CINQUIEME SEMESTRE
Spécialité Avionique et Systèmes de
Contrôle du Trafic Aérien

SB508
Ground based Safety Nets

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Outline

- Personal presentation
- Lesson 1 : Context
- Lesson 2 : Safety nets in general
- Lesson 3 : MSAW & APM
- Lesson 4 : APW + Conclusions
- Lesson 5 : STCA

Outline

- Personal presentation
- Lesson 1 : Context
- Lesson 2 : Safety nets in general
- Lesson 3 : MSAW & APM
- Lesson 4 : APW + Conclusions
- Lesson 5 : STCA

Outline of lesson3

- Chapter 1 : Introduction CFIT
- Chapter 2 : Basis of MSAW
- Chapter 3 : Acquisition of data
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- Chapter 7 : Alert process
- Chapter 8 : French implementation
- Chapter 9 : Conclusion

Outline of lesson3

1.1 introduction : CFIT

- In France, in 1992 an Airbus A320 From Air Inter crashed onto a mountain (Mont Saint Odile) with 87 persons died
- All system on board were good !!!
- The pilot and his crew were all right !!!

This **CFIT** (**C**ontrolled **F**light **I**nto **T**errain) started the study of MSAW in France

1.2 introduction : ICAO recommendation

- ICAO, regarding all the accident all over the world, recommend a system on board and another on ground to avoid CFIT.

- **MSAW** is the name of this system on ground, to avoid collision on terrain
- **GPWS** is the name of the system on board, to avoid collision on terrain

1.3 introduction : Features …

- Since the 50's, collisions on terrain are the most important part of accident in civil aviation
- 70 % of accident are due to collision on terrain, without technical problem on board
- Those accidents are CFIT
- CFIT :
  - 66 % during approach
  - 12 % climbing
  - 10 % landing
  - 12 % others

1.4 introduction : TAWS

- ICAO recommends to install on board a safety system against terrain collision
  - It was the beginning of GPWS
- Now there is new others system on board like :
  - **EGPWS** : **E**nhanced **G**round **P**roximity **W**arning System
  - **GCAS** : **G**round **C**ollision **A**lerting **S**ystem
- They are parts of **TAWS** – **T**errain **A**wareness and **W**arning **S**ystem

1.5 introduction : Since 1976 …

- With the computing development, a safety net (preventing collision on the terrain) implementation is possible in the operational center in the ATM.
- USA started MSAW in 1976 in Los Angeles
- In France, the studies of MSAW started in the 80’s
- In 1993, MSAW was installed in some important French approaches

1.6 introduction : MSAW installed in APP or ACC ?

- In Farnce MSAW is :
  - only in Approach
  - not installed in ACC

- But in others country it's different

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2.1 Basis : Risk of collision

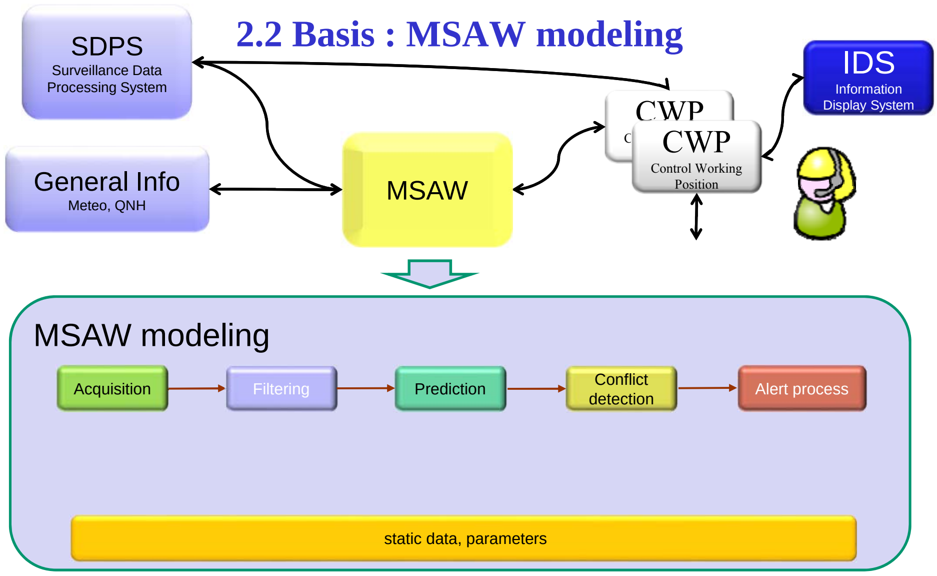
- Objective of MSAW service :

alert the controller when an increased risk of collision into terrain is detected and confirmed

2.2 Basis : MSAW principles

- MSAW uses :
  - Dynamic data :
    - the cinematic information of the flight (given by Radar Data Processing System).
    - Meteo data to calculate the plane altitude using the flight level (FL) and the atmospheric pressure at the level of the sea (QNH)
  - Static data : the model of the terrain and objects (a specific file) . In fact it's a terrain database
- Theses information are used to :
  - predict the trajectory and detect a potential conflict with the terrain.
  - Inform the controller if conflict is confirmed

