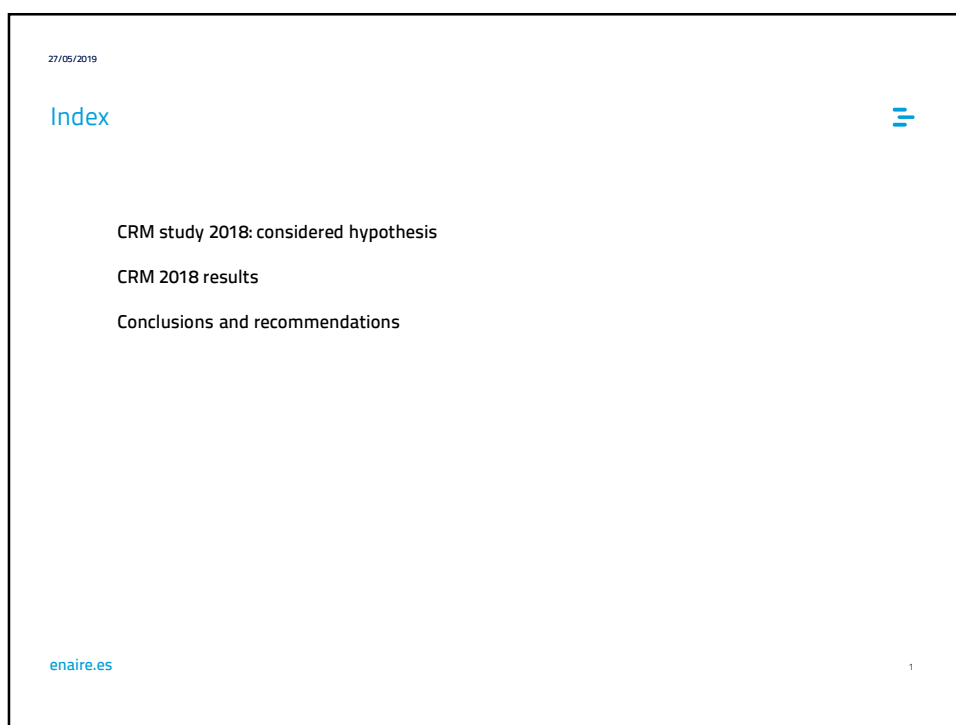
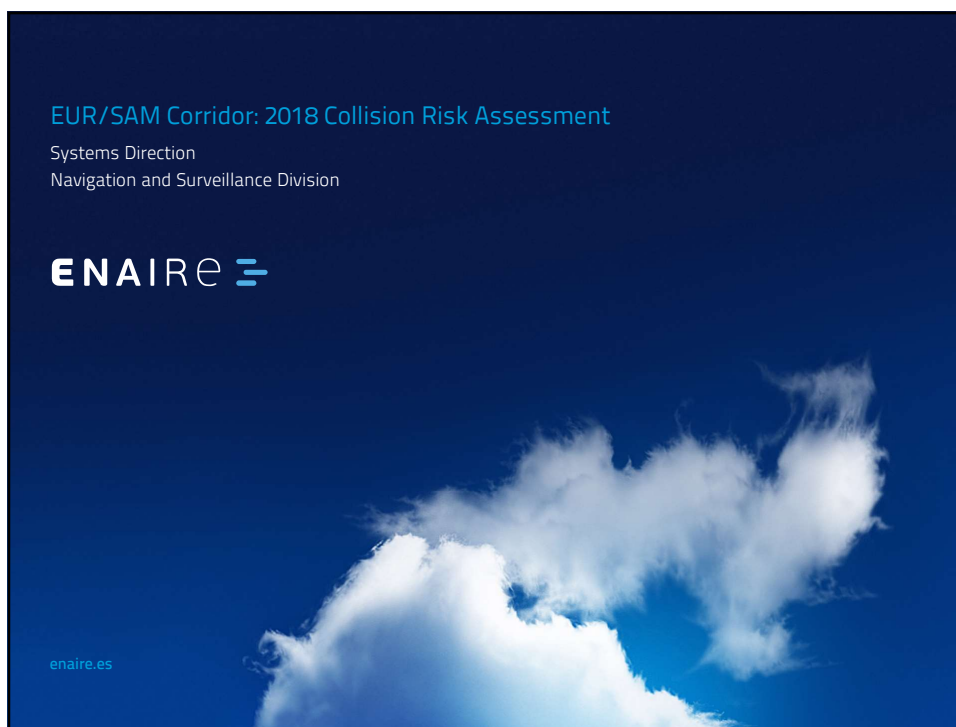




