Beschreibung der Validierungsumsetzung

ADELE

Ergebnis [E5.1] Beschreibung der Validierungsumsetzung | 1.0

ÄNDERUNGEN

VERSION	DATUM	GEÄNDERTE ABSCHNITTE	ÄNDERUNGSGRUND	AUTOR(EN)
0.1	15.03.2025	Sämtliche Abschnitte	Neues Dokument	J. Ziegler (FRQ) P. Cornelius (FRQ)
0.2	04.06.2025	Stark erweiterte Detailbeschreibungen der Übungen in den Unterabschnitten in Plan der agilen technischen Integration(see page 23) und Plan der technischen Integration(see page 28) inkl. neuem Abschnitt im Anhang mit den Testskripten zur technischen Integration, entsprechende Anpassungen in Unterabschnitten in KoPa 45 - ADELE - VALP - Plan der Einsatzübung(see page 44), entsprechende redaktionelle Anpassungen im Abschnitt Liste der Übungen zur technologischen Validierung(see page 20).	Dokumentation der Planung und Vorbereitung der Einsatzübung	P. Cornelius (FRQ)
0.3	27.06.2025	Einführung(see page 10), Dokumentenvorlage, Kontext des technologischen Validierungsplanes(see page 12), Technologischer Validierungsplan(see page 19), Übungen zur technologischen Validierung(see page 23)	Einarbeitung der Kommentare aus Review 115462, Anpassung Logo und Nennungen des BMI, Präzisierungen in der Wortwahl.	P. Cornelius (FRQ)
0.4	19.11.2025	Inhaltliche Erweiterungen und Korrekturen in sämtlichen Unterabschnitten zum Plan der Einsatzübung(see page 44), neuer Anhang mit Details zur Beantragung der Betriebsgenehmigung(see page 99), neue Review-Checkliste(see page 278), Schreibfehler in der Liste der Übungen zur technologischen Validierung(see page 20).	Vervollständigung aller unferrtigen Abschnitte und Abschluß der Formalisierung der Vorgehensweisen, neue Reviewcheckliste im Anhang, Korrektur von Schreibfehlern.	P.Cornelius (FRQ)
1.0	18.12.2025	Korrekturen in den Abschnitten über die Validierungsplattform, -werkzeug und Validierungstechnik der agilen technische	Einarbeitung der Kommentare und Korrekturen aus Review 121031 und dem Konsortialreview,	P.Cornelius (FRQ)

VERSION	DATUM	GEÄNDERTE ABSCHNITTE	ÄNDERUNGSGRUND	AUTOR(EN)
		Integration(see page 24), der technischen Integration und der Einsatzübung(see page 48), im Abschnitt zur Beschreibung und Umfang(see page 44) sowie der Planung und Management der Einsatzübung(see page 51), fehlenden Anhang für die Testskripte für die Validierungsübung zur Einsatzübung(see page 87) ergänzt, Abschnitt Operations_Manual_FL_v1.0 aus dem Anhang mit den Details zur Betriebsgenehmigung(see page 99) entfernt, Korrektur von Schreibfehler in den Abschnitten Schlüsselanforderungen an Forschung und Entwicklung(see page 14), Beschreibung und Umfang der agilen technischen Integration(see page 23) und Planung und Management der Übung (agile technische Integration)(see page 26).	Operations_Manual_FL_v1.0 bildet die Liefergegenstände [E2.5] und [E2.6] und muss hier daher nicht mehr reproduziert werden.	

Gesamtanzahl Seiten: 279

Aktuellste Version genehmigt von: KOHLMAIER Petra

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Bundesministerium des Innern

Bundesanstalt für den Digitalfunk der Behörden und Organisationen mit Sicherheitsaufgaben

aufgrund eines Beschlusses des Deutschen Bundestages

Das diesem Dokument zugrunde liegende Vorhaben wurde mit Mitteln des Bundesministerium des Innern, vertreten durch die Bundesanstalt für den Digitalfunk der Behörden und Organisationen mit Sicherheitsaufgaben, unter dem Förderkennzeichen 16BEC0034K gefördert. Die Verantwortung für den Inhalt liegt bei den Autoren.

Für das

PROJEKT: ADELE
KONSORTIUM: Deutsches Zentrum für Luft- und Raumfahrt (DLR); FREQUENTIS DEUTSCHLAND GmbH; ELARA Leitstellentechnik GmbH; Vodafone Group Service GmbH; Landesamt für zentrale Aufgaben und Technik der Polizei, Brand- und Katastrophenschutz Mecklenburg-Vorpommern, Abt.2 / Dezernat 230 IuK; Hanse- und Universitätsstadt Rostock, Amt für Brandschutz, Rettungsdienst und Katastrophenschutz, Abteilung Abwehrender Brand und Katastrophenschutz 37.2
PROGRAMM: KoPa_45 (BDBOS)

Erstellt von:

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INHALT

ABBILDUNGEN

TABELLEN

1 Einführung

1.1 Projektname und Akronym

Automatisierter **D**rohnen**E**insatz aus der **L**eitstell**E** (ADELE)

1.2 Zusammenfassung

Das vorliegende Dokument enthält die Beschreibung der Validierungsumsetzung (Validierungsplan, VALP) für das Projekt **A**utomatisierter **D**rohnen**E**insatz aus der **L**eitstell**E** (ADELE).

1.3 Einführung

1.3.1 Zweck des Dokumentes

Anforderungen zum Projekt entstehen aus den technischen, gesetzlichen und operativen Rahmenbedingungen der beteiligten BOS.

Das vorliegende Dokument beschreibt die Validierung eines automatisierten Drohnenentsendungssystems und bildet den Liefergegenstand E5.1 für das BDBOS KoPa45 Projekt „**A**utomatisierter **D**rohnen**E**insatz aus der **L**eitstell**E** (ADELE)“.

1.3.2 Zielgruppe

Die Beschreibung der Validierungsumsetzung richtet sich an alle, die an der Entwicklung, Implementierung und Nutzung des Projekts ADELE beteiligt sind. Es dient als Basis für die Durchführung der Validierungsübung im Rahmen des Projektes. Folgende Zielgruppen werden adressiert:

1.3.2.1 Konsortialführer und (Technische-) Projektleiter

Verantwortlich für die Planung, Durchführung und Überwachung des Projektes (Gesamt- und Teilverantwortung).
Nutzung: Verwendung des Dokuments zur Verifizierung der Projektziele und Meilensteine.

1.3.2.2 Entwicklungsteams (Softwareentwickler, Softwarearchitekten, UI-Designer)

Direkt an der Erstellung und Implementierung der Gesamtlösung beteiligte Personen
Nutzung: Das Dokument bietet die Grundlage für ein Verifizieren der Spezifikation und Implementierung der funktionalen und nicht-funktionalen technischen Anforderungen.

1.3.2.3 Qualitätssicherungsteams (Tester)

Verantwortlich für die Überprüfung und Sicherstellung, dass die entwickelten Systemkomponenten und die Gesamtlösung den Anforderungen entsprechen.
Nutzung: Grundlage für die Durchführung und Vorbereitung der finalen Systemtests.

1.3.2.4 Operative Endnutzer

Bedarfsträger, die die entwickelte Gesamtlösung für den automatisierten Drohneneinsatz nutzen werden.
Nutzung: Nutzung der Inhalte des Dokuments zur Sicherstellung, dass ihre Bedürfnisse und Erwartungen korrekt erfasst und umgesetzt wurden.

1.3.2.5 Nutzerseitige Entscheidungsträger

Übergeordnete Behörde für die strategische Bewertung der Projektergebnisse und zuständig für die Bewertung des Systems als Einsatzmittel(-ergänzung).
Nutzung: Überblick über das Validierungsszenario, Anforderungen und erwarteten Ergebnisse, um zukünftige Investitionen für die Einführung der Technologie als Einsatzmittel zu rechtfertigen und strategische Entscheidungen zu unterstützen.

1.3.2.6 Projektträger (VDI_VDE)

Organisation, die das Projekt finanziert und fördert.
Nutzung: Nutzung des Dokuments zur Überwachung des Projektfortschritts und zur Sicherstellung, dass die bereitgestellten Mittel ordnungsgemäß verwendet und die Projektziele erreicht werden. Sie benötigen Einblick in die Durchführung der Validierungsaktivitäten, um die Effektivität und den Erfolg des Projekts unter Gegenüberstellung der förderpolitischen Ziele bewerten zu können.

1.3.3 Hintergrund

Das Projekt **A**utomatisierter **D**rohnen**E**insatz aus der **L**eitstell**E** (ADELE) ist ein durch die Bundesanstalt für den Digitalfunk der Behörden und Organisationen mit Sicherheitsaufgaben (BDBOS) im Rahmen des 45. Elementes des Konjunkturpakets „Corona-Folgen bekämpfen, Wohlstand sichern, Zukunftsfähigkeit stärken“ gefördertes Projekt, das eine technische Umsetzung eines Konzeptes zum automatisierten Einsatz von Drohnen als disponierbares Einsatzmittel aus der Leitstelle demonstrieren soll.

Das diesem Dokument zugrunde liegende Vorhaben wurde mit Mitteln des Bundesministeriums des Innern, vertreten durch die Bundesanstalt für den Digitalfunk der Behörden und Organisationen mit Sicherheitsaufgaben unter dem Förderkennzeichen 16BEC0034K gefördert. Die Verantwortung für den Inhalt dieser Veröffentlichung liegt bei den Autoren.

1.3.4 Aufbau des Dokuments

Dieses Dokument enthält – nach den einleitenden Abschnitten – eine detaillierte Darstellung des Projektkontexts sowie eine Beschreibung der Umsetzung der Validierung.

2 Kontext der technologischen Validierung

2.1 Kontext des technologischen Validierungsplanes

2.1.1 Globaler Forschungs- und Förderkontext

Die Bundesanstalt für den Digitalfunk der Behörden und Organisationen mit Sicherheitsaufgaben (BDBOS) hat aus dem 45. Element des Konjunkturpakets „Corona-Folgen bekämpfen, Wohlstand sichern, Zukunftsfähigkeit stärken" Mittel zugewiesen bekommen, um die Wirtschaft im Aufgabenbereich der BDBOS gezielt zu fördern. Die BDBOS hat im Rahmen des eigens eingerichteten BDBOS-Projektes KoPa_45 ein Förderprogramm aufgesetzt, um diese Mittel in Innovationen für den breitbandigen Digitalfunk BOS zu investieren. Auf diese Weise sollen zum einen die Vorteile der Mobilfunkstandards 5G und perspektivisch 6G für einsatzkritische Kommunikationsnetze nutzbar gemacht werden. Zum anderen soll im Rahmen des BDBOS-Projektes grundsätzlich erforscht werden, wie Edge- und Cloud-Technologien im einsatzkritischen Bereich sinnvoll genutzt werden können.

Die BDBOS hat im Rahmen dieses Förderprogrammes mehrere Fördervorhaben aufgesetzt, die einerseits die netzwerkseitige Implementation von missionskritischen Kommunikationsdiensten (mission-critical services, MCX) in die be- und entstehenden 5G- und perspektivisch auch 6G-Netze gefördert voran treibt, sowie wichtige Dienste für die Behörden und Organisationen mit Sicherheitsaufgaben (BOS) implementiert, die diese Netzwerkinfrastruktur in ihrer Umsetzung benötigen. Das Förderprojekt „Automatisierter DrohnenEinsatz aus der LeitstellE" (ADELE) ist eines der KoPa_45-Fördervorhaben, das einen hochkomplexen Anwendungsfall für breitbandigen Digitalfunk untersucht, der auf missionskritischen Kommunikationsdiensten aufbaut und diese notwendigerweise für seine Funktion benötigt. Es läuft aufgrund seines erwarteten hohen Nutzens bereits parallel zur Entwicklung der MCX, obwohl diese noch gar nicht vollständig zur Verfügung stehen.

2.1.2 Kontext des Gesamtvorhabens „Automatisierter DrohnenEinsatz aus der LeitstellE" (ADELE)

Die Bedeutung von zuverlässiger, sicherer und schnellerer Ende-zu-Ende (E2E) Verfügbarkeit von (multimedialen) Inhalten ohne Medienbrüche für einsatzkritische Zwecke für Überwachungs- und Erkundungsaufgaben zur Unterstützung der Aufgaben von Behörden und Organisationen mit Sicherheitsaufgaben (BOS) steigt stetig an. Zusätzlich existiert im Bereich BOS die Forderung nach frühzeitiger Erkundung von Einsatzlagen, die derzeit immer davon abhängig ist, wie schnell eine Einsatzkraft vor Ort ist. Im städtischen Gebiet dauert dies typischerweise zwischen 5-10 Minuten. Gerade im ländlichen Bereich oder im Bereich der Autobahnen ist die Erkundung zum Erkennen von notwendigen Nachforderungen entscheidend, um Einsatzpersonal der Lage entsprechend quantitativ und qualitativ zielgerichtet einzusetzen. Ein zukünftiger automatisierter Drohneneinsatz und die zuverlässige Einbindung der (multimedialen) Inhalte als potenzielle Ablöse des Hubschraubers unterliegen dabei besonderen europäischen sowie nationalen (gesetzlichen) Rahmenbedingungen.

Obwohl BOS grundsätzlich von Betriebsverboten und Genehmigungsprozessen für Drohneneinsätze außerhalb der Sichtweite des Drohnenpiloten (Beyond Visual Line Of Sight – BVLOS) ausgenommen sind, sollte eine generelle sowie eine einsatzbezogene Risikobewertung vorgenommen werden. Dazu gehört im Besonderen die Analyse von Wetterbedingungen, weiterer Luftfahrzeuge im Luftraum über dem Einsatzgebiet, besondere luftfahrtrechtliche Rahmenbedingungen (Flugbeschränkungsgebiete und Kontrollzonen etc.) sowie die Bedingungen im Einsatzraum und Gefahren für Dritte. Abgeleitet vom Bedarf und den rechtlichen Rahmenbedingungen und Empfehlungen ergibt sich daraus die Forderung, eine vollautomatisierte und digitalisierte Drohnennutzung zu ermöglichen, in der der Anwender nur noch eine überwachende Funktion übernimmt, und gleichzeitig eine höchstmögliche Sicherheit und Risikominimierung für eigene Einsatzkräfte sowie Dritter gewährleistet wird.

2.1.3 Zielsetzung ADELE

Die Zielsetzung des Projektes ADELE ist daher die Durchführung von spezifischen vorwettwerblichen Entwicklungen von Machbarkeitsstudien sowie einer Technologiedemonstration, welche teilweise auf bestehenden Produkten basiert. Des Weiteren werden Anwendertests durchgeführt, bei denen die skizzierten, zukünftigen Technologien für den breitbandigen Digitalfunk in deren operativen Prozess integriert werden, um die Fähigkeitserweiterung (MCX für Drohnensteuerung) und neue Leitstellenfunktionalität (MCX für Medienübertragung) unter Verwendung des breitbandigen Digitalfunk operativ zu evaluieren. Eine interoperable und modulare Systemarchitektur, sowie einsatzkritische Breitbanddienste stellen eine durchgängige E2E Übertragung von einsatzunterstützenden Videostreams sicher und ermöglichen die gemeinsame Kommunikation aller Kräfte sowie organisationsübergreifende Nutzung der Drohnentechnologie und der (multimedialen) Inhalte. Ferner soll der Einsatz von Drohnen möglichst wartungsarm 24/7 betrieben werden können und insbesondere Datenschutzrechtliche sowie notwendige Sicherheitsstandards in Bezug auf das Gesamtsystem sowie der Datenübertragung berücksichtigen.

Einen Erfolg dieses Projekts liefern die Verbundpartner mit dem Nachweis der Machbarkeit eines vollautomatisierten und organisationsübergreifenden Drohneneinsatzes basierend auf einem verteilten System mit voller Leitstellenintegration (End-2-End Lösung) und einer wesentlichen Verbesserung der Leistungskennzahlen im Rahmen der Überwachungs- und Erkundungsaufgaben. Das Gesamtsystem der Verbundpartner ergibt sich aus den folgenden Systemkomponenten:

- Flugsteuerung und „fliegende Endstelle“ sowie Systemmodul zur Risikobewertung (DLR)
- Leitstellenkommunikationslösung und Bereitstellung verschiedener Drohnen-Services zur Erhöhung der Betriebssicherheit (Frequentis)
- Systemmodul zur Bereitstellung von „3D Connectivity Daten“ und dynamischer Bevölkerungsdichte (Vodafone)

Die folgende Abbildung(see figure 1) vergleicht die aktuelle und zukünftige von ADELE genutzte Prozesskette der Informationsgewinnung für die Leitstelle.

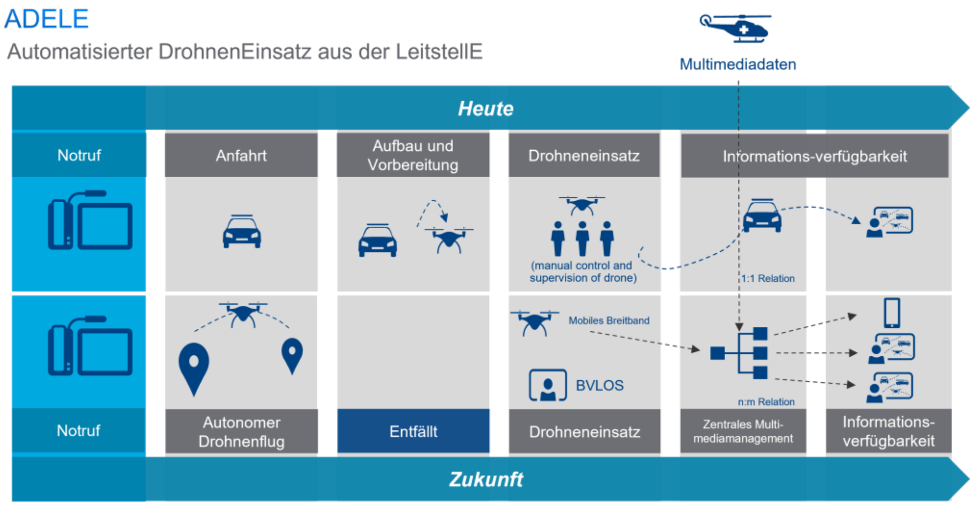

Abbildung 1 Schnellere Informationsverfügbarkeit durch automatisierten Drohneneinsatz aus der Leitstelle

Für die Nutzervertreter schließt sich die Lücke bei der Automatisierung von Drohneneinsätzen. Hierbei kann eine signifikante Zeitersparnis erreicht werden. Das praktische Erproben von drohnenspezifischen Anwendungsfällen und deren Ergebnisse dienen den Nutzervertretern als Grundlage zur Erhebung weiterer Anforderungen an den breitbandigen Digitalfunk. Daraus können in weiterer Folge konkrete Produkte und Dienstleistungen für BOS entwickelt und angeboten werden.

2.2 Forschungsfragen des Bundes im Projektkontext

Adressierte Forschungsfragen gemäß Bundesanzeiger [AF-BA], veröffentlicht am Mittwoch, 16. August 2023, BAnz AT 16.08.2023 B1, Schwerpunkt Interessengebiet 4 – Leitstellen, Smart Devices und sonstige Endgeräte		
Nr.	Forschungsfrage [AF-BA]	Beitrag des Projekts zur Forschungsfrage
#1	Wie kann ein Roboter oder eine Drohne remote über 5G ohne direkte Sichtverbindung zum Operator gesteuert werden und Sensordaten (z. B. einen zweiten, nicht für die Steuerung benötigten Videostream) in Echtzeit an eine mobile oder feste Einsatzleitstelle übertragen?	Für das komplexe Szenario für den automatisierten Drohneneinsatz über 5G ohne Sichtverbindung, sind technische Herausforderungen zu bewältigen. Die „fliegende Endstelle“ wird mit einer hochauflösenden Sensorik und einem 5G-Modem ausgestattet. Die Gewährleistung der zeitigen und korrekten Übertragung der Steuerbefehle wird über ein 5G-Netz sichergestellt. Echtzeit-Sensordatenübertragung wird über eine priorisierte SIM-Karte und MCX-Services sichergestellt. Der Einsatzradius der Drohne, die aus einem zentralen Hangar-System operiert, wird 4-8 Kilometer betragen. Das Flugplanungs- und Einsatzführungsservice beinhaltet eine Echtzeitbewertung des

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		Bodenrisikos unter Berücksichtigung von „Mobility Daten“ und der Luftraumstruktur. MCX-Services verhindern Datenverluste des 5G Netzwerks und stellen den datenschutzrechtlichen Zugriff von (multimedialen) Inhalten sicher. Nationale und europäische regulatorische Aspekte und Leitlinien werden erarbeitet und berücksichtigt.
#2	Was können Anforderungen an ein Sicherheitskonzept für den Einsatz von Robotern und Drohnen in kritischen Kommunikationsnetzen auf der Basis von LTE/5G unter Berücksichtigung der Anforderung, dass sowohl die Steuerung der Roboter und Drohnen selbst als auch die von zusätzlichen Sensoren zu übertragenden Echtzeitdaten zu schützen sind, sein?	In sicherheitskritischen LTE/5G-Kommunikationsnetzen für Drohnen sind technisch implementierte Interoperabilität und Standardisierung sowie ein operatives Betriebskonzept von zentraler Bedeutung. Im Rahmen des Projektes werden einheitliche Kommunikationsprotokolle und Standards sowie eingebettet MCX-Services entwickelt, die eine nahtlose Integration von Steuerungs- und Sensorkomponenten verschiedener Geräte und Hersteller in die Infrastruktur gewährleisten, während standardisierte Sicherheitsprotokolle ein kohärentes Sicherheitsniveau darstellen. Die Test- und Validierungsmethoden werden entwickelt, um die Konformität zu überprüfen, begleitet von klaren Richtlinien und Dokumentation. Die nationalen und europäischen rechtlichen Rahmenbedingungen werden kontinuierlich überwacht und fließen zusätzlich in das Sicherheitskonzept ein.
#3	Wie kann eine Freund-/Feind Erkennung für Drohnen und Methoden, um fremde Drohnen zu blockieren und ggf. unschädlich zu machen, ohne den Betrieb der eigenen Drohne zu gefährden, implementiert werden?	Basierend auf europäischen Regularien wird die Pflicht für eine technische Identifizierung von Drohnen (Remote ID) zeitnah in deutsches Recht überführt. Zusätzlich werden eine drohnengestützte Hinderniserkennung sowie systembasierte Negativ- und Positivlisten verarbeitet. Die bodengestützte Telemetrie-Verarbeitung wird in das Gesamtsystem implementiert. Anmerkung: Das Projekt adressiert das Blockieren und unschädlich machen von „Feind-Drohnen“ nicht.
#4	Wie kann ein DSGVO-konformes E2E Sicherheitskonzept von der Aufnahme bis hin zur Speicherung, Auswertung und letztendlichen Löschung von Bild- und Videodateien aussehen? Welche Unterschiede ergeben sich im Sicherheitskonzept zwischen einer Übertragung in Echtzeit (z. B. Streaming) und der Speicherung der Daten für eine spätere Nutzung und Auswertung?	Die DSGVO-konforme Sicherheit für Bild- und Videodateien erfordert eine sorgfältige Herangehensweise. Im ersten Schritt wird eine Datenschutz-Folgenabschätzung (DPIA) erstellt, um Risiken unter Berücksichtigung MCX spezifischer Services zu beschreiben, die sich aus der Speicherung, Auswertung, Darstellung und letztendlichen Löschung von Bild- und Videodateien ergeben. Folgend wird

Adressierte Forschungsfragen gemäß Bundesanzeiger [AF-BA], veröffentlicht am Mittwoch, 16. August 2023, BAnz AT 16.08.2023 B1, Schwerpunkt Interessengebiet 4 − Leitstellen, Smart Devices und sonstige Endgeräte		
		ein rechtkonformes Sicherheitskonzept erstellt, welches Nutzergruppen und Datenelemente berücksichtigt, die in einer E2E Verarbeitung Zugriff auf die Daten erhalten. Echtzeitübertragungen, wie Streaming, Priorisierung, Verschlüsselung und Zugangskontrolle werden über MCX-Services sichergestellt. Für die längerfristige Speicherung werden ein Datensicherheitskonzept sowie Löschrichtlinien definiert.
#5	Wie können innovative Leitstellenfunktionalitäten (z.B. Videoübertragung und -auswertung, Roboter- und Drohnensteuerung, Augmented Reality) in ein einsatzkritisches Breitbandnetz implementiert werden?	Im ersten Schritt werden die Anforderungen der Leitstelle, des Anwenderkreises sowie der rechtlichen Rahmenbedingungen ermittelt. Zusätzlich werden Anforderungen an eine zuverlässige Breitbandinfrastruktur unter der Einbettung spezifischer MCX-Dienste erfolgen. Daraus abgeleitet wird ein technisches Konzept zur Einbindung von Videoübertragung und -auswertung, der Drohnensteuerung sowie Augmented Reality Funktionen in das Leitstellensystem erarbeitet und umgesetzt. Über implementierte MCX-Dienste werden Sicherheitsmaßnahmen wie Verschlüsselung und Zugriffskontrollen, sowie Netzwerksicherheit und der Schutz sensibler Daten gewährleistet. Die Anwender werden umfassend auf die neuen Funktionen geschult, um diese in der Validierungsphase effektiv nutzen zu können.
#7	Wie können verschiedene Anschaltmethoden für Leitstellen sinnvoll als Rückfallebenen für einen Ausfall kombiniert eingesetzt werden?	Das für das Projekt verwendete Leitstellensystem kann mit eigenen Servern als auch Cloud-basiert verwendet werden. Durch die optionale Cloud-basierte Nutzung der Leitstellenfunktionen; und hier im speziellen der automatisierte Drohneneinsatz, wird die Infrastruktur für zusätzliche Redundanz und Skalierbarkeit getestet. Breitband-Mobilfunk-Backup: Neben der Priorisierung der verwendeten SIM-Karte für das „fliegende Endgerät“ bietet diese auch eine Roaming Funktionalität, die auf die Verfügbarkeit anderer Mobilfunkbetreiber zurückgreift.
#8	Wie können Leitstellen untereinander vernetzt werden und wie können untereinander Funktionen im Ausfall übernommen werden?	Im Projekt werden Leitstellen verschiedener BOS unter Verwendung von Mission Critical Services (MCS) untereinander vernetzt, um ein hochverfügbares und zuverlässiges Kommunikationsnetzwerk zwischen den

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#9	Wie können mobile Leit- oder Befehlsstellen mit der koordinierenden Leitstelle vernetzt werden?	Leitstellen sicherzustellen. Somit werden die Leitstellen mit Mission Critical Services (MCS)-Technologien ausgestattet, die einen sicheren und zuverlässigen Austausch (multimedialer) Inhalte sicherstellen. Dafür werden spezielle Kommunikationsprotokolle, Endgeräte und Infrastrukturen verwendet. Als darunterliegende Infrastruktur werden je nach Gegebenheit private Netzwerke, Glasfaserkabel oder drahtlose Verbindungen verwendet, und eine Redundanz berücksichtigt. Roaming und Interconnect stellt sicher, dass Leitstellen nahtlos zwischen verschiedenen Netzwerken "roamen" können. Dadurch wird die Kommunikation zwischen Leitstellen auch dann aufrechterhalten, wenn eine einzelne Leitstelle das Netzwerk verlässt und in ein anderes Netzwerk wechselt. Zusätzlich werden MC-Dienste zur intelligenten Lastverteilung implementiert, sodass die Kommunikationslast gleichmäßig auf verschiedene Leitstellen verteilt wird.
#10	Wie können mobile Endgeräte auf einsatzrelevante Daten im Einsatzleitsystem sicher zugreifen?	Um eine sichere Nutzung von mobilen Endgeräten zur Verbindung mit der Leitstelle unter Verwendung von MC-Services zu entwickeln, werden verschiedene Methoden evaluiert. • Virtual Private Network (VPN) • Authentifizierung und Autorisierung • Verschlüsselung und • Mobile Device Management (MDM)

Tabelle 1 Forschungsfragen gemäß Bundesanzeiger [AF-BA]

Forschungsfrage Nr.	**Technisches/ wissenschaftliches Ziel**	**Bezug zur Validierung**
#1 - #10	Ziel 1: Erfolgreiche Umsetzung des Projektvorhabens	Indirekter Bezug: Gesamtheit der Projektergebnisse

Forschungsfrage Nr.	Technisches/ wissenschaftliches Ziel	Bezug zur Validierung
#1 - #10	Ziel 2: Erstellung Anforderungskatalog	Indirekter Bezug: Separate Projektergebnisse: • [E2.1] Gesetzlicher Anforderungskatalog • [E2.2] Operationaler Anforderungskatalog • [E2.3] Technischer, funktionaler Anforderungskatalog • [E2.4] Technischer Nicht-funktionaler Anforderungskatalog
#1 - #3 & #5 - #10	Ziel 3: Erstellung Architekturbeschreibung	Indirekter Bezug: Separate Projektergebnisse: • [E3.1] Architektur- und Schnittstellenbeschreibung • [E3.2] Definierte Datenmodelle und Austauschformate
#1 - #3 & #5 - #10	Ziel 4: Entwicklung und Bereitstellung Demonstrator	Indirekter Bezug: Separates Projektergebnis: • [E4.1] Funktionaler Demonstrator
#1 - #3 & #5 - #10	Ziel 5: Validierung anhand anwenderspezifischer Flugtests	Direkter Bezug: Vorliegendes Projektergebnis, sowie die Dokumentation der Ergebnisse dessen: • [E5.1] Beschreibung der Validierungsumsetzung • [E5.2] Dokumentierte Validierungsergebnisse
#1 - #3 & #5 - #10	Ziel 6: Verwertung und Kommunikation der Ergebnisse	Indirekter Bezug: Separate Projektergebnisse: • [E6.1] Teilnahme an Fachmessen (z. B. PMRExpo): Vorstellung und Feedbackerhebung von breiten Nutzergruppen im Kontext BOS • [E6.2] Publikationen in der Fachpresse • [E6.3] Workshops mit Nutzervertretern und rechtsgebenden Institutionen

Tabelle 2 Wissenschaftliche und/ oder technologische Ziele im Projekt

3 Technologischer Validierungsplan

3.1 Ansatz der technologischen Validierung

Die Teilsysteme der technischen Projektteilnehmer (DLR, Vodafone, Frequentis) werden schrittweise zu einem integrierten Gesamtsystem zusammengeführt. Dabei wird agil und online gearbeitet, so dass fertig angepasste Teilkomponenten sofort integriert und im Systemverbund getestet und Fehler unmittelbar behoben und ihre Behebung nachgewiesen werden können.

Auf diese Weise entsteht zunächst ein online-integrierter Demonstrator. Sobald die Integration es zulässt, wird die technische Integration in einem realitätsnahen Feldtest beim DLR in Cochstedt geprüft. Dieser Test nutzt die bereits online bereitgestellten und geprüften Systemteile und baut auf diesen auf. Im Laufe dieser Übung auftretende Fehler werden sofort agil behoben, so dass zügig ein integrierter Demonstrator zur Verfügung steht, auf dessen Basis ein Feldtest unter Einsatzbedingungen durchgeführt werden kann.

In einer realitätsnahen Einsatzübung wird schlussendlich der integrierte Demonstrator unter Einsatzbedingungen validiert und die Erkenntnisse aus dieser Validierung im Validierungsbericht zusammengetragen.

