Effect of ZFW / ZFWCG on Aircraft Operations

Customer Services

AIRBUS

Contents

Single-Aisle (SA)

- FM Architecture
- FAC Architecture
- Incorrect ZFW entered on the MCDU
- Incorrect ZFWCG entered on the MCDU

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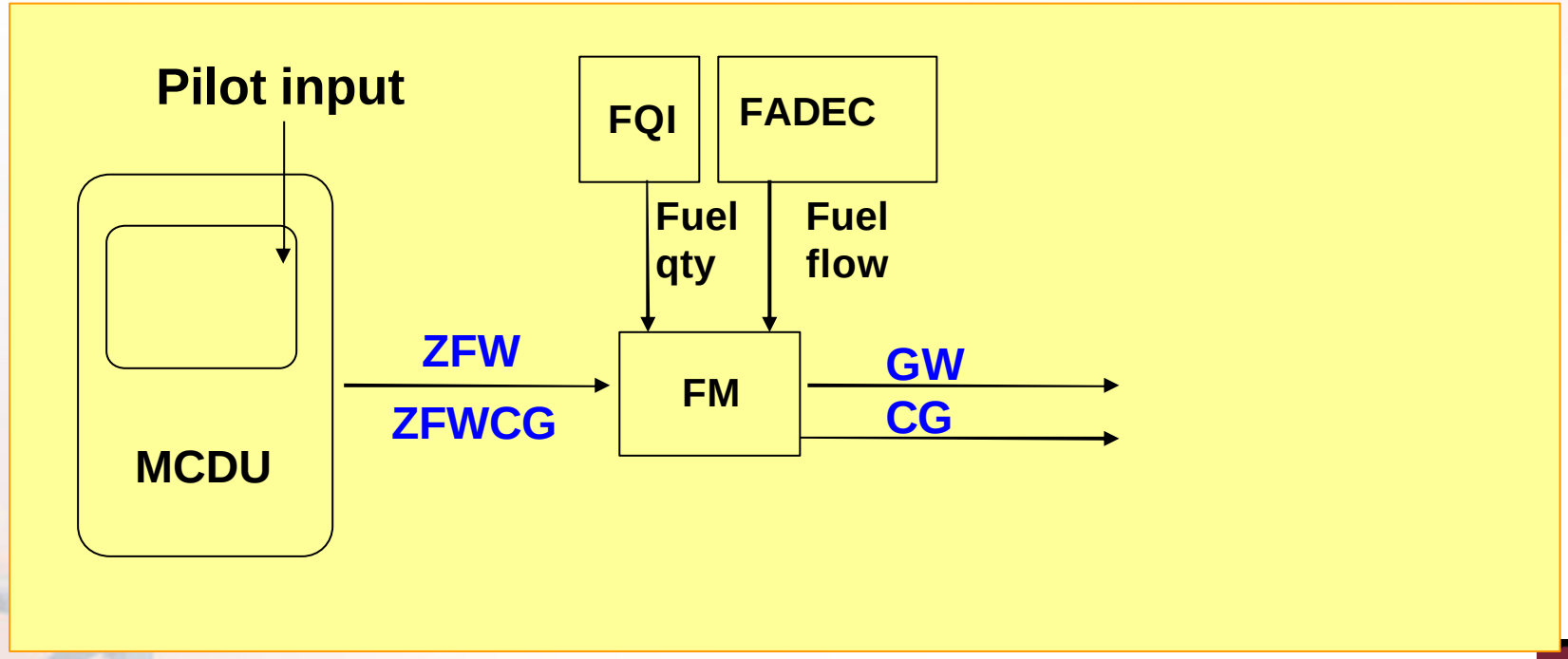
SA: FM Architecture

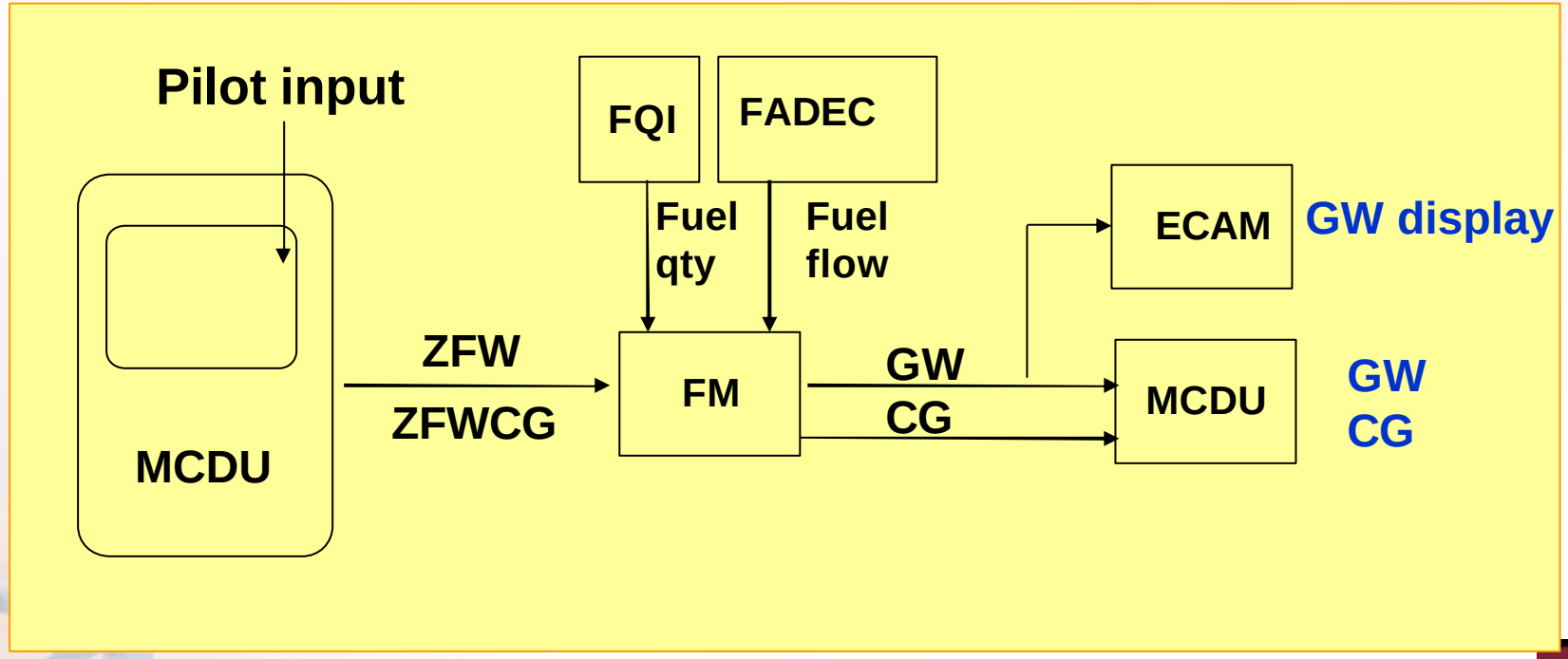
- **The Flight Management computes the Gross Weight and the Center of Gravity based on:**
  - **ZFW/ZFWCG entered by the pilot**
  - **The fuel quantity indication (from the FQI)**
  - **The fuel flow information (from the FADEC)**



SA: FM Architecture …

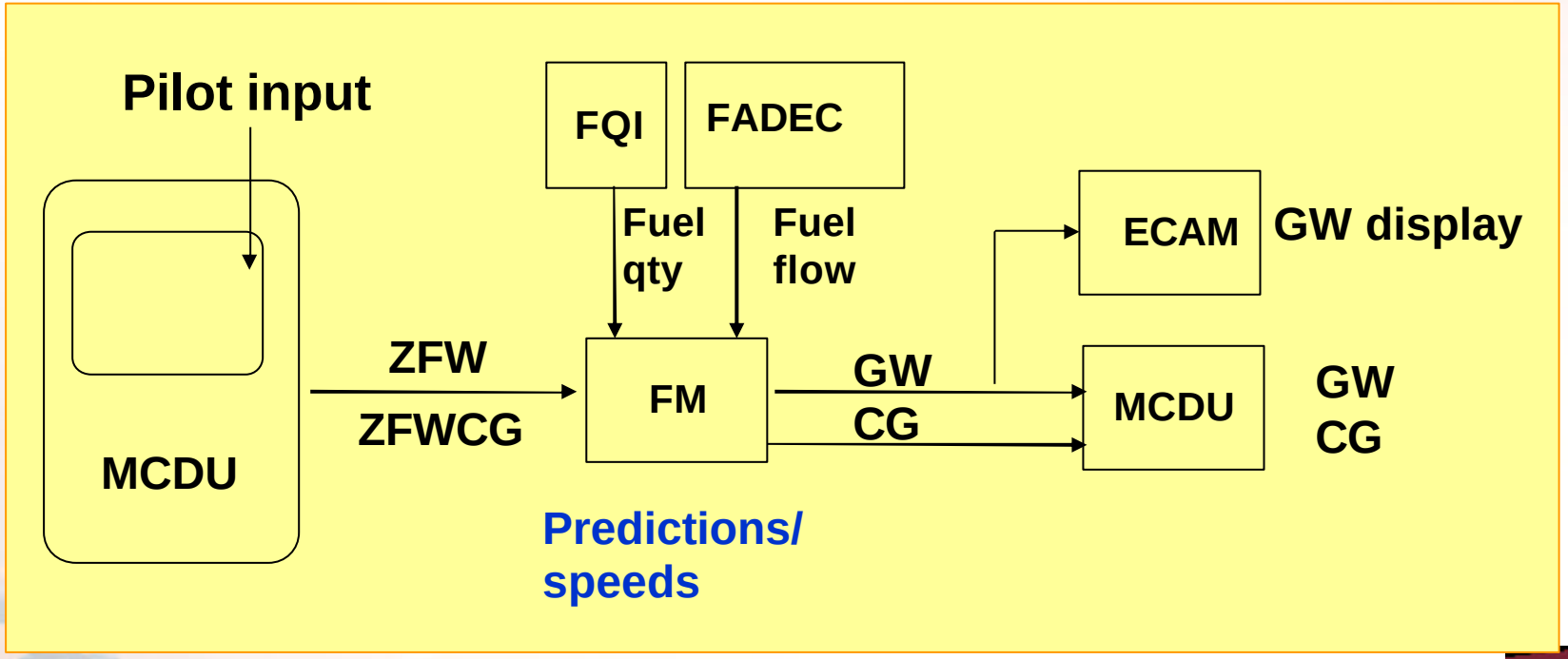
- The GW is displayed on the ECAM.

- Both the GW and CG are displayed on the MCDU's FUEL PRED page.



SA: FM Architecture …

- **Both the GW and CG are used by the FM for predictions that include optimum managed speeds and operating speeds (Vls, Vapp, F, S and green dot)**



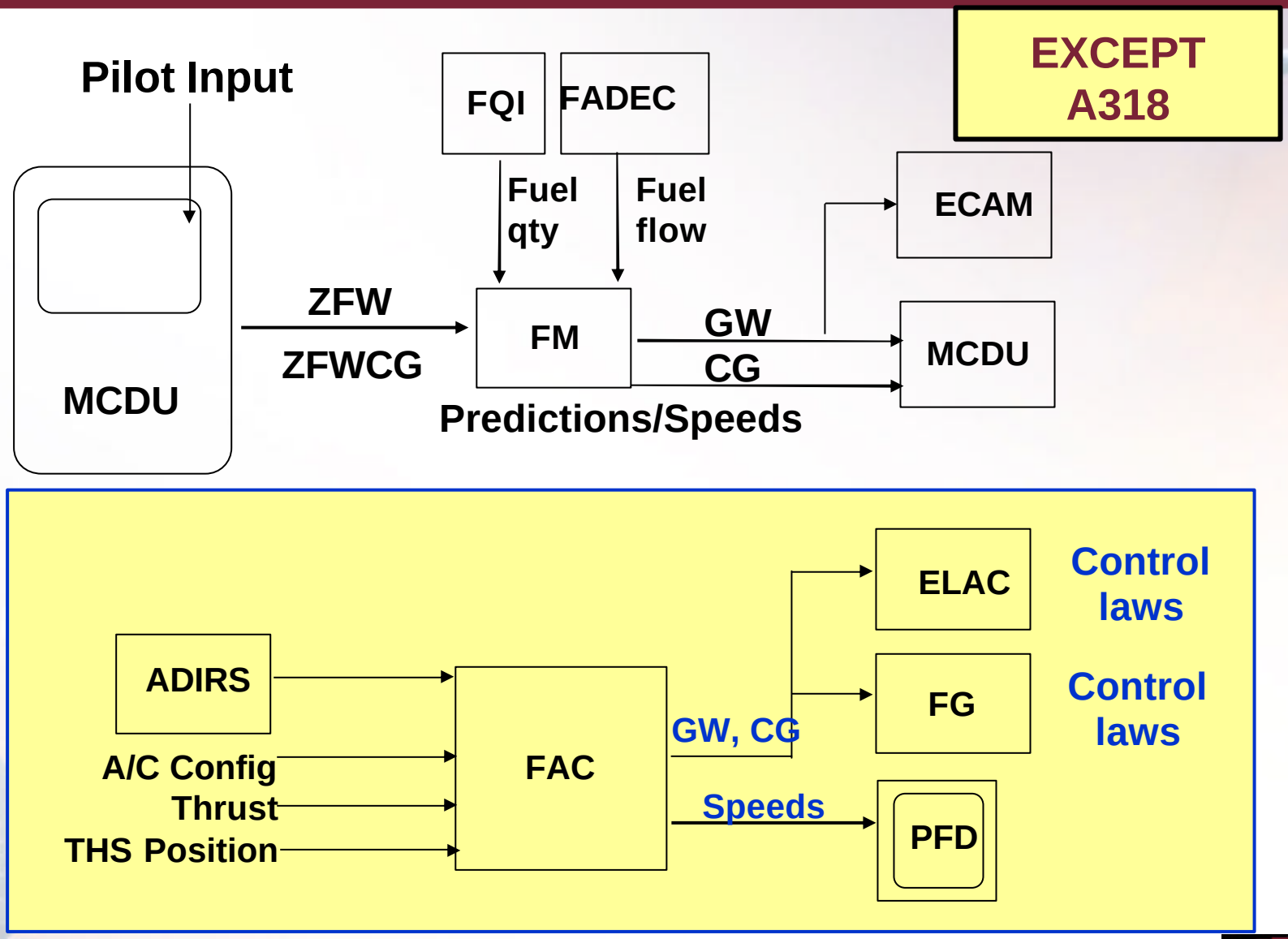
SA: FAC Architecture …

- On the A320, the FAC computes its own CG and GW from aerodynamic data.

