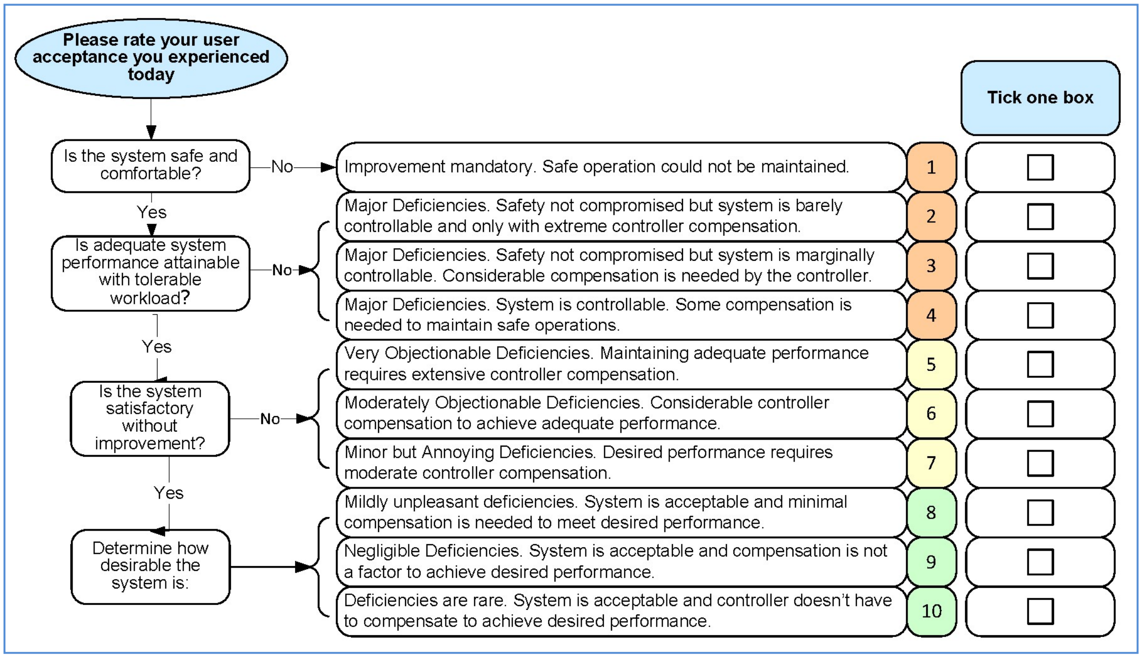

Figure 4-7: Exercise 2 ATCO Questionnaire

4.1.4 Preparation for Exercise 3

Exercise 3 was aimed at undertaking all the planning and procedure development necessary to undertake live flights in non-segregated airspace. The exercise attempted to provide validation of the processes and procedures developed in a real time simulation environment together with Exercises 1 and 2 by testing on real RPAS equipment followed by live flights of an unmanned RPAS in a non-segregated environment. This also provided a communications opportunity.

It should be noted that the preparatory work for Exercise 3, represented the largest component of the work in project CLAIRE and required a dedicated team of engineers and access to a wide range of stakeholders. The following sections detail the scope of the preparatory work undertaken.

4.1.4.1 Safety Approach

Clearly for live flights to take place, they must be shown to be acceptably safe. This involves two main areas of work:

- Work by Thales to develop the Safety Case for the air vehicle in the airspace to be flown
- Work by NATS to develop the Safety Case for the use of the airspace for RPAS flights.

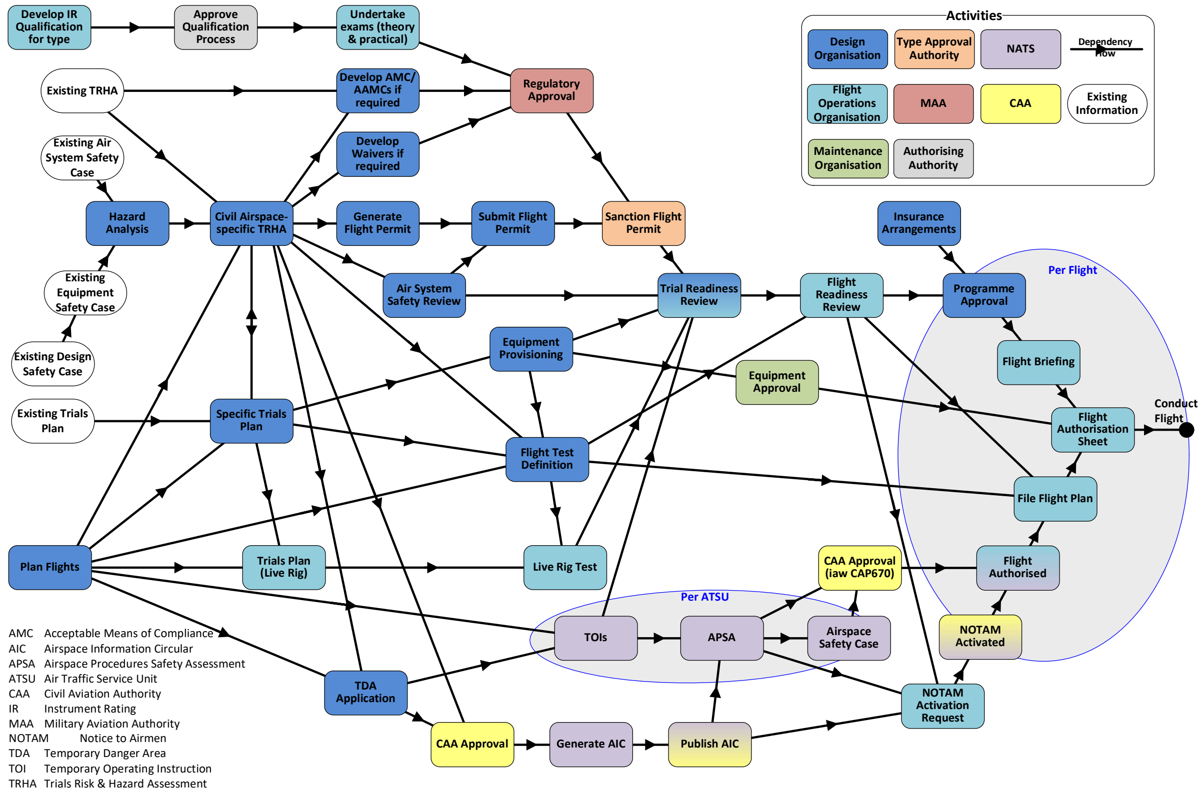

Figure 4-8: Summary of Safety Activities

Figure 4-8 provides an overview of the general safety-related activities necessary to allow exercise 3 to proceed. In parallel with this work, the Thales Flight Organisation was undergoing a change in approval schemes from the MAA's MFOC (Manual of Flying Orders for Contractors) scheme to CFAOS (Contractor Flying Approved Organisation Scheme). This resulted in delays to some of the activities shown in the diagram as resources were shared across the two work-strands.

The safety work was based upon the prior existence of five key documentation sets which all relate to flight in segregated airspace:

- An existing Trials Risk and Hazard Assessment covering operations on the range
- An existing Design Safety Case covering the safety of the design of the air vehicle and associated ground system components
- An existing Equipment Safety Case, based on the Design Safety Case, but including all on-airfield equipment such as towing vehicles
- An existing Air System Safety Case covering air operations within the range area
- An existing trials plan covering ongoing trials and production acceptance operations

Guidance from the UK MAA was that considering the effort and resources required to secure approval of the existing documentation set, the project should focus only on the differences between the existing system and operations and changes to support Project CLAIRE. It should be noted that no design or equipment changes were required to undertake flight in non-segregated airspace.

The Air System Safety Case covered only operations within the confines of the range area, and although operations in non-segregated airspace were considered identical, the pilot qualifications needed to be re-assessed. It was recognised that whilst the pilots were already qualified to fly the air vehicle in segregated airspace, in order to fly in non-segregated airspace, a type rating was needed to cover operations in shared airspace. This is covered in more detail in section 4.1.4.6.

The key document used to identify the work required to secure approval for flight in non-segregated airspace was a revised Trials Risk and Hazard Assessment based on the existing Trials Risk Analysis but addressing the specifics associated with flight outside the range area and in non-segregated airspace. This document was generated following a series of hazard analysis workshops as described in 4.1.4.2.

The Trials Risk and Assessment informed the flight approvals and the airspace approvals processes. The flight approvals activities are discussed in section 4.1.4.3, and involved engagement with a large number of stakeholders as described in section 4.1.4.4

The Trials Risk and Hazard Assessment identified that although the flight could take place in non-segregated airspace, the CAA stated that under no circumstances should the air vehicle enter uncontrolled airspace. To allow for an emergency such as an engine failure, it was agreed that the project should apply for a temporary danger area in class G airspace immediately below the planned route. The generation and approval (by the CAA) of this application, together with the proposed flight plans informed the airspace access approvals led by NATS as discussed in section 4.1.4.5.

4.1.4.2 Risk Assessment

The start point for the Thales work was to examine and address the hazards and risks associated with flying an RPAS in non-segregated airspace. This was based on a series of workshops held to identify risks and hazards and to consider mitigation approaches which may be required.

The Hazard Identification workshops were open to both industry and regulatory stakeholders, although the first workshop was actually attended only by industry stakeholders with outcomes reported to the regulators at subsequent briefing sessions. The MAA and CAA regulators actively participated offering guidance and interpretation in the more mature detailed workshops that followed.

The initial Hazard workshop explained the System, the environment (the ATC landscape), and the context to all stakeholders. With this understanding, and ability for each stakeholder group to understand the capability and limitations of the other parties, a hazard identification process was undertaken which identified hazards, mitigations and other issues which would threaten (or bear upon) a number of key safety objectives.

The output comprised hazards and mitigations (control measures) which could be compared with the existing Thales Flight Operations Air System Safety Case (for the RPAS operator) and NATS Airspace Safety Case (for the ANSP), the baseline references for normal operation for each organisation.

It is important to note that when compared with existing Safety Case for flight in segregated airspace, no new hazards were identified to the overall Operator/ANSP collaboration. Hazards which could be regarded as new to one party, generally by being outside their traditional scope, were addressed by technology or procedures of another party in the collaboration. New, additional or developed control measures and mitigations relevant to the context of the expansion into controlled airspace were identified. This would lead to specific control measures both for the platform operator – via Flight Trials Reference Cards, and the ANSP – via Temporary Operating Instructions. Both organisations operate systems with sufficient maturity to have formalised processes for addressing departures from normal operations.

The Thales-facilitated and NATS-facilitated sessions adopted a broadly similar approach to engage with the contributors at the first workshop:

- Identifying and Agreeing Safety Objectives, Topics or Themes.
- Small break-out team discussions, brainstorming around flip-charts focused on each of the Safety Objectives, posting relevant hazards & related material (using Post-It Notes).
- Free rotation & mixing of the break-out teams once the initial ideas had been posted.
- Round-table discussion and development of the key flip-chart themes.

The technique enabled small teams to contribute in an animated and dynamic format, and the teams rapidly bought-into the process which initiated much valuable discussion. The format enabled both expert and peripheral contributors in any topic area to make a valuable contribution by initiating, developing or clarifying a posting. The process led to the articulation of a great number of hazard, accident and control descriptions, along with observations and other relevant commentaries.

The findings from the Hazard Identification Workshop were collated into a raw (lists everything) and consolidated Hazard Log (merged and removed duplicates) which was circulated to participants for comments and revision. The resulting Hazard log was reviewed against existing Hazard logs and assessed to contain no fundamentally new hazards for the Operator-ANSP collaboration, but a wealth of new useful mitigations and ways that one side of the collaboration could assist or improve the interface with the mitigations of the other party.

The first workshop, and particularly the NATS-facilitated session, informed the planning for the subsequent simulation in the NATS *SPACE* synthetic ATM environment. It identified areas where the aircraft or ATC system may be limited, and where multiple failures may have an impact so that realistic scenarios could be devised and that the simulation might test the resilience.

Whilst some subsequent workshops also used the break-out discussion technique to initiate stakeholder engagement, they were more focussed on developed documentation such as the CLAIRE Trails Risk & Hazard Assessment which used the output of the initial workshops to describe the mitigations required in each hazard area. This assessment (and its report) represented the operator's beyond-baseline-operation Safety Case for the flight

Later workshops also described how the CLAIRE flights would address relevant MAA Regulatory Articles – in particular any regulatory requirements for the flights which were novel compared to previous operations. The need for an Instrument Rating has been a particular case in point and addressed by the Flight Operations Organisation. The CLAIRE project has helped bring a better understanding and interpretation to how it should be addressed, as current training is a de-facto integrated flight training and Instrument Rating Training.

It was through the workshops that the need for Temporary Danger Areas (TDAs) was identified and clarified from its regulatory origin as an airspace policy prohibition not to fly in Class G airspace without a Detect & Avoid system under <u>any</u> foreseeable circumstances including engine failure. Although it was possible to fly in non-segregated, controlled airspace without the use of TDAs, it was clear that some level of protection below the planned route should be included to allow for a possible engine failure. This resulted in the need to develop and apply for TDAs below the planned route to cover the uncontrolled (class G) airspace below the route in controlled airspace.

4.1.4.3 Flying Approvals

Currently, nearly all high-end tactical RPAS have a military pedigree, and one of the main aims of project CLAIRE was to assess how the approvals could map on to the civil environment. As a military platform the selected RPAS is governed by the MAA's Regulatory Articles (RAs). These are closely aligned with civil regulations, but since the MAA is a relatively young organisation, have been subject to a relatively high rate of change. The RAs were reviewed in the context of the CLAIRE demonstration flights and since the flights represent an extension of normal military operation and the scope of previous authorisations, some RAs require specific attention to undertake the flights.

At the time of planning the RPAS operated under arrangements described in the *Manual of Flying Orders for Contractors* (MFOC) and the authorisations associated with MFOC. The Thales *Flying Operations Organisation* (FOO) is transitioning to a new regulatory arrangement, *Contractor Flying Approved Organization Scheme* (CFAOS) and the planned flights would take place once the transition to CFAOS approval was complete.

While the RA's were the same for both regimes, the scope of the Thales' approvals was slightly different, and the RAs themselves continued to evolve during the period of transition.

The rationale published for each RA was considered in order to assess its applicability to RPAS flight generally or the CLAIRE Flight in particular. RAs with some relevance to the CLAIRE project were identified at a workshop with MAA, CAA & NATS and some were quickly determined not to be applicable to the CLAIRE flights (e.g. flying displays, low flying)

Two RAs required specific attention for flight under the CFAOS authorisation in order to address extensions wrt normal operation, namely:

- Flight outside Segregated airspace (RA2320 Role Specific RPAS)
- Airspace Navigation Equipment Fit (RA2307 Rules of the Air)

In addition, a third Regulatory Article (Pilots' Instrument Rating Scheme), while addressed by the CFAOS approval would be exercised to its full extent for the first time on the CLAIRE flights in Class A airspace.

Flight outside segregated airspace is normally prohibited for RPAS without an approved Detect & Avoid system. As no such system exists, a safety argument was developed within the CLAIRE Trials Risk & Hazard Assessment which formed the basis for a waiver request. This cited the ATC services as the primary means of separation control and the provision of TDAs as a safety net in the event that an engine failure caused the aircraft to drop out of the airway into Class G airspace on a glide-path to a pre-arranged recovery site. This was the only waiver request and was based on the premise that separation is maintained for all IFR traffic in Controlled Airspace by the Air Traffic Control Service. The other significant mitigations (e.g. TDAs) were established for a propulsion system emergency only, as individual system failures (and combinations thereof) would be handled by Standard Operating Procedures on the part of the platform operator or ATC.

This was simulated by extensive exercises in the NATS' *SPACE* synthetic ATM environment and in the Thales Hybrid Rig environment.

4.1.4.4 Stakeholder Engagement

Throughout the exercise, and in particular within the preparatory phase, a number of stakeholders were engaged. The following sections detail the stakeholders and the reasons for their involvement. In addition, recommendations for future engagement are given.

4.1.4.4.1 CAA

The CAA is the civil regulatory authority for the UK and was consulted at a very early stage in the project. It recognises the aims and benefits of the project and was keen to provide guidance where needed. It was clear that any flight trials would need to comply with the CAA's Air Traffic Services Safety Requirements [3].

The CAA is the author of CAP722 which is a highly regarded guidance document for RPAS operations. This states that for access to non-segregated airspace, an RPAS should have some form of Detect & Avoid system fitted. In early discussions, the CAA suggested that for an experimental flight in controlled airspace, it may not be necessary to include a D&A capability. However at subsequent meetings, in the absence of established regulation, it was agreed that flights would only be permitted if one of the following could be achieved:

a) A detect & avoid system was fitted

b) It could be demonstrated that the reliability of the RPAS was such that it could never penetrate uncontrolled airspace

c) There was no chance of a collision outside controlled airspace

Taking each of the above in turn:

a) It was noted that no clear standards exist for the performance of a D&A capability, and even though Thales is actively developing a D&A solution, it would not be possible to specify and install a suitably compliant system within the timescale of the project.

b) The trials will be based upon the Watchkeeper platform which is a single-engined aircraft. In the event of an engine failure, however unlikely, for the planned scenarios it may not be possible to prevent the air vehicle descending into uncontrolled airspace.

c) Considering (b) and in order to eliminate the risk of collision outside controlled airspace, it may be necessary to advise other airspace users and provide a deconfliction service below the planned routes.

The decision was made to adopt option (c), which necessitated the development of a series of temporary danger areas (see section 4.1.4.5.1) which would protect the airspace below the planned route. This would mean that the flights could still take place in controlled, non-segregated airspace, but in the event of an emergency resulting in the air vehicle descending into uncontrolled airspace, no midair collision could occur because a deconfliction service would be provided by ATC.

4.1.4.4.2 MAA

The MAA is responsible for granting certification of the candidate platform. Current type certification allows access only to segregated airspace (in the absence of an approved Detect & Avoid system), but it was recognised that future requirements are likely to require access to non-segregated airspace, and that the flight of RPAS in non-segregated airspace would be a useful exercise for the MAA by proving the regulations in the context of RPAS.

Throughout the Watchkeeper procurement programme, as a relatively young organisation, the MAA has been establishing and developing procedures which has led to some changes to regulatory articles and information to support certification. Whilst this is considerably more mature than early in the Watchkeeper programme, some level of update has been observed during the lifetime of Project CLAIRE.

Whilst some RPAS regulation has evolved significantly, to address the issues of small UAVs in particular, some areas of operation are currently only relevant to the larger RPAS and an interpretation of the regulation aimed at manned platforms is required. An example of this is, Operation under Instrument Flight Rules and the need for a Pilot's Instrument Rating, as discussed in 4.1.4.6.

4.1.4.4.3 MoD

Though the majority of input was focused through the Unmanned Air Systems (project) Team (UAST) (see 4.1.4.4.5) a number of UK Ministry of Defence (MoD) and other government agencies (such as the Department of Transport) maintained a close interest in the project. The ability to operate military RPAS in non-segregated airspace has well established benefits in applications such as extended training exercises and military assistance to civil agencies as well as transit to remote military exercises or areas of operation.

4.1.4.4.4 TAA

The Type Airworthiness Authority (TAA) is an individual responsible for the Type Airworthiness of an air system throughout its life from development to disposal. The TAA is the Military Type Certificate Holder for the platform.

The TAA ensures that the platform type meets all applicable airworthiness regulatory requirements through-life, including all civil mandatory, advisory and deferred instructions (e.g. Airworthiness Directives (ADs) and Service Bulletins) for civil type aircraft.

The TAA is a member of the UAST, the MoD customer for Watchkeeper.

4.1.4.4.5 UAST

The MoD Unmanned Air Systems Team (UAST) supported the CLAIRE programme throughout the exercise planning and execution phases by providing equipment, facilities and infrastructure as well as TAA expertise to approve the Trials Risk & Hazard Assessment (TRHA) document set which underpins the extended Military Flight Test Permit (MFTP). A number of meetings and workshops were supported by the UAST to ensure suitable equipment and facilities (such as the Hybrid Rig Simulator the infrastructure at West Wales Airport) were made available to Project CLAIRE in full cognisance of the main Watchkeeper programme requirements and its priorities.

A formal loan agreement was established between Thales and UK MOD, Defence Equipment & Support (DE&S), UAST to enable Watchkeeper assets and associated support items at the West Wales trials site, to be used for Project CLAIRE. The loan agreement included a set of assumptions (MDAL) and items lists specifying equipment build standards, item descriptions and nominal insurance values.

4.1.4.4.6 MCA

As part of the contingency management aspects of RPAS operations, a series of Emergency Recovery Locations were identified for each route being considered. The preferred sites for these locations contain low densities of population and therefore sites over water are preferred. In addition, portions of the proposed flights involved transit over UK territorial water and it was therefore considered appropriate to engage with the UK Maritime & Coastguard Agency (MCA) to provide briefings and to ensure that the MCA had no objections to trials involving RPAS.

Prior to briefing the MCA, the sites of the ERLs were compared with 'heat maps' of marine traffic to assist in the identification of shipping lanes. Even though the use of an ERL is unlikely, this ensured, that should an emergency occur requiring the use of an ERL, its position would not coincide with significant levels of marine traffic.

A briefing was held in April 2015. The MCA requested a copy of the Trials Risk & Hazard Assessment and provided a letter of 'no objection' to the project partners which also stated that the MCA does not consider there to be any material risk to mariners.

4.1.4.4.7 Cardiff Airport

A number of exploratory meetings were held with Cardiff International Airport Limited (CIAL) Operations Director to investigate potential use of Cardiff TMA for RPAS approach and overflight. The intention was for the project to replicate standard approaches and demonstrate that the RPAS can navigate to civil position routes to support Project CLAIRE requirements. Cardiff Airport was chosen as a preferred airport to allow the trial to integrate with civilian air traffic due to its proximity to the L9 airway and the fact that the airport supports both VFR and IFR traffic.

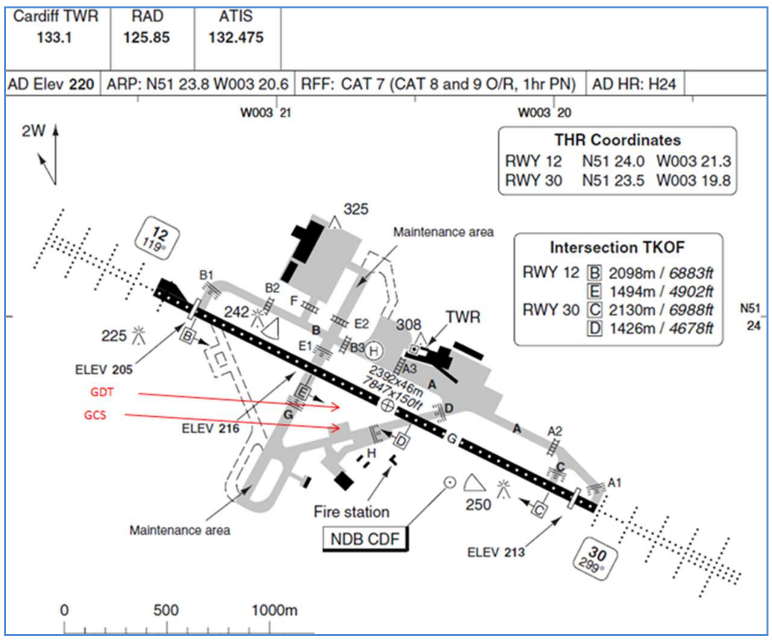

Figure 4-9: Cardiff International Airport

The meetings were informative and well received by CIAL and included an initial assessment of Cardiff Airport layout and ground infrastructure to determine where equipment (including Ground Control Station & Ground Data Terminal) may be safely and securely located in support of any future RPAS trial using remotely deployed RPAS ground infrastructure.

4.1.4.5 Airspace Access

In order to achieve access to non-segregated airspace, as discussed in 4.1.4.4.1, the CAA required the provision of a series of Temporary Danger Areas (TDA) in order to protect other airspace users in the event of the platform descending into uncontrolled airspace as a result of an engine failure. The TDA process for RPAS together with the corresponding Aeronautical Information Circular (AIC) and Temporary Operating Instructions (TOI) are described in the following sections.

For two of the routes (Yankee/Green and Zulu/Black) the RPAS would be required to transit a small section (7.5NM) of uncontrolled airspace. Since a collision avoidance capability is not yet fitted to the RPAS, the CAA required this section to be included within a TDA.

4.1.4.5.1 Temporary Danger Areas

TDAs require a sponsor which within the UK is normally only the military, and there is little precedent for industrial sponsorship. Nevertheless, the partners developed an application for TDAs which was processed normally by the CAA and accepted. This was the first time that the CAA had been requested to allocate TDAs for industry, and specifically for RPAS flights.

Due to the complex shape of the airspace structure in the planned operational area (West Wales), it was necessary to design a series of interlinked TDAs which slotted in with the existing structure with no overlaps or gaps. This was used as the basis of discussion with the CAA and it was agreed that a simpler approach should be adopted. This would result in fewer TDAs, but include overlaps with existing airspace as shown in Figure 4-10

The application referring to the *Yellow*, *Green* and *Black* route was submitted to the CAA in November 2014. This was duly processed and feedback was received and incorporated into issue 2 [4] of the application. The main concern was that Aeronautical Information Circulars are printed in monochrome on coloured sheets and the CAA requested that the routes were re-designated using a non-colour-related scheme. The routes were therefore redefined as the letters *X*, *Y* and *Z* referring to the previous yellow, green and black routes respectively.

The CAA processed[2] and accepted the TDA application and allocated five TDA referenced as D198A to D198E. The intention was that the required TDAs would be activated by NOTAM 72 hours before each flight was scheduled to take place.

