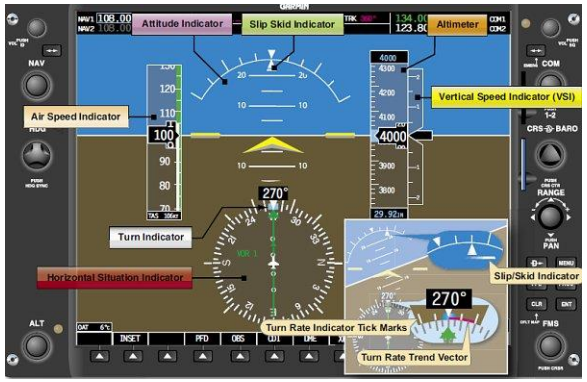
By FLEURY Christian
DSNA Spectrum manager

Why sharing the 960 - 1 164 MHz band is a very sensitive problem for Civil Aviation?

https://youtu.be/Gq-E-xBRuiA



Ressources, territoires, habitats et logement
Prévention des risques
Énergies et climat
Développement durable
Infrastructures, transports et mer

Présent pour l'avenir

Direction des services de la Navigation aérienne

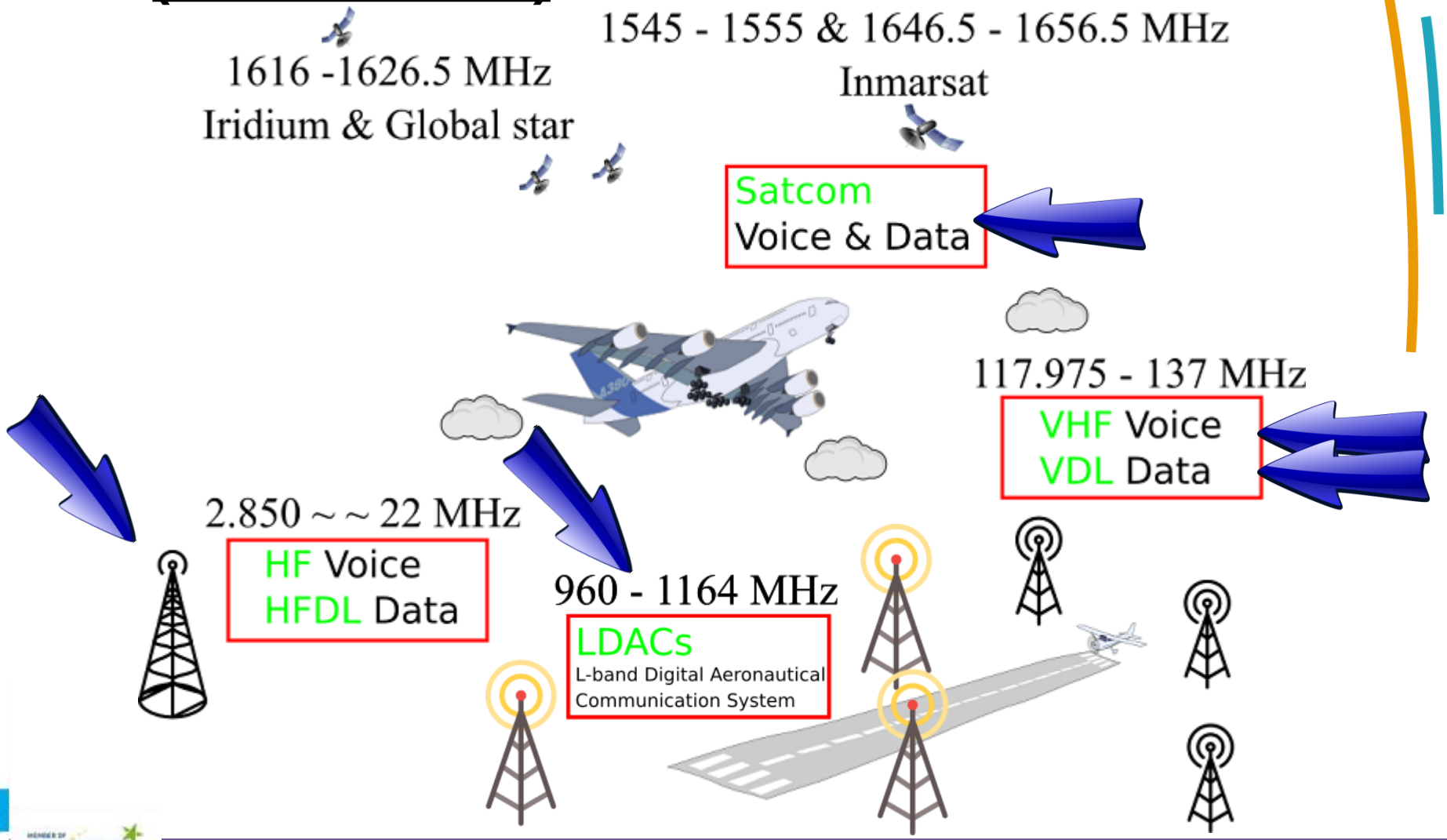
What is C.N.S?

Communication, Navigation, Surveillance

THE KEYSTONE

C : Communication

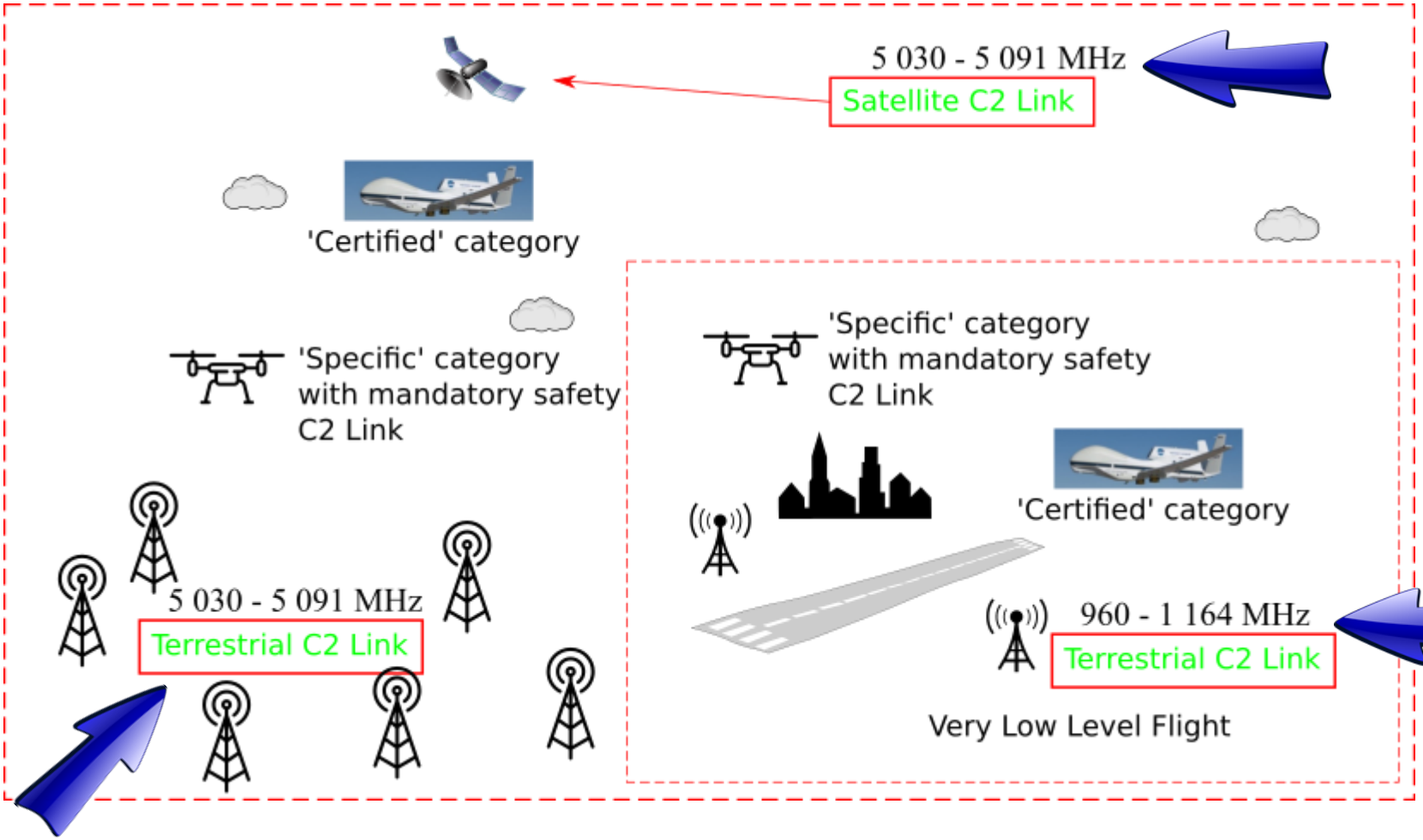
Frequency bands used for communication (voice and data)