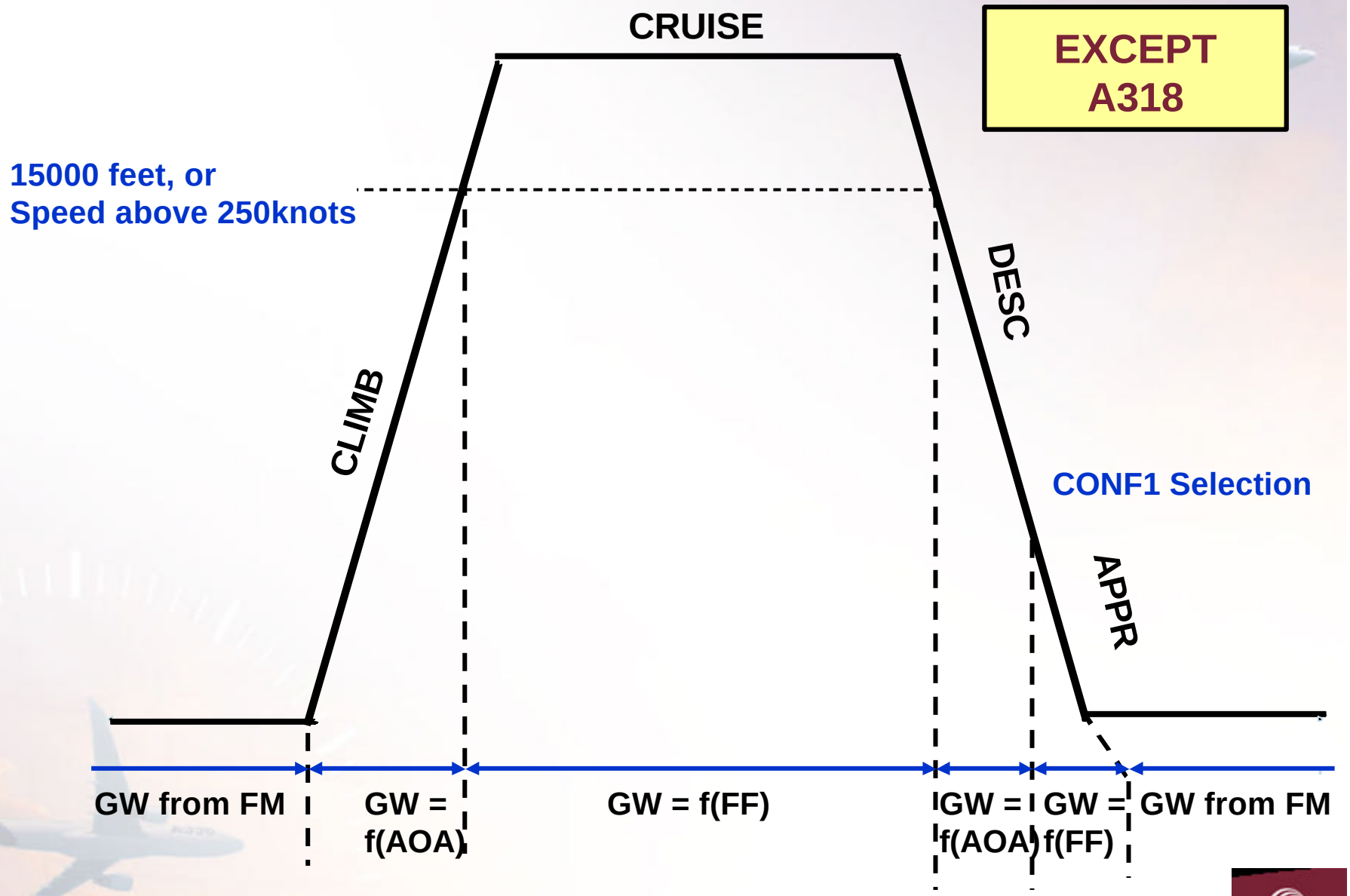
- These values have a minor impact on ELAC control laws and FG control laws, as they are used to adjust the gains of the flight control laws.

- Also, the FAC computes the operating speeds (Vls, F, S, O) that are displayed on the PFD.

SA: FAC Architecture …

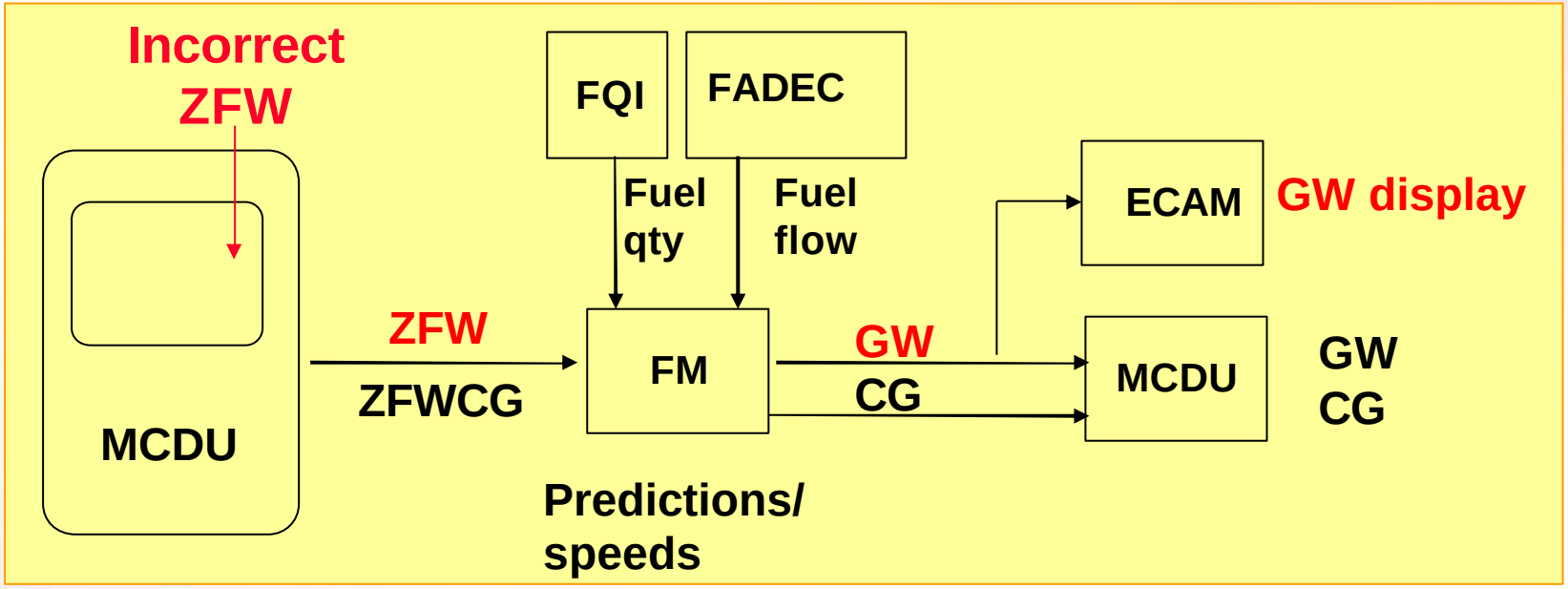


SA: FAC Architecture…



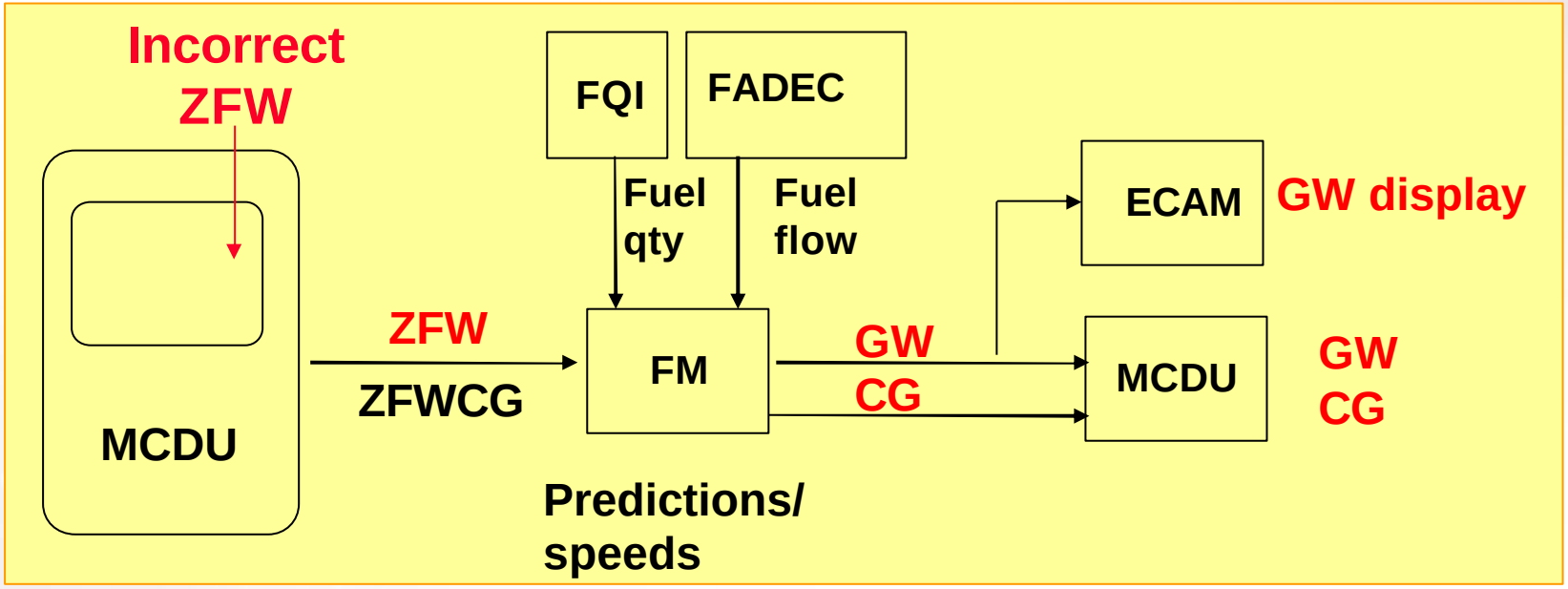
SA: If Incorrect ZFW Entered

- The GW, computed by the FM and displayed on the ECAM, is incorrect.



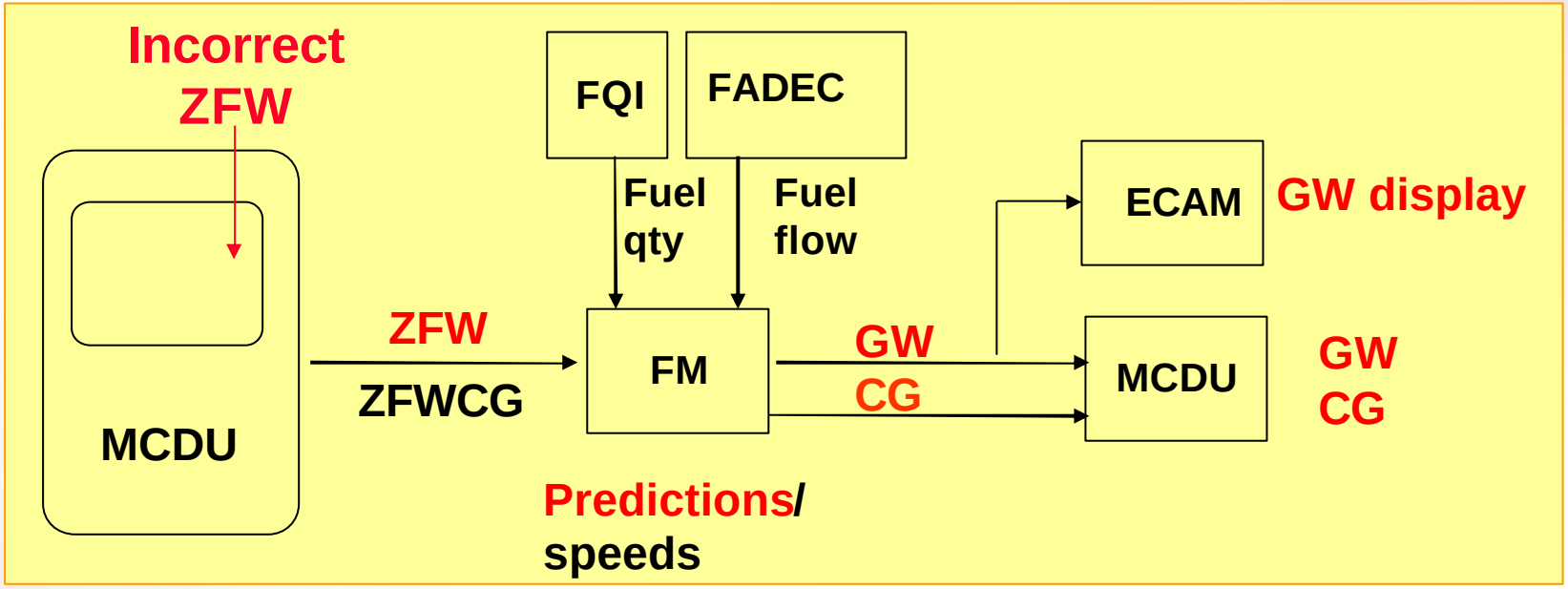
SA: If Incorrect ZFW Entered…

The GW and CG, displayed on MCDU, are incorrect.



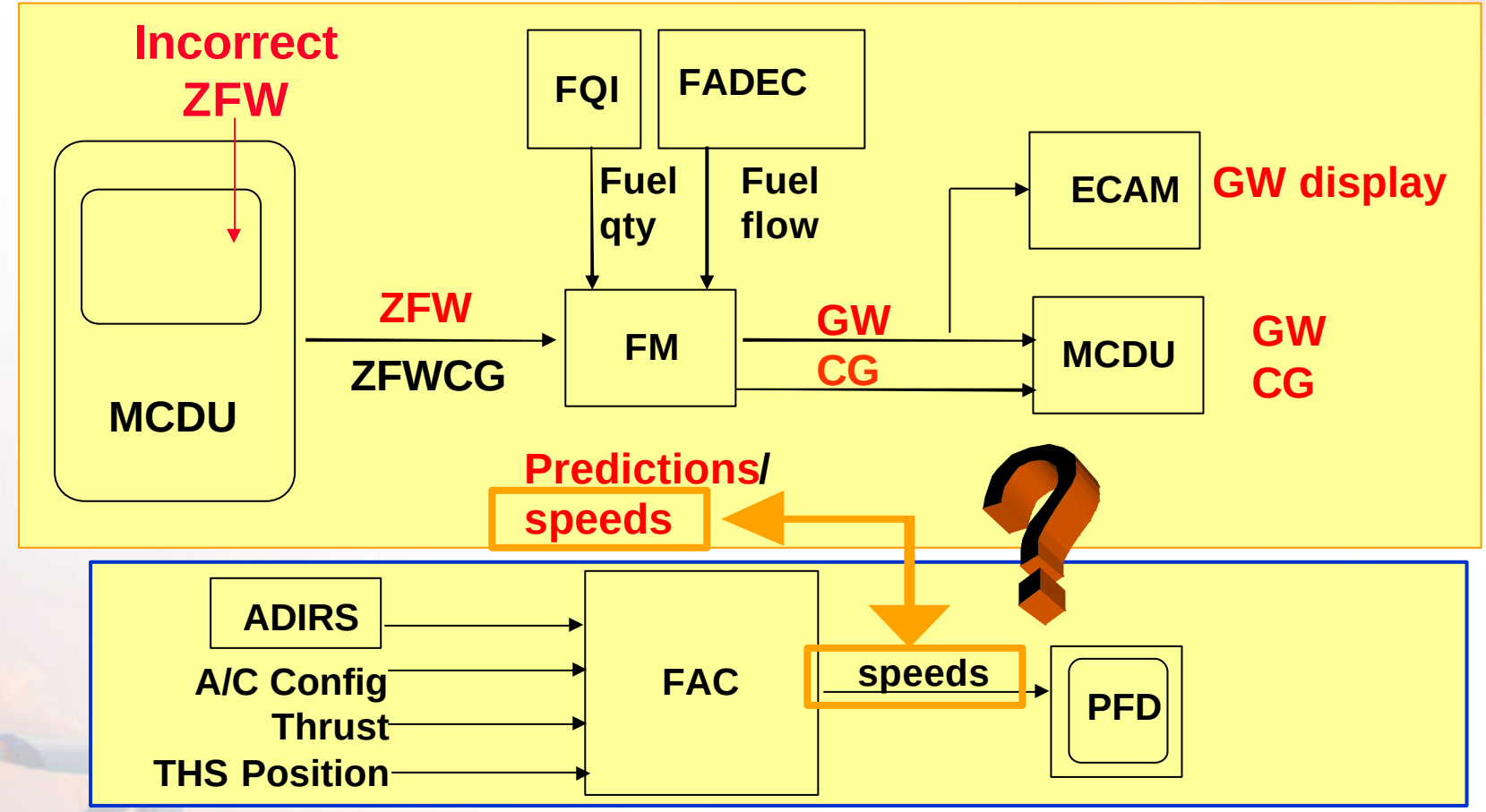
SA: If Incorrect ZFW Entered…

- The FM predictions are affected.