2.2 Basis : MSAW modeling



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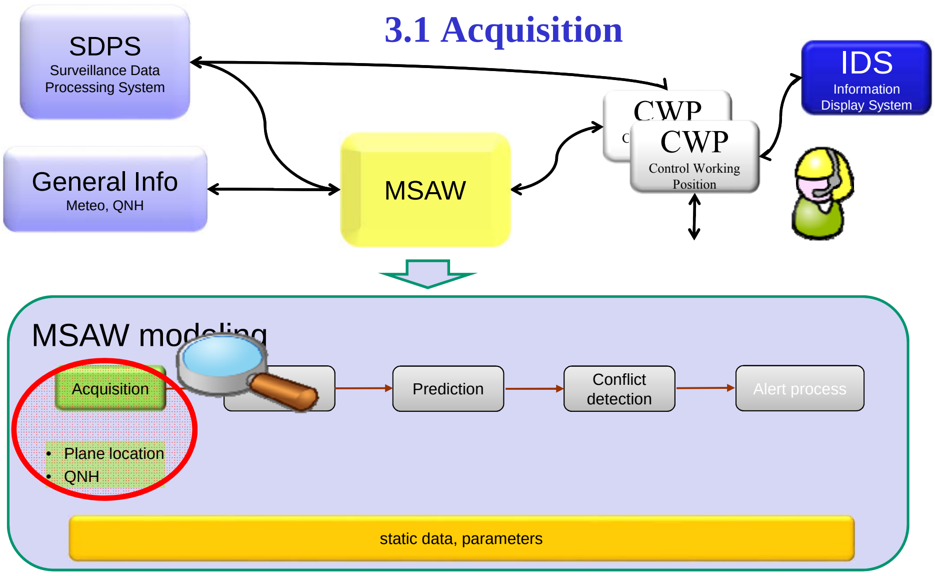
3.1 Acquisition



3.2 Acquisition : dynamic data

- MSAW uses inputs data :
  - from a Surveillance Data Processing System (SDPS) :
    - Cinematic data vertical and horizontal speed (using the position, the vertical and the horizontal speed, the future position will be calculated and the system will compare with the terrain)
    - Flight Level of plane
  - from meteo systems : QNH : Q code indicating the atmospheric pressure of airport adjusted to sea level.

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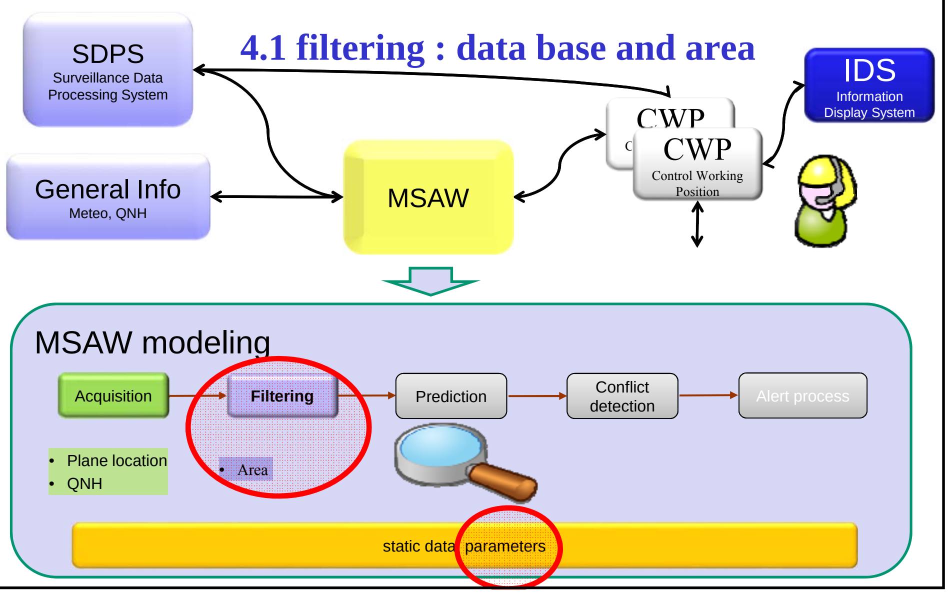
4.1 filtering : data base and area