C : Communication

Frequency bands for UA Command & Control

C2 Link



N : Navigation

Frequency bands used for Navigation

L1: 1 575.42 MHz
L5 : 1 176.45 MHz

SBAs
Satellite-based Augmentation system

F1

F2

960 - 1215 MHz

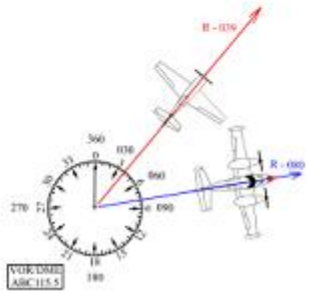
DME
Distance Measuring Equipment

providing range information

108 - 117.95 MHz

VOR
VHF Omnidirectional range encodes azimuth direction

from the station

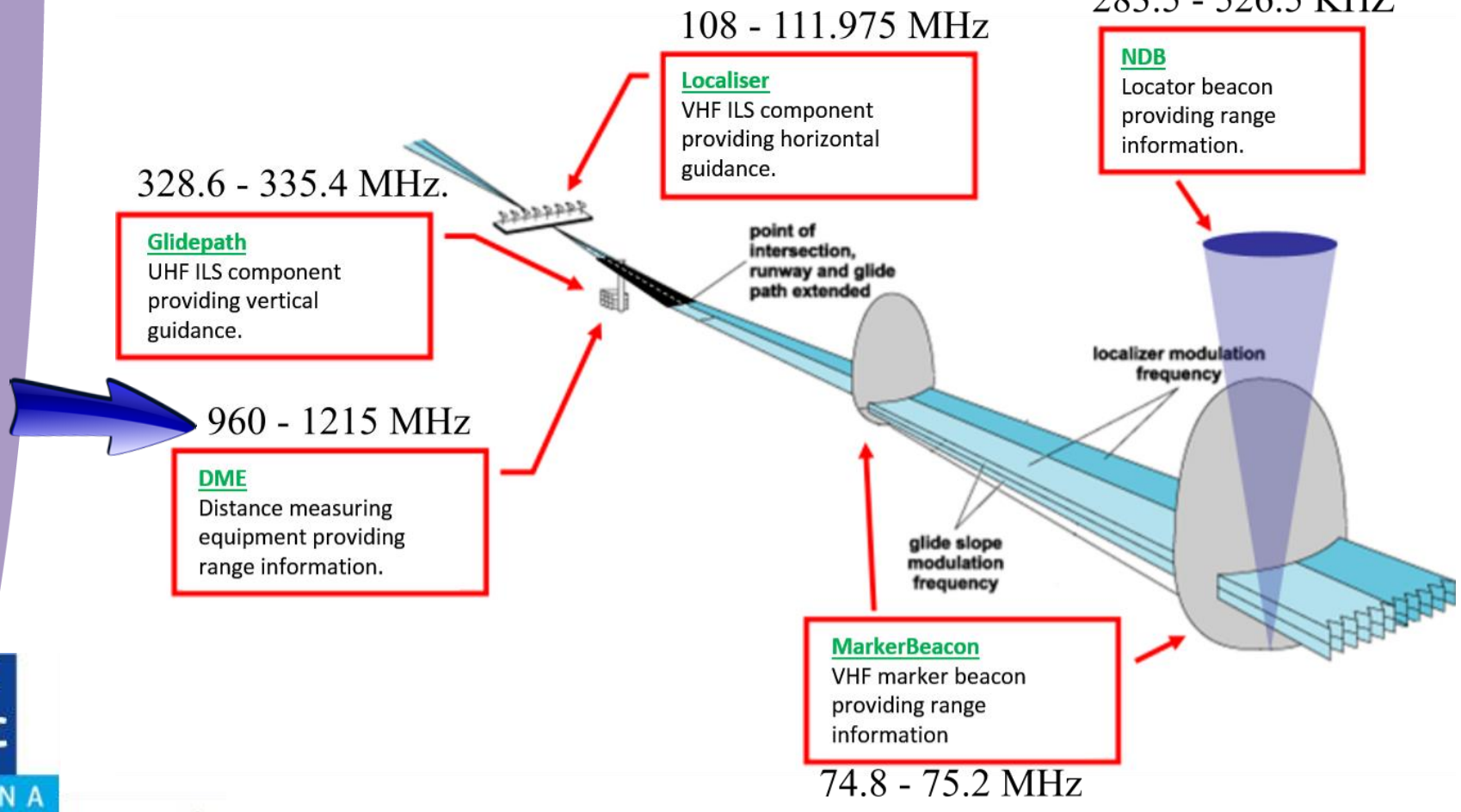


N : Navigation

Frequency bands used for Navigation

ILS (Instrument Landing Systems)

Some frequency bands in the band 283.5 - 526.5 KHZ

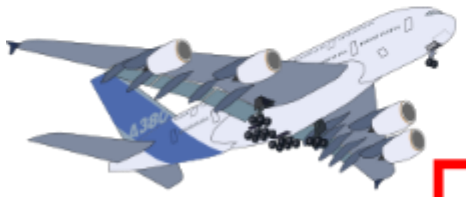


Navigation & Surveillance

Frequency bands used for Navigation

1 030 & 1 090 MHz

Tcas/Acas
Traffic/Alert Collision
Avoidance System



1 090 & 978 MHz

ADS-B
Automatic Dependent
Surveillance-Broadcast

S : Surveillance

Frequency bands used for Surveillance

1545 - 1555
1646.5 - 1656.5 MHz
Inmarsat

1616 -1626.5 MHz
Iridium & Global star

ADS-C
Automatic Dependent
Surveillance-Contract

1 215 - 1 350 MHz
2 700 - 3 100 MHz

Primary Radar (PSR)
Non-cooperative detection

978 MHz

UAT
Universal Access Transceiver

TDD

S : Surveillance

Surveillance based on 1 030 & 1 090 MHz

1 090 MHz

SPACE-BASED ADS-B
ADS-B via Sat
1090 ES

1 090 MHz

ADS-B
Automatic Dependent
Surveillance-Broadcast

1 030 & 1 090 MHz

Secondary Radar (SSR)
Cooperative detection

1 030 & 1 090 MHz

TDOA

MLAT & WAM
Multilateration & Wide Area Multilateration

Systems used by civil aviation in the 960-1164 MHz and 2,7-2,9GHz bands

960-1164 MHz	*2,7-2,9 Ghz*
DME	Primary Radar
TACAN	
Secondary Radar Mode A,A/C and S	
ADS-B	
ADS-B via Satellite	
TCAS/ACAS	
UAT*	
MLAT	
WAM	
RSBN	

For more information, please consult FM51(17)Info74

Systems used by Air Traffic Management (ATM)

960-1164 MHz	2,7-2,9 Ghz
DME	Primary Radar
TACAN	
Secondary Radar Mode A,A/C and S	
ADS-B	
ADS-B via Satellite	
~~TCAS/ACAS~~	
UAT*	
MLAT	
WAM	
RSBN	

For more information, please consult FM51(17)Info74

Airborne systems used

960-1164 MHz	*2,7-2,9 Ghz*
DME	~~Primary Radar~~
TACAN	
Secondary Radar Mode A,A/C and S	
ADS-B	
ADS-B via Satellite	
TCAS/ACAS	
UAT*	
MLAT	
WAM	
RSBN	

For more information, please consult FM51(17)Info74

Systems used by pilots

960-1164 MHz	2,7-2,9 Ghz
DME	~~Primary Radar~~
TACAN	
~~Secondary Radar Mode A,A/C and S~~	
ADS-B	
~~ADS-B via Satellite~~	
TCAS/ACAS	
UAT*	
~~MLAT~~	
~~WAM~~	
RSBN	

For more information, please consult FM51(17)Info74

Futur
Systems used by pilots

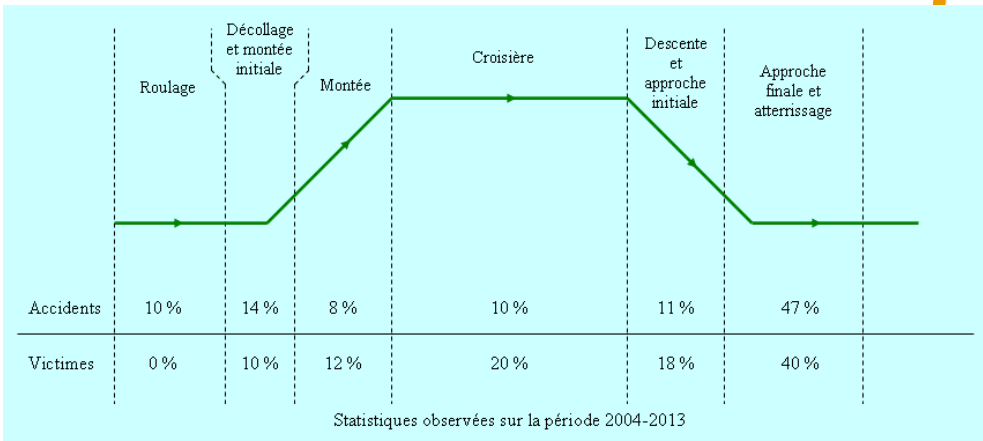
960-1164 MHz	*2,7-2,9 Ghz*
Short term : C2 Link for Drones	
Mid term: LDACs	None
Long term : CNS Long Term	

For more information, please consult FM51(17)Info74

Statistical study of air crashes

Statistical study of air crashes (2004-2013)

- Taxing of aircraft
  - 10% of accident, 0% victims
- Take off
  - 14% of accident, 10% victims
- Climb
  - 8% of accident, 12% victims
- Cruise
  - 10% of accident, 20% victims
- Descent
  - 11% of accident, 18% victims
- Final & Landing
  - **47% of accident, 40% victims**



Statistical study of air crashes

ACCIDENTS BY CAUSE						
Cause	1960s	1970s	1980s	1990s	2000s	All
Pilot Error	**60%**	**55%**	**54%**	**60%**	**60%**	**58%**
Mechanical	21%	16%	18%	15%	18%	17%
Weather	6%	5%	6%	6%	7%	6%
Sabotage	5%	11%	11%	8%	9%	9%
Other	8%	13%	11%	11%	6%	10%