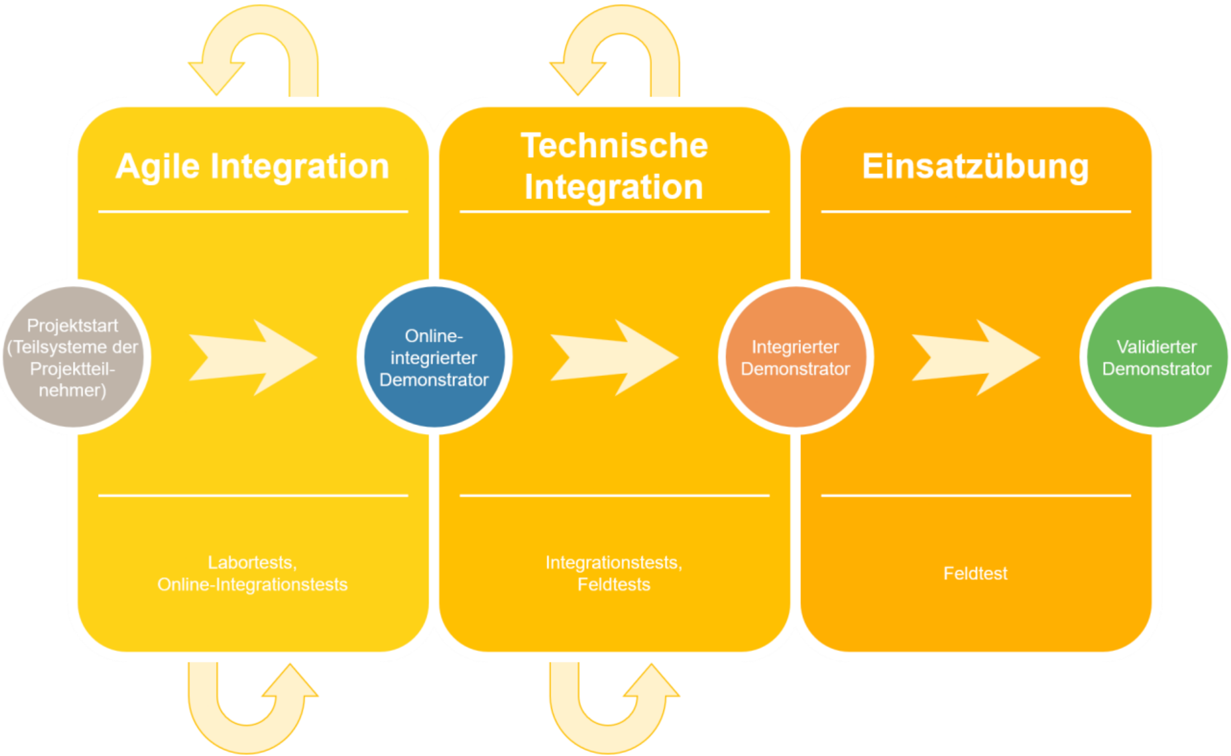

Abbildung 2 Ansatz der technologischen Validierung

Während der agilen Integrationsübung stehen Integrationstests auf Modul- bzw. Interface-Ebene zwischen zwei Systemteilen im Zentrum.

Während der technischen Integration wird die Funktionalität integrativ über Systemteile und schließlich das Gesamt-Demonstratorsystem geprüft.

Die Einsatzübung stellt die abschließende Ende-zu-Ende-Validierung des Gesamtsystems unter Einsatzbedingungen dar.

3.2 Erwartungen der Bedarfsträger und deren Einbeziehung

Die Erwartungen der Bedarfsträger und deren Einbeziehung wird, wo relevant, weiter unten, bezogen auf die jeweilige Übung, betrachtet.

3.3 Liste der Übungen zur technologischen Validierung

Kennung	TVAL-1-ADELE-KoPa_45
Titel	Agile technische Integration (online)
Beschreibung	Iterative agile technische Integration der Systemteile
Angesprochene(r) erwartete(r) Leistungsbeitrag(e)	Integration der Teilsysteme der Projektpartner zum Demonstrator (Projektergebnis [E4.1] Funktionaler Demonstrator)
T. Validierungstechnik	Labortests, Integrationstests
T.-Validierungsplattform	Integration der Teilsysteme: • Teilsystem UAS des DLR • Teilsystem Automated Drone Dispatch von Frequentis
T. Validierungsstandort	online
Datum des Beginns	01.12.2024
Datum des Endes	15.09.2025
Koordinator der Validierung	Frequentis
Status	<in Arbeit>
Abhängigkeiten	Eingangs: Projektbeginn Folgend: Integrierte Validierungsübung.

Tabelle 3 Validierungsübung: Agile technische Integration (online)

Kennung	TVAL-2-ADELE-KoPa_45
Titel	Technische Integrationstests
Beschreibung	Technische Integrationstests der Systemteile
Angesprochene(r) erwartete(r) Leistungsbeitrag(e)	Integration der Teilsysteme der Projektpartner zum Demonstrator (Projektergebnis [E4.1] Funktionaler Demonstrator)
T. Validierungstechnik	Integrationstests, Feldtests
T.-Validierungsplattform	Integriertes System der Teilsysteme: • Teilsystem UAS des DLR • Teilsystem Automated Drone Dispatch von Frequentis
T. Validierungsstandort	Cochstedt
Datum des Beginns	26.05.2025
Datum des Endes	28.05.2025
Koordinator der Validierung	DLR
Status	<abgeschlossen>
Abhängigkeiten	Eingangs: Vorintegration im Rahmen der fortlaufenden agilen technischen Integration Folgend: Einsatzübung.

Tabelle 4 Validierungsübung: Technische Integration

Kennung	TVAL-3-ADELE-KoPa_45
Titel	Einsatzübung
Beschreibung	Realistische Einsatzübung der Bedarfsträger mit Einsatz des Demonstrators.
Angesprochene(r) erwartete(r) Leistungsbeitrag(e)	Demonstration des integrierten Systems unter Einsatzbedingungen (Projektergebnis [E4.1] Funktionaler Demonstrator)
T. Validierungstechnik	Demonstration/Feldtest
T.-Validierungsplattform	Integriertes System der Teilsysteme: • Teilsystem UAS des DLR • Teilsystem Automated Drone Dispatch von Frequentis
T. Validierungsstandort	Rostock

Datum des Beginns	22.09.2025
Datum des Endes	24.09.2025
Koordinator der Validierung	DLR
Status	<geplant>
Abhängigkeiten	Eingangs: Technische Integration.

Tabelle 5 Validierungsübung: Einsatzübung

4 Übungen zur technologischen Validierung

4.1 Plan der agilen technischen Integration

4.1.1 Beschreibung und Umfang der agilen technischen Integration

Zur agilen technischen Integration wird eine Serie von technischen Online-Sitzungen mit den integrierenden und ggf. auch den entwickelnden Mitarbeitern der integrierenden Parteien angesetzt, die allen interessierten Projektteilnehmern zur informativen Teilnahme offenstehen.

Die integrierenden und entwickelnden Mitarbeiter berichten in jeder Sitzung informell über

- ihren aktuellen Implementierungs- bzw. Integrationsfortschritt seit der letzten Sitzung,
- die für den Zeitraum bis zur nächsten Sitzung geplanten Implementierungen,

und

- stimmen die Maßnahmen und Inhalte ab,
- stellen ein gemeinsames Verständnis der Inhalte (wie z. B. Schnittstellen, Abläufe, Dokumentation dieser) sicher, und
- integrieren und überprüfen aktiv gemeinsam die im Zeitraum seit der letzten Sitzung bereitgestellten Neuerungen.

Ziel dieser iterativen Übungen ist es, durchgeführte Integrationen und Anpassungen schrittweise, eine nach der anderen, zeitnah zu prüfen und fokussiert in Betrieb zu nehmen.

Dazu werden auszutauschende Daten bedarfsbezogen simuliert und ausgetauscht. Die agile technische Integration nutzt hierbei die durch die Konsortialparteien bereitgestellten Plattformen. Verbunden sind diese durch das Internet.

Ein Integrations- bzw. Anpassungsschritt wird als abgeschlossen betrachtet, wenn die beteiligten Mitarbeiter einig sind, dass die integrierte Funktionalität gegeben ist. Die beteiligten Parteien dokumentieren dies gemäß ihren betriebsinternen Vorgaben mit den jeweils vorgeschriebenen Betriebs- bzw. Dokumentations- oder Implementierungswerkzeugen und -umgebungen. Eine darüberhinausgehende formale Abnahme findet in diesem Schritt nicht statt.

Dieses Vorgehen hat sich in der Vergangenheit in verschiedenen Forschungs- und Förderprojekten als sehr effektiv und effizient erwiesen, weil Unklarheiten sofort auffallen, geklärt und sowohl in der Integration, in Programmcodes, als auch in der entsprechenden Dokumentation korrigiert werden können und zeitintensive Kommunikationswege vermieden werden. Eine mögliche Teilnahme aller Projektteilnehmer inklusive der Bedarfsträger kann diese Effekte noch verstärken, weil das operative Wissen unmittelbar präsent ist. Daher bildet die agile technische Integration die Grundlage für eine erfolgreiche Integration und damit die Voraussetzung für die nachfolgenden Validierungsschritte.

4.1.2 Erwartungen der Bedarfsträger und deren Einbeziehung

Es werden die folgenden Bedarfsträger mit den dargestellten Erwartungen identifiziert.

Bedarfsträger	Projektbezug	Einbindung	Signifikanz für den Bedarfsträger
Feuerwehr der Hansestadt Rostock	Intern	Assoziierter Projektpartner	Möglichkeit der Beobachtung des technischen Projektfortschrittes Möglichkeit zum Einbringen operativer Erfahrung Möglichkeit zur Einflussnahme auf Entwicklung und Integration
Landespolizei Mecklenburg-Vorpommern	Intern	Assoziierter Projektpartner	Möglichkeit der Beobachtung des technischen Projektfortschrittes Möglichkeit zum Einbringen operativer Erfahrung Möglichkeit zur Einflussnahme auf Entwicklung und Integration

Tabelle 6 Erwartungen der Bedarfsträger (agile technische Integration)

Die assoziierten Bedarfsträger sind in dieser Phase zur Teilnahme eingeladen. Diese ist aber keine zwingende Voraussetzung für das nachfolgende weitere Vorgehen.

4.1.3 Validierungsplattform, -werkzeug und Validierungstechnik

4.1.3.1 Validierungsplattform

Die eingesetzte Plattform besteht aus den in der Architektur dargestellten Bestandteilen, die von den Projektpartnern im jeweiligen Entwicklungsstand beigestellt und sukzessive integriert werden. Diese sind:

Systembestandteil	Standort	Beistellende Partei	Beschreibung
HD4-1100 Rettungsdrohne	DLR/Cloud	DLR	Unbemanntes Luftfahrzeugsystem (ggf. Simulation über Cloud)
DroNet	Cloud	Vodafone	Zusatzdienste zur dynamischen Risikoabschätzung (zeitaktuelle Bevölkerungsdichte und Netzwerkabdeckung)
ASGARD	Cloud	ELARA	Leitstellensystem für die Feuerwehr (Simulation)
LifeX	Cloud	Frequentis	Befehlsstellensystem für die Polizei (Simulation)
ADD	Cloud	Frequentis	Automatisierte Drohnendisposition mit Verbindung zum Risikobewertungsdienst und dem UTM

Tabelle 7 Übersicht der Bestandteile der Validierungsplattform

In der Architekturübersicht sind die Systembestandteile innerhalb der blau gestrichelten Linie dargestellt.

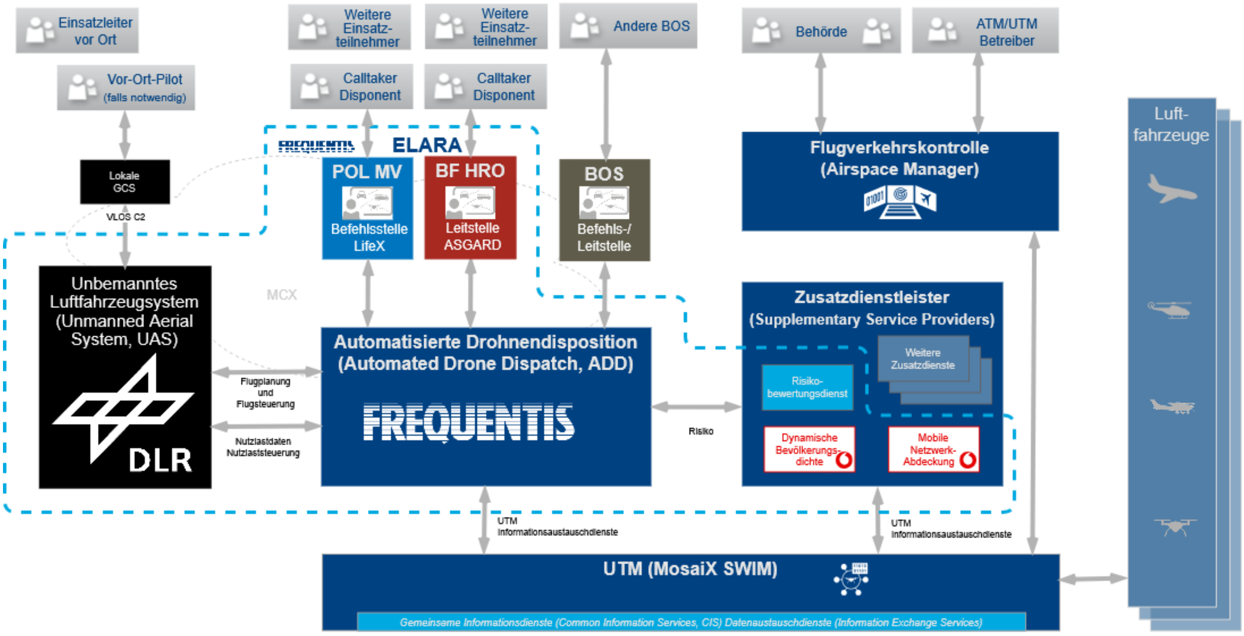

Abbildung 3 Übersicht der Validierungsplattform

4.1.3.2 Werkzeuge und Techniken zur Validierung

Die integrierenden Parteien setzen die gemäß ihrer jeweiligen Betriebsvorgaben zur Verfügung stehenden Werkzeuge ein. Diese schließen insbesondere die folgenden Werkzeuge ein.

Werkzeug	**Zweck/Beschreibung**	**Verfügbarkeit**
UAS (HD4-1100 Rettungsdrohne) im Simulationsmodus	Realistische Simulation des UAS	Nach Absprache mit dem DLR (Gerät muss physisch eingeschaltet werden), Zugriff über Netzwerk/Internet
Edge Cloud Server	Bereitstellungspunkt der Kommunikation zum UAS	Während mit dem DLR abgestimmter Betriebszeiten, Zugriff über Netzwerk/Internet
Leitstellensimulator ASGARD	Simulation der Dispositionsanforderung einer Einsatzdrohne durch das Leitstellensystem ASGARD	24/7, lokal betriebene Software, welche projektintern bei Bedarf bereitgestellt werden kann
Leitstellensimulator LifeX	Simulation der Dispositionsanforderung einer Einsatzdrohne durch das Leitstellensystem LifeX inkl. Simulation eines Notrufes	24/7, Zugriff aus technischen Gründen beschränkt auf Frequentis-Mitarbeiter

Werkzeug	Zweck/Beschreibung	Verfügbarkeit
WebDirector	Im Projekt fortentwickelte drohneneinsatzbezogene Nutzerschnittstelle, welche u. a. ein manuelles Anfordern eines Einsatzflugplanes und eine Live-Darstellung der Videonutzlastdaten beinhaltet und damit zur Ansteuerung des UAS aus dem ADD ermöglicht.	24/7, Zugriff über Netzwerk/Internet durch autorisierte Projektmitarbeiter nach kurzer Einweisung.
Sonstige Werkzeuge	Gemäß der jeweiligen Betriebsvorgaben der Parteien zur Verfügung stehende Werkzeuge	Gemäß der Betriebsvorgaben der jeweiligen Partei

Tabelle 8 Eingesetzte Werkzeuge (agile Integration)

In dieser Integrationsphase werden weitestgehend simulierte Daten verwendet.

Der WebDirector ermöglicht darüber hinaus eine Anforderung eines real geflogenen Drohneneinsatzes, sowie die Darstellung der dabei entstehenden Videonutzlastdaten.

4.1.4 Datenerhebung und -analyse

Die agile technische Integration dient vornehmlich zur Integration der Systembestandteile. In den Sitzungen werden bedarfsbezogen beispielsweise Inhalte individueller Datenelemente betrachtet, um eine korrekte Übertragung sicherzustellen. Eine systematische oder wissenschaftliche Datenerhebung findet in dieser Phase noch nicht statt.

4.1.5 Planung und Management der Übung

4.1.5.1 Aktivitäten

Im Rahmen der agilen technischen Integration finden regelmäßige technische Online-Integrationssitzungen statt. Jede teilnehmende Partei kann bedarfsbezogen technische Agendapunkte eintragen.

4.1.5.2 Rollen und Zuständigkeiten bei der agilen technischen Integration

Rolle	Zuständig	Bemerkungen
Organisator	Frequentis	
Integrierende Teilnehmer	DLR, Vodafone, ELARA, Frequentis	
Beobachtende Teilnehmer	assoziierte Projektpartner	

Tabelle 9 Rollen und Zuständigkeiten bei der agilen technischen Integration

4.1.5.3 Zeitplanung

Die Termine werden durch Outlook-Einladung an die Projektteilnehmer koordiniert.

4.1.5.4 Ermittelte Risiken und Maßnahmen zur Risikominderung

Risiken	Auswirkungen (1-niedrig, 2-mittel, 3-hoch)	Wahrscheinlichkeiten (1-niedrig, 2-mittel, 3-hoch)	Kritikalität (berechnet auf der Grundlage von Wahrscheinlichkeit und Auswirkungen)	Maßnahmen zur Risikominderung	Wahrscheinlichkeit nach Maßnahme	Kritikalität nach Maßnahme
Schnittstellen der Systembestandteile passen nicht zueinander	3	3	hoch	Regelmäßige Überprüfung im Rahmen der Durchführung der agilen Integration	1	niedrig
Unerwartete/falsche Interpretation von Daten	3	3	hoch	Regelmäßige Abstimmung im Rahmen der Durchführung der agilen Integration Kontextualisierung vorab durch Erhebung der operationalen Anforderungen im Vorfeld	1	niedrig
Kein ausreichendes operatives Wissen vorhanden	3	2	mittel	Erhebung der operationalen Anforderungen im Vorfeld Einladung der Bedarfsträger zur technischen Integration	1	niedrig

Risiken	Auswirkungen (1-niedrig, 2-mittel, 3-hoch)	Wahrscheinlichkeiten (1-niedrig, 2-mittel, 3-hoch)	Kritikalität (berechnet auf der Grundlage von Wahrscheinlichkeit und Auswirkungen)	Maßnahmen zur Risikominderung	Wahrscheinlichkeit nach Maßnahme	Kritikalität nach Maßnahme
Integrationsbestandteile werden unbemerkt nicht rechtzeitig fertig	2	2	mittel	Regelmäßige Kontrolle im Rahmen der Durchführung der agilen Integration	1	niedrig

Tabelle 10 Übung: Ermittelte Risiken und Maßnahmen zur Risikominderung (agile technische Integration)

4.2 Plan der technischen Integration

4.2.1 Beschreibung und Umfang der technischen Integration

4.2.1.1 Einsatzszenarien

Zur Ermittlung der operativen Anforderungen wurden mehrere fragebogenbasierte direkte Befragungen der am Projekt beteiligten Endnutzer durchgeführt und in den Fragebogen-Dokumenten festgehalten ([ADELE-E2.2-FBOA-BF-HRO], [ADELE-E2.2-FBOA-POL-MV], [DRN-E1100-1-FBOA-POL]).

In diesen Befragungen wurde eine Reihe von bestehenden und möglichen neuen Einsatzszenarien ermittelt, die Drohnen als Einsatzmittel einsetzen, und in verschiedenen Detailgraden festgehalten.

Diese Gesamt-Einsatzszenarien zeigen signifikante Parallelen in einigen Bereichen und unterscheiden sich in anderen. Dabei lassen sich die folgenden Teilschritte erkennen, die zumeist in dieser Reihenfolge durchlaufen werden.

- Herstellen der Einsatzbereitschaft
- Alarmierung
- Initiale Einsatzbewertung
- Missionsplanung
- Transfer zum Einsatzort
- Einsatzbeginn

- Vor-Ort-Einsatz
- Einsatzende
- Einsatznachbereitung

BPMN diagram: PS-EinsatzszenarienUebersicht

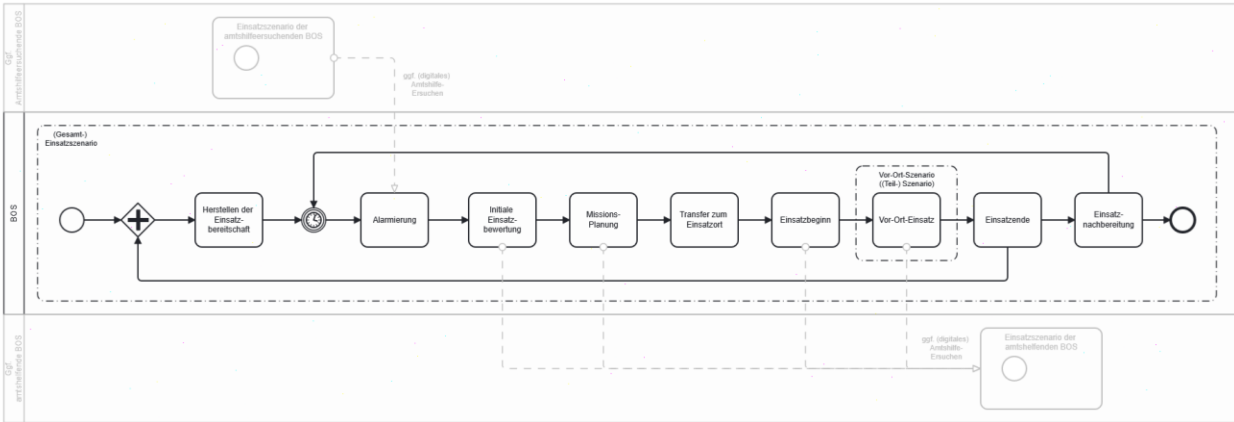

Abbildung 4 (Gesamt-) Einsatzszenario mit (Teil-) Szenarien.

Die Gesamtheit der Teilschritte bildet ein gesamtes Einsatzszenario. Wir zerlegen dieses in (Teil-) Szenarien, die die erkannten Teilschritte beinhalten. In der vorstehenden Abbildung(see figure 4) ist beispielsweise, neben dem gesamten Einsatzszenario, ein derartiges Vor-Ort-Szenario markiert.

Auf diese Weise lassen sich die beobachteten Parallelen in zahlenmäßig wenigen Szenarien beschreiben, anstatt diese wieder und wieder in jedem Einsatzszenario wiederholen zu müssen.

Für die Validierungsübung zur technischen Integration werden aus den in den operationalen Anforderungen ermittelten Szenarien ein oder mehrere geeignete Szenarien ausgewählt und im Rahmen der Übung mit den beteiligten technischen Projektteilnehmern in einer kontrollierten Umgebung wiederholt durchgeführt.

4.2.1.2 Darstellung der Szenarien

Die Darstellung der Szenarien im Folgenden nutzt die Business Process Model Notation (BPMN). Dabei wird die BPMN zunächst relativ naiv verwendet und dient der Veranschaulichung der Abläufe in einer für Nicht-Techniker nachvollziehbaren Weise. Es handelt sich dabei also nicht um strenge BPMN-Modelle im engeren Sinne.

Wir verwenden die folgenden Symbole.

BPMN diagram: PS-SzenarienNotation

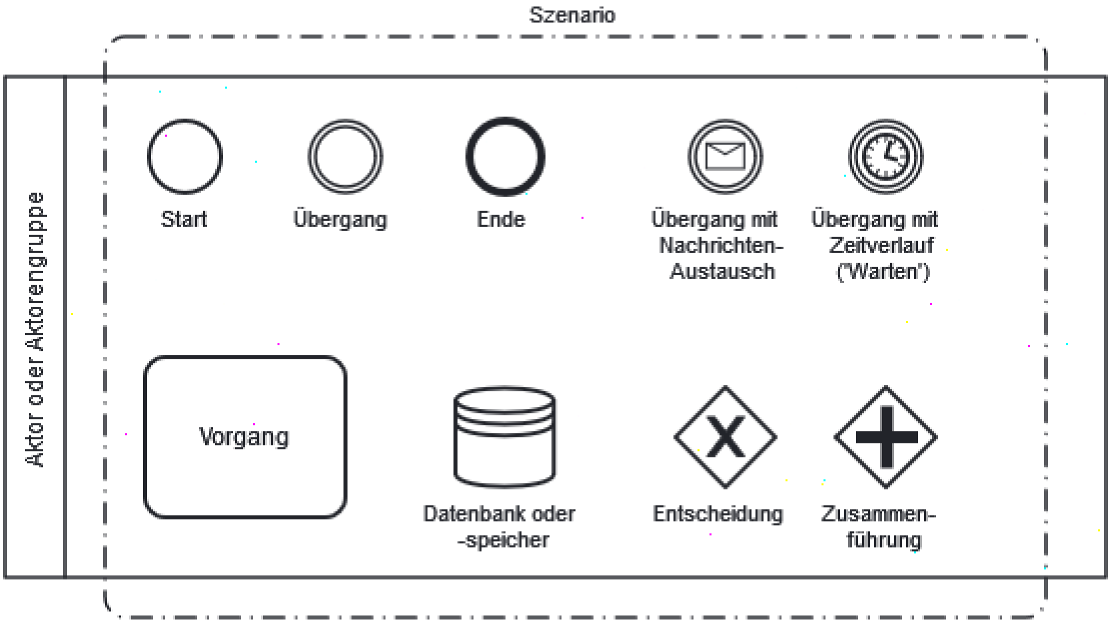

Abbildung 5 Notationselemente für die Darstellung der Szenarien

"Agierende" oder "teilnehmende" Beteiligte und Akteure können Menschen, aber auch technischen Ursprungs sein. Beteiligte und Akteure dabei schließen die folgenden mit ein.

Akteur / Beteiligter	Beschreibung
Calltaker	Ein Calltaker einer Leit- oder Befehlsstelle nimmt die Notfall-Anrufe entgegen und trägt diese in sein Frontend ein. In vielen Fällen sind Calltaker und Disponent ein und dieselbe Person.
Disponent	Ein Disponent einer Leit- oder Befehlsstelle nimmt die Notfall-Anrufe entgegen und trägt diese in sein Frontend ein. In vielen Fällen sind Calltaker und Disponent ein und dieselbe Person.
Drohne	Unbemanntes Luftfahrzeug, das ggf. eine für den Einsatz notwendige Nutzlast zum Einsatzort verbringt.
Einsatzmittel	Eingesetzte Einsatzmittel. In den vorliegenden Szenarien ist das i. d. R. die Drohne.
Einsatzteam	Das Einsatzteam wird aus den Rettungskräften gebildet, die zum Einsatzort fahren, und ist ein system-externer Akteur.
Einsatzteilnehmer	Einsatzteilnehmer sind zu informierende Parteien, die i. d. R. mittelbar am Einsatzgeschehen teilnehmen. Beispiele für diese system-externen Akteure können beauftragte Mitarbeiter der Verwaltungsleitung sein, die vorrangig über das Einsatzgeschehen informiert werden müssen.
Extern	Externe Teilnehmer sind am Einsatz beteiligt und interagieren mit den betrachteten Beteiligten und Aktoren, befinden sich i. d. R. jedoch außerhalb des betrachteten Systems.
Fernpilot	Ein Fernpilot steuert bzw. überwacht den Flug einer Drohne.

Akteur / Beteiligter	Beschreibung
Frontend	Bedienoberfläche für den Calltaker oder Disponenten.
Luftraumbeobachter	Bei Drohneneinsätzen innerhalb der Sichtbarkeitsgrenze beobachtet der Luftraumbeobachter den umliegenden Luftraum und warnt den Drohnenpiloten vor einfliegenden Flugobjekten.
Missionsverwaltung	Die Missionsverwaltung ist i. d. R. das System, in dem die Not-Vorfälle vom Frontend übernommen und informationstechnisch abgewickelt werden.
Nutzlast	Die Nutzlast einer Drohne umfasst die für einen Einsatz notwendigen Sensoren, wie optische oder Wärmebildkamera, LIDAR, oder auch eine kleine Funkzelle.
Payload	s. Nutzlast
UTM	Das System für den unbemannten Luftverkehr (unmanned traffic management, UTM) verwaltet die angemeldeten unbemannten Luftraumbewegungen und stellt für unbemannte Flüge notwendige Daten und Informationen bereit, die im vorliegenden Projekt zur sicheren Abwicklung der Drohneneinsätze unabdinglich sind.
Vorfall	Ein Vorfall ist das digitale Abbild des Notfalles in Frontend bzw. Missionsverwaltung und enthält alle zu dessen Abarbeitung entstehenden Daten und Informationen.

Tabelle 11 Akteure und Beteiligte

Eine Liste weiterer Abkürzungen und Terminologie befindet sich im Anhang.

4.2.1.3 Übung zur technischen Integration

Übersicht

Für diese Validierungsübung wird ein Feldtest am deutschen nationalen Erprobungszentrum für Unbemannte Luftfahrtsysteme des DLR in Cochstedt durchgeführt. Die kontrollierte Umgebung bietet ideale Möglichkeiten, die Tests der technischen Integrationsübung sicher und wiederholbar durchzuführen.

Abbildung 6 Gelände des nationalen Erprobungszentrums für Unbemannte Luftfahrtsysteme des DLR in Cochstedt aus der Luft mit markierten Runways, Taxiways und Stop Bars

Im Rahmen der bestehenden UAS-Betriebsgenehmigung des nationalen Erprobungszentrums für Unbemannte Luftfahrtsysteme besteht keine Notwendigkeit für eine projekteigene Risikobetrachtung zur Durchführung für die Flüge der Übung zur technischen Integration.

Übersicht des Ablaufes

Die im Rahmen der Übung zur technischen Integration durchzuführenden Tests werden von Frequentis in Jama geskriptet (s. u.), entsprechend dieser Skripte durchgeführt und die Ergebnisse in Jama dokumentiert. Die Ergebnisse können aus Jama exportiert und in den Validierungsbericht eingefügt werden.

- Die Leitstellensysteme ASGARD (ELARA) und LifeX werden im Rahmen dieser Übung durch die jeweiligen Simulatoren abgebildet, die eine simulierte Anruferposition als Zielkoordinaten an die automatisierte Drohnendisposition des Demonstrators der Projektpartner übergibt.
- Die automatisierte Drohnendisposition von Frequentis plant den Einsatzflug und koordiniert ihn über das UTM.
- Auf die Anweisung der automatisierte Drohnendisposition aktiviert das UAS des DLR die Drohne, steuert diese zum Einsatzort und liefert dessen genaue Position, sowie Lagebilder von dort.
- Sowohl die Leit- und Befehlsstellensimulation, als auch ein mobiles Tablet können diese Daten visualisieren.

Bezug zum Operationalen Anforderungskatalog

Die im Rahmen der Übung zur technischen Integration durchzuführenden Tests lehnen sich insbesondere an das Vor-Ort-Szenario der Fernerkundung zur Suche nach Person, Tier, oder anderem interessantem Gegenstand/Punkt aus dem operationalen Anforderungskatalog an.

Beschreibung

Das Szenario "Fernerkundung" beschreibt Einsatzfälle, bei denen die Drohne einen Punkt am Einsatzort anfliegt (point of interest, POI) und von diesem aus mit der in ihrer Nutzlast mitgeführten Sensorik ein möglicherweise relativ großes Einsatzgebiet erfasst, ggf. kartiert, nach vorgegebenen Kriterien einen interessanten Punkt (point of interest, POI) darin sucht, findet und diesen in einer Kartendarstellung und vor Ort durch Halten der Position markiert, bis sie einen anderen Auftrag erhält, oder der Einsatz beendet wird.

Ziel des Szenarios ist ein schnelles Auffinden eines Gegenstandes, einer Person, oder eines Tieres in einem möglicherweise großen, gefährlichen oder komplexen Einsatzgebiet durch die Leit- bzw. Befehlsstelle bzw. die Einsatzführung vor Ort zum zeitnahen Heranführen der erforderlichen Einsatzkräfte an den aufgefundenen Einsatzort.