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## Considered hypothesis



- For time flight during 2018, Canaries has been used as a reference.
- Only deviations in nominal routes or incorporating to nominal routes have been considered.
- Only crossing routes with four or more flights per month have been considered.
- Whenever time information in deviations is not known, **five minutes** has been considered.
- $P_z$  obtained from Eurocontrol information:  $P_z(1000)=9.647 \cdot 10^{-13}$
- Traffic growth hypothesis from STATFOR information (February 2019): 3,3%

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## Considered hypothesis. Not published crossing routes. Canaries and SAL. Direct routes

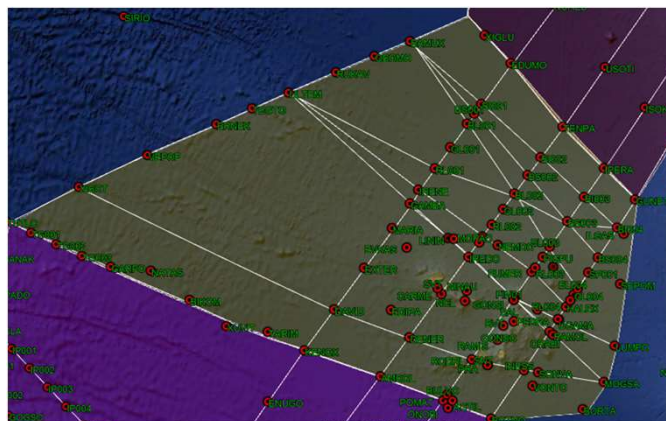


### Canaries

- NORED-ETIBA

### SAL

- BAMUX-LUMPO
- BAMUX-ILGAS
- ULTEM-ILGAS
- ULTEM-LUMPO
- BAMUX-SEPOM
- XIBOT-MOGSA



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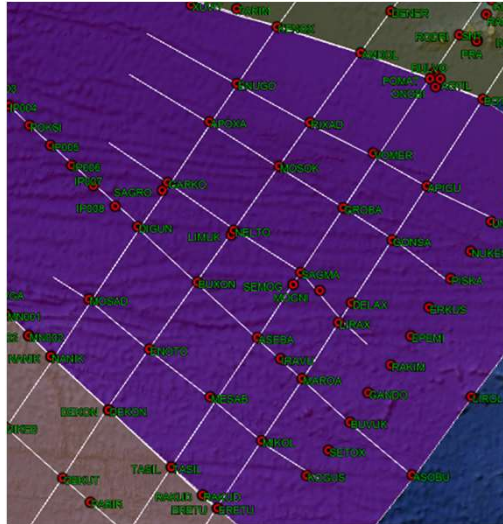
Considered hypothesis. Not published crossing routes. Dakar. Direct routes