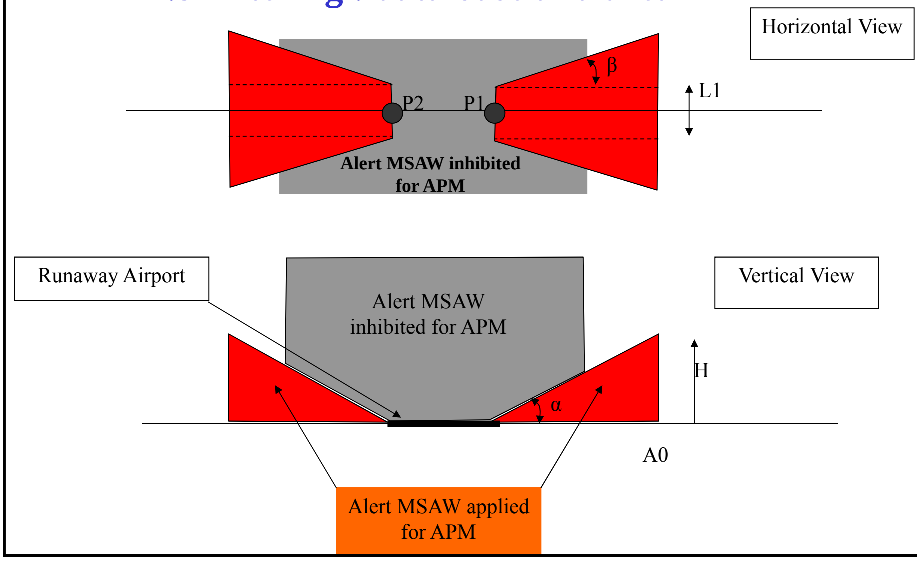
4.2 Filtering : only IFR

- MSAW is applied only for IFR, so some Mode A are rejected in the process.
- For example, we can configure the mode A = 7000 to be rejected in the process.
  - This code is the code for VFR.
  - Even , if some mode A code are specific to military traffic, we can configure it in the system.

4.3 Filtering : data base and area

- The filtering function "MSAW processing area", define the area where MSAW must execute the process.
  - In operational condition, the MSAW processing area is the TMA (Terminal Area).
- The airport area is also defined for the APM (**A**pproach **P**ath **M**onitor).
- In the 2 next figure we see how is this area tuned.
  - In fact for APM, the surveillance is done only in the descending plan configured with the ILS glide plan

4.3 Filtering : data base and area



4.4 Filtering : inhibited area

- Others areas are present, in particular the “inhibited areas”
- “inhibited areas” :
  - are special. Inside those areas, alert is calculated but not sent to the controller because there is a specific activity or traffic (vue approach instead of using instruments).
  - can be selected by the responsible controller of the center
  - depend on the activity of the day

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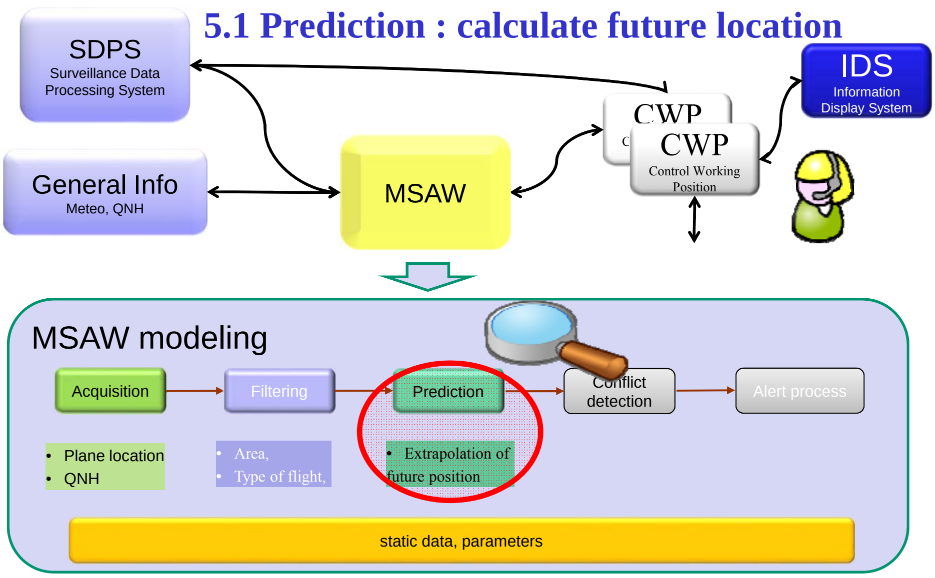
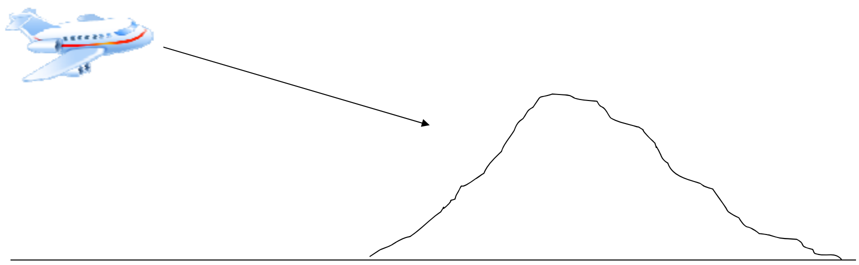
5.1 Prediction : calculate future location



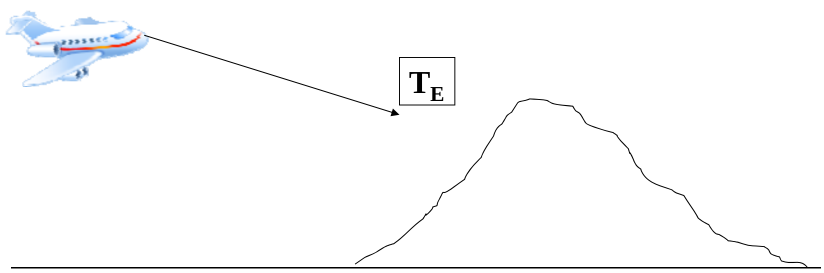
5.2 Prediction : calculate future location

- MSAW uses SDPS data :
  - using the position, the vertical and the horizontal speed, the future position will be calculated



5.3 Prediction : configure different time

- Future position will be calculated… but with witch <u>Extrapolation time</u> $\mathbf{T_E}$?



