VTOL Workshop

06 June 2019

EUROCAE

EASA

European Union Aviation Safety Agency

VTOL Workshop Agenda

1000	Welcome	EUROCAE & EASA
1015	EASA Introduction: Proposal & Expectations	David Solar, Head of VTOL Department, EASA
1045	EUROCAE Introduction: Organisation, process & relevant activities	Anna von Groote, Director Technical Programme, EUROCAE
1115	Stakeholder presentations & inputs	Moderated by Anna von Groote, Director Technical Programme, EUROCAE
1200	*Lunch break*	
1300	Stakeholder presentations & inputs	Moderated by Anna von Groote, Director Technical Programme, EUROCAE
1430	*Coffee break*	
1500	Development of initial work programme and priorities	Moderated by Volker Arnsmeier, Section Manager eVTOL and New Concepts, EASA & Alain Vallée, Technical Secretary – Expert, EUROCAE
1630	Roadmap and next steps	Anna von Groote, Director Technical Programme, EUROCAE
1650	Final remarks	David Solar, Head of VTOL Department, EASA
1700	Close of workshop	EUROCAE & EASA

VTOL Workshop

Welcome Address by EUROCAE

Anna von Groote
Director Technical Programme, EUROCAE

Welcome

- Refreshments and Lunch
- Mobile devices
- WiFi
- Fire exits
- Restrooms

Questions and Comments

Please join VTOL Workshop

at **www.slido.com**

with this code **#9926**

VTOL Workshop

Welcome Address by EASA

David Solar
Head of VTOL Department, EASA

VTOL Workshop

EASA Introduction

David Solar
Head of VTOL Department, EASA

EASA
European Union Aviation Safety Agency

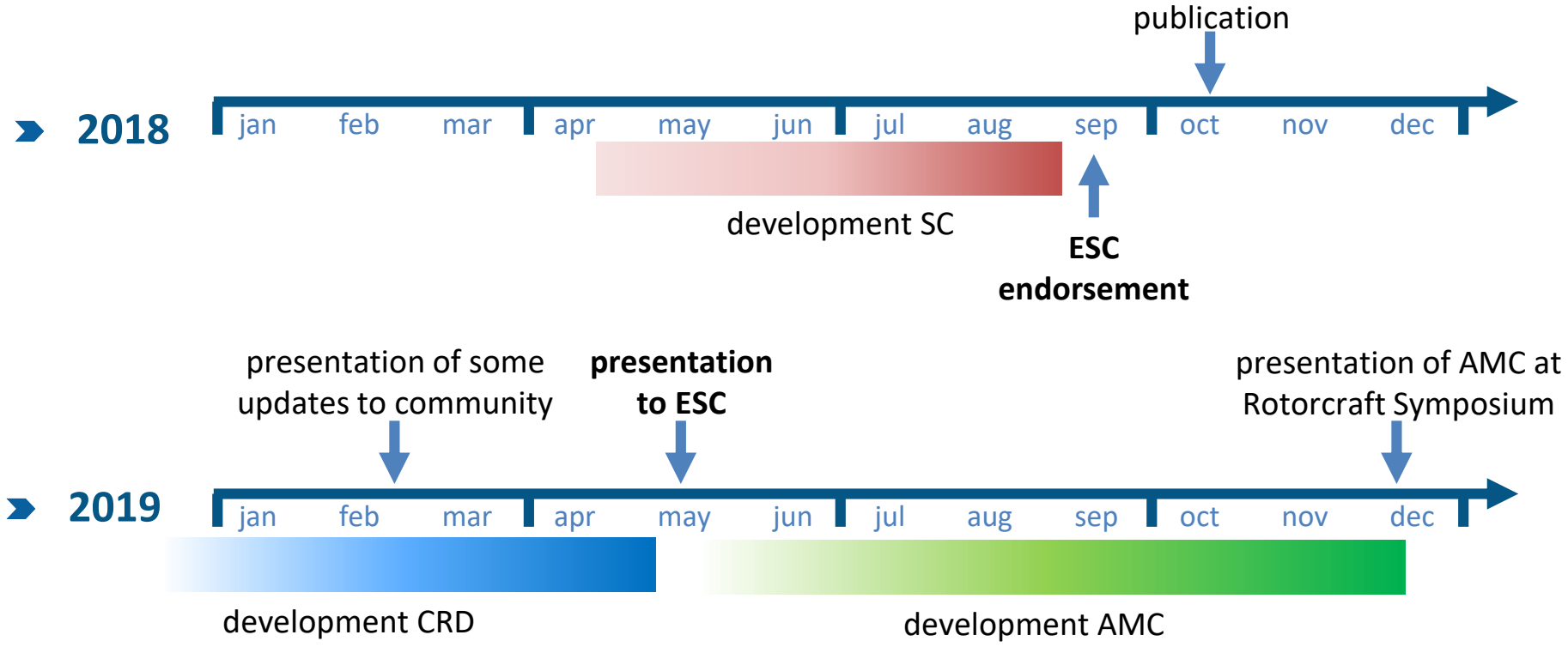
SC VTOL AMC

06 June 2019

Your safety is our mission.

An Agency of the European Union

Special Condition Timeline



Special Condition

→ standalone, incorporating elements of CS-27 and CS-23

→ composed of high-level objectives, complemented by Accepted Means of Compliance (AMC), similar to CS-23 Amdt 5

→ will be supplemented by dedicated material to address specific aspects such as remote piloting or autonomy at future stages

Accepted Means of Compliance

- → Due to Special Condition, accepted on project level
- → Various a/c designs, thus:
  - → As applicable and to the best extent, re-use of existing CS-23 Amdt. 4/CS-27 Amdt. 6 as AMC
  - → Complement as necessary for specific aspects
- → Various degrees of priority, depending on design driving elements
- → Strong industry involvement to ensure adequateness and timeliness

Prioritisation and retained elements

- → straight forward AMC; usually proposed by EASA for initial set of AMC
- → Derived from CMs, ARAG, NPA, CRIs, etc.; usually proposed by EASA for initial set of AMC
- → New technical features, new approaches; usually for industry working groups to propose to EASA
- → Design drivers first and as soon as possible (e.g. Birdstrike, No-single-failure in structures, ...)

Industry – Authority cooperation is essential

- → for mutual understanding and common success
- → for timeliness
- → for sustainable designs
- → for commonalities in OPS and licensing
- → for safe design solutions with efficient compliance demonstrations methods
- → for continued safety in operation and quick resolution of issues

New way of working – Test phase

- → Keep it SIMPLE
  - → Common sense as a driver
- → Rapid Development
  - → Long lasting WG are not an option
  - → Streamline process for validation
  - → Small groups
- → Clean sheet of paper
  - → Consensus based on technical aspects

EASA
European Union Aviation Safety Agency

THANK YOU FOR YOUR SUPPORT !!!

easa.europa.eu/connect

Your safety is our mission.

An Agency of the European Union

VTOL Workshop

EUROCAE Introduction

Anna von Groote
Director Technical Programme, EUROCAE

EUROCAE Introduction

Anna von Groote

Director Technical Programme

EUROCAE Governing Bodies

- Founded in 1963 in Lucerne by ECAC
- President and General Assembly
  - Strategic decisions through “Full Members” votes
- Council
  - Final decision-making body
- Technical Advisory Committee (TAC)
  - Technical and operational advisor to the Council and the General Secretariat
- General Secretariat
  - Day to day management and further development of the Association

Inputs for Standardisation Membership

EUROCAE partners

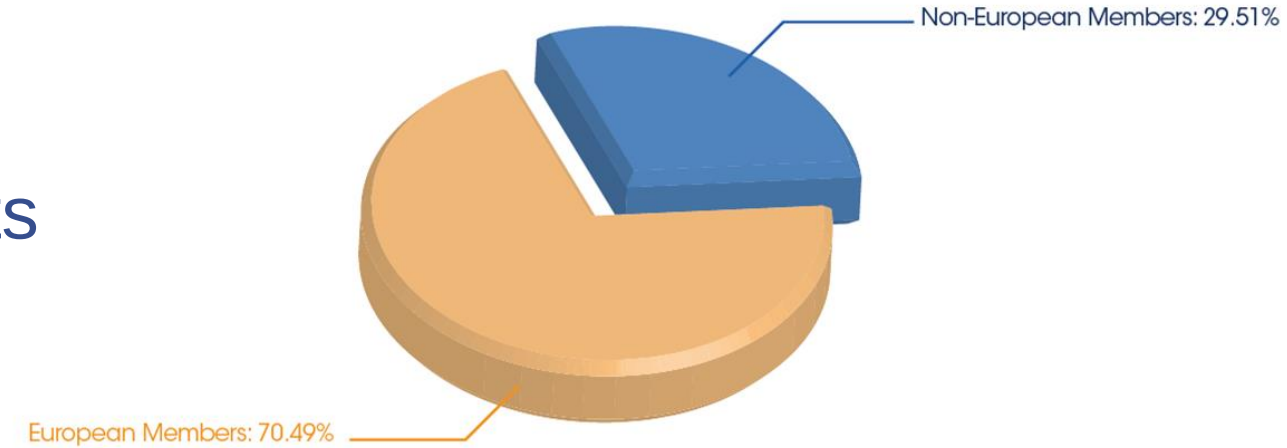
EUROCAE members & partners, …

EUROCAE partners

EUROCAE members & partners, …

EUROCAE facts and figures

- 270+ Members (+10% p.a.)
  - 146 in 2013
- 39 active working groups, 5 dormant
  - 26 in 2010
- 2100+ experts



Domains of activities

- **Avionics**
- **Communication**
- **Navigation**
- **Surveillance**
- ATM Systems
- Airports
- SWIM

- Security
- AIS / MET
- UAS & General Aviation
- Miscellaneous
  - Fuel cells
  - Space

VTOL relevant EUROCAE activities

- Complex aircraft systems, safety assessment
- Cybersecurity
- Software
- Aeronautical Databases
- Airports
- Environmental qualification
- Lightning, EMC, HIRF, high voltage
- Flight recorders, ELT, RLS
- EFB
- Avionics equipment
- CNS, ATM
- Datalink
- UAS:
  DAA, C3S, UTM, D&AW, ERA, SORA
- Hydrogen fuel cells
- Hybrid electric propulsion
- Artificial intelligence

Global coordination

Recognised SDO

50 % joint WGs

10 % joint WGs

European coordination

EASCG

SESAR JOINT UNDERTAKING

EUSCG

EUROCAE

SESAR DEPLOYMENT MANAGER

ECSCG

EUROPEAN DEFENCE AGENCY

R&D-standardisation-deployment

R&D

CARATS
Collaborative Actions for Renovation of Air Traffic Systems

NextGEN

SESAR
JOINT UNDERTAKING

Standardisation and Regulation

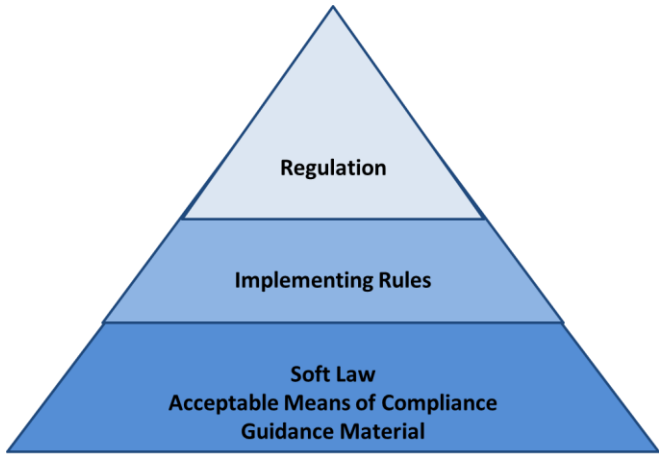
EUROCAE

Deployment

SESAR
DEPLOYMENT MANAGER

Regulation – Standard

- PB & RB regulations by EASA, FAA and ICAO
  - Reference to industry standards
- Standardisation reaction to regulation
- Forward looking
  - In anticipation of regulatory requirements
- Referenced by the regulator
  - EASA, EU, FAA, ICAO
- ETSO – MOPS, SW, Environment



EUROCAE process

- Transparent and open process
- Consensus driven development approach
- Standards validation
- Open consultation
- Worldwide recognition
- Worldwide application
- Open for worldwide participation
- By the industry – for the industry

EUROCAE lean process

- **Pilot project for WG-112 VTOL**
- **Process adapted**
  - gain time and minimise administrative efforts
  - safeguarding high quality & main principles of EUROCAE: openness, transparency, consensus
- **Lean process**
  - Decision-making and tasking by WG
  - Open Consultation shortened to 28 days
  - Approval shortened to 7 days, Secretariat responsibility
- **Total duration**
  - OC to publication: 8-10 weeks

EUROCAE lean process

Document development approved by WG	If within scope
Drafting of document by WG	Use of ED Template
EUROCAE Open Consultation	4 weeks
Comment resolution & Finalisation	4-6 weeks
EUROCAE Secretariat approval	1 week; Appeals process
Publication of EUROCAE Document	1 week

Participation in EUROCAE WGs

EUROCAE is a membership-based organisation

- Participation to EUROCAE activities is reserved for EUROCAE members
- Non-members are welcome to participate for a limited period of time to understand the scope of activities (1-2 meetings / 3 months max)
- After this period, should they wish to continue their participation, they must become members
- Otherwise, WG membership and workspace access will be suspended

EUROCAE Council has reaffirmed this principle at its 287th meeting (Nov 2015)

Membership

- Full members
  - Access of experts to any EUROCAE WG
  - Free access to all published EUROCAE deliverables
- Limited members
  - Access of experts to 1 EUROCAE WG
  - Free access to published EUROCAE deliverables of that WG; 30 % discount for purchase of other deliverables
- Membership for VTOL activities
  - Access of 1 expert to EUROCAE WG VTOL
  - No access / discount for purchase of any EUROCAE deliverables

Workspace

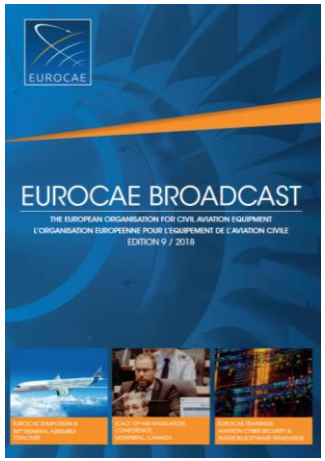
- **Registration**
  - https://register.eurocae.net

- **WG-112 VTOL Workspace**
  - General WG information
  - WG and SG Meetings
  - Draft deliverables
  - Open Consultation

My working groups

Name	Title	Link
WG-14	Environment	Go to WG | Leave WG
WG-14 SG-1	Ground Stations Environment	Go to WG | Leave WG
WG-28	Ground Based Augmentation Systems (GBAS)	Go to WG | Leave WG
WG-31	Lightning	Go to WG | Leave WG
WG-41	A-SMGCS	Go to WG | Leave WG
WG-44	Aeronautical Databases	Go to WG | Leave WG
WG-49	Mode S Transponders	Go to WG | Leave WG
WG-51	Automatic Dependent Surveillance - Broadcast (ADS-B)	Go to WG | Leave WG
WG-51 SG-1	ADS-B 1090 MHz Extended Squitter MOPS	Go to WG | Leave WG
WG-51 SG-3	ADS-B Airborne and Ground Surveillance Applications	Go to WG | Leave WG
WG-51 SG-4	Composite ADS-B/WAM System	Go to WG | Leave WG
WG-59	Flight Data Processing (FDP) Interoperability	Go to WG | Leave WG
WG-62	GALILEO	Go to WG | Leave WG
WG-63	Complex Aircraft Systems	Go to WG | Leave WG
WG-67	Voice on Internet Protocol (VoIP) for ATM	Go to WG | Leave WG
WG-68	Altimetry	Go to WG | Leave WG