#### Dakar

- ENUGO-APIGU
- APOXA-GONSA
- GARKO-LIRAX
- MOSAD-MIKOL

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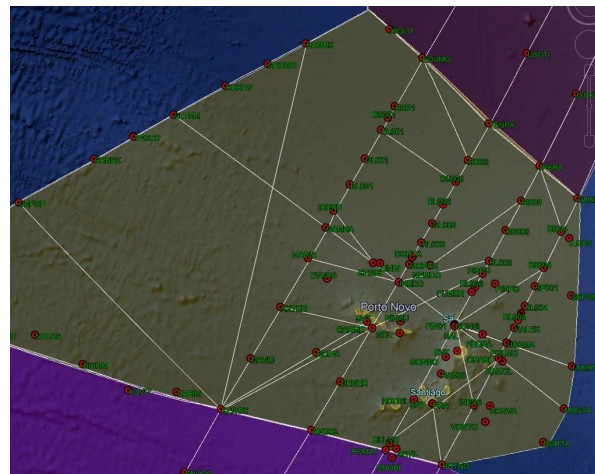
Considered hypothesis. Not published crossing routes. SAL.



#### SAL

- EDUMO-BI002
- BL002-CVS
- NEMDO-BI003
- BL003-IREDO
- IPERA-BI004
- PISPU-CARME
- CVS-BS004
- IRENE-KESIK
- CVS-UGAMA
- BL001-BS002
- MARIA-IREDO
- BOTNO-SNT
- EXTER-CARME
- BAMUX-KENOX
- VEPop-KENOX
- CARME-KENOX
- SVT-KENOX
- ORABI-BULVO
- CVS-INESS

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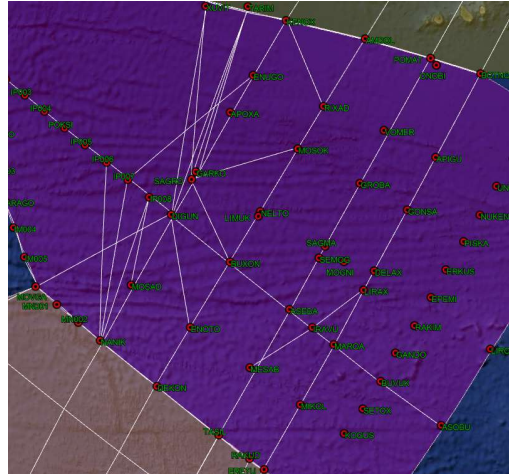
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Considered hypothesis. Not published crossing routes. Dakar.



#### Dakar

- XUVIT-DIGUN
- TARIM-DIGUN
- TARIM-GARKO
- TARIM-SAGRO
- KENOX-RIXAD
- SAGRO-MOSOK
- LIRAX-IRAVU
- SAGRO-BUXON
- XUVIT-SAGRO
- IP006-NANIK
- IP007-NANIK
- IP008-NANIK
- IP008-MOSAD
- ENUGO-IP007
- DIGUN-MOVGA
- ENOTO-DIGUN
- IRAVU-MESAB



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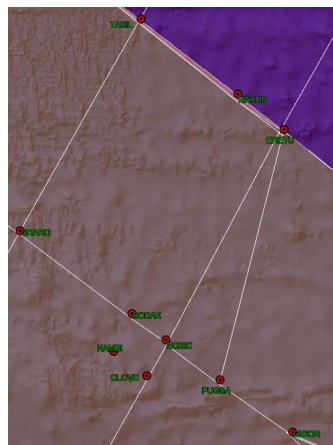
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Considered hypothesis. Not published crossing routes. Recife.



#### Recife

- ERETU-PUGSA



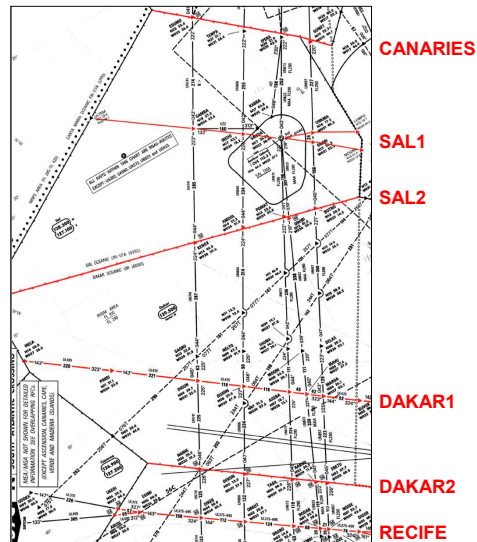
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## 2018 CRM results. Evaluation points

