Engineering, Operations & Technology
Boeing Research & Technology

Galician SkyWay

The **Way** to Integration of Autonomous Aircraft in a Shared **Sky**

Civil UAVs Initiative for Galicia

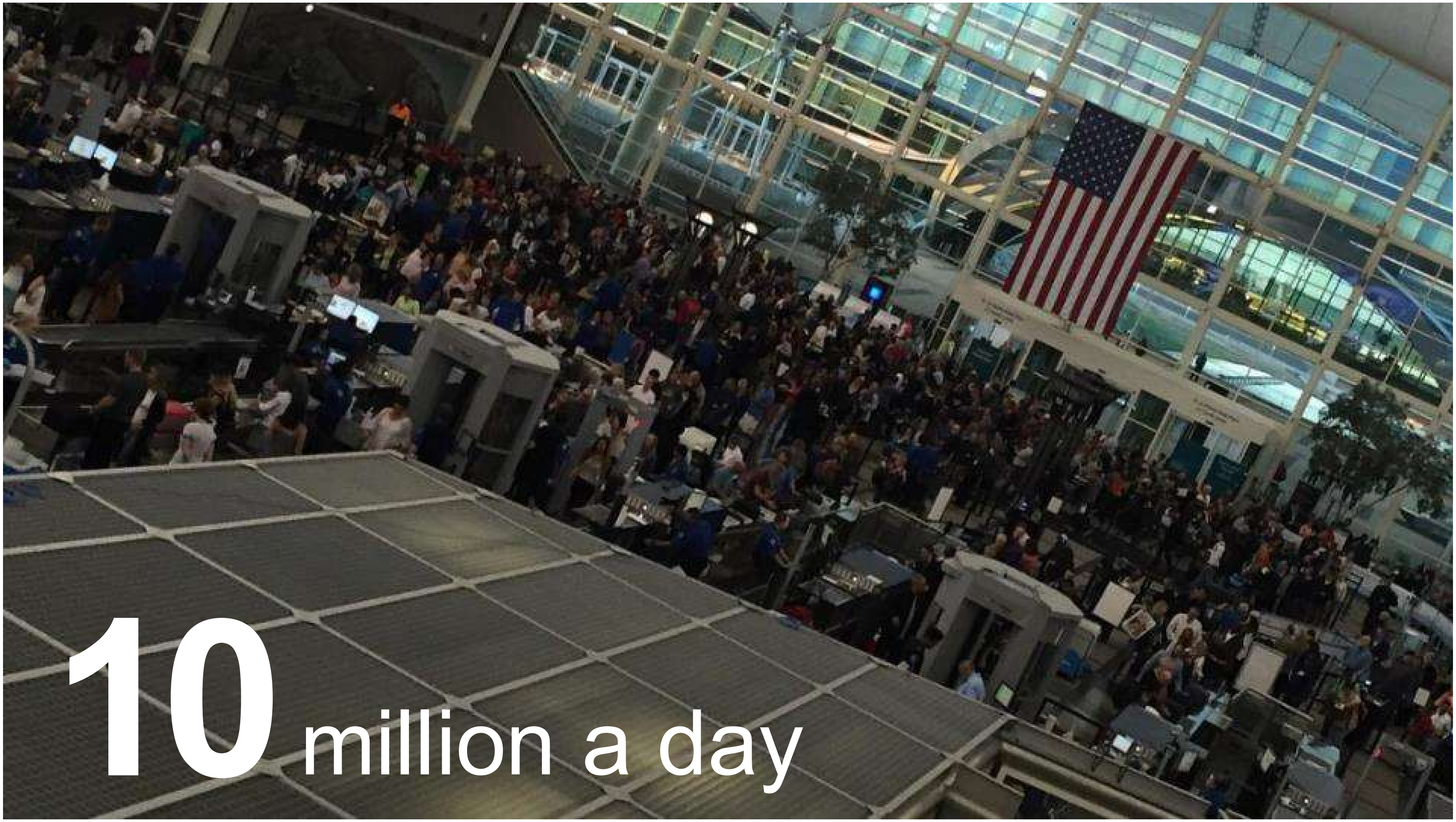
Rozas, March 6, 2019

Global Aerospace Industry

2017 Global Aerospace Industry – Top 10 Countries

Ranking	Country	Industry Size ($B)
1	United States	$408.4
2	France	$69.0
3	China	$61.2
4	United Kingdom	$48.8
5	Germany	$46.2
6	Russia	$27.1
7	Canada	$24.0
8	Japan	$21.0
9	Spain	$14.4
10	India	$11.0