For further information…



www.eurocae.net

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VTOL Workshop

Stakeholder's Presentations

Moderated by

Anna von Groote

Director Technical Programme, EUROCAE

- ***FRAPORT***
- ***GAMA***
- ***ADSE***
- ***Callen Lenz***

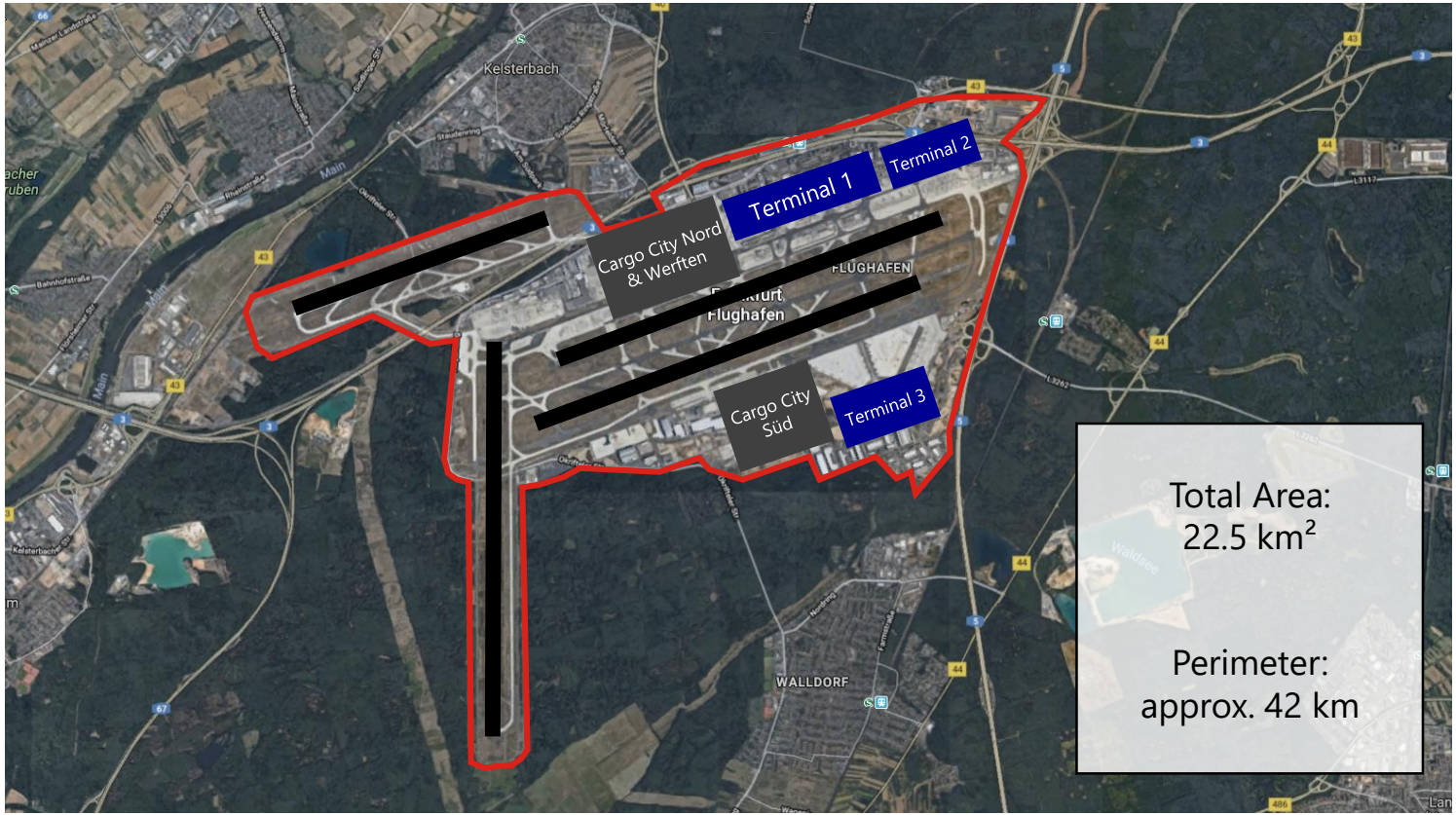
Paris, 6th June 2019

Personal Air Transport at Frankfurt Airport

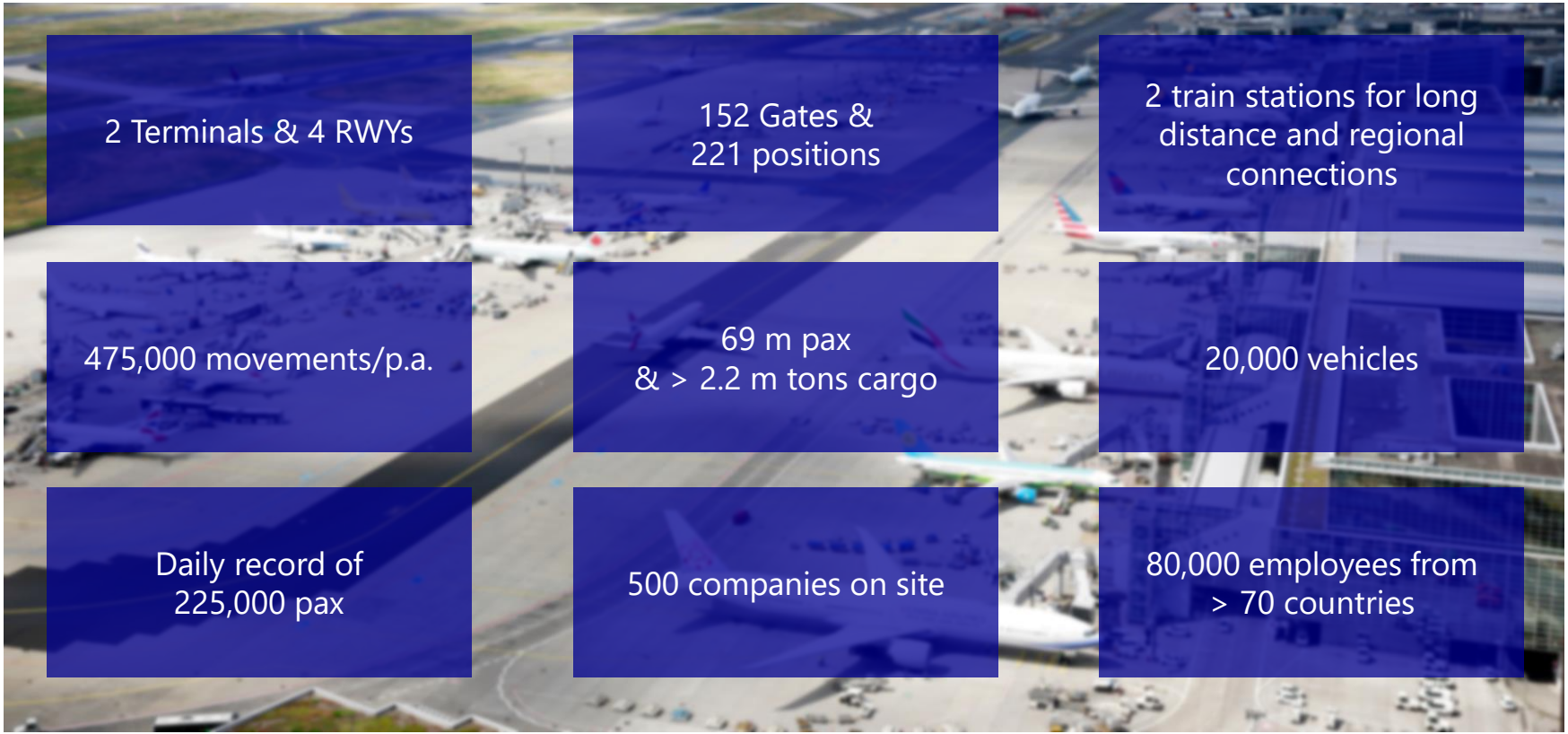
Ansgar Sickert, Fraport AG

Fraport

Frankfurt Airport –Facts & Figures



Frankfurt Airport –Facts & Figures



VTOL Air Taxi – Status Quo: Leveraging Future Technologies

Technology ✓

Pa…

…lopment …of …ucture

…tegration into the airspace ✗

No negative impact on commercial aircraft operations and capacity!

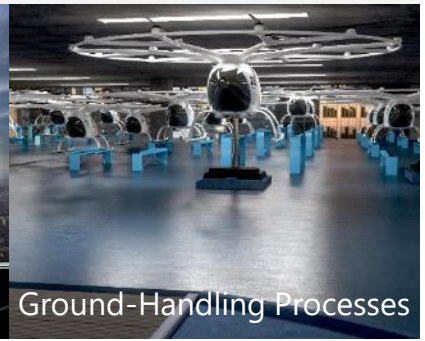
Fraport and Volocopter Cooperation – Promoting sustainable urban mobility concepts

Fraport and Volocopter have become strategic partners aiming at jointly leveraging the potential of electrically powered Air Taxi technology in Europe.

1

The key objective of the cooperation is the development of **optimised ground handling processes** for eVTOL Air Taxis.
Flights and handling should be as efficient and smooth as possible.


Passenger processes

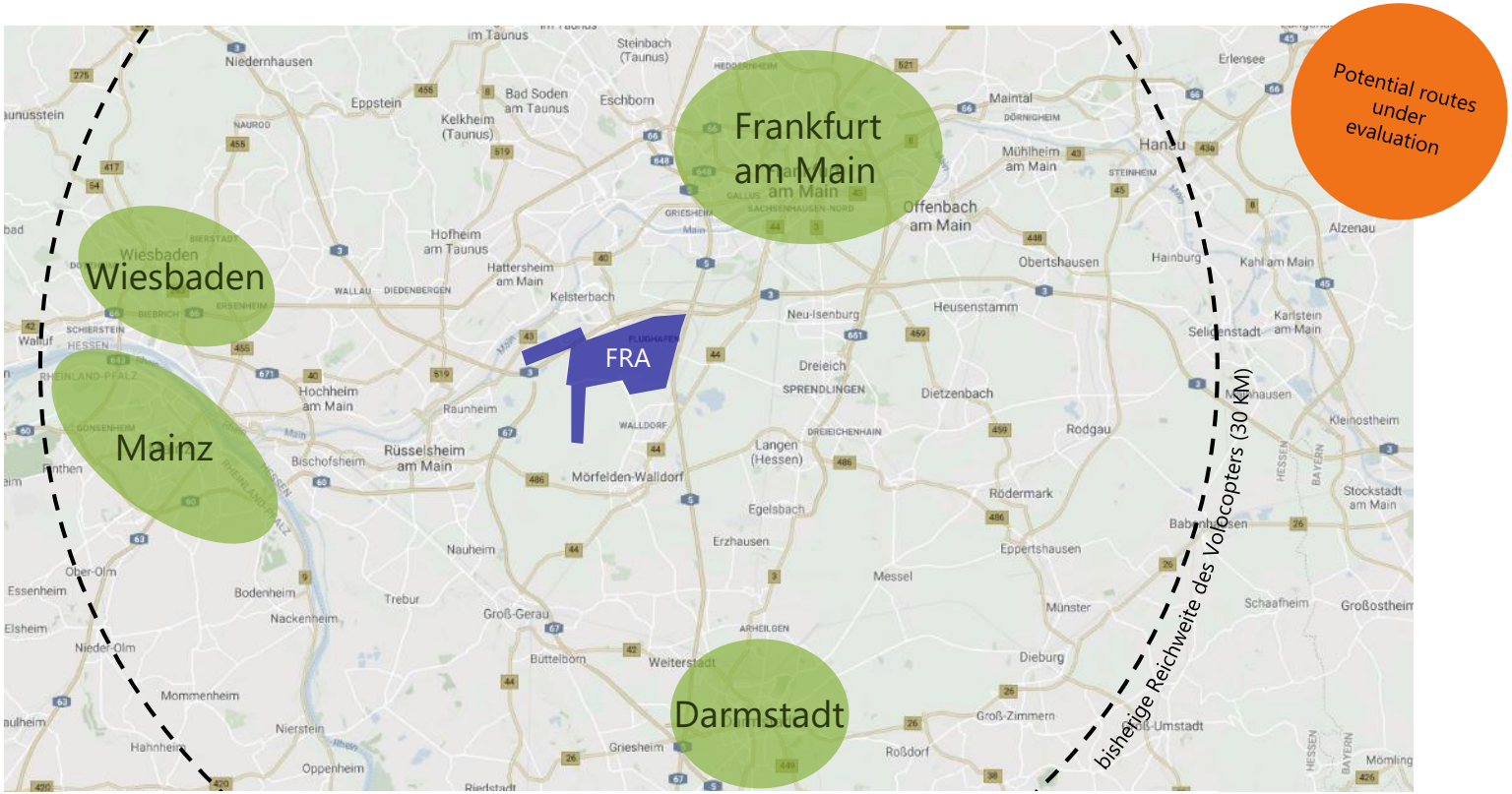

Ground-Handling Processes

2

Volocopter and Fraport will evaluate if **test flights in the Frankfurt area** are feasible. Close coordination with DFS and competent authorities is a prerequisite for a successful demonstrator.


Proof of Concept “Airport shuttle”

Evaluation of potential Air Taxi routes in the Rhine-Main Area



Key issues to consider:

Noise

Assessment of **Environmental and Noise** aspects.

Most **Air Taxis** are **electrically powered** and are **relatively quiet**. This minimises the problem of noise pollution and should foster societal acceptance.

Safety

VTOL Air Taxis will have to meet the **highest safety requirements** – both with regards to air worthiness as well as the integration in to the airspace (U-space and controlled airspace).

Certification

Ground Processes will depend largely on the aircraft type and performance of the VTOL.

Clear **Classification** and **Certification** of VTOL Air Taxis is **imperative.**

Approvals

Flight procedures and **infrastructure** require approvals from relevant authorities.

Close and co-ordination with ANSP, relevant authorities and political decision-makers at local, regional, national and European level is needed.

Gute Reise!
Wir sorgen dafür

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GAMA

General Aviation Manufacturers Association

Enabling the Next Revolution in Aviation

Kyle Martin
Director, European Regulatory Affairs
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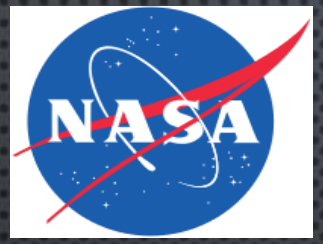
+32 472 94 69 38

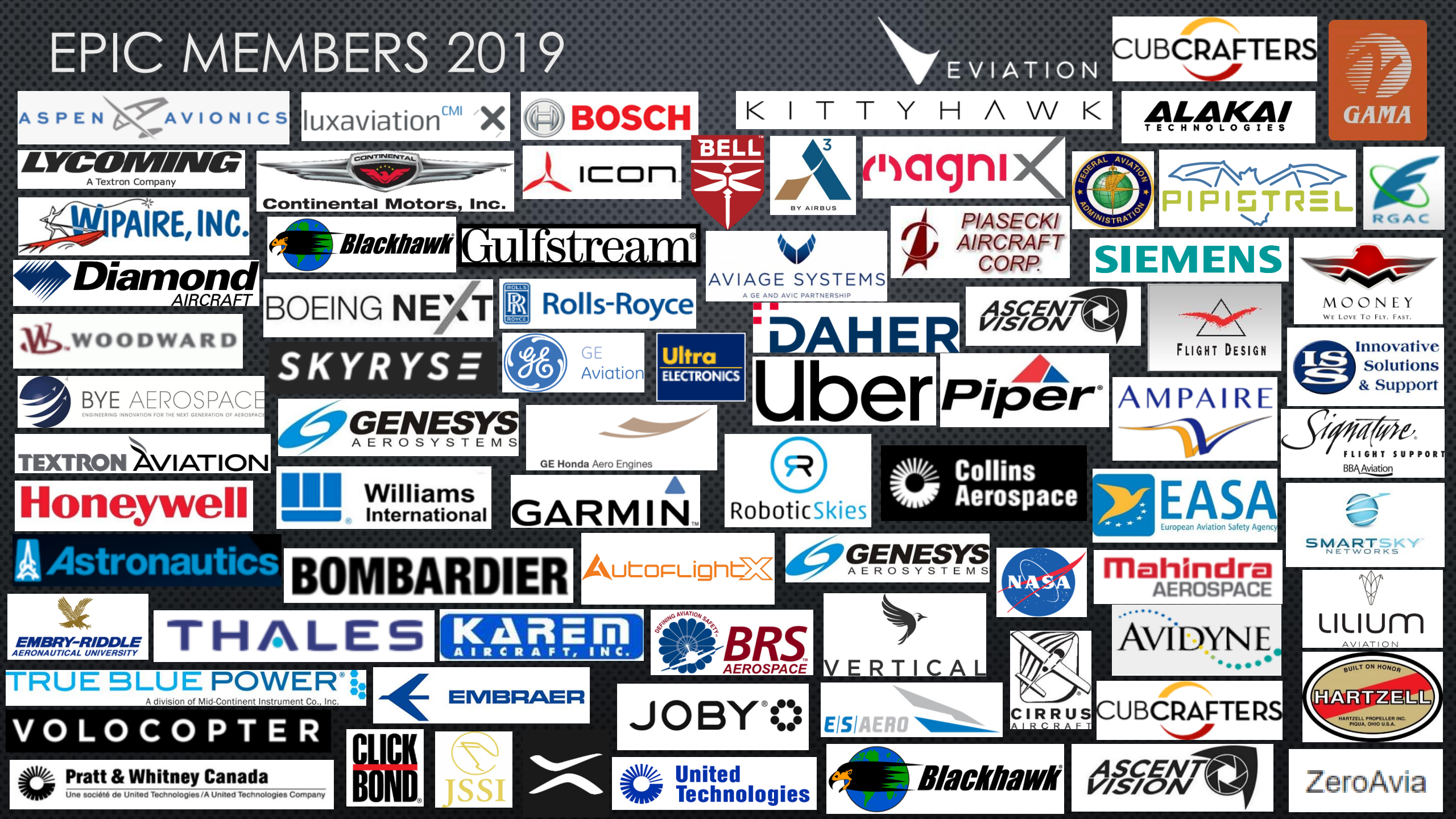
ELECTRIC PROPULSION AND INNOVATION COMMITTEE (EPIC)