BPMN diagram: PS-VorOrt-FernerkundungPersonensuche

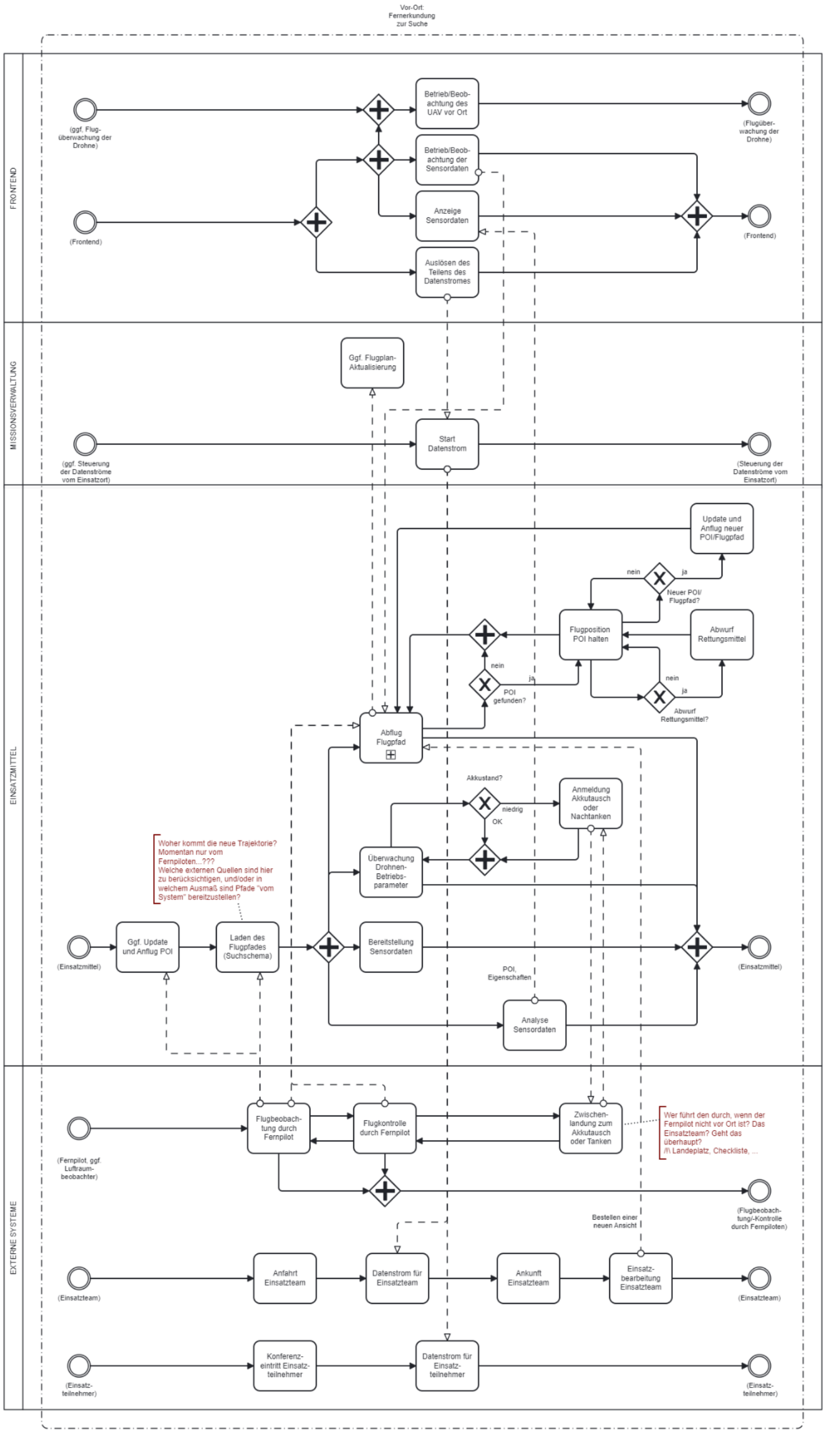

Abbildung 7 Vor-Ort-Szenario Fernerkundung zur Suche nach Person, Tier, oder anderem interessantem Gegenstand/Punkt

Besonderheiten

In diesem Szenario wird zunächst genau ein Punkt angeflogen (Aufpunkt), von dem aus ausgehend nach einem vordefinierten oder auswählbaren Schema ein Bereich abgeflogen und von der Sensorik der Nutzlast erfasst wird. Bei Auffinden des POI oder auf Anforderung eines Nutzers wird das Suchschema unterbrochen und der gefundene POI untersucht.

Die Nutzlast der Drohne wird geeignet ausgewählt (z. B. Wärmebildkamera, Rettungsmittel, Lautsprecher o. ä.).

Die folgenden Aktoren im Szenario können bei Bedarf die Suche fortsetzen, einen weiteren Punkt oder ein anderes Fluggebiet und -schema auswählen bzw. bestellen, welcher bzw. welches dann in vergleichbarer Weise durchflogen und erfasst wird.

- Fernpilot (Annahme: mündliche Anweisung durch einen Einsatzbeteiligten; kann zwar eine direkte Fluganweisung an die Drohne geben, wird diese i. d. R. aber zunächst "bestellen", wie alle anderen auch);
- Entferntes Personal, wie z. B. in einer Leitstelle ("Bestellung" einer Ansicht z. B. durch Click auf einer Kartendarstellung im Einsatzsystem);
- Personal vor Ort, wie z. B. der Einsatzleiter vor Ort ("Bestellung" einer Ansicht z. B. von einem mobilen Anzeigegerät aus);
- Die höchste Priorität wird dabei aus Sicherheitsgründen den direkten Steuerungsanweisungen des Fernpiloten zugeordnet. Die weitere Priorisierung der Anfragen wird im System hinterlegt. Sofern nichts anderes festgelegt ist, hat der Einsatzleiter vor Ort die nächsthöhere Zugriffspriorität, gefolgt von der der Leitstelle.

Durch den gewählten Ansatz ist gewährleistet, dass sämtliche Einsatzbeteiligten zeitnah die für sie notwendigen Daten und Informationen erhalten, die direkte Kontrolle über den Flug aber beim (menschlichen oder automatischen) Fernpiloten verbleibt.

Erfasste Sensordaten aus der Nutzlast der Drohne können automatisiert weiterverarbeitet und das Ergebnis dieser Verarbeitung weiteren Zwecken zugeführt werden. Diese Zwecke schließen die folgenden ein.

- Erkennen von Objekten wie PKW und LKW, Fahrrädern und Motorädern oder LKW-Gefahrgutschildern, Tieren, oder Personen in Videodaten, z. B. mittels künstlicher Intelligenz, und Markieren der Positionen dieser in einer Kartendarstellung (POI), um den Einsatzort im Einsatzgebiet zu markieren.
- Je nach eingesetzter Drohne (s. u.) soll diese durch Schweben ('hover') oder Kreisen ('loiter') um den Zielpunkt den POI für die anrückenden Einsatzkräfte markieren.
- Ggf. Aufbau eines aktuellen und genauen Lagebildes mit allen POI und deren Eigenschaften für eine Lagedarstellung für die genannten oder weitere Zwecke der taktischen Einsatzführung aus der Leit- bzw. Führungsstelle und in der Einsatzleitung vor Ort.

- Ggf. Aufbau eines genauen Lagebildes mit detaillierteren Terraindaten und gefährlichen Punkten zur sicheren Einsatzführung aus der Leit- bzw. Führungsstelle und in der Einsatzleitung vor Ort.
- Erkennen von Objekten, Tieren, oder Personen in Videodaten, z. B. mittels künstlicher Intelligenz, und Markieren dieser in einem Videodatenstrom, um menschliche Beobachter zu unterstützen.

Je nach Typ der eingesetzten Drohne kann sich das für eine Fernerkundung notwendige Flugverhalten der Drohne unterscheiden.

- Die meisten senkrechtstartenden Drohnen (Multicopter, aber auch einige andere VTOL) verfügen über Rotoren, die auch ein genaues Halten einer Position in der Luft ermöglichen ("hover"). Dadurch kann ein kurzfristiges Unterbrechen des Überfluges und ein sehr genaues Manövrieren sowie ein präzises Positionieren an einem Einsatzort möglich sein. Häufig bedingt dieser Vorteil einen erhöhten Energieverbrauch und damit einhergehend relativ geringe Flugzeiten, bis z. B. ein Akkutausch notwendig wird.
- Viele Starrflügler (fixed-wing) hingegen müssen in einer Vorwärtsbewegung verbleiben, um Auftrieb zu erzeugen. Ein Halten einer festen Position ist somit nur begrenzt möglich, weil die Drohne dafür ggf. in der Luft kreisen müsste ("loiter"). Aktuelle Nutzlastsysteme ermöglichen aber auch mit diesen Luftfahrzeugen genaue Aufnahmen am Boden. Wegen der deutlich effizienteren Flugeigenschaften sind i. d. R. der Energieverbrauch geringer und damit die erreichbaren Flugzeiten deutlich länger, oder höhere Nutzlasten möglich, als bei vergleichbaren Drehflüglern, wodurch auch sehr große Gebiete abgeflogen und/oder umfangreichere Daten erhoben werden können.
- Es gibt Mischformen, die, u. U. mit Kompromissen, die Energieeffizienz eines Starrflüglers mit den VTOL-Fähigkeiten eines Senkrechtstarters bis zu einem gewissen Grad vereinen.

Das vorliegende Szenario geht davon aus, dass die entsprechenden Flugeigenschaften der vorgeschlagenen Einsatzmittel hinterlegt sind und der Flug entsprechend geplant werden kann, ohne dass weitere Nutzerinteraktionen notwendig sind.

Anwendungsfälle

Bedarf an einer Fernerkundung zum Auffinden eines Objektes, Tieres, oder einer Person findet sich bei vielen Einsätzen, beispielsweise:

- Ungenau bestimmter Einsatzort bei unklarer Notfallmeldung
  - Suche nach einem verunglückten Fahrzeug am Boden, Luft- oder Wasserfahrzeug;
  - Suche nach dem "Kopfende" eines Staus zum Lokalisieren einer Unfallstelle und zum Festlegen von Anfahrtswegen der Einsatzkräfte;
  - Suche nach beweglichen Einsatzzielen, z. B. einem treibenden Havaristen auf einem Gewässer oder einem abgetriebenen Schwimmer;

        - Eine Dokumentation eines Schadensereignisses wie einer Havarie eines Wasserfahrzeuges kann bei Bedarf im Rahmen des Szenarios zur Fernerkundung ausgedehnter Einsatzbereiche durchgeführt werden.
        - Ein Abbergen einer Person kann in Zusammenarbeit mit einem geeigneten bemannten Rettungsmittel, beispielsweise einem Rettungshubschrauber (helicopter emergency medical service, HEMS) durchgeführt werden, wie es im Szenario zum Einsatz mit bemannter Luftfahrt dargestellt ist.
    - Suche nach Rauch oder sonstigen Auffälligkeiten, die einen Einsatzort markieren können.
- Vermissten oder vermutlich verletzten Person bei unklarer Zielposition im Gelände
    - Absuchen des Umfeldes der letzten bekannten oder vermuteten Position der Person mit gewählter Sensorik in der Nutzlast der Drohne;
    - Absuchen des Umfeldes eines Verkehrsunfalles nach vermissten Personen;
    - Zuführung geeigneter Rettungskräfte und -Mittel an einen entsprechenden Einsatzort.
- Person im Wasser
    - Ertrinkende nach Badeunfall oder Mann-über-Bord-Situation, in kleineren und größeren Gewässern, sowie ggf. auch seeseitig;
    - Suche nach einer suizidgefährdeten Person in größeren Gewässern wie der Elbe;
    - Ggf. Abwurf von in der Nutzlast mitgeführten Hilfsmitteln. Beispielsweise wurde in den großen Tagebauseen in der Lausitz im Projekt RescueFly für den Ertrinkenden nach dessen Auffinden eine Schwimmhilfe abgeworfen.

4.2.2 Erwartungen der Bedarfsträger und deren Einbeziehung

Es werden die folgenden Bedarfsträger mit den dargestellten Erwartungen identifiziert.

Bedarfsträger	Projektbezug	Einbindung	Warum es für den Stakeholder wichtig ist
Feuerwehr der Hansestadt Rostock	Intern	Assoziierter Projektpartner	Möglichkeit der Beobachtung des technischen Projektfortschrittes Möglichkeit zum Einbringen operativer Erfahrung Möglichkeit zur Einflussnahme auf Entwicklung und Integration
Landespolizei Mecklenburg-Vorpommern	Intern	Assoziierter Projektpartner	Möglichkeit der Beobachtung des technischen Projektfortschrittes

Bedarfsträger	Projektbezug	Einbindung	Warum es für den Stakeholder wichtig ist
			Möglichkeit zum Einbringen operativer Erfahrung Möglichkeit zur Einflussnahme auf Entwicklung und Integration

Tabelle 12 Erwartungen der Bedarfsträger (Feldtest zur technischen Integration)

4.2.3 Validierungsplattform, -werkzeug und Validierungstechnik

4.2.3.1 Validierungsplattform

Die eingesetzte Plattform besteht aus den in der Architektur dargestellten Bestandteilen, die von den Projektpartnern beigestellt werden. Diese sind:

Systembestandteil	Standort	Beistellende Partei	Beschreibung
HD4-1100 Rettungsdrohne	Vor Ort/Cloud	DLR	Unbemanntes Luftfahrzeugsystem (UAV vor Ort mit Anbindung über 4G/5G Mobilfunk (teilweise mit für MCX freigeschalteter Vodafone-SIM) an die Cloud)
DroNet	Cloud	Vodafone	Zusatzdienste zur dynamischen Risikoabschätzung (zeitaktuelle Bevölkerungsdichte und Netzwerkabdeckung)
ASGARD	Vor Ort	ELARA	Leitstellensystem für die Feuerwehr (lokaler Simulator, inkl. "stationärem" Zugang zur WebDirector-Komponente des ADD über den Internetzugang des DLR)
LifeX	Vor Ort/Cloud	Frequentis	Befehlsstellensystem für die Polizei (Simulator in der Frequentis Cloud mit lokalem Zugang, inkl. "stationärem" Zugang zur WebDirector-Komponente des ADD, über den Internetzugang des DLR)
ADD	Vor Ort/Cloud	Frequentis	Automatisierte Drohnendisposition mit Verbindung zum Risikobewertungsdienst und dem UTM mit lokalem Zugang zur WebDirector-Komponente von einem mobilen Gerät (Galaxy Tab S9 FE+ Tablet) über 4G/5G Mobilfunk (Vodafone, Dt. Telekom, Telefónica/O2)

Tabelle 13 Übersicht der Bestandteile der Validierungsplattform

In der Architekturübersicht sind die Systembestandteile innerhalb der blau gestrichelten Linie dargestellt.

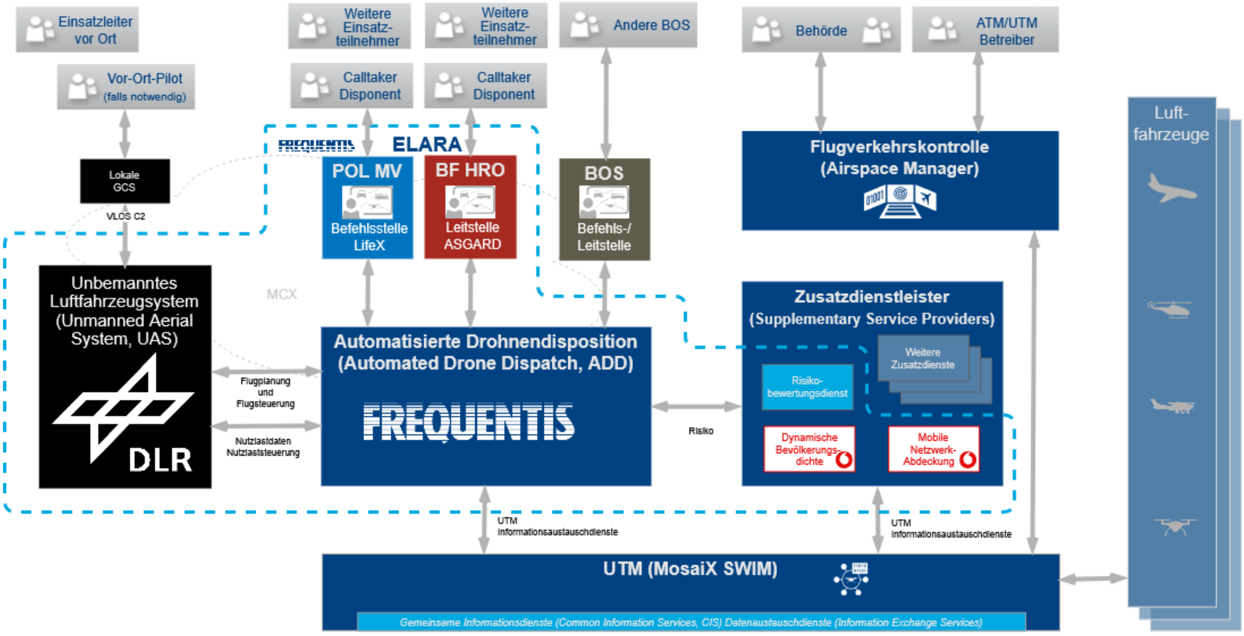

Abbildung 8 Übersicht der Validierungsplattform

4.2.3.2 Werkzeuge und Techniken zur Validierung

Die integrierenden Parteien setzen die gemäß ihrer jeweiligen Betriebsvorgaben zur Verfügung stehenden Werkzeuge ein. Diese schließen für den vorliegenden Feldtest insbesondere die folgenden Werkzeuge ein.

Werkzeug	Zweck/Beschreibung	Verfügbarkeit
HD4-1100 Rettungsdrohne	UAS des DLR	Durchgehend während der Validierungsübung
Edge Cloud Server	Bereitstellungspunkt der Kommunikation zum UAS	Durchgehend während der Validierungsübung, Zugriff über Netzwerk/Internet
Leitstellensimulator ASGARD	Simulation der Dispositionsanforderung einer Einsatzdrohne durch das Leitstellensystem ASGARD	24/7, lokal betriebene Software, welche durchgehend während der Validierungsübung bereitgestellt wird
Leitstellensimulator LifeX	Simulation der Dispositionsanforderung einer Einsatzdrohne durch das Leitstellensystem LifeX inkl. Simulation eines Notrufes	24/7, Zugriff aus technischen Gründen beschränkt auf Frequentis-Mitarbeiter
WebDirector	Im Projekt fortentwickelte drohneneinsatzbezogene Nutzerschnittstelle, welche u. a. ein manuelles Anfordern eines Einsatzflugplanes und eine Live-Darstellung der Videonutzlastdaten beinhaltet und damit zur Ansteuerung des UAS aus dem ADD ermöglicht.	24/7, Zugriff über Netzwerk/Internet durch autorisierte Projektmitarbeiter nach kurzer Einweisung

Werkzeug	Zweck/Beschreibung	Verfügbarkeit
Jama	Durch Frequentis genutztes Werkzeug zur Verwaltung der Anforderungen und Tests und zur Dokumentation der Ergebnisse	24/7, Zugriff beschränkt auf Frequentis-Mitarbeiter
OBS Studio, Snipping Tool, Android Bildschirmrecorder	Werkzeuge zur Aufnahme von Screenshots und Bewegt-Screenrecordings auf Windows-Rechnern bzw. Android-basierten Mobilgeräten.	24/7, lokal betriebene Software
VLC media player	Wiedergabe von screenrecordings inkl. Extraktion von Einzelbildern für die Ergebnisdokumentation in Jama	24/7, lokal betriebene Software
Sonstige Werkzeuge	Gemäß der jeweiligen Betriebsvorgaben der Parteien zur Verfügung stehenden Werkzeuge	Gemäß der Betriebsvorgaben der jeweiligen Partei

Tabelle 14 Eingesetzte Werkzeuge (technische Integration)

4.2.4 Datenerhebung und -analyse

4.2.4.1 Daten und Methoden der Datenerhebung

Es soll eine Abschätzung für das inhärente Delay der Videoübertragung des Gesamtaufbaus vorgenommen werden. Dazu wird mit der Kamera des UAV gleichzeitig neben einem Zeitgeber (Timer mit Sub-Sekundendarstellung auf einem Mobiltelefon) das übertragene Videobild des Zeitgebers (auf einem Tablet) erfasst, so dass die Zeitdifferenz abgelesen werden kann.

Darüber hinaus werden, auf Basis von vorbereiteten Skripten, Flugtests im Feld durchgeführt und mit Screenrecordings und in Jama im Rahmen eines oder mehrerer Test Runs dokumentiert.

4.2.4.2 Analyseverfahren

Die Abschätzung des Systemdelays der Videoübertragung des Gesamtaufbaus erfolgt durch Ablesen der Zeitdifferenz aus dem Videostream.

Die Flugtests im Felde erfolgen gemäß der vorbereiteten Skripte im Anhang dieses Dokumentes. Entspricht die Beobachtung dem erwarteten Ergebnis eines Testschrittes, so wird in Jama ein "Pass" als Testresultat eingetragen, ansonsten ein "Fail". Wenn immer möglich, wird in Jama außerdem ein Screenshot der zum Testschritt gehörenden Beobachtung eingefügt.

4.2.5 Planung und Management der technischen Integration

4.2.5.1 Aktivitäten

Vorbereitung

Das DLR reserviert Testzeiten am und Zugang zum nationalen Erprobungszentrum für unbemannte Luftfahrtsysteme. Der dafür notwendige Vorlauf liegt typischerweise bei ca. 4-8 Wochen.

Das nationale Erprobungszentrum für unbemannte Luftfahrtsysteme befindet sich auf dem Flughafen Cochstedt. Für den Zugang zum Gelände ist das Bestehen einer Online-Sicherheitsunterweisung und das Vorlegen eines gültigen Identitätsdokumentes Voraussetzung. Der Zeitbedarf nach der Freischaltung der Unterweisung liegt, je nach Vorkenntnissen, bei 10-40 min.

Aufgrund der bestehenden UAS-Betriebsgenehmigung für das nationale Erprobungszentrum für unbemannte Luftfahrtsysteme ist keine projektbezogene Risikobetrachtung (SORA) notwendig.

Vodafone stellt dem DLR für MCX freigeschaltete SIM-Karten zur Verfügung. Der Vorlauf dafür liegt bei ca. 6 Wochen.

Frequentis bereitet Testskripte und Test Runs in Jama vor. Je nach Umfang der Skripte und deren Review sollte dafür ein Vorlauf von ca. 2-4 Wochen berücksichtigt werden.

Anreise und Unterkunft organisieren die beteiligten Parteien im Vorfeld eigenständig. Das DLR kennt u. a. die folgenden Übernachtungsmöglichkeiten.

- Hotel Ascania in Aschersleben
- Hotel Stadtschloss Hecklingen bei Staßfurt
- Hotel Eichengrund in Hecklingen

Persönliche Schutzausrüstung, wie Regen- oder Sonnenschutz (Brille, Hut, Sunblocker) organisieren die beteiligten Parteien eigenständig. Das DLR kann für Gäste violette Gast-Warnwesten bereitstellen.

Ein Pavillon als Sonnenschutz kann am Flughafen aufgrund des FOD-Risikos nicht aufgestellt werden. Das DLR reserviert stattdessen einen wettergeschützten Arbeitsraum mit Schreibtischen im UAS-Hangar. Weitere Hilfsmittel, wie z. B. Klapptische, werden nur im Bereich des UAS Hangars toleriert, dürfen nicht unbeaufsichtigt stehen gelassen werden und müssen jederzeit kurzfristig und unverzüglich entfernt werden können.

Ausführung

Die in der Sicherheitsunterweisung geschulten Sicherheitsvorschriften des Flughafens Cochstedt sind zu befolgen. Die Übung findet im Bereich des UAS-Hangars auf dem luftseitigen Teil des Geländes des nationalen Erprobungszentrums für unbemannte Luftfahrtsysteme statt. Geflogen werden darf in Absprache mit den anderen Nutzern vor Ort nur nach Freigabe durch den Tower.

Geflogen wird gemäß der Testskripte im Anhang ggf. mehrmals. Zwischen einzelnen Flügen (Test Runs) können bedarfsbezogen Korrekturen an Implementierung oder Konfiguration vorgenommen werden. Während der Einsätze werden Bildschirmrecordings und andere Bewegt- oder Stillaufnahmen angefertigt, die nachfolgend in die Testdokumentation in Jama übertragen werden. Darüber hinaus werden die angefertigten Aufnahmen mit allen Beteiligten zur Verwendung im Marketing geteilt.

Nachbereitung

Frequentis erfasst die Ergebnisse der Test Runs in Jama zeitnah nach den Testdurchläufen.

4.2.5.2 Rollen und Zuständigkeiten bei der Übung

Rolle	Zuständig	Bemerkungen
Organisator, UAS-Betreiber und Fern- und Sicherheitspilot	DLR	
Mobilfunkbetreiber	Vodafone	
BOS-Leitstellenbetreiber, mobile Einsatzkraft	Frequentis	
Beobachtende Teilnehmer	assoziierte Projektpartner	

Tabelle 15 Rollen und Zuständigkeiten bei der technischen Integration

4.2.5.3 Zeitplanung

Die Übung zur technischen Integration findet vom 26.-28.05.2025 statt.

DLR und Frequentis beginnen am 26.05. ab 09.30 mit den technischen Vorbereitungen vor Ort. Die anderen Beteiligten stoßen im Laufe des Tages dazu.

Beginn und Dauer der Aktivitäten an den Folgetagen legen die Übungsteilnehmer wetter- und fortschrittsabhängig vor Ort fest.

4.2.5.4 Ermittelte Risiken und Maßnahmen zur Risikominderung

Risiken	Auswirkungen (1-niedrig, 2-mittel, 3-hoch)	Wahrscheinlichkeiten (1-niedrig, 2-mittel, 3-hoch)	Kritikalität (berechnet auf der Grundlage von Wahrscheinlichkeit und Auswirkungen)	Maßnahmen zur Risikominderung	Wahrscheinlichkeit nach Maßnahme	Kritikalität nach Maßnahme
Schnittstellen der Systembestandteile passen nicht zueinander	3	1	niedrig	Nach Abschluss der agilen Integration keine Notwendigkeit zu weiterer Mitigation erwartet	n/a	n/a
Unerwartete/falsche Interpretation von Daten	3	1	niedrig	Nach Abschluss der agilen Integration keine Notwendigkeit zu weiterer Mitigation erwartet	n/a	n/a
Kein ausreichendes operatives Wissen vorhanden	3	1	niedrig	Nach Abschluss der agilen Integration keine Notwendigkeit zu weiterer Mitigation erwartet	n/a	n/a
Integrationsbestandteile werden unbemerkt nicht rechtzeitig fertig	2	1	mittel	Nach Abschluss der agilen Integration keine Notwendigkeit zu weiterer Mitigation erwartet	n/a	n/a
Widriges Wetter	3	3	hoch	Anpassung der Flug- und Arbeitszeiten an die beobachteten und erwarteten	1	niedrig

Risiken	Auswirkungen (1-niedrig, 2-mittel, 3-hoch)	Wahrscheinlichkeiten (1-niedrig, 2-mittel, 3-hoch)	Kritikalität (berechnet auf der Grundlage von Wahrscheinlichkeit und Auswirkungen)	Maßnahmen zur Risikominderung	Wahrscheinlichkeit nach Maßnahme	Kritikalität nach Maßnahme
				Wetterbedingungen		

Tabelle 16 Übung: Ermittelte Risiken und Maßnahmen zur Risikominderung (technische Integration)

4.3 Plan der Einsatzübung

4.3.1 Beschreibung und Umfang der Einsatzübung

4.3.1.1 Einsatzszenarien

Im Rahmen der Validierungsübung wird das gleiche Szenario wie im Abschnitt zur Beschreibung und Umfang der technischen Integration(see page 28) bereits dargestellt ausgewählt und mit den beteiligten Bedarfsträgern im Rahmen einer geplanten Einsatzübung durchgeführt.

4.3.1.2 Einsatzübung

Übersicht

Für die Validierung wird ein Übungseinsatz der Feuerwehren in Rostock in der Heide im Nordwesten der Stadt durchgeführt. Dieses Heidegebiet ist vergleichsweise unzugänglich. Für die Feuerwehren stellt es eine Herausforderung dar, denn häufig ist ein Bereich am Boden nur über einen oder wenige Zufahrtswege erreichbar. Ein ungeschicktes Einfahren in das Einsatzgebiet aufgrund einer eingeschränkten Erfassung der Lage kann somit einen erheblichen Zeitverlust bedeuten, der im Zweifel ein frühzeitiges Eingreifen verhindert. In der Folge kann beispielsweise ein zu Beginn relativ kleines Brandereignis zu einer erheblichen Einsatzlage anwachsen.

Das ausgewählte Szenario nimmt also einen Brandherd im Heidegebiet an, der mit Hilfe einer parallel zur Alarmierung der Wehr ausgesendeten Drohne lokalisiert wird. Leitstelle und anfahrende Kräfte erhalten so frühzeitig Information über den Einsatzort und können sich durch das übertragene Video ein Bild der Situation machen.

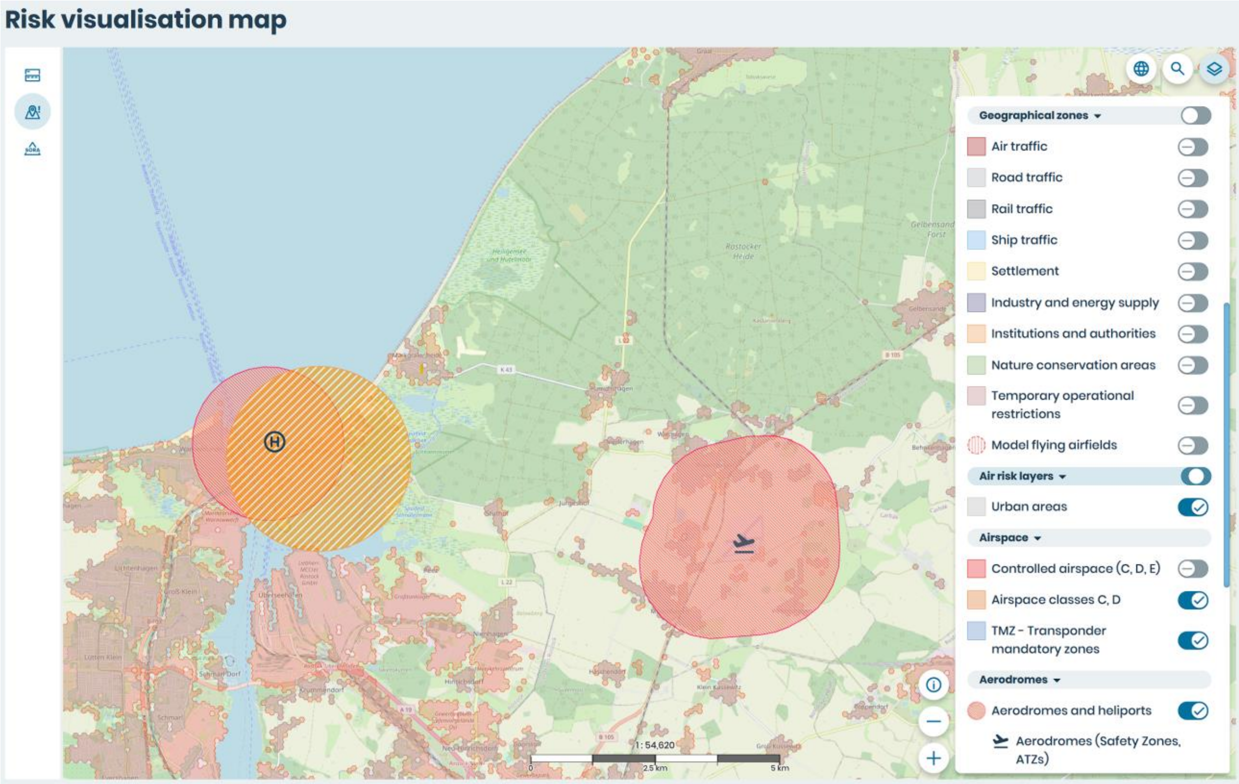

Abbildung 9 Einsatzübung: Grafische Darstellung der Luft- und Bodenrisikogebiete im Gebiet im Nordosten der Stadt

Die vorstehende Abbildung gibt eine Übersicht über das Einsatzgebiet im Nordosten der Stadt Rostock. Für das vereinbarte Einsatzgebiet wird vorab unter Führung des DLR im Rahmen eines Betriebshandbuches eine Bewertung des spezifischen Betriebsrisikos (specific operation risk assessment, SORA) durchgeführt.