TOTAL $731B


10 million a day


777
747
BOEING
1/3 the value of global trade


Connecting people and things


1 in 5
MAUR
SAAREE
EMPORIUM
शादी
कार्ड


1% of all global goods
T 216
TUG


2050


350 million

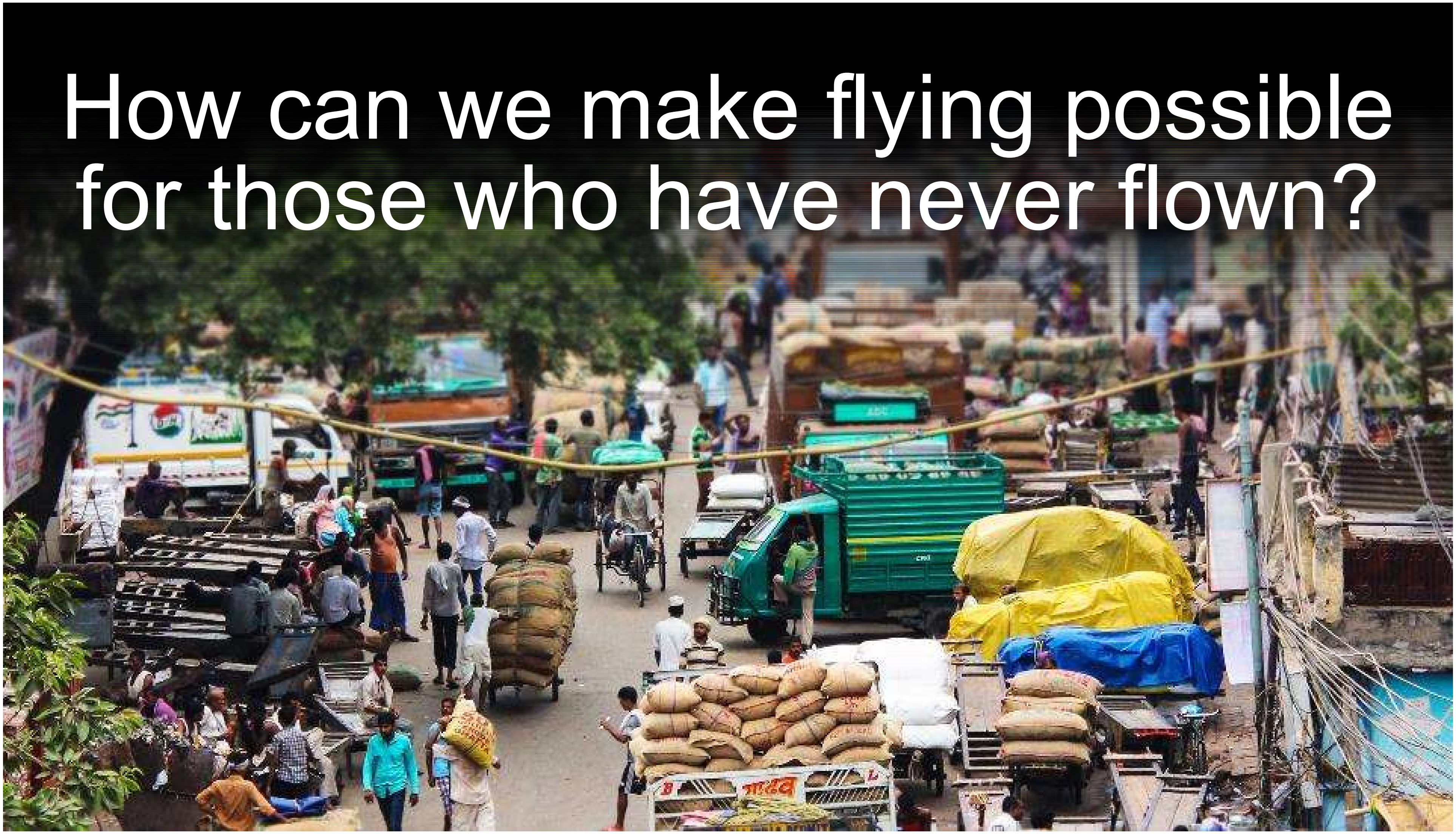

2/3 live in urban areas


Older,
more diverse,
more connected


Pain points will intensify

For passengers and our planet

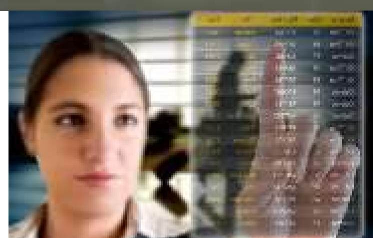
How can we make flying possible for those who have never flown?



And easier for those who have?

