GATEMAN Workshop
8th SESAR Innovation Days

5. GATEMAN. Next Steps

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[GMV]

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SESAR JOINT UNDERTAKING

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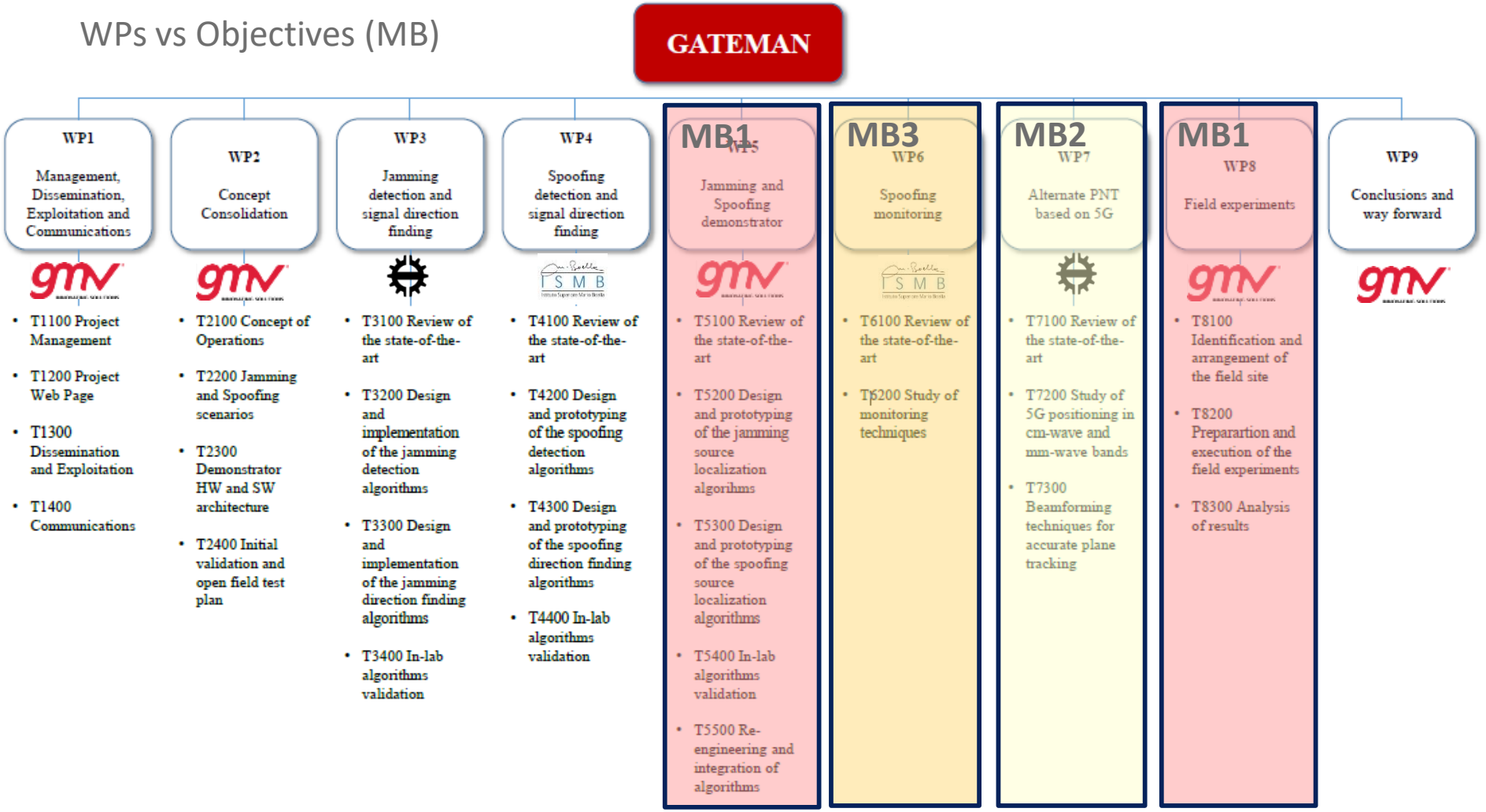
EUROPEAN UNION EUROCONTROL

Summary

1. **Context in GATEMAN**
2. On-Going Activities
    1. Localization
3. Next Steps
    1. GNSS Spoofing Monitoring
    2. A-PNT. 5G
    3. Demonstrator. Field Experiments

1. Context in GATEMAN

WPs vs Objectives (MB)