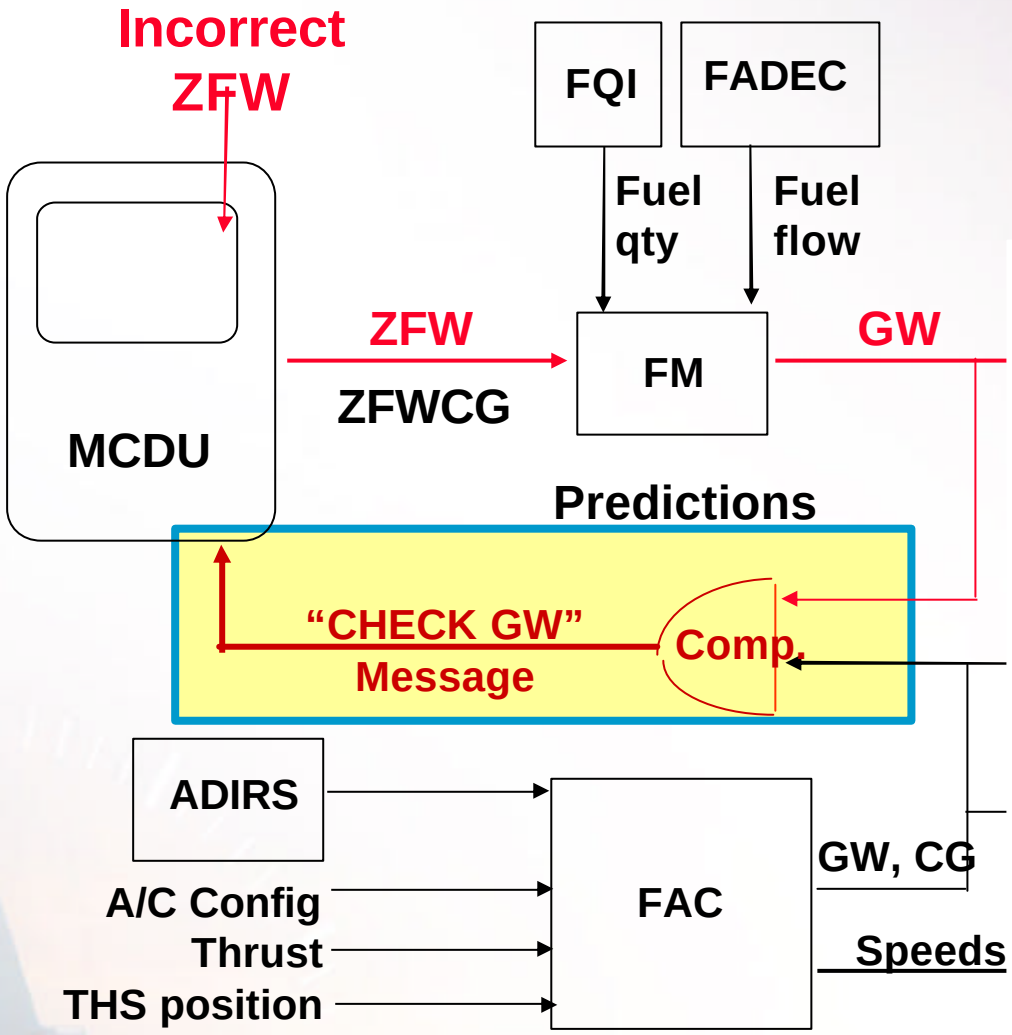


SA: If Incorrect ZFW Entered…

- A discrepancy can be observed between the operating speeds, displayed on the MCDU and those displayed on the PFD (PFD speeds are not affected (Except on the A318)).



SA: If Incorrect ZFW Entered …



In flight if the ZFW error is significant, the « CHECK GW » message automatically triggers if the FM and FAC GW differ by more than 7 tons.

SA: If Incorrect ZFWCG Entered

- An incorrect ZFWCG has a minor impact on the predictions computed by the FM.
- There is an impact on the Vls and VApp that is displayed on the MCDU.
- On SA (except A318), there is no effect on the Vls displayed on PFD, due to the fact that, in flight, the FAC computes its own CG.

SA: If Incorrect ZFWCG Entered …

- **In flight, the correct CG is not accessible:**

  – **The pilot has no access to the FAC value (It is never displayed on the ECAM).**

  – **In flight, the THS position is not representative of the current CG (depends on Mach, weight, altitude):**

In flight, the THS position does not enable the current CG to be determined.

A318: FM and FAC Architecture

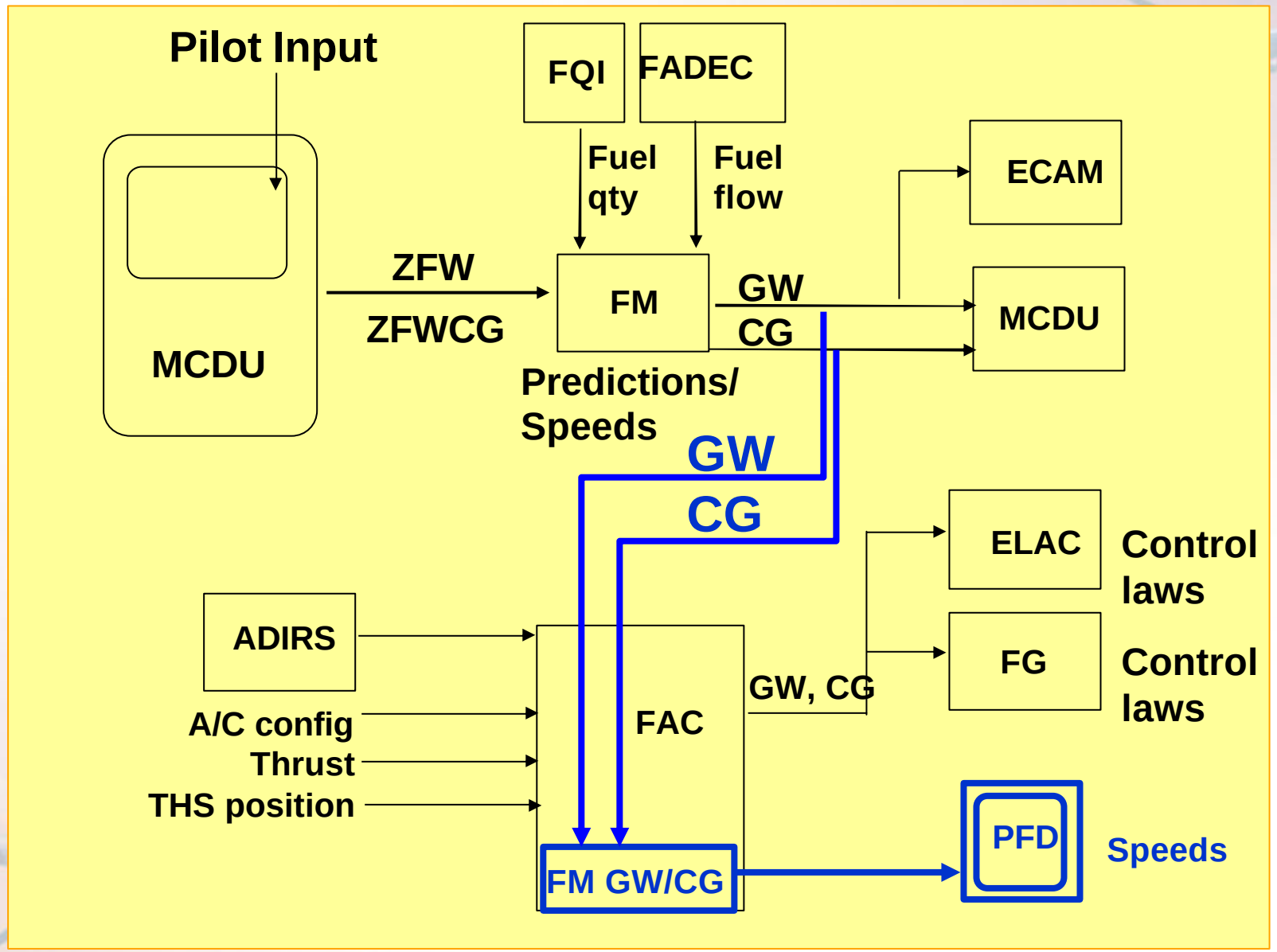
- **Goal of the A318 FAC Standard:**
  - **To cancel speed discrepancies between the MCDU and the PFD.**

- **A318 FAC Design:**
  - **The FAC uses the GW/CG, computed by the FM, only for the computation of the operating speeds that are displayed on the PFD.**

- **The rest of the FAC architecture remains unchanged.**
  In particular, the comparison between the GW computed by the FM and FAC (CHECK GW message).

A318: FM and FAC Architecture …

A318



A318: FM and FAC Architecture…

- **The rest of the FAC architecture remains unchanged.**

The comparison between the GW computed by the FM and FAC still exists.

(CHECK GW message)

A318: If Incorrect ZFW Entered

- **As with the A320:**
  - **Same effect on FM predictions/speeds**

- **The Speeds (Vls, F, S, O) that are displayed on the PFD are impacted in the same way as on the MCDU (no longer speed discrepancies).**

But V_{aPROT}, V_{aMAX} and V_{SW} are not affected since based on aerodynamic data.

A318: If Incorrect ZFW Entered…

- **As with the A320:**

  If the ZFW error if significant:

  - **The « CHECK GW » message automatically triggers once, in flight, if the FM and the FAC GW differs by more than 7 tons.**

A318: If Incorrect ZFWCG Entered

- **As with the A320:**
  - **Same effect on FM predictions / speeds.**

- **The VLS that is displayed on the PFD is impacted in the same way as on the MCDU.**
  - **No PFD/MCDU discrepancy**

But V_{aPROT}, V_{aMAX} and V_{SW} are not affected since based on aerodynamic data.

Long-Range (LR)

- FCMC/FE Architecture
- CG Control
- If Incorrect ZFW entered on the MCDU
- If Incorrect ZFWCG entered on the MCDU

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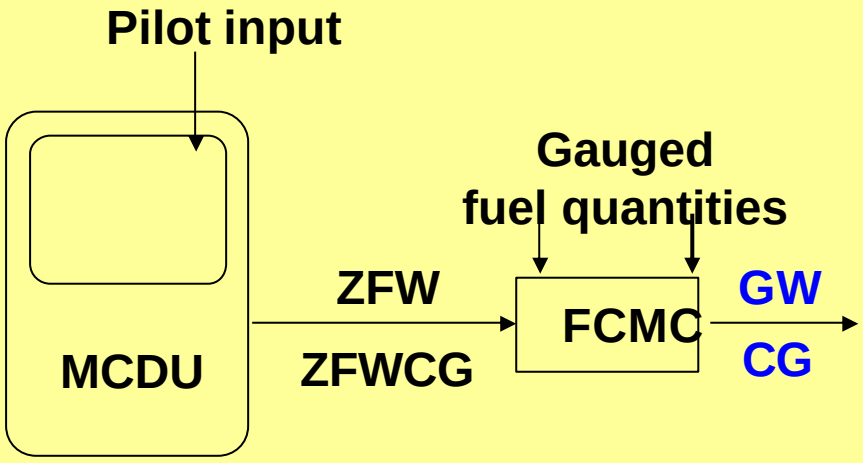
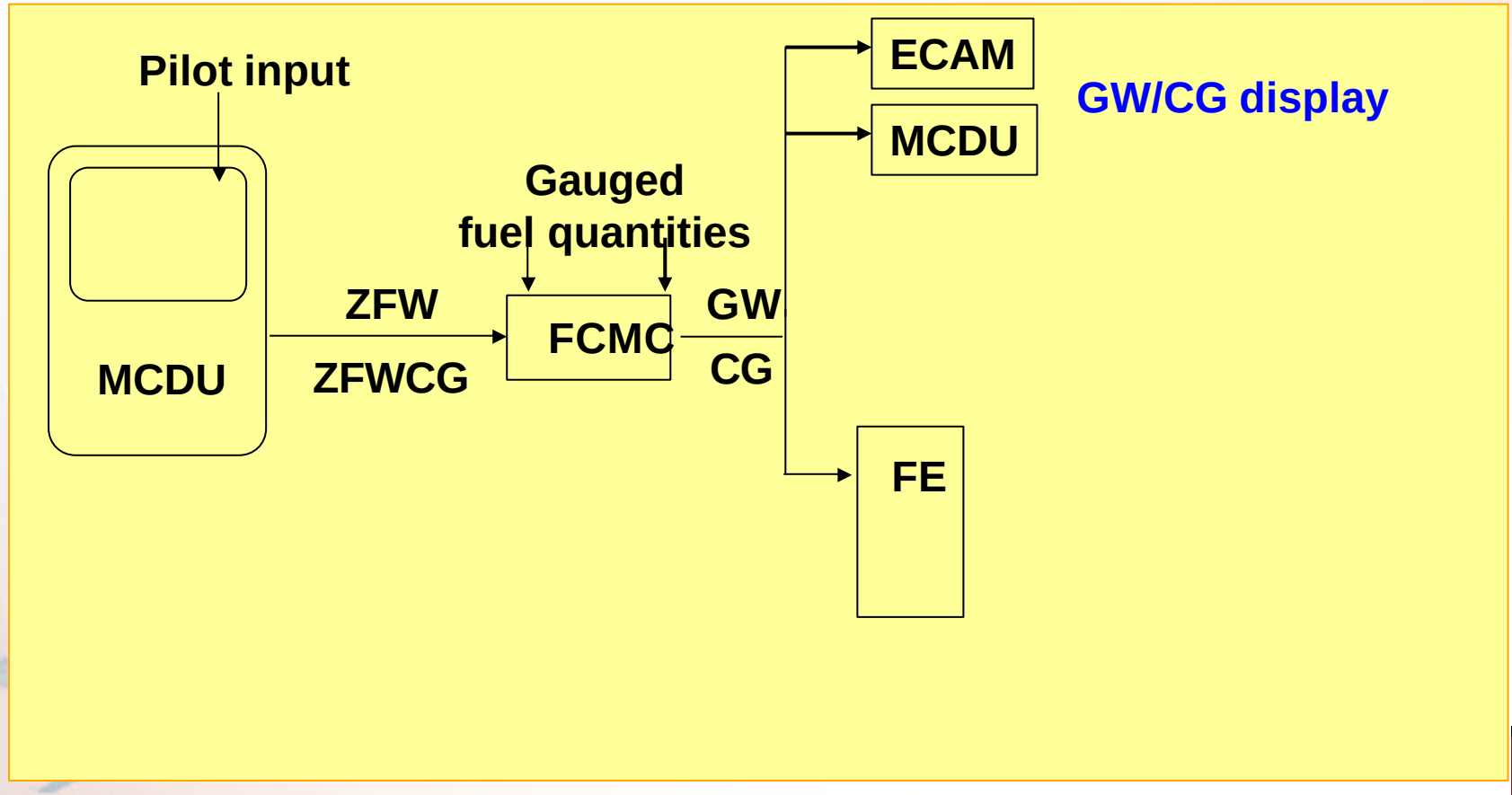
LR: FCMC/FE Architecture

- The Fuel Control and Monitoring Computer (FCMC) computes the GW and CG, based on the :
  - Mandatory ZFW and ZFCG entered by the pilot, and
  - The fuel quantities gauged in each individual tank.



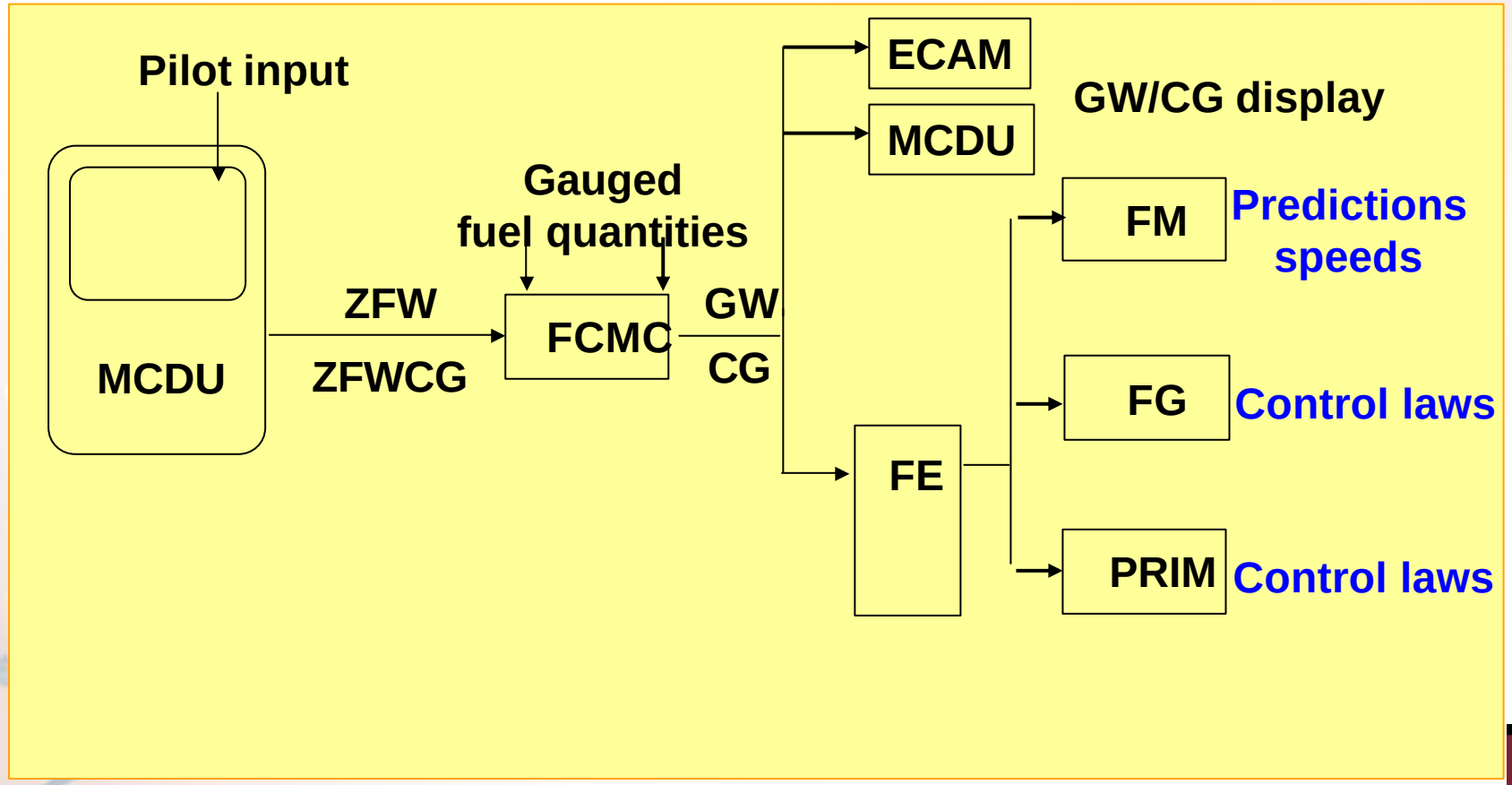
LR: FCMC/FE Architecture …

- The current **GW** and **CG** are displayed on the ECAM.
- They are also displayed on the **MCDU's FUEL PRED** page.
- And transmitted to the **Flight Envelope** (FE).