5.3 Prediction : configure different time

- To be efficient a conflict must be detected and reported to ATCO an pilot before a time called : Notice time (T_N) in order to have a reaction for the controller, the pilot, and the plane (in operational condition, the Notice time (T_N) is the Minimum Notice time (T_{MN}))
- So to be efficient the **E**xtrapolation time (T_E) for the future position must be longer than **M**inimum **N**otice time (T_{MN}). So we have :
  - $T_E > T_{MN}$

5.3 Prediction : configure different time

- How to calculate the **M**inimum **N**otice time (T_{MN}) ?
- T_{MN} is the addition of :
  - Time for **R**eaction of the **C**ontroller = 3 s = T_{RC}
  - Time for data **T**ransmission = 9 s = T_T
  - Time for the **R**eaction of the **P**ilot = 3 s = T_{RP}
  - Time for **R**eaction of the **M**achine (plane) = 15 s = T_{RM}
  - Time to refresh **R**adar information (SDPS) = 4 s up to 8 s = T_R
- $T_{MN} = T_{RC} + T_T + T_{RP} + T_{RM} + T_R$ = 3 + 9 + 3 + 15 + 4 or 8 = 34s or 38 s
- The **E**xtrapolation time T_E must be longer then T_{MN}.
  - So, T_E = 42 s (up to 54 s)

5.4 Prediction : 2 types of extrapolation

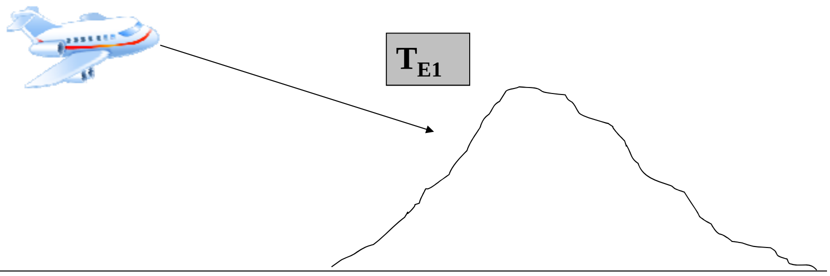
- The 2 hypothesis for prediction in MSAW are :
  - the flight descends
  - the flight descend and stabilized to a flight level

As the same in STCA, it’s important to have different hypothesis to calculate alert (In MSAW, the hypothesis is simpler than in STCA)

- Let ‘s see in the next slide …

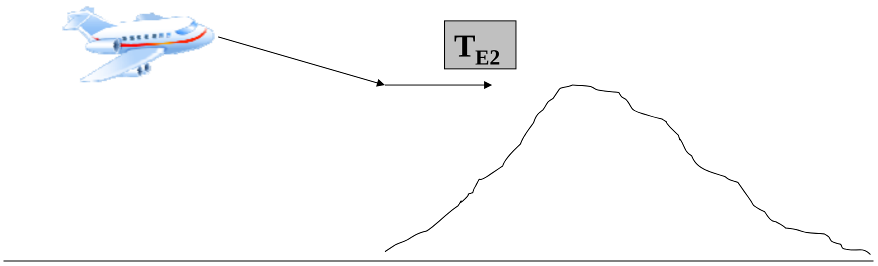
5.4 Prediction : 2 types of extrapolation

- **<u>First prediction :</u>**
  - the plane descends



5.8 Prediction : 2 types of extrapolation

- **Second prediction :**
  - the plane descends an stabilized his flight level



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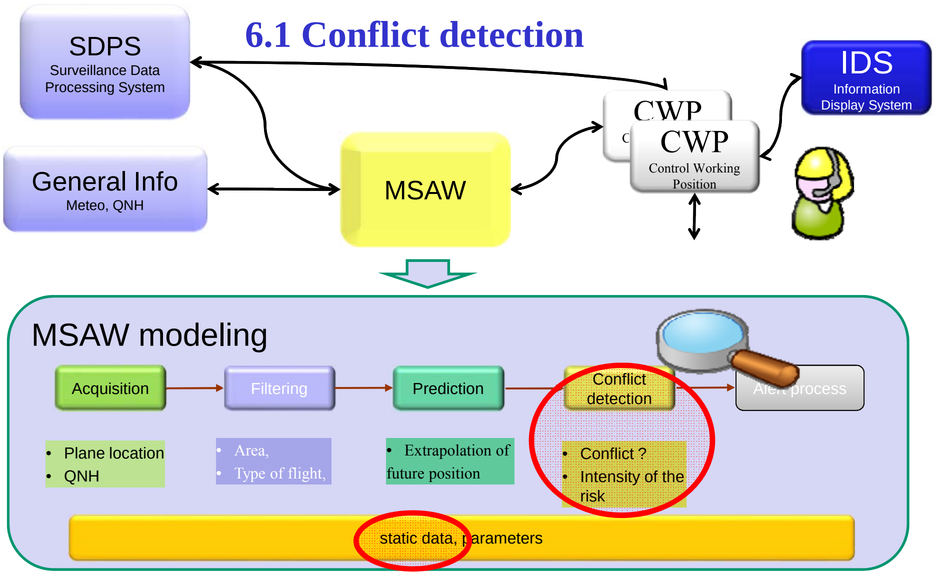
6.1 Conflict detection