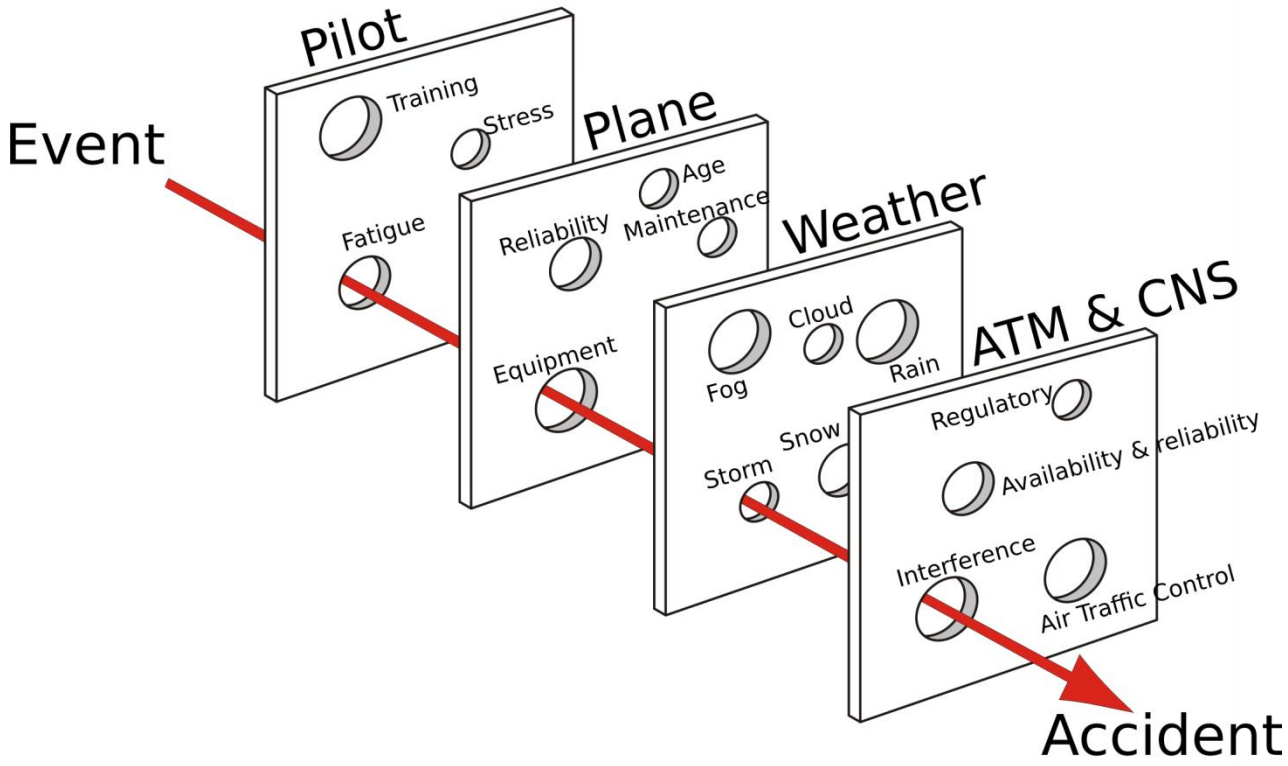
Accident reports show that human errors are the main cause of air crashes since safety of life equipment guarantee the highest level of safety

Statistical study of air crashes

Many of the accidents in aviation are due to pilot error, and fatigue is a major cause of those errors.

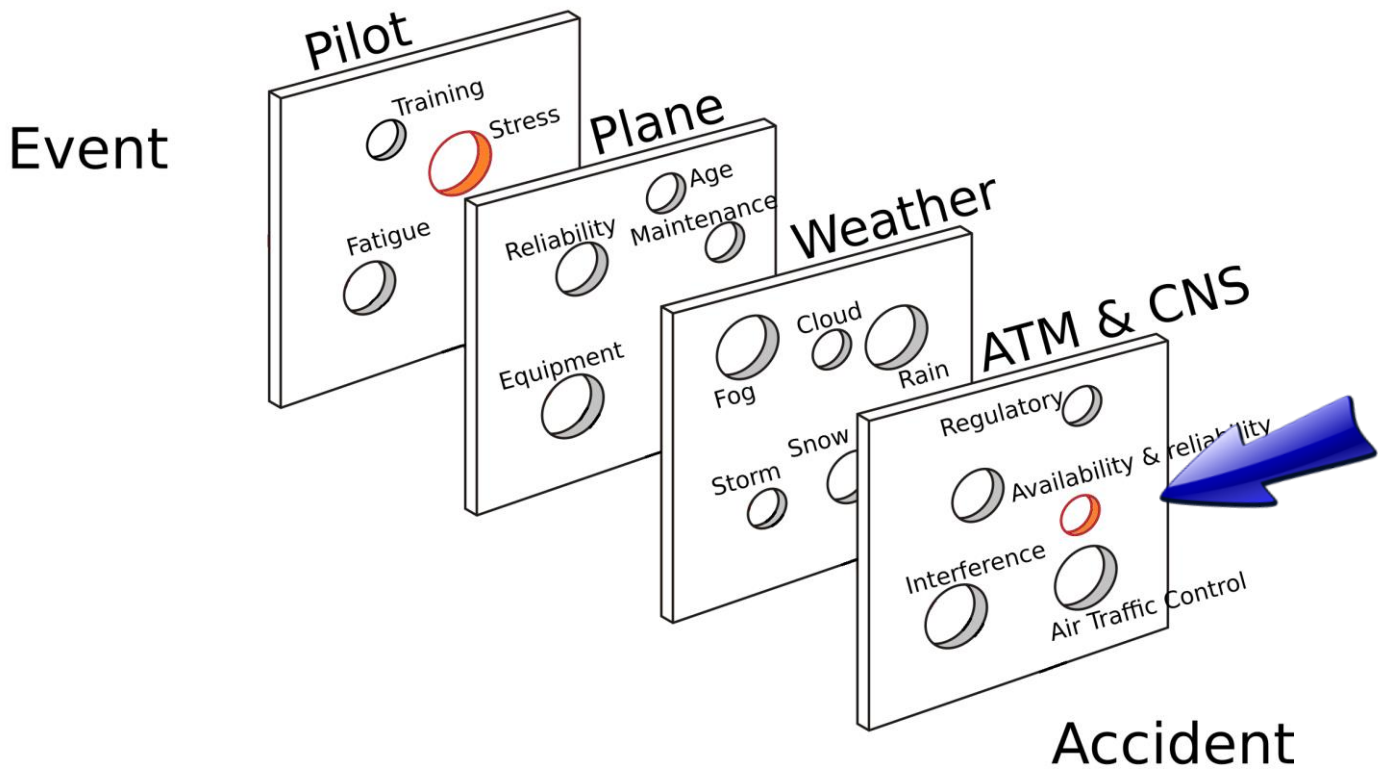
Statistical study of air crashes

But all scenarios leading to incidents involve various events without which those incidents would not have occurred.



Statistical study of air crashes

An external event could have an impact on pilot's layer.



Systems used by pilots in the band

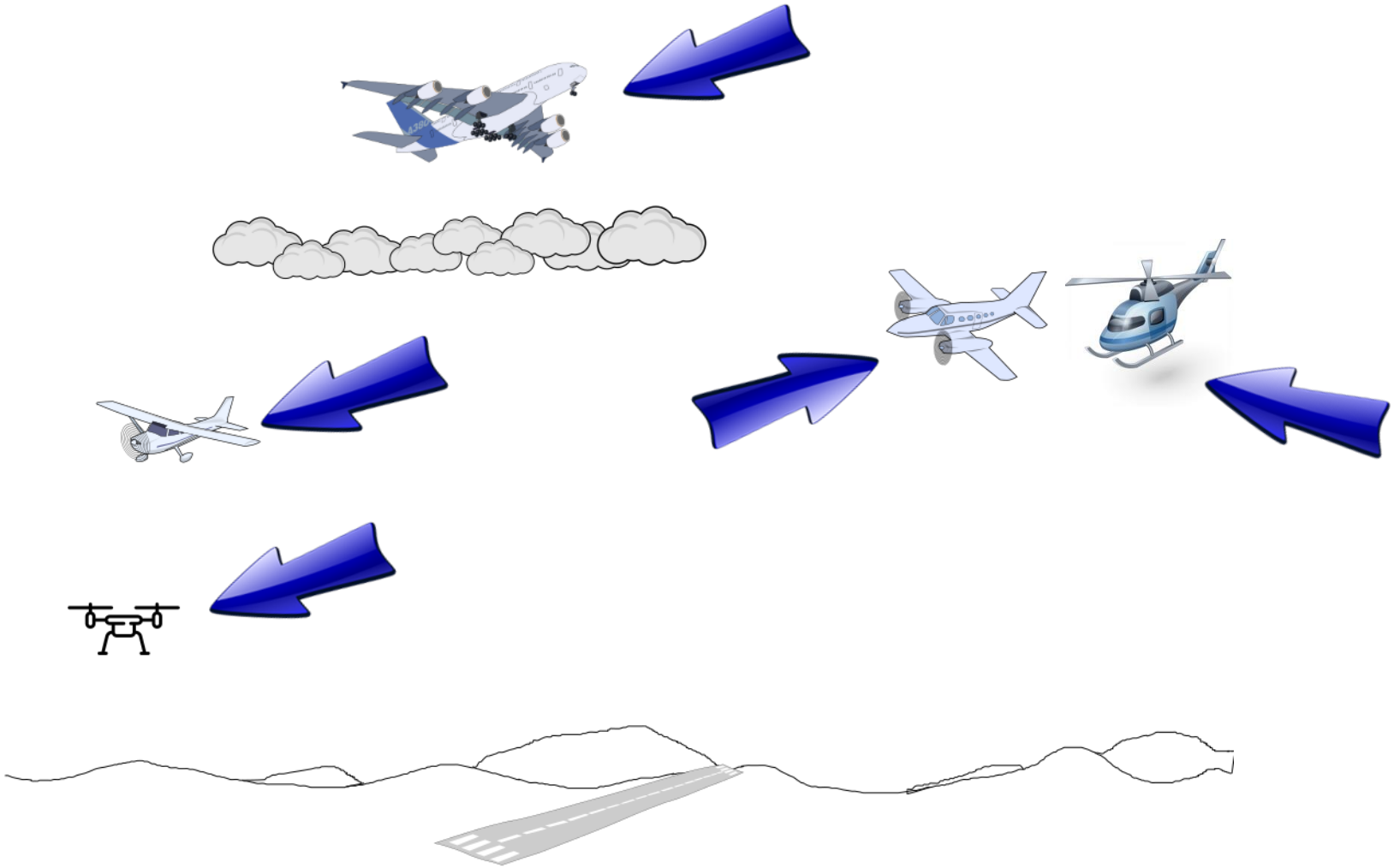
960-1164 MHz	2,7-2,9 Ghz
DME	~~Primary Radar~~
TACAN	
~~Secondary Radar Mode A,A/C and S~~	
ADS-B	
~~ADS-B via Satellite~~	
TCAS/ACAS	
UAT*	
~~MLAT~~	
~~WAM~~	
RSBN	