2050 focus areas

Solutions for developing countries



Low-stress travel

Regional and urban mobility

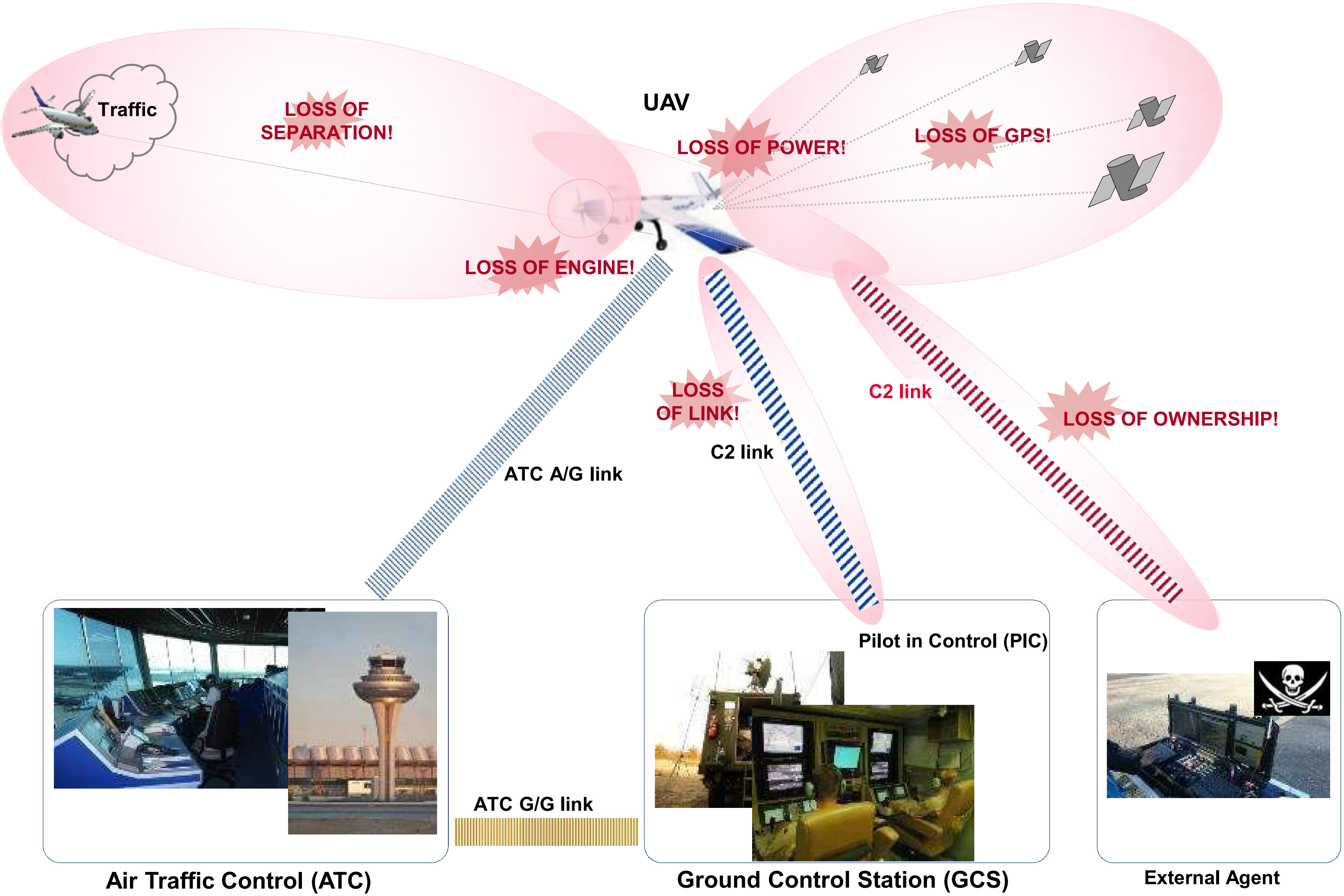
Connectivity and big data

Sustainability

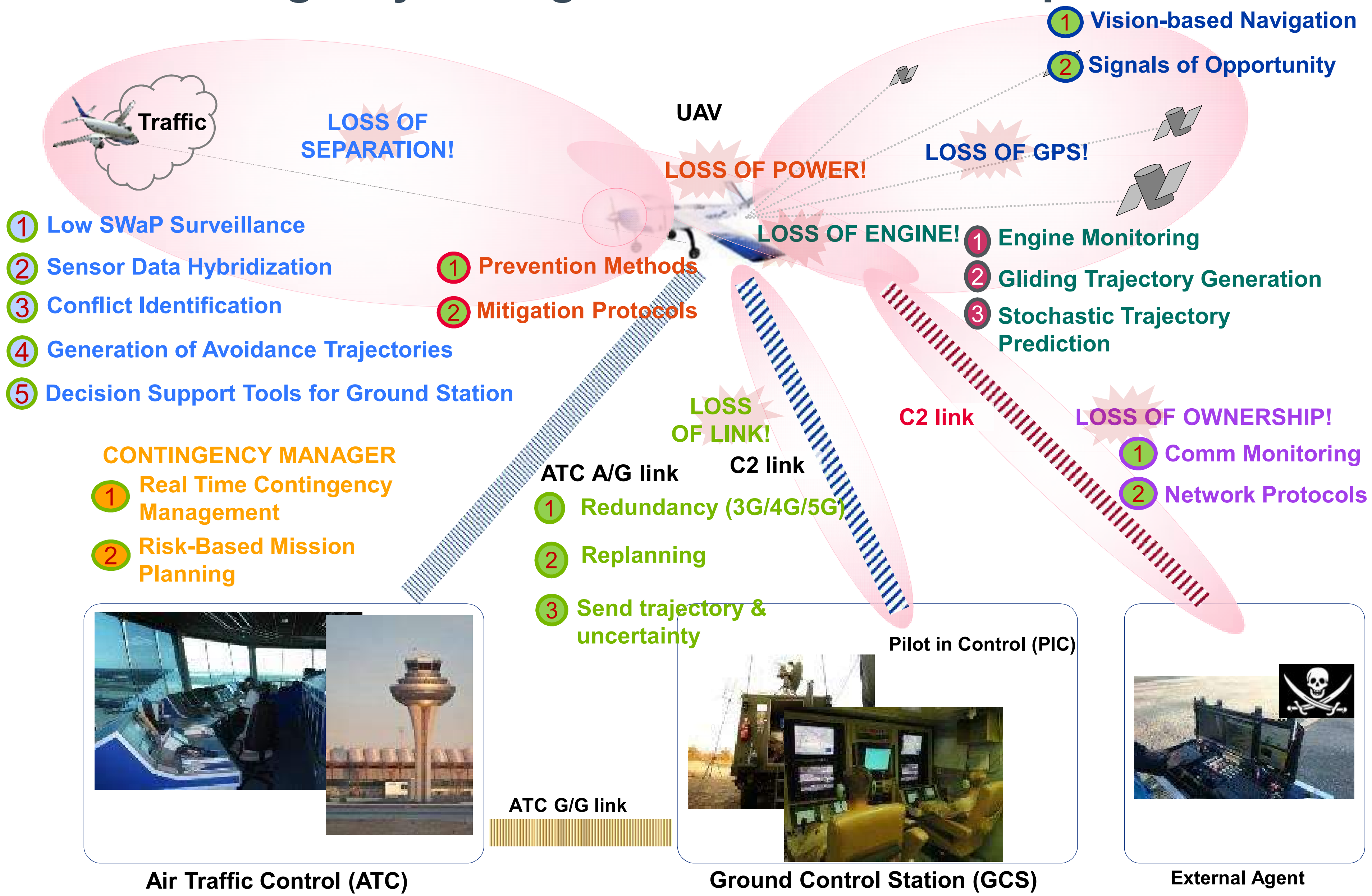
Objectives

- The Spanish region of Galicia has set out to grow its industrial base in the field of *unmanned civil aircraft applications* creating a 7M€ project for the development of *contingency management solutions* for these systems.
  - create an aerospace technological park around Rozas airport which is to become a center for development in unmanned systems
  - resolve critical remaining issues for UAS insertion in civil airspace
  - provide global visibility for unmanned aerospace activities and create new opportunities for Galician industry