6.2 Conflict detection : objective

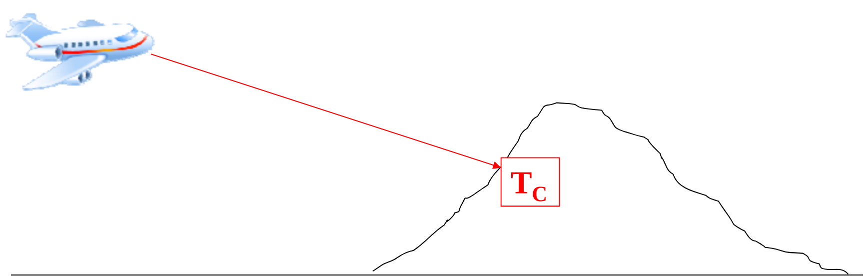
- The function verify if a flight (in fact a track from the RDPS) inside the MSAW processing area, could be in conflict with the terrain or an object.
- For each potential conflict, an intensity of the risk is calculated.
- If the risk is confirmed, the alert will be sent to the controller.

6.3 Conflict detection : conflict time

- Remain filtering function : Eligibility of flight :
  - If the flight is inside MSAW processing area
  - Cinematics data are present
- Remain prediction function : with position and speed, the system predicts the future position using Extrapolation time (T_E)
  - In horizontal, the predicted position is linear during Extrapolation time (T_E) and using speed vector
  - In vertical, the vertical speed is used with the Vertical time T_V , ($T_V < T_E$). After T_V , the flight has an horizontal movement
- A conflict is detected if predict position intercept thin relief or an object :
  - In this case , a Conflict time (T_C) is calculated

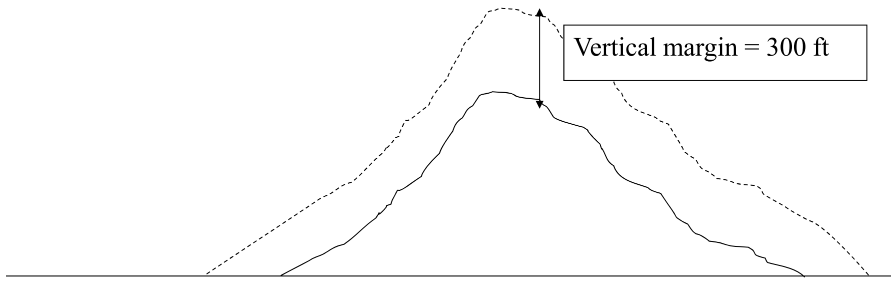
6.4 Conflict detection : conflict time

- A conflict is detected if predict position intercept thin relief or an object :
  - In this case , a Conflict time (T_C) is calculated



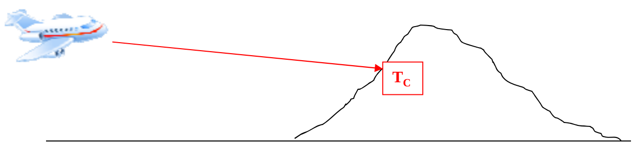
6.5 Conflict detection : Vertical margin

- To calculate the conflict time, a vertical margin (300 feet) is added to the thin relief.
- So the process is not a conflict with the terrain but when the prediction intercept this margin
- So we have this kind of configuration:



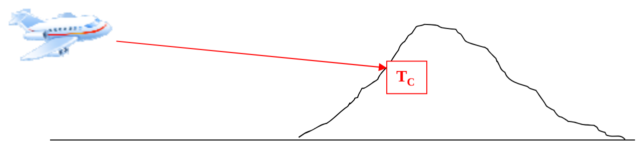
6.6 Conflict detection : process

- How predict if future plane position will intercept thin relief or an object ?
  - The system has to compare the real altitude of :
    - future plane location (calculated with mode C and QNH)
    - thin relief or an object (internal database of thin relief and objects)



6.7 Conflict detection : plane altitude process

- How predict if future plane position will intercept thin relief or an object ?
  - The system has to compare the real altitude of :
    - future plane location (calculated with mode C and QNH)
    - thin relief or an object (internal database of thin relief and objects)



6.8 Conflict detection : plane altitude process

- Problem :
  - The vertical position of the plane is given by the transponder sending the mode C (Flight Level : it's not the real altitude) : the reference is 1013,25 Hpa.
  - The relief is in real altitude and the reference is the sea level

- Solution :
  - Using the QNH, giving the local atmospheric pressure, it is possible to calculate the real altitude of the plane with the next equation :
    - Real plane altitude = (100xFL) + [28 x (QNH-1013)]

    28 is the air pressure gradient used in the low level of the atmosphere (28ft/hpa)

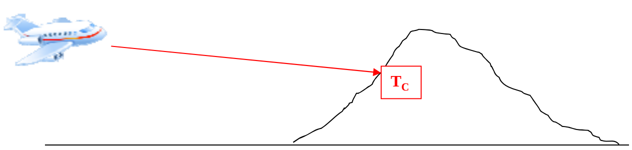
    FL = Flight Level expressed in hundred of feet