Impact on Pilot Layer

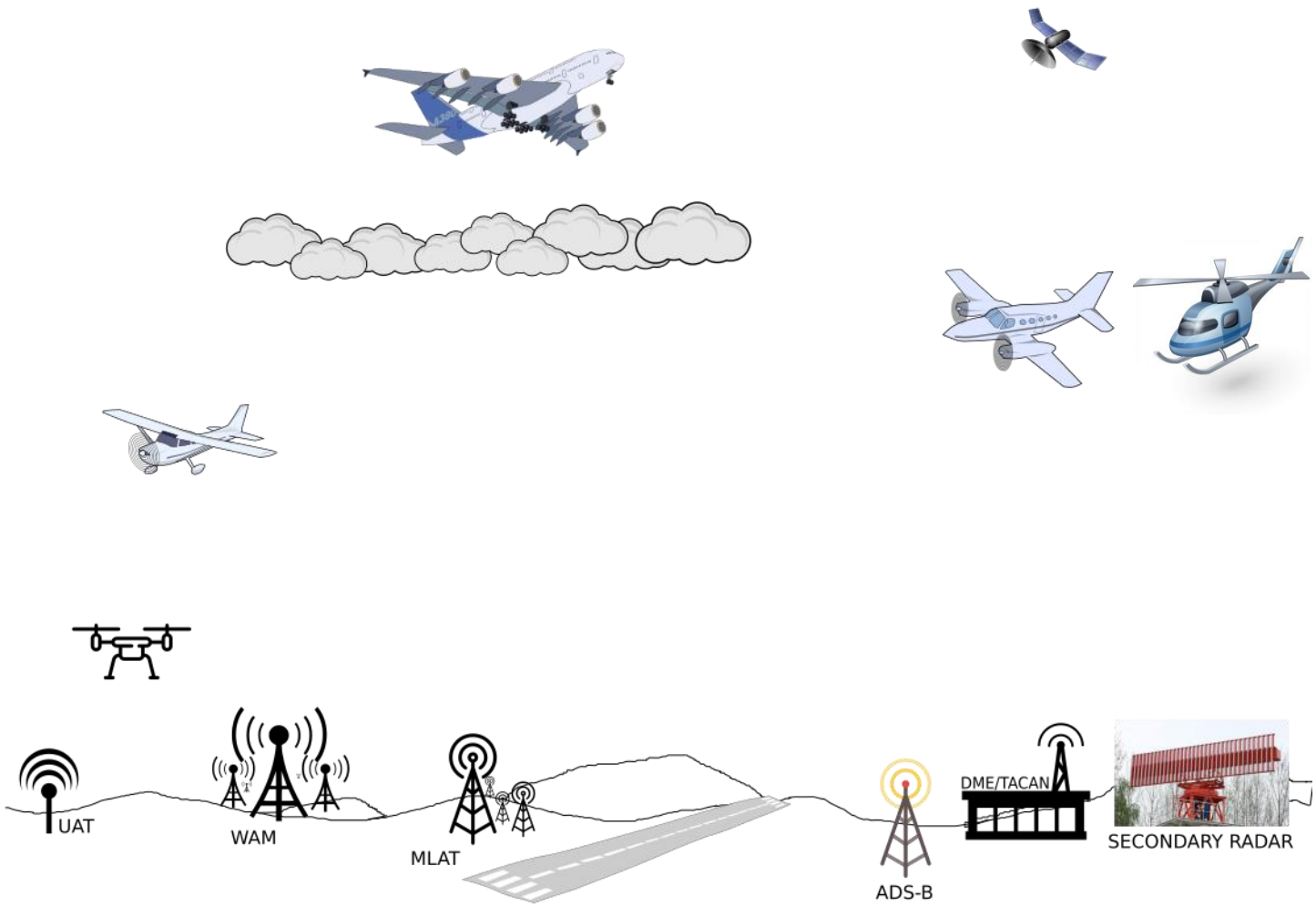
960-1164 MHz	*2,7-2,9 Ghz*
High impact	**No impact**
on pilot layer	on Pilot Layer

Use of the bands 960-1164MHz

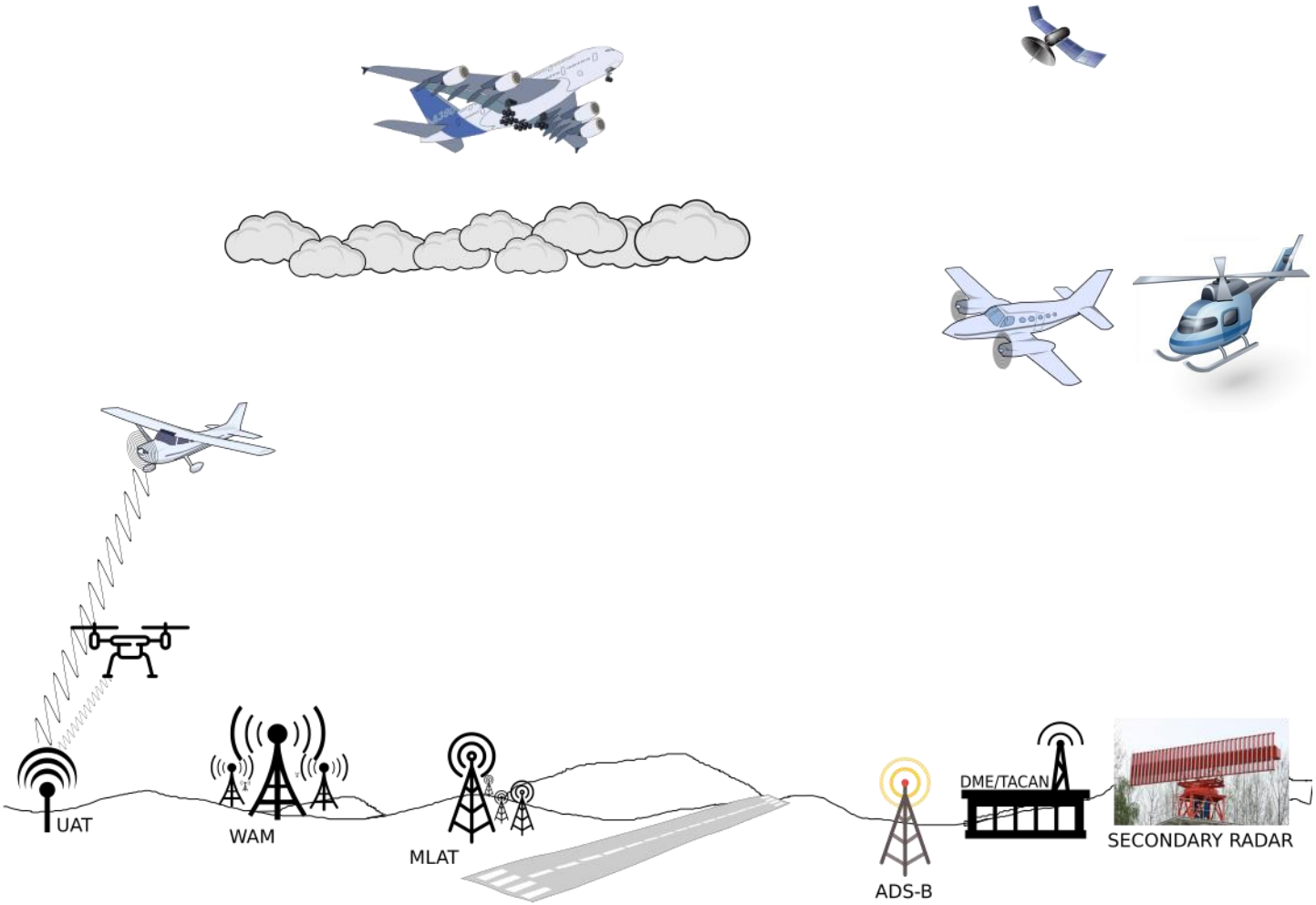
Various types of aircrafts



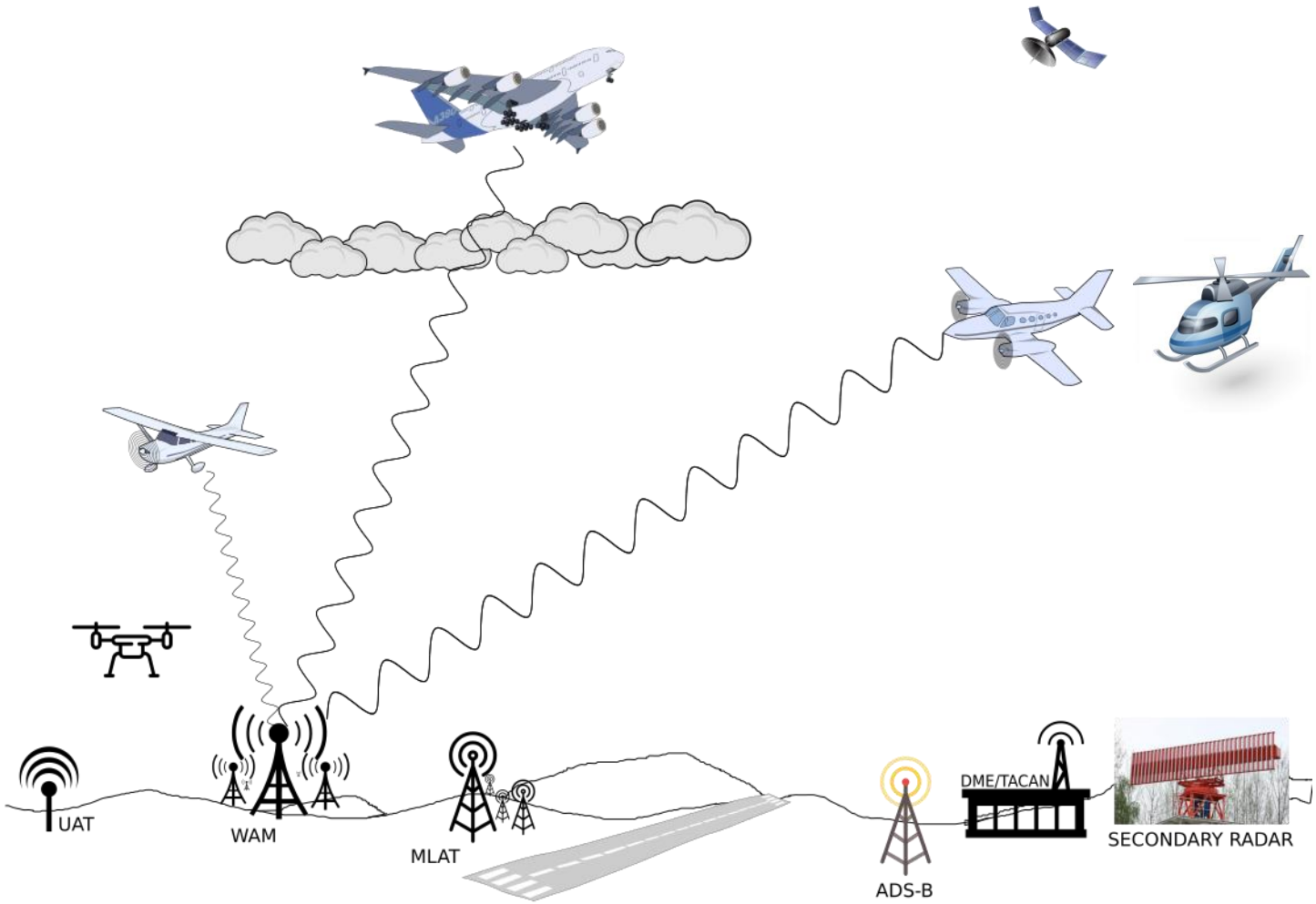
Systems using the band 960-1164MHz currently by Civil Aviation