  - vital needs in public and private sectors which can potentially be met by mature UAS such as: forest fire reconnaissance, marine border patrol and fish farming efficiency, or others of *high social, economic and/or environmental value*
- Flight Contingency Management remains most critical open issues for civil UAS insertion into airspace
  - approved behaviors and systems need to be in place for UAS insertion
  - some use of *autonomy* is required in *any* complete contingency management solution
  - Boeing Research & Technology Europe shall lead the design, implementation, and validation of a wide spectrum of contingency management solutions

Which Contingencies?



Contingency Management Products & Capabilities



Flight & Contingency Simulator (FCS)

Experiment, Prototype and Test solutions in scenarios adapted to the specific TRL of its development.

Characteristics:

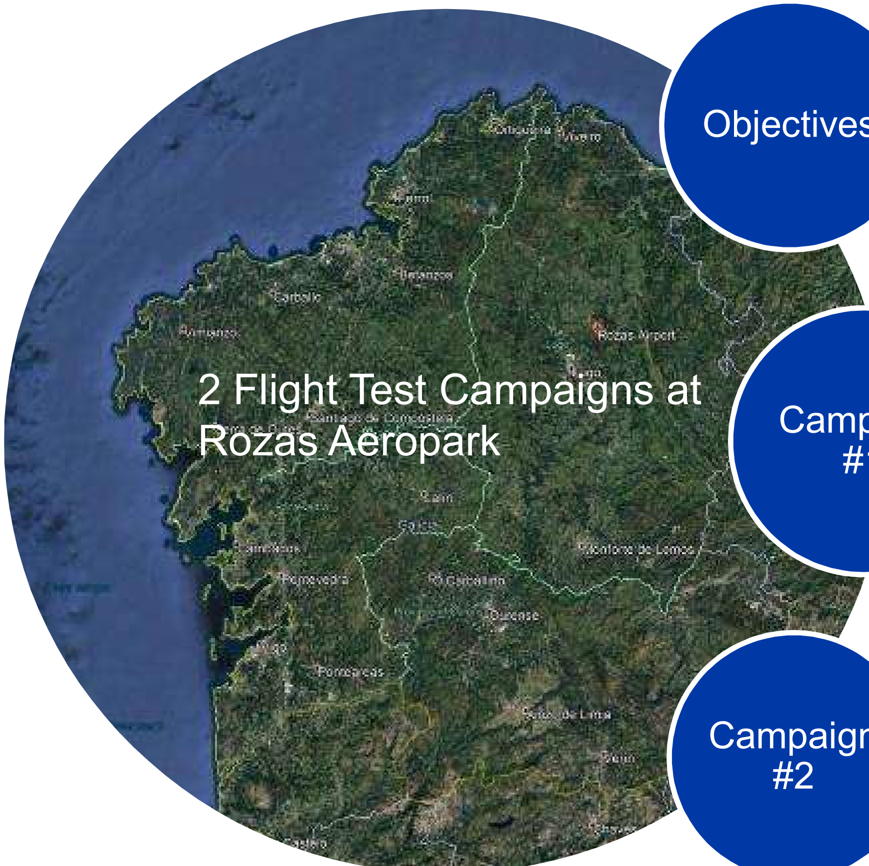
- **High fidelity** in modeling aircraft dynamics, sensors, and GNC algorithms
- **Ground and air** simulation, including ATC services and RPAS operational support.
- **Real** time & **fast** time.
- Software in the loop & hardware in the loop (including PIC).
- Decision support by means of GCS.
- Suite of graphical interfaces for administration, monitoring, and simulation control.
- Heterogeneous traffic simulation (different conflicts, aircraft sizes, and speeds).
- Distributed by means of centralized communication bus.
- To be deployed at Rozas Aeropark, Lugo (Galicia).