- FORMED IN 2015
- 80 MEMBER COMPANIES
- 400+ EXPERTS ENGAGED
- MEETINGS ALTERNATE BETWEEN US AND EUROPE

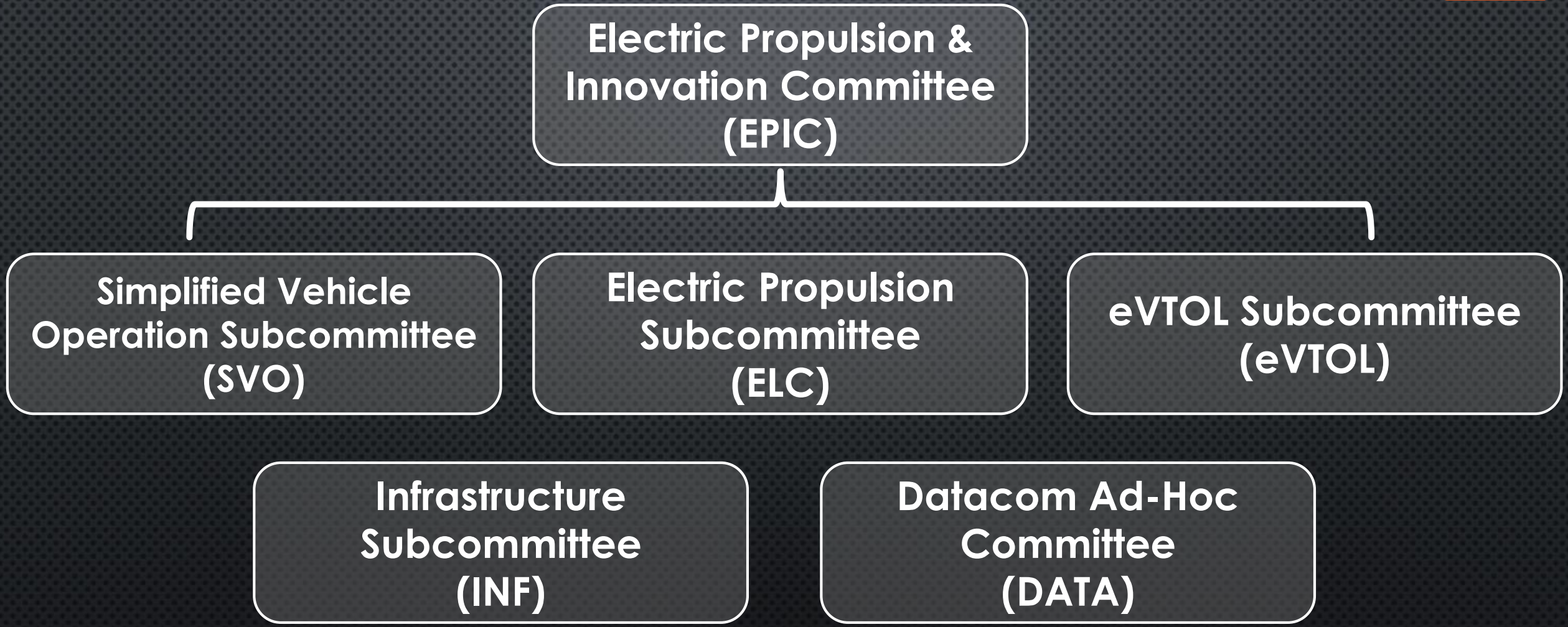
EPIC MEMBERS 2015



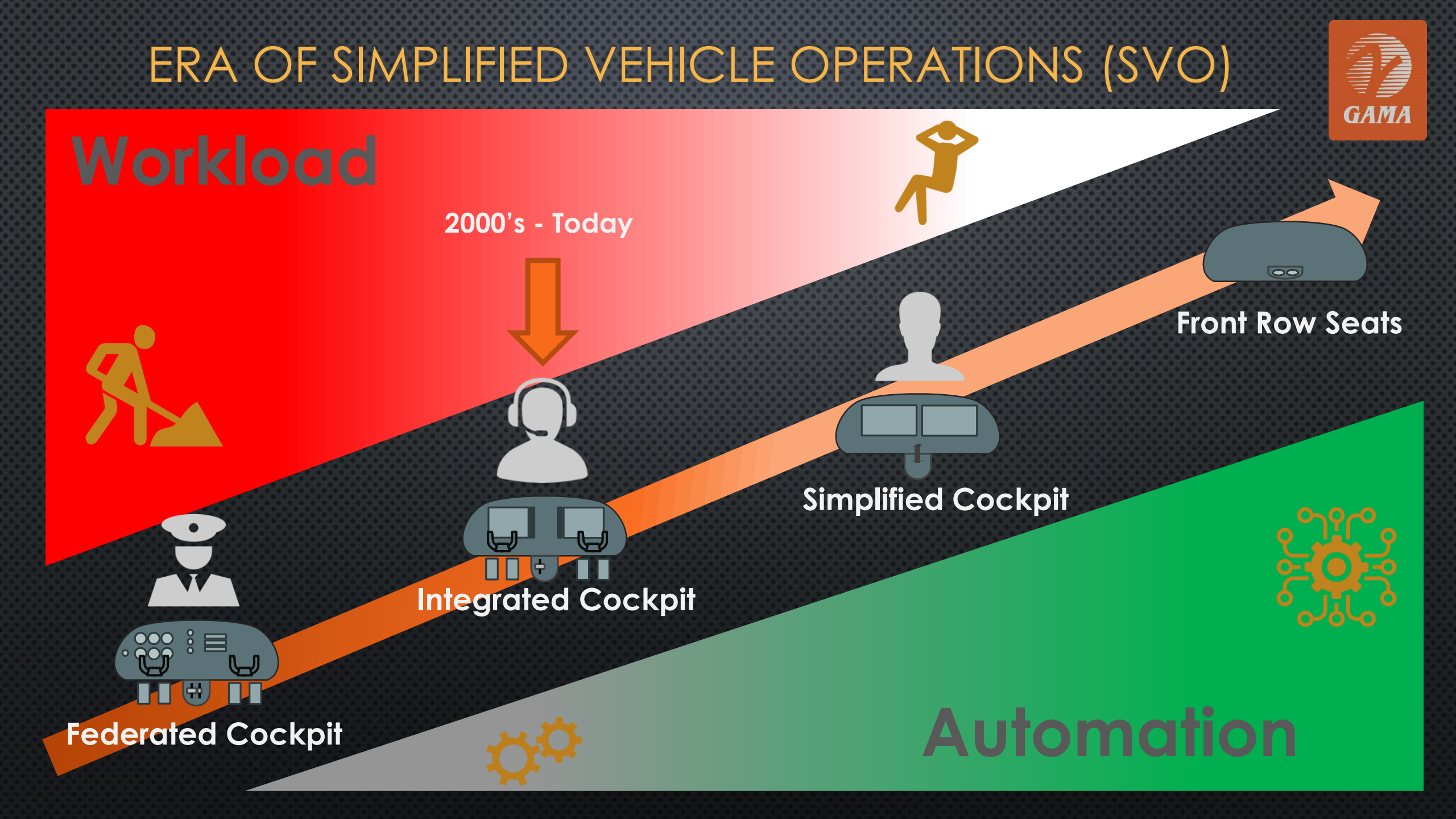
EPIC MEMBERS 2019



GAMA EPIC & SUBCOMMITTEES



ERA OF SIMPLIFIED VEHICLE OPERATIONS (SVO)

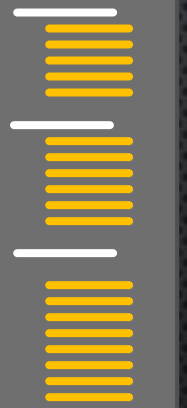


SEPARATING SAFETY REQUIREMENTS FROM METHODS OF COMPLIANCE

Authority

377 Regulations

Historic CS-23



71 Regulations

New CS-23

Auth. Acceptance

High-level requirements. (safety driven)
NO technical solutions prescribed
No tiers or categories

International Aviation Community

Systems &
Powerplant:
Structures: Design
Structures General
Flight Characteristics, Performance, & Operating Limits

- Technical Solutions that meet standards
- Test specifications
- Specific compliance methods

<u>Detailed Design Standards</u>
- Tiered where it makes sense
- Contains detailed compliance requirements
- Current CS-23 used as a starting basis

MEANS OF COMPLIANCE

EPIC Subcommittees Evaluating Existing MOC:

- Applicability of existing MOC
- Readiness for use to obtain authority approvals
- Revisions and new MOC necessary to achieve objectives

Challenges & Opportunities

- Vehicle designs vary significantly
- Innovative systems with autonomous capabilities
- Regulatory path not clear/standardized

MOC

- Industry standards provide pathway during early stage uncertainties
- Standards are well positioned

EXISTING STANDARDS EFFORTS

- ASTM International
  - GA aircraft & Systems
  - Roadmap to support eVTOL
- EUROCAE / RTCA
  - Systems
  - DAA
- SAE International
  - Eaircraft charging
  - Energy storage
  - Developing roadmap to support eVTOL

Gaps:

- SVO Systems
- Battery Management Systems
- DataCOM

QUESTIONS

- Kyle Martin, kmartin@gama.aero
- Christine DeJong, cdejong@gama.aero

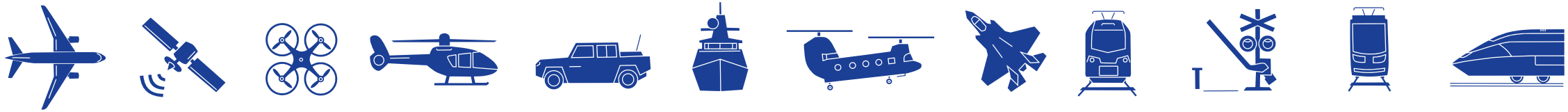
ADSE
CONSULTING AND ENGINEERING

From pioneering to part 21 compliance

EUROCAE VTOL workshop Paris

June 6, 2019

Frank Kaiser



www.adse.eu

Big dreams

Flying taxis: Uber partner reveals design

Uber on track to deliver aerial rideshare network by 2023 as manufacturer Bell Helicopter unveils full-scale model in Las Vegas

▲ Aerial rideshare ambition ... an artist's rendering of Bell Helicopter's Nexus in the air. All photographs: Bell Helicopter

Eviation Aircraft

Eviation: A nine-passenger all-electric aircraft.

Courtesy Eviation Aircraft

Aviation behemoth Boeing has invested in Seattle-based startup Zunum Aero.

Zunum Aero

Technology

London-Paris electric flight 'in decade'

22 March 2017 | Share

A mock-up of the Wright One, Wright Electric's plan for short-haul, electric-powered flight

Sources: BBC news, Guardian, CNN

VTOL aspects

- Start up companies
- Novel Technologies
- New regulations
- From pioneering to part 21 compliant DOA and POA
- And then some…

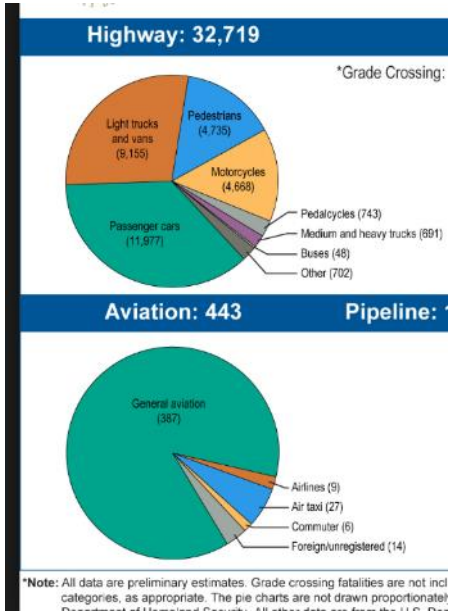
Start Up Companies

- Aircraft pioneers with a bright idea
- Automotive, venturing into aerospace
- Company Life Cycle, Transitions, Reshuffles
- Aerospace Regulations to face
  - Technical requirements
  - Process requirements
  - Certification

Novel Technologies

- Electrical propulsion
- Vertical Take-off and Landing
- Flight Control
- Optionally Piloted Aircraft

Regulations



- New developments require new regulations
- Culture shift
  - from prescriptive regulations
  - to consensus standards
- Industry Push
- Authorities involved and committed

Certification compliance

- A trade-off to be made
  - Over-regulation frustrates needed innovation
  - under-regulation compromises needed safety
- Not if, but **when** to transition from pioneer / innovator to part 21 compliance
  - DOA - Design Organisation Approval
  - POA - Production Organisation Approval
- How to obtain sufficient part 21 process understanding at the right time

And then some…

- Explicit business goal: Type Certification and start of Production
- Type Certificate Holder is responsible for
  - Preparing Flight Crew Training material
  - Prepare Maintenance Training material
- Allowing compliance with operational constraints
  - E.g. Urban Traffic

Callen-Lenz

EUROCAE/EASA Workshop on VTOL

6 June 2019






Callen-Lenz

- Developer of autopilots for manned and unmanned air vehicles
- Safety-Critical Autopilot for Personal Air Vehicles and Air Taxis
  - Low pilot workload
  - Autonomous flight
- Dewi Daniels (Chief Software Engineer)
  - Member of SC-205/WG-71 (the DO-178C/ED-12C committee)
  - Member of RTCA/EUROCAE Forum on Aeronautical Software
  - Member of IEC GEL/065/01 (the IEC 61508 committee)







Forum on Aeronautical Software

- FAS UAS Ad-Hoc Group
- White paper on the applicability of DO-178C/ED-12C to Unmanned Air Systems
- Presented to RTCA PMC and EUROCAE TAC
- Issues raised equally relevant to Small-Category VTOL
- They include:
  - COTS, including open-source, software
  - Software tool qualification
  - Alternative development approaches, including Agile
  - Artificial Intelligence, including Machine Learning







Small-Category VTOL

- Text of the regulation same for small-category VTOL as for large airliners:
  - VTOL.2510: Each catastrophic failure condition is extremely improbable and does not result from a single failure
  - CS 25.1309: Any catastrophic failure condition is extremely improbable and does not result from a single failure
- Context is different, e.g.
  - 5 passengers vs 500+ passengers
  - Small-category VTOL could land in a very small space in an emergency
  - Small-category VTOL could deploy Ballistic Recovery System
- What is an acceptable means of compliance?
  - Do we need dissimilar hardware?
  - Do we need dissimilar software?
  - Can we use COTS microcontrollers?