Übersicht des Ablaufes

Der Drohneneinsatz fügt sich nahtlos in das Einsatzgeschehen ein und wird im Rahmen dieses Projektes mit möglichst geringem Zusatzaufwand bei der Feuerwehrleitstellendisposition durchgeführt.

- Eine für die Übung ausgewählte Arbeitsposition des ELARA-Leitstellensystems ASGARD in der Leitstelle der Feuerwehr Rostock wird mit dem Demonstrator verbunden, auf der der die Übung auslösende Notruf auflaufen kann.
- Der Disponent an dieser Arbeitsposition entscheidet, dass ein Drohneneinsatz notwendig ist und disponiert die Einsatzdrohne entsprechend.
- ASGARD übergibt die für die Abarbeitung des Übungsfalles notwendigen Daten an den Demonstrator der Projektpartner weiter.
- Die Landespolizei greift aus ihrem Befehlsstellensystem LifeX (ebenfalls Frequentis) auf den Drohneneinsatz zu und kann die Informationen entsprechend nutzen und disponieren.

- Das Drohnen-Dispatch-System von Frequentis plant den Einsatzflug und koordiniert ihn über das UTM.
- Bei Planung und Koordination wird das Risiko des geplanten Flugweges berücksichtigt. Wesentlich hierbei sind digitale Daten zur aktuellen Bevölkerungsdichte und Mobilfunknetzabdeckung, welche von Vodafone aktuell ermittelt und beigesteuert werden (Vodafone DroNet).
- Auf die Anweisung des Dispatch-Systems aktiviert das UAS des DLR die Drohne, steuert diese zum Einsatzort und liefert dessen genaue Position, sowie Lagebilder von dort.
- Sowohl die Leit- und Befehlsstellen, als auch anfahrende Kräfte, können diese Daten visualisieren und z. B. für eine gezielte Anfahrt nutzen.

Bezug zum Operationalen Anforderungskatalog

Diese Übung realisiert insbesondere das Vor-Ort-Szenario der Fernerkundung zur Suche nach Person, Tier, oder anderem interessantem Gegenstand/Punkt aus dem operationalen Anforderungskatalog. Dieses Szenario wurde im vorhergehenden Abschnitt Beschreibung und Umfang der technischen Integration(see page 28) bereits detailliert zitiert und wird hier daher nicht erneut wiederholt.

4.3.2 Erwartungen der Bedarfsträger und deren Einbeziehung

Es werden die folgenden Bedarfsträger mit den dargestellten Erwartungen identifiziert.

Bedarfsträger	Projektbezug	Einbindung	Signifikanz für den Bedarfsträger
Bundes- oder Landespolitik	Extern	Einladung zur Einsatzübung Information über die Erkenntnisse	• Öffentlichkeitsarbeit • Interessensvertretung • Finanzierung
Lokalpolitik	Extern	Einladung zur Einsatzübung Information über die Erkenntnisse	• Öffentlichkeitsarbeit • Interessensvertretung • Finanzierung
BDBOS	Extern / intern	Einladung zur Einsatzübung Ggf. Einladung zu Integrationsübungen	• Projektträger • Interessensvertretung
Feuerwehrverband	Extern	Einladung zur Einsatzübung Information über die Erkenntnisse	• Interessensvertretung • Möglichkeit zur Teilnahme als qualifizierter Beobachter während der Einsatzübung

Bedarfsträger	Projektbezug	Einbindung	Signifikanz für den Bedarfsträger
Feuerwehr der Hansestadt Rostock	Intern	Assoziierter Projektpartner	• Unmittelbare Betroffenheit und Einsatzrelevanz im Rahmen des Projektes und in der Rolle als assoziierter Projektpartner • Öffentlichkeitsarbeit • Interessensvertretung • Finanzierung
Landespolizei Mecklenburg-Vorpommern	Intern	Assoziierter Projektpartner	• Unmittelbare Betroffenheit und Einsatzrelevanz im Rahmen des Projektes und in der Rolle als assoziierter Projektpartner • Öffentlichkeitsarbeit • Interessensvertretung • Finanzierung
Bundespolizei am Standort Rostock	Extern	Vorab-Information über Einsatzübung Einladung zur Einsatzübung Information über die Erkenntnisse	• Vorab-Information zur Sicherstellung der Luftsicherheit während der Einsatzübung • Möglichkeit zur Teilnahme als qualifizierter Beobachter während der Einsatzübung
Marine am Standort Rostock	Extern	Vorab-Information über Einsatzübung Einladung zur Einsatzübung Information über die Erkenntnisse	• Vorab-Information zur Sicherstellung der Luftsicherheit während der Einsatzübung • Möglichkeit zur Teilnahme als qualifizierter Beobachter während der Einsatzübung
Luftwaffe am Standort Rostock-Lage	Extern	Vorab-Information über Einsatzübung Einladung zur Einsatzübung Information über die Erkenntnisse	• Vorab-Information zur Sicherstellung der Luftsicherheit während der Einsatzübung • Möglichkeit zur Teilnahme als qualifizierter Beobachter während der Einsatzübung
Johanniter Unfallhilfe / Christoph Rostock	Extern	Vorab-Information über Einsatzübung Einladung zur Einsatzübung Information über die Erkenntnisse	• Vorab-Information zur Sicherstellung der Luftsicherheit während der Einsatzübung • Möglichkeit zur Teilnahme als qualifizierter Beobachter während der Einsatzübung

Tabelle 17 Erwartungen der Bedarfsträger

4.3.3 Validierungsplattform, -werkzeug und Validierungstechnik

4.3.3.1 Validierungsplattform

Die Einsatzübung zur Validierung wird unter Einsatzbedingungen durchgeführt und greift für das Entsenden einer Drohne im Rahmen der Übung auf das von den Projektpartnern im Projekt entwickelte und integrierte Demonstrator-Systems zurück. Das Demonstratorsystem wird dazu wie folgt eingebunden.

Komponente	Standort	Bediener/Betreiber	Bemerkungen
ASGARD	Leitstelle HRO	BF HRO	
LifeX	Befehlsstelle	POL MV	
HD4-1100 Rettungsdrohne	Fluggerät: Vor Ort Infrastruktur: Cloud	DLR	Das UAS wird digital betrieben
Automated Drone Dispatch (ADD)	Cloud	FREQUENTIS	
Supplementary Services / Risikobewertung	Cloud	DLR / Subcontractor	Skyzr
Supplementary Services / aktuelle Bevölkerungsdichte	Cloud	Vodafone	DroNet
Supplementary Services / aktuelle Netzwerkqualität	Cloud	Vodafone	DroNet

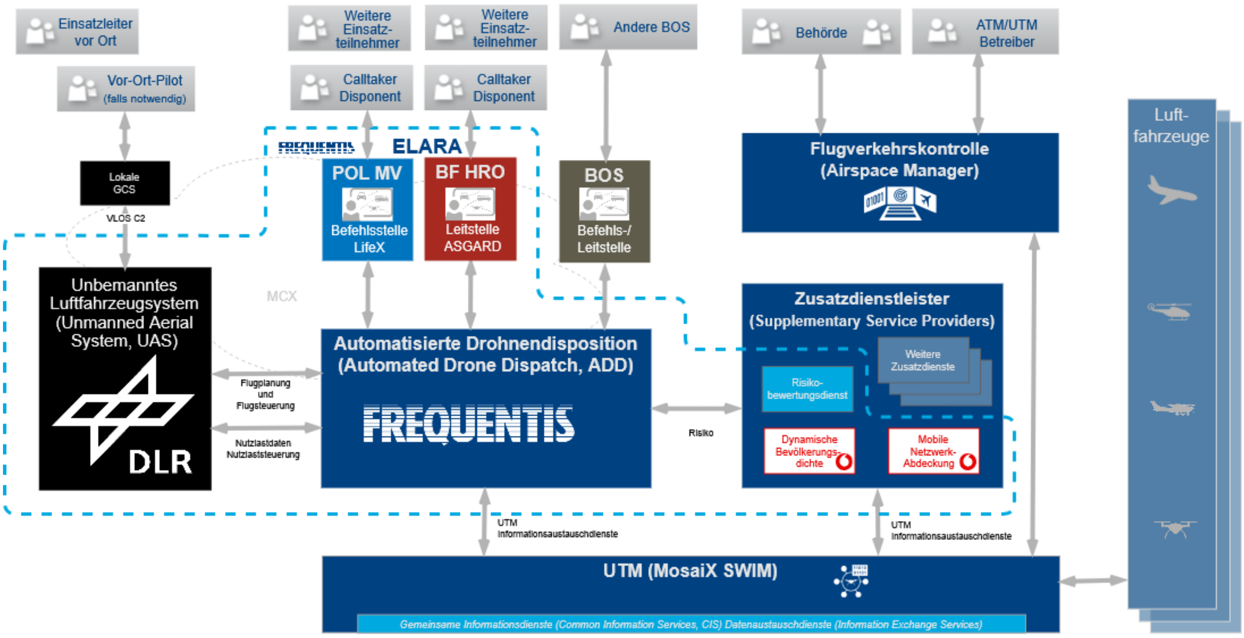

Abbildung 10 Übersichtszeichnung der Validierungsumgebung

4.3.3.2 Werkzeuge und Techniken zur Validierung

Technische Werkzeuge

Die integrierenden Parteien setzen die gemäß ihrer jeweiligen Betriebsvorgaben zur Verfügung stehenden Werkzeuge ein. Diese schließen für den vorliegenden Feldtest insbesondere die folgenden Werkzeuge ein.

Werkzeug	Zweck/Beschreibung	Verfügbarkeit
HD4-1100 Rettungsdrohne	UAS des DLR	Durchgehend während der Validierungsübung
Edge Cloud Server	Bereitstellungspunkt der Kommunikation zum UAS	Durchgehend während der Validierungsübung, Zugriff über Netzwerk/Internet
ASGARD	Leitstellensystem ASGARD	24/7, in der Leitstelle der Feuerwehr Rostock betriebene Software
Leitstellensimulator LifeX	Simulation der Dispositionsanforderung einer Einsatzdrohne durch das Leitstellensystem LifeX	24/7, Zugriff aus technischen Gründen beschränkt auf Frequentis-Mitarbeiter; während der Einsatzübung ist ein Mitarbeiter für die Befehlsstelle zur Verfügung zu stellen.
WebDirector	Im Projekt fortentwickelte drohneneinsatzbezogene Nutzerschnittstelle,	24/7, Zugriff über Netzwerk/Internet durch

Werkzeug	Zweck/Beschreibung	Verfügbarkeit
	welche u. a. ein manuelles Anfordern eines Einsatzflugplanes und eine Live-Darstellung der Videonutzlastdaten beinhaltet und damit zur Ansteuerung des UAS aus dem ADD ermöglicht.	autorisierte Projektmitarbeiter nach kurzer Einweisung
Sonstige Werkzeuge	Gemäß der jeweiligen Betriebsvorgaben der Parteien zur Verfügung stehenden Werkzeuge	Gemäß der Betriebsvorgaben der jeweiligen Partei

Tabelle 18 Eingesetzte technische Werkzeuge (Einsatzübung)

Befragung der Einsatzkräfte

Die Einsatzteilnehmer werden nach dem Einsatz mit einem Fragebogen um ihre Beobachtung und eine Einschätzung aus ihrer Sicht gebeten:

- Anfahrende Einsatzkräfte,
- Leitstellenpersonal,
- Ggf. Beobachter.

Ermittelt werden sollen:

- Wie hilfreich die bereitgestellten Informationen sind.
- Ob die bereitgestellten Informationen zu einem geeigneten Zeitpunkt zur Verfügung stehen.
- Ob und ggf. wie die Chaosphase durch die Bereitstellung der Informationen beeinflusst wird.
- In welcher Qualität insbesondere Videodaten bereitgestellt werden, mit einem besonderen Augenmerk auf
    - der Qualität der Darstellung und
    - der zeitnahen Verfügbarkeit der Darstellung bezüglich Übertragungsverzögerungen.

Auswertung von Einsatzkennzahlen

Alarmierungs-, Ausrück- und Ankunftszeit der Einsatzmittel, inklusive der Drohne, werden erfasst. Daraus wird ermittelt, wie früh im Einsatzgeschehen die neuen Informationen zur Verfügung stehen. Insbesondere wird ein Vergleich der Ankunftszeit der Drohne mit dem der bodengebundenen Einsatzmittel vorgenommen.

Nach Möglichkeit werden diese Zeiten mit historischen Daten vergleichbarer Einsätze verglichen. Aus diesem Vergleich soll eine weitere Einschätzung des Effektes des Einsatzes der Drohne auf die Entwicklung des durchgeführten Einsatzes im Vergleich zu historischen Einsätzen entstehen.

4.3.4 Datenerhebung und -analyse

4.3.4.1 Daten und Methoden der Datenerhebung

Fragebögen werden vor der Übung in MS Forms erstellt und abgestimmt. Das Ausfüllen durch die beteiligten Kräfte der Bedarfsträger erfolgt unmittelbar nach Einrücken und Wiederherstellung der Einsatzbereitschaft online.

Daten zu Einsatzzeiten und Kennzahlen werden aus dem Einsatzleitsystem ausgelesen oder während des Einsatzes protokolliert.

DLR und Vodafone erfassen während des Einsatzes fortwährend Daten zur Netzwerkqualität, insbesondere zu Latenz, verfügbarer und genutzter Bandbreite, Jitter, und, sofern möglich, weiteren Parametern, wie Paketverlustraten, Noise, o. ä.

4.3.4.2 Analyseverfahren

Die Bewertung der erfassten Daten erfolgt entsprechend der Datenquelle in MS Excel oder einer geeigneten Datenbank.

4.3.5 Planung und Management der Einsatzübung

4.3.5.1 Aktivitäten zur Einsatzübung

Vorbereitung

Regelmäßige Abstimmung

Die Planung der Einsatzübung wird über das freitägliche 11:00-Uhr-Regel-Projektmeeting koordiniert. Zusätzlich finden bedarfs- und themenbezogen spezielle Meetings mit dem betroffenen Teilnehmerkreis statt, zu denen im Regel-Projektmeeting berichtet wird.

Redaktionell treibende Partei ist Vodafone. Die vor der Durchführung der Einsatzübung abzuarbeitenden Aufgaben werden in einer Liste auf dem Projektshare (https://teamsites-extranet.dlr.de/sites/ADELE/Dokumente/AP6_Kommunikation/Event%20Planung%20September/Projektplanung%20ADELE%20Event.xlsx?d=w07fa7183ae2e42618a2f971a9e7fe472) getrackt.

			ADELE								
	ID		AUFGABE	Zuständig	Status	Due	Kommentare	Update	ERLÄUTERUNG	START	ENDE
Do not delete this row. This row is hidden to preserve a formula that is used to highlight the current day within the project schedule.											

			ADELE								
	Genehmigungen		Genehmigungen								
	1	Genehmigungen-1	Fluggenehmigung	DLR, Frequentis	Wartet (extern)	7/3/2025	skyzr meldet sich noch bei Andreas; Bei skyzr Stand der SORA und OM nachgefragt. Zudem Interview-mäßige Abfrage von fehlenden Infos unsererseits erbeten.	16.07: Dokumente sind in DLR internem Review. Weiterer Review und dann nä. Zustellung an LBA. Frage: Flug über Naturschutzgebiet! Info an Hrn. Rost zu Unterstützung. Alternative/Präferenz: Übernahme der Haftung durch Feuerwehr, Abstimmung 23.07 wichtig. Fall-back: Fliegen eVLOS. 23.07: Antrag bei LBA eingereicht.	Aufgrund höher Bearbeitungszeit keine Genehmigung für BVLOS Flug	7/3/2025	7/31/2025
	2	Genehmigungen-2	Genehmigung der Übung	Feuerwehr	Abgeschlossen	7/3/2025		16.07: Polizei ist aktuell blockiert, keine Aufnahmen aus der Polizeileitstelle. Sonst keine		7/3/2025	7/31/2025

			ADELE								
								Einschränkungen zu erwarten.			
	3		Genehmigung der Übung	Polizei	Abgeschlossen	7/3/2025		16.07: Polizei ist aktuell blockiert, keine Aufnahmen aus der Polizeileitstelle. Sonst keine Einschränkungen zu erwarten. 25.07: POL-MV zieht sich offiziell aus dem Projekt zurück		7/3/2025	7/31/2025
	4	Genehmigungen-4	Genehmigung zum Flug in der Heide (Naturschutz)	Feuerwehr	Abgeschlossen	7/3/2025			Anfrage an Herrn Hamuth (Forstleiter). Schriftliche Genehmigung für Flug in Heide erhalten	7/3/2025	7/31/2025
	5	Genehmigungen-5				7/3/2025				7/3/2025	7/31/2025
	6	Genehmigungen-6				7/3/2025				7/3/2025	7/31/2025

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	7	Genehmigungen-7				7/3/2025				7/3/2025	7/31/2025
	8	Genehmigungen-8				7/3/2025				7/3/2025	7/31/2025
	Generelle		Generelle Organisation								
	1	Generelle-1	Ablauf der Amtshilfe im Detail zu klären	Polizei	Abgeschlossen	7/3/2025	Absprache mit Leitstelle	16.07: Klärung zw. Polizei und FW - unkritisch 25.07: POL-MV zieht sich offiziell aus dem Projekt zurück		7/3/2025	7/31/2025
	2	Generelle-2	Briefing der Disponenten Feuerwehr	Feuerwehr	Zurückgestellt	9/22/2025			Wird vor Ort bearbeitet (am Montag)	9/22/2025	9/22/2025
	3	Generelle-3	Statements von Projektpartnern freigeben (PM)	Alle	Abgeschlossen	7/16/2025	Sina Version Pressemitteilung, erste Version Statements	16.07: Review ab kommender Woche	Zitat FW. PM final erstellt.	7/16/2025	7/23/2025
	4	Generelle-4	Fragebogen an alle Beteiligte von Feuerwehr und Polizei zu Bewertung des Einsatzes	DLR, Frequentis, Vodafone	Abgeschlossen	11/19/2025			Fragebogen werden ausgedruckt und mitgebracht (DLR)	11/19/2025	11/19/2025

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	5	Generelle-5	Ansprachen an Tag 3	Alle	In Bearbeitung	8/1/2025				8/1/2025	8/15/2025
	6	Generelle-6	Konkreter Tagesablauf Tag 1,2,3	Alle	In Bearbeitung	8/1/2025				8/1/2025	8/15/2025
	7	Generelle-7	Kapazität Standort Freiwillige Feuerwehr	Feuerwehr	Abgeschlossen	11/19/2025			Bestuhlung für bis zu 50 Leute	11/19/2025	7/9/2025
	8	Generelle-8	Abstimmung Teilnehmerliste	Alle	Abgeschlossen	7/3/2025			Siehe Teilnehmerliste für aktuellen Stand	7/3/2025	7/31/2025
	9	Generelle-9	Wer hält Ansprachen, wie und wann werden Bilder und Videos gezeigt?	Alle	Offen	7/3/2025		16.07: Kein Update, Polizei ausgeschlossen 25.07: POL-MV zieht sich offiziell aus dem Projekt zurück		7/3/2025	7/31/2025
	10	Generelle-10	Welche Kapazität hat die Location bei der Freiwilligen Feuerwehr?	Feuerwehr	Abgeschlossen	7/3/2025	Raum verfügbar	16.07: Kein Udpate Startpunkt Drohne? Dach oder Hinterhof Klärung Tag 1	Übersicht, wie die Raumverteilung bei der FF aufgebaut ist	7/3/2025	7/31/2025

			ADELE								
	11	Generelle-11	Wie ist die Begehung der Heide geregelt	DLR	Abgeschlossen	7/3/2025	Zuständigkeit Stadtforstamt	16.07: Klärung mit Feuerwehr. Für Übung formal geregelt?	Schriftliche Bestätigung für Flug in Heide erhalten	7/3/2025	7/31/2025
	12	Generelle-12	Brauchen wir Zelt, Sitzplätze, Bühne?	Alle	Abgeschlossen	7/3/2025			Können wir auch selber etwas mitbringen	7/3/2025	7/31/2025
	Technik		Technik								
	1	Technik-1	Zugriff auf Webdirector von ASGARD Arbeitsplätzen	ELARA	In Bearbeitung	1/0/1900	Abstimmung geht nicht um IP Adressen, sondern um Erreichbarkeit der Drone Dispatch Webseite aus	16.07: Freischaltung URL ist notwendig. Doro kümmert sich.			
	2	Technik-2	Rufnummer des Notrufs	Evtl. Testgerät VF, ELARA	Zurückgestellt	9/22/2025	Wir müssen hier nur wissen, mit welchem/wessen Handy der Notruf abgesetzt wird. Bringen wir dazu ein separates Handy mit?	Kurz vorher / Evtl. Testgerät Vodafone / Tag 1		9/22/2025	9/22/2025

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	3	Technik-3	Visualisierung Bodenrisiko	Vodafone, Frequentis	Abgeschlossen	1/0/1900	Evtl. Slides Direkte vs. Gewählte Route	16.07: Separater Termin Peter Christoph	Risikokarte kann gezeigt werden		
	4	Technik-4	Wie kann das Tablet genutzt werden, wie kommen die Infos in Anwendung	DLR	Abgeschlossen	11/19/2025	Klärung vor Ort	16.07: Geklärt. Hr. Torsten Dittmer Kontaktperson	Update Jan	11/19/2025	8/15/2025
	5	Technik-5	Sollte ein Tablet der FW genutzt werden, muss vorab geklärt werden, wie die Infos in die Anwendung kommen	DLR	Abgeschlossen	11/19/2025	Klärung vor Ort	16.07: Abstimmung mit Hrn. Rost von Andreas	DLR Tablet wird von Einsatzleiter genutzt	11/19/2025	8/31/2025
	6	Technik-6	ASGARD Softwareupdate	ELARA	Abgeschlossen	8/31/2025		Anfang/Mitte August	Update wird am 11.8. durchgeführt	8/31/2025	8/31/2025
	7	Technik-7	Stabile Mobilfunkabdeckung entlang der gesamten Route	Vodafone	Abgeschlossen	8/31/2025				8/31/2025	8/31/2025
	8	Technik-8	Physischer Test mit Laptop für Polizei	Peter, Hr. Thorn	Abgeschlossen	8/31/2025		25.07: POL-MV zieht sich offiziell aus dem Projekt zurück		8/31/2025	8/31/2025

			ADELE								
	9	Technik-9	Klärung Standort Pilot	DLR	Abgeschlossen	8/31/2025	Drohnenpilot steht an der Einsatz-/Landestelle, also direkt neben dem Aussichtsturm "Moorhof"		Planung: Am Zielort	8/31/2025	8/31/2025
	10	Technik-10	Klärung, was den Brand auslöst (zB Rauchtopf)	Feuerwehr klärt nach Erhalten der Details aus dem Call	Abgeschlossen	8/31/2025	Stadtforstamt, zwei Nebelmaschinen?		Nebelmaschine	8/31/2025	8/31/2025
	11	Technik-11	Klärung, wie die Bilder des Einsatzortes im Fahrzeug analysiert werden können	Peter	Abgeschlossen	8/31/2025	Web Director oder DLR App	16.07: Ongoing	DLR Tablet wird von Einsatzleiter genutzt,	8/31/2025	8/31/2025
	12	Technik-12	Klärung wie lange die Drohne vor Ort in der Luft bleiben kann, evtl. Austausch des Akkus	DLR	Abgeschlossen	8/31/2025	Entfernung FFW Markgrafenheide --> Aussichtsturm "Moorhof" = 3430m. Flugzeit bei 10 m/s GS 6 min,			8/31/2025	8/31/2025

			ADELE								
							bei 8 m/s 8 min. Hoverzeit vor Ort etwa 15 Minuten. Einsatzfahrzeuge				
	13	Technik-13	Fragebogen an alle Beteiligte von FW und Polizei zur Bewertung des Einsatzes	DLR, Frequentis, Vodafone	Abgeschlossen	8/31/2025		Vorlage von Andreas; 23.07: Fragebogen an FW/ Polizei geschickt u Nachfrage v FW am 23.07 online geklärt	Fragebogen werden ausgedruckt und mitgebracht (DLR)	8/31/2025	8/31/2025
	14	Technik-14	Bereitstellung Einsatzbericht durch FW	Feuerwehr	Zurückgestellt	8/31/2025	Wird im Nachgang zur Verfügung gestellt			8/31/2025	8/31/2025
	15	Technik-15	Brauchen wir Flugfunkzeug, bzw. eine Frequenz in der Nähe, wo wir dem Flugverkehr zuhören können	Alle	Abgeschlossen	9/15/2025			Nein, VLOS	8/31/2025	8/31/2025
	16	Technik-16	Rechtzeitig die anderen fliegenden Parteien im Umkreis	Alle	Abgeschlossen	9/15/2025			Wäre nett, aber Nein -> VLOS	8/31/2025	8/31/2025

			ADELE								
			informieren (Bundespolizei, Bundeswehr, Rettungshubschrauber, etc.)								
	17	Technik-17				8/31/2025				8/31/2025	8/31/2025
	18	Technik-18				8/31/2025				8/31/2025	8/31/2025
	Presse		Presse / PR								
	1	Presse-1	Beauftragung der Agentur	Vodafone	In Bearbeitung	1/0/1900					7/15/2025
	2	Presse-2	Einbindung der Agentur für Bilder vom Flug, Leitstelle, Leitstellensysteme, Videos, Rettungstrupp	Vodafone	In Bearbeitung	7/16/2025		16.07: Angebote gehen raus, dann kann auch Mittelumwidmung starten. Offene Frage: Catering über Agentur beauftragen.		7/16/2025	7/31/2025
	3	Presse-3	Erster Bild- und Videomaterial Tag 1	Vodafone	In Bearbeitung	7/16/2025				7/16/2025	7/31/2025
	4	Presse-4	Vertragliche Grundlage (Bildrechte) Tag 1	Vodafone	In Bearbeitung	7/16/2025	Christoph fragt Sina	16.07: Vorschlag zum Vertrag von Neoseen?	Feedback von Hrn. Rost an Jochen	7/16/2025	7/31/2025

			ADELE								
	5	Presse-5	Freigabe des Videos (zeitliche Beschränkung, Medien, Locations)	Vodafone	In Bearbeitung	7/16/2025		16.07: Mit Feuerwehr zu klären, Erfahrungen Neoseen?		7/16/2025	7/31/2025
	6	Presse-6	Details zu Drehorten und Lageplan	Vodafone	Abgeschlossen	8/1/2025		16.07: Kein Update	Ansprechpartner bei FFW wichtig	8/1/2025	8/15/2025
	7	Presse-7	Pressemitteilung Erste Version	Vodafone	Abgeschlossen	11/19/2025				11/19/2025	7/9/2025
	8	Presse-8	Pressemittelung Final	Vodafone	Abgeschlossen	11/19/2025			PM finalisiert. VF und DLR PM vorhanden	11/19/2025	7/15/2025
	9	Presse-9	Klärung, ob wir in Leitstelle der Feuerwehr filmen oder fotografieren können	Feuerwehr	Abgeschlossen	11/19/2025	Was soll genau gefilmt werden? Ggf. Müssen Inhalte gepixelt werden	16.07.: Freigabe Leitstellenaufnahmen durch Feuerwehr, personenbezogene Daten müssen verpixelt werden.	Solange verpixelt	11/19/2025	7/15/2025
	10	Presse-10	Klärung, ob wir in Leitstelle der Polizei filmen oder fotografieren können	Polizei	Abgeschlossen	11/19/2025	genauere Abstimmungen folgen noch	16.07: Abstimmung mit Agentur. 25.07: POL-MV zieht sich offiziell aus dem Projekt zurück		11/19/2025	7/15/2025

			ADELE								
	11	Presse-11				11/19/2025				11/19/2025	7/15/2025
	12	Presse-12				11/19/2025				11/19/2025	7/15/2025
	13	Presse-13				11/19/2025				11/19/2025	7/15/2025
	Event		Event								
	1	Event-1	Tag 1	Alle	In Bearbeitung	9/22/2025				9/22/2025	9/22/2025
	2	Event-2	Tag 2	Alle	In Bearbeitung	9/23/2025				9/23/2025	9/23/2025
	3	Event-3	Tag 3	Alle	In Bearbeitung	9/24/2025				9/24/2025	9/24/2025
	4	Event-4	Absagefrist	Alle	Abgeschlossen	7/31/2025				7/31/2025	7/31/2025
	5	Event-5	Ablauf an Tag 1 und 2: Einsatzkräfte sollen an Tag1 (22.09) verfügbar sein, um Details zu besprechen	Vorschlag Vodofone	In Bearbeitung	7/31/2025				7/31/2025	7/31/2025
	6	Event-6	Briefing der Disponenten Feuerwehr	Feuerwehr	Abgeschlossen	7/31/2025	Briefing kurz vorher / Tag 1			7/31/2025	7/31/2025

			ADELE									
	7	Event-7	Catering	Freiwillige Feuerwehr	Abgeschlossen	7/31/2025			Done. Kaffee, Getränke vorhanden. Soljanka über FFW organisiert. Kein/ wenig Personal für Catering. Projekt muss mithelfen	7/31/2025	7/31/2025	
	8	Event-8	Streckenposten	-	Abgeschlossen	7/31/2025			Nicht nötig da VLOS	7/31/2025	7/31/2025	

Tabelle 19 Aufgaben zur Vorbereitung der Einsatzübung

Interessierter und beteiligter Teilnehmerkreis

In der o. a. Datei auf dem Projektshare (https://teamsites-extranet.dlr.de/sites/ADELE/Dokumente/AP6_Kommunikation/Event%20Planung%20September/Projektplanung%20ADELE%20Event.xlsx?d=w07fa7183ae2e42618a2f971a9e7fe472) wird eine Liste der individuellen Teilnehmer und der Anmeldestand geführt. Auf die Reproduktion des Inhaltes wird an dieser Stelle bewusst verzichtet. Eingeladen sind, entsprechend der identifizierten Stakeholder Teilnehmer der folgenden Parteien.

Partei	Rolle
Berlin	Interessierte BOS/Feuerwehr
DLR	Konsortialführer, Projektteilnehmer, Presse- und Öffentlichkeitsbetreuung
ELARA	Projektteilnehmer, Presse- und Öffentlichkeitsbetreuung
FRQ	Projektteilnehmer, Presse- und Öffentlichkeitsbetreuung
Hansestadt Bremen Hansestadt Bremen/Bremerhaven	Interessierte BOS/Feuerwehr
Hansestadt Rostock	Assoziierter Projektteilnehmer, Presse- und Öffentlichkeitsbetreuung, interessierte BOS/Feuerwehr
Kreis Paderborn	Interessierte BOS/Feuerwehr
Kreis Vorpommern/Greifswald	Interessierte BOS/Feuerwehr
Land Hamburg, Landesbetrieb Straßen, Brücken und Gewässer	Interessierte BOS/Feuerwehr
Landkreis Rostock	Interessierte BOS/Feuerwehr
POL Bremen POL Bremerhaven	Interessierte BOS
Polizei Hamburg	Interessierte BOS
POLMV	Assoziierter Projektteilnehmer, Presse- und Öffentlichkeitsbetreuung, interessierte BOS
Schwerin	Interessierte BOS/Feuerwehr
VDI	Fördergeber
Vodafone	Projektteilnehmer, Presse- und Öffentlichkeitsbetreuung

Ausführung

Die Aktivitäten zur Validierungsübung "Einsatzübung" verteilen sich wie folgt auf insgesamt drei Tage.

Tag	Datum	Inhalt
Tag 1	Mo., 22.09.2025	Aufbau und Funktionstest als "Trockenlauf" der Einsatzübung ohne paralleles Entsenden von anderweitigen Einsatzmitteln und Erhebung der projektbezogenen Testdaten und -ergebnisse
Tag 2	Di., 23.09.2025	Durchführung der Einsatzübung und Erhebung der projektbezogenen Testdaten und -ergebnisse
Tag 3	Mi., 24.09.2025	Präsentation der Ergebnisse für Öffentlichkeit, Politik, Presse und die geladenen und interessierten Teilnehmer.