- Canaries: FIR/UIR limit
- SAL1: UR-976/UA-602
- SAL2: UIR SAL Oceanic/UIR Dakar Oceanic
- Dakar1: UL-435
- Dakar2: UIR Dakar Oceanic/Atlantic FIR
- Recife: UL-375/UL-695

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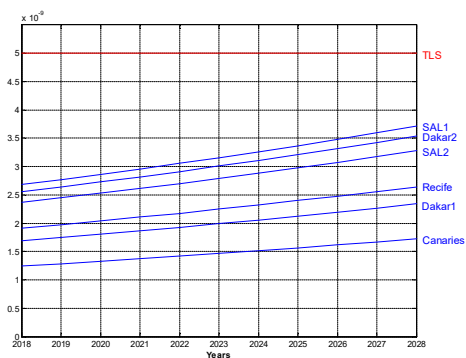


## 2018 CRM results. Lateral risk

- It models the lateral collision risk due to the separation loss between parallel routes at the same flight level.
- $TLS = 5 \times 10^{-9}$



| FIR      | Lateral Collision Risk 2018 | Lateral Collision Risk 2028 |
|----------|-----------------------------|-----------------------------|
| Canaries | $1.2461 \times 10^{-9}$     | $1.7240 \times 10^{-9}$     |
| SAL1     | $2.6845 \times 10^{-9}$     | $3.7142 \times 10^{-9}$     |
| SAL2     | $2.3702 \times 10^{-9}$     | $3.2794 \times 10^{-9}$     |
| Dakar1   | $1.6920 \times 10^{-9}$     | $2.3410 \times 10^{-9}$     |
| Dakar2   | $2.5580 \times 10^{-9}$     | $3.5392 \times 10^{-9}$     |
| Recife   | $1.9113 \times 10^{-9}$     | $2.6444 \times 10^{-9}$     |



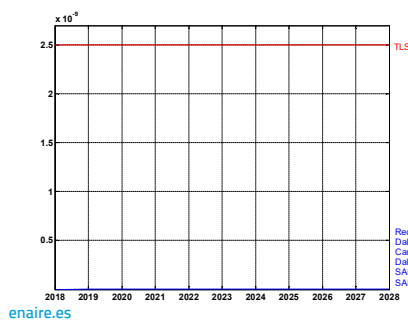
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## 2018 CRM results. Vertical technical risk

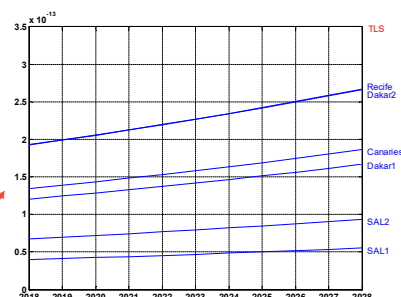
- Vertical risk: technical vertical risk + operational risk
  - Vertical technical risk models the risk due to vertical separation loss between aircraft at adjacent flight levels due to normal deviations
  - Operational risk models risk due to large height deviations (LHDs)

### • TLS

- Vertical technical risk:  $TLS = 2.5 \cdot 10^{-9}$
- Total vertical risk:  $TLS = 5 \cdot 10^{-9}$



| FIR      | Technical Collision Risk 2018 | Technical Collision Risk 2028 |
|----------|-------------------------------|-------------------------------|
| Canaries | $1.3458 \cdot 10^{-13}$       | $1.8620 \cdot 10^{-13}$       |
| SAL1     | $3.9851 \cdot 10^{-14}$       | $5.5136 \cdot 10^{-14}$       |
| SAL2     | $6.7553 \cdot 10^{-14}$       | $9.3464 \cdot 10^{-14}$       |
| Dakar1   | $1.2056 \cdot 10^{-13}$       | $1.6681 \cdot 10^{-13}$       |
| Dakar2   | $1.9260 \cdot 10^{-13}$       | $2.6648 \cdot 10^{-13}$       |
| Recife   | $1.9301 \cdot 10^{-13}$       | $2.6704 \cdot 10^{-13}$       |