Flight Test Campaign

ALO
(INTA)

DJI Matrice 100
(Boeing, operated by 3rd party)

DJI Matrice 600 (Boeing, operated by 3rd party)



2 Flight Test Campaigns at Rozas Aeropark

Objectives

- Integration Flight Tests of Embedded Equipment
- Flight Data Acquisition for Demonstration of Representative Application Scenario
- Product Demonstration in Realistic Setting (LoE)

Campaign #1

- Prior to Milestone 3 ~ October – November 2019
- 2 weeks duration
- System Integration Tests
- Flight Data Acquisition

Campaign #2

- Prior to Milestone 4 ~ May 2020
- Flight Data Acquisition

Partners

Televés S.A.

Galician and one of Spain's largest companies specialized in design, development and manufacturing of telecommunication systems.

Centum Research & Technology

Galician company specialized in design, development and commercialization of embedded electronic systems for manned and unmanned flight platforms.

Gradiant Telecommunications Technology Center

Galician Technological Development Center specialized in advanced, embedded UAV technologies related to communications, perception, and navigation.

Boeing Research & Technology - Europe

Digital Aviation Services & Autonomy Group providing innovations in technologies related to Trajectory Based Operations, Digital Aviation Services, GPS-denied Navigation, Detect and Avoid Strategies, & High Fidelity Simulation of Platforms, Onboard Systems, Traffic and Geospatial Imagery

Aerospace Technical Institute

Spanish public aerospace institute which performs independent research in all areas of aerospace as well as performing testing and flight services to industry.

Enaire

Spain's Aerial Navigation Services Entity, fourth largest in Europe, with ample infrastructures controlling Spanish airspace. Provides advisory services in certification and operations.

Soticol Robotics Systems

Spanish robotics company specialized in UAS guidance, navigation & control technologies; in particular, innovative sensor and fusion technologies.

Drone Waves

Drone Weather and Artificial Vision-Enabled Safety

Objective: Facilitate safe and efficient UAV operations in complex and demanding environments, particularly at low altitudes with obstacles, such as urban environments and takeoff/landing operations.

Tasks:

1. Develop service that identifies airspace volumes representing potential risks for drone operations:
   - Adverse weather effects: wind, precipitation, storms, convective phenomena, reduced visibility and gelation.
   - Low-altitude operations in urban environments where these phenomena can greatly affect the safety of operations.
2. Explore computer-vision technologies based on artificial intelligence techniques capable of emulating human pilot visual perception to enable safe autonomous take-off and landing operations under demanding operating conditions.

Collaborators:

- León University, Hannover University, Jeppesen and Aurora Flight Sciences.

Drone Waves

Task 2. Computer-vision techniques based on AI for enabling safe autonomous UAVs take-off and landing operations

This project is composed of the following milestones:

1. **Data collection/simulation.** Real images are collected, others generated, for training and validating the AI models. UAV landing and take-off image database shall aid AI model in learning to recognize representative patterns.
2. **Use of AI and big data techniques.** Deep Learning techniques, such as Convolutional Neural Networks, will be applied to recognize objects, shapes and obstacles in the images, in particular, runways and safety hazards during landing. ADAPT will be used - an infrastructure for storing and processing of large-scale data.
3. **Identification of vertices for SLAM**. After pattern recognition, features are identified for use with SLAM and Visual Odometry algorithms enabling autonomous guidance, navigation & visual servoing.
4. **Image filtering.** Image processing techniques are applied for obstacle detection along track.
5. **Stop**. Final stage where the UAV is guided to a safe place to make the final stop.


BOEING NEXT
FLIGHT PATH FOR THE
FUTURE OF MOBILITY

Ten Keys to Unlocking the Future of Autonomous Mobility

Air Routes

The design of performance-based routes for UAS in trajectory-based operations and new operations in and around existing terminal areas.