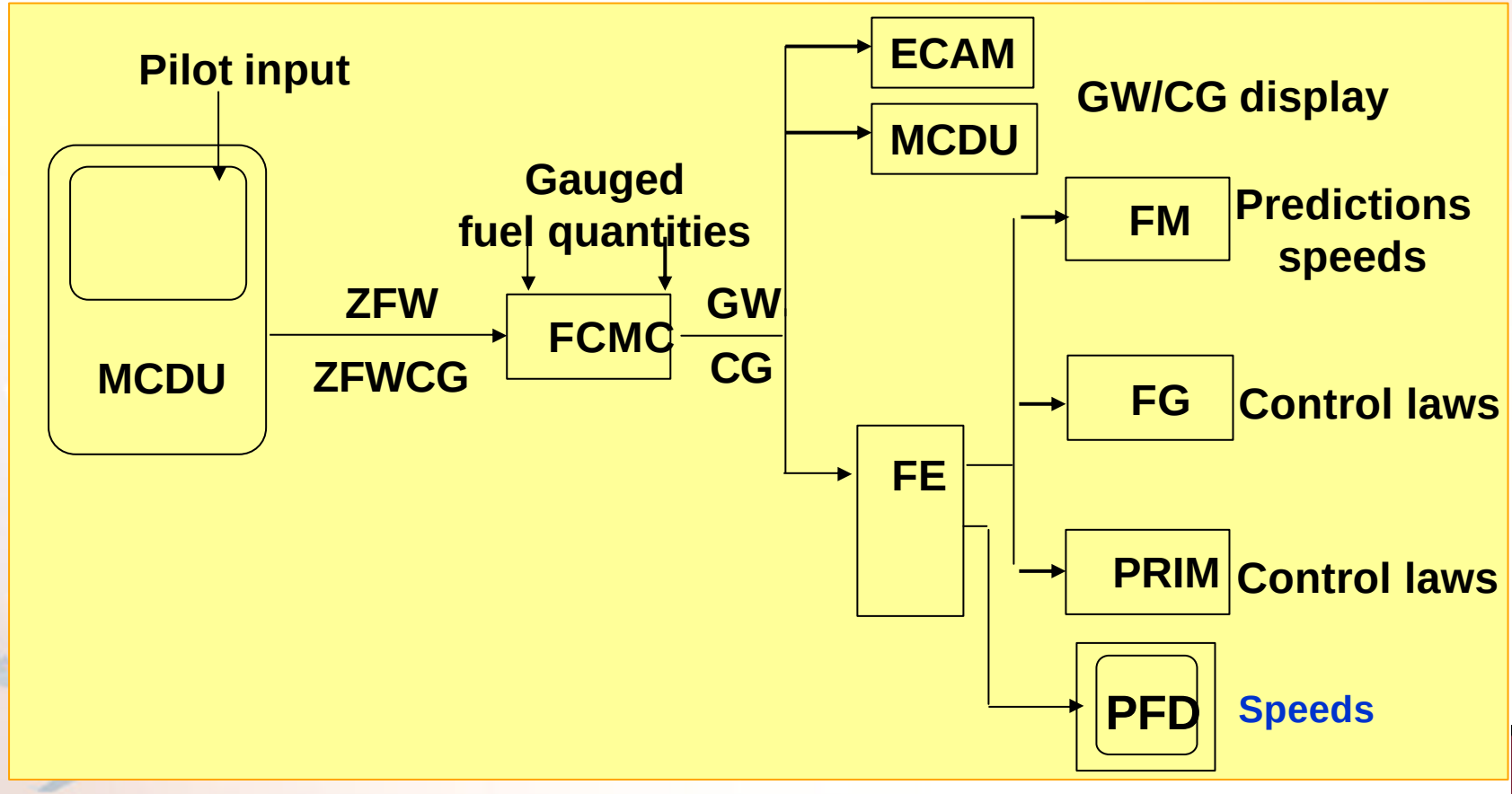
LR: FCMC/FE Architecture …

- The FE transmits the GW and CG, computed by the FCMC, to the FM, PRIM and FG, for a use similar to that of Single-Aisle aircraft.



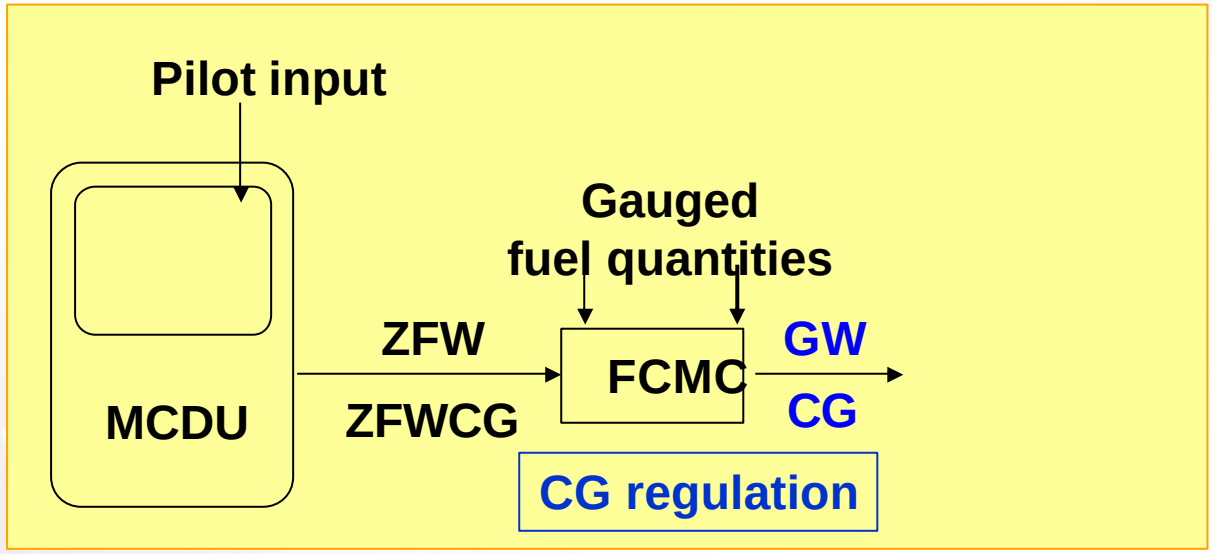
LR: FCMC/FE Architecture …

- The **GW** and **CG** from **FCMC** are also used by the FE for computing the **operating speeds** displayed on the **PFD.**

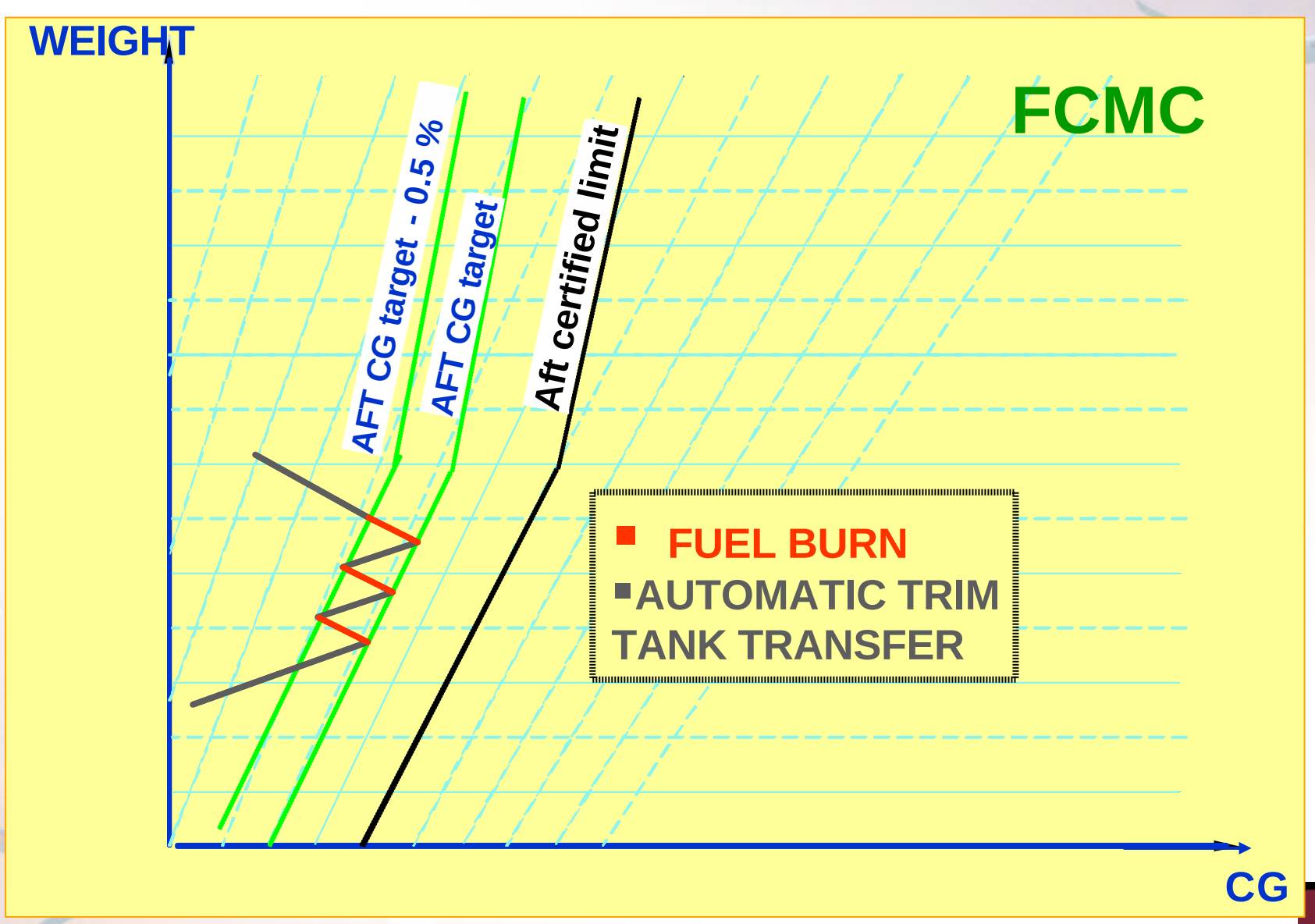


LR: CG Control

- The FCMC also ensures CG control according to the current GW and CG,
- It moves the CG backwards, and maintain the AFT CG target to reduce fuel consumption in cruise.