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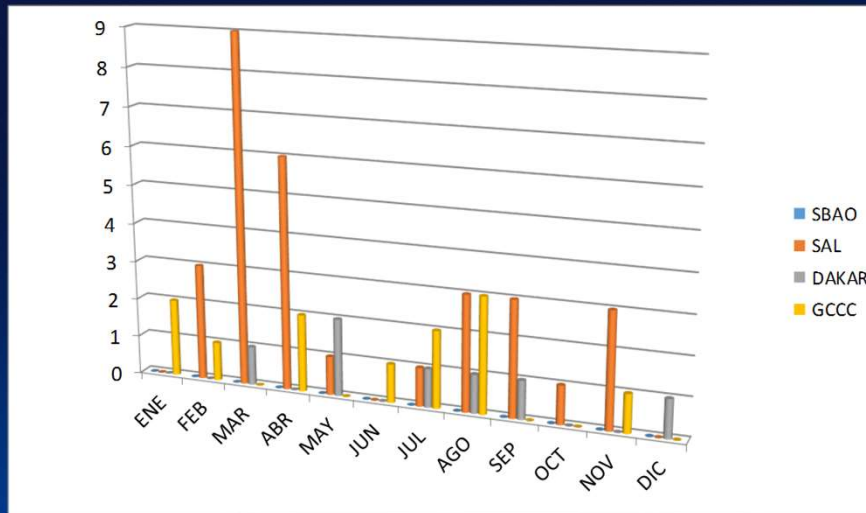
## 2018 CRM results. Vertical operational risk

- Operational risk includes:
  - Risk due to aircraft climbing or descending a flight level
  - Risk due to an aircraft at a wrong flight level
  - Large height deviations not involving whole numbers of flight levels
- Depends on the reported LHD by the States
- All LHDs are due to coordination errors between ATC units:
  - No transfer notified
  - Transfer at an unexpected flight level
- All reported deviations in Recife were not related to the corridor

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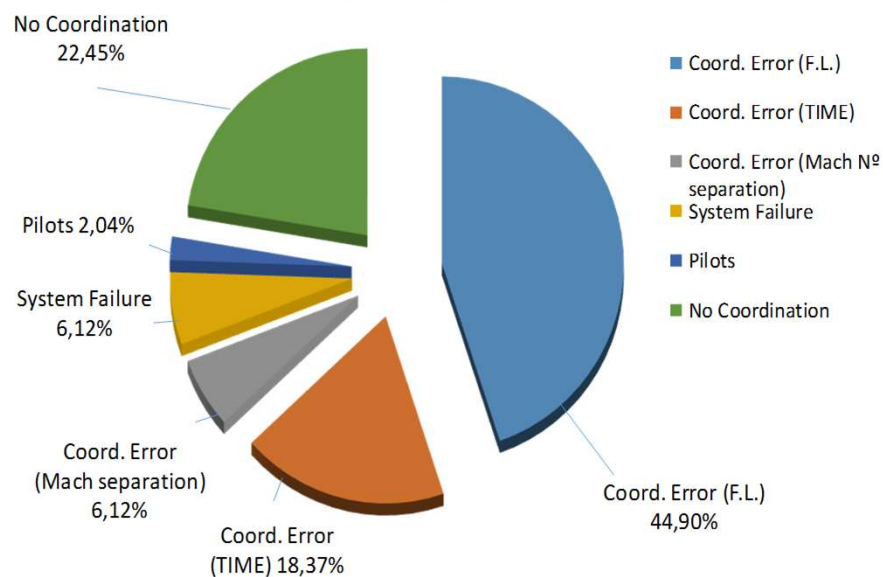
## Number of LHD's reported