Tabelle 20 Übersicht des Ablaufes der Einsatzübung

Der gewählte Ansatz stellt sicher, dass einerseits die projektseitig erwarteten Daten und Ergebnisse ermittelt werden können, während der Betrieb der Berufsfeuerwehr Rostock und der Landespolizei Mecklenburg-Vorpommern möglichst wenig betroffen sind, und andererseits eine angemessene Betreuung der Öffentlichkeit, Politik, Presse und geladenen und interessierten Teilnehmer gewährleistet wird.

Nachbereitung

Nachbereitend werden die Testergebnisse, sofern noch nicht geschehen, erfasst und aufbereitet.

Im Anschluss wird die Öffentlichkeitsarbeit fortgeführt (Fertigstellung des Projektvideos, Vorbereitung weiterer Verwertungsaktivitäten wie z. B. die Teilnahme an der PMR Expo im November). Diese Aktivitäten finden im allgemeinen Projektrahmen statt. Dieser Plan beschreibt sie daher nicht mehr.

4.3.5.2 Rollen und Zuständigkeiten bei der Einsatzübung

Rollen und Zuständigkeiten sind in der dargestellten Vorbereitung und Einsatzplanung enthalten.

4.3.5.3 Zeitplanung

Die Planung der Aufgaben zur Vorbereitung der Einsatzübung sind bereits im Abschnitt zur Vorbereitung aufgeführt. Im Folgenden findet sich die entsprechende detaillierte Darstellung der Aktivitäten vor Ort während der Einsatzübungstage.

Die Einsatzübung wird durch einen "Notruf" von einer voher vereinbarten Telefonnummer gestartet, so dass dieser Anruf auf der vorbereiteten Einsatzstation bearbeitet werden kann, ohne den allgemeinen Leitstellenbetrieb zu stören.

Tagesablauf ADELE Tag 1-3										
Tag 1: 22.09.2025										
Uhrzeit	Aktivität	Leitstelle (Wache 1)	Wache 3	Freiwillige Feuerwehr	Streckenposten	Einsatzort	Notizen	Was benötigen wir	Offene Fragen	Kommentare
7:30	Treffpunkt	Dorothee & Peter		Team Einsatzort: Andreas, Christoph, BF						
7:30-8:30	Aufbau & Test & Briefing	Dorothee & Peter		Team Einsatzort: Andreas, Christoph, BF			Anruf erfolgt vom Standort FF, Test der Videoübertragung zur Leitstelle, Funktionstest ASGARD, Aufnahmen aus der Leitstelle, Tablets			
8:30-9:30	Verteilung der Positionen	Dorothee & Peter		Jan, etc.	DLR + TBD	Andreas, Christoph, BF	Fahrt zur FF			
9:30-10:30	Notruf + Drohnenflug (Dry Run)	Dorothee & Peter		(Jan, etc.)	DLR + TBD	Andreas, Christoph, (BF)	Christoph tätigt Notruf			

Tagesablauf ADELE Tag 1-3										
10:30-12:30	Rückfahrt zur FF			alle						
10:30-12:30	Aufnahmen Drohne			alle						
10:30-12:30	Aufnahmen Standort FF			alle						
11:00	Debriefing			alle			Beobachtungen Tag 1			
ab 1400			Team Wache 3: DLR, Jan, Einzuweisende BF				BF / Hr. Rost bittet um Einweisung des BF-Einsatzleiters an der FW3			
Tag 2: 23.09.2025										

Tagesablauf ADELE Tag 1-3										
Uhrzeit	Aktivität	Wache 1 (Leitstelle)	Wache 3	Freiwillige Feuerwehr	Einsatzort	Standorte	Notizen	Was benötigen wir	Offene Fragen	Kommentare
7:00	Treffpunkt	Dorothee & Peter	Jan, Eingewiesende BF	Team Einsatzort: Andreas, Christoph, BF Team Streckenposten: DLR, TBD	Treffpunkt noch zu bestimmen		Einsatzort: Aussichtsturm Moorhof			
7:30-8:30	Aufbau & Test & Briefing	Dorothee & Peter	Jan, Eingewiesende BF	Team Einsatzort: Andreas, Christoph, BF Team Streckenposten: DLR, TBD			Anruf erfolgt vom Standort FF, Test der Videoübertragung zur Leitstelle, Funktionstest ASGARD, Aufnahmen aus der Leitstelle, Tablets			
8:30-9:30	Verteilung der Positionen	Dorothee & Peter	Jan, Eingewiesende BF		DLR + TBD	Andreas, Christoph, BF	Fahrt zur FF, Gemeinsame Fahrt zum Einsatzort (Jochen, Joonas, Ben)			

Tagesablauf ADELE Tag 1-3										
9:30-10:30	Notruf + Drohnenflug (Dry Run)	Dorothee & Peter	Jan, Eingewiesende BF		DLR + TBD	Andreas, Christoph, (BF)	Ben tätigt Notruf			
10:30-12:30	Rückfahrt zur FF			alle						
10:30-12:30	Aufnahmen Drohne			alle						
10:30-12:30	Aufnahmen Standort FF			alle						
Tag 3: 24.09.2025										
Uhrzeit	Aktivität	Offene Fragen	Kommentare	Spalte1	Spalte2	Spalte3				
9:00-11:00	Treffpunkt, Aufbau & Technikprüfung	Offene Fragen zu Location: - Beschreibung Anfahrt - Parkmöglichkeit? -> Wiese wird geöffnet. Parkmöglichkeiten somit vorhanden -	- 50 Stühle sind im Raum - Aufbau der Technik, Prüfung der Technik (Bildschirm / Leinwand,							

Tagesablauf ADELE Tag 1-3										
		Bildschirm / Leinwand im Raum? -> Bildschirm an Wand befestigt (HMDI); mehr nicht - Mikrofon im Raum? -> Nein. - WLAN? -> Vorhanden & für uns verfügbar - HDMI zum Bildschirm? -> Ja - Möglichkeit Zelt auf dem Gelände aufzubauen (z.B. für Catering)? -> 3x3m Zelt vorhanden - Kann FF das Zelt stellen und aufbauen? -> Nein, wir müssen aufbauen - 3-4 Tische / Hochtische vorhanden? -> Bierbänke/ Tische vorhanden; wir müssen aufbauen - Sind mehrere Steckdosen im Raum? -> Ja. Mehrfachsteckdose	WLAN, Drohne einrichten							

Tagesablauf ADELE Tag 1-3										
		n sollen wir aber selber mitbringen								
11:00-11:20	Empfang, Begrüßung & ADELE Einführung und Vorstellung der Agenda, Lageplan der Stände	- Wer kommt von FW oder BDBOS?	Präferenz: Empfang durch FW und ggf. BDBOS (3 FW, 3 Min BDBOS) Projektpartner stellen sich auch in 3 Min vor (DLR, Frequentis, VF)							
11:20-11:30	Fototermin	- Planung der Fotos vorab. Wichtig: Ein Vertreter je Partner muss immer verfügbar sein	Optimalerweise draußen							
11:30-12:30	Mediengespräche		Jeder Projektpartner stellt and Ständen seine Themen vor. DLR fliegt mit Drohne							
12:30-13:00	Austausch & Essen	- Catering FF noch zu klären -> geklärt.								

Tagesablauf ADELE Tag 1-3										
		Soljanka wird vorbereitet								
13:00-14:30	Keynotes von BDBOS, Feuerwehr und Projektpartnern	Wer hält hier Vorträge und wie lange?	jeder partner inkl. Feuerwehr 30min Power Point Präsentationen der verschiedenen Partner (wie besprochen einheitliches Slidedeck), anschließende Q&A							
14:30-15:00	Networking		Freier Austausch mit allen Anwesenden							
15:00-15:30	Abbau / Feedbackrunde		Feedback Runde mit Projektpartnern							
15:30	Abreise									

Tagesablauf ADELE Tag 1-3										

Tabelle 21 Rollen und Ablauf der Einsatzübung

4.3.5.4 Ermittelte Risiken und Maßnahmen zur Risikominderung

Risiken und Mitigation							
Risiko	Auswirkung	Wahrscheinlichkeit	Kritikalität	Maßnahmen zur Risikominderung	Wahrscheinlichkeit nach der Maßnahme	Kritikalität der Maßnahme	Status
Schnittstellen der Systembestandteile passen nicht zusammen	hoch	niedrig	niedrig	Nach Abschluss der agilen Integration keine Mitigation notwendig	n/a	n/a	
Unerwartete / falsche Interpretation der Daten	hoch	niedrig	niedrig	Nach Abschluss der agilen Integration keine Mitigation notwendig	n/a	n/a	
Kein ausreichendes operatives Wissen vorhanden	hoch	niedrig	mittel	Nach Abschluss der agilen Integration keine Mitigation notwendig	n/a	n/a	
Integrationsbestandteile werden unbemerkt nicht rechtzeitig fertig	mittel	niedrig	mittel	Nach Abschluss der agilen Integration keine Mitigation notwendig	n/a	n/a	
Widriges Wetter	hoch	hoch	hoch	Anpassung der Flug- und Arbeitszeiten an die beobachteten und erwarteten Wetterbedingungen	niedrig	niedrig	
Unzureichende Verfügbarkeit des Mobilfunknetzes	hoch	niedrig	hoch	Testflug in Rostock vor dem Event, Verzicht auf	n/a	n/a	

				Konnektivität während des Fluges, Reduzierung der Bildqualität, Satellite-Backup			

Tabelle 22 Übung: Ermittelte Risiken und Maßnahmen zur Risikominderung für die Einsatzübung

5 Anhang

5.1 Testskripte für die Validierungsübung zur technischen Integration

5.1.1 INBDLAB-TC-70 Automated drone dispatch from expert system with video point inspection

Related Requirements

ID	Name
INBDLAB-SSS-829(see page 78)	Availability of payload data in a control center
INBDLAB-SSS-71(see page 78)	Dispatcher triggers RTH
INBDLAB-SSS-626(see page 78)	Drone deployment from the control center
INBDLAB-SSS-760(see page 78)	Ending an operational scenario: return to home
INBDLAB-SSS-651(see page 78)	Health status of an operational drone
INBDLAB-SSS-656(see page 78)	Manual return to home location
INBDLAB-SSS-767(see page 78)	Point inspection
INBDLAB-SSS-928(see page 78)	Remaining relative state of charge
INBDLAB-SSS-627(see page 78)	Selection from available operational drones
INBDLAB-SSS-325(see page 78)	The software must allow the input of the aircraft battery status in percentage. State of charge in per cent.
INBDLAB-SSS-541(see page 78)	The software must provide an option to document "Battery check". Values: - validated - Open Input field for state of charge

Test Case

Automated dispatch of a drone from the 'expert system' to the point of interest where the emergency call has come from.

Pass Fail Criteria:
PASS: The UAS' UAV starts, flies to its destination and provides video data of the point of interest.
FAIL: The UAS fails to dispatch the UAV to the point of interest, or there's no video from the point of interest.
Devices in Use:

- Expert system
- Automated drone dispatch system
- UAS system incl. video payload
- UTM
  Precondition:

- Expert system ready to receive call
  - Call simulation ready to call if simulated call (call and calling number coordinated with control centre if testing a 'real' emergency call – which would skip the simulated call steps)
  - User authenticated to automated drone dispatch interface
- Automated drone dispatch available and ready
- UAS available and prepared to fly, UAS' video mounted and available
- UTM available
  Note:
  Test Type: Unassigned
  Test Steps:

Step	Action	Expected Reaction	Pass/Fail	Comment
1	The control centre user (dispatcher, calltaker) logs in at the expert system and at	The user is logged in. A click on the symbol of a drone reveals the status of the		

Step	Action	Expected Reaction	Pass/Fail	Comment
	the user interface to automated drone dispatch, and conducts a brief check of the available assets.	corresponding UAV below the (blank) video display. One may observe the battery status, the number of GPS satellites visible to the UAV, and the flight status of the UAV.		
2	At the simulator, prepare the expert system call simulation with the caller's data (calling number, coordinates), and give it an ID, if required.	The call is ready to be sent to the expert system.		Skip for "real" emergency call.
3	At the expert system, the call enters at the expert system.	There is an indication of the call.		During simulation, send the prepared call. In a "real" call, call the agreed emergency number from the agreed mobile.
4	At the expert system, the control centre user takes the call.	The call is online.		
5	At the expert system, the control centre user decides to dispatch a UAV and opens the interface to automated drone dispatch.	The automated drone dispatch user interface shows a map view with the location of the available UAS. There is a dialogue to select a UAS and request the dispatch of a UAV.		
6	At the expert system, the control centre user	Automated drone dispatch sets the route for the UAV		Per default, UAV altitude should be 40m, heading

Step	Action	Expected Reaction	Pass/Fail	Comment
	selects the preferred drone to dispatch, checks (or adjusts) the flight parameters for the mission, and uploads mission the mission to the UAS to request the dispatch of the UAV.	and immediately dispatches it to the destination.		'forward' towards the incident location, speed 8.3 m/s, and the size of the search area 75m radius, for instance. The values may be modified by the user if need be.
7	At the expert system, the control centre user dispatches any other resource required by the call, and concludes the call when ready.	The other resources operate independently from the UAV, as per operation instructions valid for the control centre.		We record the dispatch time but otherwise do not consider these resources in this script.
8	At the expert system, the control centre user left-clicks on the drone symbol on the map of the interface to automated drone dispatch and requests the video from the UAV with the start video button.	There is a live video from the drone.		If can be observed, check that the video display coincides with a direct observation of the UAV made from an observer nearby.
9	At the expert system, the control centre user observes the UAV status.	Below the video display, one can see the battery status, the number of GPS satellites visible to the UAV, the flight status of the UAV, its altitude, and its current heading.		
10	At the expert system, the control centre user has received the information	The UAV returns to its home position and lands.		

Step	Action	Expected Reaction	Pass/Fail	Comment
	required from the scene and clicks on the return home button so that the UAV may return to its home position to end the mission.			

Sign Box	Pass	Fail	Signature	Date
FREQUENTIS				
CONTRACTOR				
Signature Box for Test Case INBDLAB-TC-70				

5.1.2 INBDLAB-TC-72 Automated drone dispatch from expert system with video point inspection and distribution to mobile device

Related Requirements

ID	Name
INBDLAB-SSS-829(see page 78)	Availability of payload data in a control center
INBDLAB-SSS-830(see page 78)	Availability of payload data in the on- scene commander
INBDLAB-SSS-71(see page 78)	Dispatcher triggers RTH
INBDLAB-SSS-626(see page 78)	Drone deployment from the control center
INBDLAB-SSS-760(see page 78)	Ending an operational scenario: return to home

ID	Name
INBDLAB-SSS-651(see page 78)	Health status of an operational drone
INBDLAB-SSS-656(see page 78)	Manual return to home location
INBDLAB-SSS-767(see page 78)	Point inspection
INBDLAB-SSS-928(see page 78)	Remaining relative state of charge
INBDLAB-SSS-627(see page 78)	Selection from available operational drones
INBDLAB-SSS-325(see page 78)	The software must allow the input of the aircraft battery status in percentage. State of charge in per cent.
INBDLAB-SSS-541(see page 78)	The software must provide an option to document "Battery check". Values: - validated - Open Input field for state of charge

Test Case

Automated dispatch of a drone from the 'expert system' to the point of interest where the emergency call has come from. The video payload is made available at the control centre as well as to a mobile client.

Pass Fail Criteria:

PASS: The UAS' UAV starts, flies to its destination and provides payload data of the point of interest.

FAIL: The UAS fails to dispatch the UAV to the point of interest, or there's no payload data from the point of interest.

Devices in Use:

- Expert system
- Automated drone dispatch system
- UAS system incl. payload and corresponding processing if required
- UTM

Precondition:

- Expert system ready to receive call
  - Call simulation ready to call if simulated call (call and calling number coordinated with control centre if testing a 'real' emergency call – which would skip the simulated call steps)
  - User authenticated to automated drone dispatch interface
- Automated drone dispatch available and ready
- UAS available and prepared to fly, UAS' payload mounted and available
- UTM available

Note:

Test Type: Unassigned

Test Steps:

Step	Action	Expected Reaction	Pass/Fail	Comment
1	The control centre user (dispatcher, calltaker) logs in at the expert system and at the user interface to automated drone dispatch, and conducts a brief check of the available assets.	The user is logged in. A click on the symbol of a drone reveals the status of the corresponding UAV below the (blank) video display. One may observe the battery status, the number of GPS satellites visible to the UAV, and the flight status of the UAV.		
2	At the simulator, prepare the expert system call simulation with the caller's data (calling number, coordinates), and give it an ID, if required.	The call is ready to be sent to the expert system.		Skip for "real" emergency call.

Step	Action	Expected Reaction	Pass/Fail	Comment
3	At the expert system, the call enters at the expert system.	There is an indication of the call.		During simulation, send the prepared call. In a "real" call, call the agreed emergency number from the agreed mobile.
4	At the expert system, the control centre user takes the call.	The call is online.		
5	At the expert system, the control centre user decides to dispatch a UAV and opens the interface to automated drone dispatch.	The automated drone dispatch user interface shows a map view with the location of the available UAS. There is a dialogue to select a UAS and request the dispatch of a UAV.		
6	At the expert system, the control centre user selects the preferred drone to dispatch, checks (or adjusts) the flight parameters for the mission, and uploads mission the mission to the UAS to request the dispatch of the UAV.	Automated drone dispatch sets the route for the UAV and immediately dispatches it to the destination.		Per default, UAV altitude should be 40m, heading 'forward' towards the incident location, speed 8.3 m/s, and the size of the search area 75m radius, for instance. The values may be modified by the user if need be.
7	At the expert system, the control centre user dispatches any other resource required by the call, and concludes the call when ready.	The other resources operate independently from the UAV, as per operation instructions valid for the control centre.		We record the dispatch time but otherwise do not consider these resources in this script.

Step	Action	Expected Reaction	Pass/Fail	Comment
8	At the expert system, the control centre user left-clicks on the drone symbol on the map of the interface to automated drone dispatch and requests the video from the UAV with the start video button.	There is a live video from the drone.		If can be observed, check that the video display coincides with a direct observation of the UAV made from an observer nearby.
9	At the mobile client device, on the way to the incident site, the mobile user requests the video from the UAV.	There is a live video from the drone.		If can be observed, check that the video display coincides with a direct observation of the UAV made from an observer nearby.
10	At the expert system, the control centre user observes the UAV status.	Below the video display, on can see the battery status, the number of GPS satellites visible to the UAV, the flight status of the UAV, its altitude, and its current heading.		
11	At the expert system, the control centre user has received the information required from the scene and clicks on the return home button so that the UAV may return to its home position to end the mission.	The UAV returns to its home position and lands.		

Sign Box	Pass	Fail	Signature	Date
FREQUENTIS				
CONTRACTOR				
Signature Box for Test Case INBDLAB-TC-72				

5.2 Testskripte für die Validierungsübung Einsatzübung

5.2.1 INBDLAB-TC-84_Automated drone dispatch from expert system with video point inspection and UTM integration

Related Requirements

ID	Name
INBDLAB-SSS-829(see page 87)	Availability of payload data in a control center
INBDLAB-SSS-71(see page 87)	Dispatcher triggers RTH
INBDLAB-SSS-626(see page 87)	Drone deployment from the control center
INBDLAB-SSS-760(see page 87)	Ending an operational scenario: return to home
INBDLAB-SSS-651(see page 87)	Health status of an operational drone
INBDLAB-SSS-656(see page 87)	Manual return to home location
INBDLAB-SSS-767(see page 87)	Point inspection
INBDLAB-SSS-928(see page 87)	Remaining relative state of charge

ID	Name
INBDLAB-SSS-627(see page 87)	Selection from available operational drones
INBDLAB-SSS-325(see page 87)	The software must allow the input of the aircraft battery status in percentage. State of charge in per cent.
INBDLAB-SSS-541(see page 87)	The software must provide an option to document "Battery check". Values: - validated - Open Input field for state of charge

Test Case

Automated dispatch of a drone from the 'expert system' to the point of interest where the emergency call has come from.

Pass Fail Criteria:

PASS: The UAS' UAV starts, flies to its destination and provides video data of the point of interest.

FAIL: The UAS fails to dispatch the UAV to the point of interest, or there's no video from the point of interest.

Devices in Use:

- Expert system
- Automated drone dispatch system
- UAS system incl. video payload
- UTM
  Precondition:
- Expert system ready to receive call
  - Call simulation ready to call if simulated call (call and calling number coordinated with control centre if testing a 'real' emergency call – which would skip the simulated call steps)
  - User authenticated to automated drone dispatch interface
- Automated drone dispatch available and ready
- UAS available and prepared to fly, UAS' video mounted and available

- UTM available
  - UTM Operator Manager application and
  - Airspace Manager application as required.

Note:

Test Type: Unassigned

Test Steps:

Step	Action	Expected Reaction	Pass/Fail	Comment
1	The control centre user (dispatcher, calltaker) logs in at the expert system and at the user interface to automated drone dispatch, and conducts a brief check of the available assets.	The user is logged in. A click on the symbol of a drone reveals the status of the corresponding UAV below the (blank) video display. One may observe the battery status, the number of GPS satellites visible to the UAV, and the flight status of the UAV.		
2	At the simulator, prepare the expert system call simulation with the caller's data (calling number, coordinates), and give it an ID, if required.	The call is ready to be sent to the expert system.		Skip for "real" emergency call.
3	At the expert system, the call enters at the expert system.	There is an indication of the call.		During simulation, send the prepared call. In a "real" call, call the agreed emergency number from the agreed mobile.

Step	Action	Expected Reaction	Pass/Fail	Comment
4	At the expert system, the control centre user takes the call.	The call is online.		
5	At the expert system, the control centre user decides to dispatch a UAV and opens the interface to automated drone dispatch.	The automated drone dispatch user interface shows a map view with the location of the available UAS. There is a dialogue to select a UAS and request the dispatch of a UAV.		
6	At the expert system, the control centre user selects the preferred drone to dispatch, checks (or adjusts) the flight parameters for the mission, and uploads the mission to the UAS to prepare the UAV for the mission.	Automated drone dispatch sets the route for the UAV.		Per default, UAV altitude should be 40m, heading 'forward' towards the incident location, speed 8.3 m/s, and the size of the search area 75m radius, for instance. The values may be modified by the user if need be.
7	At the expert system, the control centre user sends the flight plan request to the UTM and has it authorized.	Automated drone dispatch shows the flight plan state (PENDING, AUTHORIZED). The button changes to activate the plan. The plan also can be observed accordingly as Drone Dispatch Mission at the UTM Operation Manager and inspected at the Airspace Administrator applications.		Flight authorization occurs as configured in the UTM. If the UTM requires ATC authorization also for state flights in the areas affected by the flight, ATC must authorize the flight. Otherwise, authorization is entirely automatic.

Step	Action	Expected Reaction	Pass/Fail	Comment
8	At the expert system, the control centre user activates the flight plan via the UTM, opens the cockpit, and proceeds to start the drone.	Automated drone dispatch shows the flight plan state (ACTIVE). The button changes to open the cockpit. The Start flight command from the Commands drop-down starts the drone. If supported by the drone, the live video from the drone is visible in the background. The plan also can be observed accordingly as Drone Dispatch Mission at the UTM Operation Manager and inspected at the Airspace Administrator applications.		Flight activation occurs as configured in the UTM. If the UTM requires ATC takeoff clearance also for state flights in the areas affected by the flight, ATC must clear (activate) the flight. Otherwise, activation is entirely automatic.
9	At the expert system, the control centre user dispatches any other resource required by the call, and concludes the call when ready.	The other resources operate independently from the UAV, as per operation instructions valid for the control centre.		We record the dispatch time but otherwise do not consider these resources in this script.
10	At the expert system, the control centre user can follow the drone position on the map and at any time may left-click on the drone symbol on the map of the interface to automated drone dispatch to request the video from the	The position of the drone is shown on the map. There is a live video from the drone.		If can be observed, check that the video display coincides with a direct observation of the UAV made from an observer nearby. Some control centre systems such as LifeX also may show the drone position in another map view.

Step	Action	Expected Reaction	Pass/Fail	Comment
	UAV with the start video button.			
11	At the expert system, the control centre user observes the UAV status.	Below the video display, one can see the battery status, the number of GPS satellites visible to the UAV, the flight status of the UAV, its altitude, and its current heading.		
12	At the expert system, the control centre user has received the information required from the scene and clicks on the return home button so that the UAV may return to its home position to end the mission.	The UAV returns to its home position and lands.		

Sign Box	Pass	Fail	Signature	Date
FREQUENTIS				
CONTRACTOR				
Signature Box for Test Case INBDLAB-TC-84				

5.2.2 INBDLAB-TC-85_Automated drone dispatch from expert system with video point inspection and distribution to mobile device and with UTM integration

Related Requirements

ID	Name
INBDLAB-SSS-829(see page 87)	Availability of payload data in a control center
INBDLAB-SSS-830(see page 87)	Availability of payload data in the on- scene commander
INBDLAB-SSS-71(see page 87)	Dispatcher triggers RTH
INBDLAB-SSS-626(see page 87)	Drone deployment from the control center
INBDLAB-SSS-760(see page 87)	Ending an operational scenario: return to home
INBDLAB-SSS-651(see page 87)	Health status of an operational drone
INBDLAB-SSS-656(see page 87)	Manual return to home location
INBDLAB-SSS-767(see page 87)	Point inspection
INBDLAB-SSS-928(see page 87)	Remaining relative state of charge
INBDLAB-SSS-627(see page 87)	Selection from available operational drones
INBDLAB-SSS-325(see page 87)	The software must allow the input of the aircraft battery status in percentage. State of charge in per cent.
INBDLAB-SSS-541(see page 87)	The software must provide an option to document "Battery check". Values: - validated - Open Input field for state of charge

Test Case

Automated dispatch of a drone from the 'expert system' to the point of interest where the emergency call has come from. The video payload is made available at the control centre as well as to a mobile client.

Pass Fail Criteria:

PASS: The UAS' UAV starts, flies to its destination and provides payload data of the point of interest.

FAIL: The UAS fails to dispatch the UAV to the point of interest, or there's no payload data from the point of interest.
Devices in Use:

- Expert system
- Automated drone dispatch system
- UAS system incl. payload and corresponding processing if required
- UTM
  Precondition:
- Expert system ready to receive call
  - Call simulation ready to call if simulated call (call and calling number coordinated with control centre if testing a 'real' emergency call – which would skip the simulated call steps)
  - User authenticated to automated drone dispatch interface
- Automated drone dispatch available and ready
- UAS available and prepared to fly, UAS' payload mounted and available
- UTM available
  - UTM Operator Manager application and
  - Airspace Manager application as required.

Note:
Test Type: Unassigned
Test Steps:

Step	Action	Expected Reaction	Pass/Fail	Comment
1	The control centre user (dispatcher, calltaker) logs in at the expert system and at the user interface to	The user is logged in. A click on the symbol of a drone reveals the status of the corresponding UAV below		

Step	Action	Expected Reaction	Pass/Fail	Comment
	automated drone dispatch, and conducts a brief check of the available assets.	the (blank) video display. One may observe the battery status, the number of GPS satellites visible to the UAV, and the flight status of the UAV.		
2	At the simulator, prepare the expert system call simulation with the caller's data (calling number, coordinates), and give it an ID, if required.	The call is ready to be sent to the expert system.		Skip for "real" emergency call.
3	At the expert system, the call enters at the expert system.	There is an indication of the call.		During simulation, send the prepared call. In a "real" call, call the agreed emergency number from the agreed mobile.
4	At the expert system, the control centre user takes the call.	The call is online.		
5	At the expert system, the control centre user decides to dispatch a UAV and opens the interface to automated drone dispatch.	The automated drone dispatch user interface shows a map view with the location of the available UAS. There is a dialogue to select a UAS and request the dispatch of a UAV.		
6	At the expert system, the control centre user selects the preferred drone to			

Step	Action	Expected Reaction	Pass/Fail	Comment
	dispatch, checks (or adjusts) the flight parameters for the mission, and uploads the mission to the UAS to prepare the UAV for the mission.			
Automated drone dispatch sets the route for the UAV.				
	Per default, UAV altitude should be 40m, heading 'forward' towards the incident location, speed 8.3 m/s, and the size of the search area 75m radius, for instance. The values may be modified by the user if need be.			
7	At the expert system, the control centre user sends the flight plan request to the UTM and has it authorized.	Automated drone dispatch shows the flight plan state (PENDING, AUTHORIZED). The button changes to activate the plan. The plan also can be observed accordingly as Drone Dispatch Mission at the UTM Operation Manager and inspected at the Airspace Administrator applications.		Flight authorization occurs as configured in the UTM. If the UTM requires ATC authorization also for state flights in the areas affected by the flight, ATC must authorize the flight. Otherwise, authorization is entirely automatic.
8	At the expert system, the control centre user activates the flight plan via	Automated drone dispatch shows the flight plan state (ACTIVE). The button		Flight activation occurs as configured in the UTM. If the UTM requires ATC takeoff

Step	Action	Expected Reaction	Pass/Fail	Comment
	the UTM, opens the cockpit, and proceeds to start the drone.	changes to open the cockpit. The Start flight command from the Commands drop-down starts the drone. If supported by the drone, the live video from the drone is visible in the background. The plan also can be observed accordingly as Drone Dispatch Mission at the UTM Operation Manager and inspected at the Airspace Administrator applications.		clearance also for state flights in the areas affected by the flight, ATC must clear (activate) the flight. Otherwise, activation is entirely automatic.
9	At the expert system, the control centre user dispatches any other resource required by the call, and concludes the call when ready.	The other resources operate independently from the UAV, as per operation instructions valid for the control centre.		We record the dispatch time but otherwise do not consider these resources in this script.
10	At the expert system, the control centre user can follow the drone position on the map and at any time may left-click on the drone symbol on the map of the interface to automated drone dispatch to request the video from the UAV with the start video button.	The position of the drone is shown on the map. There is a live video from the drone.		If can be observed, check that the video display coincides with a direct observation of the UAV made from an observer nearby. Some control centre systems such as LifeX also may show the drone position in another map view.
11	At the mobile client device, on the way to the incident	The position of the drone is shown on the map. There is a		If can be observed, check that the video display

Step	Action	Expected Reaction	Pass/Fail	Comment
	site, the mobile user requests the video from the UAV.	live video from the drone.There is a live video from the drone.		coincides with a direct observation of the UAV made from an observer nearby.
12	At the expert system, the control centre user observes the UAV status.	Below the video display, on can see the battery status, the number of GPS satellites visible to the UAV, the flight status of the UAV, its altitude, and its current heading.		This data also can be observed at the mobile device.
13	At the expert system, the control centre user has received the information required from the scene and clicks on the return home button so that the UAV may return to its home position to end the mission.	The UAV returns to its home position and lands.		

Sign Box	Pass	Fail	Signature	Date
FREQUENTIS				
CONTRACTOR				
Signature Box for Test Case INBDLAB-TC-85				

5.3 Betriebsgenehmigung

5.3.1 Antrag auf eine neue Betriebsgenehmigung in der speziellen Kategorie gemäß Art. 12 DVO (EU) 2019/947


Luftfahrt-Bundesamt

Antrag auf eine neue Betriebsgenehmigung in der speziellen Kategorie gemäß Art. 12 DVO (EU) 2019/947

Deutsches Zentrum für Luft- und Raumfahrt e.V.