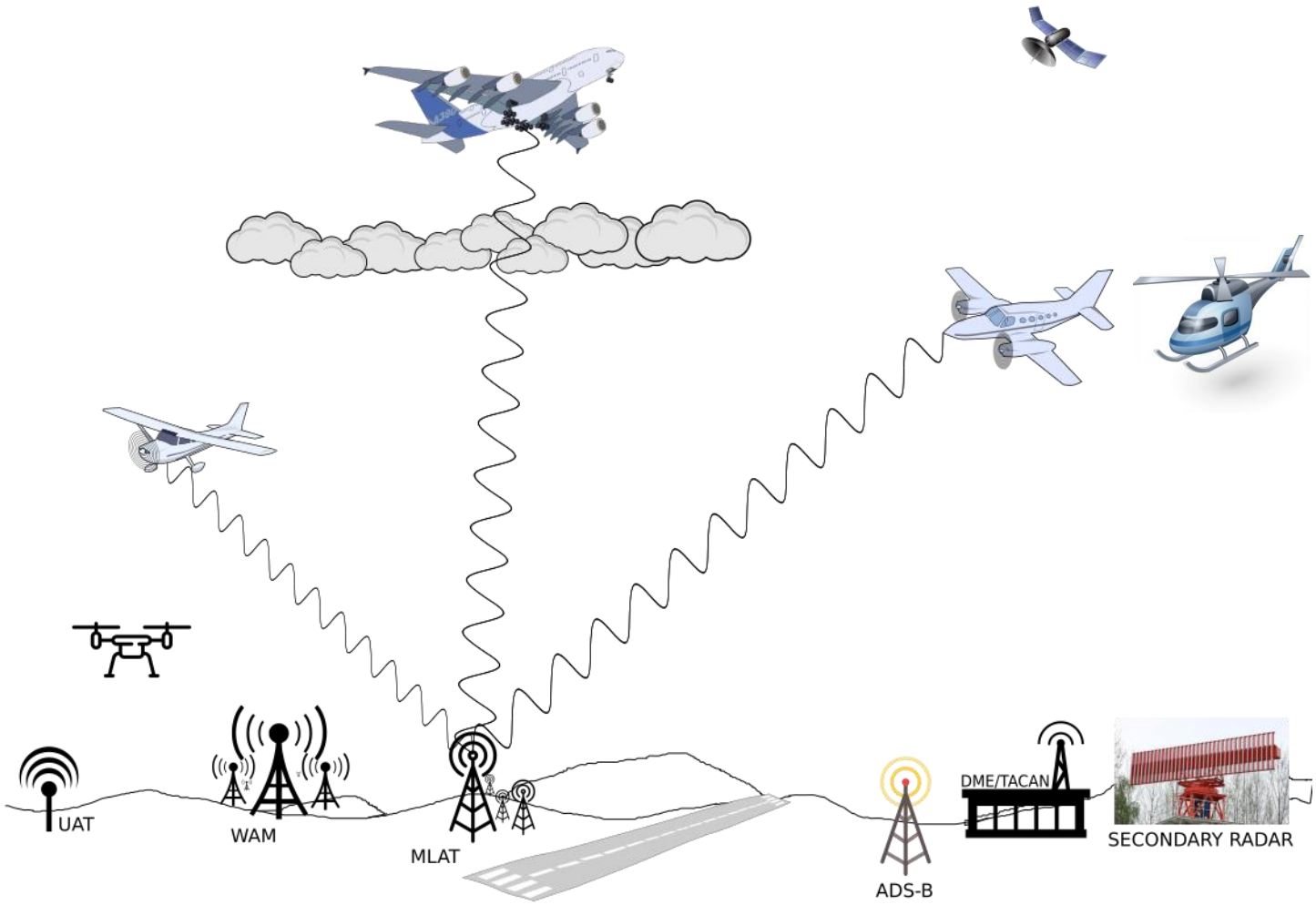
UAT 978MHz *(air to ground & ground to air)*



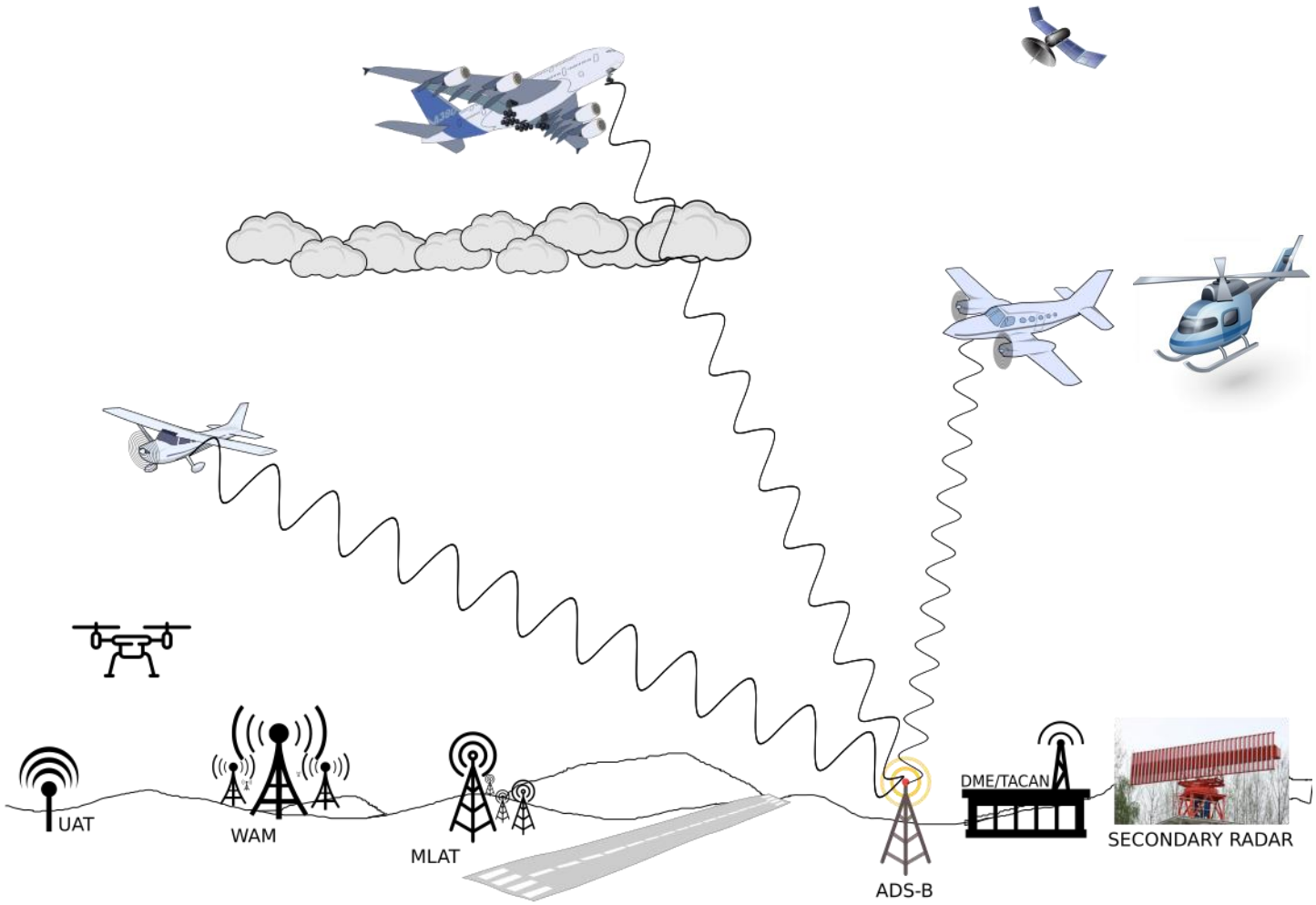
WAM (1090MHz air to ground & 1030MHz ground to air)