TOTAL LHD'S : 49



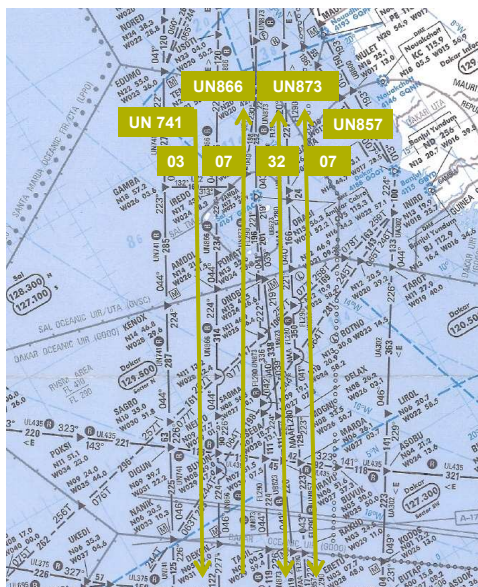
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## Percentage of LHD'S Contributing Factors

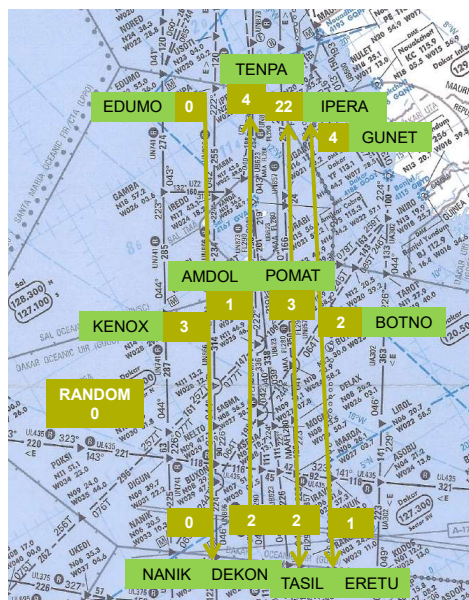




## Distribution of LHD's per ATS route



## Distribution of LHD per Fix Point



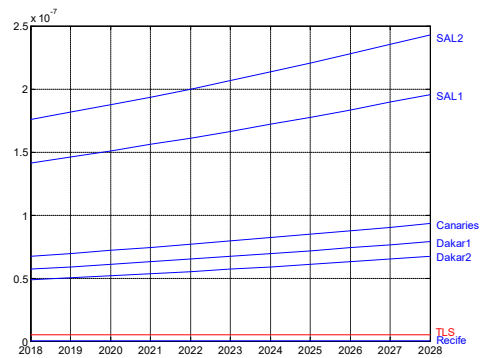


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## CRM 2018 results. Total vertical risk



| FIR      | Overall vertical Collision Risk 2018 | Overall vertical Collision Risk 2028 |
|----------|--------------------------------------|--------------------------------------|
| Canaries | $6.7431 \times 10^{-8}$              | $9.3296 \times 10^{-8}$              |
| SAL1     | $1.4141 \times 10^{-7}$              | $1.9565 \times 10^{-7}$              |
| SAL2     | $1.7560 \times 10^{-7}$              | $2.4296 \times 10^{-7}$              |
| Dakar1   | $5.7046 \times 10^{-8}$              | $7.8928 \times 10^{-8}$              |
| Dakar2   | $4.8489 \times 10^{-8}$              | $6.7088 \times 10^{-8}$              |
| Recife   | $1.9301 \times 10^{-13}$             | $2.6704 \times 10^{-13}$             |



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## Conclusions and recommendations



- Lateral risk and vertical technical risk have values below TLS.
- Vertical operational risk is above TLS (except in Recife), as it includes LHDs contribution.
- Main LHDs source is identified: coordination error between ATC units. Correction measures should be applied.
- Accuracy and reliability if the studies depend on the availability and accuracy of data: more accurate information should be made available, both for traffic measures and LHDs.

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