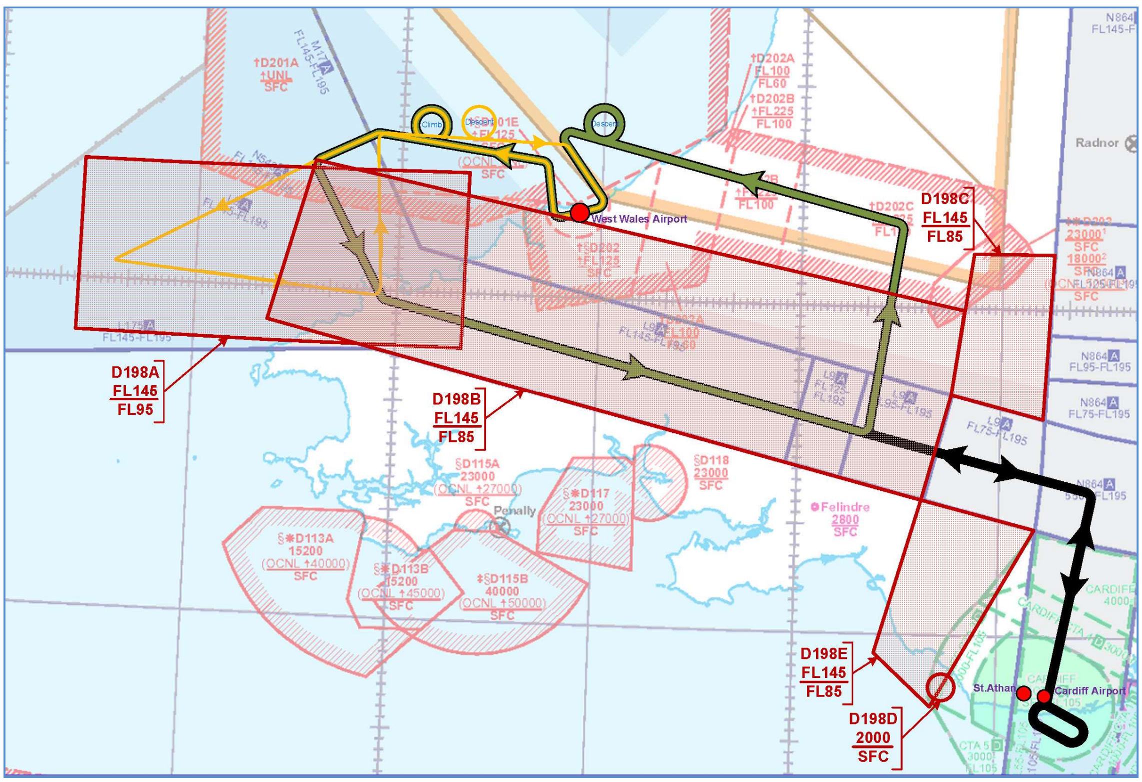

Figure 4-10: Agreed TDA Configuration

4.1.4.5.2 AIC

On acceptance of the TDA application, NATS developed an Aeronautical Information Circular (AIC) [5] which was published with CAA approval on the 19th March 2015. A copy of the circular can be found at Appendix B.

[2] For simplicity the TDAs were requested in the form of monolithic slabs of airspace which overlapped existing controlled airspace. When activated, the TDAs were to be contiguous with the adjacent controlled airspace but no part of a TDA would exist within controlled airspace.

The AIC defines the geographical and altitude limits for the TDAs and indicates the likely dates and duration of activation - to be activated by NOTAM. Promulgation of the AIC assumes that copies will be made at remote locations, and are therefore limited to monochrome. This meant that naming conventions, terminology or symbology referencing colours were to be avoided.

4.1.4.5.3 ATC Temporary Operating Instructions

For the respective ATSUs, control is in accordance with the established ATC procedures for flight in the sector or airspace concerned and supplemented with Temporary Operation Instructions (TOIs). This is an established practice supported by the NATS safety process. The TOIs, developed during workshops and simulations, inform the ATCOs of any differences affecting their interaction with the CLAIRE flights and are specific to each ATSU.

The 3 ATC units involved in the trials followed different but equally valid approaches to build their TOIs.

- Aberporth, due to their familiarity in managing RPAS in the Danger Area created a TOI based on that general experience and added an Appendix to cover the particularities of CLAIRE trial.
- Cardiff approached the creation of TOIs based on the experience gained by Aberporth and provided extensive background detail on the Watchkeeper RPAS performance envelope, detail on the routes, emergency modes and recommendation to controllers.
- Swanwick embraced the trial flight aim of equivalence and normalcy of the RPAS operation. The TOI therefore only contained those few material changes in procedure that were required, and useful background data regarding the vehicle.

Despite the three different approaches, the following commonalities can be found in the information provided by the ATC Temporary Operating Instructions:

- the air vehicle’s general performance;
- that it cannot comply with the rules of the air with respect to ceding passage;
- the contingency behaviour;
- the Comms back-up by telephone (and contact details) in a loss of communications situation;
- the existence of a range of contingencies for equipment failures;
- that LLRs & ERLs are updated as the flight progresses;
- the requirement to remain in controlled or segregated airspace;
- the presence & reason for TDAs (a contingency to protect the glide to ERLs).

Prior to use, the ATC TOI is subject to approval by the person holding the Unit safety accountabilities for approving ATC procedures for operational use. NATS ATC experts including air traffic controllers from the relevant unit participated in this task. The facilitators of the APSA process must have undertaken NATS’ training in the APSA process. The output is a validated set of Temporary Operating Instructions, and a completed NATS *ATC HAZARD ANALYSIS PRO-FORMA 4120* for each unit, which constitutes the Airspace Safety Case.

4.1.4.5.4 Air Navigation Order

Air Traffic Service Units in NATS assessed evidence provided by Thales to confirm that the level of vertical and horizontal navigation capability of WK450 under normal operating conditions is acceptable for the intended flights in Project CLAIRE, and that any residual risks could be operationally mitigated. In accordance with the Air Navigation Order [6], Schedule 5, “Radio Communication and Radio Navigation Equipment to be carried in Aircraft”, this allows ATC to permit the flights to proceed.

4.1.4.6 Licensing

In their guidance [7] for RPAS operations, the CAA indicates that approvals for pilots to operate larger RPAS will be considered on a case-by-case basis with no definitive rules. Although not stated, there seems to be an expectation that pilots would need to hold an instrument rating. Study work within the project has identified key differences between the requirements for instrument flying for manned and unmanned aviation:

- Type instrument ratings for manned aircraft assume that the pilot is able to directly control the aircraft according to the information displayed in the cockpit. For unmanned aircraft it is very often the case that the flight of the air vehicle is managed automatically. Although the pilot is able to manually override this automatic control (e.g. in response to an ATC instruction), the normal mode of operation is to fly automatically between a series of 3- or 4-dimensional waypoints.
- Ratings for manned aviation include the ability to control the aircraft in a wide range of physiological conditions. This ensures that the pilot can remain orientated whilst the aircraft is manoeuvring with few visual cues. For unmanned operations, the pilot is likely to be located in a benign, static environment where such conditions do not occur.

In discussion with the MAA, it was agreed that a new rating specifically for the RPAS type is required, which aligns with existing practice for manned platforms where the rating is valid for the platform type. This was assessed as part of the CFAOS approval sought by the RPAS operator. Until now there has been no requirement for a high-end tactical RPAS to fly outside segregated airspace, but Project CLAIRE is aimed at investigating the requirements to enter non-segregated airspace and therefore two ratings have been considered:

- *Instrument Rating [Segregated]* to allow the air vehicle to fly within segregated airspace
- *Instrument Rating* to allow the air vehicle to access controlled, non-segregated airspace

The current RPAS pilot flight training and refresher training *Certificate of Competence for Watchkeeper* is a de-facto combined Flight Training & Instrument Rating leading to the award of an *Instrument Rating [Segregated]* valid for flight within segregated airspace.

An additional training module is required for flight outside segregated airspace. The candidate is required to demonstrate competence in the airspace understanding, radio-telephony, meteorology and airmanship required to navigate complex airspace integrated with other airspace users. In the case of Watchkeeper pilots, this is via a flight skills test and separate written exam assessed by an independent examiner, leading to the award of an Instrument Rating valid in all classes of airspace. Within the Thales Flight Operations Organisation, only candidates with extensive previous experience of navigating Controlled Airspace are eligible to apply for this rating.

Whilst the CAA have a formal written examination for the award of an instrument rating, the UK military commonly adopt an approach where the theoretical knowledge assessment is integrated into the skills assessment. The Thales Flight Operations Organisation has elected for a process closer to the former in order to emphasise the additional skill-set required, and the exceptional relationship to the Flight Operations Organisation’s current operating environment.

4.1.4.7 Insurance

A number of specialist insurance brokers were consulted before a certificate of insurance was issued for a specific number of flight hours within a defined period of time. A period of consultation and familiarisation, including an Insurers Underwriters workshop, hosted by Thales, helped reduce initial premiums coupled with opportunities to purchase a composite cover incorporating additional Watchkeeper flights not related to CLAIRE.

The insurance policy covered three principal risks, namely:

- Hull Insurance – covering all specified risks of physical damage to the RPAS
- Payload Equipment Insurance – covering all specified risks of physical damage to Payload Equipment
- Legal Liability Insurance - liability to third parties arising out of the operation of the RPAS by Thales

4.2 Exercises Execution

The exercises were planned to incrementally address the issues associated with RPAS operation at airports, within the TMA, and en-route with opportunities for lessons learnt to be incorporated into successive exercises. To maximise the effect of each exercise both internal and external stakeholders were invited to be involved. Exercises 1 and 2 focussed upon RPAS ATM within the ATM environment and provided a good foundation for exercise 3 which was aimed at preparing for live flights involving the use of the ATM procedures developed together with intensive regulatory engagement in order to achieve flight approvals.

Exercise ID	Exercise Title	Actual Exercise execution start date	Actual Exercise execution end date	Actual Exercise start analysis date	Actual Exercise end date
EXE-RPAS-07-001	Airport & TMA RPAS Operations	20-May-2014 14-Oct-2014	22-May-2014 16-Oct-2014	20-May-2014	30-Jul-2015
EXE-RPAS-07-002	En-route RPAS Operations	03-Jun-2014	06-Jun-2014	07-Jun-2014	30-Jun-2014
EXE-RPAS-07-003	Live Flight Rehearsal	25-Feb-2015	26-Feb-2015	27-Feb-2015	20-Mar-2015
	Live Flights	28-Sep-2015	22-Oct-2015	29-Sep-2015	31-Oct-2015

Table 4-2: Exercises Execution/Analysis Dates

4.3 Deviations from the planned activities

Project CLAIRE has successfully flown an unmanned RPAS in non-segregated airspace. It is believed that to-date this is a first and has pushed the boundaries for RPAS operations, involving a significant learning curve for the partners and for many stakeholders. Much work has been required to address RPAS ATC integration and to ensure that flights can be undertaken safely with sufficient contingency measures in place. Therefore, as the project has progressed, emphasis has changed as issues have developed, or been resolved. This has resulted in more effort being required in certain areas with a corresponding reduction in others considered less significant. The resulting impact on objectives is relatively minor, and this is discussed within the appropriate demonstration exercise reports (see sections 6.1.2.3, 6.2.2.3 and 6.3.2.3).

The following sections describe deviations from the initial demonstration plan:

4.3.1 Live Flight Delays

As described in 4.1.4.3, the approvals under which Thales operates Watchkeeper have been transitioning from a regulatory oversight scheme based on the *Manual of Flying Orders for Contractors* (MFOC) to a new scheme referred to as *Contractor Flying Approval Organisation Scheme* (CFAOS)[3]. This resulted in the requirement to overhaul the exposition to the MAA regulator to gain new approval to continue flying. Flights under MFOC specifically excluded flight in non-segregated airspace and as that regulatory framework was to be discontinued, approval to fly in such airspace had to be secured through a CFAOS approval process.

Although the military owner and regulator were supportive of the exercise and assets were assigned to complete the live flights, the planned flights could not be undertaken until the transition from MFOC to CFAOS was completed and approved in August 2015. In addition, to the approvals scheme transition, the project identified specific regulatory articles within CFAOS which need to be addressed (see 4.1.4.3). Whilst it was possible to develop the required Acceptable Means of Compliance and Waiver application associated with the flights before the transition to CFAOS oversight was complete, Approval could not be considered until CFAOS accreditation had been achieved.

4.3.2 Removal of Black Route/Route Z

The Black Route/Route Z was originally planned to provide extended occupancy within controlled airspace with an opportunity to transit across two separate air traffic control sectors (Swanwick and Cardiff) together with overflight within the Cardiff CTA. The flight would also require provisioning and remote deployment of an additional Watchkeeper GCS and infrastructure located at Cardiff Airport to

[3] CFAOS reflects the trend towards more autonomous self-authorisation of operators with regulatory oversight through audit

enable operations beyond radio line-of-sight of the GCS at West Wales Airport. The intent was to include GCS to GCS handover at a suitable point on the outbound and return flight paths from West Wales Airport. However, it became apparent that additional equipment provisioning, additional manpower (i.e. pilots and ground crew) and logistical requirements, insurance premiums and Safety Case extensions would not be practical nor completed within the available timescales and budgetary allowances.

4.3.3 Exercise 3 Dry Runs

Representatives from London Area Control Centre, Aberporth and Cardiff Airport, considered that the scope of section 5.3.1(a) of the Demonstration Plan [2], detailing Exercise 3 Dry-runs, had already been met by the extensive simulations performed in *SPACE* and informed by the two sessions in NLR.

Following the experience gained in high fidelity simulation, TOIs were developed to cover operation of the RPAS vehicle and reflect its flight characteristics from the ATC viewpoint. Simulations and ATC Procedure Safety Assessment also indicated that individual training was not required for involved ATCOs, as the RPAS trial flights as planned would have little operational impact.

In addition to the development of the relevant TOIs, a full and comprehensive briefing was provided to the affected ATC staff at each unit prior to each flight trial.

An additional set of high fidelity simulations was undertaken using the Watchkeeper Hybrid Rig facility in February 2015. This allowed the routes to be rehearsed using real system components in a high fidelity synthetic environment. It also allowed emergency procedures to be validated prior to the live flights.

4.3.4 Collision Avoidance

Thales and NLR are both heavily involved in various RPAS Detect & Avoid (D&A) initiatives with many flying hours dedicated to data gathering and system evaluation using surrogate RPAS based on manned platforms. As part of this process, Thales has developed a good understanding of cooperative and non-cooperative[4] sensor requirements and performance together with detect & avoid algorithms and has developed and demonstrated a prototype system suitable for further flight trials in the near future.

In addition, both Thales and NLR are involved in the regulatory work associated with Detect & Avoid and collision avoidance for use on RPAS as well as new initiatives such as ACAS-X which is expected to support collision avoidance for RPAS through its Xu variant.

The current situation is that although collision avoidance systems for RPAS can be demonstrated, there are no formal standards in place to allow the performance of such systems to be validated. The project's focus was on the ATM context, and whilst recognising that collision avoidance should be addressed as part of the airspace integration, the team considered this to be a lower priority when compared with the work associated with flying RPAS normally in non-segregated airspace controlled by ATC. The project included a Detect & Avoid study and rather than commit simulator and exercise time to collision avoidance, objective OBJ-RPAS07-14 was addressed in detail in the study and its associated report [8].

[4] Cooperative sensing involves the use of transponder-based technologies such as Mode S, ADS-B and TCAS. Non-cooperative sensing does not require a potential intruder to cooperate and is performed using sensors such as primary radar and electro-optic.

5 Exercises Results

5.1 Summary of Exercises Results

As discussed in section 4.2, the exercises were iterative in nature. This means that the objectives were not necessarily addressed by a single exercise. The following table describes the exercise results in terms of the objectives.

Objective OBJ-RPAS07-	Demonstration Objective Title	Success Criterion	Exercise Results	Demonstration Objective Status
001	Preparation and de-risking of live flight	No additional risks identified or clear mitigation approach	Exercises RPAS07-001,002 & 003: No additional risks identified, or clear mitigation approach. Emphasis required on contingency management	OK
002	Clarification of regulatory requirements for RPAS flight in non-segregated airspace	Training and assessment plan complete	Exercises RPAS07-001,002 & 003: Training conducted prior to each exercise culminating in hardware-in-the-loop hybrid rig training. Instrument rating process assessed and type Instrument rating developed with RPAS pilots achieving new type rating	OK
		Regulator approval for live flight achieved	Exercises RPAS07-002 & 003: Engagement with CAA with agreement to set buffer zones below non-segregated airspace. Generated and submitted application [4] for TDAs which were approved, resulting in an AIC [9] (see Appendix B). Engagement with MAA to complete transition to new flying organisation scheme incorporating flight in non-segregated airspace. Military Flight Test Permit granted by MAA.	OK
003	Confirm procedures to be used during live flight	All participants agree to progress live flights	Exercises RPAS07-001, 002 & 003: Simulations allowed procedure development resulting in Temporary Operating Instructions [10] [11] [12] acceptable to all parties, including the CAA and MAA.	OK
004	Development of Emergency Procedures	All participants clear on actions required in an emergency	Exercises RPAS07-001, 002 & 003: All simulations involved the development and testing of emergency procedures. Candidate procedures documented in Trials Plan [13] and in NATS ATSU Temporary Operating Instructions approved [10] [11] [12].	OK

Objective OBJ-RPAS07-	Demonstration Objective Title	Success Criterion	Exercise Results	Demonstration Objective Status
005	Fly RPAS in multi-agency, mixed traffic non-segregated environment	High level CONOPS for UAS flight in controlled airspace incorporating: • Contingency Procedures for Lost Link • Radio Comms Failure Procedures • Transponder Failure Procedures • Emergency Procedures	Exercises RPAS07-001, 002 & 003: All simulations involved the demonstration of emergency CONOPS. In addition, the hybrid rig was used to validate the emergency procedures were found to be achievable and acceptably safe.	OK
		RPAS flies in segregated airspace	Exercise RPAS07-003: Hardware-in-the-loop test on the hybrid rig demonstrated flight in segregated airspace.	OK
		RPAS flies in controlled airspace (A-E)	Exercise RPAS07-001, 002, & 003: Demonstrated in all exercises.	OK
		RPAS flies in uncontrolled airspace (F-G)	Exercise RPAS07-002, & 003: RPAS was flown through segregated class G airspace in the en-route simulations, and in the hardware-in-the-loop hybrid rig.	OK
		RPAS is handed over from one ATC agency to another	Exercise RPAS07-001, 002, & 003: Exercises demonstrated successful handovers between approach & tower, and between ATC sectors.	OK
		RPAS demonstrates lost-link contingency procedures	Exercise RPAS07-001, 002, & 003: Demonstrated in all simulation exercises and also validated for safe flight in the hybrid rig. No separation breaches identified.	OK
		RPAS demonstrates radio communications failure procedures	Exercise RPAS07-001, 002, & 003: Demonstrated in all simulation exercises and also validated for safe flight in the hybrid rig. No separation breaches identified.	OK
		RPAS operates with transponder failure	Exercise RPAS07-001, 002, & 003: Demonstrated in all simulation exercises and also validated for safe flight in the hybrid rig. Emphasised the necessity for ensuring an operational transponder for RPAS.	OK

Objective OBJ-RPAS07-	Demonstration Objective Title	Success Criterion	Exercise Results	Demonstration Objective Status
		RPAS demonstrates emergency procedures	Exercise RPAS07-001, 002, & 003: Demonstrated engine failure in all simulation exercises and also validated for safe flight in the hybrid rig. Contingency management procedures were considered acceptable and safe with no separation breaches detected.	OK
006	RPAS operates at a medium-sized airport	High level CONOPS for UAS airfield operations incorporating: • Contingency Procedures for Lost Link • Radio Comms Failure Procedures • Transponder Failure Procedures Emergency Procedures	Exercise RPAS07-001: Simulation demonstrated validity of contingency procedures for lost link, lost comms and transponder failure, as well as emergency procedures associated with engine failure. Procedures found to operate successfully with no safety issues identified.	OK
		RPAS takes off from non-segregated runway	Exercise RPAS07-001: Simulation demonstrated ground movement management and RPAS take-off from Rotterdam Airport.	OK
007	RPAS operates in a mixed-traffic, non-segregated environment	RPAS operations are all in a mixed traffic environment.	Exercise RPAS07-001, 002, & 003: All simulations demonstrated RPAS operations in mixed-traffic, non-segregated airspace. In all cases controllers and pilot were able to ensure safe flight with no separation breaches.	OK
008	RPAS Taxiing Capability Investigated	RPAS taxis from parking area to runway under ATC instruction.	Exercise RPAS07-001: RPAS pilot demonstration that simulated RPAS could taxi according to instruction from Rotterdam tower in the same way as manned aircraft.	OK
009	Identify security threats to RPAS ground operations	Security requirements clearly identified.	Not addressed by specific exercises, but covered by study [14] which addressed security across all flight phases and all parts of the RPAS system.	OK

Objective OBJ-RPAS07-	Demonstration Objective Title	Success Criterion	Exercise Results	Demonstration Objective Status
010	Assess the impact of inbound/outbound RPAS flight operations in the TMA on air traffic management procedures, safety and controller workload	RPAS inbound/outbound flight operation impact assessment performed	Exercise RPAS07-001: Assessment of operational impact of RPAS flight was undertaken in all simulation runs, including stress testing in terms of emergencies. Slower speed and performance of RPAS was found to increase controller workload by a small amount.	OK
011	Quantify minimum RPAS flight performance requirements without impacting airport throughput significantly for departure and arrival RPAS flight operations	Performance requirements quantified	Exercise RPAS07-001 & 002: Assessment of operational impact of RPAS flight performance undertaken. RPAS performances could be seen to vary widely, ranging from slow and small to fast and large. The slower operations were regarded as similar to some GA flights and had a similar impact on airfield operations. Although no specific performance requirements have been defined, it is likely that RPAS with lower performance than small GA will have some impact on operations and ATCO workload. A further recommendation is that the RPAS should be able to vacate the runway either automatically, or under pilot control as quickly as possible.	OK
012	Assess the impact of RPAS runway vacation procedures including interaction with other departing & arriving traffic	Performance requirements quantified	Exercise RPAS07-001: Runway vacation procedures were assessed including under emergency conditions. Although no specific performance requirements were defined, it was identified that further work is required to determine the appropriate response to an RPAS stopping on the runway.	Partially OK
013	Assess the impact of RPAS start-up and take-off procedures for airport surface operation management and airport capacity	Start-up and take-off procedures impact assessment performed	Exercise RPAS07-001: Although start-up procedures were not considered, taxiing; taxiway management and take-off were assessed. Normal R/T between controller and RPAS pilot meant that taxiing and take-off procedures were equivalent to manned aircraft.	Partially OK

Objective OBJ-RPAS07-	Demonstration Objective Title	Success Criterion	Exercise Results	Demonstration Objective Status
014	Assess the impact of D&A for RPAS TMA operations taking into consideration wake turbulence and meteorological conditions	D&A impact assessment performed	Exercise RPAS07-001: Provision for wake turbulence was including within the simulation, resulting in a small increase in controller workload caused by identifying suitable take-off and landing slots. Detect & Avoid analysis was performed as part of the Detect & Avoid Study [8].	Partially OK
015	Define and assess impact of RPAS lost link procedures on airspace management procedures, safety, and controller workload	RPAS lost link procedures defined and impact assessment carried out.	Exercise RPAS07-001, 002, & 003: All simulations assessed the effect of RPAS lost-link on ATM operations. Contingency management procedures were developed and captured within a series of approved Temporary Operating Instructions [10] [11] [12] to be used for each ATSU. No separation issues were identified.	OK
016	Assess and demonstrate RPAS trajectory exchange with ATC for optimizing inbound traffic flow	RPAS – ATC trajectory exchange assessed	Exercise RPAS07-001, 002 & 003: RPAS – ATC trajectory exchange assessed	OK
017	Assess the impact of RPAS re-routing procedures to avoid bad weather on airspace management, safety, and controller workload	Impact assessment of RPAS TMA re-routing procedures established	Exercise RPAS07-001, 002 & 003: Impact assessment of RPAS TMA re-routing procedures established	OK
018	Raise awareness regarding SESAR activities and objectives to stakeholders	Demonstration sessions to stakeholders given.	Exercise RPAS07-001, 002 & 003: External stakeholders were invited to all simulation events. In addition, two communications events were held in July and October 2014, and the live flights in September/ October 2015 provided additional communications opportunities to raise awareness.	OK

Objective OBJ-RPAS07-	Demonstration Objective Title	Success Criterion	Exercise Results	Demonstration Objective Status
019	RPAS operation in mixed traffic, non-segregated ground environment	Impact to other traffic is identified.	Exercise RPAS07-001: Ground operations, taxiing and runway were simulated with little impact on other traffic. ATCO workload monitored and suggested a small increase in workload mainly due to determining a suitable slot for take-off considering RPAS take-off and climb performance.	OK
		Loss of control procedures are tested	Exercise RPAS07-001: Loss of control was tested only on landing (RPAS not authorised to leave stand or take off without proper control), resulting in the RPAS failing to vacate the runway causing a significant impact on operations	Partially OK
		Loss of comms procedure demonstrated	Exercise RPAS07-001: Loss of comms was tested only on landing (RPAS not authorised to leave stand or take off without proper control). Minimal impact on operations as RPAS pilot was able to communicate with ATC using back-up comms.	OK
020	RPAS taxi from landing point to parking area	RPAS taxis from runway to parking stand under ATC instruction	Exercise RPAS07-001: RPAS pilot demonstrated that simulated RPAS could taxi according to instruction from Rotterdam tower in the same way as manned aircraft.	OK
021	The successful take off, transit and landing of a MALE/HALE platform from one country to the next.	High level CONOPS for cross border operations prepared	RPAS Operating Procedures are not yet aligned across Europe. However, using existing ATC procedures and pan-European levels of service, CONOPS should be the same as transition through FIRs/FABs.	Partially OK
		Successful take off of the RPAS from a non-segregated airport.	Exercise RPAS07-001: Simulation demonstrated ground movement management and RPAS take-off from Rotterdam Airport.	OK
		Successful transit of RPAS in Class A airspace	Exercise RPAS07-002 & 003: Simulations demonstrated transit along airway, validated by hardware-in-the-loop testing on the hybrid rig and live flight. No separation breaches were detected.	OK

Objective OBJ-RPAS07-	Demonstration Objective Title	Success Criterion	Exercise Results	Demonstration Objective Status
022	Assess the handover procedures and processing between ATC sectors, FABs and GCS	RPAS handover procedures between sectors and FABs prepared	Exercise RPAS07-001 & 002: Handovers between approach and tower, and between different sectors were conducted and found to be equivalent to manned aviation. FAB handovers were not conducted as these were considered to be the same as FIR handovers. GCS handovers were simulated and found to operate safely.	Partially OK
		Identification of issues and approaches associated with RPAS transit between sectors and FABs	Exercise RPAS07-002: Handovers between different sectors were conducted and found to be equivalent to manned aviation. FAB handovers were not conducted as these were considered to be the same as FIR handovers.	Partially OK
		Identification of issues and approaches associated with handover from one GCS to another	Exercise RPAS07-002: GCS handovers were simulated and found to operate safely. However GCS handover near sector boundaries should be avoided to prevent simultaneous sector and GCS handovers.	OK
023	RPAS transition from En-route to TMA operations	Successful routing through the airspace to TMA and subsequent landing	Exercise RPAS07-001 & 002: Exercise 002, demonstrated successful routing through en-route sectors into TMA. Exercise 001, demonstrated successful approach and landing of the RPAS	OK

Table 5-1: Summary of Demonstration Exercises Results

5.2 Choice of metrics and indicators

Project CLAIRE success criteria were not entirely based upon the use of Key Performance Indicators, as its aim was to identify issues per KPA associated with the introduction of RPAS into the current and future ATM infrastructure, processes and operations.