Abbildung 11 Antrag auf eine neue Betriebsgenehmigung in der speziellen Kategorie gemäß Art. 12 DVO (EU) 2019/947

Braunschweig 10.07.2025

Abbildung 12 Antrag auf eine neue Betriebsgenehmigung in der speziellen Kategorie gemäß Art. 12 DVO (EU) 2019/947

5.3.2 SORA-Formular (FV.GO-UASOPA-01/03)

Operational risk analysis overview for operations
in the specific category
according to AMC1 to Article 11 IR (EU) 2019/947

LBA

[illegible]	[illegible]	
[illegible]	[illegible]	
[illegible]	HD4-1180	
[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]
[illegible]	1,77	m
[illegible]	11	kg
[illegible]	18	m/s
[illegible]	[illegible]	
[illegible]	[illegible]	
[illegible]	[illegible]	
[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]

Abbildung 13 SORA-Formular (FV.GO-UASOPA-01/03)

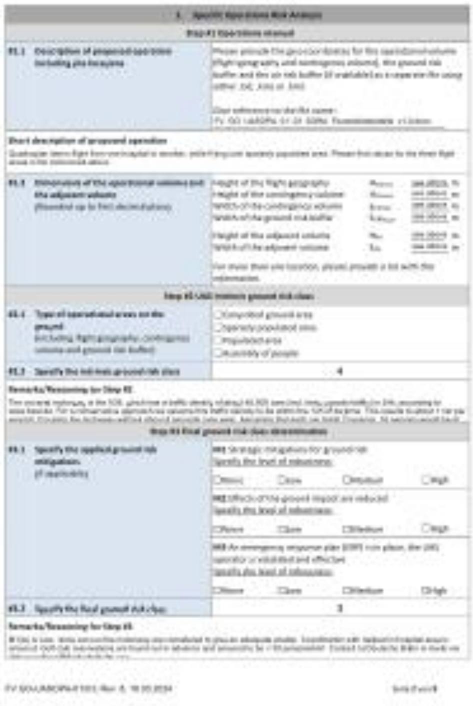


Abbildung 14 SORA-Formular (FV.GO-UASOPA-01/03)

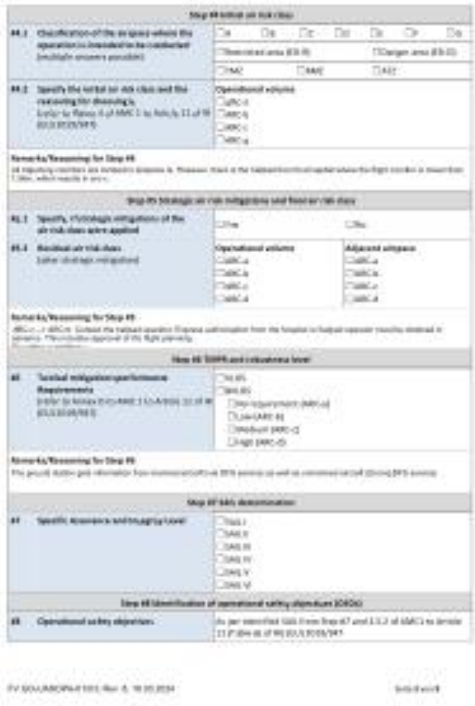


Abbildung 15 SORA-Formular (FV.GO-UASOPA-01/03)

Place, date	Name and signature
Braunschweig, 18.07.2025	

Abbildung 16 SORA-Formular (FV.GO-UASOPA-01/03)

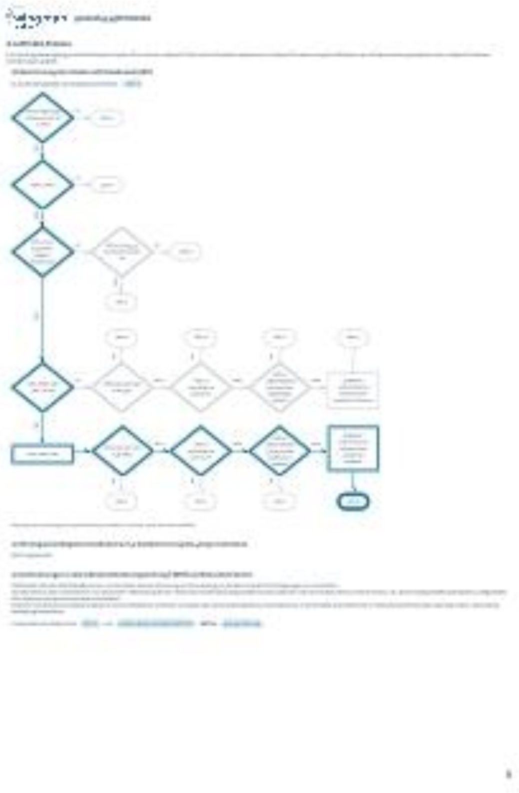


Abbildung 17 SORA-Formular (FV.GO-UASOPA-01/03)

Mitigation	Level of robustness	Remarks (e.g. EASA design verification)	Reference to documentation
	Tactical mitigations performance requirements		
TMPR level	☐ VLOS (deconfliction scheme) ☐ BVLOS ☐ No requirement (ARC-a) ☐ Low requirement (ARC-b) ☐ Medium requirement (ARC-c) ☐ High requirement (ARC-d)		Document name: [illegible] Page number: [illegible] Chapter number: [illegible]
TMPR function	Detect		Document name: [illegible] Page number: [illegible] Chapter number: [illegible]
	Decide		Document name: [illegible] Page number: [illegible] Chapter number: [illegible]
	Command		Document name: [illegible] Page number: [illegible] Chapter number: [illegible]
	Execute		Document name: [illegible] Page number: [illegible] Chapter number: [illegible]
	Feedback loop		Document name: [illegible] Page number: [illegible] Chapter number: [illegible]
TMPR robustness	TMPR integrity and assurance objectives		Document name: [illegible] Page number: [illegible] Chapter number: [illegible]
	Safety requirement		
Safety requirement	☐ Basic containment ☐ Enhanced containment		Document name: [illegible] Page number: [illegible]

[illegible]

Abbildung 18 SORA-Formular (FV.GO-UASOPA-01/03)

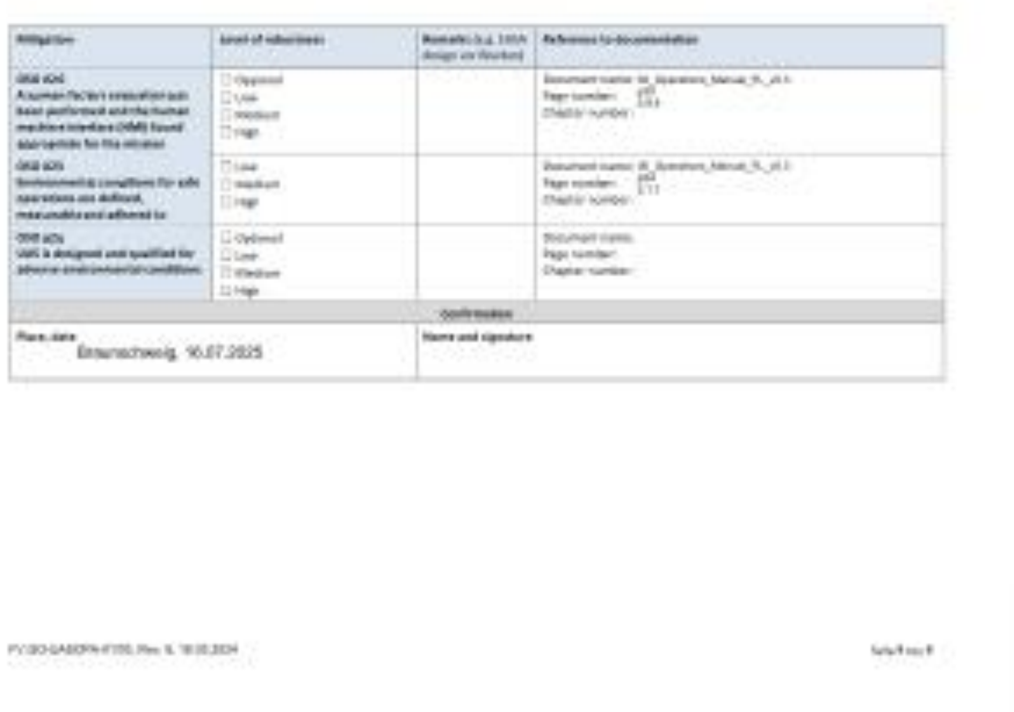
Mitigation	Level of robustness	Remarks (e.g. EASA design verification)	Reference to documentation
Operational Safety Objectives			
OSO #01 Ensure that the UAS operator is competent and/or proven	☐ Optional ☐ Low ☐ Medium ☐ High		Document name: [illegible] Page number: [illegible] Chapter number:
OSO #02 UAS manufactured by competent and/or proven entity	☐ Optional ☐ Low ☐ Medium ☐ High		Document name: [illegible] Page number: [illegible] Chapter number:
OSO #03 UAS maintained by competent and/or proven entity	☐ Low ☐ Medium ☐ High		Document name: [illegible] Page number: [illegible] Chapter number:
OSO #04 UAS developed to authority recognised design standards	☐ Optional ☐ Low ☐ Medium ☐ High		Document name: Page number: Chapter number:
OSO #05 UAS is designed considering system safety and reliability	☐ Optional ☐ Low ☐ Medium ☐ High		Document name: Page number: Chapter number:
OSO #06 C3 link characteristics are appropriate for the operation	☐ Optional ☐ Low ☐ Medium ☐ High		Document name: [illegible] Page number: [illegible] Chapter number:
OSO #07 Inspection of the UAS (product inspection) to ensure consistency with the ConOps	☐ Low ☐ Medium ☐ High		Document name: [illegible] Page number: [illegible] Chapter number:

FV.GO-UASOPA-01/03, Rev. [illegible] [illegible]

Abbildung 19 SORA-Formular (FV.GO-UASOPA-01/03)

Mitigation	Level of robustness	Remarks (e.g. [illegible])	Reference to documentation
OSO #08, OSO #11, OSO #14 and OSO #21 Operational procedures	☐ Low ☐ Medium ☐ High		Document name: [illegible] Page number: [illegible] Chapter number:
OSO #09, OSO #15 and OSO #22 Remote crew competencies	☐ Low ☐ Medium ☐ High		Document name: [illegible] Page number: [illegible] Chapter number:
OSO #10 and OSO #12 Safe design	☐ Low ☐ Medium ☐ High		Document name: [illegible] Page number: [illegible] Chapter number:
OSO #13 External services supporting UAS operations are adequate for the operation	☐ Low ☐ Medium ☐ High		Document name: [illegible] Page number: [illegible] Chapter number:
OSO #16 Multi crew coordination	☐ Low ☐ Medium ☐ High		Document name: [illegible] Page number: [illegible] Chapter number:
OSO #17 Remote crew is fit to operate	☐ Low ☐ Medium ☐ High		Document name: [illegible] Page number: [illegible] Chapter number:
OSO #18 Automatic protection of the flight envelope from human error	☐ Optional ☐ Low ☐ Medium ☐ High		Document name: Page number: Chapter number:
OSO #19 Safe recovery from human error	☐ Optional ☐ Low ☐ Medium ☐ High		Document name: Page number: Chapter number:

Abbildung 20 SORA-Formular (FV.GO-UASOPA-01/03)



[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	☐ Optional ☐ Low ☐ Medium ☐ High		Document name: [illegible] Page number: [illegible] Chapter number:
[illegible]	☐ Low ☐ Medium ☐ High		Document name: [illegible] Page number: [illegible] Chapter number:
[illegible]	☐ Optional ☐ Low ☐ Medium ☐ High		Document name: Page number: Chapter number:
Confirmation			
Place, date Braunschweig, 16.07.2025		Name and signature	

Abbildung 21 SORA-Formular (FV.GO-UASOPA-01/03)

5.3.3 Risikobewertung für Drohnenflug

Abbildung 22 Risikobewertung für Drohnenflug

Abbildung 23 Risikobewertung für Drohnenflug

Abbildung 24 Risikobewertung für Drohnenflug

Abbildung 25 Risikobewertung für Drohnenflug

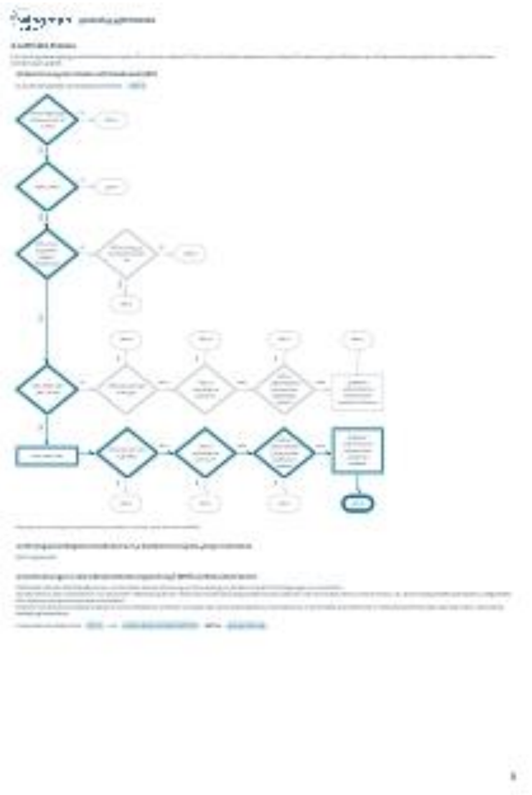


Abbildung 26 Risikobewertung für Drohnenflug

Abbildung 27 Risikobewertung für Drohnenflug

Abbildung 28 Risikobewertung für Drohnenflug

Abbildung 29 Risikobewertung für Drohnenflug

Abbildung 30 Risikobewertung für Drohnenflug

Abbildung 31 Risikobewertung für Drohnenflug

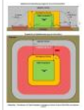
5.3.4 Berechnung der Ausdehnungen der Fluggebiete

Die Berechnung der Ausdehnung des Fluggebietes erfolgt mittels ausgefüllter Excel-Berechnungshilfe des Deutschen Zentrums für Luft- und Raumfahrt.

Im folgenden finden sich die Berechnungen jeweils für den Startbereich, den Bereich der Flugstrecke, und den Landebereich.

Berechnungstool zur Dimensionierung von Flight Geography, Contingency Volume und Ground Risk Buffer													
												Version:	1.8
Angaben zum verwendeten UAV												basierend auf den Gleichungen aus Leitfaden zur Dimensionierung von Flight Geography, Contingency	
			Typ		Multikopter							Volume und Ground Risk	

												Buffer in Revision 1.6 (20.11.2023)	
					Multikopter								
		Maximale im Betrieb geflogene Geschwindigkeit	v0	=	5	m/s	5					Angaben zu Antragsteller:	
		Maximal charackteristische Dimension UAV	CD	=	1.77	m							
		Höhenmessfehler										Name:	Deutsches Zentrum für Luft- und Raumfahrt e.V.
		- barometrisch	HΔ	=	1	m	Eigener Wert:		m			e-ID:	DEUu3vtmt4tt9e8y
		GPS – Ungenauigkeit	SGPS	=	3	m	Eigener Wert:		m			Datum:	11/19/2025
		Positionshaltefehler	SPos	=	3	m	Eigener Wert:		m				
		Kartenfehler	SK	=	1	m	Eigener Wert:		m			Beispielhafte Darstellung von flight geography, contingency volume, ground	

												risk buffer und adjacent area:									
		Reaktionszeit des Fernpiloten / der Automatik	tRZ	=	1	s															
8.1 Mindestmaß der Flight Geography (FG)																					
		Höhe Flight Geography	HFG	=	25	m					25										
		Mindesthöhe bei kleinen FG	HFG	≥	5.31	m															
		Mindestbreite bei kleinen FG	SFG	≥	5.31	m															
8.2 Berechnung Contingency Volume (CV)																					
	Lateral																				

		Contingency Manöver:	Anhalten						0				
		Nickwinkel	Θ	=	30	°					2.20699644 2		
					2								
		Reaktionsweg	SRZ	=	5	m							
		Contingency Manöver	SCM	=	2.2	m							
		Minimum laterale Ausdehnung des CV	SCV	≥	14.2	m (Tipp: Ergänzen Sie einen sinnvollen Sicherheitspuffer in der kml)					14.2069964 4		
	Vertikal												
		Reaktionshöhe	HRZ	=	3.5	m	Eigener Wert:		m				
		Contingency Manöver:	Kinetische in potentielle Energie umwandeln						0	1.2742099 9	0.76452599 4		
					2		2			7	7		

			HCM	=	1.3	m							
		Minimum vertikale Ausdehnung des CV	HCV	=	30.8	m					30.8		
8.3 Berechnung Ground Risk Buffer (GRB)													
		Methode der Terminierung:	Vereinfachter Ansatz (1:1 Regel)						1				
		Gleitzahl	E	=	20								
		Öffnungszeit Fallschirm	t	=	1.5	s							
		Maximal zulässige Windgeschwindigkeit	vWind	=	3	m/s							
		Sinkgeschwindigkeit mit geöffneten Fallschirm	vZ	=	5	m/s							

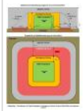
		Minimum laterale Ausdehnung GRB	SGRB	≥	31.7	m (Tipp: Ergänzen Sie einen sinnvollen Sicherheitspuffer in der kml)					31.7		
8.4 Berechnung Adjacent Volume													
		Adjacent volume lateral	SAV	=	600	m							
		Adjacent volume vertikal	HAV	=	180.8	m	593.1	ft					
9 Berechnung VLOS/BVLOS - Grenze													
		Attitude Line of Sight	ALOSmax	=	598.8	m							

		Ground Visibility - Bodensicht (GVmax = 5000 m)	GV	=	5000	m	Eigener Wert:		m				
		Detection Line of Sight	DLOSmax	=	1500	m							
		VLOS Grenze	VLOSmax	=	598.8	m							

Tabelle 23 Berechnungstool_FG_CV_GRB_de_SAFIR-ready_v1.0 Start.xlsx

Berechnungstool zur Dimensionierung von Flight Geography, Contingency Volume und Ground Risk Buffer													
												Version:	1.8

Angaben zum verwendeten UAV												basierend auf den Gleichungen aus Leitfaden zur Dimensionierung von Flight Geography, Contingency	
			Typ		Multikopter							Volume und Ground Risk Buffer in Revision 1.6 (20.11.2023)	
					Multikopter								
		Maximale im Betrieb geflogene Geschwindigkeit	v0	=	10	m/s	10					Angaben zu Antragsteller:	
		Maximal charackteristische Dimension UAV	CD	=	1.77	m							
		Höhenmessfehler										Name:	Deutsches Zentrum für Luft- und Raumfahrt e.V.
		- barometrisch	$H\Delta$	=	1	m	Eigener Wert:		m			e-ID:	DEUu3vtmt4tt9e8y

		GPS – Ungenauigkeit	SGPS	=	3	m	Eigener Wert:	m				Datum:	11/19/2025
		Positionshaltefehler	SPos	=	3	m	Eigener Wert:	m					
		Kartenfehler	SK	=	1	m	Eigener Wert:	m				Beispielhafte Darstellung von flight geography, contingency volume, ground risk buffer und adjacent area:	
		Reaktionszeit des Fernpiloten / der Automatik	tRZ	=	1	s							
8.1 Mindestmaß der Flight Geography (FG)													
		Höhe Flight Geography	HFG	=	50	m					50		
		Mindesthöhe bei kleinen FG	HFG	≥	5.31	m							

		Mindestbreite bei kleinen FG	SFG	≥	5.31	m							
8.2 Berechnung Contingency Volume (CV)													
	Lateral												
		Contingency Manöver:	Anhalten						0				
		Nickwinkel	Θ	=	30	°					8.827985767		
					2								
		Reaktionsweg	SRZ	=	10	m							
		Contingency Manöver	SCM	=	8.8	m							
		Minimum laterale Ausdehnung des CV	SCV	≥	25.8	m (Tipp: Ergänzen Sie einen sinnvollen Sicherheitspuffer in der kml)					25.82798577		

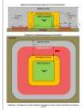
	Vertikal												
		Reaktionshöhe	HRZ	=	7.0	m	Eigener Wert:		m				
		Contingency Manöver:	Kinetische in potentielle Energie umwandeln						0	5.096839959	3.058103976		
					2		2			14	14		
			HCM	=	5.1	m							
		Minimum vertikale Ausdehnung des CV	HCV	=	63.1	m					63.1		
8.3 Berechnung Ground Risk Buffer (GRB)													
		Methode der Terminierung:	Vereinfachter Ansatz (1:1 Regel)						1				
		Gleitzahl	E	=	20								

		Öffnungszeit Fallschirm	t	=	1.5	s							
		Maximal zulässige Windgeschwindigkeit	vWind	=	3	m/s							
		Sinkgeschwindigkeit mit geöffneten Fallschirm	vZ	=	5	m/s							
		Minimum laterale Ausdehnung GRB	SGRB	≥	64.0	m (Tipp: Ergänzen Sie einen sinnvollen Sicherheitspuffer in der kml)					64.0		
8.4 Berechnung Adjacent Volume													
		Adjacent volume lateral	SAV	=	1200	m							
		Adjacent volume vertikal	HAV	=	213.1	m	699.1	ft					

9 Berechnung VLOS/BVLOS - Grenze													
		Attitude Line of Sight	ALOSmax	=	598.8	m							
		Ground Visibility - Bodensicht (GVmax = 5000 m)	GV	=	5000	m	Eigener Wert:		m				
		Detection Line of Sight	DLOSmax	=	1500	m							
		VLOS Grenze	VLOSmax	=	598.8	m							

Tabelle 24 Berechnungstool_FG_CV_GRB_de_SAFIR-ready_v1.0 Strecke.xlsx

Berechnungstool zur Dimensionierung von Flight Geography, Contingency Volume und Ground Risk Buffer													
												Version:	1.8
Angaben zum verwendeten UAV												basierend auf den Gleichungen aus Leitfaden zur Dimensionierung von Flight Geography, Contingency	
			Typ		Multikopter							Volume und Ground Risk Buffer in Revision 1.6 (20.11.2023)	
					Multikopter								
		Maximale im Betrieb geflogene Geschwindigkeit	v0	=	5	m/s	5					Angaben zu Antragsteller:	

		Maximal charackteristische Dimension UAV	CD	=	1.77	m							
		Höhenmessfehler										Name:	Deutsches Zentrum für Luft- und Raumfahrt e.V.
		- barometrisch	HΔ	=	1	m	Eigener Wert:		m			e-ID:	DEUu3vtmt4tt9e8y
		GPS – Ungenauigkeit	SGPS	=	3	m	Eigener Wert:		m			Datum:	11/19/2025
		Positionshaltefehler	SPos	=	3	m	Eigener Wert:		m				
		Kartenfehler	SK	=	1	m	Eigener Wert:		m			Beispielhafte Darstellung von flight geography, contingency volume, ground risk buffer und adjacent area:	
		Reaktionszeit des Fernpiloten / der Automatik	tRZ	=	1	s							
8.1 Mindestmaß der Flight													

Geography (FG)													
		Höhe Flight Geography	HFG	=	25	m					25		
		Mindesthöhe bei kleinen FG	HFG	≥	5.31	m							
		Mindestbreite bei kleinen FG	SFG	≥	5.31	m							
8.2 Berechnung Contingency Volume (CV)													
	Lateral												
		Contingency Manöver:	Anhalten						0				
		Nickwinkel	Θ	=	30	°					2.20699644 2		
					2								
		Reaktionsweg	SRZ	=	5	m							
		Contingency Manöver	SCM	=	2.2	m							

		Minimum laterale Ausdehnung des CV	SCV	≥	14.2	m (Tipp: Ergänzen Sie einen sinnvollen Sicherheitspuffer in der kml)					14.20699644		
	Vertikal												
		Reaktionshöhe	HRZ	=	3.5	m	Eigener Wert:		m				
		Contingency Manöver:	Kinetische in potentielle Energie umwandeln						0	1.27420999	0.764525994		
					2		2			7	7		
			HCM	=	1.3	m							
		Minimum vertikale Ausdehnung des CV	HCV	=	30.8	m					30.8		

8.3 Berechnung Ground Risk Buffer (GRB)													
		Methode der Terminierung:	Vereinfachter Ansatz (1:1 Regel)						1				
		Gleitzahl	E	=	20								
		Öffnungszeit Fallschirm	t	=	1.5	s							
		Maximal zulässige Windgeschwindigkeit	vWind	=	3	m/s							
		Sinkgeschwindigkeit mit geöffneten Fallschirm	vZ	=	5	m/s							
		Minimum laterale Ausdehnung GRB	SGRB	≥	31.7	m (Tipp: Ergänzen Sie einen sinnvollen Sicherheitspuffer in der kml)					31.7		

8.4 Berechnung Adjacent Volume													
		Adjacent volume lateral	SAV	=	600	m							
		Adjacent volume vertikal	HAV	=	180.8	m	593.1	ft					
9 Berechnung VLOS/BVLOS - Grenze													
		Attitude Line of Sight	ALOSmax	=	598.8	m							
		Ground Visibility - Bodensicht (GVmax = 5000 m)	GV	=	5000	m	Eigener Wert:		m				
		Detection Line of Sight	DLOSmax	=	1500	m							

		VLOS Grenze	VLOSmax	=	598.8	m															

Tabelle 25 Berechnungstool_FG_CV_GRB_de_SAFIR-ready_v1.0 Landung.xlsx

5.3.5 *.kml Dateien der Fluggebiete

Die grafischen Darstellungen der *.kml-Dateien finden sich im Abschnitt zu den lokalen Aspekten weiter unten.

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Codeblock 1 Flightarea_Braunschweig_v1.1.kml

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Codeblock 3 Flightarea_Rostock_v1.1.kml

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5.3.6 Zusätzliche Dokumente

5.3.6.1 Übersicht

Weitere Dokumente sind gemäß Operations_Manual_FL_v1.0, Seite 4 die folgenden.

Name	Revision Number	Description
Local_Aspects	1.0	Coordinates, description and calculations of flight areas
OM(D)	1.0	Training manual and role allocation, Part D was outsourced and is not under revision control
IM-SAFE-Checklist	1.0	Query of the most important aspects that speak against a temporary fitness to fly
Flight Test Card	1.0	All relevant data of the test flight (e.g. weather, crew, UA)
Maintenance Manual HD4-1100	1.0	Maintenance instruction for the HD4-1100
Configuration and Maintenance Log	1.0	Recording of changes, repairs and regular maintenance
Checklist	1.0	Preflight, Inflight and Postflight checklist

Tabelle 26 Liste der zusätzlichen Dokumente zum Betriebsgenehmigungsantrag

5.3.6.2 Local_Aspects

5.3.7 1 Flight Area 1 (Braunschweig)

5.3.7.1 1.1 Description

The following flight area is located in Braunschweig/Germany .

The flight area and its exact coordinates is described in the file “ Flightarea_Braunschweig.kml ” and is shown in the illustration below.

The center point of the illustration is at the following coordinates: N52.244604, E10.561115 .

The pilot's position is at the landing site at the following coordinates: N52,2510679 E10,5752186 .

The maximum flight altitude (H FG) is 30 m AGL (above ground level) for departure and arrival phase and 80 m AGL (above ground level) for cruise flight .

5.3.7.2 1.2 Calculation of CV / GRB

The calculation of the contingency volumes and of the ground risk buffer is based on the guidelines of the volume planner of Digital Platform for Unmanned Aviation (dipul), version 4.6.4.

1.2.1 Input values used for the calculation of CV/GRB

UAS properties

- Type: Rotorcraft without parachute
- Type of altimetry: Barometric
- Maximum speed V_0 : 10.0 m/s
- Maximum wind speed allowed V_{Wind} : 8.0 m/s
- Characteristic Dimension: 1.77 m

- Maximum pitch angle Θ_{max} : 30.0 °
- ~~Parachute opening time $t_{parachute}$: 2.0 s~~
- ~~Descent rate with parachute v_z : 2.0 m/s~~

- The following parameters have been used:
- Height of flight geography H_{FG} :
  - Departure and Arrival: 30.0 m
  - Cruise: 80.0 m
- Calculation method: From inside
- Horizontal contingency volume Manoeuvre: stopping
- Vertical contingency manoeuvre: stopping
- Ground risk buffer manoeuver: Ballistic

- Assumptions
- GPS inaccuracy S_{GPS} : 3.0 m
- Position holding error S_{POS} : 3.0 m
- Map error S_K : 1.0 m
- Reaction time t_{Reak} : 1.0 s
- Altitude error (barometric) H_{Baro} : 1.0 m
- Altitude error (GPS) H_{Baro} : 4.0 m
- Additional error (horizontal) S_{Add} : 0.0 m
- Additional error (vertical) H_{Add} : 0.0 m

- Rationales for deviation from standard parameters:
- S_{GPS} : 3.0 m Default value
- S_{POS} : 3.0 m Default value
- S_K : 1.0 m Default value
- t_{Reak} : 1.0 s Default value

- H_{Baro} : 1.0 s Default value
- H_{GPS} : 4.0 m Default value

5.3.7.3 o Results of the CV/GRB calculation

- Departure and arrival phase:
  - Horizontal contingency volume S_{CV} : 14.2 m
  - Vertical contingency volume H_{CV} : 35.8 m
  - Ground risk buffer calculation S_{GRB} : 14.4 m
  - Height of flight geography H_{FG} : 30.0 m
- Cruise phase:
  - Horizontal contingency volume S_{CV} : 25.8 m
  - Vertical contingency volume H_{CV} : 93.1 m
  - Ground risk buffer calculation S_{GRB} : 44.5 m
  - Height of flight geography H_{FG} : 80.0 m

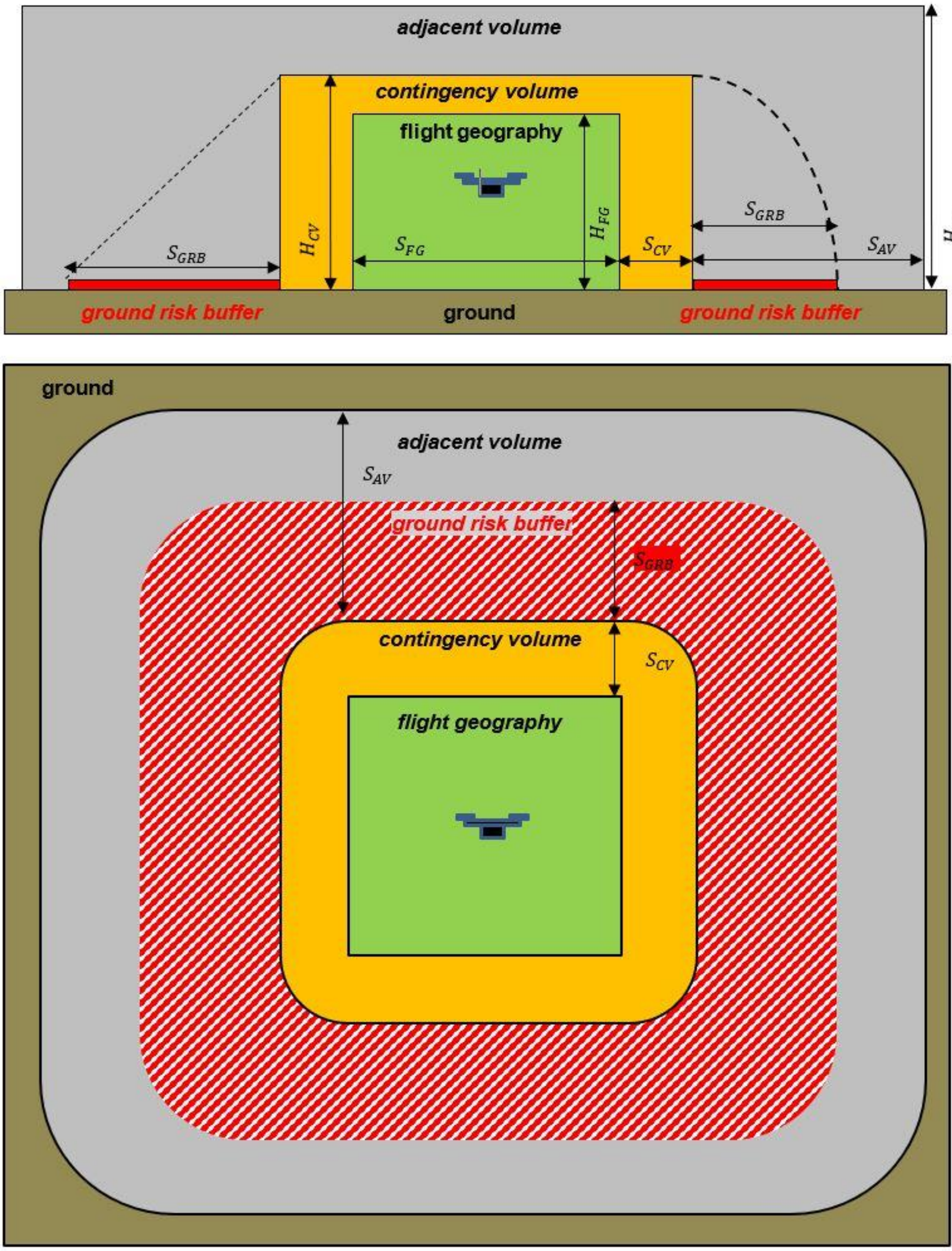

Figure 2: Simplified presentation of flight geography, contingency volume and ground risk buffer

5.3.7.4 1.3 Specific Procedures of the Flight Area

1.3.1 Controlled Ground

Not applicable

1.3.2 M1 Mitigation

M1(A) is Low, since cars on the motorway are considered to give an adequate shelter. Coordination with helipad in hospital area is ensured. Golf club reservations are found out in advance and ensured to be < 30 persons/km². Contact to Deutsche Bahn is made via sky-operations@deutschebahn.com

1.3.3 ARC-Mitigation

ARC-c □ ARC-b

Contact to helipad operator: Express authorisation from the hospital or helipad operator must be obtained in advance. This includes approval of the flight planning.