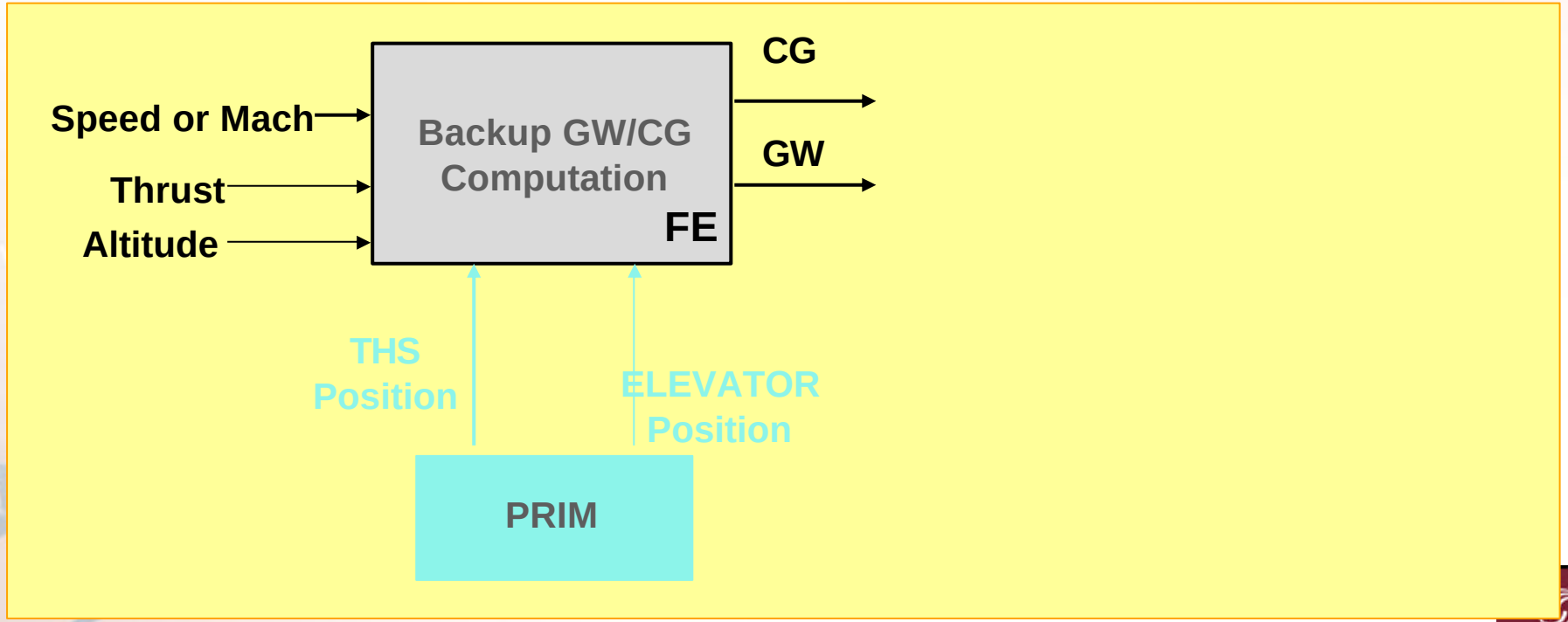
LR: AFT CG Target



LR: FE's Backup GW and CG

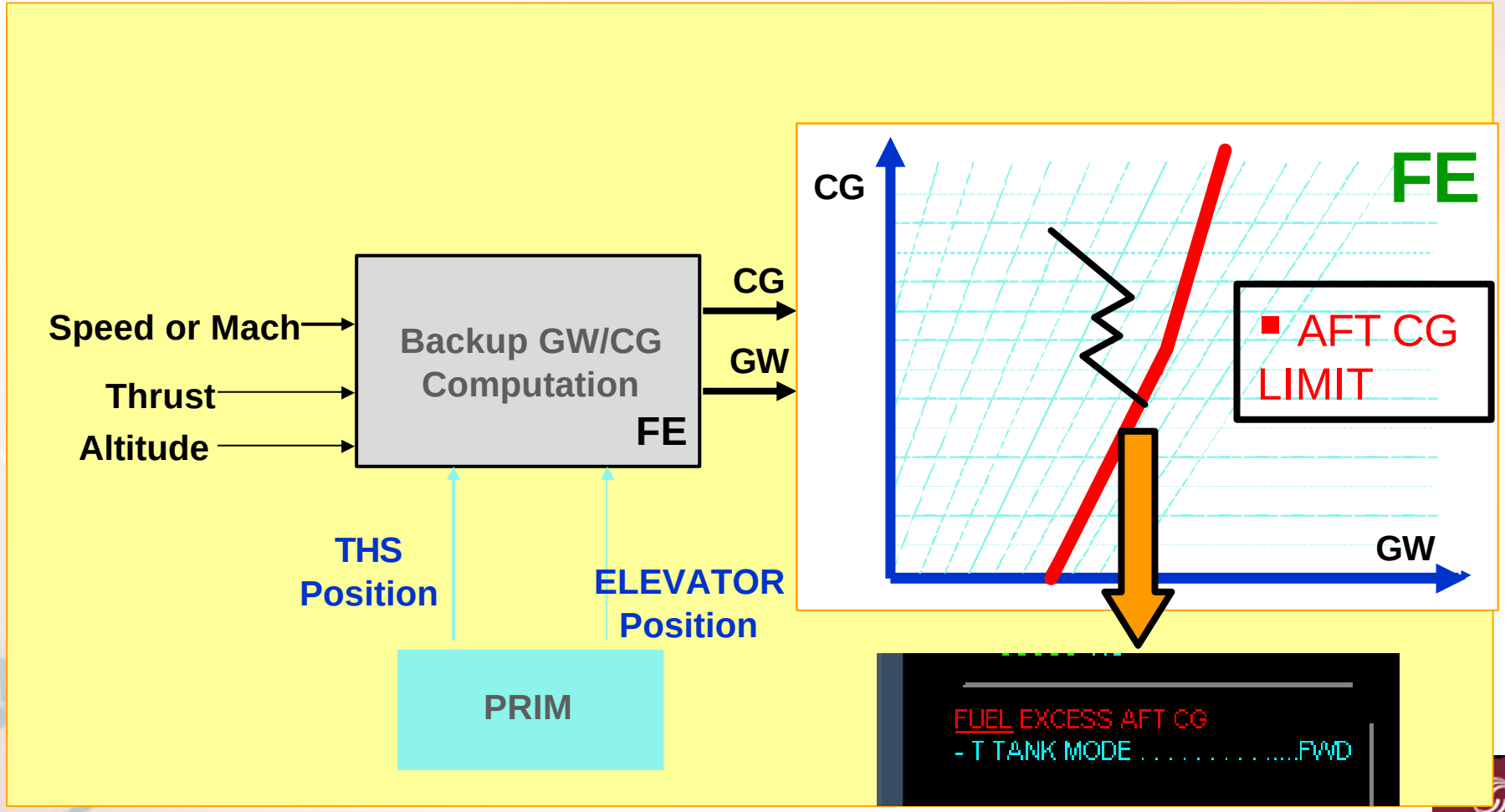
- A backup CG, along with the backup GW, are computed by the FE from aerodynamic data.

- It is used by the FM, FG and PRIMs, in case of a dual FCMC GW/CG failure.



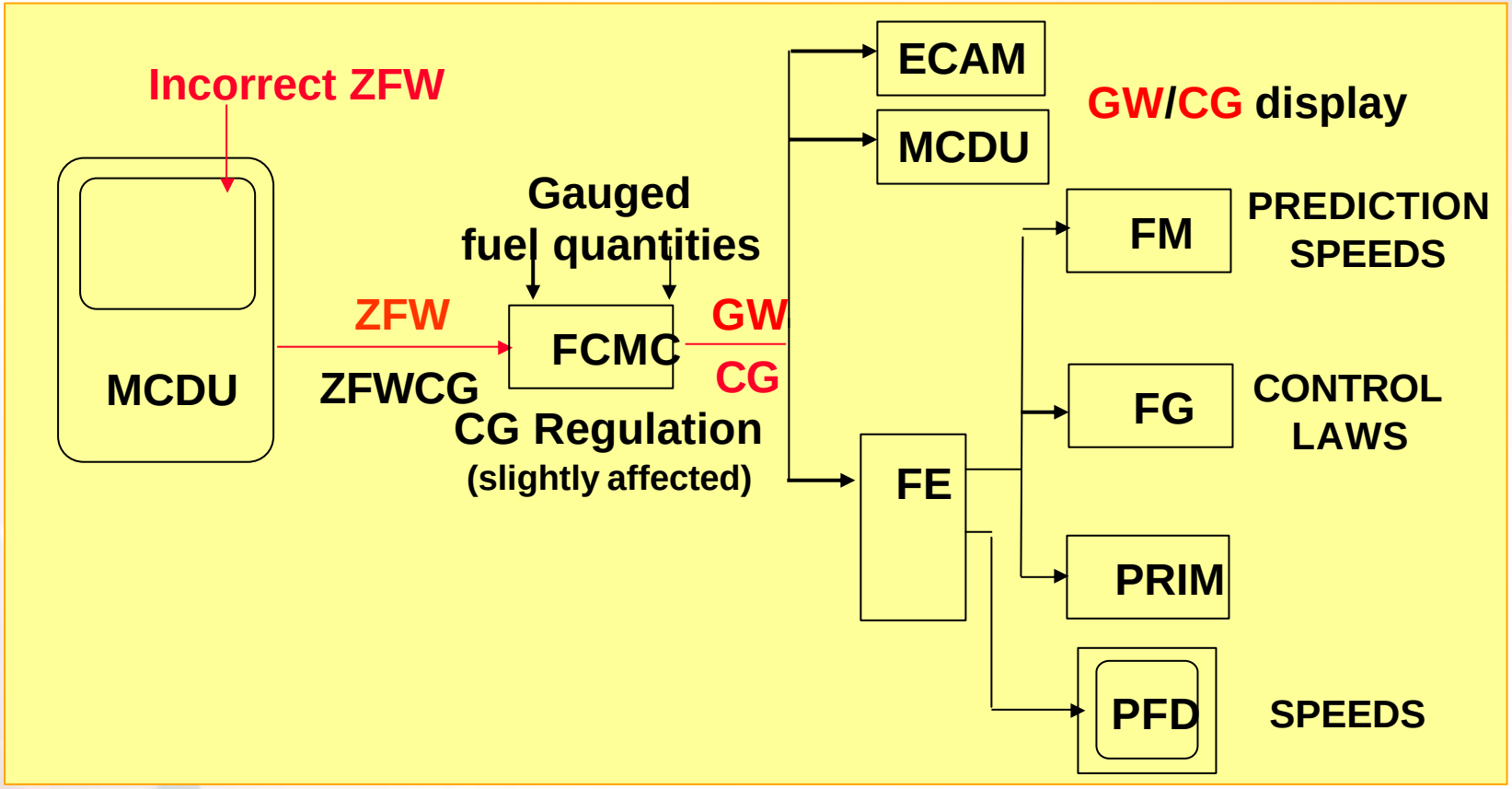
LR: EXCESS AFT CG Warning

- An **EXCESS AFT CG** warning is also generated **independently** from the CG computed by FCMC, in order to limit the AFT CG.



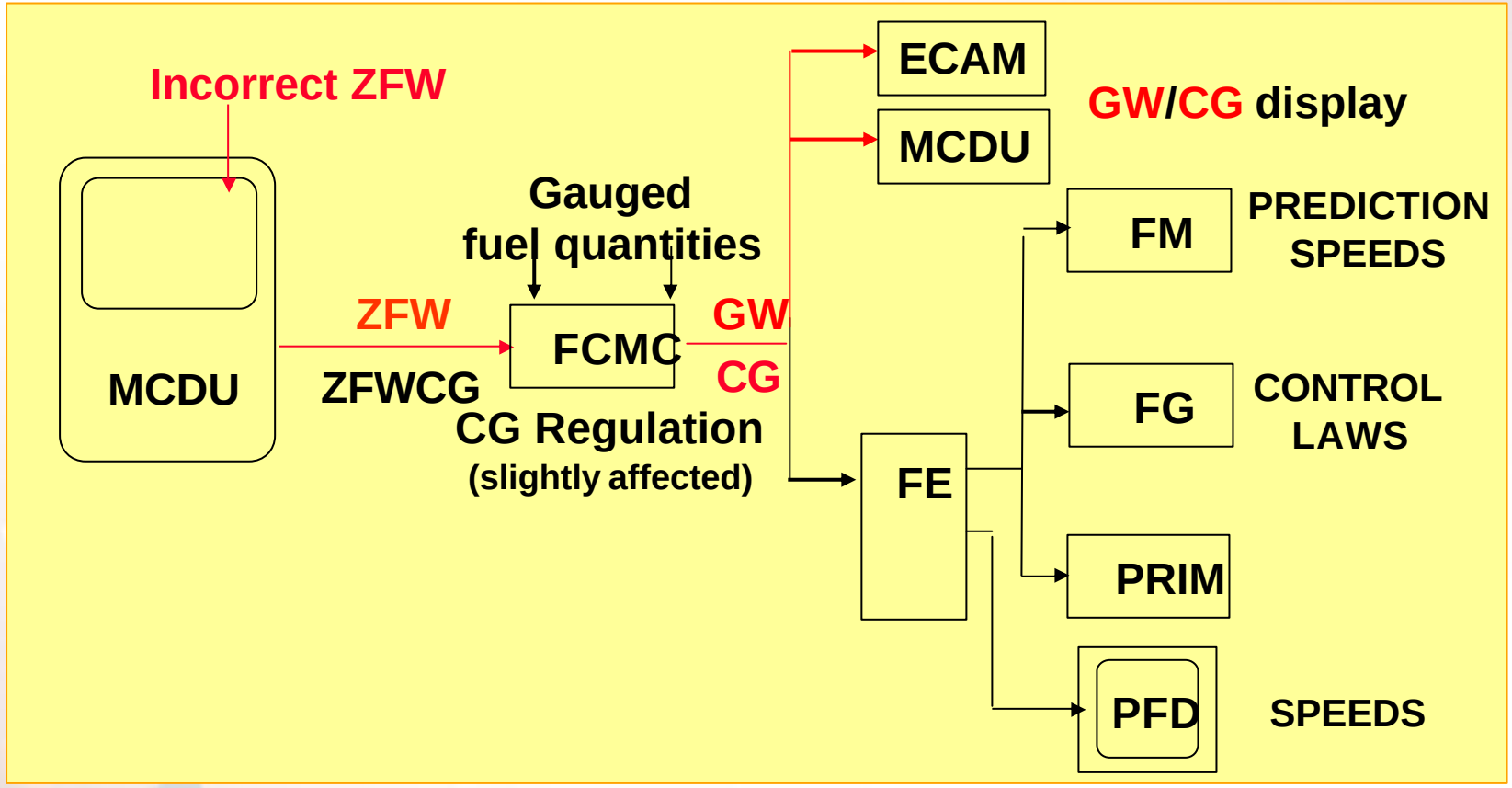
LR: If Incorrect ZFW Entered

- The GW that is computed by the FCMC is incorrect.
- The CG that is computed by the FCMC is also incorrect.



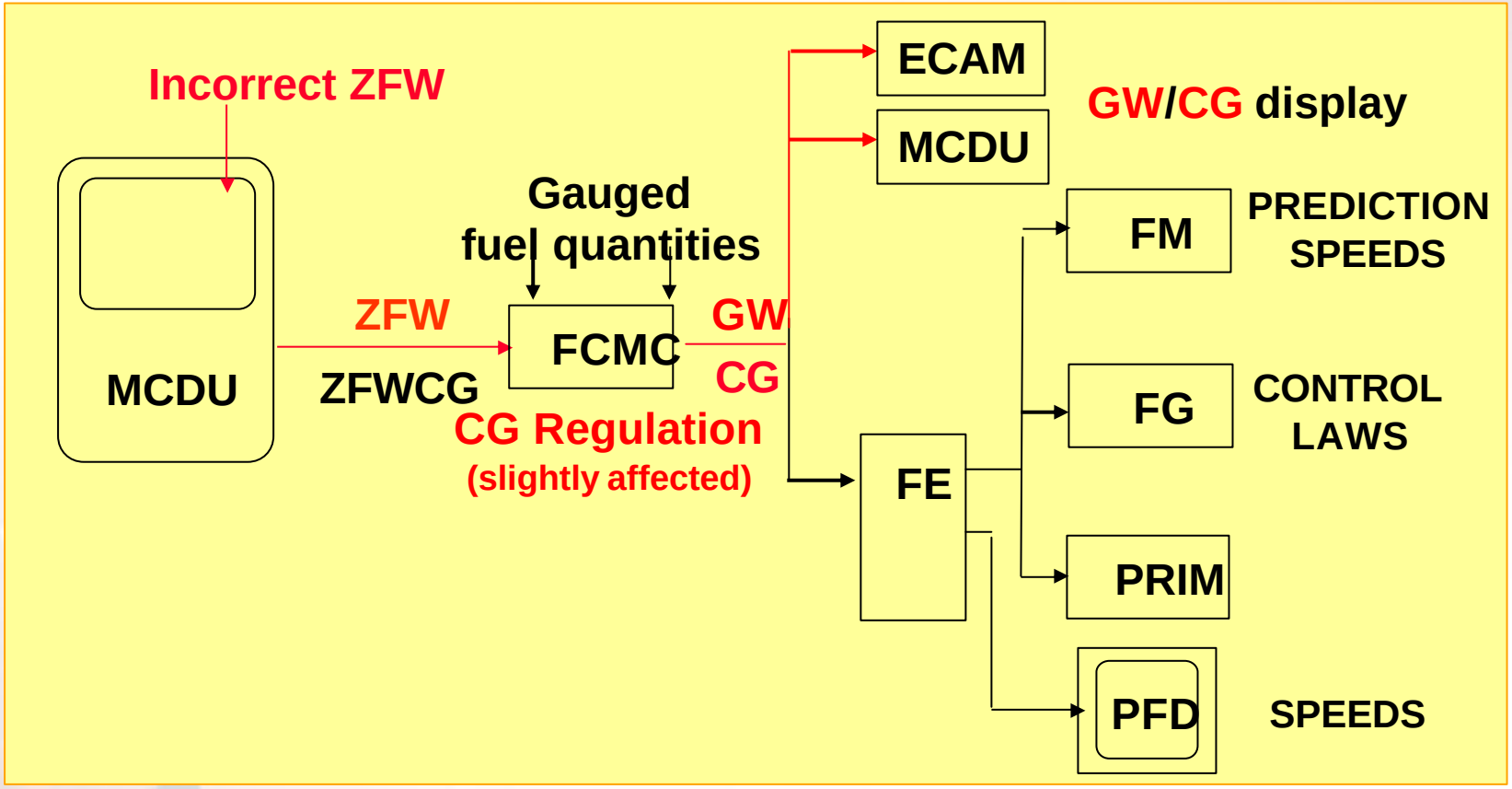
LR: If Incorrect ZFW Entered…

The GW and CG displayed on ECAM/MCDU are incorrect.