The exercises were assessed using qualitative methods based on observation, experience and questionnaires. Detailed reports were produced for exercise 1 [15] and exercise 2 [16]. For Exercise 3, the majority of the work addressed processes and procedures which are captured within this report. Specific detail on the activities required to undertake live flights in non-segregated airspace can be found in section 4.1.4.

5.3 Summary of Assumptions

The following table lists the assumptions made at the start of the project. An additional row has been added for each assumption to justify the validity or otherwise of the assumption, during and at the end of the project.

Identifier	ASS-RPAS07-001
Title	RPAS Platform Type
Type of Assumption	Demonstration Environment
Description	The study; development of processes and procedures; and the live flight will focus on a High-end Tactical RPAS such as the Watchkeeper platform as this has already achieved restricted type certification in the UK.
Justification	Small unmanned aircraft (<=20kg) and Light RPAS (<=150kg) are considered less able to carry technologies (e.g. radio relays, detect & avoid system) required for integration with other air traffic and are therefore of less significance to ATM in the current epoch. High-end Tactical; MALE and HALE platforms are considered most likely to interact with civil aircraft in the short and medium terms. By focussing on a High-end Tactical platform the project benefits from one of the very few RPAS types that currently have limited type approval and permission to operate in UK airspace.
Flight Phase	All
KPA Impact	Environment, Capacity/Quality of Service
Source	Project team and Proposal
Value(s)	Zero
Owner	Thales
Impact on Assessment	Allows more detailed analysis of an RPAS that may challenge some of the SESAR ATM concepts
Post-exercise Comment	The assumption remained valid throughout the project. Basing the study and exercises on a representative RPAS meant that real-world processes and procedures could be assessed and evaluated.

Identifier	ASS-RPAS07-002
Title	Trials Platform is available
Type of Assumption	Live Demonstration Enabler
Description	The live flight demonstration will take place using the Watchkeeper RPAS, with the provision of ground and support equipment confirmed with the UK MoD. It is further assumed that flights will be authorised by an extension to the current Military Flight Test Permit enabling operations to take place in non-segregated airspace.
Justification	As described in the original proposal
Flight Phase	All
KPA Impact	Not relevant to KPAs as the planned verification work can still be undertaken in Synthetic Environments.
Source	Project team and Proposal
Value(s)	Zero
Owner	Thales

Impact on Assessment	None, as the planned verification work can be undertaken in Synthetic Environments.
Post-exercise Comment	Although much work was required to secure the use of a military platform for this exercise, the Watchkeeper RPAS was used to validate the study work.

Identifier	ASS-RPAS07-003
Title	Regulatory approval for live flight outside a TDA is granted
Type of Assumption	Live Demonstration Enabler
Description	The live flight demonstration will take place using the Watchkeeper RPAS but will require the UK CAA (airspace) and UK MAA (platform – using the MFTP) to approve a Safety Case for flight in Class A airspace.
Justification	Part of the normal approvals process
Flight Phase	All
KPA Impact	Not relevant to KPAs as the planned verification work can still be undertaken in Synthetic Environments.
Source	Project team and Proposal
Value(s)	Zero
Owner	Thales & NATS
Impact on Assessment	None, as the planned verification work can still be undertaken in Synthetic Environments. Some process and procedure validation can still take place during operations in a Danger area.
Post-exercise Comment	This assumption is a pre-requisite for any live flying and involved a significant amount of effort by the partners, and the regulatory stakeholders. The preparation for flight required the development of justifications; acceptable means of compliance supported the required regulatory approval. Such an exercise would not have attracted the same level of support from the regulatory bodies unless this assumption was made.

Identifier	ASS-RPAS07-004
Title	It will only be possible to perform some of the verification activities in a synthetic environment
Type of Assumption	Demonstration Enabler
Description	For safety reasons, and due to the lack of standards to certify against, certain RPAS functions such as Detect & Avoid will only be demonstrated within Synthetic Environments.
Justification	RPAS-specific MOPS and MASPS (e.g. for Detect & Avoid) will not be available within the project timescale. As no certifiable Detect & Avoid system can be flown, this would prevent close interaction with other airspace users in non-segregated airspace. Therefore any operation involving safety-critical functions such as Detect & Avoid will be demonstrated only in Synthetic Environments.
Flight Phase	All
KPA Impact	Not relevant to KPAs as the planned verification work can still be undertaken in Synthetic Environments.
Source	Project team and Proposal

Value(s)	Zero
Owner	Thales & NATS
Impact on Assessment	None as the planned verification work can still be undertaken in Synthetic Environments. Some process and procedure validation can still take place during operations in a Danger area.
Post-exercise Comment	No specific collision avoidance scenarios were exercised due to the prioritisation of airspace integration activities. Detect & Avoid activities applicable to RPAS were covered by the Detect & Avoid Study Report [8]. At this early stage there was understandable reluctance amongst some of the stakeholders to test the contingency management associated with equipment failures during a real flight. This reinforced the usefulness of being able to test such conditions in a safe synthetic environment. It also allowed many more combinations of such failures to be tested using both high fidelity computer models and very high fidelity rigs incorporating real RPAS equipment.

Identifier	ASS-RPAS07-005
Title	ATC Communications
Type of Assumption	Demonstration Enabler
Description	It is assumed that the normal mode of operation for communications between the RPAS pilot and ATC will be via VHF relayed via the air vehicle. It is further assumed that the backup options of a direct VHF link between the Ground Control Station and ATC and fixed and mobile phone lines will be acceptable.
Justification	These capabilities already exist for the Watchkeeper system and have operated satisfactorily in West Wales D201 range area. There is no obvious reason why this cannot be applied to other airspace and localities.
Flight Phase	All
KPA Impact	Safety and Capacity/Quality of Service.
Source	Project team
Value(s)	Zero
Owner	Thales & NATS
Impact on Assessment	None if alternative and feasible communications are identified.
Post-exercise Comment	The assumption remained valid throughout the project. For access to segregated airspace, the normal modes of operation involve the use of dedicated ground radio links between the RPAS pilot and the sector controller for the segregated airspace. Preparatory work for this project resulted in a change to the communications method to utilise a relayed VHF link via the air vehicle providing equivalence and transparency with manned aviation.

Identifier	ASS-RPAS07-006
Title	RPAS Control – Radio Line-of-Sight
Type of Assumption	Demonstration Enabler
Description	BLOS, VLOS and EVLOS will not be considered as part of the project.

Justification	The provision of satellite communications for an RPAS has a significant impact on the size, weight and power of an RPAS. For the type of RPAS being considered for this project, this capability would be impractical and very expensive. In addition operations using Line-of-Sight or Extended Line-of-Sight are considered unlikely to have any significant ATM implications. Therefore the study will consider only Radio Line-of-Sight operations.
Flight Phase	All
KPA Impact	Environment, Capacity/Quality of Service.
Source	Project team
Value(s)	Zero
Owner	Thales & NATS
Impact on Assessment	More relevant analysis of RPAS in civil airspace.
Post-exercise Comment	The assumption remained valid throughout the project. Operations involving VLOS and EVLOS are not likely to interact with air traffic control to any significant degree. BLOS technology has been proven to handle pilot – ATC communications, but can be subject to significant latency. This has been addressed by other studies and would have added a further dimension to an already comprehensive project and was therefore excluded. The candidate RPAS platform is already fitted with suitable radio links to allow pilot – ATC communication with minimal latency and therefore only RLOS operations were considered.

Identifier	ASS-RPAS07-007
Title	Flight Rules
Type of Assumption	Demonstration Environment
Description	The project will consider only RPAS operations for RPAS flying according to IFR.
Justification	In the short and medium term, it is very unlikely that RPAS will be able to comply with VFR.
Flight Phase	All
KPA Impact	Environment
Source	Project team
Value(s)	Zero
Owner	Thales, NATS & NLR
Impact on Assessment	Allows project to focus on relevant airspace integration within the SESAR deployment timescale.
Post-exercise Comment	The assumption remained valid throughout the project. No VFR RPAS operations were considered.

Identifier	ASS-RPAS07-008
Title	Licensing
Type of Assumption	Demonstration Environment
Description	The MAA or CAA will authorise a qualified RPAS pilot to fly in civil airspace.

Justification	Currently, RPAS qualifications are examined on a case-by-case basis rather than through a formal process. It is considered that due to the number of routine flights performed by the trials team (over 300), members of the trials team will have the necessary airmanship skills for flight in civil airspace.
Flight Phase	All
KPA Impact	Environment, Safety
Source	Project team
Value(s)	Zero
Owner	Thales
Impact on Assessment	None as flights can be verified in a synthetic environment.
Post-exercise Comment	The assumption remained valid throughout the project and was used to justify the development of a new type Instrument Rating Qualification for this type of RPAS in association with the MAA.

Identifier	ASS-RPAS07-009
Title	Meteorological Conditions
Type of Assumption	Demonstration Environment
Description	Although RPAS operations will be carried out under IFR, it is assumed that the RPAS flight will be carried out under sufficiently good weather conditions to enable safe operation of the RPAS to/from the airport. For the synthetic exercise, meteorological conditions will be defined in terms of cloud base, visibility and wind conditions. For the live flights, take-off can only take place under suitable conditions and therefore some flexibility in the dates and times of the live flights is assumed as discussed at the kick-off meeting.
Justification	Meaningful and realistic weather conditions are necessary for synthetic flying and may constrain live flying.
Flight Phase	All, but particularly take-off and landing
KPA Impact	Environment, Safety
Source	Project team
Value(s)	Zero
Owner	Thales
Impact on Assessment	None for synthetic flights, but may constrain live flight timings and routes.
Post-exercise Comment	The assumption remained valid throughout the project.

Table 5-2: Demonstration Assumptions

5.3.1 Results per KPA

The Single European Sky performance-driven approach focuses, according to the European ATM Master Plan, on four Key Performance Areas (KPAs) of environment, cost-efficiency, safety and capacity. However it is recognised that capacity and safety are linked with workloads and human factors and therefore the Human Factors KPA is included.

Objective ID	KPA	Success Criterion/Expected Benefit	Result of the demonstration
OBJ-RPAS07-001 OBJ-RPAS07-002 OBJ-RPAS07-003 OBJ-RPAS07-004 OBJ-RPAS07-005 OBJ-RPAS07-006 OBJ-RPAS07-007 OBJ-RPAS07-009 OBJ-RPAS07-010 OBJ-RPAS07-011 OBJ-RPAS07-012 OBJ-RPAS07-014 OBJ-RPAS07-015 OBJ-RPAS07-019 OBJ-RPAS07-021 OBJ-RPAS07-022 OBJ-RPAS07-023	Safety	Live flight in non-segregated airspace is achievable Identify security requirements Identify impact on ATM operations and workload	Project CLAIRE has demonstrated the viability of RPAS flights in non-segregated and mixed traffic environment. Security requirements were identified and are presented in the Security Study Report [14] Although ATC workload is impacted by the introduction of a slow moving RPAS, no issues were identified that would indicate a significant impact on safety and existing ATM processes appeared to accommodate the introduction of RPAS.
OBJ-RPAS07-005 OBJ-RPAS07-006 OBJ-RPAS07-007 OBJ-RPAS07-008 OBJ-RPAS07-010 OBJ-RPAS07-011 OBJ-RPAS07-012 OBJ-RPAS07-013 OBJ-RPAS07-015 OBJ-RPAS07-016 OBJ-RPAS07-017 OBJ-RPAS07-019 OBJ-RPAS07-020 OBJ-RPAS07-021 OBJ-RPAS07-022 OBJ-RPAS07-023	Capacity	Capacity constraints	The introduction of RPAS impacts ATM sector capacity. This impact is due to the additional air traffic movements these RPAS represent, as well as the specific performance characteristics of some of the RPAS and its mission type, affecting sector occupancy and complexity. For low performance RPAS, continuous decent profiles tended to block out large areas of airspace for excessive periods.

Table 5-3: Summary of Results per KPA

5.3.2 Impact on Safety, Capacity and Human Factors

The exercises were performed with the premise that Safety could not be compromised nor impacted in any way. In order to achieve this, Temporary Danger Areas below the area of operation were set up to prevent any possible collision in the unlikely event of an emergency such as an engine failure. Temporary Operating Instructions for ATC developed and approved by the CAA and emergency procedures agreed in advance of the flight trials.

It was found that the introduction of RPAS did impact ATM sector capacity. This impact is due to the additional air traffic movements these RPAS represent as well as the specific performance characteristics of some of the RPAS and its mission type, affecting sector occupancy and complexity.

ATM sector capacity is limited by airspace availability and controller workload, which in turn is largely influenced by individual controller behaviours and is subjective in nature. Whilst it has been concluded that RPAS will have an impact upon capacity through an increase in complexity and controller workload, it is important to consider the specific RPAS types rather than treat all RPAS as common entities. Attention should be given to the airspace being assessed, as the traffic characteristics or sector occupancy could present different levels of suitability for RPAS flights.

Sector occupancy statistics are greatly impacted by the introduction of new mission types flown with RPAS, such as media and infrastructure monitoring missions. This situation stands out particularly for those en-route ATC sectors accustomed to commercial aircraft flying point to point. Sector complexity is the other factor taken into account when assessing capacity constraints. In this case, slow moving RPAS with non-conventional flight patterns increase the number of interactions and, as a result, the sector complexity.

Large RPAS with similar performance characteristics to conventional commercial jet aircraft and operating as OAT via the airway system would have minimal impact above that presented by the additional air traffic movements.

Some RPAS with reduced speed and altitude performance characteristics would present a relatively greater impact upon workload due to the tendency to de-homogenise the system compared to the characteristics, such as speed, of other aircraft present. Additional time to monitor slow RPAS and ensure deconfliction against trailing aircraft operating at greater speeds would account for the majority of this workload.

In addition, some RPAS with reduced speed and altitude performance characteristics operating at lower altitudes, either by way of their performance limitations or a requisite of their missions or both, may have no impact at all due to the lack of a requirement to enter controller airspace. However, such RPAS will effectively be operating in uncontrolled airspace and this would necessitate at least a Detect & Avoid capability, and probably a method of providing self-separation [8].

5.3.3 Description of Assessment Methodology

The main objective of the developed methodology to assess the outcome of the three exercises was to collect qualitative feedback from the stakeholders involved in the trials (ATCOs, RPAS pilots, UAS and ATC experts) aimed to inform the preparation of the live flight and the recommendations for future work detailed in Section 8. Questionnaires were completed by ATC and RPAS pilots to enhance the feedback gathering.

It should be noted that a significant part of the project was the planning and developing the procedures for live RPAS flights. This does not easily lend itself to a clear assessment methodology other than the achievement of the clearance to fly.

Assistance from WP16 was not requested.

5.3.4 Results Impacting Regulation and Standardisation Initiatives

In the UK both the Civil (CAA) and Military (MAA) regulators currently prohibit the operation of the RPAS in non-segregated Class G airspace without an approved Detect & Avoid system under any circumstances of normal or foreseeable operation. Flight under IFR in Controlled Airspace is not prohibited but can be permitted in special circumstances if adequate mitigation is in place. This is assessed on a case-by-case basis through a Waiver process and so is clearly outside any routine operation.

Both military and civil regulations in the UK require that a pilot flying IFR in controlled airspace holds an Instrument Rating. The regulation does not distinguish between operation of RPAS and manned platforms.

An Instrument Rating (IR) is normally awarded following the successful completion of:

- Flying Skills Test (including physiological ability)
- Knowledge and understanding of airspace, IFR flight and related matters
- Ground examination following a skills-test flight

This required some re-interpretation in the context of the Watchkeeper class of RPAS.

In manned flying the basic competency and IR are compartmentalised in that they are generally trained and awarded separately through a modular training programme.

For the Watchkeeper class of RPAS, the basic flight training and pilot competency assessment provides de-facto IR training and assessment as all operations are undertaken under IFR.

Furthermore, in this class of RPAS, the static ground-based pilot cannot suffer from vestibular disorientation and the aircraft's flight management system replaces all aspects of conventional flying skills for all phases of flight. The pilot remains able to respond to ATC instructions, but through a programmed interface, not via conventional flying controls/instruments or an emulator. The flying skills element of the IR test should be re-interpreted as a flight management test focusing on airmanship, and management of system failures.

The Thales Flight Operations Organization has chosen to implement a two-tier rating, and this has been accepted by the regulator (MAA):

- *Watchkeeper IR*
  - limited to segregated airspace (the normal environment for current operations)
- *Watchkeeper IR (Non-segregated)*
  - with no segregation limitations, demonstrating additional knowledge and competence, including knowledge & understanding of airspace, IFR flight, behaviour of other IFR airspace users etc with an additional flight assessment by an independent examiner.

Both Watchkeeper Instrument Ratings are based on the basic Watchkeeper Pilot training and assessment – a de facto combined flight training and instrument flight training programme and assessment. The Watchkeeper IR for flight in non-segregated airspace includes an additional written test relevant to flight in controlled airspace, and an assessment by a Type Rated Examiner (TRE) or Instrument Rated Examiner (IRE) addressing aspects of IFR flight in non-segregated controlled airspace relevant to the platform.

The validity of this type of IR depends on the platform's ability to fly to the requisite level of accuracy both horizontally and vertically. This ability must be demonstrated and accepted by the certification authority for the air vehicle (a flight certification issue), and calibrated and maintained through the aircraft's schedule of continuing airworthiness.

There are no IR pilot skill and currency levels associated with this rating as an appropriate and consistent level of precision is provided by the flight management system.

An IR would not be appropriate to Visual Line of Sight (VLOS) operations and so is not applicable to some classes of RPAS/UAV.

While the Instrument Rating is an integral part of the Watchkeeper Pilot competency, it was only exercised to its full extent (in controlled airspace) for the first time on the CLAIRE flights.

It is mandatory for all pilots operating a VHF transmitter to hold an appropriate transmitting licence or authorisation (military operators). In the case of RPAS pilots this will ensure that they are familiar with and competent with R/T phraseology. For RPAS pilots operating in controlled airspace it is essential that they are familiar with the behaviour of other airspace users, and will require an understanding similar to that of a commercial operator (holder of a CPL), holder of an IR or instructor rating, or an

ATCO. In practice this means an understanding of the airspace procedures and ideally through some form of Instrument Rating.

It is important that an agreed set of RPAS terminology is introduced into the wider R/T lexicon for all pilots so that pilots of manned platforms have increased situational awareness, and are not surprised by the normal operating behaviour of bona fide RPAS in shared airspace.

5.4 Analysis of Exercises Results

The main focus of the programme was to determine the issues associated with flying unmanned RPAS in non-segregated airspace in the context of air traffic management. This was achieved using a series of studies and exercises involving both high fidelity simulations and live flights to exercise the boundaries of what is currently achievable. Although the questionnaires used at each of the exercises provide some quantitative assessment of the effect RPAS flights within Air Traffic Control, the main outputs of the project are aimed at the assessment and implications of RPAS flight in non-segregated airspace, together with the development of processes necessary to achieve approvals to fly in such airspace.

Section 6 of this report provides detailed descriptions on the exercises and the results and findings obtained. This has resulted in a series of recommendations and future work which are addressed in section 8.2.

5.4.1 Unexpected Behaviours/Results

The coherent nature of the exercises and the significant amount of planning and preparation together with stakeholder engagement throughout meant that no unexpected behaviours were identified. The comprehensive nature of Exercises 1 and 2, together with the large amount of contingency management work ensured that any abnormal events could be safely managed in all the exercises, including the live flights in non-segregated airspace using an unmanned RPAS. As a result of this, no unexpected results were identified, but it is recognised that further work is required on contingency management and this is identified in section 8.2.

5.5 Confidence in Results of Demonstration Exercises

5.5.1 Quality of Demonstration Exercises Results

Exercises 1 and 2 both involved the use of very high fidelity, real-time simulation environments at the NLR and NATS facilities. These environments allowed immersive scenarios to be tested involving pilots (manned and RPAS) together with multiple ATCOs. In most cases, the scenarios were pre-scripted but a certain amount of free-play was included to allow the RPAS pilot to introduce a series of challenging abnormal situations. The environments were able to simulate all the required situations and observers and questionnaires were used to assess the impact (if any) on the ATCOs and pilots. The level of fidelity used provided a high degree of confidence that the results replicate the real-world situation.

Exercise 3 was focussed on the plans, processes and procedures associated with RPAS. This culminated with live unmanned RPAS flying in non-segregated airspace in the presence of other air traffic. Whilst the live flights did not attempt to validate procedures associated with emergency conditions, the outcomes of exercises 1 and 2 allowed contingency management processes to be developed to ensure that safe flight could be achieved.

5.5.2 Significance of Demonstration Exercises Results

The project focussed on operational activities backed up by qualitative questionnaires and analysis. However, the number of runs undertaken within exercises 1 and 2, together with the fidelity of the environments and the consistency of the results suggest that the approach taken was valid and the results should be considered as valid.

As with all such exercises, significance can be improved by the addition of further exercise runs to repeat many of the scenarios. The existing simulation environments were appropriate for the exercises undertaken, and could easily support further runs if required.

The live flights provided the opportunity to validate the findings of the simulation exercises.

5.5.3 Conclusions and Recommendations

The approach taken by the project (simulation exercises validated by live flights) was considered to be the best method of determining issues associated with the integration of RPAS in non-segregated airspace.

It became clear that ATM procedures could be applied equally to RPAS flights, but that potentially lower speeds and performance could cause increases in ATCO workload. A significant amount of work was undertaken on contingency management aspects of RPAS, focussing on the unique aspects of remote operation. It is recommended that the issues identified in this report are progressed as a series of studies or further exercises as proposed in section 8.

Although not specifically part of an exercise, project CLAIRE undertook specific studies on key areas which although not directly related to ATC, will affect how RPAS can be integrated into the airspace.

- Detect & Avoid [8]

  Some form of collision avoidance system is required to correspond to the pilot's eyes and situation awareness in manned aviation. The study identified that a mixture of both cooperative and non-cooperative techniques are required. The regulatory environment in this area is still evolving which means that any system design will need to rely on a series of regulatory assumptions. To assist in the development of a collision avoidance solution for both manned and unmanned aviation, it is recommended that engagement with RTCA and EUROCAE should be increased to support the *ACAS-X* initiative. In particular, work on cooperative and non-cooperative sensing for the *Xu* variant is encouraged.

- Security [14]

  Security requirements for manned aviation are well understood. For unmanned aviation, although some aspects of physical security are common to manned aviation (e.g. physical security on the airfield), physical security on board is not relevant. However cyber-security is considered more significant to unmanned systems. It is recommended that further study is required in this area to assess the feasibility of a set of security standards which could be applied to all unmanned operation.

- Current and future ATM/CNS needs for RPAS integration [17]

  From the point of view of the on-board equipment, this assessment has not identified any special circumstances upon which the RPAS integration in current and future airspace should follow different principles to those defined for equivalent manned aviation. Compliance with equivalent standards would benefit not only the Air Traffic Controllers, allowing transparent interaction with the RPAS pilot, but also the RPAS industry, in obtaining regular and standard access to controlled airspace, without the need for special concessions. The development of an effective Detect and Avoid system, equivalent to the 'See and Avoid' in manned aviation as stipulated within the rules of the air, is a key enabler to the safe integration of RPAS into the airspace.

6 Demonstration Exercises Reports

6.1 Demonstration Exercise 1 Report

6.1.1 Exercise Scope

An overview of the scope of Exercise 1 is provided in Table 2-1 in section 2.1.

Exercise 1 of Project CLAIRE targeted the aspects of Airport and Terminal Airspace operations to verify the ATM procedures associated with the operation of RPAS in this controlled airspace and assess normal and abnormal events as well as any unexpected behaviour. The simulator evaluations were carried out using the NLR ATC research simulator *NARSIM* and Multi-UAS Simulation Testbed *MUST*. The simulated traffic and environment was comparable to that for Rotterdam The Hague airport. The exercise was conducted during two separate sessions, 20-22 May and 14-16 Oct 2014, allowing for some improvements to the overall setup during the second series of evaluations.