Air Traffic Management Procedures

Standard procedures for managing contingencies for new autonomous airspace users in existing controlled airspace, including:

- New procedures for convoys of autonomous aircraft and procedures for managing failures in the Air Traffic Management System (ATMS).
- 4D trajectory-based separation management to maintain a safe distance for autonomous aircraft operating in free flight, including during approach and departure for operations around hubs and terminal locations.

Digital Information Management

An autonomous cloud-based system for the rapid collection, processing and real-time distribution of aeronautical data to large numbers of subscribing aircraft.

Performance Based Communication, Navigation, and Surveillance (CNS)

A framework of performance-based CNS requirements and standards enabling new operations on established routes, and the design and certification of new routes, separation standards, and infrastructure and equipment for high-complexity operations in obstacle-rich environments.

Aircraft Autonomy

A level of aircraft autonomy where systems exhibit operational behavior indistinguishable from that of a human pilot.

Autonomous Flight Planning

On-board algorithms for real-time predictive flight planning and route generation in complex and dynamic airspace environments. Systems will make use of near real-time updates to aeronautical data to plan safe and efficient routes, consistent with dynamic changes to airspace, predicted weather, and other operational restrictions (e.g., noise).

Contingency Management Systems

Robust autonomous systems that enable aircraft to safely and efficiently manage contingency situations, including situations requiring a precautionary or forced landing.

Detect And Avoid (DAA)

A suite of automated DAA systems that:

- Are compatible with existing Airborne Collision Avoidance Systems
- Concurrently address the full scope of potential operational hazards (e.g., adverse weather, birds, obstacles and terrain);
- Dynamically adjust well clear and collision avoidance volumes to account for specific operating conditions (e.g., parallel approaches) and the quality of available surveillance information;
- Can be used during both airborne and surface movement phases of operation, and those airborne phases where there is significant aircraft maneuvering;
- Are suitable for vertical take-off and landing in cluttered obstacle environments; and
- Provide efficient and safe recovery to a flight plan.

Autonomous Flight Rules

A new set of flight rules tailored to account for the varying levels of autonomy in emerging aviation systems and interoperable with the existing flight rules for conventional airspace users.

Certification Framework

A framework for the comprehensive and efficient certification of complex autonomous aviation systems. The framework would supplement existing software and hardware assurance approaches, with the aim of providing an acceptable level of assurance in the behaviour of adaptive autonomous aviation systems for a wide range of operational conditions.

www.boeing.com/NeXt

BOEING NEXT FLIGHT PATH FOR THE **FUTURE OF MOBILITY**

The next-generation airspace operating system

SkyGrid, a Boeing and SparkCognition company, is developing an airspace management software platform that will enable the future of urban aerial mobility. SkyGrid will deliver an artificial intelligence and blockchain-powered platform capable of providing safe, secure airspace operations—a key step toward enabling broad integration of autonomous air vehicles in the global airspace.

Using blockchain technology, AI-enabled dynamic traffic routing, data analytics and cybersecurity features, SkyGrid's platform will go beyond UAS traffic management. Its customers will be able to perform a broad range of missions and services using UAS, including package delivery, industrial inspections and emergency assistance.

Learn more at **www.skygrid.com.**

www.boeing.com/NeXt

BOEING NEXT FLIGHT PATH FOR THE **FUTURE OF MOBILITY**

The NeXt step

As we chart the flight path for the future of urban mobility, industry and regulators alike must prioritize the safety, reliability and environmental impact of the UAM ecosystem. As an enabler, UAM has the potential to dramatically improve the way people, goods and ideas move around the world—but that potential hinges on building and maintaining public confidence in the system's safety. **UAS regulations and airspace management are crucial for unlocking the potential of this disruptive market.**

Developing the regulatory framework will pace adoption of these emerging technologies and development of the mobility ecosystem. Boeing's focus on expanding the entire mobility ecosystem beyond air vehicle development and requirements will be essential in our future work. Components of the overall UAM ecosystem may likely include interoperability with ground vehicles and space-based technologies. Demonstrations adaptable to global requirements and the unique needs of the international community will play a crucial role in the design and execution of our efforts.

www.boeing.com/NeXt


PROPULSION
AUTONOMOUS VEHICLE
CONNECTIVITY
AIR VEHICLE
MACHINE LEARNING
ANALYTICS
MULTI-MODAL
TRAFFIC INTEGRATION