LR: If Incorrect ZFW Entered …

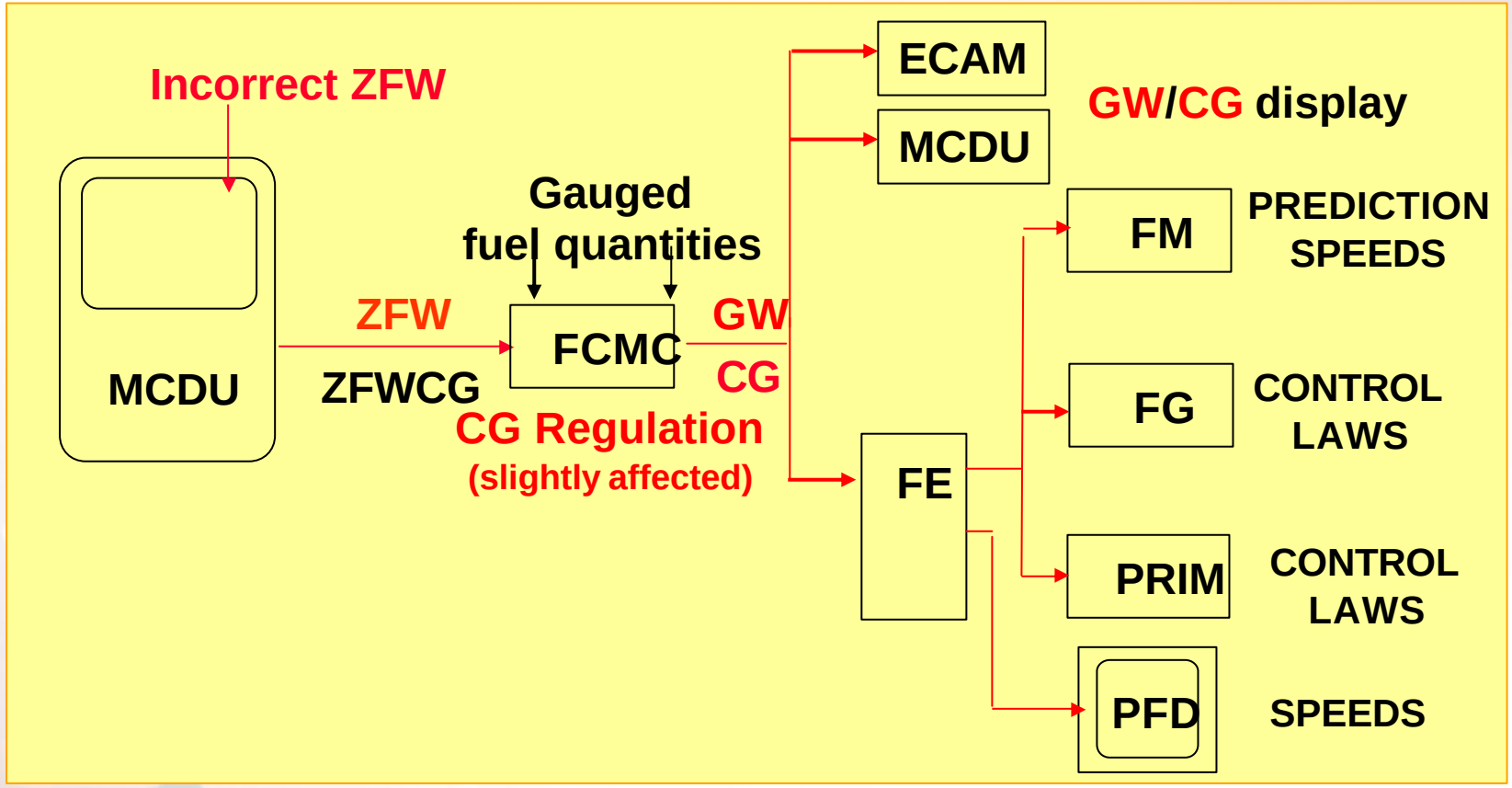
The CG regulation is slightly affected, since the AFT CG target depends on the weight.



But, the "EXCESS AFT CG" warning is not affected.

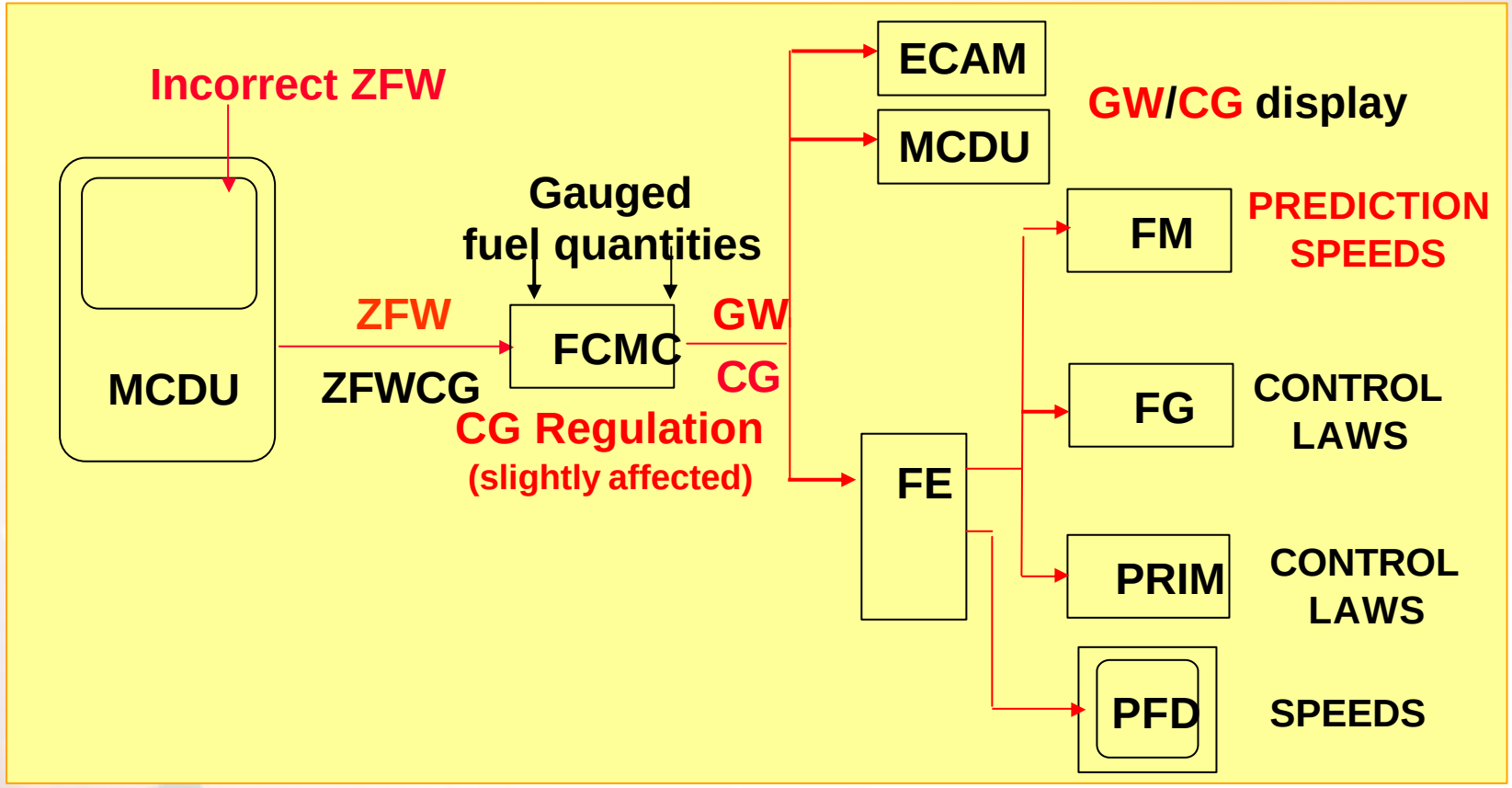
LR: If Incorrect ZFW Entered …

The incorrect GW and CG are transmitted by the FE to the FM, FG and PRIM.



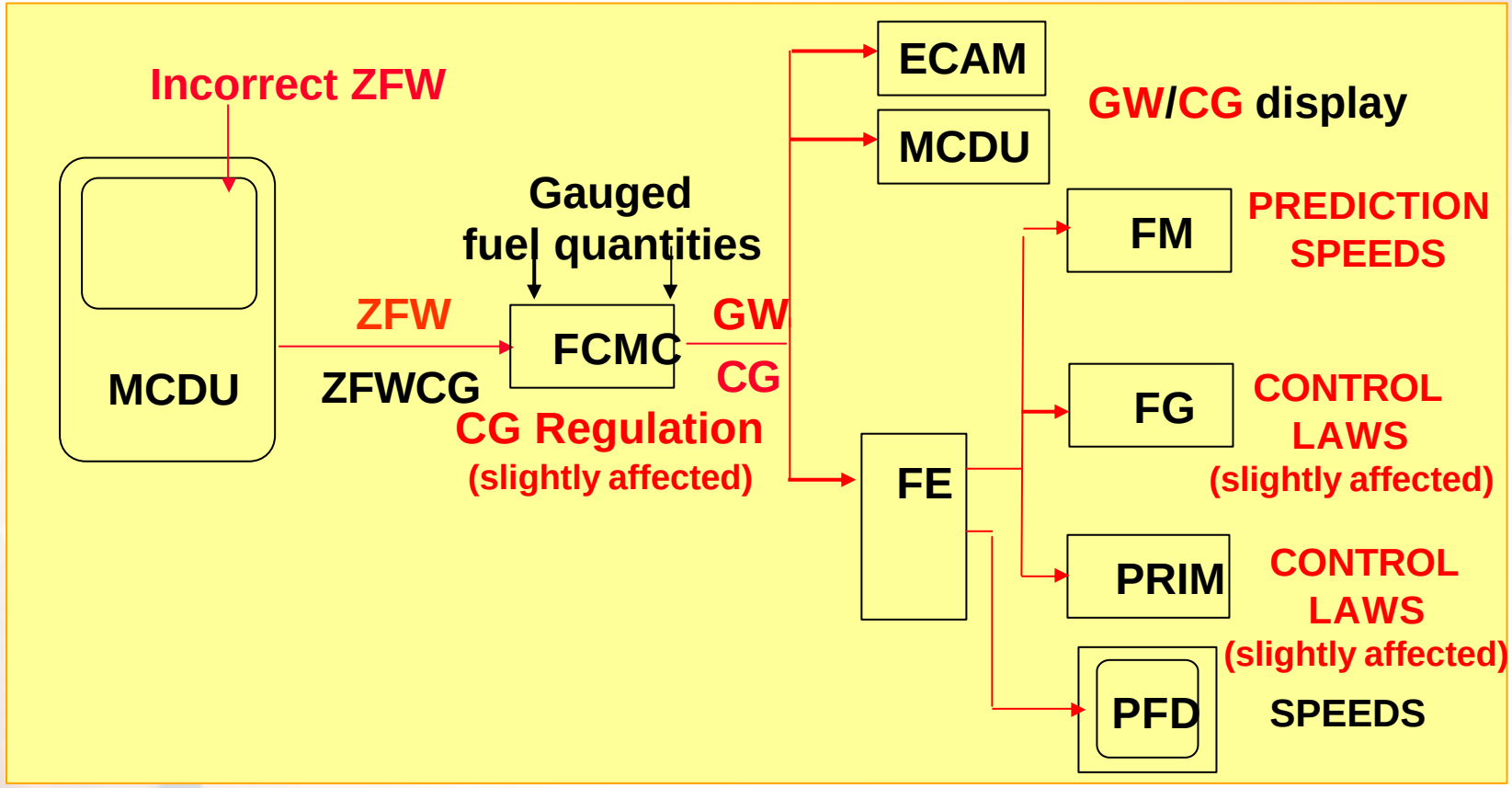
LR: If Incorrect ZFW Entered …

The FM predictions/speeds will be affected …



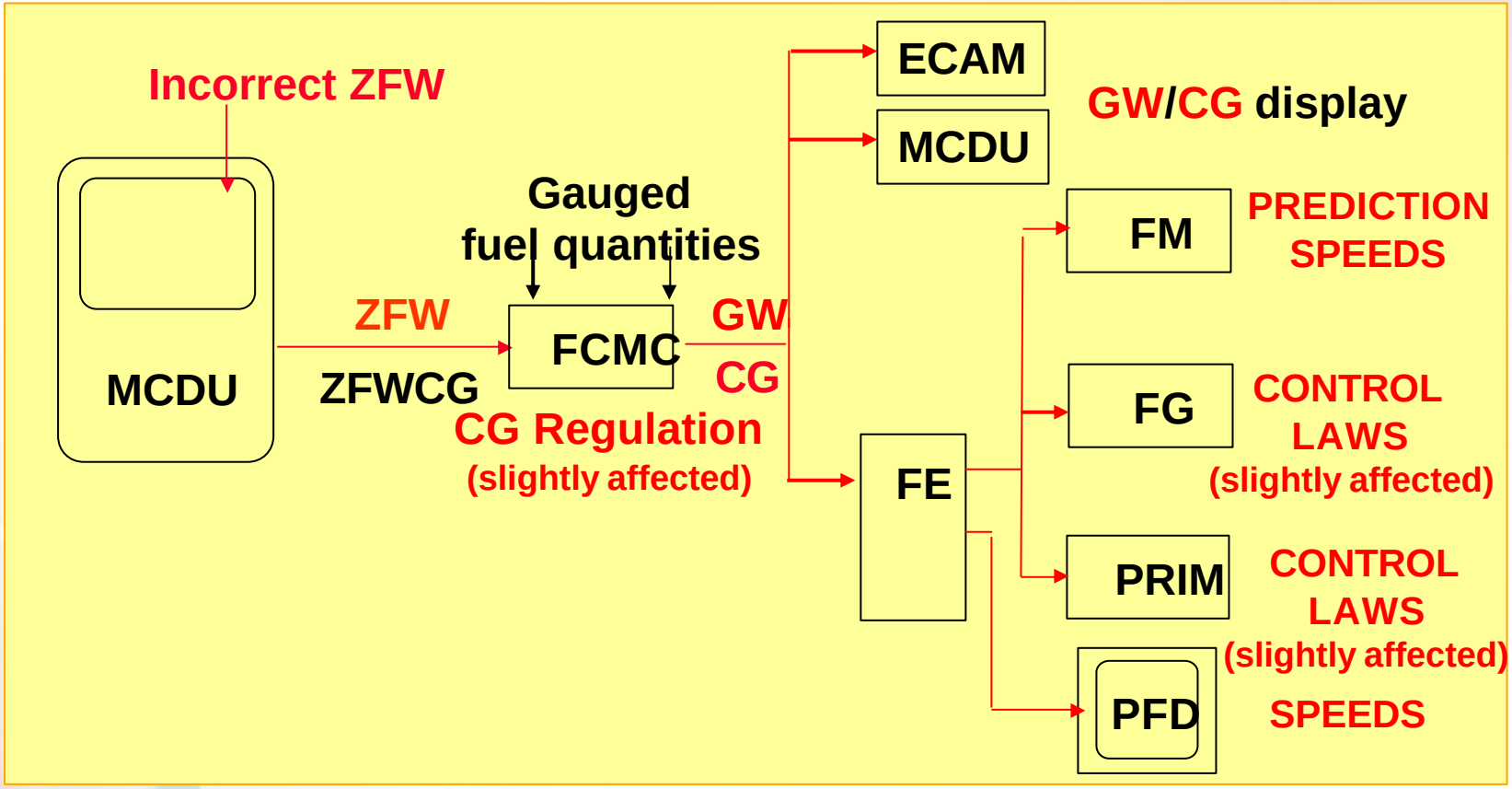
LR: If Incorrect ZFW Entered …

The FG and PRIM control laws are slightly affected.



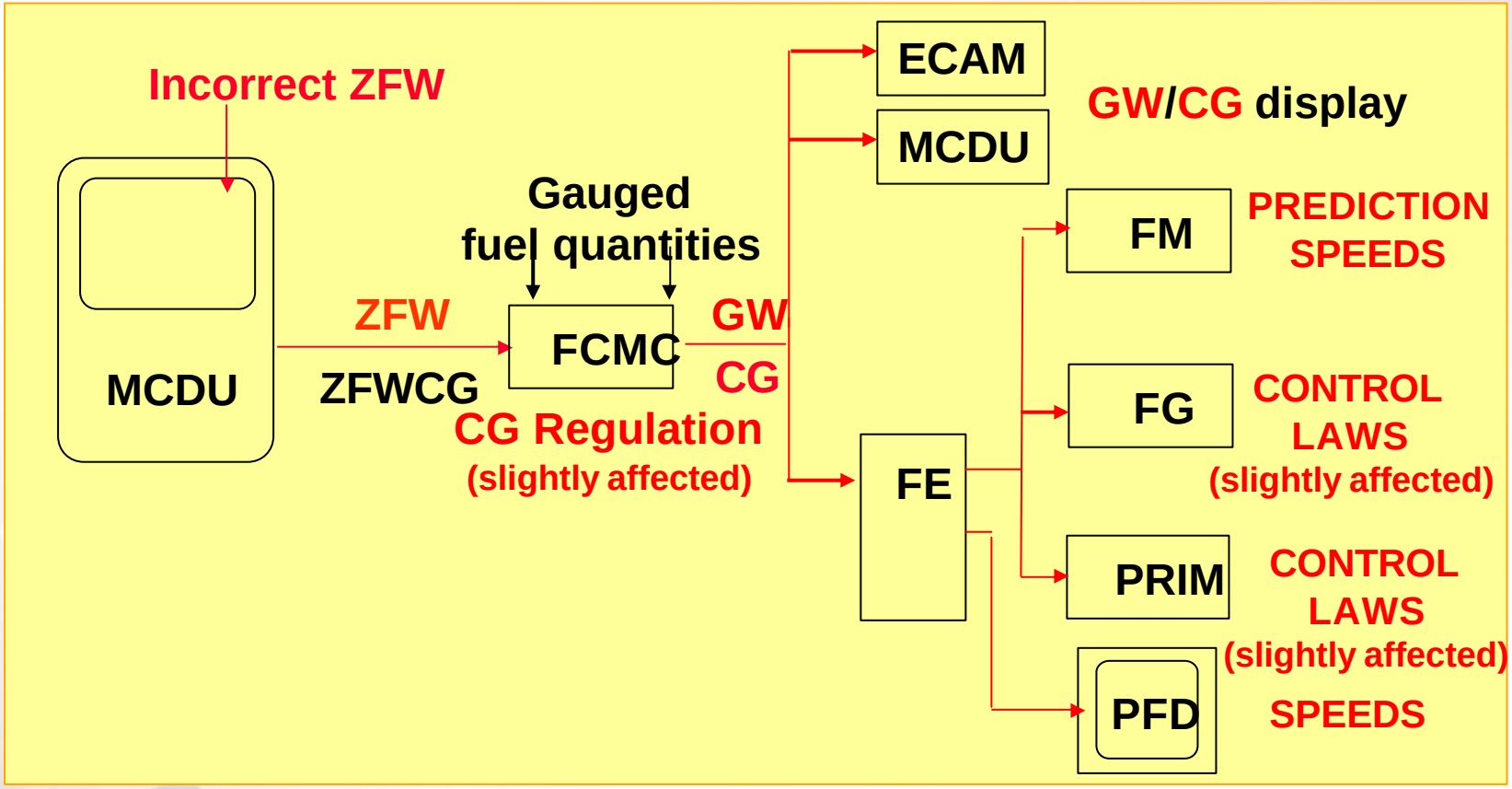
LR: If Incorrect ZFW Entered …

Vls, F, S, and green dot displayed on the PFD are affected.