The simulations successfully demonstrated all identified nominal and non-nominal ATM procedures as described in Section 4.1.1.2. In particular, the non-nominal events should trigger contingency management procedures to be carried out by the participating controllers and pilots. The outcome of the evaluations should be consistent with existing procedures for manned aircraft and developed procedures specific to RPAS contingencies, to be applied during live flight trials planned for Exercise3. Results from the Exercise 1 evaluations should be consistent with the results from the Exercise 2 and provide input to the Temporary Operating Procedures and the ATM Safety Procedure Analysis process that determines their use during the live trials.

6.1.2 Conduct of Demonstration Exercise EXE-RPAS07-001

6.1.2.1 Exercise Preparation

As already discussed in 4.1.2, the exercise 1 simulations were run using the NLR Air Traffic Control Research Simulator (*NARSIM*) and Multi-UA Supervision Testbed (*MUST*). These platforms comprise modules that work together to form a complete simulation of an ATC environment as well as RPAS ground control station. The following setup was used:

- NLR Air traffic Control Research Simulator (*NARSIM*), with the following components:
    - *NARSIM* Radar, allowing EHRD approach radar simulation.
    - *NARSIM* Tower, for EHRD airport simulation with a 360 degrees visual system.
- Multi-UA Supervision Testbed (*MUST*)

The ATC simulator facility was connected to the *MUST* RPAS simulation and control facility, enabling an integrated demonstration and assessment. The CLAIRE Exercise 1 simulation setup consisted of one approach controller working position, the *NARSIM* tower simulator, 2-3 pseudo-pilot workstations and the *MUST* RPAS ground control station/simulator connected. Images of the facilities are shown below. The environment for carrying out the simulations was Rotterdam airport (EHRD) acting as a “typical” medium size airport with both VFR and IFR traffic.

Figure 6-1: View of *NARSIM* Tower with Rotterdam Airport Visual Scenery

Figure 6-2: View of *NARSIM* Radar Controller Working Positions

The controllers communicated with the pseudo-pilots and RPAS operators using voice (R/T) in the same way as in current-day practice. The *NARSIM* built-in R/T system for ATC simulators was used to emulate VHF voice communication. For backup purposes, in case of loss-of-link or loss-of-communication, a backup (land) phone line was also emulated for direct phone communication between the RPAS control station and ATC.

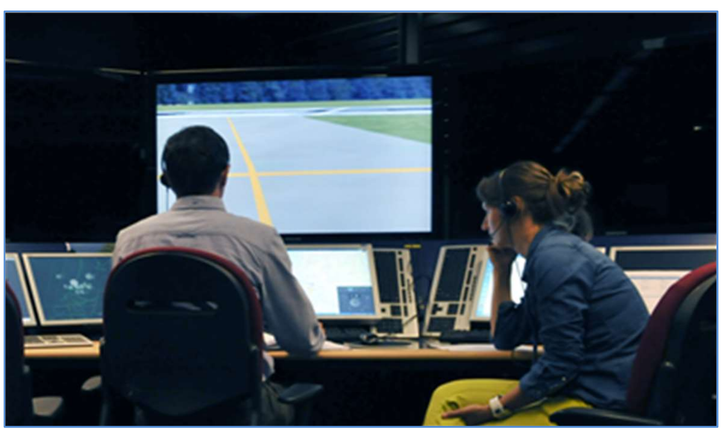

Figure 6-3: View of NLR's *MUST* Facility

The figure below illustrates the hardware set-up of the simulations in Exercise 1.

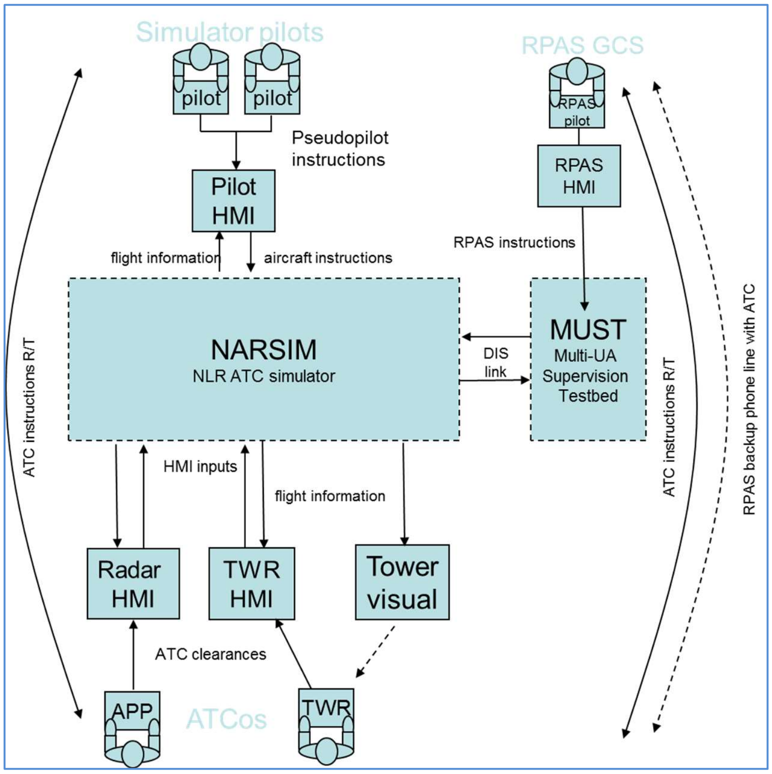

Figure 6-4: Simulation Overview

For the specific RPAS oriented simulator evaluations, the following activities were carried out:

- Adaptation of *NARSIM* radar and tower environment for the specific evaluation
- Preparation of *MUST* with RPAS characteristics comparable to Watchkeeper
- Adaptation of connection between *NARSIM* and *MUST* for the particular evaluation
- Development of RPAS arrival and departure routes and drawings
- Preparation of (suitable) air traffic scenarios and traffic samples, representative of a busy medium size airport with both VFR and IFR traffic
- Preparation of normal, contingency and emergency scenarios
- Briefing material for participating ATCOs, pseudo-pilots and RPAS pilot
- Preparation of (web-based) questionnaires for use during debriefing sessions

The actual simulation runs that were developed were based on the scenarios described in section 4.1.1.2. These were used to evaluate the impact of RPAS operations both at the airport, and within the TMA. The scenarios were based around Rotterdam Airport with its associated runway and airspace structure. The map below provides an indication of arrival and departure routes for runway 24 as flown during the evaluations. An explanation of the routes is the following:

- Green: RPAS specific departure route
- Blue: RPAS route following published SID route (only during Exercise 1b)
- Orange: RPAS specific arrival route
- Yellow: RPAS route following published RNAV/ILS approach (only during Exercise 1b)

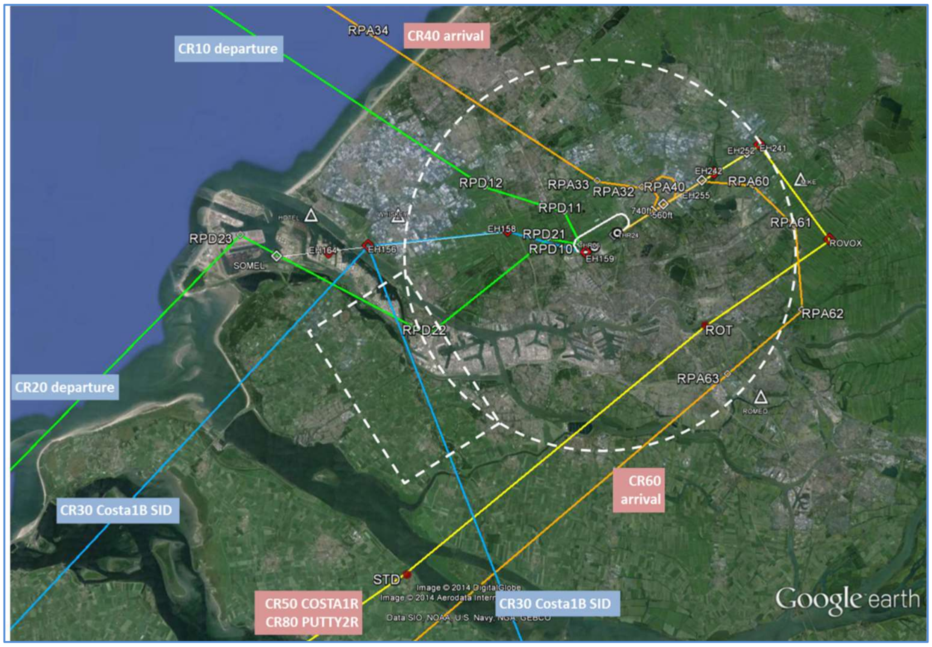

Figure 6-5: Overview of RPAS Arrival and Departure Route

6.1.2.2 Exercise Execution

The table below summarises the simulation runs that were carried out during exercise 1a (* denotes special event), 20-22 May 2014:

Run No.	RPAS Callsign		Runway	Traffic Scenario		Weather				Comment/Occurrence
	Arrival	Dep.		No.	VFR/IFR	visibility	clouds	wind	lighting	
T	CR40	-	24		IFR	10km	3000ft	calm	day	Training familiarisation
3	CR40	CR10	24	3	VFR/IFR	8km	2300ft	calm	day	including taxi
4	CR40	CR20	24	1	VFR/IFR	8km	3000ft	calm	day	
11	CR40	CR20	24	4	VFR/IFR	10km	2600ft	calm	day/dusk	
5	CR60	CR10*	24	1	VFR/IFR	8km	1900ft	calm	day/dusk	*lostlink after DEP (15min in flt) SQ7300
6	CR40*	CR20	24	2	VFR/IFR	5km	1800ft, CB	calm	day	*CB over Scheveningen: WX deviation Go-Around at low altitude
7	CR60*	CR20	24	3	VFR/IFR	10km	2100ft	calm	Dusk	*Simulated lost comm during arrival
8	CR40*	CR10	24	1	VFR/IFR	7km	1900ft	calm	day	*missed approach at 100-200ft, return to land
9	CR60	CR20	24	5	IFR	5km	1600ft	calm	day/dusk	-

Run No.	RPAS Callsign		Runway	Traffic Scenario		Weather				Comment/Occurrence
	Arrival	Dep.		No.	VFR/IFR	visibility	clouds	wind	lighting	
10	CR40*	CR10	24	3	VFR/IFR	8km	2300ft	calm	day	*XPDR failure
12	CR40*	CR20	24	5	IFR	5km	1600ft	calm	sunset	*Emergency: engine fail during arrival

Table 6-1: Overview of Exercise 1a Simulation Runs

The second series of simulations in exercise 1b evaluated similar scenarios to those used initial trials in exercise 1a, with some improvements and changes to the simulation. The modification included additional RPAS routes along published IFR arrival and departure routes, representation of VFR traffic and some improvements in the RPAS HMI for easier control of the vehicle. The exercise 1b trials also allowed a stakeholder demonstration to be held at the end of the trials.

Run No.	RPAS Callsign		Run-way	Traffic Scenario		Weather				Comment/Occurrence
	Arrival	Dep.		No.	VFR/IFR	visibility	clouds	wind	lighting	
T	CR40	CR10	24	T	IFR	10km	3000ft	calm	day	training familiarisation
23	CR40	CR20	24	2	VFR/IFR	10km	2300ft	calm	day	
24	CR50	CR70	24	3	VFR/IFR	5km	1700ft	calm	day	*COSTA* arr/*WOODY* dep
25	CR80*	CR10	24	4	VFR/IFR	8km	1900ft	calm	day/dusk	*lost comm during arrival (@T=8min)
26	CR40*	CR30	24	2a	VFR/IFR	5km	1800ft	calm	day	*missed approach at 100-200ft
27	CR60	CR20	24	1a	VFR/IFR	10km	1700ft	calm	day	
28	CR40	CR30*	24	3a	VFR/IFR	7km	1900ft	calm	day	*lostlink after DEP (15min in flt) SQ7300
29	CR80	CR70	24	2a	VFR/IFR	10km	1600ft	calm	day/dusk	*PUTTY* arr/*WOODY* dep
30	CR50*	CR10	24	3a	VFR/IFR	8km	2300ft	calm	day	*XPDR failure (*MUST* sets 7700)
										Demonstration scenarios:
26	CR40*	CR30	24	2a	VFR/IFR	5km	1800ft	calm	day	*missed approach at 100-200ft
28	CR40	CR30*	24	3a	VFR/IFR	7km	1900ft	calm	day	*lostlink after DEP (15min in flt) SQ7300

Table 6-2: Overview of Exercise 1b Simulation Runs

6.1.2.3 Deviation from the Planned Activities

No deviation from the Demonstration Plan [2] was required for the execution of EXE-RPAS07-001.

6.1.3 Exercise Results

6.1.3.1 Summary of Exercise Results

Following each simulation session the controllers were asked to fill out a questionnaire. This comprised the following questions:

1. I was able to handle the traffic in the simulation efficiently: *<never … always>*
2. I was satisfied with my level of control in the simulation: *<never … always>*
3. I experienced safety during the simulation as: *<very low … very high>*
4. I was able to plan and organise my work as I wanted: *<never … always>*
5. What is the impact of RPAS on Situation Assessment? *<never … always>*
6. What is the impact of RPAS on Attention and Workload management? *<no impact … very high>*
7. What is the impact of RPAS on Problem solving and Decision making? *<no impact … very high>*
8. What is the impact of RPAS on required controller actions?

   (e.g. system inputs, R/T calls, coordination) <no impact … very high>
9. I was surprised by an event I did not expect: *<never … always>*
10. During normal operation of the RPAS, did something interfere with your work as controller?

    If yes, please specify.
11. Were contingency procedures applied? If yes, which problems did occur?
12. Which modifications or improvements do you suggest for contingency procedures?
13. Please provide any comments or suggestions here:

The controller responses have been combined in the figures below, showing (average) ratings given by the participating APP and TWR controllers.

It should be noted that there was a learning effect in the ratings, resulting in somewhat poorer average ratings at the beginning of each evaluation session. Also, the initial runs in Exercise 1b proved to give an unrealistically high traffic and hence workload. This excessive high traffic load was corrected in later scenarios and it was noted that the workload average ratings were revised accordingly.

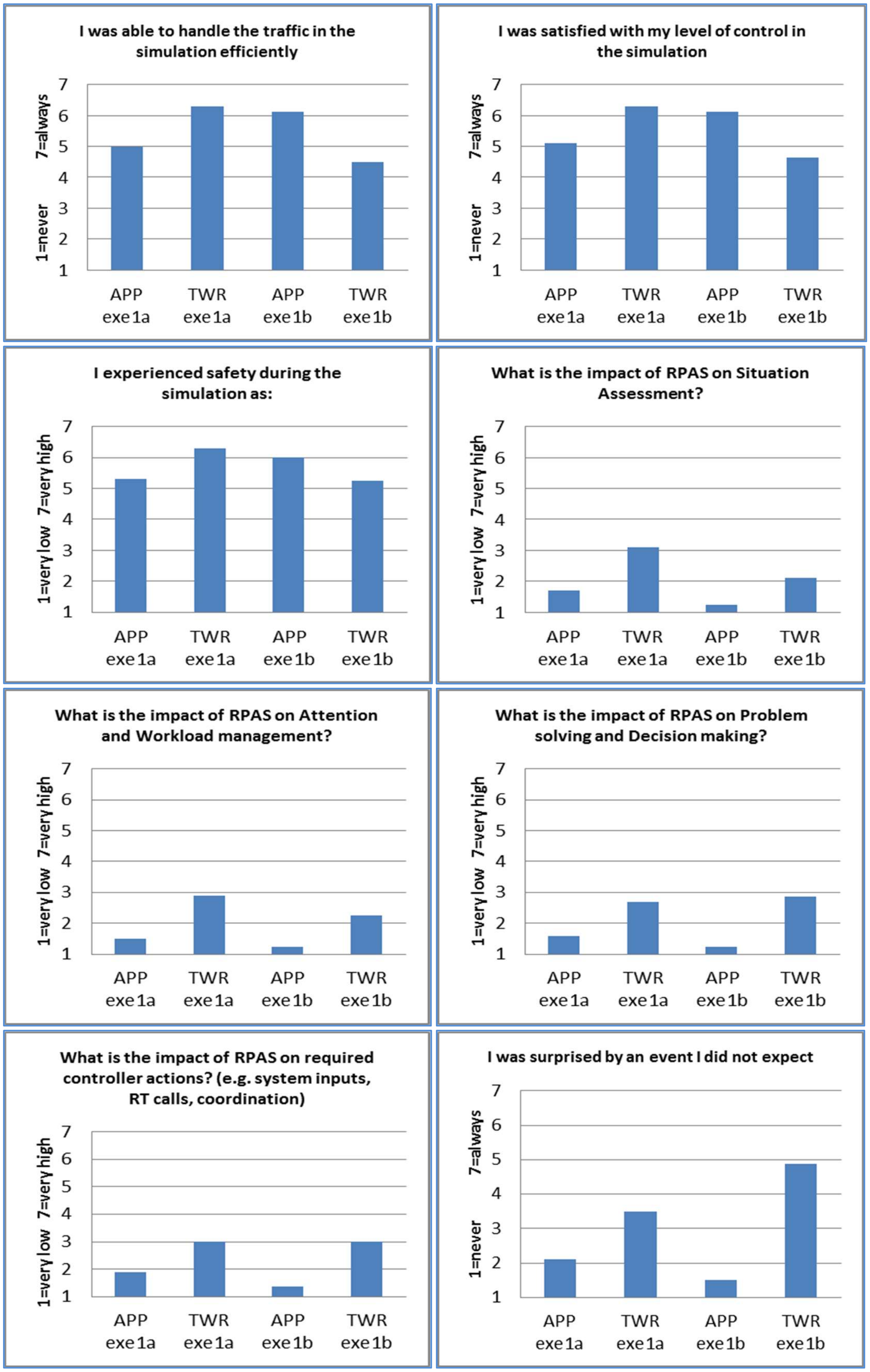

Figure 6-6: Post Run Controller ratings

6.1.3.2 Post-run Comments

The table below summarises the comments that were provided by the participating ATCOs in response to the open questions in the post run questionnaire. Note that it was not essential to reply using the form, as during the debriefings the observers also collected comments and remarks.

Question Event /ATCO	During normal operation of the RPAS, did something interfere with your work as controller? If yes, please specify.	Were contingency procedures applied? If yes, which problems did occur?	Which modifications or improvements do you suggest for contingency procedures?	Please provide any comments or suggestions here:
Run 23 TWR ATCO	EFPS (Electronic Flight Progress System) failed completely. Workload medium high.	Yes. Two ATC commanded missed approaches	Not applicable to this simulation.	Standard published RPAS procedures IFR and VFR could expedite RPAS ops
Run 24 TWR ATCO	RPAS not a problem. but in the context of all the other traffic it made planning and coordination more difficult	Not required.	Already covered in previous.	Traffic loading in excess of experience/familiarity level. The system is basically sound and issues relate more to load and being out of comfort zone.
APP ATCO	No	fitting RPAS back into inbound stream		
Run 25 (RPAS loss of comms) TWR ATCO	Not really an issue. Loss of comms (simulated) took extra capacity for very brief period (3 mins) after which no impact was noted.	Usual coordination effective but could have been better due system and ATCO loading. Not RPAS related.		Simulation well above the airport capacity with presented VFR and IFR traffic levels. Simulation needs to be busy but not beyond Airport and ATCO capacity.
APP ATCO	No	R/T fail - no impact	none	
Run 26 (RPAS missed approach) TWR ATCO	Normal operation RPAS impact low. Only when it has a problem does its impact etc rise and then very briefly. But this is no different to any other aeroplane. However there is a slight increase in coordination required to adapt to the aircraft low speed.	Yes but as expected.	None really required. But see comments from previous exercises/simulations	Nice scenario. Busy but not too busy with good traffic mix. Not easy but manageable. Just right!

Question Event /ATCO	During normal operation of the RPAS, did something interfere with your work as controller? If yes, please specify.	Were contingency procedures applied? If yes, which problems did occur?	Which modifications or improvements do you suggest for contingency procedures?	Please provide any comments or suggestions here:
Run 27 TWR ATCO	Not during normal operation.	Only when required. Items 6 to 8 only apply for short period where RPAS began to experience Emergency type stations. In normal ops this was rated as low impact. Higher loading was typical for any aircraft experiencing similar problems	Nil	
Run 28 TWR ATCO	As per previous reports	Individual coordination required but SOP	Nil	RPAS becoming easier to integrate. Good spacing by colleague. Fundamentally other than the speed this is just another aircraft.
Run 29 (RPAS engine fail) TWR ATCO	Nil	Yes	Nil	RPAS engine fail. Airport sterilised. Job done! Game Over.
Run 30 (RPAS XPDR fail) TWR ATCO	Nil Impact	Coordinated unusual situation	As per previous	Q9 Increased coordination, but this was the same as if the events happened to any other aircraft.

Table 6-3: ATCO responses as provided in the post-run questionnaire

Overall, controllers commented the operation of an RPAS to be not much different compared to a manned aircraft. The difficulties experienced with the operation of the RPAS arose from the difference in speeds between RPAS and the faster commercial jet traffic in particular. It was commented that this was not due to the fact that the aircraft was an RPAS but was fully performance related. A fast(er) moving RPAS operating at speeds compatible with typical IFR operating speeds at a medium size airport would pose no problems in the air during operations.

As part of the contingency events that were evaluated, the loss of link was simulated between RPAS and ground control station in a few traffic scenarios. This was followed by a simulated automatic return to the departure aerodrome. The contingency return procedures included coordination between the ground control station and ATC using a backup (phone) line, as well as the use of a dedicated RPAS lost link SSR code, which would be automatically set by the RPAS. Overall, following notification of ATC by the GCS using the backup phone line, the event would not be handled any differently to other manned aircraft e.g. an aircraft with lost communication.

There was also some debate on how to handle the RPAS close to the airport when sequencing for landing. During the exercises the tower controllers indicated that it was most practical to instruct the

RPAS to loiter in close visual range from the tower. This aided in minimising time spent on the final approach path once cleared for the approach, thus minimising delays for other traffic.

This was comparable to instructing light VFR traffic to hold or orbit on the downwind leg of the landing runway until a suitable gap occurred in the stream of medium or heavy IFR traffic following the instrument approach path.

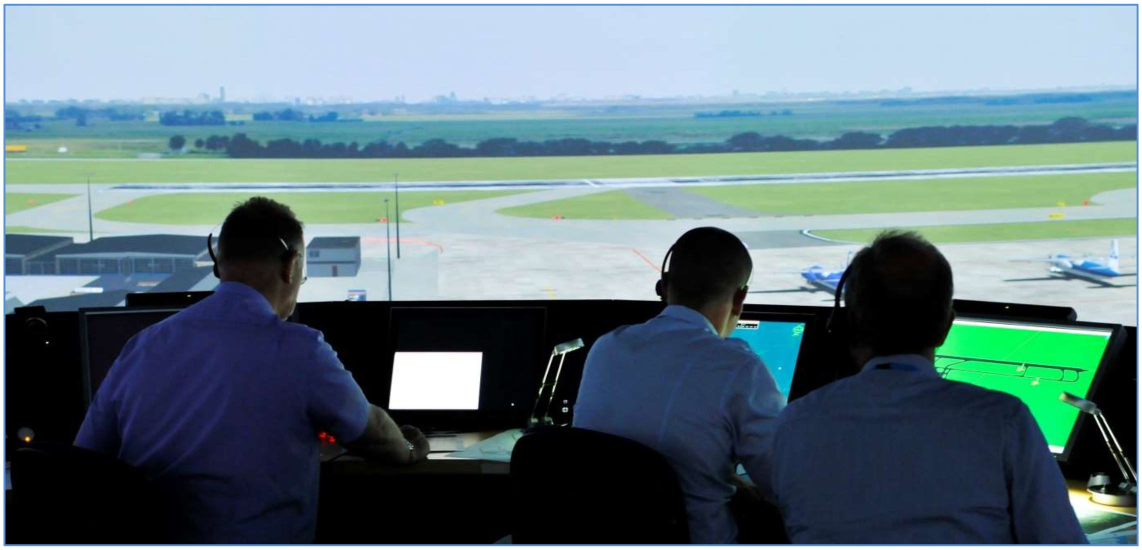

Figure 6-7: Tower Operation and Observers during Exercise 1

Compared to manned aviation, the operation of RPAS could include a few novel differences. An RPAS pilot could potentially operate more than one RPAS at the same time. However, if a pilot is operating more than one RPAS at a time and they are in controlled airspace on different frequencies, the question arises how the pilot can actively listen and answer to more than one frequency, particularly if one of these is busy.

Also, if the RPAS cannot achieve the required flight parameters (speed, altitude, rate of climb) whilst flying a published SID or STAR profile (e.g. if the aircraft is above or below the profile), it may automatically climb or descend 'itself' in an orbit in order to meet these requirements. Such behaviour is unacceptable and it should be ensured before flight that the RPAS can meet the required profile. Similarly, if an RPAS considers itself to be incorrectly positioned on final approach, it will self-initiate a missed approach (this could also be due to cross wind, turbulence etc). Some types of such behaviour might not be acceptable for ATC in certain traffic situations, and the programming of the flight profile should be carefully considered. Whilst this should be similar to a go-around or missed approach, the subsequent rerouting might give a bit more workload compared to manned operations.