Operating regulations:

Airspace observer: An additional spotter must be used to immediately recognise manned aircraft/helicopter.

Abort protocols: The drone must land immediately when a helicopter approaches.

1.3.4 Information to Third Parties

In case third parties are affected by the operation, all necessary information will be provided in advance to all persons concerned and relevant authorisations will be obtained if needed.

1.3.5 Documentation

The flight locations are recorded in the Flight-Log.

All data must be available for an audit at any time.

5.3.7.5 1.4 Emergency Response Plan (ERP) - Local Information

Instructions and completion aids for the ERP template (see Operations Manual section 8.3.1)

Air traffic controllers possibly affected (ATM)

- Bremen (Wachleiter) +49(0) 421 5372141
- Braunschweig +49(0) 531 3544030

Rescue Coordination Centre:

- RCC Münster Land +49(0)251 135 757

E-Mail SARLeitstelleLand@bundeswehr.org

- ARCC Glücksburg See +49(0)4361 666 3255

E-Mail ARCCGlücksburg@bundeswehr.org

- MRCC Bremen +49(0)421 536 870

E-Mail mrcc@seenotretter.de

Nearest emergency services:

- Fire/Police/EMS 112

5.3.8 2 Flight Area 2 (Rostock)

5.3.8.1 2.1 Description

The following flight area is located near Rostock/Germany .

The flight area and its exact coordinates is described in the file " Flightarea_Rostock.kml " and is shown in the illustration below.

The center point of the illustration is at the following coordinates: N54.203296, E12.173386 .

The pilot's position is at the landing site at the following coordinates: N54.215012, E12.186611
.

The maximum flight altitude (H FG) is 30 m AGL (above ground level) for departure phase and 80 m AGL (above ground level) for cruise flight .

5.3.8.2 2.2 Calculation of CV / GRB

The calculation of the contingency volumes and of the ground risk buffer is based on the guidelines of the volume planner of Digital Platform for Unmanned Aviation (dipul), version 4.6.4.

2.2.1 Input values used for the calculation of CV/GRB

UAS properties

- Type: Rotorcraft without parachute
- Type of altimetry: Barometric
- Maximum speed V_0 : 10.0 m/s
- Maximum wind speed allowed V_{Wind} : 8.0 m/s
- Characteristic Dimension: 1.77 m

- Maximum pitch angle Θ_{max} : 30.0 °
- ~~Parachute opening time $t_{parachute}$: 2.0 s~~
- ~~Descent rate with parachute v_z : 2.0 m/s~~

- The following parameters have been used:
- Height of flight geography H_{FG} :
  - Departure and Arrival: 30.0 m
  - Cruise: 80.0 m
- Calculation method: From inside
- Horizontal contingency volume Manoeuvre: stopping
- Vertical contingency manoeuvre: stopping
- Ground risk buffer manoeuver: Ballistic

- Assumptions
- GPS inaccuracy S_{GPS} : 3.0 m
- Position holding error S_{POS} : 3.0 m
- Map error S_K : 1.0 m
- Reaction time t_{Reak} : 1.0 s
- Altitude error (barometric) H_{Baro} : 1.0 m
- Altitude error (GPS) H_{Baro} : 4.0 m
- Additional error (horizontal) S_{Add} : 0.0 m
- Additional error (vertical) H_{Add} : 0.0 m

- Rationales for deviation from standard parameters:
- S_{GPS} : 3.0 m Default value
- S_{POS} : 3.0 m Default value
- S_K : 1.0 m Default value
- t_{Reak} : 1.0 s Default value

- H_{Baro} : 1.0 s Default value
- H_{GPS} : 4.0 m Default value

5.3.8.3 o Results of the CV/GRB calculation

- Departure and arrival phase:
  - Horizontal contingency volume S_{CV} : 14.2 m
  - Vertical contingency volume H_{CV} : 35.8 m
  - Ground risk buffer calculation S_{GRB} : 14.4 m
  - Height of flight geography H_{FG} : 30.0 m
- Cruise phase:
  - Horizontal contingency volume S_{CV} : 25.8 m
  - Vertical contingency volume H_{CV} : 93.1 m
  - Ground risk buffer calculation S_{GRB} : 44.5 m
  - Height of flight geography H_{FG} : 80.0 m

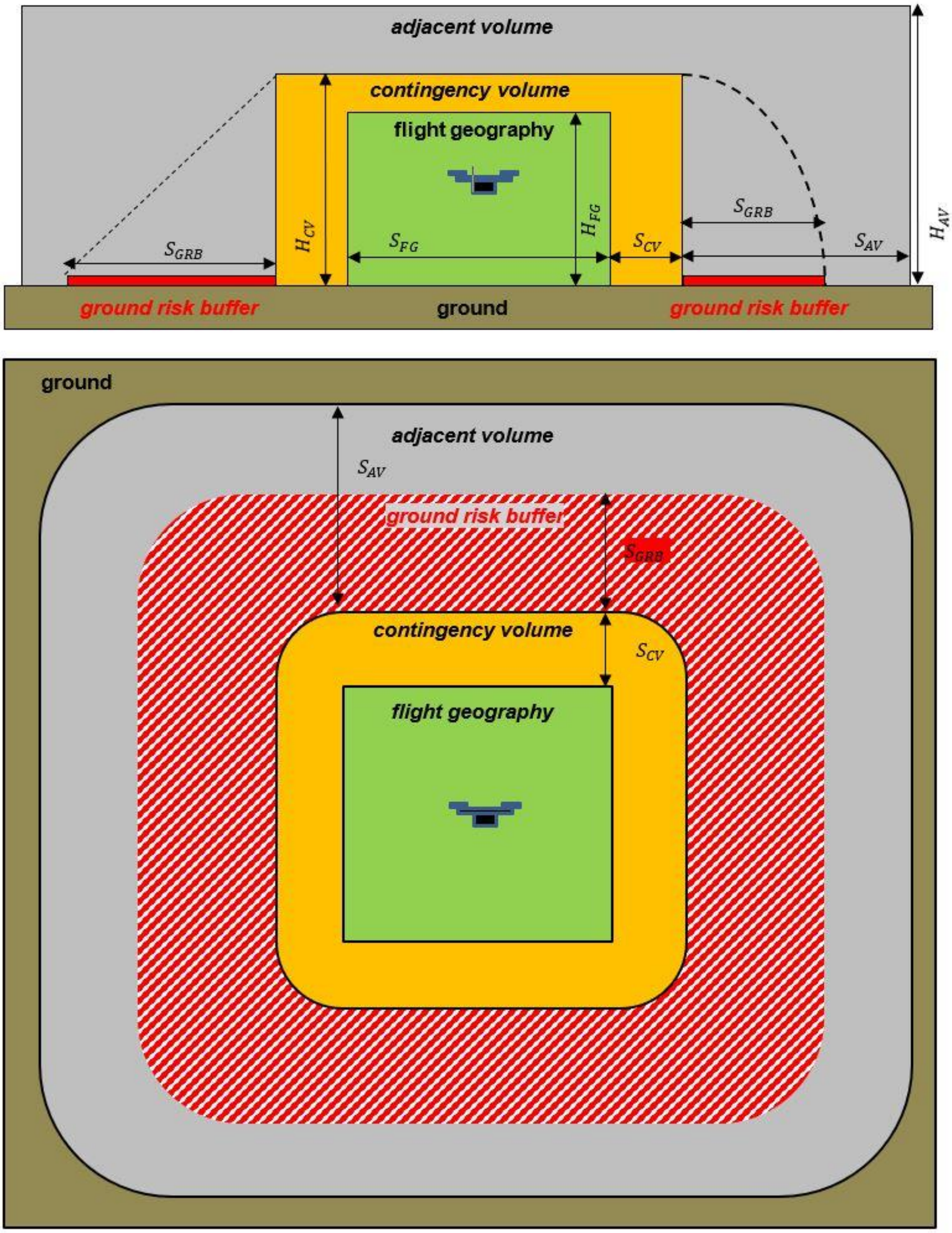

Figure 2: Simplified presentation of flight geography, contingency volume and ground risk buffer

5.3.8.4 2.3 Specific Procedures of the Flight Area

2.3.1 Controlled Ground

Not applicable

2.3.2 M1 Mitigation

M1(A) is Low. Tennis chord reservations are found out in advance and ensured to be < 30 persons/km². The parking area will be controlled by a crew member and ensured to be < 30 persons/km².

2.3.3 ARC-Mitigation

Not applicable

2.3.4 Information to Third Parties

In case third parties are affected by the operation, all necessary information will be provided in advance to all persons concerned and relevant authorisations will be obtained if needed.

2.3.5 Documentation

The flight locations are recorded in the Flight-Log.

All data must be available for an audit at any time.

5.3.8.5 2.4 Emergency Response Plan (ERP) - Local Information

Instructions and completion aids for the ERP template (see Operations Manual section 8.3.1)

Air traffic controllers possibly affected (ATM)

- Bremen (Wachleiter) +49(0) 421 5372141
- Rostock Laage +49(0) 38454 321390

Rescue Coordination Centre:

- RCC Münster Land +49(0)251 135 757

E-Mail SARLeitstelleLand@bundeswehr.org

- ARCC Glücksburg See +49(0)4361 666 3255

E-Mail ARCCGlücksburg@bundeswehr.org

- MRCC Bremen +49(0)421 536 870

E-Mail mrcc@seenotretter.de

Nearest emergency services:

- Fire/Police/EMS 112

5.3.8.6 OM(D)

OM(D)

Training and role allocation

Version 1.0

Dokumenteigenschaften(see page 99)

Titel	Training and role allocation
Institut	Institute of Flight Guidance
Erstellt von	Andreas Volkert
Datum	04.07.2025

5.3.9 Document Control

The contents of this document and all other applicable documents are subject to revision control and changes require prior approval of the competent authority.

(see page 99)

Revision Number	Revision Date	Name	Description of the Change
0	30.10.2021	Andreas Volkert	Initial document
1	04.07.2025	Andreas Volkert	Deleted roles “Ground Observer” and “Emergency Responder”.

			Deleted “Crew Rest Guidelines”. Enhanced the role “Remote Pilot” to “Remote Pilot in Command”

Inhaltsverzeichnis

5.3.10 1. Training

All staff involved in UAS operations have a formal scientific or technical education. The skills and knowledge of the individual person, necessary for a safe UAS operations, are mainly obtained by self-training or passed on by experienced members of the UAS operations team. Where necessary, certificates from certified third parties are obtained i.e. the German National Civil Aviation Authority.

The roles and responsibilities presented in this document have been proven to be efficient. The denominations used in this document do not refer to the partly licensed denominations used in manned aviation.

The term "responsibility" is not directly associated with a single person. During experiments one person can hold several roles. It is crucial that the responsibilities are clearly assigned.

5.3.10.1 1.1. Role descriptions and duties

During numerous flight tests of several unmanned aircraft systems by DLR, specific roles have been identified. Their nominal communication flow is shown in Figure 2.2. The roles are documented explicitly within the team to avoid inefficiencies or misunderstanding. During less complex experiments some of these roles might be occupied by one person. However, experience shows that all roles should be assigned separately as often as possible to decrease workload and thus the probability of errors.

This section gives a short description of the different roles defined for the members of the flight crew. In the following all roles are listed:

- Flight Test Lead (FTL)
- Safety Pilot (SP)
- Remote Pilot in Command (RPIC)
- Airspace Observer (AO)
- Design Engineer (DE)
- Maintenance Technician (MT)

1.1.1. Flight Test Lead (FTL)

A Flight Test Lead (FTL) is responsible for the safe flight test operations. The FTL is in charge of the preparation for the flight operation. He or she schedules the flight test operation, allocates all necessary resources and submits the flight order to the head of department for approval. The FTL is responsible for the safe operation. This includes the planning of the test assets in cooperation with the DE, the planning of the waypoint mission in cooperation with the GCS, the performance of the preflight checks and safety assessment in cooperation with the RP. The FTL briefs the flight crew on the specifics of the flight operation. The FTL assigns the observation tasks to the AO and coordinates the communication between crew members. The FTL gives clearance for takeoff, monitors and commands execution of flight operation according to flight test cards. The FTL is authorized to abort the flight operation by landing or flight termination. In the case of an emergency the FTL manages the execution of the emergency responds plan. The role of FTL is mandatory and should be filled by an experienced researcher who has participated in flight tests for years.

The FTL can also be the RPIC in one person.

1.1.2. Remote Pilot in Command (RPIC)

The Remote Pilot in Command (RPIC) is responsible for the whole flight. He can delegate the flying of the UA to the SP (e.g. in VLOS), but has to monitor the flight at all time and intervene as necessary.

The handover to the SP is done with the phrase “You have control”, with the SP responding/acknowledging “I have control”. The handover from the SP back to the RPIC is done with the phrase "I have control", with the SP responding “You have control”.

The RPIC is also planning the mission for the UA through the ground control software. The RPIC supervises the state of the system and sends mission commands to the aircraft. The RPIC informs the Flight Test Lead about problems, delays and status of the overall system.

The RPIC is responsible for the preflight check procedures. The RPIC can delegate his tasks to other crew members. The RPIC can also be the FTL in one person.

1.1.3. Safety Pilot (SP)

The Safety Pilot (SP) is allowed to fly the UA in VLOS, when the RPIC hands over the control to him. He inspects the aircraft in preparation of the flight. He is empowered to abort an automated mission or experiment without confirmation of the FTL or RPIC, when the situation demands it.

During automatic flights, the SP shall observe the UA and be ready to take control at any time. The SP may abort a test, if he believes that the aircraft is entering an unsafe condition without direct coordination with the FTL or RPIC. Controlling the UA in BVLOS is only allowed in unusal contingencies or emergencies (e.g. loss of link to GCS or loss of GNSS).

1.1.4. Airspace Observer (AO)

An Airspace Observer (AO) is responsible for the visual detection of flying objects within the operational volume. The observer continuously scans the airspace with or without binoculars for other air traffic or birds that may pose a threat to the UAS or be threatened by the UAS operation. The airspace observer shall report airborne threats to the FTL with bearing, altitude and distance information, if possible. If the RP is not able to handle the communication with other air traffic participants, the AO takes over this task. For this purpose, he uses an approved aeronautical radio and knows the rules of aeronautical radio calls.

1.1.5. Design Engineer (DE)

A Design Engineer (DE) is responsible for the design decisions made to alter the aircraft.

The design engineer files and approves design change requests. Furthermore, the design engineer is responsible for and allowed to modify the aircraft according to the filed change requests. According to the changes made to the aircraft, the design engineer specifies required tests and test procedures in cooperation with the lead flight test engineer. The design engineer is responsible to keep the system description and the configuration

management documents (log book, declaration of configuration) up to date.

1.1.6. Maintenance Technician (MT)

A Maintenance Technician (MT) is responsible for conducting the required maintenance

procedures in compliance with the defined maintenance intervals. The MT tracks the performed number of flights and the corresponding flight hours and schedules the maintenance tasks as required. The MT performs all maintenance tasks, which do not require

maintenance by the manufacturer. This includes, but is not limited to, replacement of avionic systems, motors, motor controllers, parts of the fuselage, antennas, cabling and payload. Components that require maintenance by the manufacturer are unmounted by the maintenance engineer, shipped to the corresponding manufacturer for maintenance and thereafter reinstalled on the aircraft. All actions have to be filed as a maintenance change request to be approved by a second maintenance engineer or design engineer. The maintenance engineer is also responsible for the correct repacking of deployed parachutes using the manufacturer instruction and applying the "four-eyeprinciple". The technical condition of the aircraft is reported to the FTL during preparation checklist.

5.3.10.2 1.2. Role Qualifications

At DLR all staff involved in UAS operations has a scientific or technical education. The

respective UAS user manuals and safety guidelines are reviewed by the project team before

operation. The specific functions of the UAS and its operation are mostly self-trained. New

team members are introduced to their tasks by an experienced member and will operate

or maintain the UAS under direct supervision.

In order to operate the UAS safely, the crew members should complete different types of training

like:

1. Training of operational procedures:

- Familiarization with operational, contingency and emergency procedures
- Familiarization with crew documentation
- Conduction of flight tests to train procedures under supervision

1. Theoretical training in the field of aviation law, meteorology, flight operations and navigation:

- Knowledge on aviation law, meteorology, flight operations and navigation

1. Emergency Response Plan (ERP) training:

- Familiarization with emergency procedures
- Familiarization with emergency scenarios and corresponding responses

1. Practical safety training:

- Firefighting training
- First aid training

1. Remote pilot training in simulation and flight:

- Familiarization with ground control (hardware and software)
- Conduction of flight operation in simulation environment under supervision
- Conduction of flight operation in real flight test environment under supervision

1. Safety pilot training in flight

- Familiarization with remote control hardware
- Familiarization with switch assignment
- Mature experience in remote controlled UAS operations
- At least certificate of knowledge A1/A3
- Conduction of flight operation in real flight test environment under supervision

1. Training in configuration management process

- Familiarization with configuration management processes and documents
- Review of current configuration management log books and change requests

1. Training on system design

- Familiarization with system description
- Familiarization with aircraft

- Familiarization with data link
- Familiarization with autopilot
- Familiarization with remote control
- Familiarization with power distribution and battery
- Familiarization with parachute / flight termination
- Familiarization with detect and avoid system

1. Training on maintenance procedures

- Familiarization with the system description
- Familiarization with aircraft maintenance intervals and procedures
- Familiarization with parachute installation procedures
- Familiarization with parachute maintenance intervals and procedures
- Familiarization and practical training with parachute packing procedure under supervision

Table 1 shows the applicable assignment of qualifications required by the defined roles. For each role a training checklist has to be completed to qualify a person for that role.

Table 1 (see page 99): Required qualifications

Role	Competences be means of:
Lead Flight Test Engineer	1, 3, 4
Remote Pilot in Command	1, 2, 3, 4, 5, 8
Safety Pilot	1, 2, 3, 4, 6, 8
Airspace Observer	1, 3
Design Engineer	7, 8, 9
Maintenance Technician	7, 8, 9

5.3.10.3 1.3. Authorized Crew Members

Before personnel is authorized to take part in a flight operation in accordance with one of the described roles, the person in question must complete the training checklist associated with the role. The authorized personnel is tracked in Table 2 and the completed training checklists are archived as well. Self-study tasks such as familiarization with regulatory documents or the ConOps can be self-approved by the trainee. Tasks under supervision are approved by the supervisor respectively.

Table 2 (see page 99): Authorized Maintenance Personnel

	Authorized Roles					
	FTL	RPIC	SP	AO	DE	MT
Volkert, Andreas	X	X	X	X	X	X
Lieb, Joonas	X	X	X	X	X	X
Özcan, Batuhan		X		X		
Ebrecht, Lars			X	X		X
Kuenz, Alexander	X			X		
Schwoch, Gunnar(see page 99)		X		X		
Schuchardt, Bianca	X			X		
Nagrare, Samiksha			X	X		

5.3.10.4 IM-SAFE-Checklist

Projekt	Student				
Datum	09.11.23				
Pilot	A. Volkert				
IM SAFE Checkliste					
			nein	etwas	ja
I	Illness	Krankheit: Bestehen Krankheitssymptome, welche die Steuerungsfähigkeiten beeinflussen könnten?			
M	Medication	Mediakemente: Nehmen Sie aktuell Medikamente?			
S	Stress	Stress: Stehen Sie unter Stress oder psychischem Druck?			
A	Alcohol	Alkohol: Haben Sie in den letzten 12 Stunden Alkohol getrunken?			
F	Fatigue	Müdigkeit: Hatten Sie ausreichend Schlaf, Essen und Trinken?			
E	Emotion	Gefühle: Haben Sie ausreichend Abstand zu extremen Gefühlssituationen?			

Tabelle 27 IM-SAFE-Checklist

5.3.10.5 Flight Test Card

DLR		Flight Test Card						
		TITLE						KTR
AIRCRAFT SYSTEM		PERSONNEL			WEATHER CONDITION			SPACETIME
UAS SERIAL NUMBER		LEAD FLIGHT TEST ENGINEER	GCS OPERATOR	REMOTE PILOT	TEMERATURE	AIR PRESSURE	HUMIDITY	DATE
					°C	hPa	%	
CONFIGURATION	WEIGHT	GROUND CREW ASSISTANCE	GROUND OBSERVER	AIRSPACE OBSERVER	CLOUDS	WIND SPEED	WIND DIRECTION	LOCATION
					?/8	m/s	° SW	
ORGANIZATIONAL MATTERS								
LIABILITY INSURANCE		AVIATION AUTHORITY APPROVAL	AIR SPACE CLEARANCE	GROUND CLEARANCE	FLIGHT ORDER		TRAVEL APPLICATION FILED	
					-		-	

MINIMAL VOLUME DIMENSIONS									SPECIFIC OPERATIONS RISK ASSESSMENT		
GROUND RISK BUFFER [m]		CONTINGENCY VOLUME [m]		FLIGHT GEOMETRY [m]					GROUND RISK	AIR RISK	SAIL
		CHECKLISTS / TEST PROCEDURES						SIGNATURE			
	1	Preflight									
	2	IM SAFE									
	3	InFlight									
	4	PostFlight									
	5	Contingencies									
	6	Emergencies									

Tabelle 28 Flight Test Card

5.3.10.6 Maintenance Manual HD4-1100

Maintenance Manual

HD4-1100 “Rescue Drone“

Dokumenteigenschaften

Titel	Maintenance Manual HD4-1100
Erstellt von	Joonas Lieb
Datum	05.06.2025
Version	1.0

Table of Content

5.3.11 Foreword

To ensure that the aircraft continues to offer optimal performance and to ensure flight safety, it is recommended that comprehensive maintenance be performed after every 50 flights or 10 flight hours.

Document changes, repairs and regular maintenance in the Configuration and Maintenance Log:

https://teamsites-extranet.dlr.de/fl/MultiPurpose/Shared%20Documents/Forms/AllItems.aspx?FolderCTID=0x012000BE6E164DF35EB04B9C1DA15911083320&id=%2Ffl%2FMultiPurpose%2FShared%20Documents%2FUAS%2DBetrieb%2F02%20Maintenance

5.3.12 1. Checking the Battery

1) Check the battery for damage and deformities. If there are any signs of damage to the battery, stop using it and discharge the battery to 10% or below for disposal. Do not disassemble the battery for any reason.

2) Check the battery connectors for damage. If the connectors appear burnt, try to clear them. This can be done by inserting a piece of sandpaper (1mm thick) into the connectors to polish the metal.

3) Check the contact pins on the drone site to ensure that the pins are clear. They should be able to establish easy contact with the battery connectors and should not be burnt or loose.

4) Check the battery compartment to see it is in good condition and tighten the strips to secure the battery in the compartment.

5) For long term storage, check the battery once a month to prevent the battery cells from being damaged.

6) Connect the battery checker to confirm that all battery cells are at similar voltage levels and stay at the same level when the battery is fully charged. Check, if all cells maintain voltage levels above 3.7V and no cell is 0.2V higher or lower than the others.

5.3.13 2. Checking the Aircraft

1) Confirm that all arms, propeller and screws are adequately tightened.

2) Confirm that all parts in the belly are fit in their defined position.

3) Check the aircraft and its parts for breaks or damage, especially the landing gear and arms. If there is any reason to believe that detectable damage might affect flight safety, it must be repaired.

4) Check the antennas are tight and adequately oriented.

5) Check that the belly compartment is closed before flight.

5.3.14 3. Checking the Motors

1) Check the rotors to confirm that they have not become loose.

2) Check for deformities by confirming that the gap between the motor and motor base is even. If the gap difference is greater than 1mm, replace the affected motor.

3) Ensure that the screws used to secure the motor base are tight and in good condition.

5.3.15 4. Checking the Propellers

1) Check the propellers. If there is excessive bending or breakage of a propeller, replace it. Scratches, dents and small breakage is tolerable, if no vibrations occur for this reason.

2) Ensure that the screws used to secure the propellers are tight and in good condition.

3) Turn the motors on and observe the rotating propellers. Look for excessive vibrations, imbalances and equal motor spinning.

5.3.16 5. Checking the Flight Controller

1) Examine the flight controller for any unintentional loose cables or connections.

2) Check the proper and firm seat of the flight controller.

3) Create a backup of the parameters to the designated server location.

4) Check the firmware version and update, if applicable.

5.3.16.1 Configuration and Maintenance Log

Das Configuration und Maintenance Logbook wird beim Deutschen Zentrum für Luft- und Raumfahrt geführt und hier nicht erneut wiedergegeben.

5.3.16.2 Checklist

	Version				1.0
	Project				
	Date				
--> All items have to be checked before any flight operation --> Completion of this list has to be signed in the flight logbook and Flight Test Card					
CHECKLIST DRONE FLIGHT - PREFLIGHT					
	R	N/A	Y	N	Comments
BEFORE DAY OF THE FLIGHT					
UAV used: All approvals available Bureaucratic checks carried out, evidence available					
Flight area (ground) checked for restrictions in accordance with § 21 LuftVO, further permits applied for from the state aviation authority if necessary					
Insurance policies are up to date					
UAV identification/badge available					
Pilots have an EU drone license valid for the mission					
Permission from the landowner/authorized representative of the launch site available					

Airspace checked					
Airfields or heliports within a radius of less than 1.5 km checked					
Daily updated NOTAMs (Notices of Airmen) for the flight area checked					
Information given to police and/or authorities if necessary					
Flight area checked for obstacles and hazards					
Equipment packed					
First aid kit packed					
Ground control station, controller and drone batteries charged					
Firmware checked and updated if necessary					
Camera recordings: Personal rights of all participants and neighbors respected					
DAY OF THE FLIGHT					
Weather conditions checked					
Conditions checked on site: Crowds of people? Hazardous areas?					
Suitable take-off/landing site selected					
Launch site cordoned off/marked, people using the sidewalk informed if necessary					
Full charge status of all batteries checked (UAV, transmitter unit and ground station)					
IMSAFE checklist completed					
Emergency plan for unforeseen events is ready					
BEFORE TAKE-OFF					

Transport locks removed					
Frame and all components undamaged and correctly mounted					
Batteries correctly connected					
Freewheel of the motors checked					
Propeller correctly fitted and secure					
Exposed cables and plug connections checked and fixed					
Wind direction and wind speed checked					
SD cards present in devices					
All obstacles in the surrounding area checked and flight measures taken (e.g. distance to buildings, electricity pylons, trees)					
Take-off and landing position determined					
Any observers warned					
Payload/camera correctly attached (center of gravity observed)					
UAV, transmitter and ground station have connected and are ready for use					
Number of satellites for GPS support determined and all flight aids active					
Display error messages checked					
UAV is correctly calibrated					
Fail safe loaded correctly					
Operating modes of the UAV are displayed correctly					

All transmitter unit switches are in the correct starting position					
Correct flight mode set					
Camera/sensors preset					

Tabelle 29 Pre-Flight Checklist

CHECKLIST DRONE FLIGHT - INFLIGHT					
	R	N/A	Y	N	Comments
TAKE-OFF					
Safety distances taken					
Start motors					
Environment clear					
Hover for at least 10s at 5 m to check the flight behavior					
Control inputs reactive and correct					
INFLIGHT					

Check battery capacity/voltage regularly					
Check altitude regularly					
Check speed regularly					
LANDING					
Safety distances maintained					
Correct flight mode set					
Motors off					
KillSwitch activated					
Payload disabled					
Disconnect batteries					

Tabelle 30 In-Flight Checklist

--> All items have to be checked before any flight operation --> Completion of this list has to be signed in the flight logbook and Flight Test Card					
CHECKLIST DRONE FLIGHT - POSTFLIGHT					

	R	N/A	Y	N	Comments
POSTFLIGHT					
Batteries discharged to storage voltage					
Test flight card checked and filed					
Flight logbook completed					
Post flight report completed and filed					

Tabelle 31 Post-Flight Checklist

5.4 Verzeichnis der Akronyme und Abkürzungen

5.4.1 Deutsche Akronyme und Abkürzungen

Abkürzung	Begriff	Definition	Ggf. Quelle
ULS	unbemanntes Luftfahrzeugsystem		
VEB	Vollständig einsatzbereit		

Tabelle 32 Deutsche Akronyme und Abkürzungen

5.4.2 Internationale Akronyme und Abkürzungen

Abbreviation	Term	Definition	Source
2FA	Two Factor Authentication (see also MFA)		
3D	Three dimensional/dimensions (i. e., space)		
4D	Four dimensional/dimensions (i. e., space, and time)		
A/C	Aircraft		
AAIB	Aviation Accident Investigation Body		EASA Drone Incident Management at Aerodromes
AAM	Advanced Air Mobility	Term preferred by ICAO over UAM or UTM	
ADD	Architecture Design Document	A variant of an →SSDD.	
ADD	Automated Drone Dispatch		
ADR	Aerodrome (EASA shorthand for aerodrome)		EASA Drone Incident

Abbreviation	Term	Definition	Source
			Management at Aerodromes
AFIS	Aerodrome Flight Information Service		EASA Drone Incident Management at Aerodromes
AI	Artificial Intelligence		
AIM	Aeronautical Information Management		
AIP	Aeronautical Information Publication		EASA Drone Incident Management at Aerodromes
AIR-REPORT	A report from an aircraft in flight prepared in conformity with requirements for position, and operational and/or meteorological reporting.		
AIRAC	Aeronautical Information Regulation and Control		
AIS	Aeronautical Information Service		EASA Drone Incident Management at Aerodromes
AIXM	Aeronautical Information Exchange Model		
AMC	Alternative Means of Compliance		EASA Drone Incident Management at Aerodromes

Abbreviation	Term	Definition	Source
ANSP	Air Navigation Service Provider		EASA Drone Incident Management at Aerodromes
AOI	Area of interest		
API	Application Programming Interface		
APOC	Airport Operations Centre		EASA Drone Incident Management at Aerodromes
ARC	Air Risk Class (SORA)	SORA-related	
ARO	Authority Requirements for Air Operations		EASA Drone Incident Management at Aerodromes
ASP	Airport Security Programme		EASA Drone Incident Management at Aerodromes
ASSURE	Alliance for System Safety of UAS through Research Excellence		EASA Drone Incident Management at Aerodromes
ATC	Air Traffic Control		EASA Drone Incident Management at Aerodromes
ATCO	Air Traffic Control Officer		

Abbreviation	Term	Definition	Source
ATCU	Air Traffic Control Unit		
ATIS	Automatic terminal information service		EASA Drone Incident Management at Aerodromes
ATM	Air Traffic Management		EASA Drone Incident Management at Aerodromes
ATS	Air Traffic Service(s)		EASA Drone Incident Management at Aerodromes
ATSU	Air Traffic Service(s) Unit		
ATZ	Aerodrome Traffic Zone		Skybrary
BR	Basic Regulations		EASA Drone Incident Management at Aerodromes
BRLOS	Beyond Radio Line Of Sight		
BVLOS	Beyond Visual Line Of Sight		
C2	Command and Control link		EASA Drone Incident Management at Aerodromes
C2 Link	Command and Control link (see also CNPC)	Usually a wireless radio connection for command and control communications between the GCS and the UAV but may include more elements in a more	