    QNH = local atmospheric pressure (airport for example)

  After the system associate (in real time) to each cell (32Nm) from the MSAW grid, applying correction with the distance

6.9 Conflict detection : relief database

- How predict if future plane position will intercept thin relief or an object ?
  - The system has to compare the real altitude of :
    - future plane location (calculated with mode C and QNH)
    - thin relief or an object (internal database of thin relief and objects)



6.10 Conflict detection : relief database

- In a static database, all the parameters are present and we can find :
  - The MSAW grid. In fact 20x20 cells and each cell is a square of 32Nm x 32 Nm
  - Obstacles : Building, factories, antenna, monument (human building activities) are also present in database system using cylinder or polygons
  - The thin relief (terrain) in a database (digital model of the terrain) given by the french geographic national institute. This thin relief is a 1 million cell. Each cell is 1 Nm long. For each cell we have the highest altitude
  - The large relief build with a merge of the MSAW grid and the thin relief. For each big cell (from the MSAW grid), we applied the highest altitude from the thin relief. This large relief is used to realize a first filter for flights in conflict with the terrain.

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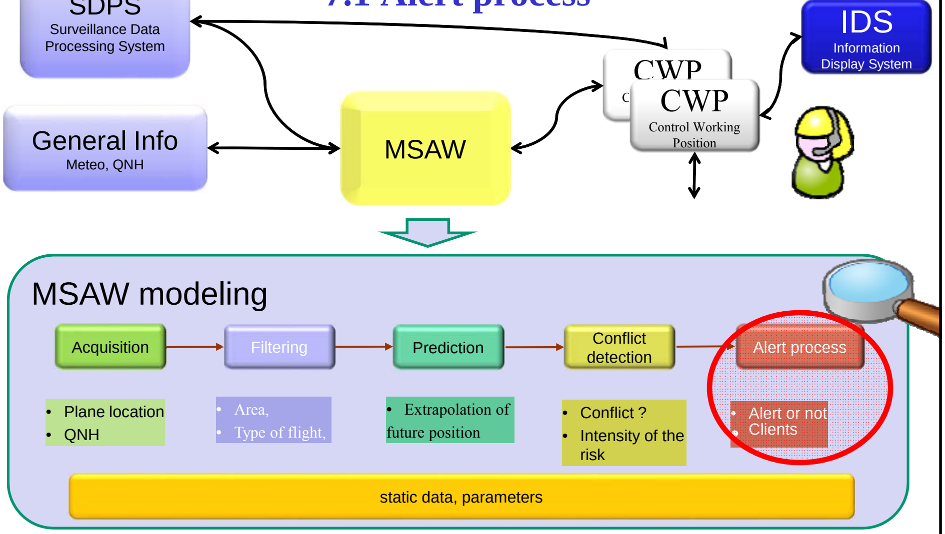
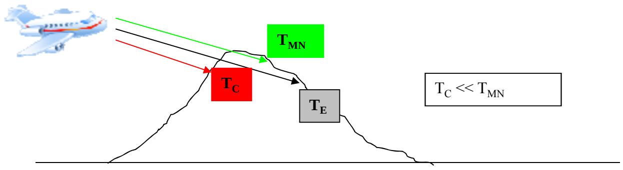
7.1 Alert process



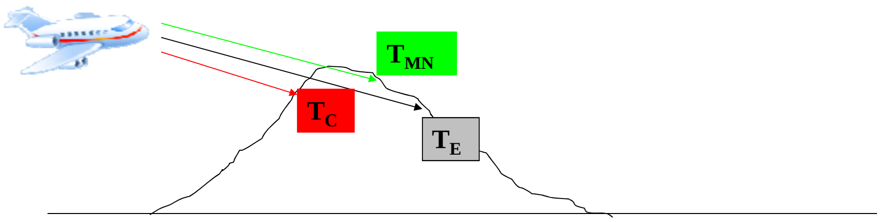
7.2 Alert process : Conflict Time (T_C) Vs Minimum Notice Time (T_{MN})

- The Conflict time (T_C) is the time calculated when a plane crashed on the relief.
- The process uses this time to compare it with the Extrapolation time (T_E) and the Minimum Notice time (T_{MN}).



7.3 Alert process : Notice time and conflict time

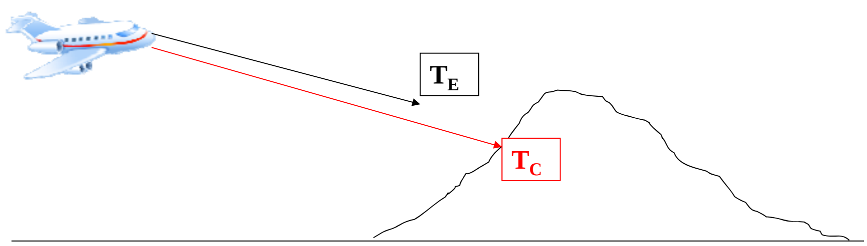
- The alert must be generated with a Notice time (T_N) in order to have a reaction for the controller, the pilot, and the plane
- If the Conflict time (T_C) is under the Notice time (T_N) then the alert is sent immediately
- In operational condition, we have seen that the Notice time (T_N) is the Minimum Notice time (T_{MN})