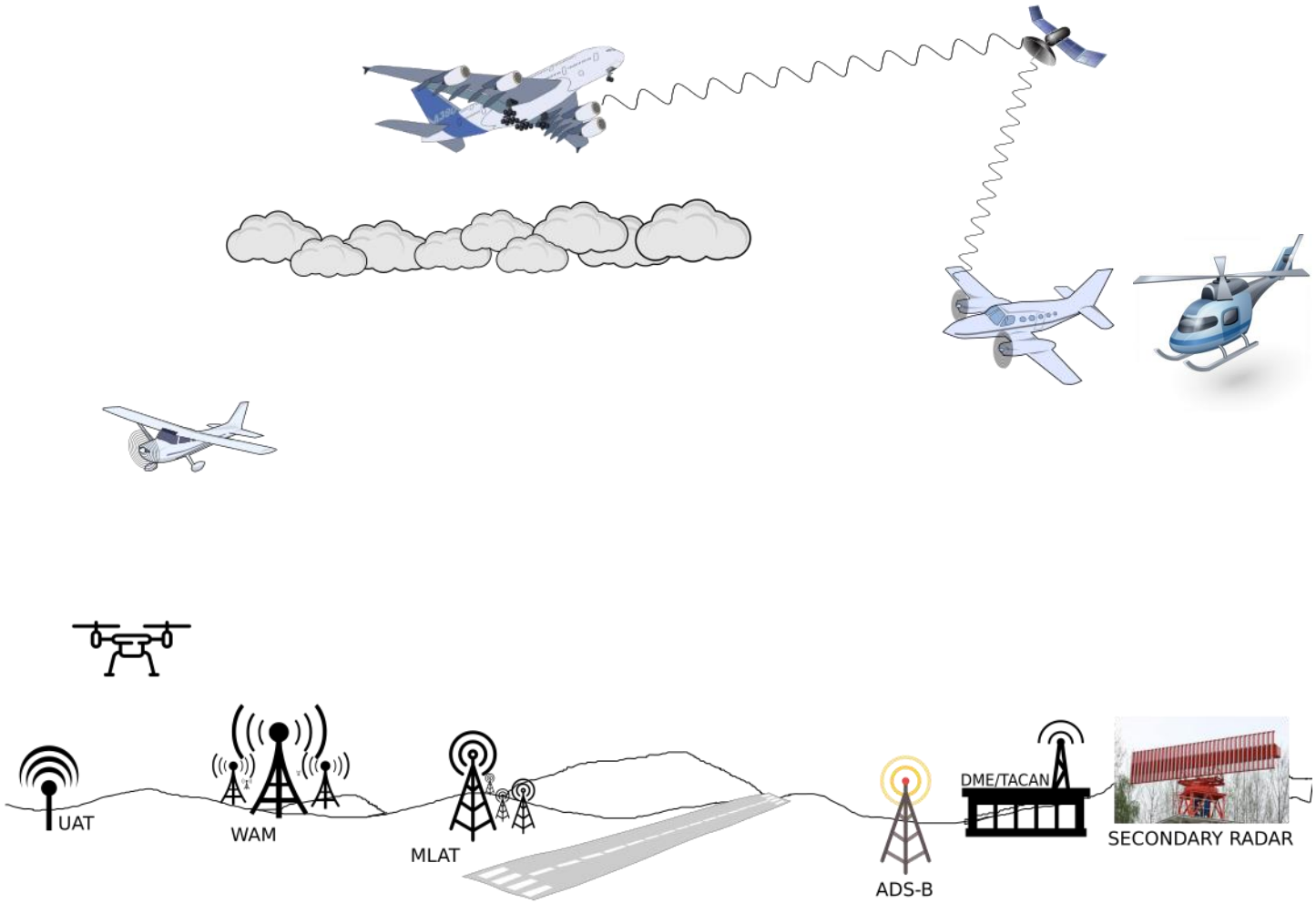
MLAT (1090MHz air to ground & 1030MHz ground to air)



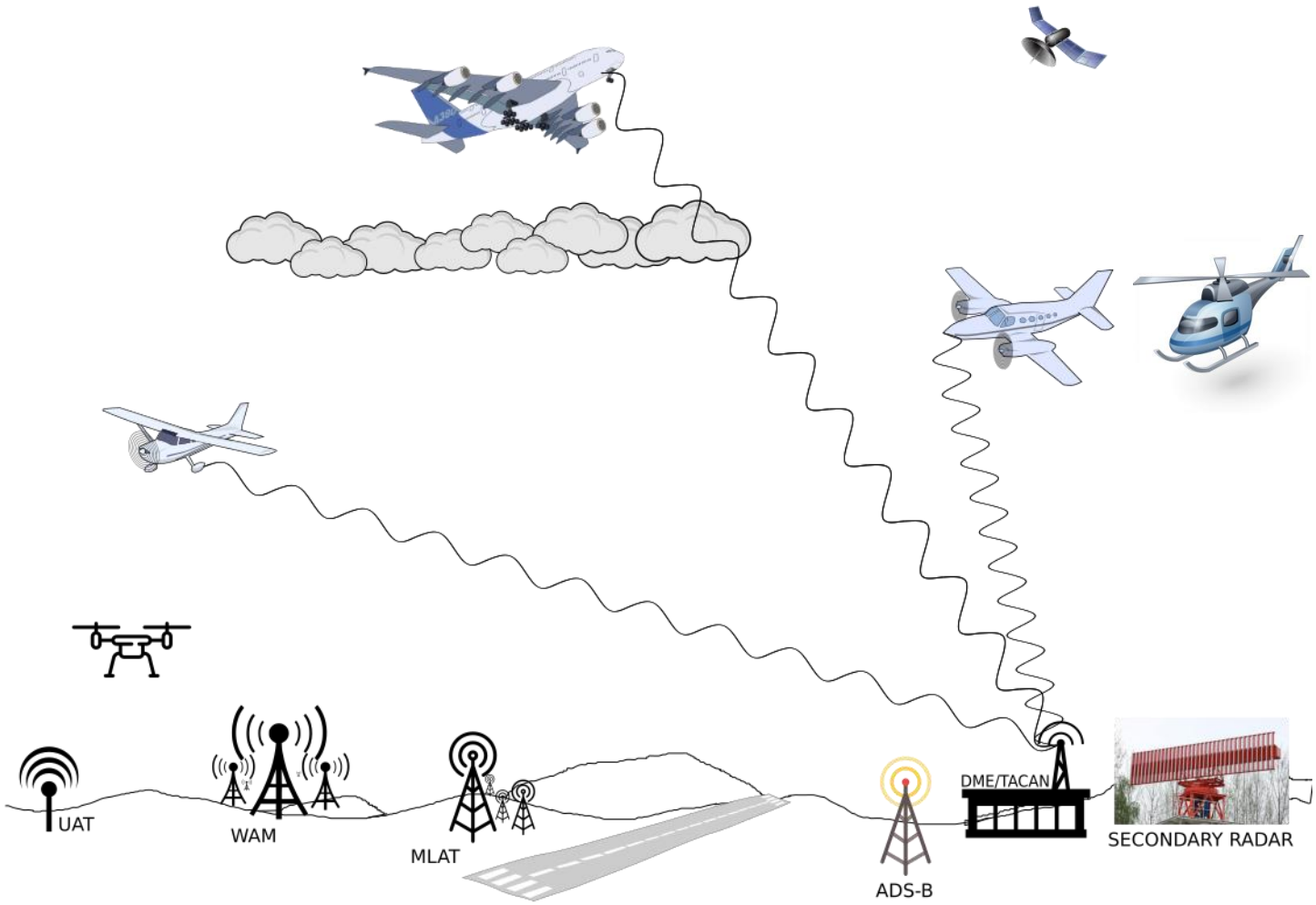
ADS-B *(1090MHz air to ground)*



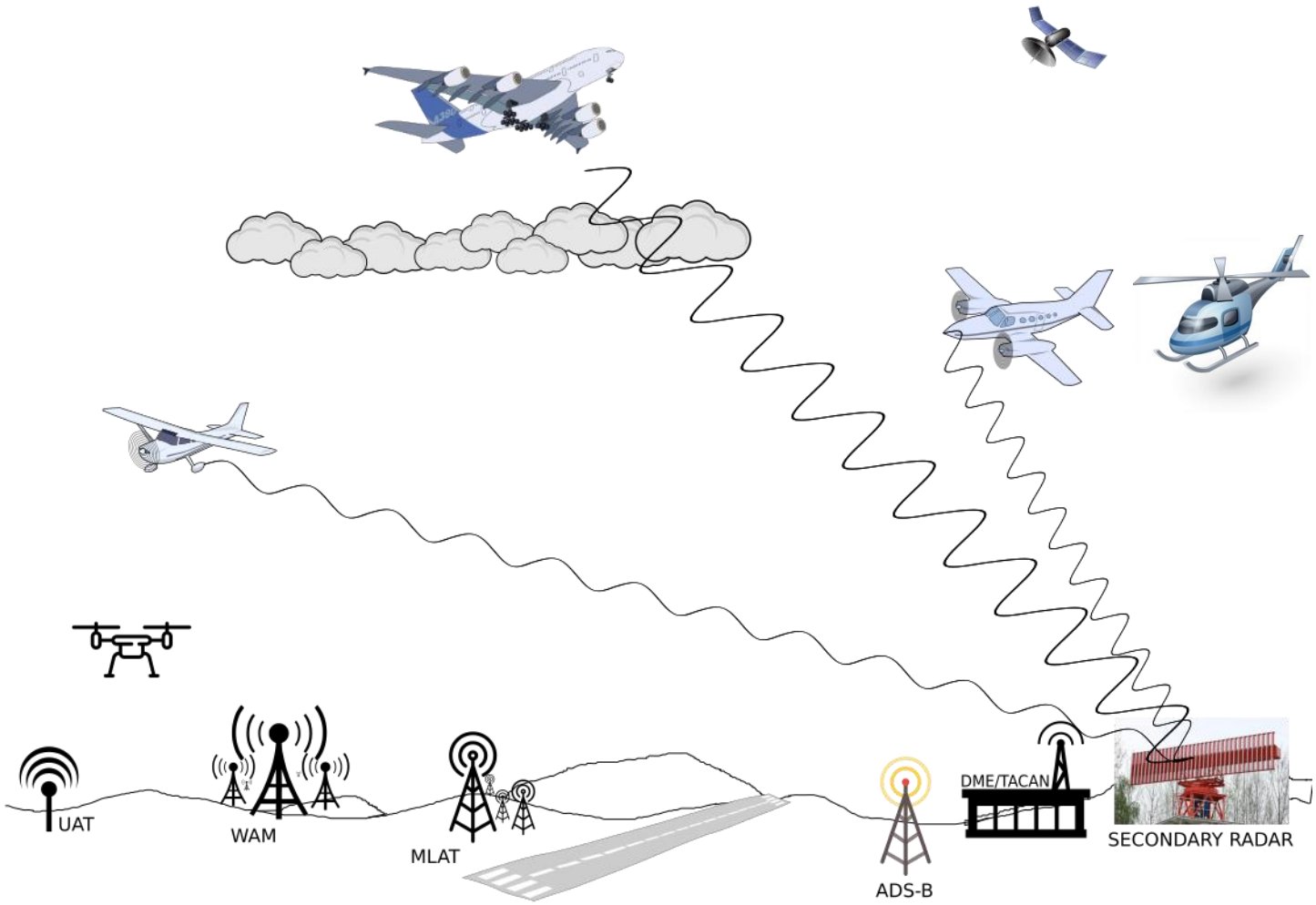
ADS-B Sat *(1090MHz air to space)*



DME or TACAN (962-1213MHz, frenquency1 air to ground, frequency2 ground to air; f2=f1-63MHz or f1+63Mhz)