6.1.3.2.1 Results per KPA

The general consensus by the participants to the evaluations with respect to the RPAS operation in and out of a medium size aerodrome and TMA was the following:

Safety

- An operational transponder was deemed essential by the controllers for normal operation. However, in case of transponder failure on-board the RPAS, ATC was able handle this event similarly to that of a manned aircraft. However, the failure could potentially cause a severe short interruption of the ATC system. To mitigate such an eventuality, the installation of a second independent transponder might be considered.
- Abnormal situations for RPAS do not appear to pose additional difficulties to ATC compared to events or emergencies occurring with manned aircraft.
- Airport emergency procedures may need to be modified. It was indicated by the controllers that in case of an RPAS incident, it may not be necessary to fully alert all medical, fire and

emergency services. Alerting of all these services may unnecessarily impact the airport alert status for manned transport aircraft.

- Backup communications between ATSU and RPAS Pilot worked well. The option of having a backup phone line available is actually an added benefit compared to manned aviation.
- RPAS operators can currently operate unlicensed. For operation of an RPAS in controlled airspace it will be essential that the future RPAS pilot is in possession of a suitable qualification which includes RTF license and knowledge of the rules of the air and behaviour of other traffic in those parts of airspace in which it is being operated.

Workload

With respect to workload, the general impression given by the participating controllers both in the post run questionnaires and during debriefing was that operating an RPAS in a non-segregated VFR/IFR environment was not much different to that of a manned aircraft with similar flight performance.

- R/T communications during normal operations were the same or similar to those for manned aviation
- Handover procedures between ATC units (TWR, APP) were the same as for manned aviation
- Unmanned Aircraft made little or no difference to ATM operations
- The increase in ATCO workload during contingencies with an RPAS was reported to be consistent with similar events in case of manned aviation
- The flight profile of the RPAS was considered to be more predictable than manned aviation
- Speed differentials for the relatively slow moving RPAS compared to commercial aviation resulted in some additional workload for ATC during manoeuvring close to the runway but well within ability of ATCOs for this size of airport.
- The (slow) RPAS operation is no factor to ATC, until close to the final approach. Faster RPAS operating speeds, more compatible to other manned aircraft will be more easy to handle within the flow of traffic
- A slow operating speed of an RPAS can be regarded as positive for ATC, since nothing will happen quickly, and the controller will have ample time to manage and plan ahead.

Capacity

- For lower performance RPAS, the runway occupancy times were regarded as too long. This can be adjusted for a particular airport by adapting the landing profiles and touchdown locations in order to have minimum time on final approach and on the runway.
- Closer to the airport a slow operating speed of an RPAS may require careful planning due to the large speed difference compared to faster (jet) aircraft. This is completely related to the performance of the vehicle, not the fact that it is unmanned.
- Bearing in mind the endurance, a (slow) RPAS was more easily put in holding/loiter location until a suitable landing gap arrived to avoid unnecessary delays for faster traffic.
- Integration of a given RPAS at an airport will therefore be mainly dependent on the RPAS performance in relation to the other traffic visiting that airport.
- While initially RPAS were handled similar to manned aircraft, first come first served principle was later abandoned for RPAS flights by the participating ATC controllers. Long endurance RPAS were kept in a close-by orbit or holding until a gap appeared in the landing traffic flow.

Predictability

With respect to the arrival and departure routing of the RPAS these air vehicles may not want to follow standardised arrival and departure routes due to the typically specialised nature of the intended flights.

- During the Exercise 1a simulations the RPAS arrival and departure flight trajectories were routed as much as possible away from the standard routes for manned VFR and IFR traffic.

The RPAS did not pose a significant challenge to ATC with respect to dedicated handling or special attention.

- During Exercise 1b, the (slow flying) RPAS was also routed along published Standard Instrument Departures and Instrument Arrival Routes. Safe separation during departures could be established by means of temporary heading instructions off the published SID routing for other aircraft.

With the above mentioned items in mind, it may still be required to provide ATC with an overview of intended flight routing in addition to information available in the standard ICAO flight plans for better awareness.

6.1.3.2.2 Results Impacting Regulation and Standardisation Initiatives

The following items provide input for future regulation and standardisation:

- An operational transponder is deemed essential by the controllers for normal operation. However, in case of transponder failure on-board the RPAS, ATC may be able to handle this event in a similar way to manned aircraft. However, the failure could potentially cause a severe short interruption of the ATC system. To mitigate such an eventuality, the installation of a second independent transponder might be considered.
- Airport emergency procedures may need to be modified. It was indicated by the controllers that in case of an RPAS incident, it may not be necessary to fully alert all medical, fire and emergency services. Alerting of all these services may unnecessarily impact the airport alert status for manned transport aircraft.
- As backup communication via land lines are possible, procedures may be put into place to determine how and when to contact operational ATC centres if needed.
- For operation of RPAS in controlled airspace, future RPAS pilots need to be in possession of a suitable qualification including RTF license and knowledge of the rules of the air and behaviour of other traffic in those parts of airspace in which it is being operated.
- RPAS will typically require special handling compared to controlled IFR traffic due to non-standard routing and flight profiles. With multiple RPAS operating in controlled civil airspace, the information provision and coordination procedures with involved ATC units may need to be organised in a structured manner.

6.1.3.2.3 Unexpected Behaviours/Results

No unexpected results were observed during the execution of the exercises and the subsequent debriefs.

6.1.3.2.4 Quality of Demonstration Results

Exercise 1 was intentionally split into 2 series of evaluations, enabling feedback received during the first series to be fed in an improved setup for the second series of simulations. Nevertheless both series of simulations received similar confidence from the exercise participants that the results successfully addressed the intended objectives.

6.1.3.2.5 Significance of Demonstration Results

The Exercise 1 evaluations were deemed operationally significant for future actual conditions.

6.1.4 Conclusions and Recommendations

6.1.4.1 Conclusions

Exercise 1 evaluations provided valuable input and feedback for the foreseeable future situation that RPAS operations are being extended into controlled airspace near and on aerodromes with other manned traffic. The feedback received from the participating controllers confirmed and were in line with observations made in Exercise 2.

6.1.4.2 Recommendations

The following recommendations are suggested:

- Standard RPAS departure and arrival procedures should be published for operations from and into airports and within controlled (terminal) airspace to expedite RPAS operations on a more regular basis.
- RPAS operating characteristics should be compatible with those of the aerodrome in order to maintain runway capacity at realistic levels. Fast RPAS operations could be well integrated into busier medium size airports, slower operating RPAS should be operated from aerodromes with lower traffic levels or with traffic operating at similar speeds.

6.2 Demonstration Exercise 2 Report

6.2.1 Exercise Scope

An overview of the scope of Exercise 2 is provided in Table 2-2 in section 2.1.

Exercise 2 of Project CLAIRE targeted the En-Route Synthetic Simulations conducted from the 3rd to the 6th of June 2014 at NATS' *SPACE* facilities which aimed to verify the ATM procedures associated with the operation of RPAS in controlled airspace and discover any unexpected behaviour.

The simulations successfully demonstrated all the nominal and non-nominal ATM procedures, and identified no issues with the use of these procedures for live flight trials planned in Exercise 3. This information was an input to the Temporary Operating Instructions and the ATM Safety Procedure Analysis process that determined their use during the live trials.

The simulations did identify issues that would need careful consideration in future work to fully integrate RPAS into non-segregated airspace. These are documented in section 6.2.4. No issues were identified that would prevent successful integration of RPAS in the future, but careful consideration is needed to maintain safety and capacity and ensure effective regulation and standardisation.

6.2.2 Conduct of Demonstration Exercise EXE-RPAS07-002

6.2.2.1 Exercise Preparation

Within NATS, the *SPACE* environment has been created to provide an area for developing rapid prototypes, small-scale scenarios, visualisation & creative problem solving. This is a multi-site operation allowing collaboration between NATS' main sites and supplier and customer sites, increasing the leverage of creative problem solving.

Traffic samples were UKFDB-sourced data from 17/10/2013 and included traffic from 1000-1200 and 1500-1700 spliced together to make 4-hour long exercises. The traffic in each case has been moved closer to the sector boundaries to avoid lengthy run-in times.

The airspace was as existing airspace, except for the following:

- A Temporary Danger Area was declared in Class G airspace separating Lima 9 and the D202 RA(T), according to the regulatory requirements established when the simulations took place. Afterwards, and in accordance with regulatory procedure, the Project requested extra segregation of Class G Airspace below the planned route in Exercise 3, as described in section 4.1.4.
- There were 4 designated Emergency Recover Locations (ERLs) as defined in Table 6-4 to be used in case of engine failure.
- To aid understanding of the routes to be flown by the RPAS, additional waypoints were defined as shown in Table 6-5:

Ref	Location	Description
ERL1	5210N 00434W	Sea ERP near WWA
ERL2	5130N 00350W	Sea ERP near Port Talbot
ERL3	5120N 00320W	Sea ERP near Cardiff
ERL4	5201.5N 00331.3W	Land ERP in D203

Table 6-4: ERL Positions

Ref	Location
WPT1	5214N 00505W
WPT2	5202N 000542W
WPT3	5212N 00513W
WPT4	5148.5N 00349.5W
WPT5	5207N 00344W

Table 6-5: Additional Waypoints

Cardiff Approach (EGFF) and Sector 6 (S06) or Sector 8 (S08), depending on the exercise, were configured as separate sectors with a dedicated ATCO, while surrounding sectors (S05, S09, S20, S23, S35, S36, Aberporth, Jersey, Brest, WR, Exeter, Cardiff Tower & Bristol) configured as feed sectors. The boundaries of EGFF, S06 and S08 can be viewed in Figure 6-10 and Figure 6-11.

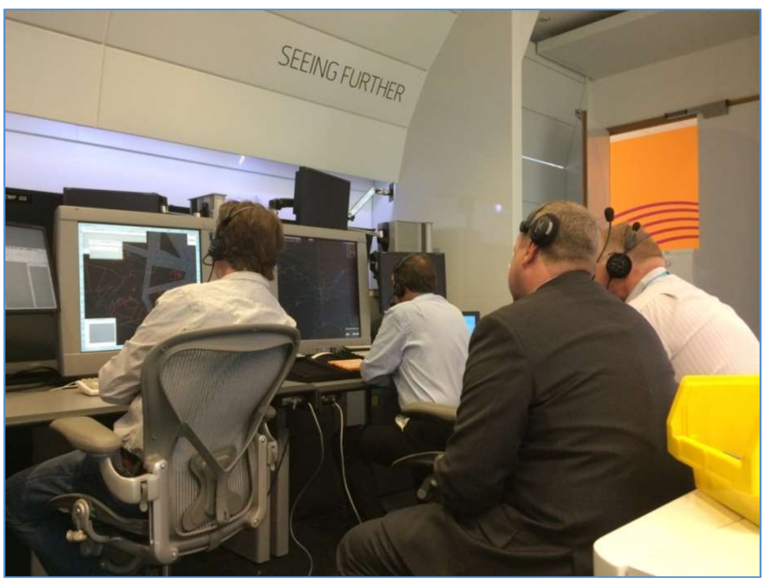

Figure 6-8: Exercise Execution

6.2.2.2 Exercise Execution

During the execution of Exercise 2, 13 exercises followed by debriefs were completed during 4 days of simulation.

A series of routes were defined to accomplish the objectives set out in the Demonstration Plan. These routes were consistent with the project scenarios described in 4.1.1.2 and shown in the following figures.

As described in the section 6.2.3, handovers between sectors were abundantly tested: Aberporth to/from S08, S08 to/from Cardiff ACC and Cardiff ACC to/from S06. The handover between sectors of different countries follow the same procedures as any of the previous exercises. As a result, it was agreed that the handover between S06 and French ATC in the grey line was not required to be simulated.

Figure 6-9: Post-exercise Debrief

Voice procedures were developed and used extensively at West Wales Airport and MOD Boscombe Down. The following represents current and future prospective voice procedures for the trial:

RPAS Handover – The RPAS Pilot will precede any initial ATC call with '*unmanned*'. Examples are: '*Aberporth Radar Unmanned CRONUS passing FL100 in the climb to FL150*' or '*Cardiff Approach, Unmanned CRONUS level at FL80*'.

LLR (Lost Link Route) Procedure – To be used when the RPAS pilot has changed a lost link route. An example is '*Cardiff, CRONUS can confirm that LLR X has been uploaded*'.

LLR Emergency Procedure – If the RPAS goes Lost Link the pilot will inform ATC that the aircraft has gone lost link, which route it will follow and squawk 7300[5]. An example is '*Cardiff be advised CRONUS has gone lost link and will follow lost link route X, standby*'

Radio Communications Failure – The RPAS has the ability to transmit through air radio and ground radio plus a land line and mobile phone access, either through the air vehicle or the Ground Control Station (GCS). If the RPAS pilot determines that he has lost VHF Comms with ATC, the pilot will Squawk 7600 and call the relevant ATC supervisor through the land line or from his mobile phone. If unsuccessful, the pilot will relay the loss of comms through his ground radio to local ATC.

Transponder Failure – In the event of a transponder failure, the RPAS pilot will inform ATC through VHF comms of the issue. An example is '*Cardiff be advised CRONUS has lost its ability to squawk, standby*'. After a short period 1-2 mins (fault finding) the RPAS pilot will inform ATC that the SSR is unserviceable and will standby for instructions.

Weather – The RPAS payload operator will use the optical capability to look ahead at the cloud structure taking note of the outside air temperature and may ask ATC for permission to deviate from track to avoid weather. An example is '*Aberporth, CRONUS requests right turn 30 degrees to avoid weather*'.

[5] Within the UK, this is the code that has been reserved to indicate a loss of data link.

Emergency Procedures – In the event of an emergency, the RPAS pilot will use standard phraseology to inform ATC of the emergency. In addition to the call, the RPAS pilot will inform ATC which ERL the RPAS will fly to in the event of an engine failure.

GCS to GCS handover – The command and control of the Watchkeeper from the GCS has a limited range defined by radio line-of-sight. GCS to GCS handover will occur in the vicinity of AMMAN on the outbound leg of the black route. On the return leg, the handover will take place during the transit from L9 to D202C. Prior to a GCS to GCS handover the operating RPAS pilot will inform ATC of the handover as follows: '*Aberporth, CRONUS commencing GCS to GCS handover, will advise when complete*'. The new RPAS pilot will call when handover is complete as follows '*Cardiff, CRONUS GCS handover complete, radio check*'.

Role	Staff
EGFF ATC	1 ATCO + 1 ACPO
S06 & S08 ATC	1 ATCO + 1 ACPO
Sectors feed	2 ACPO
RPAS pilot	1 Pilot + 1 ACPO

Table 6-6: Staff Supporting Exercise

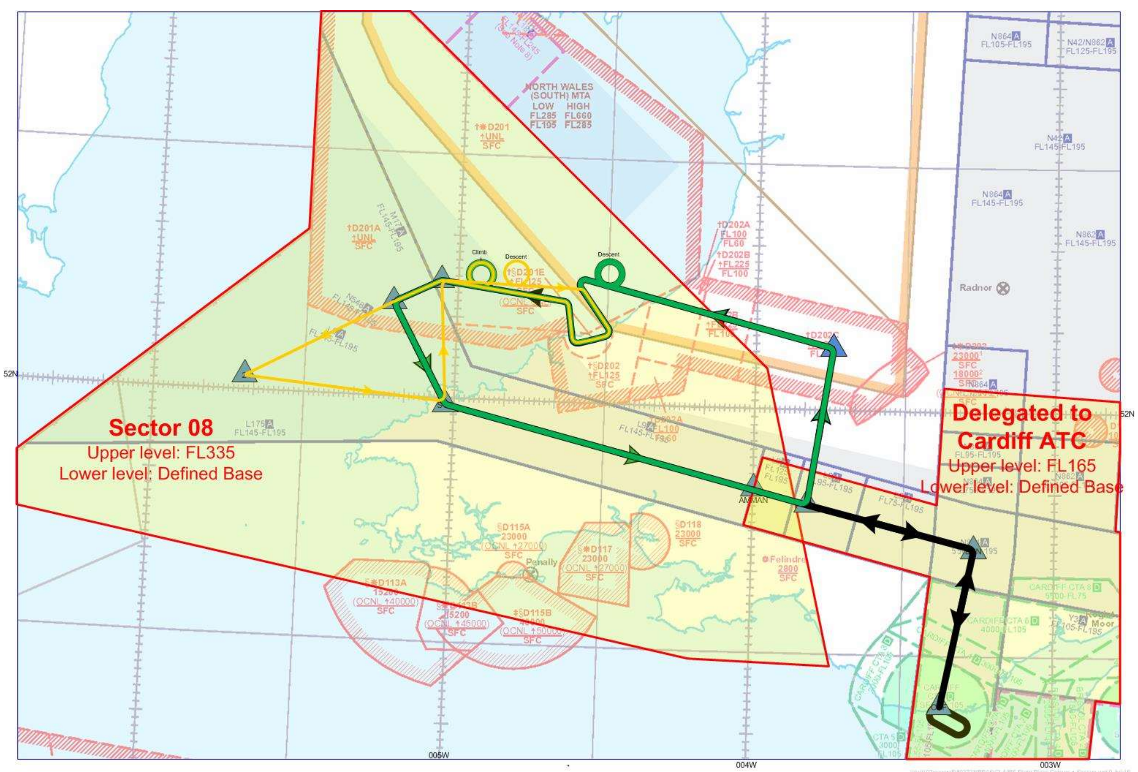

Figure 6-10: Routes X-Ray (Yellow), Yankee (Green) and Zulu (Black) with Sector Boundaries

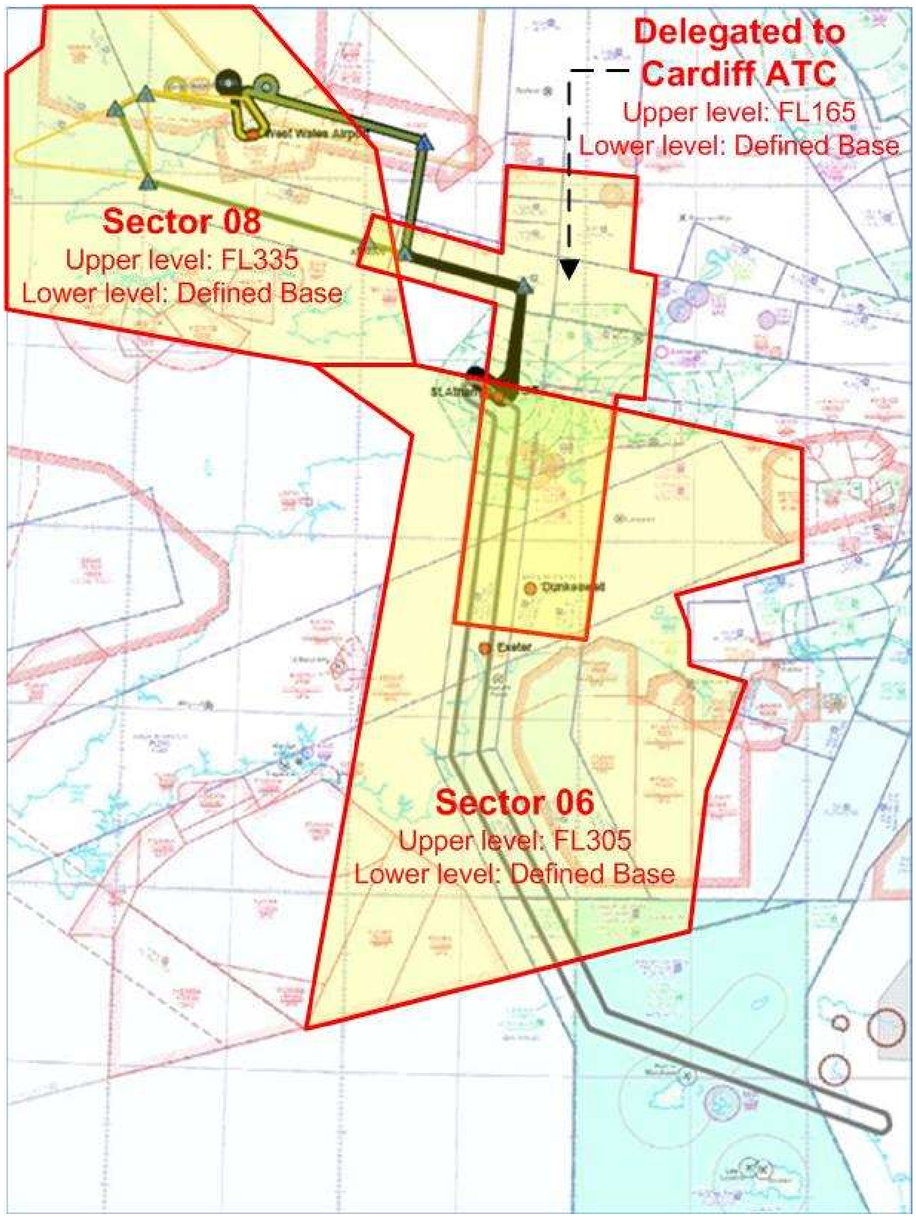

Figure 6-11: X-Ray (Yellow), Yankee (Green), Zulu (Black) & Grey Routes with Sector Boundaries

6.2.2.3 Deviation from the Planned Activities

No deviation from the Demonstration Plan [2] was required for the execution of EXE-RPAS07-002.

6.2.3 Exercise Results

6.2.3.1 Summary of Exercise Results

Day 1: Tuesday 3rd June 2014 – Route Yankee (Green)	
Attendees: Mike Fielding (Thales), Tim Smith (Thales – RPAS pilot), Joe Baker (NATS), Kathy McColl (NATS), Ramón Raposo (NATS), Kevin Powell (NATS – EGFF ATCO), Kyle Hinsley (NATS Swanwick S08 ATCO)	
Run 1: • *CRONUS* requests squawk • Handover WWA to S08 • Lost link before midway – *CRONUS* (squawk 7300) turns 180º towards STU • Lost link recovered • Handover S08 to WWA	Should ATCO be aware of LLR? Pilot can summarise route in R/T call. KH suggested laminates showing routes. This would be possible for trial but difficult in normal ops. For iFACTS tools to work in lost link situation iFACTS would need the route. It is important for situational awareness that RPAS pilot informs ATC of intended route.
	5 key items identified: • Diversionary sites (ERP/ELSS) • Transition points between diversionary sites • LLRs (currently loaded and alternatives) • LLR transition points • Lost Link significant times (T-Times) Need to determine for each one whether/what ATCO needs to know.
	Issues related to a lack of familiarity with the procedures, RPAS performance and communication channels.
Run 2: • *CRONUS* heading East along L9 from Reference midpoint to STRUMBLE (Waypoint) • Handover S08 to EGFF • *CRONUS* descends FL110 to avoid weather • Handover EGFF to WWA • Pilot requested level change due to Wx during handover • Re-do handover EGFF to WWA with new level	All routine ops, no issues raised.
	Noted RPAS offered de-confliction service if routing outside controlled airspace but not required as pilot stayed in CAS.
Run 3: • *CRONUS* heading east on L9	On transponder failure very long R/T call between Pilot & EGFF observed, not raised as issue but might be if frequency busier.

• Loss of transponder west of AMMAN • Transponder recovered • Engine fire: PAN declared and *CRONUS* routed to ERP • Bristol departure level bust at FL150	ATCOs reported no issues, accepted RPAS with no transponder as capacity available. • RPAS more predictable than manned aircraft • Easier to talk to crew who are less distracted by emergency • Aircraft continues to navigate regardless, humans often forget when distracted, resulting in further issues.
	Discussion about whether iFACTS MOPS require an aircraft with failed transponder to route to nearest airfield. WKP RPAS cannot do this (not certified outside CAS, needs landing equipment). [NOTE: ICAO Doc 4444, PANS-ATM, section 8.8.3.3 states "ATC units concerned should endeavour to provide for continuation of the flight to the aerodrome of first intended landing in accordance with the flight plan. However, in certain traffic situations, either in terminal areas or en-route, continuation of the flight may not be possible, particularly when failure is detected shortly after take-off. The aircraft may then be required to return to the departure aerodrome or to land at the nearest suitable aerodrome that is acceptable to the operator concerned and to ATC".]
	Trail dots can be almost imperceptible due to slow speed of RPAS. Display settings and radar turn rate dependent. Also may become a controller fatigue issue.
Run 4: • Radar Display Failure S08 • *CRONUS* R/T Failure, revert to telephone • Transponder failure	Radar display failure – standard evacuation procedure followed
	R/T failure - ATCO did not have phone number for pilot
	Introduction of new mitigation measure (telephone line) increased unfamiliarity with the procedures.
	Transponder failure – ATCO observed. More time available to make plan with RPAS as slower. What to do if primary radar lost as well? Would aircraft need to leave CAS? Levels can be verified if R/T is available for initial separation, but ATCO workload is greatly increased
	Further discussion about providing ANSP with LLR and RPAS information (ERPs, LLRs, etc).
	Observed RPAS descent rate steeper than other aircraft types. Multiple step descents needed to avoid leaving CAS, not continuous descents.
	Discussion about ERPs. The RPAS at 6000ft has glide range of (and therefore needs an ERL within) 12 miles. Many ERLs required. Database of ERLs discussed; who would manage and ensure currency? What ERLs monitoring and what infrastructure would be needed to maintain ERLs?