LR: If Incorrect ZFW Entered …

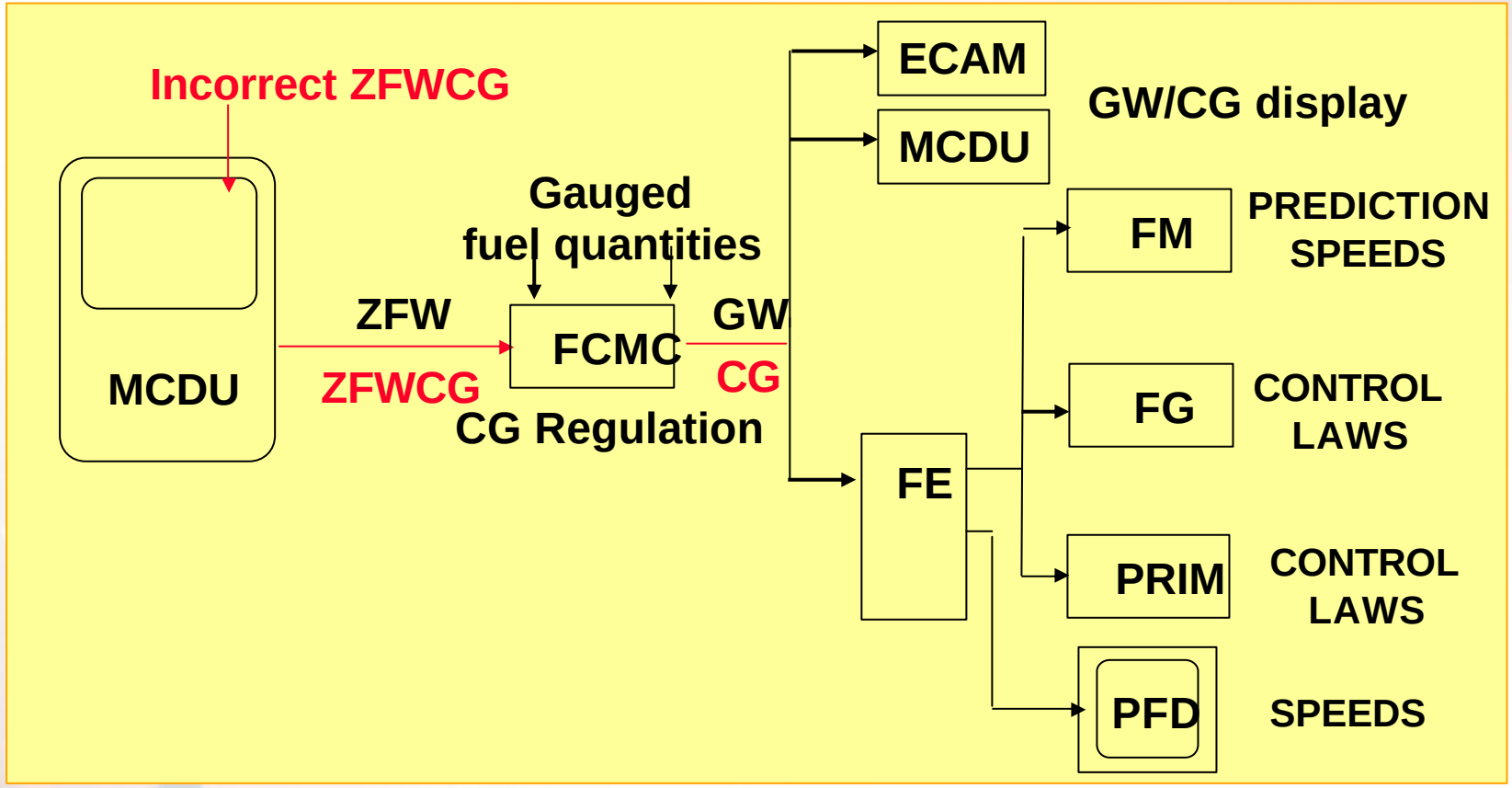
Vls, F, S, and green dot displayed on the PFD are affected.



But V_{aPROT}, V_{aMAX} and V_{SW} are not affected since based on aerodynamic data.

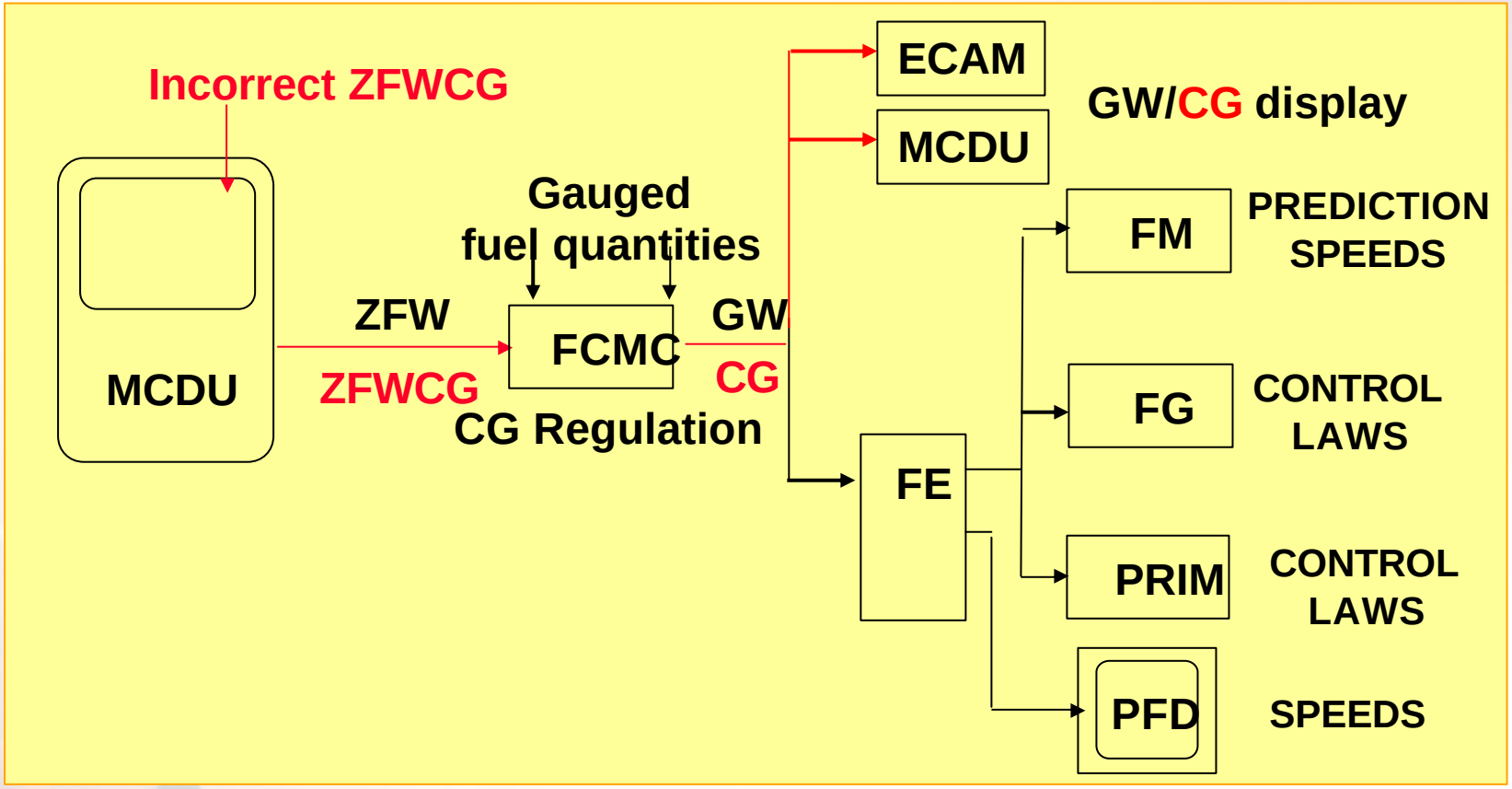
LR: If Incorrect ZFWCG Entered

The CG computed by the FCMC is incorrect.



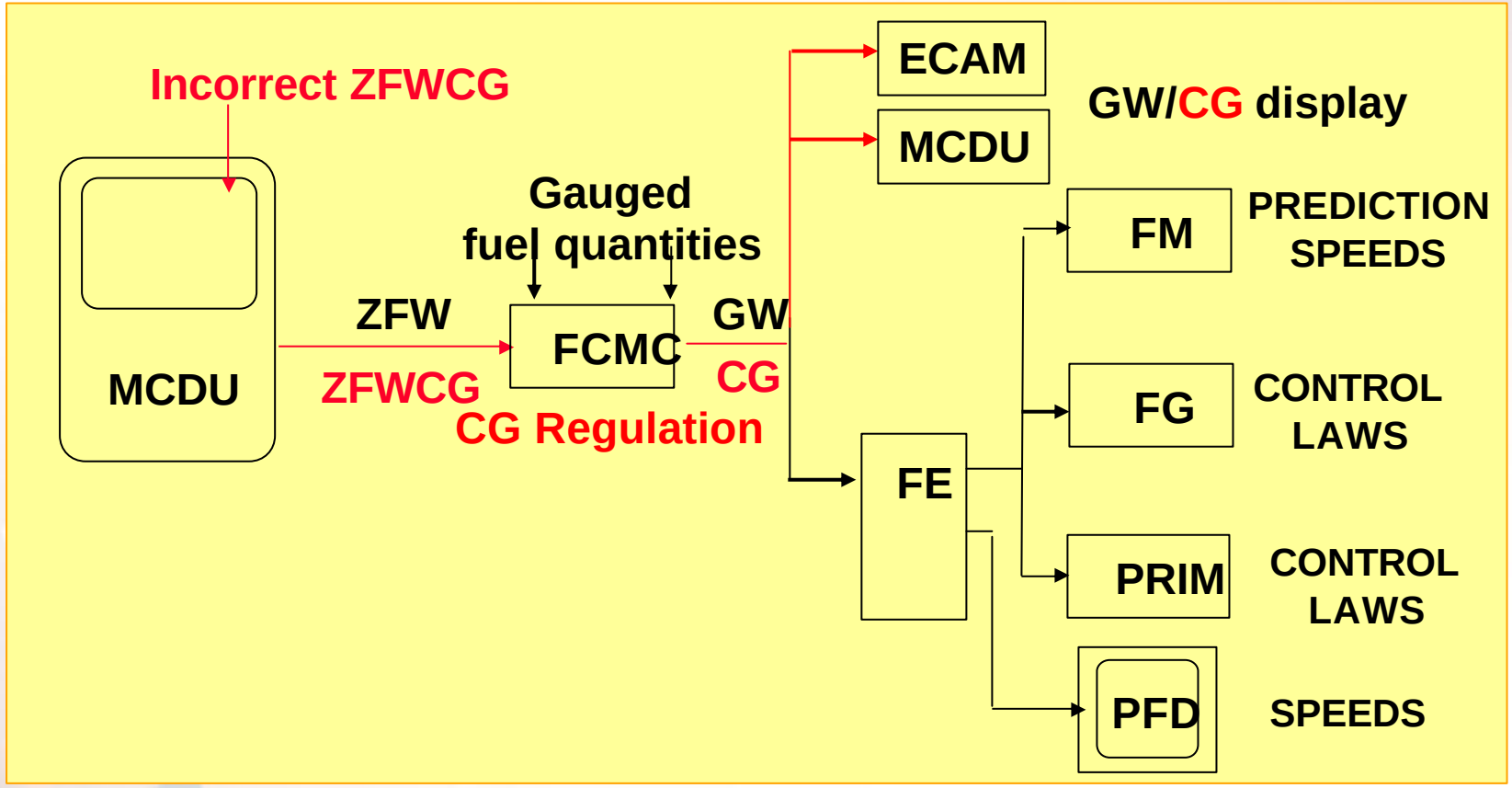
LR: If Incorrect ZFWCG Entered …

Incorrect CG is displayed on the ECAM / MCDU.



LR: If Incorrect ZFWCG Entered …

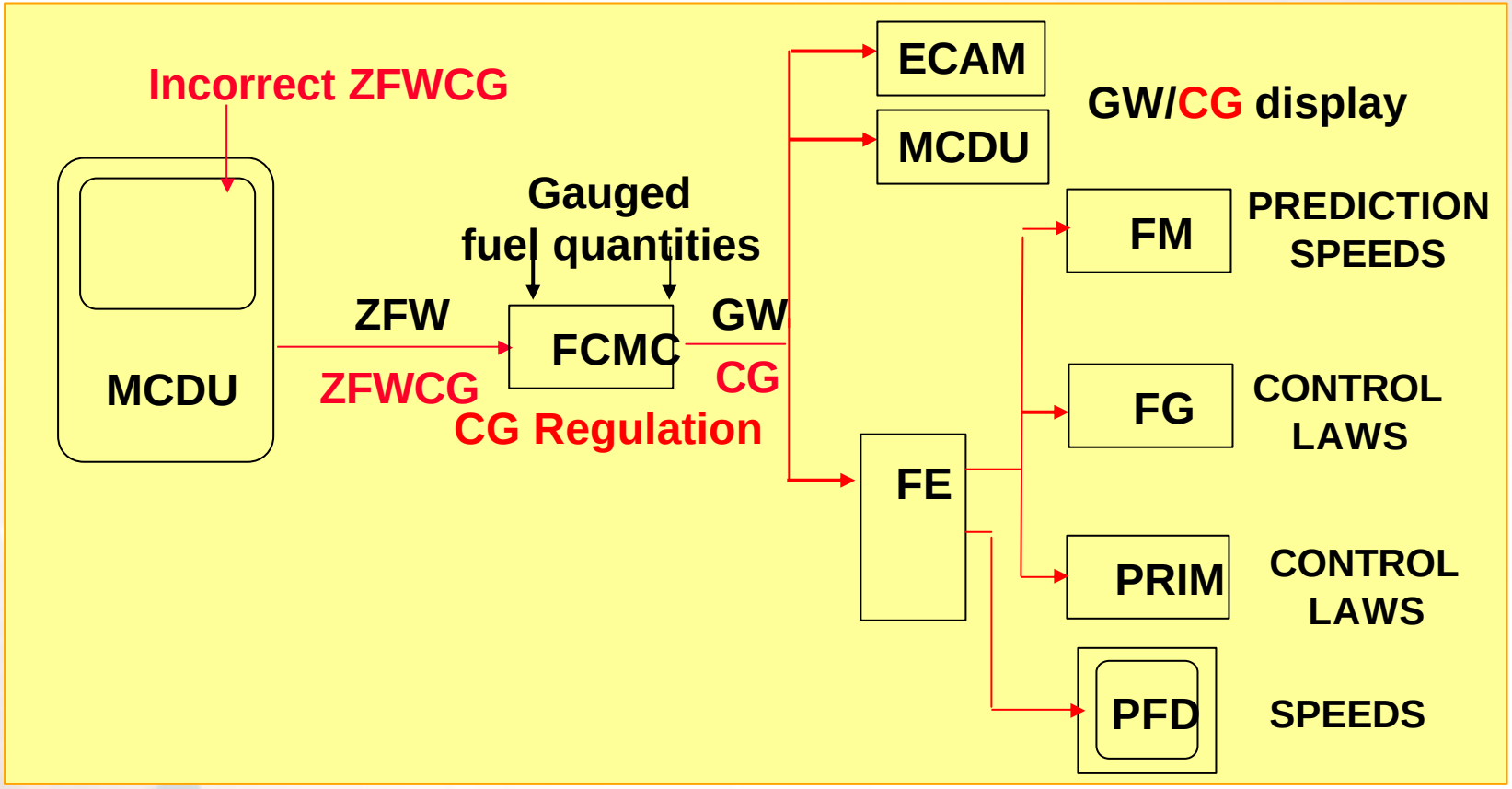
CG regulation may be affected.