Abbreviation	Term	Definition	Source
		complex setup such as telecommunications infrastructure elements.	
CAA	Civil Aviation Authority		EASA Drone Incident Managem ent at Aerodrom es
CAP	Civil Aviation Publication		EASA Drone Incident Managem ent at Aerodrom es
CANSO	Civil Air Navigation Services Organization		EASA Drone Incident Managem ent at Aerodrom es
CARS	Common Altitude Reference System		
CASA	Civil Aviation Safety Authority		
CAT	Commercial Air Transport operations		EASA Drone Incident Managem ent at Aerodrom es
CE	Conformité Européenne		EASA Drone Incident Managem ent at Aerodrom es
CEPT	Conférence Européenne des administrations des Postes et des Télécommunications (European Conference of Postal and		

Abbreviation	Term	Definition	Source
	Telecommunications Administrations)		
CET	Central European Time		
CIS	Common Information Service	From EASA draft regulation, Article 2 Definitions, para. (3): "‘common information service’ means a service collecting static and dynamic data and disseminating it to enable the provision of the services for the management of traffic of unmanned aircraft;"	
CNPC	Control and Non-Payload Communications (see also C2/C2 Link)		
CNS	Communication, Navigation and Surveillance		EASA Drone Incident Management at Aerodromes
CONOPS	Concept of Operations		
CORUS	Concept of Operations for U-space (SESAR)		
CS	Certification Specification		EASA Drone Incident Management at Aerodromes
CTM	Cumulative Threshold Map		
CTR	Controlled Traffic Region Control Zone		
C-UAS	Counter-Unmanned Aircraft System		EASA Drone Incident Management at Aerodromes
DA	Delegated Act		EASA Drone Incident Managem

Abbreviation	Term	Definition	Source
			ent at Aerodromes
DAA	Detect And Avoid		
DDS	Drone Detection Systems		EASA Drone Incident Management at Aerodromes
DF	Direction finder (see also RDF)		
DfT	Department for Transport		EASA Drone Incident Management at Aerodromes
DID	Data Item Description		
DIMC	Drone Incident Management Cell		EASA Drone Incident Management at Aerodromes
DITRDC	Department of Infrastructure, Transport, Regional Development and Communications (Australia)		
DRMS	Drone Rule Management System		
Drone	Synonymous for Unmanned Aerial Vehicle (see also UAV/UAS)		
DSS	Discovery and Synchronization Service		
EASA	European Union Aviation Safety Agency		EASA Drone Incident Management at

Abbreviation	Term	Definition	Source
			Aerodromes
EASA C-UAS TF	EASA Task Force on the objective 2 of the EASA Counter UAS action Plan		EASA Drone Incident Management at Aerodromes
EC	European Commission		EASA Drone Incident Management at Aerodromes
ECC	Electronic Communications Committee		
ECCAIRS	European Coordination Centre for Accident and Incident Reporting Systems		EASA Drone Incident Management at Aerodromes
eID	Electronic Identification		EASA Drone Incident Management at Aerodromes
EMP	Electromagnetic Pulse		EASA Drone Incident Management at Aerodromes
EO	Electro-optical		EASA Drone Incident Management at Aerodromes
EU	European Union		

Abbreviation	Term	Definition	Source
EUROCAE	European Organisation for Civil Aviation Equipment		EASA Drone Incident Management at Aerodromes
EUROCONTROL	Supporting safe and seamless air traffic management across Europe		EASA Drone Incident Management at Aerodromes
EVLOS	Extended Visual Line Of Sight		
FAA	Federal Aviation Administration (USA)		EASA Drone Incident Management at Aerodromes
FIMS	Flight Information Management System	Generally superseded by the term 'CIS', at least in Europe.	
FIXM	Flight Information Exchange Model	https://www.eurocontrol.int/model/flight-information-exchange-model	
FTE	Flight Technical Error		
FTP	File Transfer Protocol		
GA	General Aviation		EASA Drone Incident Management at Aerodromes
GCS	Ground Control Station (see also RPS)		
GEN	General requirements		EASA Drone Incident Management at Aerodromes

Abbreviation	Term	Definition	Source
GM	Guidance Material		EASA Drone Incident Management at Aerodromes
GNSS	Global Navigation Satellite System		EASA Drone Incident Management at Aerodromes
GRC	Ground Risk Class (SORA)	SORA related	
GRIB	Gridded Binary		
GS	Ground Station (see also GCS)		
GUTMA	Global UTM Association		
HEC	Hazard Effect Classification		EASA Drone Incident Management at Aerodromes
HMI	Human Machine Interface		EASA Drone Incident Management at Aerodromes
HTP	Horizontal Tail Plane		EASA Drone Incident Management at Aerodromes
IA	Implementing Act		EASA Drone Incident Management at

Abbreviation	Term	Definition	Source
			Aerodromes
IATA	International Air Transport Association		EASA Drone Incident Management at Aerodromes
ICAO	International Civil Aviation Organization		EASA Drone Incident Management at Aerodromes
ICD	Interface Control Document		
ID	Identification		EASA Drone Incident Management at Aerodromes
IDD	Interface Definition Document		
IEA	Impact Effect Assessment		EASA Drone Incident Management at Aerodromes
IEX	Information Exchange Service	Deprecated	
IFR	Instrument Flight Rules		EASA Drone Incident Management at Aerodromes
INTERPOL	The International Criminal Police Organization		EASA Drone Incident Management at

Abbreviation	Term	Definition	Source
			Aerodromes
IR	Infrared Electro Optical		EASA Drone Incident Management at Aerodromes
IT	Information Technology		
ITIL	Information Technology Infrastructure Library		
ITSM	IT Service Management		
ITU	International Telecommunications Union		
ITU-R	ITU – Radiocommunication Sector		
ISM	Information Security Manual		
ISMS	information security management system		
ISO	International Organization for Standardization		EASA Drone Incident Management at Aerodromes
IXS	Information Exchange Service		
JARUS	Joint Authorities for Rulemaking on Unmanned Systems		EASA Drone Incident Management at Aerodromes
KPI	Key Performance Indicator		EASA Drone Incident Management at

Abbreviation	Term	Definition	Source
			Aerodromes
LAANC	Low Altitude Authorization and Notification Capability (US UAS Data Exchange)	https://www.faa.gov/uas/programs_partnerships/data_exchange/	EASA Drone Incident Management at Aerodromes
LEA	Law Enforcement Authority		EASA Drone Incident Management at Aerodromes
LLA	Low-Level Airspace	See also VLL	
LoA	Letter of Agreement		EASA Drone Incident Management at Aerodromes
LRST	Local Runway Safety Team		EASA Drone Incident Management at Aerodromes
MAA	Military Aviation Authority		EASA Drone Incident Management at Aerodromes
MAB	EASA Member States Advisory Body		EASA Drone Incident Management at Aerodromes
MAC	Mid-air collision		EASA Drone Incident

Abbreviation	Term	Definition	Source
			Management at Aerodromes
MEP	Message Exchange Pattern		
MFA	Multi Factor Authentication (see also 2FA)		
MTOM	Maximum Take-Off Mass		EASA Drone Incident Management at Aerodromes
MTOW	Maximum Takeoff Weight		
NAA	National Aviation Authority		EASA Drone Incident Management at Aerodromes
NAF	NATO Architectural Framework		
NAIPS	National Aeronautical Information Processing System	Australian central ATM data and information processing system	
NASA	National Aeronautics and Space Administration	United States aerospace agency	
NCASP	National Civil Aviation Security Programme		EASA Drone Incident Management at Aerodrome
NM	Nautical Mile (1,852 km)		EASA Drone Incident Management at Aerodrome

Abbreviation	Term	Definition	Source
NMAC	Near Mid-Air Collision		
NOTAM	Notice to Airmen		
NSA	National Supervisory Authority		EASA Drone Incident Management at Aerodrome
NSE	Navigation System Error		
NTM	Noise Threshold Map		
OIV	Operational Intent Volume		
OP	Operation Plan		
ORO	Organisation Requirements for Air Operations		EASA Drone Incident Management at Aerodrome
OSO	Operational Safety Objectives (SORA)	SORA related	EASA Drone Incident Management at Aerodrome
OVN	Opaque Version Number		
PBN	Performance-Based Navigation		
PII	Personally Identifiable Information		
POIV	Performance Operational Intent Volume		
RDF	Radio direction-finding		
REST	Representational State Transfer		
RF	Radio Frequency		EASA Drone Incident Managem

Abbreviation	Term	Definition	Source
			ent at Aerodrome
RID	Remote Identification		
RNP	Required Navigation Performance		
ROI	Region of Interest		
RP	Remote Pilot ('drone pilot')		EASA Drone Incident Management at Aerodrome
RPA	Remotely Piloted Aircraft		EASA Drone Incident Management at Aerodrome
RPAS	Remotely Piloted Aircraft System ('drone')		EASA Drone Incident Management at Aerodrome
RPS	Remote Pilot Station	(see also GCS)	EASA Drone Incident Management at Aerodrome
RR	ITU-R Radio Regulations		
RTH	Return to Home		
SAB	EASA Stakeholders Advisory Board		EASA Drone Incident Management at Aerodrome
SAG	Safety Action Group		EASA Drone

Abbreviation	Term	Definition	Source
			Incident Managem ent at Aerodrom e
SAIL	Specific Assurance and Integrity Level (SORA)	SORA related	EASA Drone Incident Managem ent at Aerodrom e
SARPs	Standard and Recommended Practices		EASA Drone Incident Managem ent at Aerodrom e
SC	Safety Committee		EASA Drone Incident Managem ent at Aerodrom e
SDD	System Design Document		
SDO	Standards Development Organization		
SDSP	Supplemental Data Provider		
SESAR	Single European Sky Advanced Research		
SMS	Safety Management System		EASA Drone Incident Managem ent at Aerodrom e
SOA	Service Oriented Architecture		
SOAP	Simple Object Access Protocol		

Abbreviation	Term	Definition	Source
SORA	Specific Operations Risk Assessment		EASA Drone Incident Management at Aerodrome
SPT	Safety Promotion Task		EASA Drone Incident Management at Aerodrome
SRB	Safety Review Board		EASA Drone Incident Management at Aerodrome
SRD	System Requirements Document		
SSD	Service Specification Document		
SSDD	System/Subsystem Design Document		
STS	Standard Scenario		EASA Drone Incident Management at Aerodrome
SW	Software		
SWIM	System-Wide Information Management		
TAS	True Airspeed		EASA Drone Incident Management at Aerodrome
TBO	Trajectory-Based Operations		

Abbreviation	Term	Definition	Source
TMPR	Tactical Mitigation Performance Requirements	SORA related	
TSE	Total System Error		
TSL	Technical Support Line		
TTA	Time To Alert		
TVE	Total Vertical Error		
U-Space	(European concept for VLL airspace reserved for drone traffic)		
UA	Unmanned Aircraft	Where the term 'unmanned' usually refers to 'pilot-less', rather than 'without people on board'. For instance, a UAM airtaxi may be 'unmanned' as it does not require a pilot, but there likely will be passengers on board eventually.	EASA Drone Incident Managem ent at Aerodrom e
UAM	Urban Air Mobility		
UAS	Unmanned Aircraft System ('drone'), also Uncrewed Aircraft System Unmanned Aircraft System Unpiloted Aerial System	An aircraft and its associated elements which are operated with no pilot on board.	EASA Drone Incident Managem ent at Aerodrom e
UAS Operator	Unmanned Aircraft System Operator	The term UAS operator is reserved for the person, organization or enterprise that is engaged in or offering to engage in an aircraft operation. In other words, the term refers mainly to the legal entity that intends to operate one or more UAS.	
UAV	Unmanned Aerial Vehicle Uncrewed Aerial Vehicle Unmanned Aircraft Vehicle		EASA Drone Incident Managem ent at Aerodrom e
ULS	unbemanntes Luftfahrzeugsystem	German term for UAS	
UML	Unified Modeling Language		
URL	Uniform Resource Locator		

Abbreviation	Term	Definition	Source
USS	U-space Service System UTM Service System UAS Service Supplier		
USSP	U-space Services Provider UTM Services Provider		
UTM	Unmanned Aircraft System Traffic Management UAS Traffic Management Unmanned (air) Traffic Management UAV Traffic Management		EASA Drone Incident Management at Aerodrome
UTMSP	UTM Service Provider		
UVR	U-space volume reservation		
VCS	Voice Communication System		
VFR	Visual Flight Rules		EASA Drone Incident Management at Aerodrome
VLL	Very Low Level	Such as in VLL airspace	
VLOS	Visual Line of Sight		
VMC	Visual Meteorological Conditions		EASA Drone Incident Management at Aerodrome
VTOL	Vertical Take-off and Landing		EASA Drone Incident Management at Aerodrome
VTP	Vertical Tail Plane		EASA Drone Incident Management at

Abbreviation	Term	Definition	Source
			Aerodrom e
WSDL	Web Services Description Language		
WXXM	Weather information (XML) eXchange Model		
XML	eXtensible Markup Language		
XSD	XML Schema Definition		
YAML	YAML Ain't Markup Language		

Tabelle 33 List of Acronyms

5.5 Internationales Glossar

Term	Definition
AIR-REPORT	A report from an aircraft in flight prepared in conformity with requirements for position, and operational and/or meteorological reporting.
Alert	A human and machine readable digital message to communicate important business data. e.g. A Conformance Alert is raised if a Drone leaves its planned Operation Plan.
Authorized aircraft/drone/UAV/UAS	Any aircraft/drone/UAV/UAS activity in controlled/restricted/prohibited airspace with explicit authority or permission (i. e. explicit ATC clearance or explicit permit by the responsible authority).
Drone Flight	Information about the actual conduction of a drone flight, the practical combination of the intent (Operation Plan) plus the current state of a flight (and optionally the drone telemetry position).
Director Service	A component of the UAS Dispatching system. Director is responsible for bridging information between the expert system and either other downstream components of the dispatching system, or towards integrated 3rd party components.
Cooperative aircraft/drone/UAV/UAS	'Cooperative' and 'non-cooperative' are used (primarily/solely) in the context of surveillance where 'cooperative' surveillance includes the direct transmission or otherwise submission of surveillance information by the aircraft/drone/UAV/UAS itself. 'Non-cooperative' surveillance locates the drone without such active cooperative surveillance, by means of primary sensor technologies. In this terminology, a 'cooperative' aircraft/drone/UAV/UAS therefore emits RADAR responses of some sort, ADS-B, or remote ID (be it 'direct', or network remote ID) and hence is electronically conspicuous.
External Data Model	Describes the semantics of the domain (or a significant part thereof) by defining data structures and their relations. This could be at logical level

Term	Definition
	(e.g., in UML) or at physical level (e.g., in XSD schema definitions), as for example standard data models.
Expert System	A domain-specific business application which takes advantage of UAS dispatching to support the business processes. In the current design step, this is a Frequentis system (ICM, LifeX), but it can also be any other 3rd party business application (e.g. to support inspections, surveillance, transportation).
Flight Activation	The Flight Activation indicates the immediate intent of an aircraft operator to fly, subject to a prior Flight Approval. Precondition for the activation of a flight is a corresponding Flight Approval, and actual takeoff should be expected within a few seconds to a couple of minutes.
Flight Approval	During Flight Approval, the authority or the operator of a given airspace consents to a flight request in a given airspace. Precondition to such an approval is the Flight Authorization of the corresponding authority of the airspace. Typically, the timeframe for approval is expected to be at the order of a few minutes to a couple of hours (but may take the order of a few days in some cases). An example for an approval is an ATS unit allowing flights within a CTR.
Flight Authorization	During Flight Authorization, the overseeing airspace manager ensures that all preconditions to fly in a given airspace are met, ultimately granting a authorization to fly. Checks include that the flight is free of conflicts with other flights, and not violating any airspace restrictions.
Flight Permission	The authority consents to a flight request in a given airspace. Typically, especially if done manually. permission can take days, weeks, up to months depending on the complexity of the flight. A permission might cover a large (100+km) and long (several days+) airspace volume. For such complex operations, once permission has been granted, subsequent authorization requests are made for specific flights within the frame of the permission. Checks may range from aircraft airworthiness certification and operator licensing to aircraft performance capability requirements for the given airspace and may take, subject to complexity of the request and process requirements at the authority, months to days.
Geozone	A 4-dimensional (3 dimensions in space plus timeframe) representation of a geographic area in a digital machine and human readable format. e.g. ED-269, ED-318.
Hangar	A shelter which houses the UAS.
Take off clearance	If ATS is involved in a flight activation process (e.g. in CTR), it needs to confirm flight activation - which is (internally) called take off clearance.
Message Exchange Pattern	Describes the principles how two different parts of a message passing system (in our case: the service provider and the service consumer) interact and communicate with each other. Examples: In the Request/Response MEP, the service consumer sends a request to the service provider in order to obtain certain information; the service provider provides the requested information in a dedicated response. In the Publish/Subscribe MEP, the service consumer establishes a subscription with the service provider in order to obtain certain information;

Term	Definition
	the service provider publishes information (either in regular intervals or upon change) to all subscribed service consumers.
Operation Plan	Information about the planning of a drone operation. Also "Drone Flight", "Flight Plan", "Operational Intent Volume" OIV.
Operational Activity	An activity performed by an operational node. Examples of operational activities include activities such as Route Planning, Route Optimization, Logistics, Safety, and Weather Forecast Provision.
Operational Model	A structure of operational nodes and associated operational activities and their inter-relations in a process model.
Operational Node	A logical entity that performs activities. Note: nodes are specified independently of any physical realization. Examples of operational nodes include a Control Center, an Authority, or a Weather Information Provider, for instance.
Operational Permission	An Operational Permission allows a Drone Operator to fly Drone Operations outside of the default parameters for flight authorization of the system. The Operational Permission can be seen as a "joker" or "wildcard" to circumvent existing restrictions on operation plan authorization.
Organisation	An Organisation within the UTM solution is an entity of users and services that define specific rights and source/target configuration of data within the system.
Payload	A physical add-on component for a UAS, in the current scope this will be a camera or comparable sensor with the intent of sending media data (video + audio) to the expert system.
Safety service	Any radiocommunication service used permanently or temporarily for the safeguarding of human life and property.
Service	The provision of something (a non-physical object), by one, for the use of one or more others, regulated by formal definitions and mutual agreements. Services involve interactions between providers and consumers, which may be performed in a digital form (data exchanges) or through voice communication or written processes and procedures.
Service Consumer	A service consumer uses service instances provided by service providers.
Service Data Model	Formal description of one dedicated service at logical level. The service data model is part of the service specification. Is typically defined in UML and/or XSD. If an external data model exists (e.g., a standard data model), then the service data model shall refer to it: each data item of the service data model shall be mapped to a data item defined in the external data model.
Service Design Description	Documents the details of a service technical design (most likely documented by the service implementer). The service design description includes (but is not limited to) a service physical data model and describes the used technology, transport mechanism, quality of service, etc.
Service Implementation	The provider side implementation of a dedicated service technical design (i.e., implementation of a dedicated service in a dedicated technology).

Term	Definition
Service Implementer	Implementers of services from the service provider side and/or the service consumer side.
Service Instance	One service implementation may be deployed at several places by same or different service providers; each such deployment represents a different service instance, being accessible via different URLs.
Service Instance Description	Documents the details of a service implementation (most likely documented by the service implementer) and deployment (most likely documented by the service provider). The service instance description includes (but is not limited to) service technical design reference, service provider reference, service access information, service coverage information, etc.
Service Interface	The communication mechanism of the service, i.e., interaction mechanism between service provider and service consumer. A service interface is characterized by a message exchange pattern and consists of service operations that are either allocated to the provider or the consumer of the service.
Service Operation	Functions or procedure which enables programmatic communication with a service via a service interface.
Service Physical Data Model	Describes the realization of a dedicated service data model in a dedicated technology. This includes a detailed description of the data payload to be exchanged using the chosen technology. The actual format of the service physical data model depends on the chosen technology. Examples may be WSDL and XSD files (e.g., for SOAP services) or swagger (Open API) specifications (e.g., for REST services). If an external data model exists (e.g., a standard data model), then the service physical data model shall refer to it: each data item of the service physical data model shall be mapped to a data item defined in the external data model. In order to prove correct implementation of the service specification, there shall exist a mapping between the service physical data model and the service data model. This means, each data item used in the service physical data model shall be mapped to a corresponding data item of the service data model. (In case of existing mappings to a common external (standard) data model from both the service data model and the service physical data model, such a mapping is implicitly given.)
Service Provider	A service provider provides instances of services according to a service specification and service instance description. All users within the domain can be service providers, e.g., authorities, organizations (e.g., meteorological), commercial service providers, etc.
Service Specification	Describes one dedicated service at logical level. The Service Specification is technology-agnostic. The Service Specification includes (but is not limited to) a description of the Service Interfaces and Service Operations with their data payload. The data payload description may be formally defined by a Service Data Model.
Service Specification Producer	Producers of service specifications in accordance with the service documentation guidelines.
Technical Design	The technical design of a dedicated service in a dedicated technology. One service specification may result in several technical service designs, realizing the service with different or same technologies.

Term	Definition
Service Technology Catalogue	List and specifications of allowed technologies for service implementations. Currently, SOAP and REST are envisaged to be allowed service technologies. The service technology catalogue shall describe in detail the allowed service profiles, e.g., by listing communication standards, security standards, stacks, bindings, etc.
Spatial Exclusiveness	A service specification is characterized as “spatially exclusive”, if in any geographical region just one service instance of that specification is allowed to be registered per technology. The decision, which service instance (out of a number of available spatially exclusive services) shall be registered for a certain geographical region, is a governance issue.
UAS Cockpit	A system similar in function to a ground control station which allows control over a UAS. In this case, the cockpit will need to support integration with expert systems.
Unauthorized aircraft/drone/UAV/UAS	Any aircraft/drone/UAV/UAS activity in controlled/restricted/prohibited airspace without explicit authority or permission (i. e. without explicit ATC clearance or without explicit permit by the responsible authority).
Non-cooperative aircraft/drone/UAV/UAS	'Cooperative' and 'non-cooperative' are used (primarily/solely) in the context of surveillance where 'cooperative' surveillance includes the direct transmission or otherwise submission of surveillance information by the aircraft/drone/UAV/UAS itself. 'Non-cooperative' surveillance locates the drone without such active cooperative surveillance, by means of primary sensor technologies. In this terminology, a 'non-cooperative' aircraft/drone/UAV/UAS therefore is silent and not electronically conspicuous, or sending out erroneous or false location data, and hence only is detectable and can only be localized by non-cooperative sensor technology such as a primary RADAR, or video detection.
UTM System	A system which supports the lifecycle management of an operation plan, respectively an authorisation by Civil Aviation Authorities and activation by Air Navigation Service Providers.

Tabelle 34 Glossary of Terms

5.6 Referenzen

5.6.1 Liste Deutscher Referenzen

Nr.	Version	Referenz
[ADELE-E2.1]	V1.0 / 2024-12-19	**A**utomatisierter **D**rohnen**E**insatz aus der **L**eitstell**E** (ADELE), Gesetzlicher Anforderungskatalog
[ADELE-E2.2]	V1.0 / 2024-12-19	**A**utomatisierter **D**rohnen**E**insatz aus der **L**eitstell**E** (ADELE), Operationaler Anforderungskatalog

Nr.	Version	Referenz
[ADELE-E2.2-FBOA-BF-HRO]	V0.2 / 08.07.2024	**A**utomatisierter **D**rohnen**E**insatz aus der **L**eitstell**E** (ADELE), Fragebogen Operativer Anforderungskatalog (Berufsfeuerwehr Rostock)
[ADELE-E2.2-FBOA-POL-MV]	V0.3 / 12.09.2024	**A**utomatisierter **D**rohnen**E**insatz aus der **L**eitstell**E** (ADELE), Fragebogen Operativer Anforderungskatalog (Polizei Mecklenburg-Vorpommern)
[ADELE-E2.3] [ADELE-E2.4]	V1.0 / 2024-12-19	**A**utomatisierter **D**rohnen**E**insatz aus der **L**eitstell**E** (ADELE), Technischer Anforderungskatalog
[ADELE-E2.5] [ADELE-E2.6]	V1.0 / 19.12.2025	**A**utomatisierter **D**rohnen**E**insatz aus der **L**eitstell**E** (ADELE), Betriebs- und Sicherheitskonzept
[ADELE-E5.1]	V1.0 / 18.12.2025	**A**utomatisierter **D**rohnen**E**insatz aus der **L**eitstell**E** (ADELE), Beschreibung der Validierungsumsetzung
[ADELE-E5.2]	V0.2 / 27.02.2025	**A**utomatisierter **D**rohnen**E**insatz aus der **L**eitstell**E** (ADELE), Dokumentierte Validierungsergebnisse
[AF-BA]	16. August 2023	Bundesanzeiger, veröffentlicht am Mittwoch, 16. August 2023, BAnz AT 16.08.2023 B1, Schwerpunkt Interessengebiet 4 − Leitstellen, Smart Devices und sonstige Endgeräte
[DRN-E1100]	V1.0 / 2024-12-19	DroneResponseNet (DRN), Gesetzlicher und operativer Anforderungskatalog
[DRN-E1100-1-FBOA-POL]	V0.2 / 23.07.2024	DroneResponseNet (DRN), Fragebogen Operativer Anforderungskatalog (Polizeiinspektion Harburg)
[DRN-E1200]	V1.0 / 2024-12-19	DroneResponseNet (DRN), Technischer Anforderungskatalog

Tabelle 35 Liste Deutscher Referenzen

5.6.2 Liste Internationaler Referenzen

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[AMC-GM-947]	10 October 2019	Executive Director Decision 2019/021/R of 9 October 2019 issuing Acceptable Means of Compliance and Guidance Material to Commission Implementing Regulation (EU) No 2019/947, https://www.easa.europa.eu/en/document-library/agency-decisions/ed-decision-2019021r

Nr.	Version	Reference
[AMC-GM-947-Ann-1]	Issue 1, Amendment 3, 25 April 2024	Annex I to ED Decision 2019/021/R, Acceptable Means of Compliance (AMC) and Guidance Material (GM) to Commission Implementing Regulation (EU) 2019/947, https://www.easa.europa.eu/en/downloads/104072/en, amended by: • Amendment 1 (Acceptable Means of Compliance (AMC) and Guidance Material (GM) to the Annex (Part-UAS) to Regulation (EU) 2019/947 — Issue 1, Amendment 1, 16 December 2020), https://www.easa.europa.eu/en/downloads/120998/en • Amendment 2 (Acceptable Means of Compliance and Guidance Material to the Annex to Regulation (EU) 2019/947 — Issue 1, Amendment 2, 14 September 2022), https://www.easa.europa.eu/en/downloads/135911/en • Amendment 3 (Acceptable Means of Compliance and Guidance Material to Regulation (EU) 2019/947, Issue 1, Amendment 3, 20 October 2023 (replaced 25 April 2024)), https://www.easa.europa.eu/en/downloads/138681/en
[AMC-GM-947-Ann-2]	Issue 1, Amendment 3, 25 April 2024	Annex II to ED Decision 2019/021/R, Acceptable Means of Compliance (AMC) and Guidance Material (GM) to Part-UAS, UAS operations in the 'open' and 'specific' categories, Issue 1, 9 October 2019, https://www.easa.europa.eu/en/downloads/104073/en, amended by: • Amendment 1 (Acceptable Means of Compliance (AMC) and Guidance Material (GM) to the Annex (Part-UAS) to Regulation (EU) 2019/947 — Issue 1, Amendment 1, 16 December 2020), https://www.easa.europa.eu/en/downloads/120998/en • Amendment 2 (Acceptable Means of Compliance and Guidance Material to the Annex to Regulation (EU) 2019/947 — Issue 1, Amendment 2, 14 September 2022), https://www.easa.europa.eu/en/downloads/135911/en • Amendment 3 (Acceptable Means of Compliance and Guidance Material to Regulation (EU) 2019/947, Issue 1, Amendment 3, 20 October 2023 (replaced 25 April 2024)), https://www.easa.europa.eu/en/downloads/138681/en
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[ASTM-UTM-INTEROP]	F3548-21	ASTM International, Standard Specification for UAS Traffic Management (UTM) UAS Service Supplier (USS) Interoperability, https://www.astm.org/f3548-21.html
[AUS-CDS]	Last updated: October 2021	Australian Government, Australian Signals Directorate, Australian Cyber Security Centre: Fundamentals of Cross Domain Solutions, https://www.cyber.gov.au/sites/default/files/2021-10/PROTECT%20-%20Fundamentals%20of%20Cross%20Domain%20Solutions%20%28October%202021%29.pdf

Nr.	Version	Reference
[AUS-UTM-REQ-01]	Version 1.2, Effective Date 25 May 2021	Airservices Australia, FIMS (PROTOTYPE), System Requirements Specification, UTM-REQ-01
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[BANZ-AT-16.08.2023-B1]	31. Juli 2023	Bundesministerium des Innern und für Heimat: Bekanntmachung der Richtlinie zur Förderung von Projekten für „Innovationen im breitbandigen Digitalfunk BOS“ vom 31. Juli 2023, https://www.bundesanzeiger.de/pub/de/amtlicher-teil?8&year=2023&edition=BAnz+AT+16.08.2023
[CORUS]	Ed. 01.01.03 Ed. 03.00.02	CORUS Vol. 1, Enhanced Overview https://www.sesarju.eu/sites/default/files/documents/u-space/CORUS%20ConOps%20vol1.pdf CORUS Vol. 2, U-space Concept of Operations https://www.sesarju.eu/sites/default/files/documents/u-space/CORUS%20ConOps%20vol2.pdf (superseded by [CORUS-XUAM])
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[ED-269]	June 2020	EUROCAE ED-269 Minimum Operational Performance Standard for Geofencing, June 2020, https://eshop.eurocae.net/eurocae-documents-and-reports/ed-269/
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[EUR-2018/1139]	25 May 2025	Regulation (EU) 2018/1139 of the European Parliament and of the Council of 4 July 2018 on common rules in the field of civil aviation and establishing a European Union Aviation Safety Agency, and amending Regulations (EC) No 2111/2005, (EC) No 1008/2008, (EU) No 996/2010, (EU) No 376/2014 and Directives 2014/30/EU and 2014/53/EU of the European Parliament and of the Council, and repealing Regulations (EC) No 552/2004 and (EC) No 216/2008 of the European Parliament and of the Council and Council Regulation (EEC) No 3922/91, https://eur-lex.europa.eu/eli/reg/2018/1139/2025-05-25
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Tabelle 36 List of References

5.7 Review-Checkliste

This document is reviewed related to the following checklist (except of a draft version):

Design Review Checklist
The Design Review Checklist complies with ED 109A AL4 6.3.2 Reviews and Analyses of Low-Level Requirements, 6.3.3 Reviews and Analyses of Software Architecture and Frequentis Software Design Guideline and Checklist [IMS000012].
Are Algorithm aspects ensured?

Design Review Checklist
The objective is to ensure the accuracy and behavior of the proposed algorithms, especially in the area of discontinuities.
Is the Software Architecture compatible with the Software Requirements (high-level requirements)?
The objective is to ensure that the software architecture does not conflict with the high-level requirements, especially functions that ensure system integrity, for example, partitioning schemes.
Is there a correct relationship between the components of the software architecture via data flow and control flow ?
Is the Frequentis Software Design Guideline and Checklist followed?
Are deviations to the standard are justified? E.g. deviations to complexity restriction and design construct rules.
Is partitioning integrity guarantied?
The objective is to ensure that partitioning breaches are prevented.
Are all SW components defined and described?
Are traces between SW requirements and SW design available?
Are all interfaces defined?
Are all interfaces (data and control flow) consistent and verifiable?
Are data structures documented?
Are logging mechanisms documented?
Are design decisions, where necessary, documented?
Are re-use objects, Open Source and other COTS SW/HW identified at software level?