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VTOL Workshop

Stakeholder's Presentations

Moderated by

Anna von Groote

Director Technical Programme, EUROCAE

- ***SAE***
- ***ASTM***
- ***Volocopter***
- ***Flying Basket***

Safran

AVCP

VRCO

SJU

SAE International – Standards for VTOL

David Alexander
Director, Aerospace Standards

Looking Forward: Themes

Cross-cutting Topics

- Digital & Data
- Autonomy & AI
- Health Management & Prognostics
- Advanced Materials
- More Electric Aircraft
- Electric/Hybrid Electric Propulsion

SAE Aerospace Council, Global Custodians: Oversight and Governance

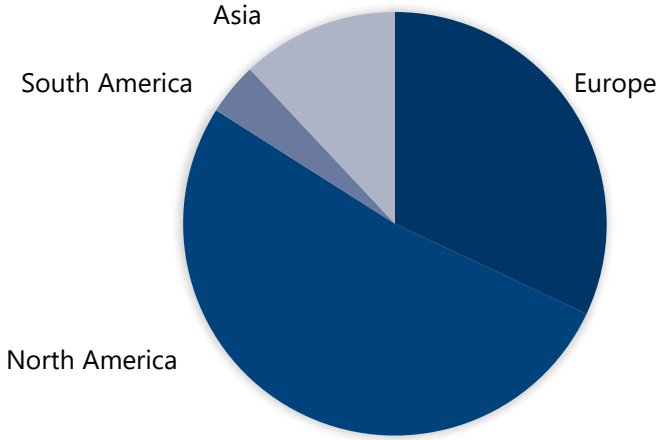
- Airbus
- A4A
- AVIC
- BAE Systems
- Boeing
- Bombardier Aerospace
- CAPE
- CIRA
- COMAC
- EASA
- Embraer
- FAA
- Leonardo
- GE Aviation
- Gulfstream Aerospace
- Honeywell Aerospace
- Lockheed Martin
- Lufthansa Technik
- Meggitt
- Northrop Grumman
- Pratt & Whitney / UTC
- Rolls-Royce (Chair)
- Safran
- Sikorsky
- Southwest Airlines
- U.S. Department of Defense
- Wichita State University

April 2018 meeting hosted by Safran, Saclay

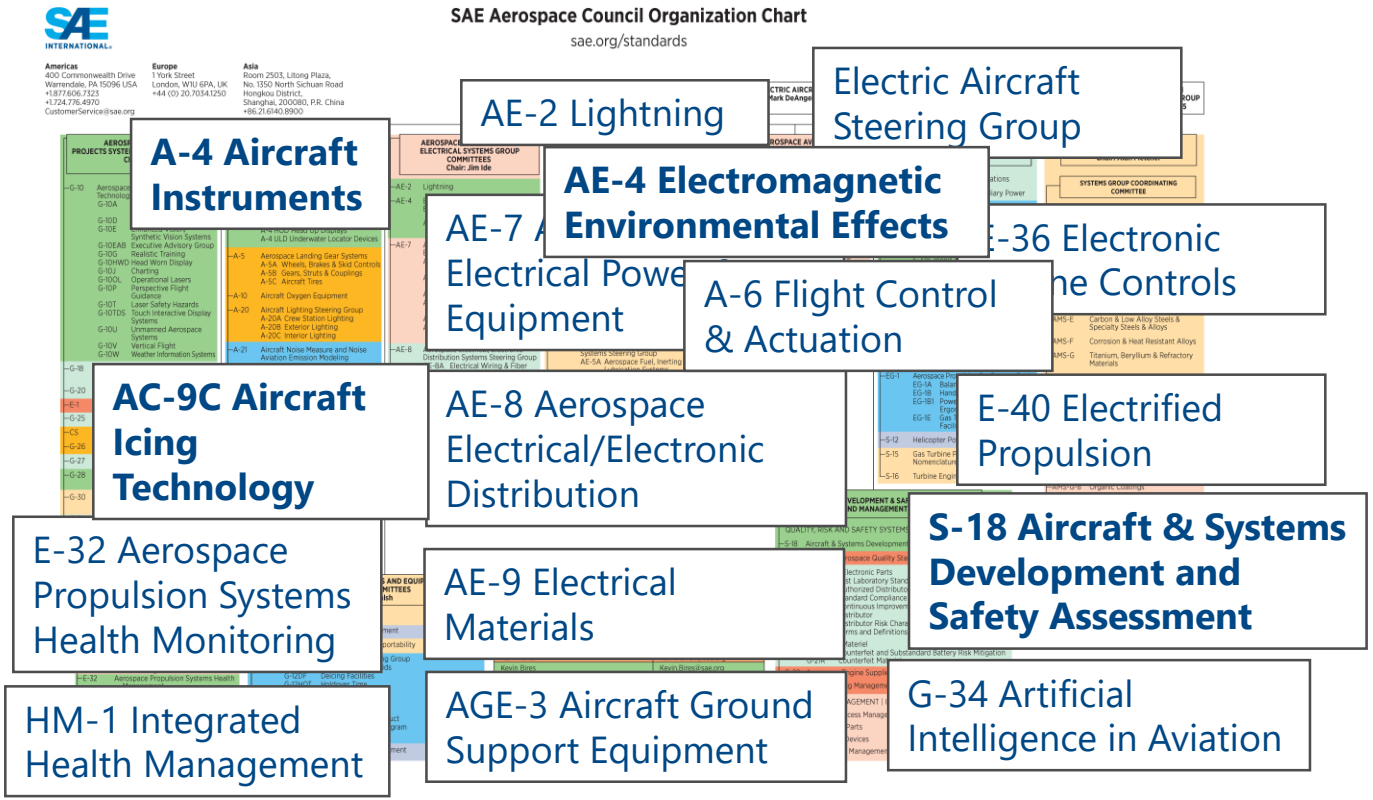
Stakeholders:
Industry, Operators, Government, Research

ICAO Observer Role

Global Stakeholders: Matching the Industry



The Big Picture – SAE Committees and Collaboration



Systems Groups	10
Steering Groups	3
Technical Committees	180+
Standards	7,500+
Unique Participants	8,300+

Partnership with EUROCAE

Goes back to 20 years; MoU updated in 2015 (“upgraded” to MoC)

S-18 / WG-63 Safety Assessment

- ARP4754A/ED-79A, ARP4761/ED-135

AE-2 / WG-31 Lightning

- Several standards supporting certification

AE-4 / WG-14 HIRF

- HIRF Certification Guidelines

A-4ADWG, AC-9C / WG-68, WG-95

- Pitot Tubes, Ice Detection

AE-7AFC / WG-80

- Fuel Cells


WG-80
Hydrogen Fuel Cell Systems

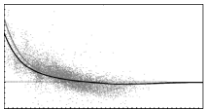
SAE Standards for Rotorcraft – Current

Recent strong push from rotorcraft industry & regulators for standards

Several recent activities:

Rotorcraft SHM, HUMS SHM / HM-1

Helicopter Noise Modelling A-21



Helicopter Hoists G-26

Seats SEAT

Rotorcraft Inlet Icing / IBF S-12

Lightning Protection AE-2

Touch Screens A-4 / G-10

COMMITTEE	TITLE	EXISTING DOCUMENTS	NOTES
HM-1	Integrat Manage	AS5391 Health and Usage Monitoring System Accelerometer Interface Specification AS5392 Health and Usage Monitoring System, Rotational System Indexing Sensor Specification	Rotorcraft WG established in April 2014 with participation from HAI to develop two AIRs: 1- AIR6314, A Power Usage Metric for Transmissions rvention, A ven by HUMS
AC-9C	Aircraft		craft Icing Update for eloping ARP on inlet icing certification"
G-10V	Vertical		inimum Qualification Pitot-Static Probes Council ballot
A-5B	Aerospa Systems Couplin		
SEAT	Aircraft		andard for Airbag l Rotorcraft, General Aviation ent
			rformance Standard alled in Civil rcraft, and General levelopment

U.S. Department of Transportation
Federal Aviation Administration

December 5, 2016

Logen Johnson
Aerospace Standards Engineer
SAE International
1200 G. Street NW, Suite 800
Washington, DC 20005

Dear Mr. Johnson,

The FAA requests SAE form a committee to create an Aerospace Recommended Practice (ARP) to provide alternate means to substantiate that engine inlet distortion limits have not been exceeded by the modification of the rotorcraft to include an airframe-mounted engine inlet barrier filter (IBF). The FAA also requests SAE form a committee to create an ARP to define means to determine and verify power available for IBF-equipped engine installations.

SAE Task Request Forms (STRs) that provide additional information are attached. Accomplishing the above tasks will support the FAA in its effort to publish additional advisory material for IBF installations.

The FAA plans to work closely with SAE, industry, and other certification authorities to support this effort and provide technical expertise. If you have any questions or require assistance, please contact Larry Kelly, ASW-110, at (817) 222-5110.

Sincerely,

Richard E. Jennings
Acting Manager, Design, Manufacturing, and Airworthiness Division
Aircraft Certification Service

Enclosures: 1) Attachment A (IBF Power Available)
2) Attachment B (IBF Inlet Distortion)

AC 27-1B Certifica

SAE Document			
J211	Instru		
J202	Synthe		
ARP5412	Aircrat		
ARP5414	Aircrat		
ARP5416	Aircrat		
ARP5672	Aircrat		
AS143B	Heate		
AIR4003	Repor		
AIR4770	Repor		
ARP1401	Aircrat		
ARP926A	Fault/		
ARP492	Aircrat		
AS8034	Minim		
ARP4754A	Guidel		
ARP4761	Guidel Airbor		
SAE AE4L Report	Test V		
AE4L-81-2	Transi		
SAE 100R14A	SAE S		
ARP1217	Instrumentation Requirements for Turboshaft Engine Performance Measurements	S-12	Helicopter Powerplant
ARP1702	Defining and Measuring Factors Affecting Helicopter Turbine Engine Power Available	S-12	Helicopter Powerplant

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Additional Areas of Rotorcraft Standardization

Committee	Document	Status
AC-9C, Aircraft Icing Technology	ARP6901 Consideration for Passive Rotorcraft Engine /APU Induction System Ice Protection	In Process
A-21, Aircraft Noise Measure	AIR1407 Prediction Procedure for Near-Field and Far-Field Propeller Noise AIR1989B Helicopter External Noise Estimation ARP1964A Measurement of Rotorcraft Interior Sound Pressure Levels	Published
AISC SHM, Structural Health Monitoring	AIR6892 Guidelines for Implementation of Structural Health Monitoring on Rotorcraft	In Process
AE-2, Lightning	ARP5414A, Aircraft Lightning Zoning	Published
A-5, Aerospace Landing Gear Systems	ARP5632 Rotorcraft: Application of Existing Aircraft Designed Tires, Wheels, and Brakes	Published
SEAT, Aircraft Seat	AS8049C Performance Standard for Seats in Civil Rotorcraft, Transport Aircraft, and General Aviation Aircraft	Rev D in process
A-6A1, System Integration	ARP4925B Aerospace Design and Installation of Commercial Transport Helicopter Hydraulic Systems	Published
AE-4, Electromagnetic Environmental Effects	ARP60493, Guide to Civil Aircraft Electromagnetic Compatibility	Published

Examples of potential SAE standards to support the EASA Proposed Special Condition for small-category VTOL aircraft.

SC-VTOL-01 section	SAE Standard
VTOL.2165	**AS5498A** Minimum Operational Performance Specification for Inflight Icing Detection Systems
VTOL.2260 (b) & (d)	**>2000** material and process specifications for metals and nonmetals
VTOL.2335	**ARP5577** Aircraft Lightning Direct Effects Certification
VTOL.2520	**ARP5583A** Guide to Certification of Aircraft in a High-Intensity Radiated Field (HIRF) Environment
VTOL.2530	**AS8017D** Minimum Performance Standard for Anticollision Light Systems
AMC VTOL.2510	**ARP4754B** Guidelines for Development of Civil Aircraft and Systems **ARP4761A** Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment

About SAE International Electric Aircraft Steering Group (EASG)

The Electric Aircraft Steering Group strategically identifies, landscapes, and coordinates the various standardization activities necessary to support full-electric and more-electric aircraft applications at the top level system, subsystem, and component levels.

Next Meeting: energytech Conference

October 21-25, Cleveland, OH, USA

SAE E-40 Electrified Propulsion

Committee launched late 2018

Fixed, rotary wing and eVTOL participants

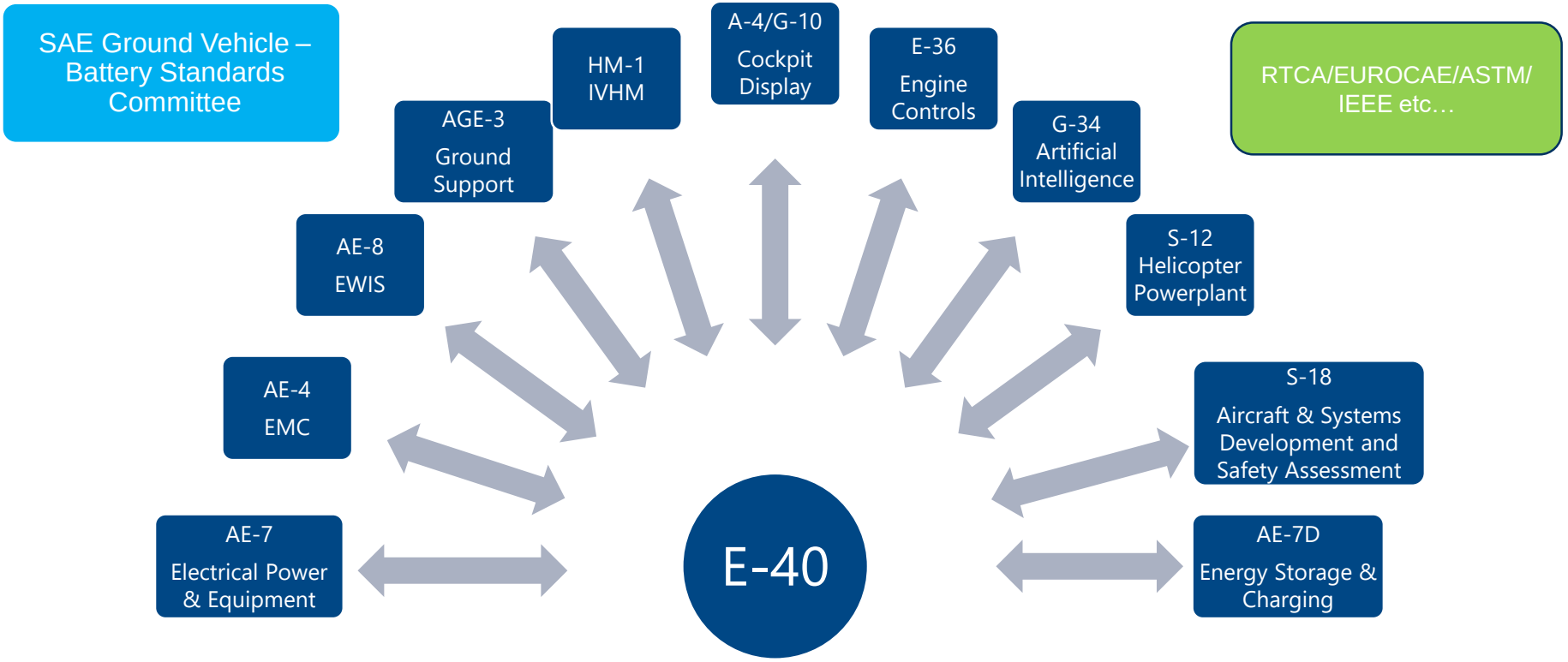
Technology, integration and certification

3 current works in progress

- ARP8676 Nomenclature & Definitions for Electrified Propulsion Aircraft
- ARP8677 Safety Considerations for Electrified Propulsion Aircraft
- ARP8678 Architecture Examples for Electrified Propulsion Aircraft