Table 6-7: Exercise 002 Results, Day 1

<table>
<tr><th colspan="2">Day 2: Wednesday 4th June 2014 – Route Zulu (Black)</th></tr>
<tr><td colspan="2">Attendees: Gerry Corbett (CAA), Martin Sutton (CAA), Mike Fielding (Thales), Tim Smith (Thales), Gavin Ward (Thales), Neil Watson (Thales), Joe Baker (NATS), Andy Edmunds (NATS), Kathy McColl (NATS), Ramón Raposo (NATS), Kevin Powell (NATS – EGFF ATCO), Kyle Hinsley (NATS – Swanwick S08 ATCO)</td></tr>
<tr><td rowspan="8">Run 1:
• 100% speed used for demo to CAA observers
• GCS Handover 5 miles before S08/EGFF boundary
• Handover S08 to EGFF
• Lost link at 4500ft
• CRONUS follows EGFF approach plate.
• Run terminated when CRONUS turns left for inbound leg to EGFF approach</td><td>ATC Handover S08 to EGFF during GCS to GCS Handover. KP requested confirmation GCS handover complete following incomm. GCS Handover should only take a few seconds and be transparent to ATCO apart from a voice change. Should GCS Handover be done earlier so complete prior to sector boundary, to avoid workload peaks for RPAS pilot (though TS stated is not an issue to make frequency changes and GCS handover concurrently)?</td></tr>
<tr><td>Discussion: do ATC need to know about GCS handover? Decided yes for CLAIRE trials as new ground but not in future normal ops.</td></tr>
<tr><td>Low speed of RPAS can work for & against. Can lead to unexpected conflictions but gives more time to resolve issues.</td></tr>
<tr><td>Predictability of RPAS a great advantage over manned flights.</td></tr>
<tr><td>KP observed RPAS should not be instructed to make continuous climbs or descents as might break out of CAS. Need step climbs and descents due to low climb rate and high descent rate to avoid blocking too many levels.</td></tr>
<tr><td>RPAS can follow SID or could be vectored instead.</td></tr>
<tr><td>Discussion about necessity of active TDA. KP concerned already pushing boundaries, CAA happy to consider no TDA if 3-4 live flights have been conducted successfully.</td></tr>
<tr><td>Query should ATC inform local glider site about trials? Cardiff will manage comms with GA. Local gliders inform Aberporth if flying.</td></tr>
<tr><td rowspan="2">Run 2:
• Engine Failure (uncommanded throttle requiring engine shutdown including loss of R/T and wideband comms)
• RPAS routes to ERP south of EGFF</td><td>Location of ERL is too close to “overhead” so descent of RPAS not visible from EGFF, therefore KP unsure when to restart departures from EGFF and EGGD. Needs to be sure of level of RPAS before passing traffic nearby. TS to look into feasibility of moving south 1-2 miles. Existing location not a blocker if it can’t be moved.</td></tr>
<tr><td>Discussion regarding change of transponder code 7300. TS changed to 7700 after engines shut down, not when initially declaring problem (PAN?) over R/T. Should this have changed as soon as problem detected? AE stated if it is a PAN the squawk should be 7700 unless instructed by ATC.</td></tr>
</table>

	AE asked about R/T latency. Not an issue for this RPAS as operated only in radio line-of-sight. Would be for SatComms in future.
	Do controllers need to be aware that an engine failure will also cut R/T? Should R/T be classed as a critical system? Not critical currently as on military certification.
Run 3: • Transponder failure • Transponder recovered • Lost link	Discussion about merging blips when separating vertically. Aberporth advise they no longer ensure blips don't merge. If RPAS loses link it may climb/descend, potentially causing loss of separation. But ATCO has time to react because of slow rate of climb.
	Discussion about whether lost link should be treated as a PAN. The system is still controlling the Air Vehicle and GCS can still contact ATC by phone/ground radio, unless runs out of fuel which would be an emergency calling for 7700. AE queried whether SSR code 7300 is the right code if lost link is not an emergency situation. Should a non-emergency conspicuity code be used instead?
	When lost link occurred KP was on telephone so TS could not call in for several minutes. KP knew it was a lost link due to SSR code change. However this followed a transponder failure and had the transponder not been recovered EGFF ATCO would have been unaware until TS got through on the phone. This was not seen as an issue by ATC or Pilot.
	Discussed whether the phones might be blocked if ATCO and pilot called each other simultaneously. Could not happen at EGFF. Not seen as issue if LLR known so behaviour predictable. LLR might not be known in future normal ops. Not issue for trial but could be future issue.
	RPAS defaults to climb on LLR to gain height required to glide to ERP. This might not be appropriate in TC for example where airspace busier. ERLs and LLRs need to be developed with ATC input to avoid conflicts.
	KP noted if the transponder had been failed for a longer period RPAS would be re-routed back to WWA rather than keeping in CAS.
	Who should contact who in the first instance? Probably the pilot who is likely to detect a failure before the ATCO.

Table 6-8: Exercise 002 Results, Day 2

Day 3: Thursday 5th June 2014 – Grey Route	
Attendees: Mike Fielding (Thales), Tim Smith (Thales), Daryl Rowlands (NATS), Kathy KcColl (NATS), Ramón Raposo (NATS), Kevin Powell (NATS – EGFF ATCO), Malcolm Crowther (NATS – Swanwick S06 ATCO)	
Run 1: • *CRONUS* departs EGFF • Handover EGFF to S06	DR noted that coordination will be required between WWA and Swanwick S08 to pass *CRONUS* squawk.
Run 2: • *CRONUS1* departs EGFF • *CRONUS2* heading north in S06 • *CRONUS2* climbs to FL160 due to interaction with EGXX Departures • *CRONUS1* R/T failure • Jersey refuses telephone comms • *CRONUS1* returns to EGFF	MC points out that RPAS could receive a lower level (too slow and blocking FL for a long time).
	If *CRONUS* loses R/T, how will it coordinate with Jersey? A possible solution is S06 asking phone number to Jersey and passing it back to RPAS by phone.
	General discussion regarding use of squawk 7300. This is an emergency code but is R/T failure an emergency? A 00xx conspicuity code might be more appropriate. ATCO needs to be aware as controlling method changes. R/T failure procedure normally to continue on flight planned route, should this apply to RPAS? The pilot should ring the ATCO in advance of any level changes.
	Discussion regarding phone numbers for RPAS pilots. These are work mobile numbers allocated prior to flight, and checked by WWA. Phone numbers would be needed for all ATC units. Does each unit need to verify each number prior to flight? Are WWA checks sufficient? Do the pilots need to verify all ATC phone numbers prior to flight?
	Discussion about phone system in Swanwick. MC suggested sectors can't take external calls, only the LAS, and it can't be transferred. [Note: On Friday MC confirmed sectors can take external calls].
	It was noted that the additional safety nets provided by the RPAS over manned flight (telephones, lost link procedures, and ERLs) adds complexity as there are more options for the ATCO to consider.
	MC (S06 ATCO) reports lack of familiarity with R/T failure procedures.
Run 3: • 3 RPAS operating concurrently • *CRONUS1* loses link then transponder, LLR descends to FL30 • *CRONUS3* transponder failure	EGFF controller relied on RPAS pilot passing LLR to demonstrate whether pre-briefed LLR is required; this worked well.
	LLR of *CRONUS1* to descend to FL30 stopped all departures EGFF and EGGD.

	Discussion about ATCO knowledge of LLRs. KP noted that LLR could cause ATC issues. They would need to be validated by ATC units, or the authors would need expert ATC knowledge of airspace restrictions, interactions. It would be as simple to brief the unit as to obtain validation and not brief. TS commented the heights for LLR could be agreed the day before the flight.
	This was first occasion when link lost in climb not cruise phase. This raised concerns about the vertical profile of the RPAS.
	MC noted the biggest issue with RPAS is that they are low & slow. Speed differentials and therefore judging catch-ups provide the greatest opportunity for errors.
Run 4: • 3 RPAS, 1 configured as B737 performance • *CRONUS3* heading west to join airway then turns north • *CRONUS2* heading north along airway • *CRONUS1* departs EGFF and heads south along airway • *CRONUS3* has engine failure including power network outage (loss of transponder, R/T)	Discussion about changing squawk when under PAN. DR suggested code should be maintained and not changed. MC suggested code should not be changed until instructed by ATC.
	Due to power failure RPAS pilot had no means of locating the RPAS. Requested radar vectors from EGFF. KP estimated there was no additional workload as the RPAS would have required vectoring into EGFF regardless.
	Emergency procedures need to be standardised across Europe. This is likely to happen. The pilot in command has ultimate responsibility, and often does not follow prescribed procedures. Variation of RPAS types and procedures will be an additional complication.
	In emergency, RPAS Pilot should inform ATC of intentions.
	Discussion of the filtering rules of the various ATC radar systems, to assess conspicuity of RPAS on primary radar. CW informed that Primary CAIT filters out movements <50kts. EGFF radar filters <30kts. TS stated the RPAS is unlikely to fly if the wind is excessive.
	Discussion about broadcasting of emergency R/T calls e.g. mayday to all aircraft in area for situational awareness. Calls over the phone between RPAS pilot and ATC won't be broadcast. Should these messages be propagated somehow?
	Issues with low RPAS speeds were not observed with the RPAS with B737 performance.
Run 5: • 3 RPAS routing as per Run 4 • Manned aircraft in vicinity declares PAN due to depressurisation • *CRONUS2* has engine failure • Weather avoidance required	MC noted that for an emergency aircraft leaving S06 airspace he can offer a de-confliction service above FL75, but only if workload is low and there are no aircraft in vicinity. A traffic service could possibly be offered. Ideally he'd look to transfer aircraft to Plymouth or London Military.
	It was noted that heading changes tend to be larger with RPAS due to the lower speeds.

	There is increased controller workload moving traffic around a slower RPAS. Ideally it would be kept out of the way on lower levels or edge of airway.
	KP noted that the CANP system supports aerial surveys, with similar information to LLRs & ERLs.
	If the ERL is not known to the controller, the RPAS pilot could pass heading, position, ETA to position and ETA to crash or land to controller. A manned aircraft would have a priority to get to the nearest airfield; contrasting requirements.

Table 6-9: Exercise 002 Results, Day 3

Day 4: Friday 6th June 2014 – Review Day	
Attendees: Tim Smith (Thales), Gavin Ward (Thales), Ramón Raposo (NATS), Kevin Powell (NATS – EGFF ATCO), Malcolm Crowther (NATS – Swanwick S6 ATCO)	
Run 1: Black route • *CRONUS* heading east at FL140 east of AMMAN requested to descend • Transponder failure at FL60 • Lost link, revert to phone to advise ATC of LLR • GCS loses visibility of *CRONUS* • EGFF identifies engine failure as *CRONUS* diverts to ERL • EGFF coordinates with WWA	The main issue for separation provision is RPAS performance: too slow in comparison with close aircraft, which affects workload and airspace capacity. Swanwick is used to speeds in the range of 250 to 420 kts. In case S08 is busy when RPAS requests access, it could be asked to hold for some time.
	It is recommended that RPAS pilots entering controlled airspace are familiar with R/T phraseology. This factor will not be an issue for the trials due to the experience of the RPAS pilots involved in the exercises.
	It is recommended that RPAS informs Swanwick about the intention to join the airway, but the communication requesting joining clearance should be within 10 minutes before entering L9.
	Potential issue if RPAS has an engine failure at 1000ft, when it does not have potential to climb, so it crashes in the lost link route. An addition ERP should be defined near Cardiff for the trials.
	The phone lines must be agreed and defined in case of R/T failure.

Table 6-10: Exercise 002 Review Day

Day	Run	ATC	User Assessment (scores out of 10)				
			Overall user acceptance	Procedures	Awareness of RPAS performance	Comms.	ATC system support
3rd June Route Y (Green)	1	EGFF	-	-	-	-	-
		S08	9	3	5	4	8
	2	EGFF	9	8	10	10	8
		S08	9	4	5	5	8
	3	EGFF	9	8	10	10	8
		S08	9	4	6	6	8
	4	EGFF	9	8	10	10	8
		S08	8	5	6	2	8
4th June Route Z (Black)	1	EGFF	8	8	8	8	8
		S08	9	5	7	6	8
	2	EGFF	9	9	8	8	9
		S08	9	-	-	-	-
	3	EGFF	9	9	9	9	9
		S08	9	-	-	-	-
5th June Grey Route	1	EGFF	-	-	-	-	-
		S06	8	7	7	7	7
	2	EGFF	9	8	9	8	9
		S06	5	5	7	5	5
	3	EGFF	9	9	9	10	9
		S06	6	7	7	7	7
	4	EGFF	9	9	9	9	9
		S06	9	7	10	10	7
	5	EGFF	9	9	9	9	9
		S06	8	8	7	7	7
6th June Route Z (Black)	1	EGFF	9	9	9	9	9

Table 6-11: Summary of ATCO Questionnaires

6.2.3.1.1 Results per KPA

All the draft ATC procedures to be used in the live flight trials were demonstrated without identifying any significant issues relevant to the live trials. User acceptance of the procedures was high, with issues relating to familiarity with new procedures. Existing procedures should be adhered to as closely as possible to reduce the need for RPAS-specific training.

The following findings relate to the Project CLAIRE flight trials and the implications on future integration of RPAS. The results have been grouped into Safety and Capacity considerations, both mainly affected by Human Factors related issues.

Safety

The distinctive performance and equipment characteristics of the RPAS and the differences with more standardised aircraft used by commercial aviation imply new challenges for ATC. The main hazard identified for RPAS management is the misjudgement of the RPAS performance:

- RPAS may cruise at significantly lower speeds.
- RPAS ROC can be slow. Usually good glide potential, but due to the low speeds involved, the rate of descent in terms of distance can be high.
- RPAS rate of turn can be very high resulting in the ability to execute a very tight holding pattern.
- RPAS can be very light and sensitive to wind, so may need larger heading offsets to maintain a set track.
- RPAS may have no de-icing capability, which make it unsuitable for operating in cloud during forecast icing conditions.
- RPAS have a unique failure mode (lost link) the fall-back for which changes the aircrafts course and potentially level.
- RPAS may only have one transponder and no ILS/VOR/NDB capability.
- RPAS is controlled by Radio Line of Sight Ground Control Stations; a GCS to GCS transfer could take longer than expected to complete and the workload on the pilot at this point can be high.
- RPAS may have a low operating ceiling and so might not be able to make higher flight levels in certain pressure conditions.

Figure 6-12: Radar screen capture of Run 3 on Grey Route

The slow speeds of the unmanned vehicle tested in Project CLAIRE allow more reacting time but also increase workload. The vehicle spends more time in the sectors than ATCOs are used to, which can lead to unusual situations.

Climb and descent performance is unusual for Air Traffic Controllers. It is suggested to use stepped climbs to avoid blocking several flight levels for a long time. On the other side, there is a potential for a CAS excursion if standard descent instructions are used, given the aircraft's steeper than normal angle of descent. For this reason, descent clearance must be given to a level above the airspace base at that particular point.

The Ground Control Station equipment and autonomy of the RPAS provides additional safety layers beyond conventional manned aircraft, for example reduced stress of the pilots in emergency situation, greater predictability of the aircraft in case of a lost link situation and more communication options.

However it also creates a layer of complexity for ATC in handling non-nominal situations and a temptation to deviate from standard emergency procedures for manned aircraft. For example in the case of R/T failure the ATCO and pilot can communicate by telephone, but this necessitates a change in controller behaviour, can increase workload and reduce situational awareness for proximal traffic.

Capacity

En-route ATCOs are used to fast jets, in the range of 250 to 420 kts. The simulated RPAS is significantly slower than surrounding conventional aircraft, spending more time in sectors than controllers are used to. Those speed differentials make it easier to move traffic around the RPAS, which can greatly alter ATC workload due to higher sector occupancy and traffic complexity, implying a reduction in capacity.

Because of this negative impact in performance consistency, there is a possibility that RPAS is asked to hold before entering Controlled Airspace at busy periods. This requirement, already experienced in specific manned aviation environments, tends to cause undesirable situations to the RPAS pilot (increased workload), the operator (extra fuel consumption) and ATCOs both handing over and taking control due to an increase in complexity and workload.

It was noted that the additional safety layers provided by the RPAS over manned flight (telephones, lost link procedures, and ERLs) add complexity to the ATC operation, as there are more options for the ATCO to consider.

6.2.3.1.2 Results Impacting Regulation and Standardisation Initiatives

Emergency procedure regulations for RPAS need to carefully consider safety impact, as the additional safety layers provided by the RPAS over manned flight (telephones, lost link procedures and ERLs) add complexity to the ATCO procedures. Those emergency procedures should be standardised across Europe.

It is essential that RPAS pilots hold a VHF R/T license before entering controlled airspace and are familiar with R/T phraseology, in order to avoid overloading R/T channel. This could be overcome by a European-wide RPAS pilot license. It is recognised that RPAS operations provide additional communication challenges such as:

- Lost link routes,
- Diversionary sites (ERPs & ELSSs),
- Transitions between diversionary sites or LLRs
- Lost link timings parameters.
- GCS-GCS handovers

It is recommended that RPAS-specific phraseology appears in the manned aircraft pilot lexicons and the following documents should be considered for amendment:

- ICAO Annex 10, Volume II
- ICAO Doc 9432, Manual of Radio Telephony
- Additional national standards such as the UK CAA CAP413, Radiotelephony Manual

The need to publish this information to ANSPs and other stakeholders, and the technical requirements for this are cause of significant debate. This information will be agreed and shared for the live trials, but the practicalities for future operations entail a lot of complexity. For future RPAS integration a safe and manageable solution for all stakeholders must be identified and agreed. From an ANSP point of view, it would be desirable that ERPs are common for all RPAS operators in order to decrease uncertainty of RPAS behaviour in case of a lost link situation, but this may constrain the flexibility of RPAS operations.

6.2.3.1.3 Unexpected Behaviours/Results

No unexpected results have been identified during the execution of the exercises and the de-briefs conducted after each run.

6.2.3.1.4 Quality of Demonstration Results

Simulation speed was accelerated in some cases in order to maximise the exercises to be performed, whilst at the same time ensuring acceptable workload levels to the participants involved in the simulation.

At the same time, the quality of feedback regarding the suitability of the procedures showed good levels of consistency. As a result there is a high confidence amongst the exercise participants that the results address the challenges of the exercise.

6.2.3.1.5 Significance of Demonstration Results

Exercise 2 completely replicated the real conditions of the planned live flight in Exercise 3, after thorough preparation as described in 4.1 and 6.2.2.1.

6.2.4 Conclusions and Recommendations

6.2.4.1 Conclusions

No issues were identified that would indicate a significant impact on safety. The RPAS performance differentials with commercial aviation, particularly at high flight levels in en-route sectors together with extra safety layers increase controller's workload and complexity. The Temporary Operating Instructions developed for the live flights ensured safety and provided briefing material to the sector controllers as discussed in section 4.1.4.5.3.

6.2.4.2 Recommendations

In general terms, UK National procedures should apply, avoiding the creation of bespoke procedures to codify RPAS management.

The RPAS has pre-loaded Emergency Recovery Locations and Lost Link Routes, which will be followed in case of a Lost-link. The ERLs and LLRs are not unique and are ranked depending on the RPAS location and meteorological conditions. There are several issues which require consideration:

- Lost link routes should be agreed or validated with ATC in advance of the flight. For instance, if an RPAS goes lost link in Airway L9 at FL150, it is desirable to prevent uploading a LLR which instructs the vehicle to climb.
- There is discussion around the need to share ERLs and LLRs in advance with ATC. The remarks field in the flight plan could host this information, although controller positions with paper strips do not have easy access to it. Obtaining this information would require the controller to access a different computer system away from the radar console, find and load the flight plan with a search on Flight ID. Electronic Flight Strips could facilitate access to this information. If this information was not shared in advance, the RPAS pilot could summarise the route in a phone call.
- From an ANSP point of view, common ERLs for all RPAS operators would facilitate ATCOs workload during a Lost Link situation. Otherwise an ATCO needs to be aware of potential multiple ERLs per individual aircraft. It would take a lot of mental processing power during what may be considered an emergency situation which would be busy enough. This would decrease uncertainty of RPAS behaviour in case of a lost link, making it more predictable.

The Command and Control link (C2) between pilot and vehicle has a limited range when operated by radio line-of-sight. In this situation, GCS to GCS handovers will be necessary when the range of the operation exceeds certain limits.

- GCS to GCS handovers should be transparent to ATC. For Project CLAIRE trials, ATC will be informed immediately before the GCS start and a radio check performed on completion. However, for future and more regular RPAS flights, ATC should be informed only if the capability of the RPAS is altered following the handover.
- ATC instructions can still be issued to the RPAS pilot during the handover and it will be complied with in the normal manner. However, because of the workload and the fact that the two units may be in the middle of a procedure there is a very small risk that ATC instructions may have

to be repeated and that ATC instructions may slightly increase the overall time taken to complete the GCS handover.

It was noted during the simulations that the RPAS should not be instructed to make continuous climbs or descents, as it might break out of CAS due to unfamiliar performance. In addition to this, CLAIRE TOIs recommend step climbs and descents to avoid blocking too many levels. This is a common tactic to deal with aircraft with differing performance characteristics.

For Project CLAIRE, RPAS pilot's phone numbers were made available to ATC and vice versa in case of an R/T failure with the RPAS, as a reasonable mitigation measure for a one-off trial. However, in the longer term, this could be an unmanageable database of phone numbers, posing further questions of how would they be made available to the ATC Units, or how to reach the controller's position with a simple phonecall. Consideration could be given to the use of the Distress & Diversion Desk in the first instance.

It would be desirable for RPAS operators to check the filtering rules of the various ATC primary radar systems, in particular the radar speed gates. However, some radar system owners may not wish to share this data. In the situation of a SSR failure, a slow moving vehicle could be removed from the radar screen. For this reason, it is recommended that ATCOs could instruct the RPAS to turn in order to the reduce headwind component if aircraft transponder fails.

From the experience gained in the simulator and the TOIs development process, it is suggested that:

- 20 minutes *Ops Normal* comms check initiated by RPAS pilot should be included subject to R/T slot availability to remind the ATCO of the RPAS presence.
- Orbit the RPAS in case of emergency to easily move traffic around.
- The TOIs are complemented with briefings to familiarise ATCOs with unusual RPAS performances.

6.3 Demonstration Exercise 3 Report

6.3.1 Exercise Scope

An overview of the scope of Exercise 3 is provided in Table 2-3 in section 2.1.

Exercise 3 of Project CLAIRE was aimed at assessing the regulatory, technical and operational issues associated with a live flight of an RPAS in non-segregated airspace. The most appropriate method for doing this was to plan for and undertake a series of live flights to validate the findings of exercises 1 and 2. This would challenge some of the proposed processes to achieve flight in non-segregated airspace, and in some cases require the development of new procedures to manage RPAS flights.

It should be stressed that this exercise was focussed on the analysis of the issues and work required to achieve RPAS flight in non-segregated airspace, and as such was undertaken across the entire duration of the project, rather than aimed at one or more specific events. Since exercise 3 operated concurrently with the other exercises this allowed all the exercises to inform and be informed by each other.

6.3.2 Conduct of Demonstration Exercise EXE-RPAS07-003

6.3.2.1 Exercise Preparation

Exercise 3 was aimed at assessing and developing the processes for unmanned RPAS flight in non-segregated airspace. In order to achieve this, the project elected to adopt a use case based upon an existing RPAS currently being deployed to military service as this represented the current state-of-the-art in terms of regulatory and technical compliance. Thales is the prime contractor for the UK MoD's Watchkeeper programme which has restricted type approval to fly in segregated airspace, and project CLAIRE provided the opportunity to push the boundaries to determine the feasibility of flight in non-segregated airspace.

Watchkeeper is classified as a High-end Tactical RPAS and is the largest RPAS acquisition programme in Europe. The system features a high degree of automation including automatic take-off and landing

(ATOL) and advanced mission management functions. The air vehicle carries a configurable dual sensor payload including optic/infrared sensors as well as an advanced synthetic aperture radar/ground moving target indicator radar.

Though the Watchkeeper system is a military Intelligence, Surveillance and Reconnaissance (ISR) platform, it is ideally suited to operate as a suitable test platform to demonstrate both local and wide-area civilian RPAS operational utility in the near term. Watchkeeper is the only tactical class RPAS certified to fly in UK airspace under military aviation rules, and in excess of 470 flights have been completed to date. To support flights outside military ranges it is important to note that the system has been accredited in general accordance with primary civilian certification standards including:

- European Civil Standards (analogous to EASA Certification Std-23 & CS-E)
- USAR Code (NATO STANAG 4671)

6.3.2.2 Exercise Execution

The majority of the work associated with this exercise is undertaken as part of the preparation activity described in section 4.1.4. The following text describes the significant events identified as part of the preparation.

It was planned to operate Watchkeeper assets using an extended Military Flight Test Permit (MFTP) approach supported by a Trials Risk & Hazard Assessment (TRHA) exercise to be agreed by the military authorities. This approach is standard practice for extending contracted trials envelopes, and enabled a robust Safety Case to be developed and submitted to the MAA & CAA.

As discussed in 4.1.4.6, there was a need to create a qualification to cover the flight of this type of RPAS in non-segregated airspace. This instrument rating qualification was endorsed by both the CAA and the MAA and two pilots successfully passed the associated theoretical and practical examinations on 7th September 2015.

Prior to the live flights, NATS formally issued Temporary Operating Instructions for Aberporth Range Area Control [10], Cardiff ATC [11], and London Area Control Centre [12]. NOTAMs were issued 4 times[6] to activate the required temporary danger areas below the non-segregated airspace as discussed is section 4.1.4.5.1. Backup telephone numbers were shared between the RPAS operator and all the ATSUs, and these were tested immediately prior to take-off.

```
J0729/15 NOTAMN                                         (EGGN J0729/15)

Q)EGTT/QRDCA/IV/BO/W/095/145/5203N00519W020

A)EGTT       B)1509300930           C)1509301300

D)0930-1530

  TEMPO DANGER AREA EG D198A (FISHGUARD) ESTABLISHED LATERAL
E)DIMENSIONS AS PER AIC Y 011/2015. PROJECT CLAIRE: UAS OPR WI AIRWAY
  L9 UNDER ATS FM LONDON AREA CONTROL. DANGER AREA CROSSING SERVICE
  (DACS) AND DANGER AREA ACTIVITY INFORMATION SERVICE (DAAIS) AVBL FM
  ABERPORTH ON FREQ 119.650MHZ. OPS CTC 01239 813219. 15-04-0003/AS4.
F)FL095      G)FL145
```

Figure 6-13: NOTAM for Flight 1

[6] Two NOTAMS were raised to cover flights 1 & 2, and a further two were raised to cover planned flights which were grounded due to bad weather.