Secondary radar *(1090MHz air to ground & 1030MHz ground to air)*



TCAS/ACAS *(Traffic / Airborne alert and Collision Avoidance System) 1090 MHz & 1030Mhz airborne use.*

Interference in the band 960-1164MHz

Interference on 1030MHz or 1090MHz

Interference on 1030MHz and 1090MHz

These Two frequencies are the keystone for

- Surveillance (the S of CN**S**) with MLAT, WAM, ADS-B, ADS-B Sat and Secondary Radar.
- The ACAS/TCAS (Traffic / Airborne alert and Collision Avoidance System) are the last defence in this risk of collision,

No interference is acceptable whatsoever, **it will have an immediate and severe impact on Safety of life and Traffic Management**

Interference in the band 960-1164 MHz

1030 MHz and 1090 MHz

are considered as a

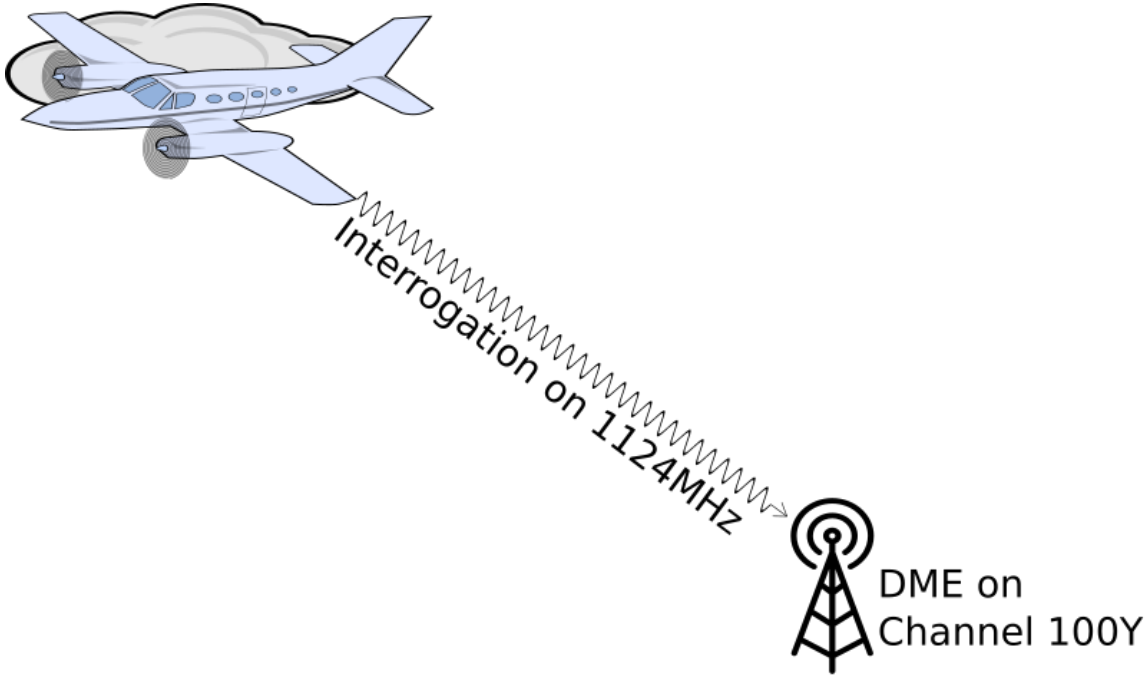
SANCTUARY

For Civil Aviation

Interference on DME

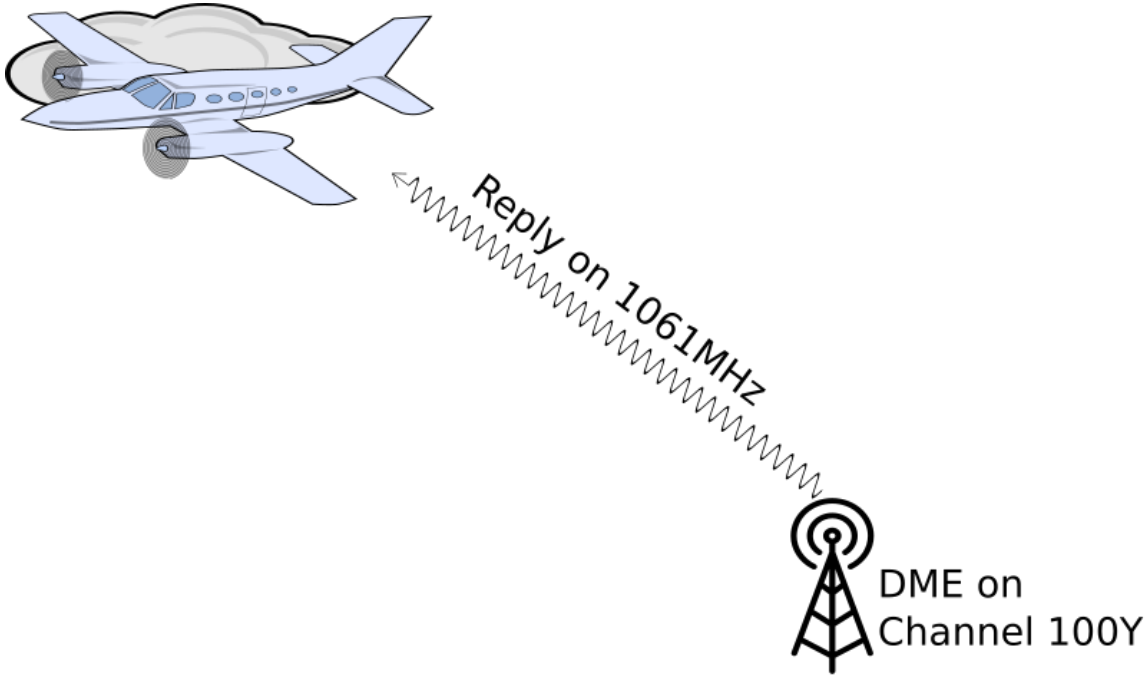
Interference in the band 960-1164 MHz

Interference on DME



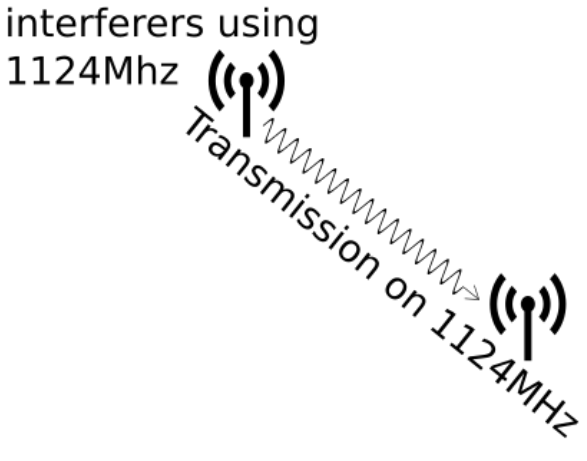
Interference in the band 960-1164 MHz

Interference on DME



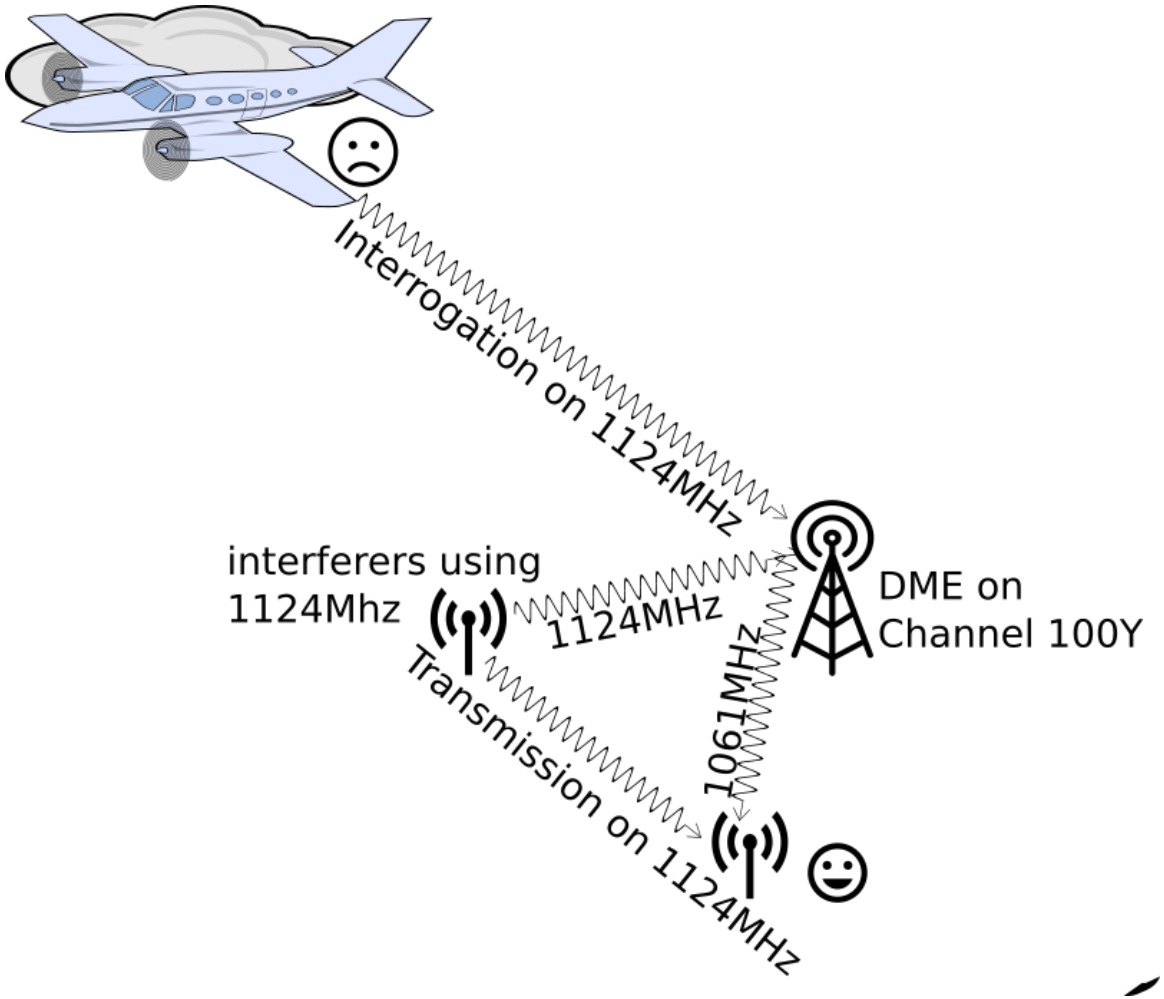
Interference in the band 960-1164 MHz

Interference on DME



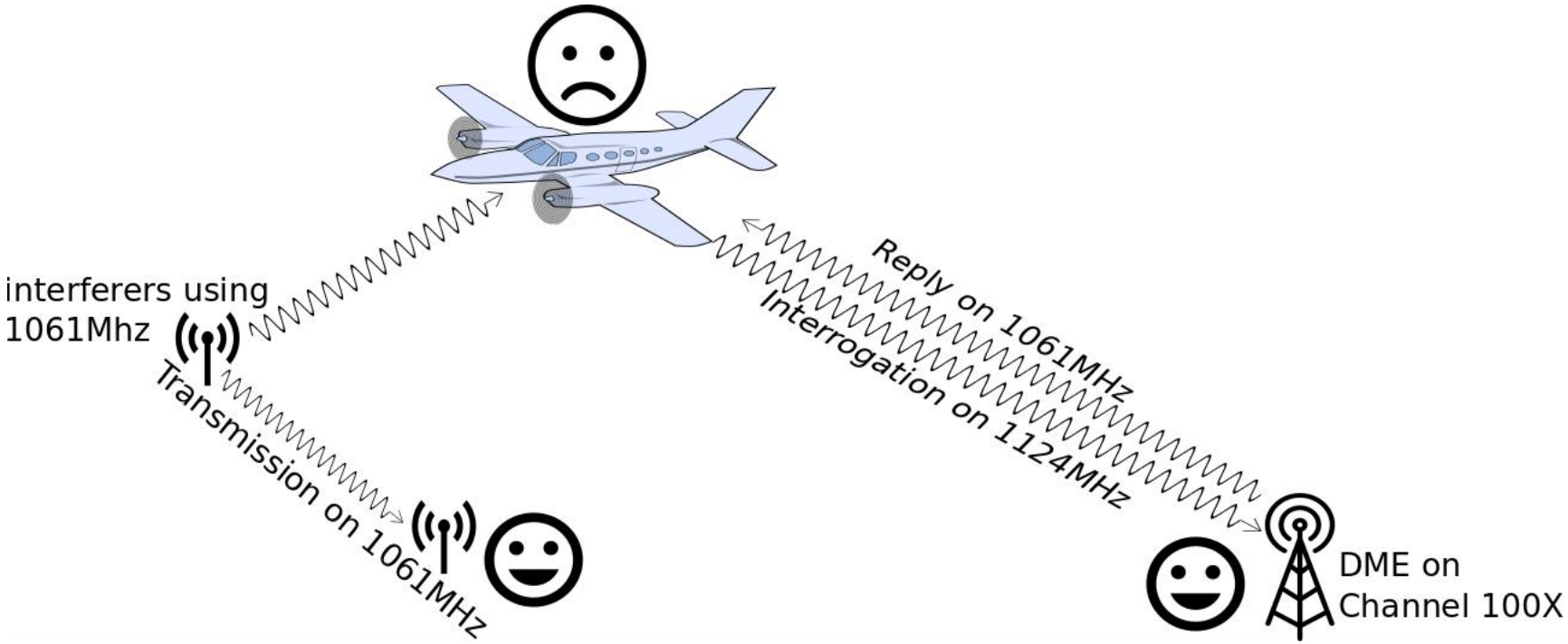
Interference in the band 960-1164 MHz

Interference on DME



Interference in the band 960-1164 MHz

Interference on Aircraft



Interference in the band 960-1164 MHz

Interference on DME

What are the problems highlighted:

- The interferer could operated without any problem.
  - The DME replies on 1061MHz have no effect on the interferer transmission 1124MHz.