But the "EXCESS AFT CG" warning is not affected

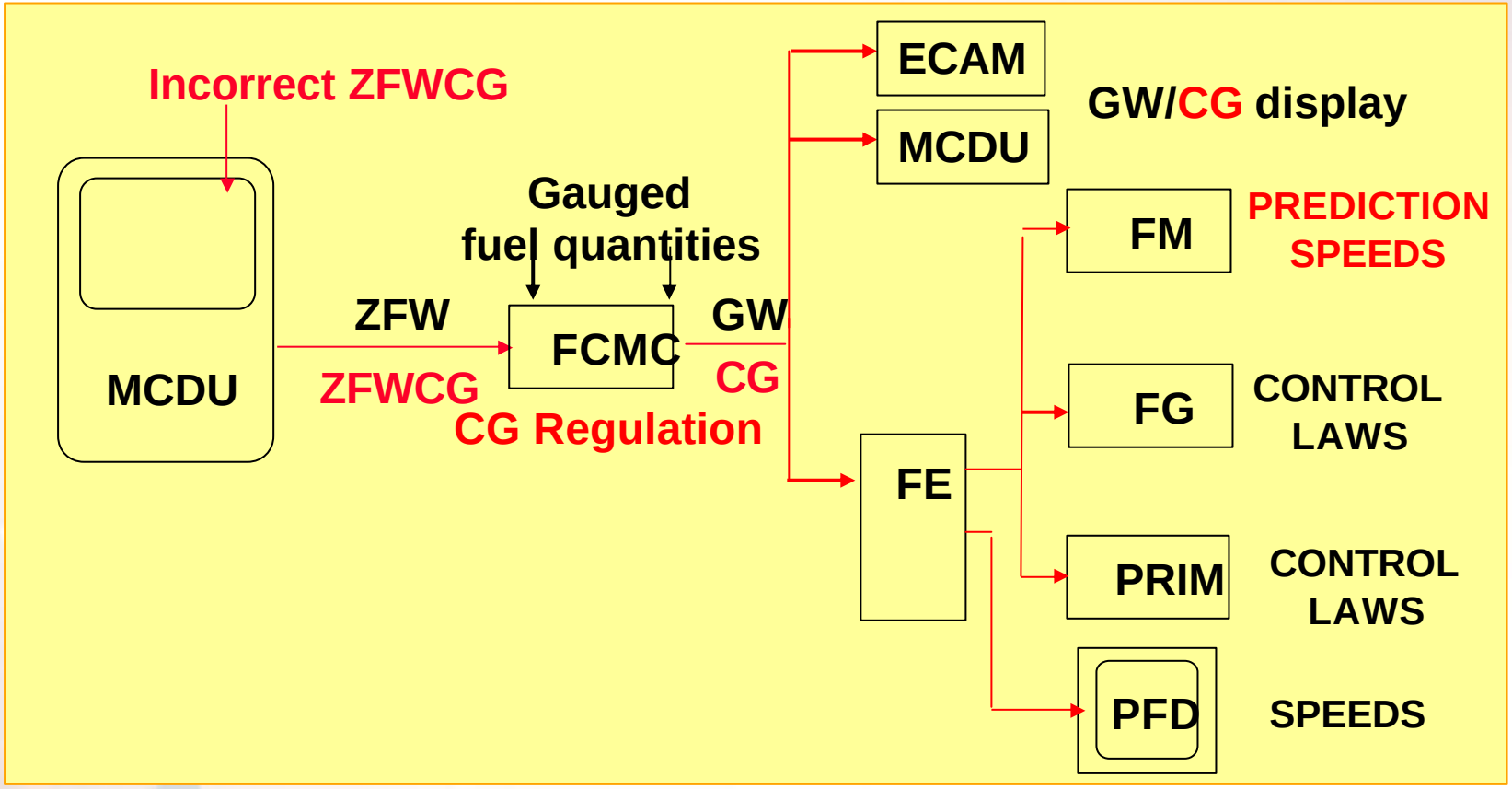
LR: If Incorrect ZFWCG Entered …

The incorrect CG is transmitted by the FE to the FM, FG, PRIM and PFD.



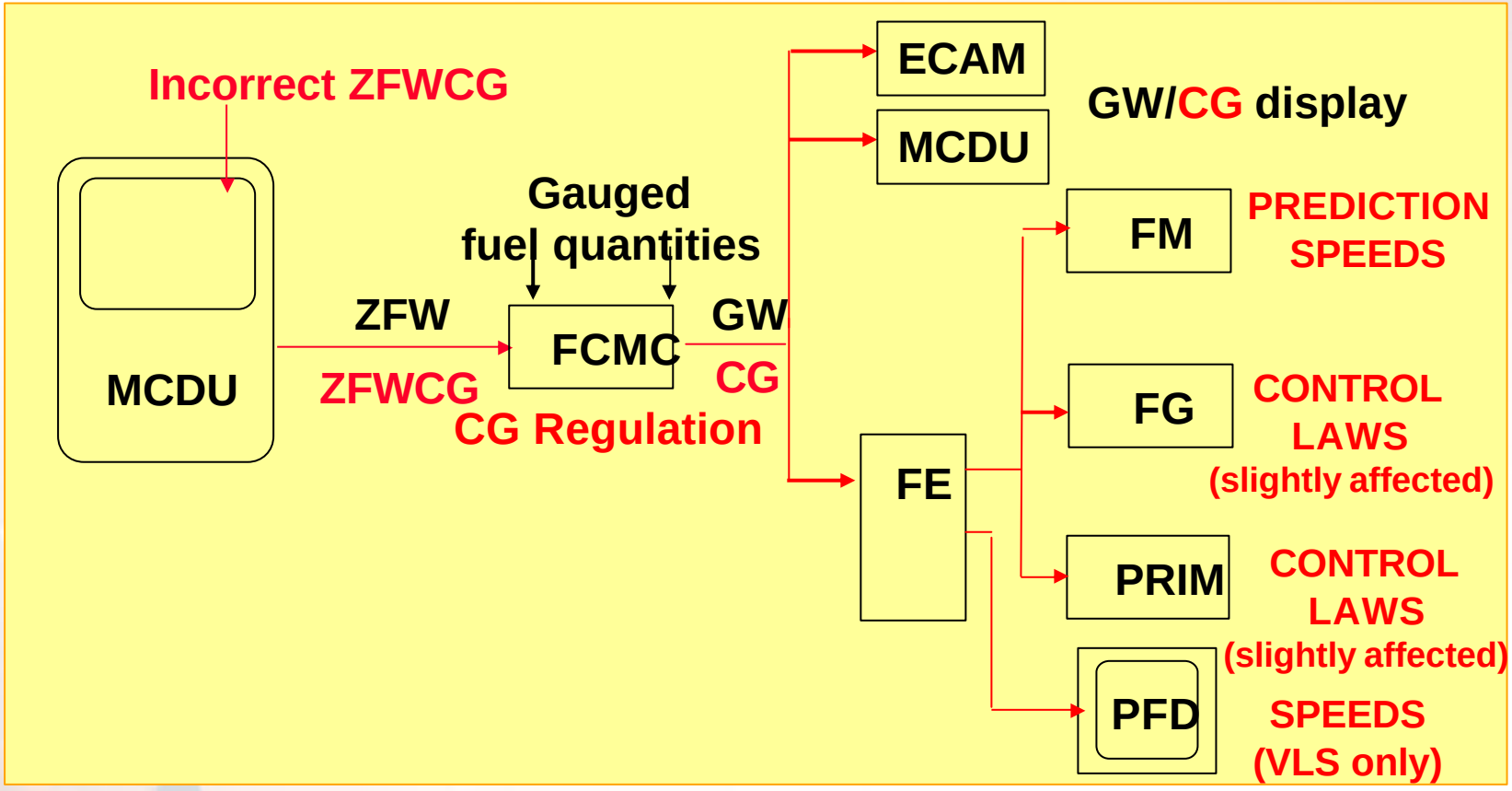
LR: If Incorrect ZFWCG Entered …

FM Predictions and speeds will be impacted..



LR: If Incorrect ZFWCG Entered …

- FG and PRIM control laws are slightly affected.
- VLS displayed on PFD is impacted.



But V_{aPROT}, V_{aMAX} and V_{SW} are not affected since based on aerodynamic data.

LR: If Incorrect ZFWCG Entered …

- **As with SA aircraft, the correct CG is not accessible:**

  – **The pilot has no access to the FE value (It is never displayed on the ECAM).**

  – **In flight, the THS position is not representative of the current CG (depends on Mach, weight, altitude):**

In flight, the THS position does not enable the CG to be determined.

Airbus Recommendations

Airbus Recommendations

FLIGHT PREPARATION

- **LTS ZFW and ZFCG must be computed CAREFULLY.**

- **Incorrect ZFW and ZFWCG computation:**
  - **May significantly affect predictions and speeds…**
  - **May significantly affect V1, V2, and VR computation.**

The only way for the crew to check ZFW, ZFCG, V1, V2, VR is EXPERIENCE…

Airbus Recommendations…

Cockpit Preparation (All FBW)

- **ZFW and ZFCG must be entered/ checked CAREFULLY…**

*** FMGS DATA INSERTION**

LR FCOM 3.03.06

GROSS WEIGHT INSERTION (INIT B page) :

***– ZFCG/ZFW . . . . . INSERT**

***– BLOCK FUEL . . . . . INSERT**

CAUTION

Part of characteristic speeds displayed on PFD (green dot, F, S, VLS) are computed from the ZFW and ZFCG entered by the crew on the MCDU. Therefore these data must be carefully checked (captain responsibility).

Airbus Recommendations …

Before Pushback, or Start,
when the final LTS is available (All FBW):

- **Check the final ZFW / ZFCG with the previously-entered data (FCOM 3.03.07)**

- **Always check that TOCG is within the LTS operational limits, not the certified limits:**

  - **The Operational limits** include tolerance on cargo loading and passenger distribution

  - **The certified limits** take no margin.

Airbus Recommendations …

- **For the A330/A340**

  - **A discrepancy between the LTS CG and the ECAM CG may occur since:**

    – **The LTS Fuel distribution is based on standard refuel distribution.**

    – **Manual refueling with non standard distribution may inadvertently be performed.**

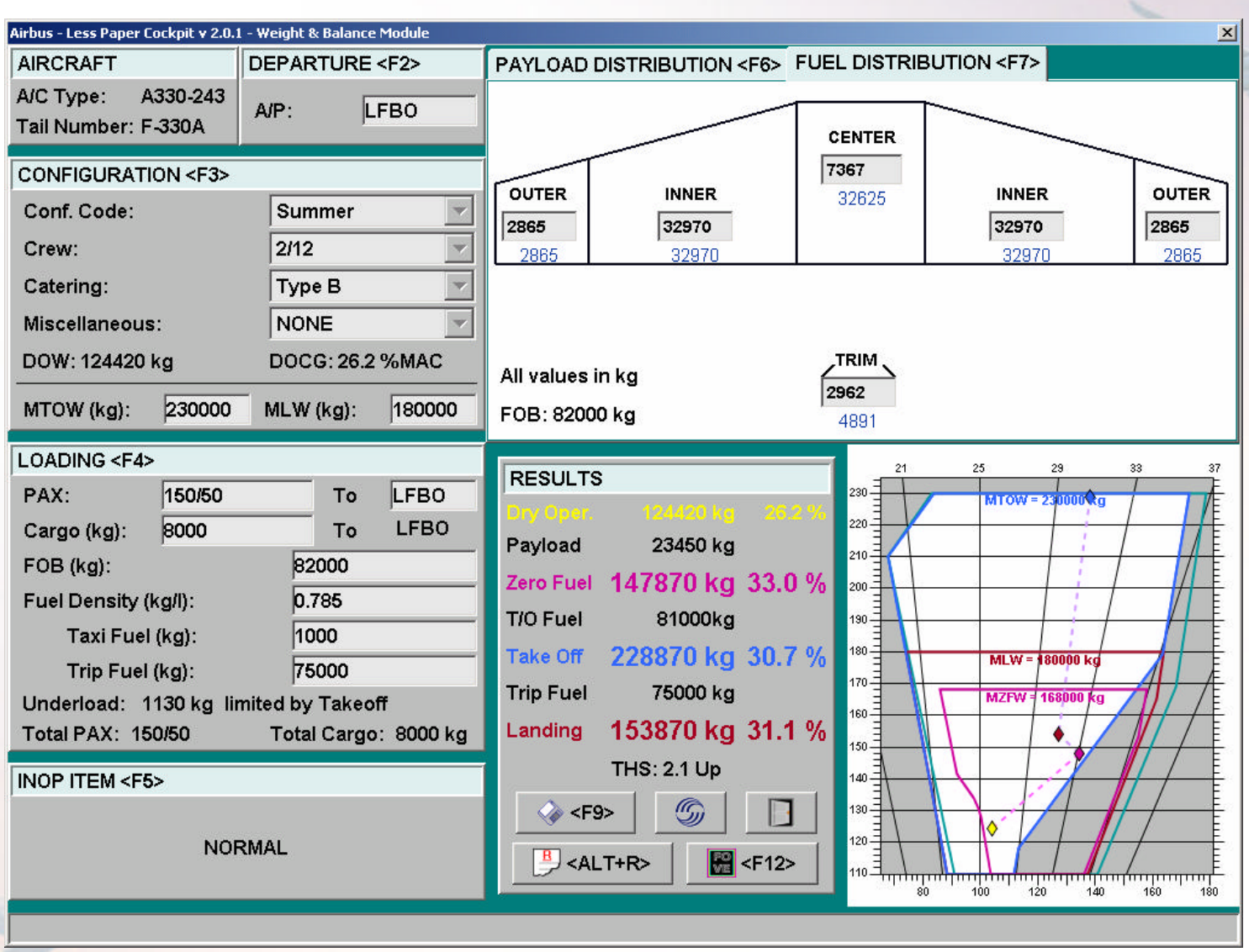
Airbus Recommendations …

- **For the A330/A340 …**

In case of a greater than 2% discrepancy between the final LTS CG and the ECAM CG:

- **Check that the ZFW / ZFCG have been entered correctly.**
- **If the discrepancy remains, rely on the ECAM CG. BUT, check that it is within the LTS operational limits** (not the certified limits).
- The ECAM CG can also be crosschecked by using the LPC weight and balance module or the FCOM 2 .01.40.

Airbus Recommendations ...



Airbus Recommendations …

- **For the A330/A340 …**

  - **In case of a less than 2% discrepancy between the final LTS CG and the ECAM CG:**

    - **No further action is required.**

    - **BUT, nevertheless, always check that the ECAM CG is within the the LTS operational limits.**

Conclusion

- Predictions and speed computations are impacted by ZFW/ZFWCG.

➔ **On ground:**

- LTS ZFW/ZFWCG should be carefully computed.
- The crew should carefully check these values and that TOCG is within the operational limits.

➔ **However, in flight:**

- GW/CG is also computed independently from these values:
  - a GW crosscheck is available in flight (SA family)
  - a CG crosscheck is available in flight (LR family)
- Protection speeds are not impacted by ZFW and ZFCG entered by the crew.

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WITH BAE SYSTEMS