Next meeting: September 10 – 12, Barcelona

E-40 Electrified Propulsion Liaison Map



SAE G-34 Artificial Intelligence

Committee approved May 2019

Follows expert panel at SAE Aerospace Standards Summit, October 2019

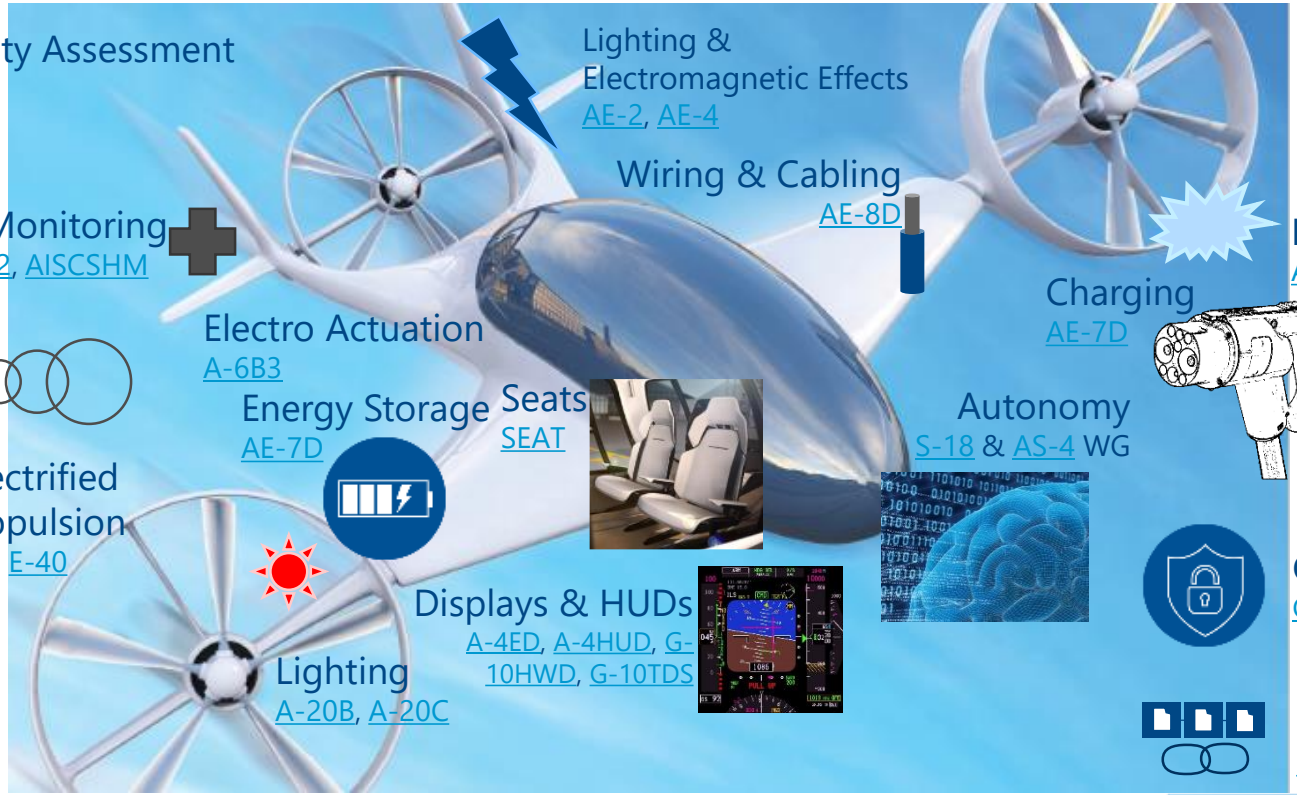
Supported by SAE Digital & Data Steering Group roadmap project

Member connection to AVSI AI Project

Safety-critical flight and wider aviation application scope

Next meeting: June 19-20, Washington DC

Which standards can we use for e/VTOL?



Safety Assessment
S-18

Lighting & Electromagnetic Effects
AE-2, AE-4

Composites
CACRC & AMS P17

Wiring & Cabling
AE-8D

Health Monitoring
HM-1, E-32, AISCSHM

Icing
AC-9C

Charging
AE-7D

Noise
A-21

Electro Actuation
A-6B3

Energy Storage
AE-7D

Seats
SEAT

Autonomy
S-18 & AS-4 WG

Powerplant
S-12

Electrified Propulsion
E-40

Displays & HUDs
A-4ED, A-4HUD, G-10HWD, G-10TDS

Cyber Security
G-32

Lighting
A-20B, A-20C

Block Chain
G-31

*Uber eCRM-002 drawing used for illustrative purposes only, not as an endorsement.

ASTM INTERNATIONAL
Helping our world work better

EVTOL/UAM Standards Efforts

www.astm.org

What is ASTM?

A Proven and Practical System

- Established in 1898
- 150 Committees & 12,500+ Standards
- 32,000 members
  - 8,000+ International Members from 135 countries
  - 5,100 ASTM standards used in 75 countries
- Accreditation:
  - American National Standards Institute (ANSI)
  - Standard Council of Canada (SCC)
- Process complies with WTO principles: Annex 4 of WTO/TBT Agreement

- Development and delivery of information made uncomplicated
- A common sense approach: industry driven
- Market relevant globally
- No project costs
- Coordination with other SDOs (ESOs; EUROCAE, ASD-Stan, RTCA, ISO etc)

An integrated requirements landscape

- Operations and certification are closely related for eVTOL/UAM aircraft
- There is a trade space between what the aircraft is certified to do and the role of the human(s) in/on the loop
- Standards have a role in each of these areas.

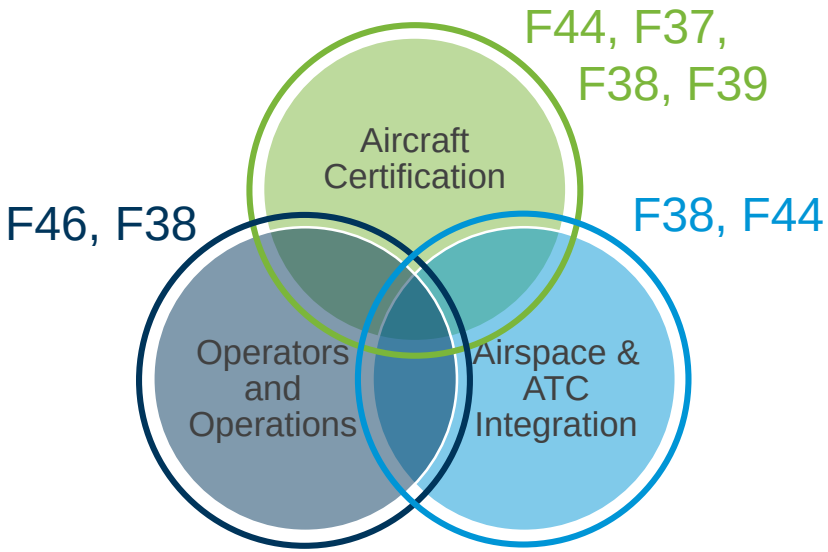
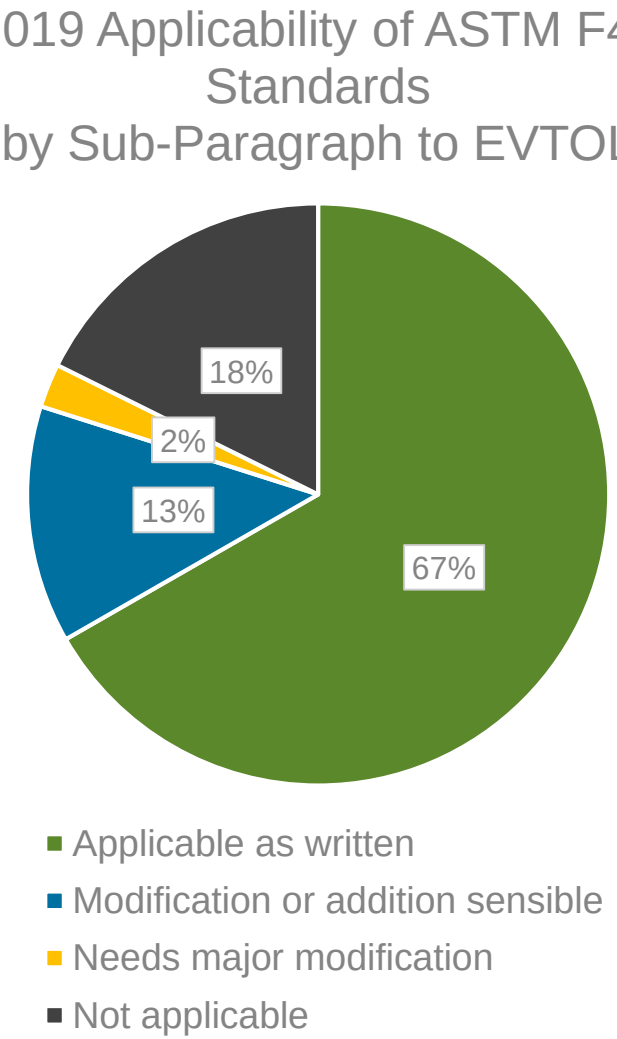


Image: NASA

- ASTM provides valuable support:
  - F44 standards are already accepted as a Means of Compliance to CS/Part 23
  - The highly involved general aviation community brings the appropriate “risk spectrum” perspective to small aircraft to be used in commercial operations
  - High level of regulator involvement assists in harmonization and acceptance
  - Flexibility and nimbleness of the consensus process mean timely solutions can be developed that capture the collective industry knowledge and best practices

Standards support innovation

- One of the key motivations for the CS/Part 23 rewrite that was completed in 2017 was to "future proof" the regulations to allow new technologies to be certificated.
- Industry standards, particularly ASTM standards, were selected as an Accepted Means of Compliance to these new Rules.
  - ASTM F44 Committee on General Aviation Aircraft was created to produce the Means of Compliance library for the new CS-23 Amdt 5 / Part 23 Amdt 64
  - The Rule is intended to be at a performance-based "safety intent" level while the Standards provide an acceptable "what" and/or "how" to satisfy that safety intent.
- EVTOL aircraft were not contemplated with the new CS/Part 23, nor with the original library of standards, but they are still acceptable starting points.
  - ASTM's committees have roadmaps to rapidly accommodate new technology standards, such a eVTOL



Efforts underway to address EVTOL needs

AC377

- Focused on Autonomy in all aspects of aviation, from sUAS through GA & UAM
- 1st technical report out June 2019
  - Terminology, alternative requirements framework to provide more nuance than the automotive-style “Levels of Autonomy”
- Now working on guidelines for key technical pillars of autonomous systems

AC433

- New effort focused on identifying and filling gaps in the existing Standards library for EVTOL/UAM aircraft
  - 1st meeting May 2019; schedule being developed
- Complimentary to other Standards Development activities
- Identifying and scoping gaps then working with technical committees to fill them

F38 & F39

- F38 working on UAS technologies that can be applied to UAM: bounding complex systems, detect & avoid (DAA), etc.
- F38 working on vertiports design.
- F39 working on electric propulsion system components: energy storage systems, electric propulsion units, etc.

F44

- Alternative approaches to system safety
- Distributed, hybrid, and all-electric propulsion system integration
- Indirect flight controls (e.g., fly-by-wire)
- Flight/Performance standards for VTOL to horizontal flight considerations

Contact Information

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E:sgobbi@astm.org
www.astm.org

Global Offices:

Canada
Belgium
Peru
China

EUROCAE VTOL Workshop

Oliver Reinhardt, Head of Airworthiness // remote // 2019-06-06

Agenda

- **VOLOCOPTER PRODUCT**
  Volocopter 2-seat urban air taxi

- **VOLOCOPTER STANDARDIZATION NEEDS**
  adding prescriptive requirements to EASA SC-VTOL

Agenda

- **VOLOCOPTER PRODUCT**
  Volocopter 2-seat urban air taxi

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  adding prescriptive requirements to EASA SC-VTOL

Volocopter 2-seat eVTOL aircraft

Flying since 2011 – extensive operational experience in manned and unmanned flights

“Flying Yoga-Ball” – Technology Test

VC200 – Proof of Concept

VC200 – Demonstration Dubai

VC2X – Continued Intensive Flight Testing

Volocopter 2-seat eVTOL aircraft

Aircraft model VC2-1 in EASA Type Certification since late 2017 and well advanced

Model	**VC200** First Flying Model	**2X** Currently Tested	**VC2-1** EASA certification ongoing
			
Usage	Testing & Demo manned & unmanned	Testing & Demo manned & unmanned	Commercial Air Taxi piloted
Certification	Experimental	Experimental	Type Certification
Permits	National German PtF	National PtF EASA PtF	EASA TC, CAT operations, internat. validations

Agenda

- **VOLOCOPTER PRODUCT**
  Volocopter 2-seat urban air taxi

- **VOLOCOPTER STANDARDIZATION NEEDS**
  adding prescriptive requirements to EASA SC-VTOL

Volocopter Standardization Needs

EASA SC-VTOL provides safety objectives – AMC required to identify prescriptive requirements

Standardization by schedule:

- Volocopter is well advanced in TC process, any standard developed now will be available too late to actively influence our certification

Standardization by topic:

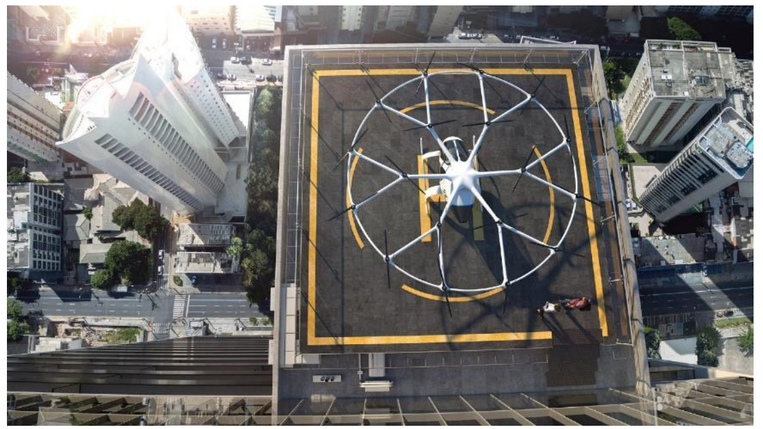
- Various standards are already in place → *no need to duplicate efforts*
- Many companies are already active in other standardization committees
  → *Focus on areas not covered elsewhere*
- EASA is leading the certification path and sets international standards by publishing SC-VTOL based upon novel CS-23 Amdt. 5 logic
  → *Well justifiable to actively push for specific standards also from Europe*
  → *Nevertheless: International harmonization is key for success in Aviation!*

Volocopter Standardization Needs

EASA SC-VTOL provides safety objectives – AMC required to identify prescriptive requirements

Standardization by topic:

- Electric Propulsion Unit → Well taken care of by ASTM F39, just published in a Part-33 compatible version
  → No need to duplicate
- Electric Energy Storage → DO311 in place, but developed for different kinds and usage of batteries, potentially overly conservative and excluding a number of technical choices
  → ASTM F39 started, stopped based on FAA feedback, tries to restart – result open
- Charging Infrastructure →VTOL aircraft likely to join vertiports,
  → requires common charging capabilities
- System Safety → Legacy standards for legacy aircraft with segregated systems
  → Highly integrated system and VTOL needs required to be aligned
- Multicopter Loads → Novel kind of vehicle, no established load cases
  → Emergency landing conditions may well be unique
- Detect & Avoid Systems → Will become significant importance once number of vehicle raises
  → Minimum performance & qualification requirements required
- UTM integration of UAM → UAM intersects all traffic management systems
  → Realistic approaches considering cyber security required
- Vertiport



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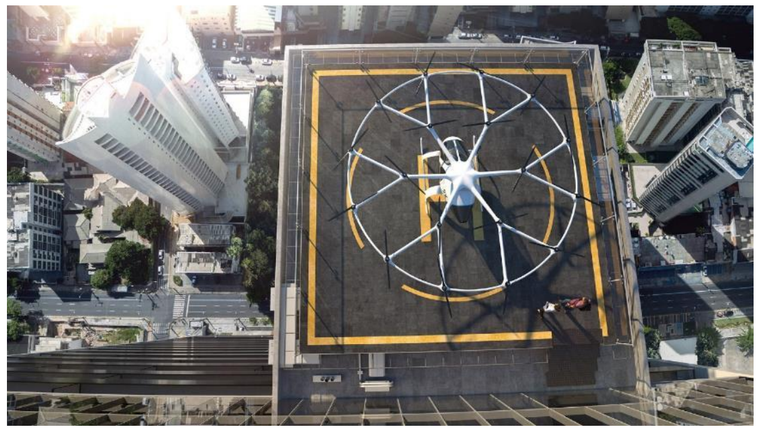