7.4 Alert process : Alert or no alert ?

- If the Conflict time T_C is under the Minimum Notice time T_{MN} , the alert is sent.
- In the other case, a risk is calculated, and at each refreshing cycle the intensity is increased.
- If the risk intensity equal to 3, the alert is also sent to the controller
- Let ‘s see in the next slides …

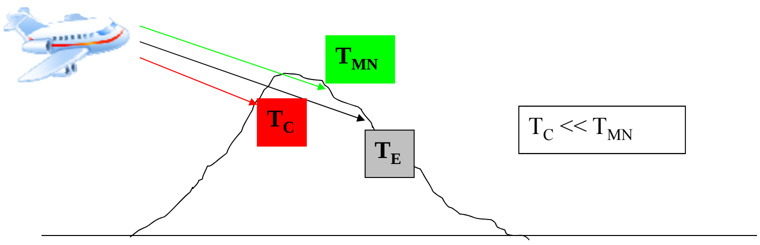
7.5 Alert process : No alert



$T_C >> T_E$

- In this case TC >>TE , then there is **NO ALERT**

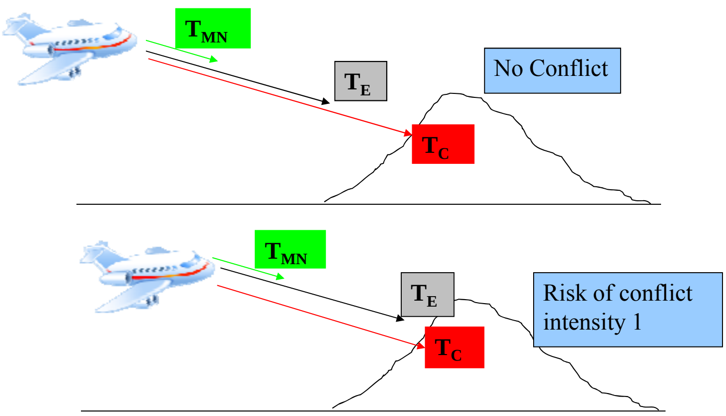
7.6 Alert process : Immediate alert



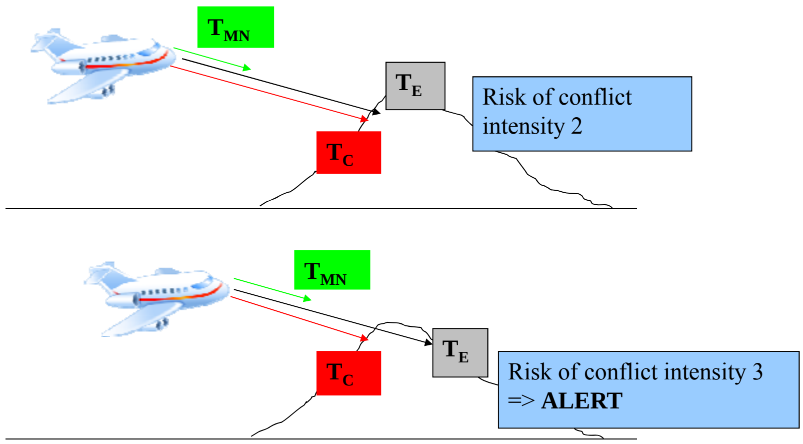
- Because TC << TMN , => immediate **ALERT** sent to controller

Delayed alert

7.7 Alert process : Intensity of risk



7.8 Alert process : Intensity of risk



7.9 Alert process : delayed alert

- We can see that T_{MN} and T_E are always the same..
- T_C is longer than T_{MN} but we see that it is decreasing every refreshing position given by the RDPS.
- Because the process detect a conflict is being arrived (T_C present 3 times and decreasing) , the alert is present when the intensity equal 3.
- In this case we have delayed the alert, and send it only when the moment is good.
- Not too early and not too late !

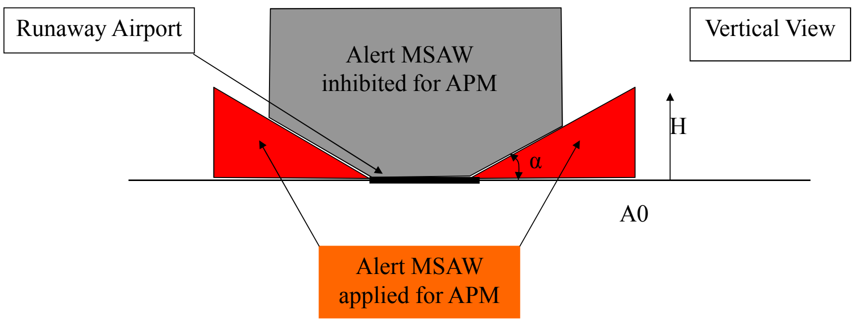
7.10 Alert process : display alert

- If the position plane is under a margin, the alert is generated
- In this case, the alert is sent to the controller with special sign on the display (it appears also on the radar display system) and with an audio message

Outline of lesson3

8.1 French system : MSAW & APM

- The French system is also configured to prevent problems during the final approach.
- This is the APM (Approach Path Monitor) function