Flight 1 (Yellow Route/Route X):

Aiming for equivalency, a flight plan was submitted within 24 hours before each flight. On the first instance, the flight plan was submitted by fax, requiring amendments before it was located and accepted by the *IFPS* (Integrated Initial Flight Plan Processing System), which provides the centralised flight plan processing and distribution service under the authority of the EUROCONTROL Network Manager. However, the preferred and standard choice for flight plan submission is the use of an *AFPEx* (Aeronautical Flight Planning Exchange) account, which is an internet based flight messaging system. The *AFPEx* service is provided by NATS and grants authorised user access to the Aeronautical Fixed Telecommunications Network (AFTN). This method was used for subsequent flights.

Figure 6-14: WK004 Take-off

Flight 1 (UK474) took place on 30th September 2015 at 1003Z with the callsign *CRONUS*. The meteorological conditions on the surface were:

Outside Air temperature:	10ºC
Wind:	080/10kts
QNH:	1034

Following take-off, the air vehicle was cleared to climb to 10,000ft[7] within segregated airspace. At 5000ft, the wind was observed to be 096/30kts.

Figure 6-15: Ground Control Station

The joining clearance for airway L9 was at FL150 (pressure reference 1013.25hPa). The Flight Crew requested a transition from QNH pressure setting to FL in the climb, and was approved by the Range

[7] In its normal operation, the Watchkeeper system operates in a region of segregated airspace (EG D201/D202) where participating aircraft normally operate to a QNH altitude reference.

ATC Controller. All subsequent clearances and communications[8] between ATC and the RPAS were by reference to the cleared Flight Level[9].

Prior to entry into non-segregated airspace, the flight crew were instructed to change the SSR code. Following this, clearance was received to leave the range area and enter the airspace controlled by sector 8.

On entry into class A airspace, NATS confirmed surveillance on both primary and secondary radar. Mode S was not active for this flight, but all subsequent flights involved the use of elementary mode S[10].

The flight in non-segregated airspace was uneventful, and traffic separation was managed following standard procedures by the sector 8 controller. It should be noted that as the air vehicle turned eastwards on the longest leg of the flight, a significant headwind was encountered which reduced the ground speed of the air vehicle to around 30-40kts. NATS confirmed that surveillance was maintained at all times, although it was noted that on the controller's display that due to the slow ground speed and selected range scale, the trail dots merged into a single dot as shown in Figure 6-17.

When the waypoint at Strumble Head (see Figure 4-2) had been reached, the air vehicle turned northwards and re-entered the range area. The total time in non-segregated airspace was around 80 minutes, during which time NATS confirmed that all standard ATM processes were applied as normal.

Figure 6-16: Controller Managing Flight WK004 (Callsign *CRONUS*) in Sector 8

Due to the low speeds involved, and the long times taken to transit between waypoints, it had been the intention to transmit an '*Ops Normal*' message to ATC periodically during the portion flight in non-segregated airspace. However, this could only occur during quiet periods of R/T. Although the sector was operating well within the monitor values, this sector appeared busy to the RPAS operator who was more used to operating in quieter segregated airspace, and few opportunities to perform an 'Ops Normal' check were identified.

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[8] Whilst the VHF radio at the GCS is fully compliant with 8.33KHz operation, the VHF radio on the air vehicle is currently only capable of 25KHz channel spacing operations. This required further assessment by NATS to confirm that safety would not be compromised.

[9] A key safety feature of the Watchkeeper RPAS (and an expectation for all approved RPAS - operating on a Release to Service or Certificate of Airworthiness) is the ability to calculate its glide range at all times, and therefore its ability to reach any of the designated ERLs in the event of propulsion failure. An essential piece of information for this calculation is knowledge of the actual height above the surface. This information is not available from Flight Level which provides a reference that floats with the ambient pressure, and therefore does not provide the actual height above the surface. Therefore, internally the Watchkeeper System uses QNH for its level reference, and "knows" the minimum height above the surface at time at all times.

[10] As a result of work on this project, even though not needed for use in the Cardigan Bay Range Area, the Mode S transponder is now routinely enabled regardless of the type of airspace.

Following re-entry into segregated airspace, the air vehicle proceeded to descend and land at West Wales Airport as normal.

Figure 6-17: Limited Trail Dots on Controller's Display

Flight 2 (Green Route/Route Y):

The flight plan was submitted 24 hours before the flight using the NATS *AFPEx* system. Following activation of the NOTAM, flight 2 took place on 8th October 2015 at 0920Z. The meteorological conditions on the surface were:

Outside Air temperature:	12ºC
Wind:	210/7kts
QNH:	1020

The climb to FL150 was uneventful, and NATS confirmed that elementary Mode S returns were being received[11]. At FL150, before entry into non-segregated airspace, the RPAS was handed over from Aberporth RAC to LACC Sector 8. At this point, the crew performed a comprehensive set of checks prior to leaving segregated airspace. These checks identified a small issue with one of the backup control links. The Sector 8 controller was advised of the issue and the ensuing delay whilst attempts were made to clear the problem. All R/T was acknowledged and ATCO workload was not affected.

Even though the air vehicle was under full control of the pilot in the GCS, with a potential problem associated with one of the contingency backup control links, to comply with the Safety Case, which stated that the pilot must be satisfied that all contingency methods were operating satisfactorily, the decision was taken to abort the flight and return to base. The decision was communicated to the sector 8 controller and acknowledged, before the air vehicle switched back to Aberporth RAC and returned to West Wales Airport where it performed a routine landing.

Subsequent Flights:

Further flights were planned for 15th and 22nd October. However, the unseasonable weather (mainly due to wind speed and direction) meant that although the flights could be safely flown along the entire Green route/route Y, if an engine failure occurred, there was a very small portion of the route where a landing at an emergency recovery position, could potentially have resulted in a slight incursion into uncontrolled airspace. Therefore, to comply with the conditions of the Safety Case, it was agreed that

[11] The Mode S transponder correctly reported the ICAO aircraft address of the air vehicle, but an error on data entry meant that the Mode S transponder was not broadcasting an appropriate flight identifier. On a subsequent flight, the correct Mode S flight identifier was observed.

the flight should not proceed. If timescales and funding permit, there is no reason why this flight could not be undertaken in the future.

6.3.2.3 Deviation from the planned activities

Although it is recognised that the commercial, insurance and flight authorisation issues took longer to achieve than expected (see section 4.1.4), the exercise achieved the majority of the planned objectives to fly an unmanned RPAS in non-segregated airspace. The following objectives were only partially addressed:

OBJ-RPAS07-21: Cross-border operations were not undertaken within Exercise 3, but was addressed in Exercise 2

OBJ-RPAS07-22: Although ATC handovers were demonstrated within Exercise 2, GCS-GCS handovers were only conducted in Exercise 2.

OBJ-RPAS07-23: As described in 4.3.2, due to logistic, cost and time constraints, it was not possible to undertake the transition between En-route and TMA operations, although flights in and out of West Wales Airport were included in the live flights.

6.3.3 Exercise Results

6.3.3.1 Summary of Exercise Results

The focus of the exercise was on establishing suitable processes and procedures for the flight of RPAS in non-segregated airspace. Exercises 1 & 2 both exercised the approaches and concepts of operation and these were confirmed within exercise 3. The following summarises the main findings of the exercise:

a) Other than the speed differential, little or no difference was observed with the operation of RPAS when compared with manned aviation.

b) Existing ATM procedures applied equally to RPAS.

c) The live flights were considered ‘uneventful’ and had minimal impact on operations or workloads.

d) Safety was not compromised by the introduction of RPAS into non-segregated airspace.

e) ATC tools and systems at LACC-S08 displayed and managed the RPAS ordinarily, in a similar fashion to any other low speed aircraft, proving the successful integration in terms of equivalency and interoperability

6.3.3.1.1 Results per KPA

The KPA results identified in exercises 1 and 2 were found to remain valid for exercise 3. Refer to sections 6.1.3.2.1 and 6.2.3.1.1 for more information.

6.3.3.1.2 Results impacting regulation and standardisation initiatives

The results of exercise 3 validated the findings of exercise 2 with the potential for impacting regulation and standardisation as described in 6.2.3.1.2.

6.3.3.1.3 Unexpected Behaviours/Results

A significant proportion of the work associated with exercise 3 was aimed at the preparation and planning for safe flights and this included the development of contingency management processes and techniques. In addition, the flights had been extensively practiced within the simulation environments associated with exercises 2 and 3 which were aimed at exercising a range of ‘what if’ and emergency scenarios. This meant that no unexpected behaviours were encountered during this exercise.

6.3.3.1.4 Quality of Demonstration Results

The results associated with this exercise were consistent with those obtained in exercises 1 & 2 and since the exercise involved live flight, the quality of the results should be considered to be high.

6.3.3.1.5 Significance of Demonstration Results

Since the exercise culminated in live unmanned RPAS flights in non-segregated airspace in the presence of other air traffic, the developed processes and exercise results should be considered valid and significant.

6.3.4 Conclusions and Recommendations

6.3.4.1 Conclusions

Exercise 3 demonstrated that unmanned RPAS flight in non-segregated, controlled airspace was achievable without impacting safety. The following summarises the conclusions and finding of exercise 3:

- Some increase in controller workload was observed, mainly due to the lower performance associated with the RPAS used for live flights.
- The preparation activity for the live flights resulted in the creation of a specific RPAS (non-segregated) Instrument Rating for the RPAS pilot.
- Pilot/Controller R/T phraseology should include some additional terminology to reflect unique RPAS conditions such as the loss of command & control link and the concept of lost link routes.
- Insurance rates are currently very high. These will only reduced after further event-free RPAS flights.
- A Mode S transponder is essential to avoid surveillance issues associated with low aircraft speeds, and for integration with other air traffic. This is particularly important for other aircraft equipped with ACAS (TCAS) that requires the use of SSR responses to avoid conflicts.
- A Mode S “Enhanced” transponder capable of producing Downlinked Aircraft Parameters (DAPs) would be an advantage in busy airspace, and is a requirement for flight in some parts of the UK airspace structure (e.g. LTMA).

6.3.4.2 Recommendations

Recommendations are detailed in section 8, and include the following

- Attempts should be made to standardise procedures associated with abnormal RPAS operation including:
  - The concepts of operation for lost-link scenarios
  - The level and format of information shared between RPAS pilot and ATC
  - The method of providing back-up communications in the event of a link failure
- The Safety Case for unmanned RPAS flying must include the vulnerabilities of control data links
- For RLOS operations, any GCS-GCS handovers should be transparent to ATC
- Consideration should be given to the level of situation awareness provided to the RPAS pilot
- The qualification and licensing requirements for RPAS pilots should be addressed.

7 Summary of the Communication Activities

Figure 7-1: Project CLAIRE in the Media following Flight Trials

The key objectives of the CLAIRE communications activity were consistent with the overarching project aims to demonstrate how unmanned air systems may be realistically and safely integrated into non-segregated airspace in a multi-aircraft and mixed traffic environment. The communications campaign was successful in:

- Maintaining awareness of Project CLAIRE amongst key stakeholder communities (such as political decision makers, RPAS operators, industrial organisations, ANSPs and regulators) as well as project participants and the general public.
- Highlighting the fact that the SESAR RPAS demonstration programme is delivering concrete results and pushing regulatory and technological boundaries. The outcomes and conclusions will assist in paving the way for the routine and safe operation of RPAS as an integral part of the next generation air traffic system both in Europe and globally.

Communications efforts were focused on demonstration events, especially following the live flying exercises which highlighted the first time a large unmanned air system has flown outside segregated airspace within the existing air traffic infrastructure. Potential civilian applications for RPAS were described enabling future RPAS utility to be showcased in the media using example applications such as search & rescue; environmental monitoring; fire-fighting; precision agriculture and fisheries protection. Interest remains high as illustrated by a recent request by a BBC based documentary '*Skies Above Britain*' to interview team members involved in the flying operations and air traffic oversight.

Media coverage was extensive; the following links highlight some of the initial press and communications headlines

- www.bbc.co.uk/news/technology-34538727
- http://www.sesarju.eu/newsroom/all-news/sesar-members-achieve-first-aviation-history
- https://www.thalesgroup.com/en/worldwide/defence/press-release/thaless-watchkeeper-achieves-another-first-aviation-history

- http://www.upi.com/Business_News/Security-Industry/2015/10/15/Unmanned-aircraft-flies-alongside-manned-craft-in-UK-civil-airspace-for-first-time/7471444911358/
- http://www.ibtimes.co.uk/uk-first-time-drone-flies-alongside-commercial-aircraft-1524071
- https://www.flightglobal.com/news/articles/watchkeeper-carries-out-sortie-in-controlled-airspac-417793/
- http://www.airtrafficmanagement.net/2015/10/unmanned-aircraft-flies-in-civil-airspace-in-uk-first/

Partners also made use of extant communication channels to disseminate information regarding participation in Project CLAIRE. This included 'day-to-day' media such as company intranet; use of social media; team briefings; weekly 'stand-ups' together with company TV channels and websites.

This table below summarises a number of important CLAIRE communication events providing a description of each activity; key dates, attendees (target audience) and venues selected. In all cases the project generated a significant level of interest followed by lively debate and appetite to exploit project outcomes in cognisance of examples of best practice and lessons learnt.

Activity	Date	Type	Attendance	Venue
Project CLAIRE Interim Stakeholder Workshop	Jul 14	Interim Presentation/SE Exercise Findings	Wide-ranging Aviation & RPAS Stakeholders (regulators; ANSPs)	Novotel Tour Noire, Brussels, Belgium
UK Cross Government Working Group & Civil Agencies	Oct 2014	Structured Presentation/Discussion Forum	UK Central Government & Aerospace Industry Reps	Department of Transport, Horseferry Road, London
European Defence Agency	Nov 2014	Structured Presentation/Questions & Answers (Q&A)	European Defence Agency (EDA) Management Board	EDA HQ, Rue des Drapiers, Brussels
ASTRAEA Project Partners, Steering Board & Industry Executive	Dec 2014	Structured Presentation/Discussion Forum	UK Aerospace Primes inc. BAES; Airbus; QinetiQ; Rolls-Royce; Cobham	Thales Offices, Crawley, UK
Technology & Airspace Integration Awareness Days UK Dstl	Dec 2014 & April 2015	Structured Presentation/Questions & Answers (Q&A)	UK Defence Science and Technology Laboratory & UK Industry	Dstl Portsdown West, Hants UK Thales Offices, Crawley, UK
CTIC Certification Together International Conference	Feb 2015	Conference Presentation/Questions & Answers (Q&A)	Certification and Safety Experts & European Stakeholders	Centre de Congrès Pierre Baudis, Toulouse, France
SESAR Joint Undertaking (SJU) Information Sharing Workshop	Feb 2015	Presentation/Information Sharing/Discussion Forum	SJU + RPAS Demonstration Project representatives	SESAR JU, Avenue de Cortenbergh 100, 1000 Brussels, Belgium

Activity	Date	Type	Attendance	Venue
World ATM Congress 2015 - Madrid	Mar 2015	Structured Presentation/Questions & Answers (Q&A)	Wide-ranging Aviation & ATM Stakeholder communities	IFEMA Conference Centre, Madrid
French DGA (Direction générale de l'armement)	June 2015	Structured Presentation/Questions & Answers (Q&A)	French Government Defence Procurement & Technology Agency	West Wales Airport, Aberporth, Ceredigion, Wales
Aerodays 2015 Aviation (Research and Innovation) Conference	Oct 2015	2 off Conference Presentations/Questions & Answers (Q&A)	Wide-ranging Aviation & RPAS Stakeholder communities	QEII Conference Centre, Westminster, London UK
Project CLAIRE Final Stakeholder Workshop	Pending Dec 2015	Interim Presentation/Flight Exercise Findings	Wide-ranging Aviation & RPAS Stakeholders (regulators; ANSPs)	SESAR JU, Avenue de Cortenbergh 100, 1000 Brussels, Belgium

8 Next Steps

8.1 Conclusions

The exercises within Project CLAIRE indicate that for the introduction of RPAS into non-segregated controlled airspace:

- Project CLAIRE has shown that future RPAS operations could be safely integrated into non-segregated airspace using existing ATC processes and procedures.
- A detect & avoid capability and compliance with European aircraft equipage requirements will be necessary for operations in all airspace. Temporary Danger Areas to protect uncontrolled airspace are not sustainable for routine operations, in order to meet the principles of equivalence and transparency.
- Lower performance RPAS could result in an increase in en-route and TMA ATCO workload as a result of lower speeds and different climb/descent profiles. The practice of blocking out large altitude bands of airspace for a manned aircraft to climb or descend could result in non-optimised trajectories for other airspace users.
- R/T operations are considered to be equivalent to manned aviation, but with additional phraseology relating to:
    - Lost link - unique to RPAS
    - ERL (Emergency Recovery Location) – similar to diversionary airfield
    - Prefixed initial contact with ‘unmanned’
- A Mode S transponder is essential to avoid surveillance issues associated with low aircraft speeds, and for integration with other air traffic. This is particularly important for other aircraft equipped with ACAS (TCAS) that requires the use of SSR responses to avoid conflicts.
- A Mode S “Enhanced” transponder capable of producing Downlinked Aircraft Parameters (DAPs) would be an advantage in busy airspace, and in emergency situations as it can provide additional information to ATC such as aircraft vertical intentions.
- For operations involving handovers of control between ground stations and/or RPAS pilots, handovers should be conducted away from sector boundaries to minimise the risk of changing pilots/GCSs and sector controllers at the same time. This process is transparent to ATC.
- The simulations identified that in abnormal conditions, RPAS were considered to be more predictable than manned aviation. Whilst there are standard procedures for manned flights, in the case of an R/T failure, it is not possible for the controller to know exactly what the aircrew will do next. Mode-S allows some units to see what is occurring with each flight, but it does not show the intentions of the aircrew. RPAS procedures can remove doubt regarding the flights trajectory in these circumstances, and the ability to actually communicate with the RPAS operator directly by telephone is a further enhancement over manned aviation.
- To allow for the loss of control links between the pilot and the RPAS, some form of backup communication is considered desirable, possibly based upon a ground or mobile telecoms infrastructure.
- Insurance rates are currently significantly higher than manned aviation and may hamper the business case for RPAS operations. However, as RPAS operations become more common and the safety and security risks identified in this report are addressed, it is expected that the cost of insurance will be significantly reduced.

The associated study work together with work undertaken within the partners’ other projects indicated that:

- For routine access to uncontrolled airspace, a full detect & avoid capability is required. As well as including collision avoidance this must be extended to include separation provision. This will require a greater emphasis on non-cooperative sensing.
- The Safety Case for RPAS operations must include the vulnerabilities associated with control via data links and the possibility for jamming or spoofing.

8.2 Recommendations

The project makes the following recommendations:

- Contingency Management requirements should be standardised. Further work is required to assess the sharing of information regarding Emergency Recovery Locations and Lost Link Routes.
- Support the development of lost-comms procedures including the ability for the ATC unit to communicate directly with the RPAS pilot using a backup mode of communication. For example, a central ATC Lost Link contact method may be an appropriate way of managing lost link back-up comms.
- Further exercises should be conducted using multiple RPAS. In particular this should focus on workloads for ATCOs.
- A study covering the legal status of controlling an RPAS in one territory with a pilot located in another territory is required.
- Support the development of standards to cover the minimum acceptable level of situation awareness to be provided to RPAS pilots. This should also address response times associated with ATC executive instructions.
- Since RPAS pilot is remote, determine the feasibility of co-location of RPAS pilot and controller.
- In order to achieve live unmanned flight in non-segregated airspace, it was necessary to develop and seek approval for a suitable qualification for an RPAS pilot. This was achieved with support from the MAA, but it is recommended that this work is extended to standardise licensing and qualification requirements for RPAS. A similar approvals process should also be considered for the Operating Organisation.
- Requirements for a (European-wide) RPAS pilot license for operation in non-segregated airspace should include knowledge on air law, operational procedures, meteorology and communications as well as a practical assessment of RPAS operation skills and communication with ATC (as appropriate for the type of airspace).
- It is recommended that ICAO develop additional RPAS specific phraseology for ATC communications, e.g. a dedicated suffix to the call sign for awareness or the coordination of contingency procedures.
- RPAS operating characteristics should be compatible with those of the aerodrome in order to maintain runway capacity at realistic levels. High performance RPAS operations could be integrated into busier medium size airports, lower performance RPAS could be operated from aerodromes with lower traffic levels or with traffic operating at similar speeds. Investigate the potential need for RPAS-specific departure and arrival procedures for operations from and into airports and within controlled (terminal) airspace to exploit RPAS performance characteristics and to minimise the impact on capacity.

9 References

9.1 Applicable Documents

None

9.2 Reference Documents

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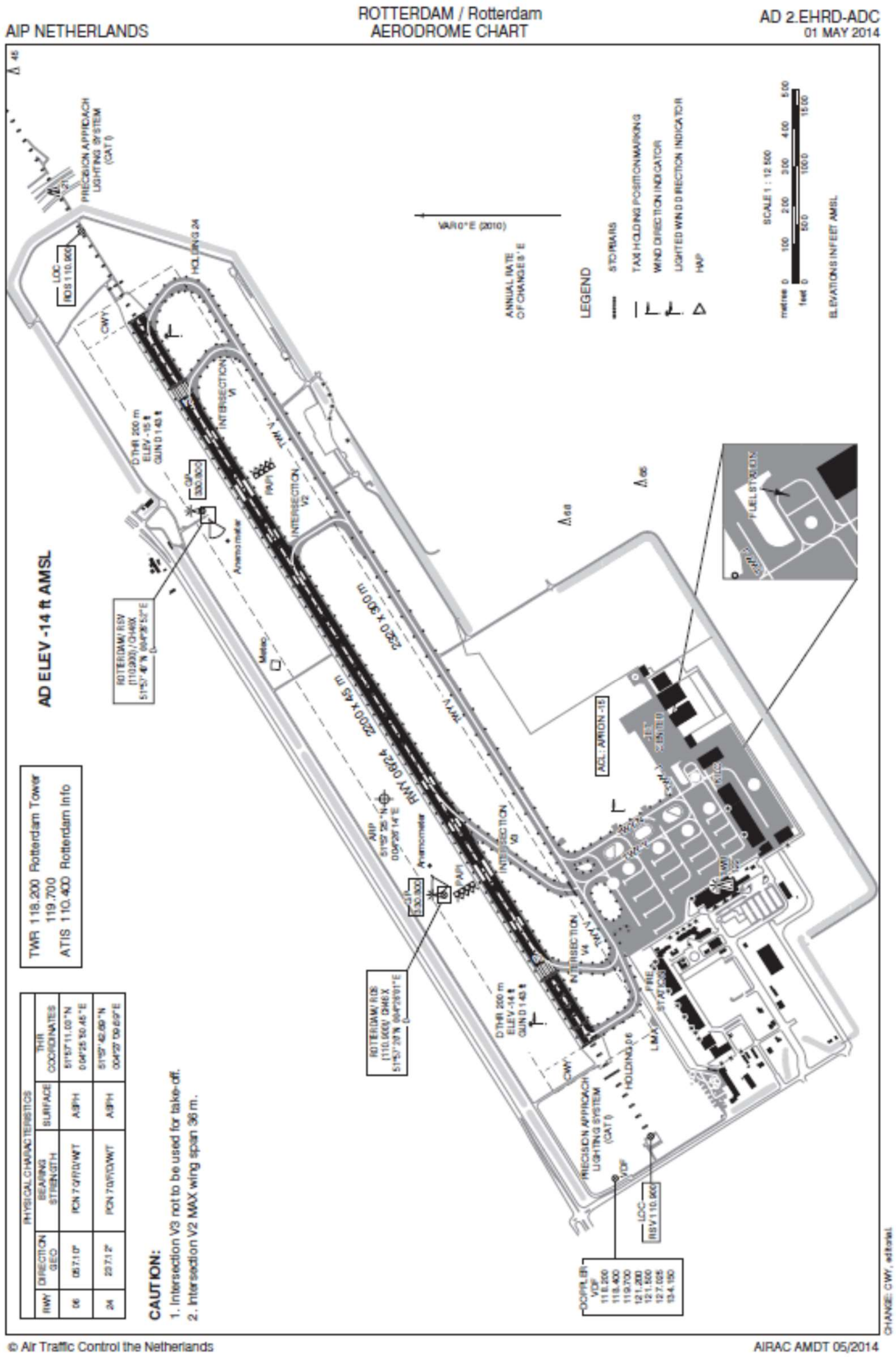
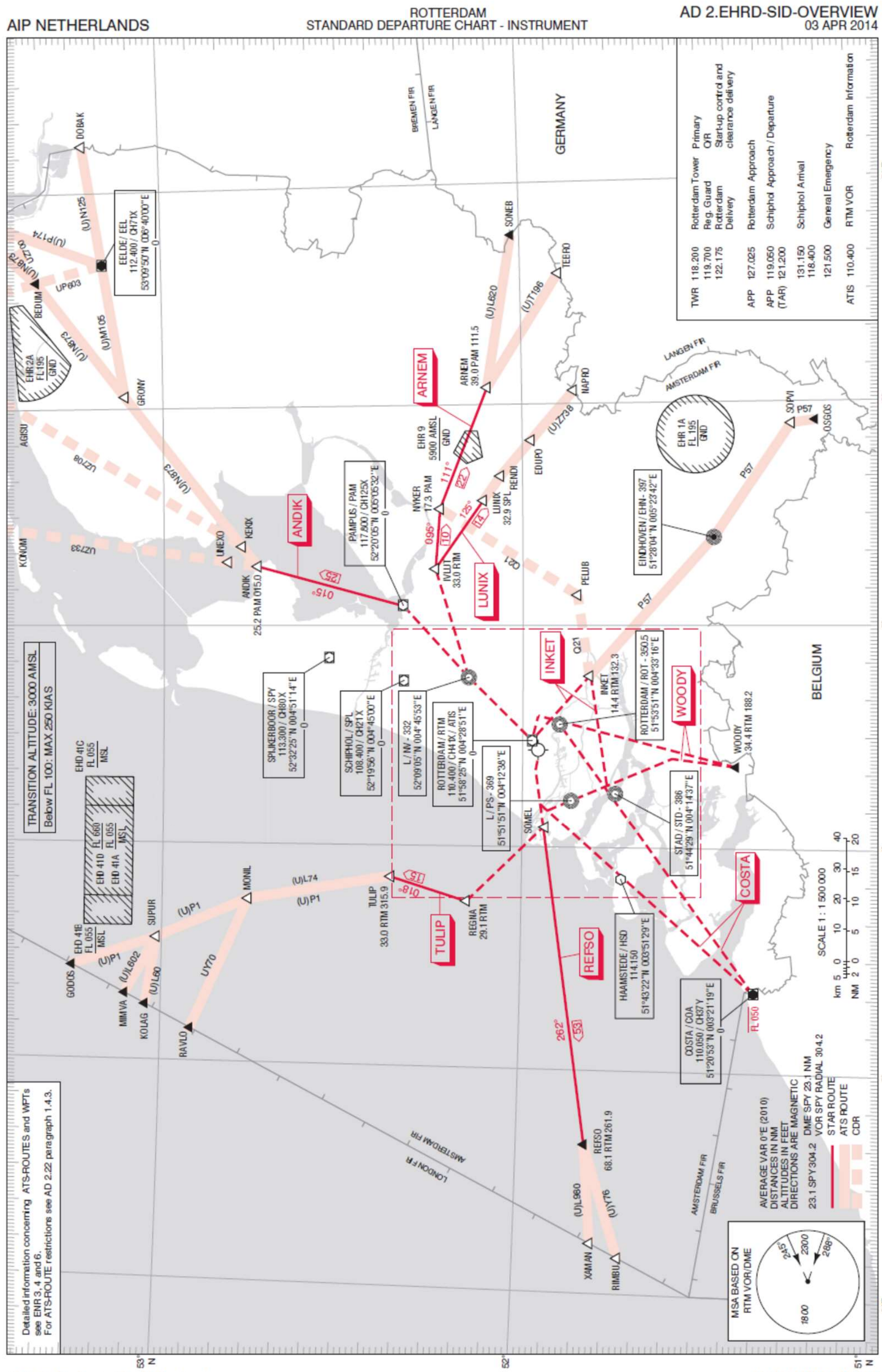
Appendix A Charts related to Exercise EXE-RPAS07-001