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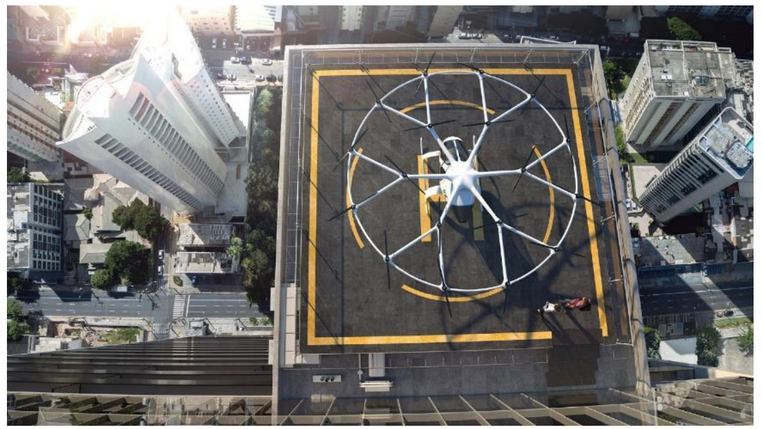

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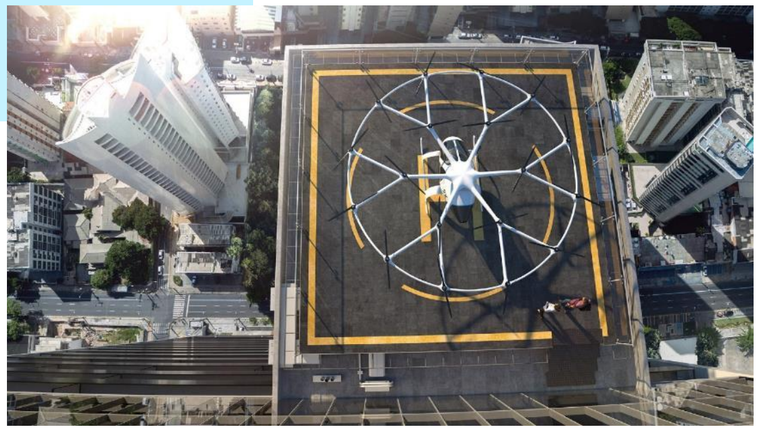

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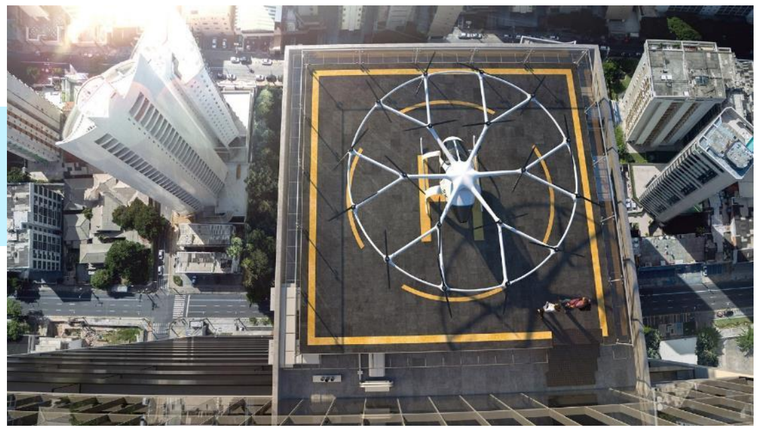

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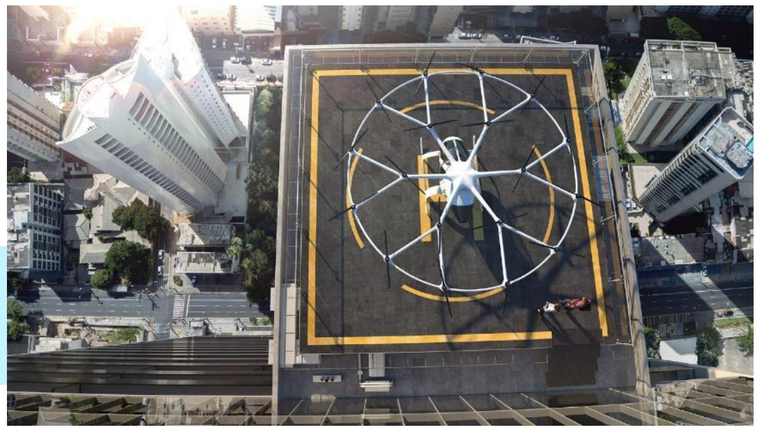

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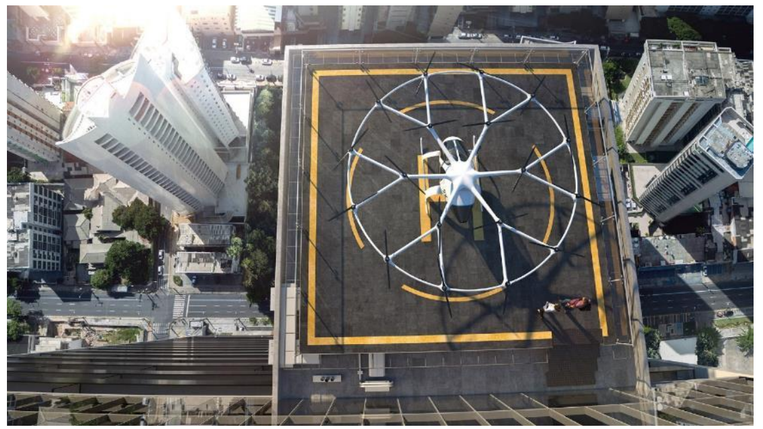


Please approach us

Oliver Reinhardt
Head of Airworthiness
Oliver.reinhardt@volocopter.com


FlyingBasket

FB3

- Payload: 100 kg
- Flight time: 15-45 min.
- Ready for immediate use

Applications

- Load Transportation
- Heavy Payload operations
- Civil protection

Future Standards

- Avoid parallel development of diverging standards
  - Aligned manned / unmanned standards
  - Requirement modulation based on risk (manned/unmanned)

- Guidelines on Common Cause Failures


FlyingBasket

EUROCAE – EASA
SC-VTOL WORKSHOP

—

06/06/2019

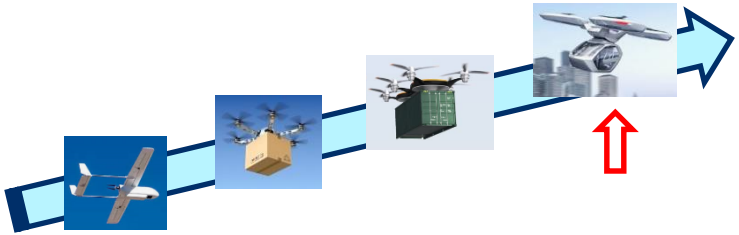
SAFRAN

UAS & VTOL – FCS Technological approach

❑ Market

FCS to address market evolution

- From manned to unmanned operations
- From LR/BVLOS survey to disruptive transport means



❑ Key Technological Streams to deliver relevant technical solutions

- Safe & Secure avionics architecture
- Accurate & safe navigation and guidance with high level integrity
- Compact and affordable electronic platform
- Cybersecure BVLOS communication
- Reliable DAA

A set of technologies applicable to a wide range of unmanned applications including VTOL

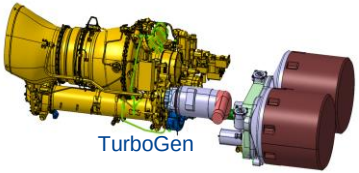
New mission profile, New technical and regulatory challenges

SAFRAN

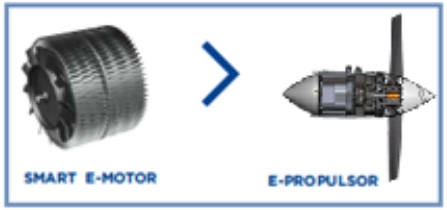
Key Hybrid Electric propulsion Technologies

Various potential future hybrid-electric propulsive architectures BUT key technologies to be developed remain similar :

- Electric generation & drive (motors, turbogen)
- Power distribution & power management (feeders, converters, harnesses…)
- Energy storage (batteries, fuel cells…)


TurboGen


ENGINeUS



Potential updates / new industry standards required as guide for the design of the key technologies, with the aim of the propulsive system meeting certification requirements

SAFRAN

Expectations for this WS - AMC

❑ Definitions & general Concepts

- Definition of the different landing situations : safety landing / emergency landing / operational “land ASAP”
- General operational objectives : after 1 failure / after more than 1 failure
- Classification of main types of aircraft : full rotorcraft / mixt aircraft with or without the capability to land as an airplane
- Database of the main Types X Operational situations (context & use)
  for identifying typical applicable MoC (CS-23 amdt4, CS-27, ASTM…)
  the purpose is to give clues but not to be exhaustive
- Convergence of SC-VTOL and CS-UAS : pilot onboard / remote piloting / autonomy

❑ Flight

- Discussion about performance according to the A/C type for each flight phases :
  TO, CLB, CRZ, LND (i.e. CS-23, CS-27/29)
- Decision point
- Minimum requirements for Avionics / Flight Control System

Expectations for this WS - AMC

Safety

- Review of key objectives:
  SC-VTOL.2510 No single evt with Cat effect # C27.602 for CAT components
- PRA: rotor burst, bird strike, FOD …
- Survivability of the VTOL in case of crash
- Safety of VTOL users on ground (ground crew, passengers…)
- Common modes treatment
- Demonstration methods
  ED135-ARP4761 / “global analysis” / SORA approach

Thrust/Lift system installation

- Boundary between T/L system and A/C
- Classification of the main T/L systems
  Impact of the number and type of T/L units

Expectations for this WS - AMC

- **High power / high voltage electrical system**
  - Installation
  - Environment
  - Protection
  - Thermal management
  - Power sources and management

POWERED
BY TRUST

Active VTOL Crash Prevention Ltd. (AVCP)

A Complete

Zero Altitude/Zero Speed

Safety System for eVTOL's and Other Light Aircraft.

A Step Change in Light Aircraft Safety.

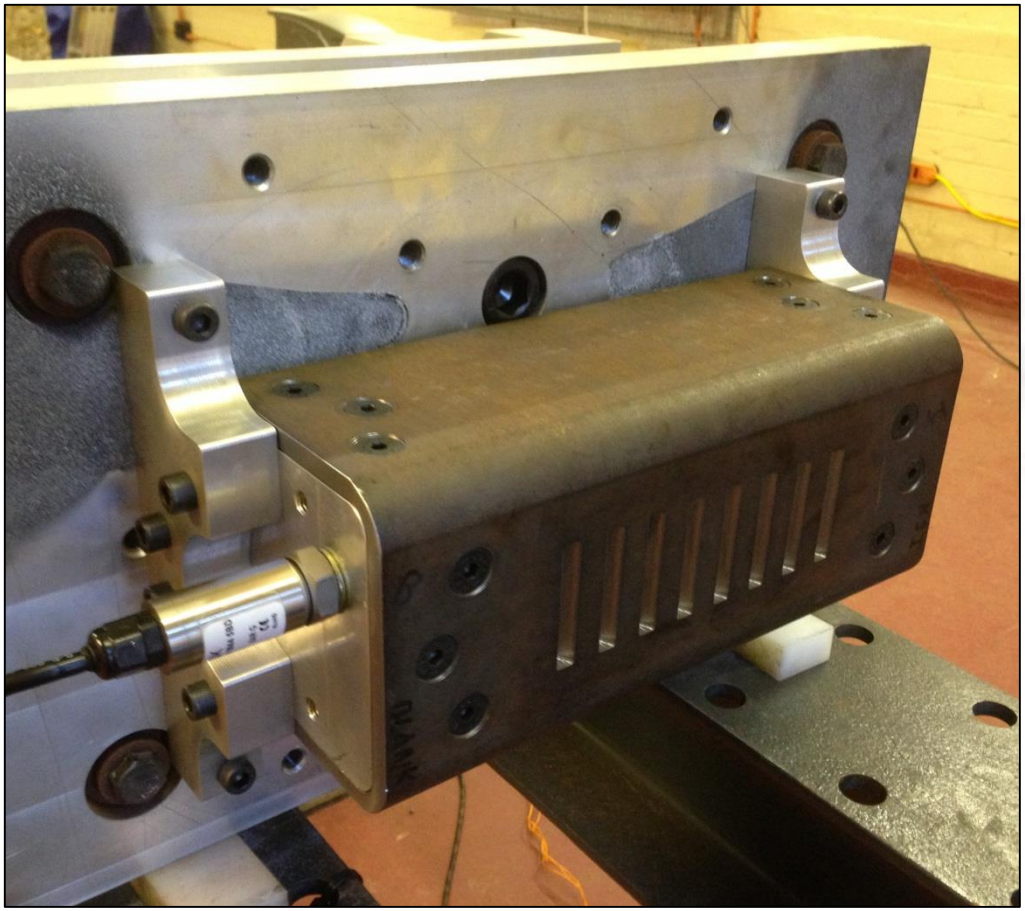
AVCP is a division of the ABBS Group.

Previous Use of the Parachute and Rocket Motor Combination.

The addition of impulse generated by a rocket motor to a conventional parachute system is not novel.

- Tanks, armoured vehicles (with USSR troops inside!) logistics loads, moon landers, Soyuz capsules etc. have made controlled landings by using retrorockets for many years.
- However, these applications are simpler than the eVTOL/Light Aircraft situation because the parachute is always fully open before landing, and the load and descent rate are known in advance.
- Hence the rocket motor impulse required and the motor initiation altitude can be pre-determined and pre-set. Burn time is 0.5 - 1s.

The Linear Rocket Motor (LRM™) Concept.



The Linear motor configuration with multiple exit slots along one side of a square tube achieves a rapid initiation response and ultra-fast impulse delivery if that is required, and an even application of force over a large surface area, eliminating points of high loading at attachments.

The Original Concept for Conventional Helicopters - 2013

- **Use Linear Rocket Motors (LRM™) as part of the skid structure to minimise weight addition.**
- **Because a lot of impulse can be delivered very quickly arming and initiation can be delayed until a hard landing or crash is certain, at about 5 – 15m altitude. The system is in Safe Mode until then.**

eVTOL Version of LRM™ With Twin Exit Nozzles in End Bulkheads.

- **eVTOL/Light Aircraft version of 10kNs LRM™ with Twin Exit Nozzles.**
- **Optimum burn time is about 1s for Light Aircraft/eVTOL's to keep deceleration levels down to 2G maximum.**

Conventional Whole Aircraft Ballistic Parachute System - The Safety Gap.

- **Ballistic parachutes (launched by a rocket)** have been fitted to light aircraft for 18years.
- Many eVTOL manufacturers say they will fit a ballistic parachute in case there is a power or control problem, **but the descent rate is up to 8-10m/s which is likely to result in some major injuries in an UAM eVTOL with passengers.**
- **And they currently only work above about 250 feet** altitude due to the time it takes for the parachute to open.
- Hence there is currently a **critical Safety Gap of about 250 feet.**
- **Any power or control failure during the VTOL phase could result in a crash at up to 25m/s.**

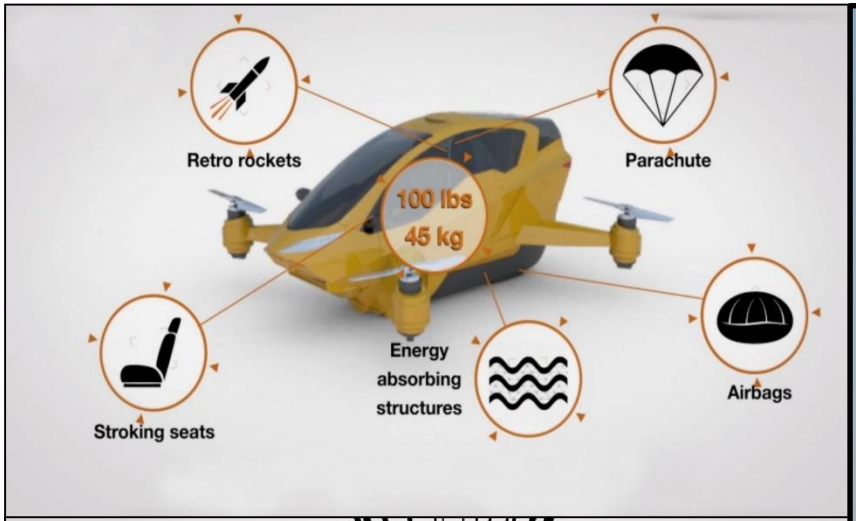
N.B. A free fall from 100ft will result in approx. 25m/s descent rate.