8.1 French system : APM function

- Some specific area are created near the airport
- Those areas can verify the path during the final approach
- When the alert is sent it appears also on the radar display system
- In the same time, a sound is sent to an audio system , to be earn by the controller

8.1 French system : ATCO & Pilot actions

- The controller who had the the radio contact with the pilot must inform him of the dangerous situation, using this sentence:
  - “ xx, Terrain Alert, Check Your Altitude Immediately “
- In this case, the pilot must do appropriate actions :
  - stop the descent
  - Verify the altitude
  - etc …

8.1 French system : The french touch …

- The French MSAW system is different from foreign MSAW
- Firstable, regarding the software, the French MSAW predicts the position on an oblic direction . Instead of comparing the altitude with a minimal safe altitude like it’s done in the over European software
- In second, in France, when the alert is sent, the controller don’t have to prepare a plan or a strategy. Using a reflex action, he only must inform the pilot that a dangerous situation is coming
- In the French system, to reduce false alert and to sustain the trust between the controller and MSAW, the software is more complex

8.1 French system : Which flight in MSAW ?

- Only IFR are concern by MSAW.
- VFR and military are rejected by a filter, so they are not concern by MSAW

8.1 French system : MSAW principles :

- MSAW uses the cinematic information of the flight (given by Radar Data Processing System).
- Theses information (position and speed in 3D) are used to predict the trajectory and detect a potential conflict with the terrain.
- The software uses 3 functions :
  - the model of the terrain and objects (a specific file) . In fact it's a terrain database .
  - the meteo process to calculate the plane altitude using the flight level (FL) and the atmospheric pressure of the terrain (QNH)
  - the creation of the alert

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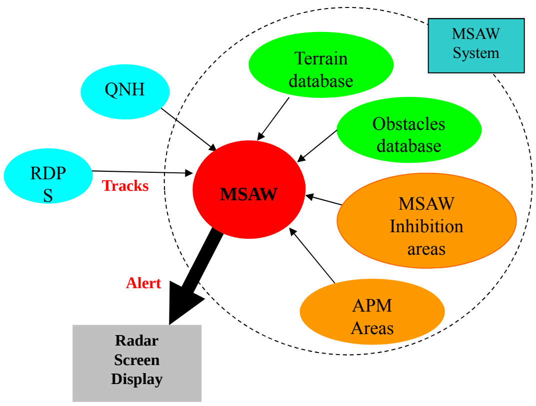
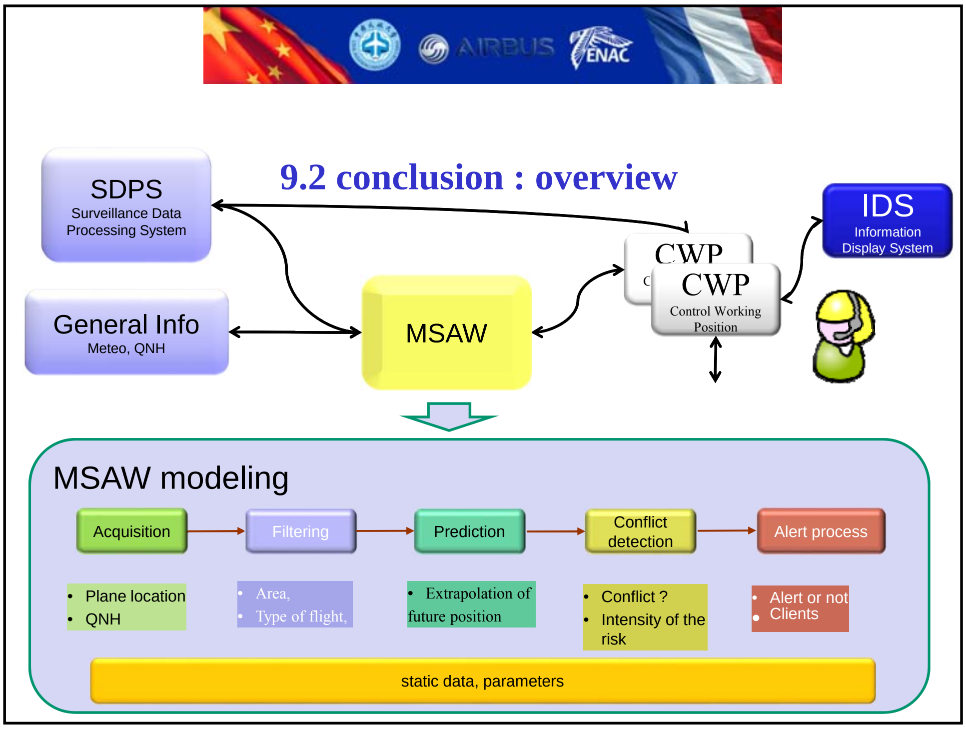
9.1 conclusion : Global inputs and outputs





AIRBUS
ENAC
9.2 conclusion : overview
SDPS
Surveillance Data Processing System
General Info
Meteo, QNH
MSAW
CWP
CWP
Control Working Position
IDS
Information Display System
MSAW modeling
Acquisition
Filtering
Prediction
Conflict detection
Alert process
• Plane location
• QNH
• Area,
• Type of flight,
• Extrapolation of future position
• Conflict ?
• Intensity of the risk
• Alert or not
• Clients
static data, parameters