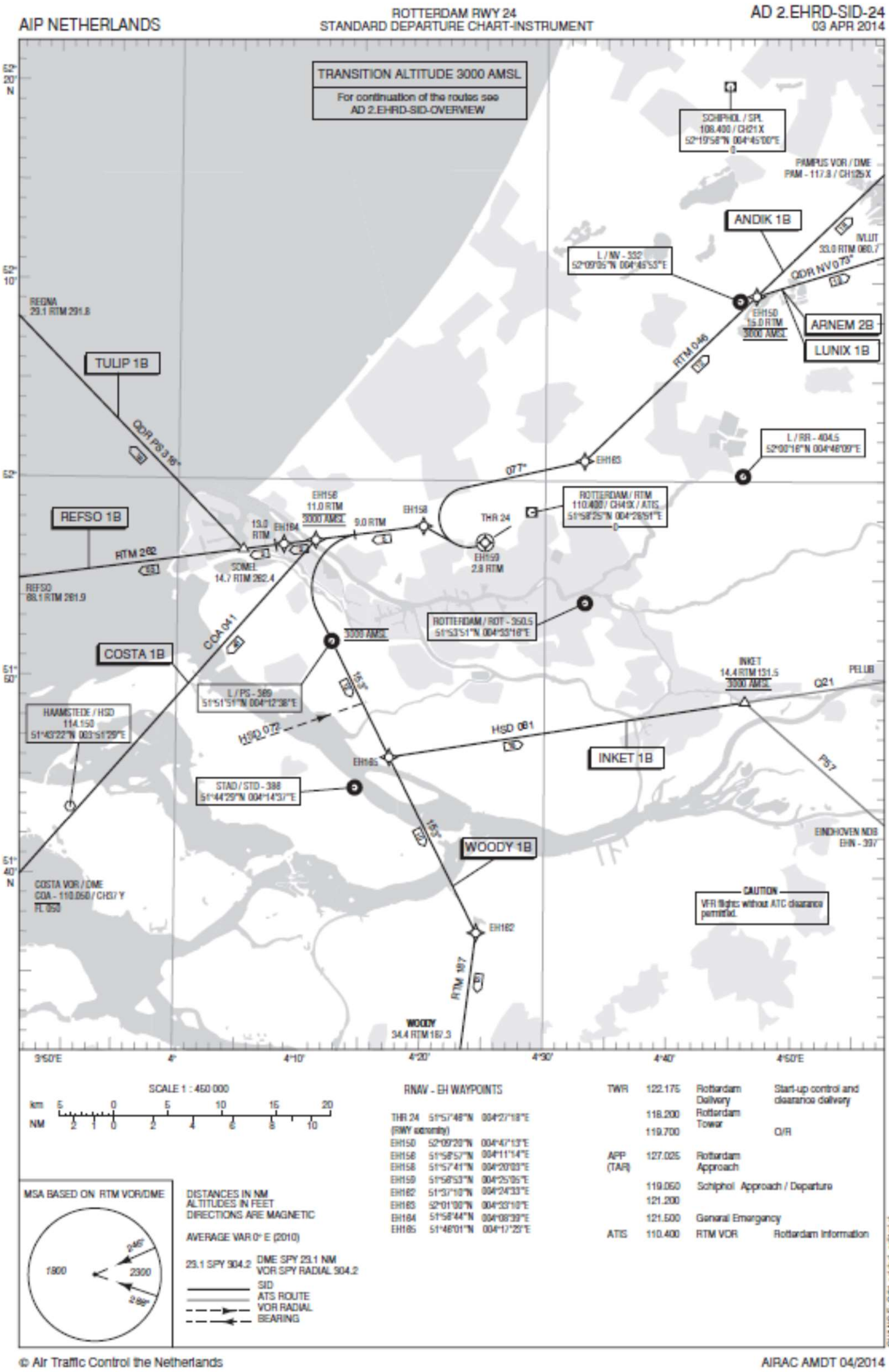
A.1 Aerodrome Chart



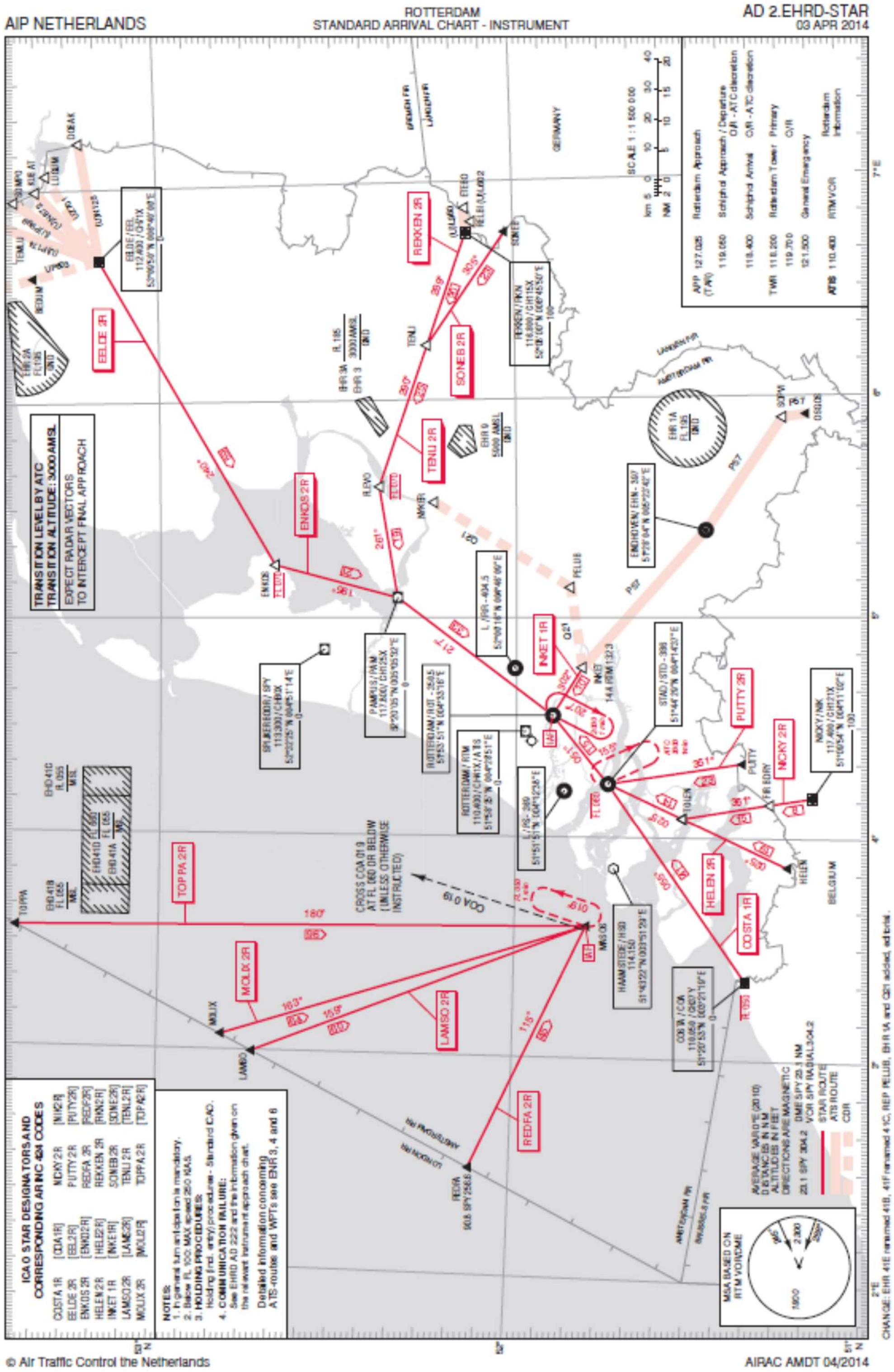
A.2 EHRD SID Overview



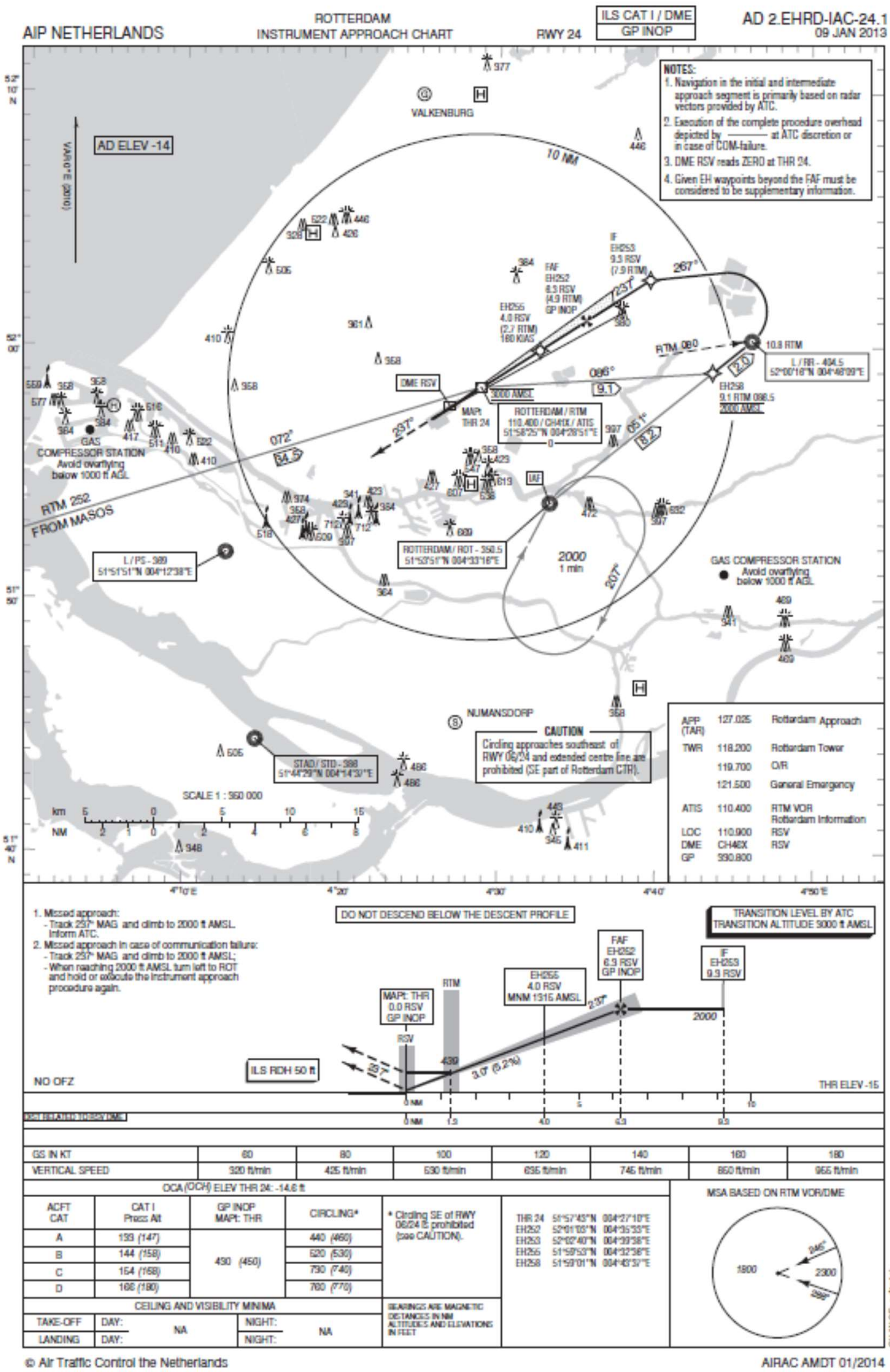
A.3 EHRD SID-24



A.4 EHRD STAR Chart

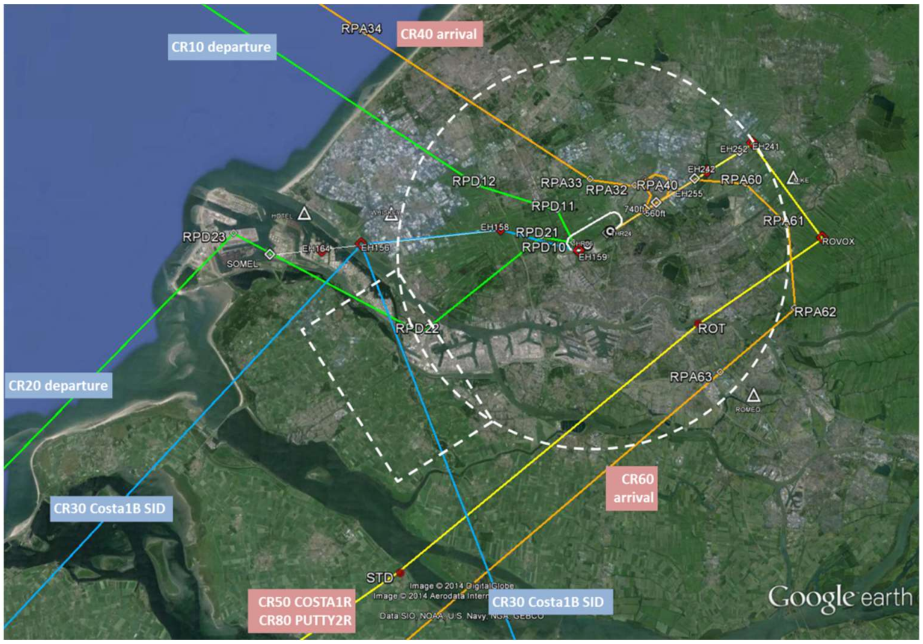


A.5 Instrument Approach Chart RWY 24



A.6 EHRD Visual Approach Charts Approach Chart RWY 24

A.7 RPAS Concept Arrival & Departure Routes



Appendix B Aeronautical Information Circular

AERONAUTICAL INFORMATION CIRCULAR Y 011/2015

UNITED KINGDOM

NATS Services
UK Aeronautical Information Services
Heathrow House
Bath Road, Cranford
Middlesex, TW5 9AT
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http://www.ais.org.uk
020-7453 6584 (Content - SARG/Airspace Regulation)
0191-203 2329 (Distribution - Communisis UK)

Date Of Publication
19 March 2015

Subject
Operational

TEMPORARY DANGER AREAS (TDA) – PROJECT CLAIRE

1 Introduction

1.1 A series of 5 Temporary Danger Areas (TDAs) will be established in South Wales (beneath Airway L9 and in the vicinity of the Cardiff CTA/CTR) to support Project CLAIRE during April and May 2015.

1.2 Project CLAIRE (**C**ivi**L** **A**irspace **I**ntegration of **R**PAS in **E**urope) is part of a 24-month SESAR Joint Undertaking programme aimed at exploring the issues associated with the operation of Remotely Piloted Aircraft Systems (RPAS) within a non-segregated mixed traffic environment. The project is co-sponsored by Thales UK Ltd, NATS (En Route) Plc and the Netherlands National Aerospace Laboratory (NLR).

1.3 Following extensive simulation and the compilation of a Trials Risk Assessment, a Thales Watchkeeper WK450 is scheduled to conduct 3 separate flights each departing West Wales Airport (WWA) within existing segregated airspace before transiting Class A and D Controlled Airspace (CAS).

1.4 In order to mitigate the risk of flight within Class G Uncontrolled Airspace should it encounter an emergency, a series of TDAs have been designed to allow the aircraft to vacate CAS and recover to one of 5 Emergency Recovery Points (ERP). The ERPs lie over the sea or within existing Danger Areas.

2 Timing

2.1 To avoid potential cancellation of the flights in the event of poor weather, specific dates have not been selected. Activation will be via NOTAM with at least 72 hours notice. The following weeks have been nominated:

- **Route X-Ray** – week commencing **20 April 2015**
- **Route Yankee** – week commencing **27 April 2015**
- **Route Zulu** – week commencing **18 May 2015**

2.2 Rescheduling of these dates by the Sponsor will be permitted provided at least 72 hours notice is given to allow for re-issuing of NOTAMs.

2.3 TDA activation is dependent on the flight profile. Only those TDAs required for each route will be activated.

2.4 **Route X-Ray.** TDA EG D198A will be activated for approximately 50 minutes.

2.5 **Route Yankee.** TDA EG D198B will be activated for approximately 1 hour 10 minutes.

2.6 **Route Zulu.** TDAs EG D198B, D198C, D198D and D198E will be activated for approximately 3 hours.

3 Temporary Danger Areas (TDAs)

3.1 TDAs EG D198A-E will be established by NOTAM and are detailed in the following table. They will be contiguous with existing Controlled Airspace and Danger Areas as depicted in Figures 1 and 2 below.

Identification and Lateral Limits	**Upper Limit Lower Limit**	**Remarks**
1	2	**3**
EG D198A FISHGUARD 521100N 0054700W - 521100N 0045000W - 515500N 0045000W - 515500N 0054700W - 521100N 0054700W	Upper limit: FL 145 Lower limit: FL 95	**Activity:** Unmanned Aircraft Operations **Hours:** When notified. **Service:** DAAIS/DACS: Aberporth on 119.650 MHz.
EG D198B CARMARTHEN 521200N 0051300W - 515950N 0033520W - 515157N 0033720W - 514210N 0034118W - 515700N 0051826W - 521200N 0051300W	Upper limit: FL 145 Lower limit: FL 85	**Activity:** Unmanned Aircraft Operations **Hours:** When notified. **Service:** DAAIS/DACS: Aberporth on 119.650 MHz.
EG D198C BATTLE 520500N 0033412W - 520500N 0032218W - 514952N 0032403W - 515157N 0033720W - 520500N 0033412W	Upper limit: FL 145 Lower limit: FL 85	**Activity:** Unmanned Aircraft Operations **Hours:** When notified. **Service:** DAAIS/DACS: Aberporth on 119.650 MHz.
EG D198D SOUTHERNDOWN A circle, 2 nm radius centred at 512600N 0033600W	Upper limit: 2000 ft ALT Lower limit: SFC	**Activity:** Unmanned Aircraft Operations **Hours:** When notified. Service: DAAIS/DACS: Cardiff on 125.850 MHz.
EG D198E PORTHCAWL 514210N 0034118W - 513932N 0032455W - 512320N 0033934W - 512810N 0034720W - 514210N 0034118W	Upper limit: FL 145 Lower limit: FL 85	**Activity:** Unmanned Aircraft Operations **Hours:** When notified. **Service:** DAAIS/DACS: Cardiff on 125.850 MHz.

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4 Flight Profiles and Controlling Authorities

4.1 The trial is designed for Watchkeeper to fly along the base of Airway L9 at FL 150 under the direction of LAC (Swanwick) or NATS Cardiff (east of AMMAN) for both Routes X-Ray and Yankee. Once outside CAS, control will be via NATS Aberporth together with local ATC at WWA.

4.2 The same arrangements are in place for Route Zulu with further control via NATS Cardiff for flight with their delegated airspace, CTA and CTR. The minimum altitude within Cardiff's airspace is planned to be 9000 ft ALT at the CDF NDB.

4.3 Figures 1 and 2 provide an overview of the trial routes together with the lateral and vertical extents of the TDAs.

Fig 1 - Routes X-Ray and Yankee

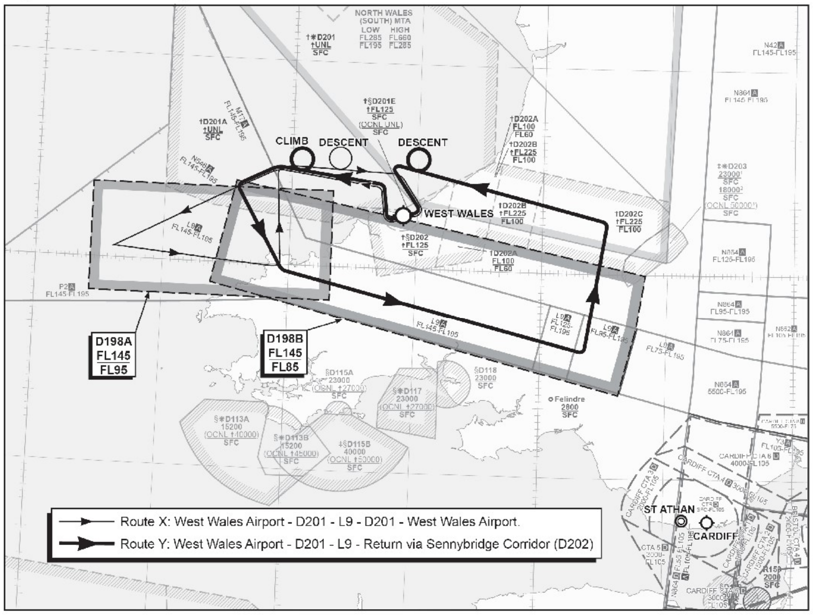
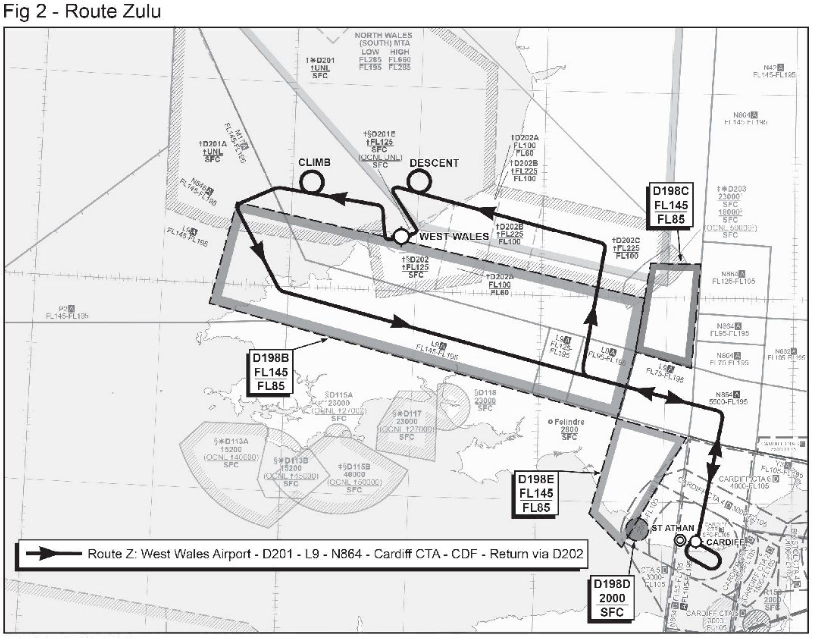


Fig 2 - Route Zulu



2015 30 Project Claire TDA 10 FEB 15

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5 Sponsor

5.1 Enquiries relating to the Project CLAIRE should be directed to:

Emma Bell
Programme Manager
Thales UK Ltd
Defence Mission Systems (DMS)
Manor Royal
Crawley
West Sussex
RH10 9HA

Tel: 01293-587510

6 Publications

6.1 These airspace arrangements are temporary. No other publications are affected and no changes will be made to either civil or military VFR or En-Route charts.

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-END OF DOCUMENT-