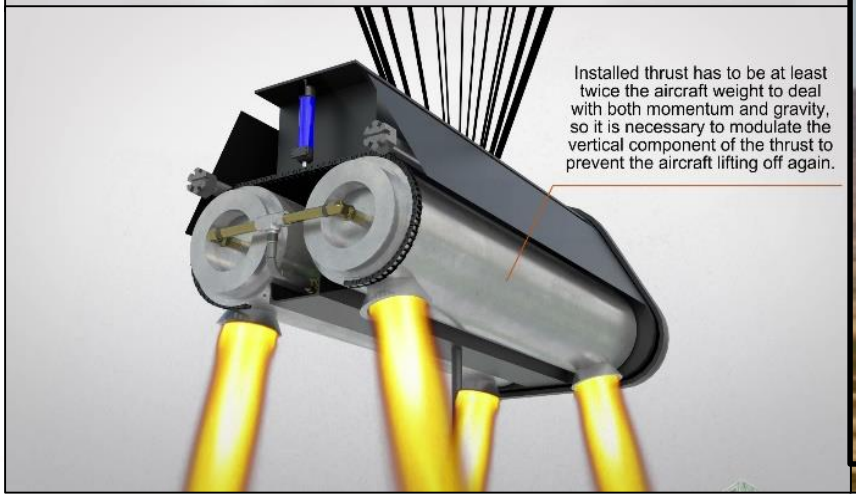
So Why Are Designers Fitting a Conventional Ballistic Parachute Anyway?

- **Given that a current BRS will not work below 250ft, i.e. during the most critical VTOL phase of a multi-rotor eVTOL flight, where it is most vulnerable to any problem, what is the point of fitting one?**

- **Clearly, it is providing a false sense of security.**
- **Essentially, it is no more than an (un-intended?) confidence trick.**
- **And none of the major eVTOL designers seem to want to talk seriously about the Safety Gap problem, and just want to rely on redundancy.**

System Target – A Ground Contact Velocity Less Than 2 m/s In All Circumstances.

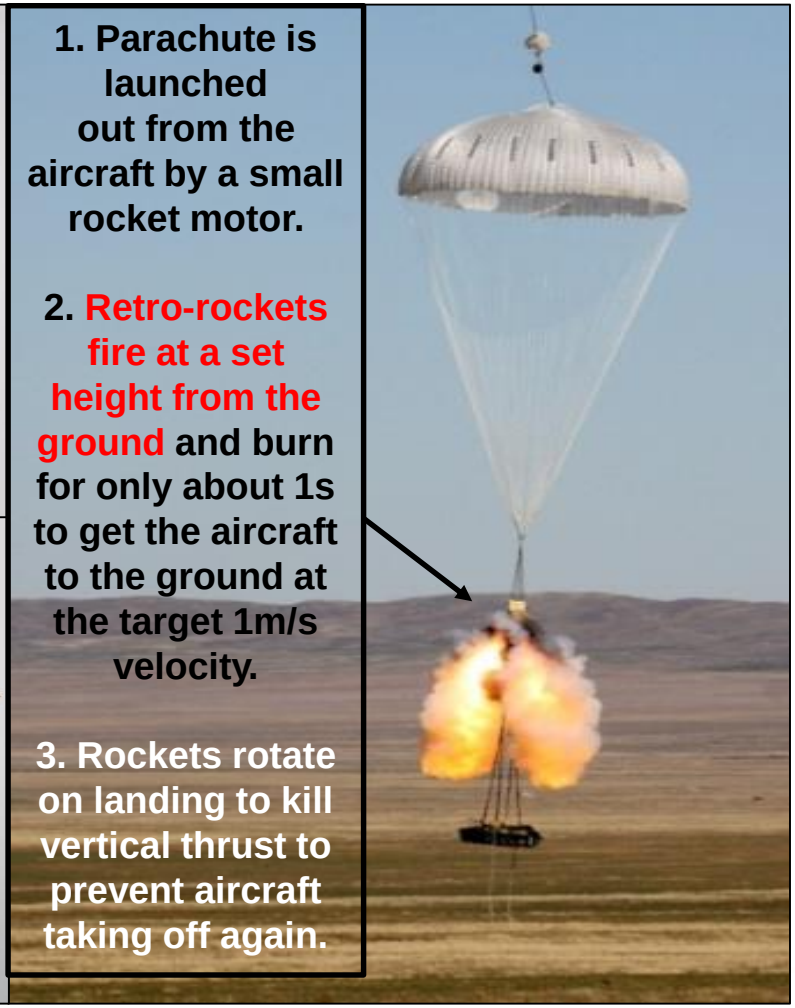




1. Parachute is launched out from the aircraft by a small rocket motor.

2. Retro-rockets fire at a set height from the ground and burn for only about 1s to get the aircraft to the ground at the target 1m/s velocity.

3. Rockets rotate on landing to kill vertical thrust to prevent aircraft taking off again.

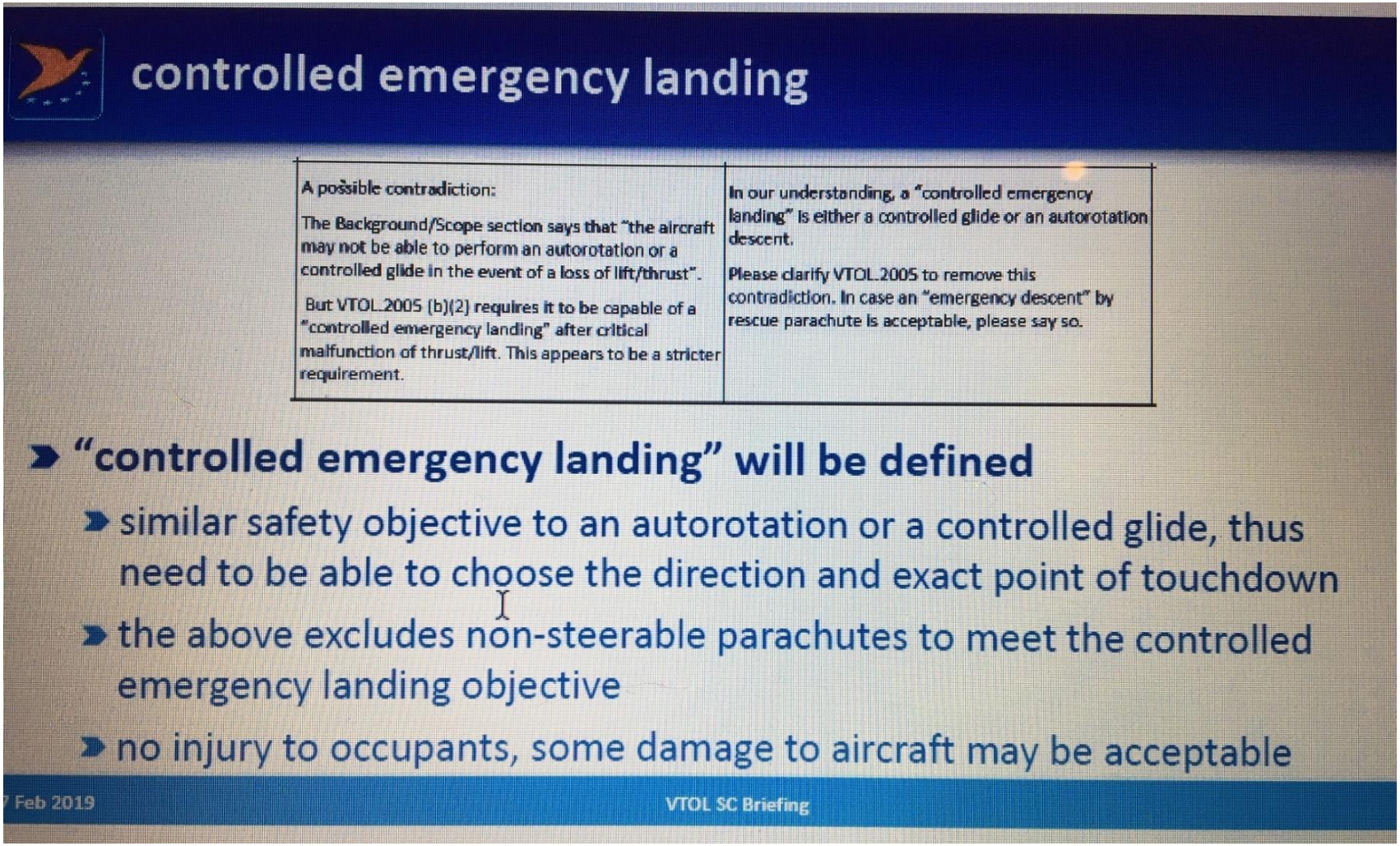


Dealing With All the Variables – A Critical Part of the System.

- An emergency within the Safety Gap could happen at any height from zero up to 250ft and at different aircraft weights.
- This means that the Total Impulse (force x time) required from the retro-rockets varies over a wide range, with about a factor of six between the minimum and worst cases.
- Installed motor thrust must exceed aircraft weight by X2 to deal with the momentum of the fall and gravity, so on landing the motors could lift the aircraft into the air again.
- **Solution ……. rotate the motors on landing.**

This is a key part of the inventions covered by the AVCP patent applications. It is essential to control the Total Impulse delivered.

EASA Conclusion – Cologne Feb.2019



The Implications of the EASA Proposal.

- "No injury to occupants" must imply an essentially fully controlled landing with a descent rate of less than 1m/s, or if not, a lot of passive safety measures such as air-bags, stroking seats, and crushable structure.
- All of which add significant cost and more importantly, weight, which is a critical factor in eVTOL design.
- The weight of the complete Zero-Zero system is little more than a current BRS whilst eliminating the Safety Gap – approx. 45kg per 1,000kg aircraft weight.

Complete flight envelope covered at very little more weight than a current ballistic parachute system which leaves a critical 250ft Safety Gap.

EASA Conclusion re Target Accident Rates.

- The current accident rate for helicopters is about 3.6 (with one fatality) per 100,000 flight hours, so a fatality probability of about 10^{-5}
- The EASA accident probability proposal is 10^{-8} for eVTOL's carrying passengers, a long way from 10^{-5} !
- Some major eVTOL projects using multi-rotor designs say they are relying on redundancy and multiple power supplies/control systems to achieve the required levels of reliability and safety.
- But what is the probability of a multiple bird strike or FOD taking out two sets of rotors, possibly on the same side of a quad/hex rotor design? Or a lightening strike disrupting the power control system?

Surely these two examples alone are sufficient to conclude that just relying on redundancy and power reserves is not going to be enough for certification without an independent Zero-Zero Safety System?

Required – Relevant Standards and a Certification Route to Follow.

- If a truly Zero-Zero system is effectively made a requirement for certification of such as multi-rotor eVTOL's for the UAM role physics dictates that it can only be achieved at an acceptable weight using retro-rockets in combination with a ballistic parachute recovery (BRS) system.
- The current use of a BRS on Light Aircraft has already been certified so presumably some standards have been used to do this, but moving from a relatively small simple parachute launch motor to a fully controllable retro-rocket system will no doubt require a much higher standard of testing and certification.
- So what standards and certification route will be required?

Clarity is needed now to meet proposed in-service entry dates!

A Coordinated Collaborative Effort to Develop a Zero-Zero System?

- **Whilst the recent UAM eVTOL developments have focussed attention on the need for a Zero-Zero system using retrorockets, the potential for a step-change in safety for Light Aircraft generally, and even helicopters, should demand that the concept is pursued to a conclusion as soon possible for much wider application than eVTOL's.**

- **Hence I would like to propose that a combination of EUROCAE, EASA, EGAMA and any UAM/eVTOL/conventional light aircraft operations interested should join forces to specify, develop, and certify a range of Zero-Zero systems to suit the full range of aircraft systems in order to achieve the step change in Light Aircraft safety that is now possible.**

A new EUROCAE or EASA committee to coordinate the activity?

Origin of the System.

The system is derived from another ABBS Group development which uses rocket motors to counteract the lifting forces of a Mine/IED blast under an armoured vehicle.

Comparison No Motors/With Motors.

Current Status of Armoured Vehicle Technology – Safety Issues.

Tested at large scale in USA in August 2018 and Israel later this year.
Ongoing US Army development programme.

****

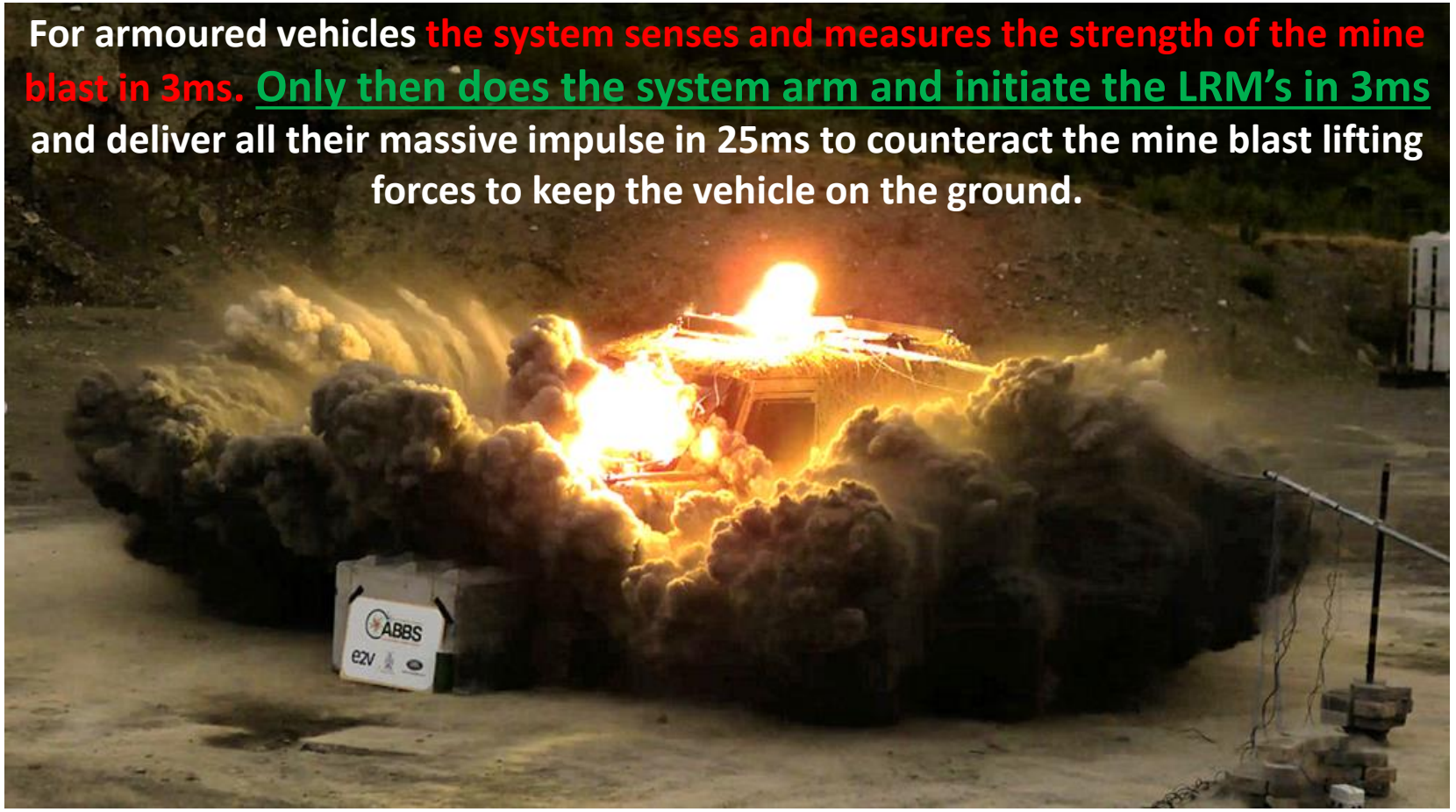
What does this have to do with the Zero-Zero Safety System?