  - The Aircraft interrogation have no effect on the interferer transmission 1061MHz.
  - The interferer doesn't have any clue about the jamming caused.
- The DME become deaf on interrogations from the aircraft, without realizing it!
- The Aircraft can become deaf to replies from the DME, and pilot thinks that DME is out of service.

Interference in the band 960-1164 MHz

Interference on DME

What are the problems highlighted:

- In case there is an interference in the band, in most cases only the end user (pilot) can figure out there is a problem, but without knowing the reason why! He has to keep flying the aircraft anyway. His priority is not reporting events!

- For Aircrafts flying at the following levels :

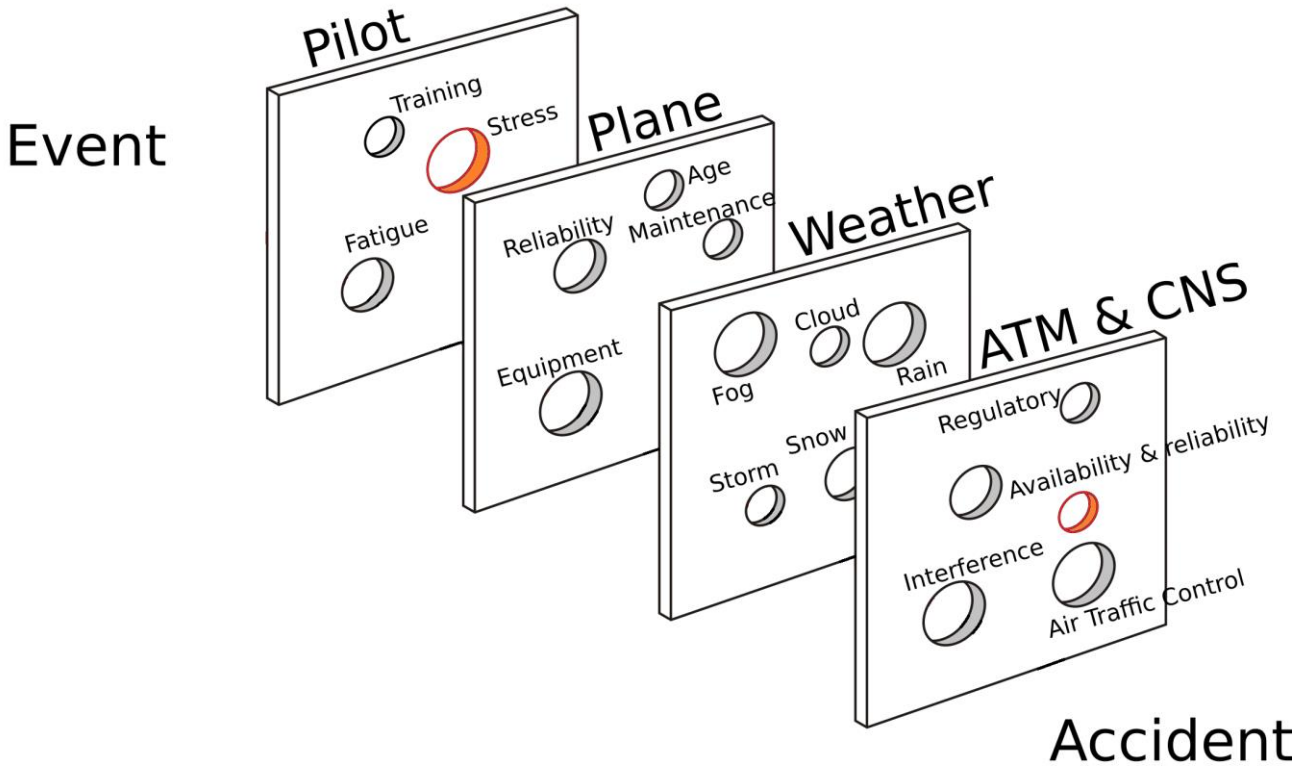
$$1000\text{ft} \approx 305\text{m} \Rightarrow RLOS \approx 72\ km \Rightarrow\ Area \approx 16\,000\ km^2$$

$$2000\text{ft} \approx 610\text{m} \Rightarrow RLOS \approx 102\ km \Rightarrow\ Area \approx 32\,000\ km^2$$

Given those large areas, how is it possible to rapidly detect a ground interfer?

Interference in the band 960-1164 MHz

All interference in the band 960-1164MHz is a very sensitive aspect for safety assesment, due to the impact on pilot environement



Conclusion

- The 960-1164MHz band has **an immediate impact** on pilot environnement.
- The interfer's localisation will take a very long time.
- Sharing this band requires a very long process for the safety assessment.

To be accepted by civil aviation authorities, this Safety Case will need heavy mitigation measures to avoid impact on pilot environement.