- It is the proven technology base on which the patented rocket motor, Safe & Arm, sensor, control, and initiation systems are being developed. It cannot initiate accidentally.
- Safety is critical, the system runs in Safe Mode and is only armed ready to fire (in less than 1ms) when it is required.
- An ultra-safe Exploding Foil Initiation (EFI) system is used to ignite the motors. (Used on air-launched missiles, bombs, torpedoes.)

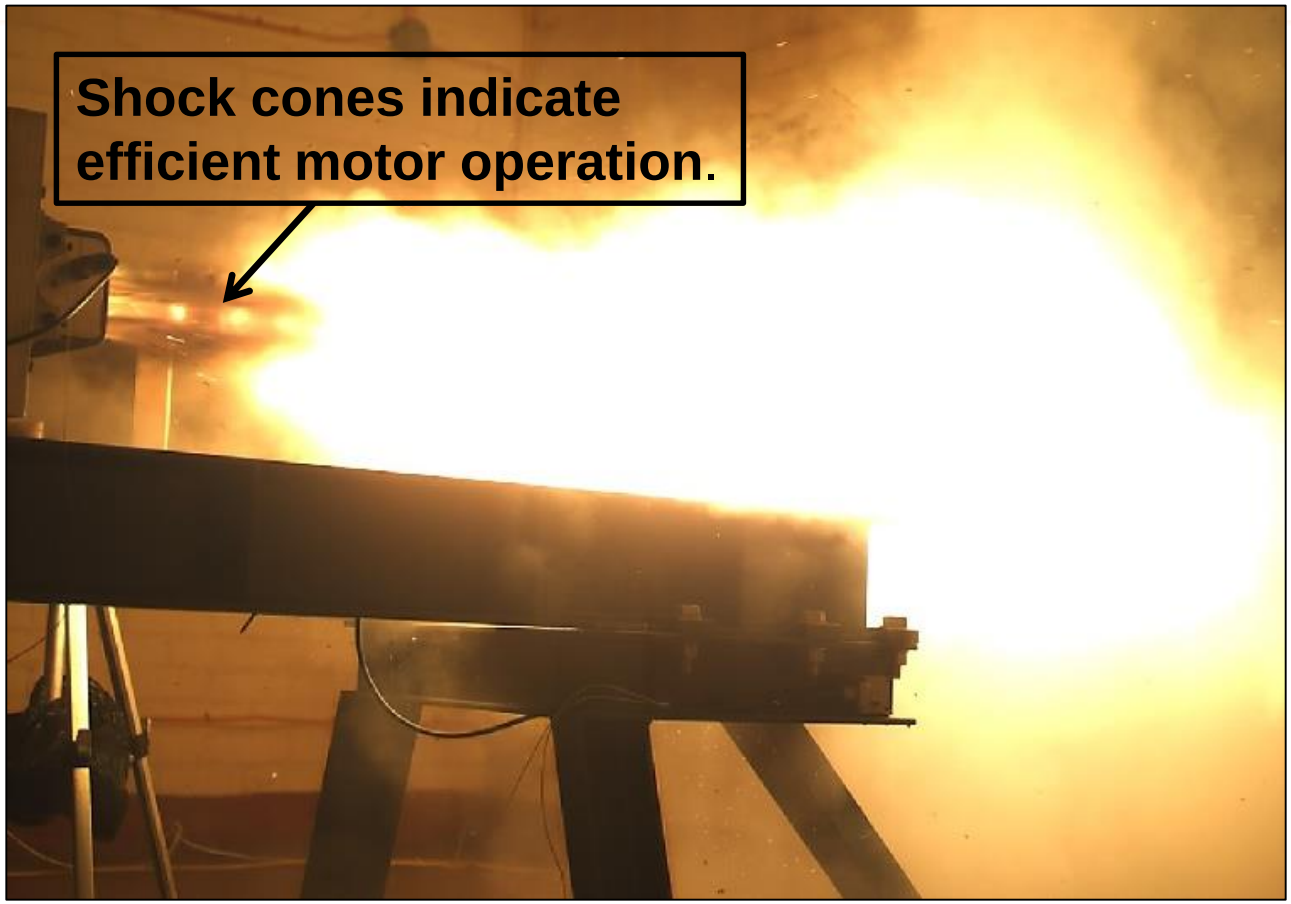
It is an inherently safe, mature system at TRL6.

LRM™ Arming and Initiation Time.

For armoured vehicles the system senses and measures the strength of the mine blast in 3ms. Only then does the system arm and initiate the LRM's in 3ms and deliver all their massive impulse in 25ms to counteract the mine blast lifting forces to keep the vehicle on the ground.



Second Firing of Novel, Patented, Linear Rocket Motor Design Concept – Sept. 2013



Current Standard Linear Rocket Motor Design for Armoured Vehicle Application.

- Dimensions:- 1100 x 120 x 120 mm with 10mm wall thickness. Weight in steel 45kg/composite 20kg
- Initiation time:- 3-4ms from shockwave detection.
- Propellant load:- 5.5kg HTPB/Al/AP
- Total impulse/peak thrust:- about 7.5kNs impulse, 135,000lbf (60 tonnes) peak thrust.
- Duration:- about 25ms after first efflux appears.
- Double width rectangular section 15kNs version currently being designed and tested.
- Motor burns propellant at the rate of 400kg per second.
- Eight motors to generate 56kNs impulse burn propellant at the rate of 3 tons per second.

The effect is like a slow, directionally-controlled explosion, a new area of the physics envelope not previously available.

Contact Details.

Thank you for your attention.

www.advanced-blast.com

roger.sloman@advanced-blast.com

Tel:- (44) 01335 360663 Mobile:- (44) 07989 381057

Inputs from VRCO Ltd, on behalf of Dan Hayes
Topics of Interest

- Cyber Security & secure duplex communications using multiple protocols (4G,5G, Sat)
- Transponders and acceptable high speed low latency location beacons such as GPS, Satcom
- Recharging standards
- Noise
- Battery Cell fabrication, modules and battery packs with proposals on in cell monitoring / sensors, welding and installation.
- Approach to Testing and validation of power systems (low volume, traceability and high quality cells)
- Data Protection (flying low altitude over city with eVTOL craft with camera systems)
- Advanced composites for airframe.

SESAR provides opportunities for large scale demonstrations

VTOL workshop

SESAR JOINT UNDERTAKING

Founding Members

EUROPEAN UNION EUROCONTROL

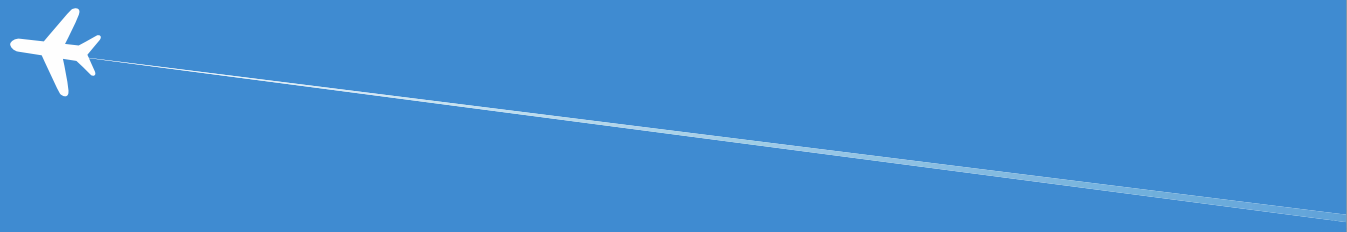
Large scale demonstrations

- The SESAR programme is currently **funding** a large number of drone and rotorcraft developments (**U-Space/UTM**, **Urban Air Mobility**, **Low Level IFR operations**…) **more than 30M€** and will continue to invest in Air/Ground integration.

- **Large scale demonstrations /live trials** involving key stakeholders (manufacturers, operators, regulators, service providers,..) are essential to **build confidence** , **validate the standards** and **de-risk certification**

- Unique **collaboration platform** with EASA, FAA, NASA…

Contact marouan.chida@sesarju.eu for more information



Thank you very much for your attention!

SESAR JOINT UNDERTAKING

Founding Members

EUROPEAN UNION EUROCONTROL

VTOL Workshop Agenda

1000	Welcome	EUROCAE & EASA
1015	EASA Introduction: Proposal & Expectations	David Solar, Head of VTOL Department, EASA
1045	EUROCAE Introduction: Organisation, process & relevant activities	Anna von Groote, Director Technical Programme, EUROCAE
1115	Stakeholder presentations & inputs	Moderated by Anna von Groote, Director Technical Programme, EUROCAE
1200	*Lunch break*	
1300	Stakeholder presentations & inputs	Moderated by Anna von Groote, Director Technical Programme, EUROCAE
1430	***Coffee break***	
1500	Development of initial work programme and priorities	Moderated by Volker Arnsmeier, Section Manager eVTOL and New Concepts, EASA & Alain Vallée, Technical Secretary – Expert, EUROCAE
1630	Roadmap and next steps	Anna von Groote, Director Technical Programme, EUROCAE
1650	Final remarks	David Solar, Head of VTOL Department, EASA
1700	Close of workshop	EUROCAE & EASA

Development of Initial Work Programme and Priorities

Moderated by
Volker Arnsmeier
Section Manager eVTOL and new concepts, EASA
&
Alain Vallée
Technical Secretary – Expert, EUROCAE

VTOL Workshop
06 June 2019

Development of Initial Work Programme and Priorities

Moderated by Volker Arnsmeier
Section Manager eVTOL and new concepts, EASA
&
Alain Vallée
Technical Secretary – Expert, EUROCAE

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Initial Work Programme

Main intent is to identify Standardisation Activities to be initiated (adapted?) to provide industry standards as AMCs for the VTOL Aircraft Special Condition

Overall Logic

- ✓ **Starting point**
  - Special Condition for VTOL Aircraft &
  - Draft Guidance Material
- ✓ **Inputs from all stakeholders**
  - Contribution from first sessions
  - Discussion during this session
- ➢ **Output**
  - Topics of Interest organised by Domains
    - ✓ *new standard, add-on to existing standard, guidance, studies…*
  - Priorities and ideas of timing
  - (expected) Support from organisations

Initial Work Programme

Topics of Interest		Regulatory work (c)	Standardisation work (c)	Priorities & Timeline (d)	Support expected (e)
Domain (a)	Item (b)				

(a) *A domain should be organised around common expertise or similar technologies… initially these domains are taken from the SC ToC*

(b) *An item of interest should normally lead to one standard*

(c) *Identification of activities On-going, Planned or Considered – who & when (start, publication). If nothing identified, indication of a Need to work could be provided*

(d) *Activity urgently needed or not, indicated as a Short (6 month to < 1 year), Medium (<2 years), Long (> 2 years) Term. Also an indication of the duration of the activity expected could be provided if different*

(e) *An indication of the support expected from the participants, by more than e.g. 3, 10, 20 organisations*

Reminder

- ✓ **Categories of Operation**
  - **Basic: the aircraft is capable of a controlled emergency landing after critical malfunction of thrust/lift.**
  - **Enhanced: the aircraft is capable of continued safe flight and landing after critical malfunction of thrust/lift.**

    Aircraft intended for operations over congested areas or for Commercial Air Transport (CAT) operations of passengers must be certified in this category
- ✓ **Assumptions on operations**
  - **Manned >> Unmanned later**
  - **VFR, day/night >> IFR later**
  - **Inadvertent icing (TBC) >> AWO later**

Initial Domains

Special Condition

Flight - Performance	Flight Control	Cabin safety
Flight - Human factors	Thrust / Lift Systems	Cybersecurity
Flight - Flight Envelope & Handling Qualities	Electrical Systems	Software
Structure	Avionics	Safety Assessment

Other Subjects

Noise	Privacy	*Towards UAS*
Ground Infrastructure	U-space	*AWO*

Flight - Performance

- Effect of ambient condition
- Ground effect
- Take-off definition
- Time limited manoeuvre
- Power check definition
- Definition of requirements for establishing Height Velocity Diagram for basic and enhanced category

Flight – Human Factors

- Evaluation of the cockpit
- Combined thrust and controls
- Easy identification of controls, Labelling
- Flight Crew Awareness of the Modes of Operation

Flight – Flight Envelope & Handling Qualities

- Definition of Handling Qualities and Mission Task elements
- Consideration on Degraded Visual Environment (DVE)
- General considerations on safe speeds, warnings when approaching operational envelope boundaries, flight envelope protection,
- Lift augmentation, in flight configurations, vortex ring state, rotor stall,
- Particular considerations for aircraft with tilting lift/thrust units: transition/conversion etc.
- Take-off margins – Obstacle clearance
- Slope and balked landing
- Wind minima
- Downwash
- Inadvertent Icing

Structure

- “No single failure catastrophic”
- Emergency landing and occupant protection: acceptable damages, load factors, dynamic conditions & HIC
- Likely bird impact
- Determination of Structural Design Envelope and Loading Conditions
- Interaction system/structures
- In-service monitoring
- Vibrations and ground resonance
- Blade release

Flight Control

- Control Margin Awareness
- Flight Crew Awareness of the Modes of Operation
- Flight Envelope protection
- Flight Control and Critical Displays at All Attitudes
- Control Signal Integrity
- Formalization of Compliance Demonstration for Flight Control Laws
- Flight Control Jams
- Consideration of Common Mode Failures and Errors in Flight Control Functions

Thrust / Lift Systems

- Definition of Designated fire zone
- Common mode analysis for thrust lift system for enhanced category
- Rotorburst analysis for enhanced category
- Shutdown and restart in flight

Electrical Systems

- High Voltage
- Energy Storage Devices
- Energy reserve
- EMC from A/C to ground
- HIRF
- Lightning Protection
- Electrical System Capacity
- Fuel Cell and Pressurized Gas Tanks
- Ground Charging Station

Avionics

- **Recorders**

Cyber Security

- **Process and threats**

Software

- Design and assurance levels
- Qualification standards
- Management of problem reports

Safety Assessment

- **Common modes: safety assessment process**
- **Alternative approach for DAL, FDAL determination**

Initial Domains

Special Condition

1 - Flight - Performance	5 - Flight Control	9 - Cabin safety
2 - Flight - Human factors	6 - Thrust / Lift Systems	10 - Cybersecurity
3 - Flight - Flight Envelope & Handling Qualities	7 - Electrical Systems	11 - Software
4 - Structure	8 - Avionics	12 - Safety Assessment

Other Subjects

Noise	Privacy	*Towards UAS*
Ground Infrastructure	U-space	*AWO*

No need for Stds	*Need for Stds*	*Urgent need for Stds*

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VTOL Workshop

Roadmap and next Steps

Anna von Groote
Director Technical Programme, EUROCAE

Roadmap and next steps

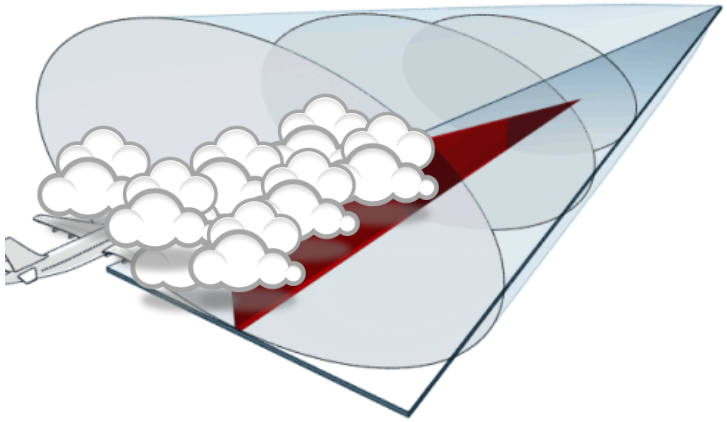
- **Detailed work programme**

- **Establishment of the WG VTOL**
  - Kick off meeting: date
  - Chair, Secretary, document leaders to be appointed
  - WG structure to be agreed and set up

- **Other stakeholders**
  - Call for Participation

EUROCAE Role

- Strong reliable partner for
  - Industry
  - R & D
  - User and
  - Regulator
- to reach the destination



VTOL Workshop

Final Remarks

David Solar
Head of VTOL Department, EASA

THANK YOU!

EUROCAE

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