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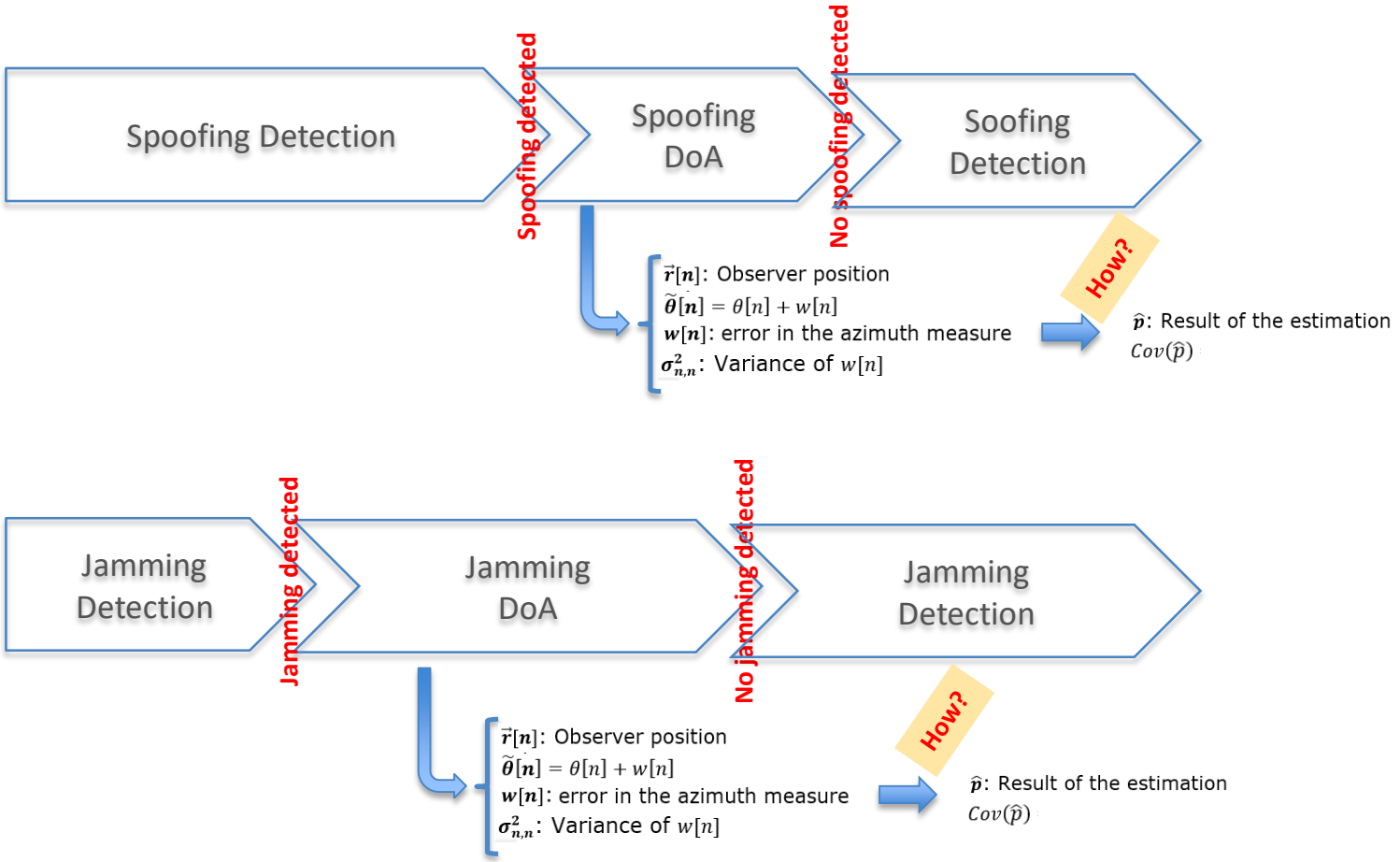
2.1 Localization



2.1 Localization

Problem definition:

- Estimate the position of the interference source ($\hat{\boldsymbol{p}}$) using the azimuths estimated by the DoA (Direction of Arrival) algorithms ($\tilde{\boldsymbol{\theta}}[\boldsymbol{n}]$), either for spoofing or jamming.
- Compute the error of the estimation (**Cov($\hat{\boldsymbol{p}}$)**).

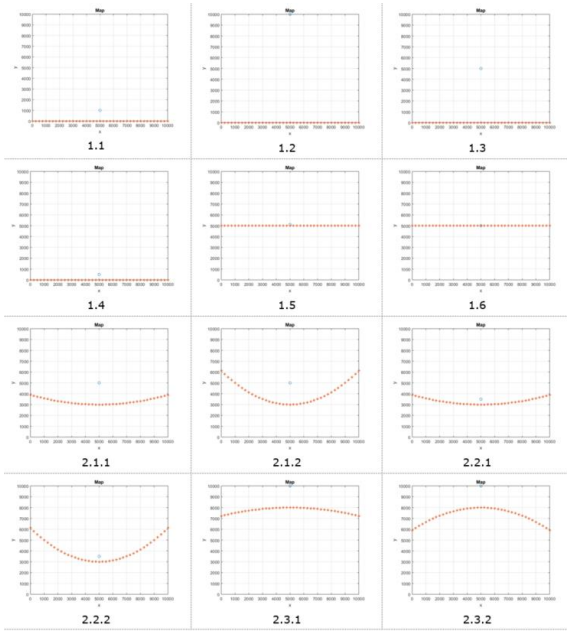
Assumptions:

- $\vec{\boldsymbol{r}}[\boldsymbol{n}]$, position of the aircraft known without error.
- $\boldsymbol{w}[\mathbf{n}]$, noise of the measured azimuth: zero mean truncated normal distribution with variance $\boldsymbol{\sigma}^{\boldsymbol{2}}_{\boldsymbol{w,n}}$
- $\boldsymbol{\sigma}^{\boldsymbol{2}}_{\boldsymbol{w,n}}$ variance of measured azimuth:
    - For jamming: function of JSR (Jamming to Signal Ratio).
        - $Var(\tilde{\theta}) = \max\left[{\sigma_0}^2\left(\frac{100}{JSR}\right), \left(\text{deg2rad}(5º)\right)^2\right]$
    - For spoofing: no model defined.

2.1 Localization

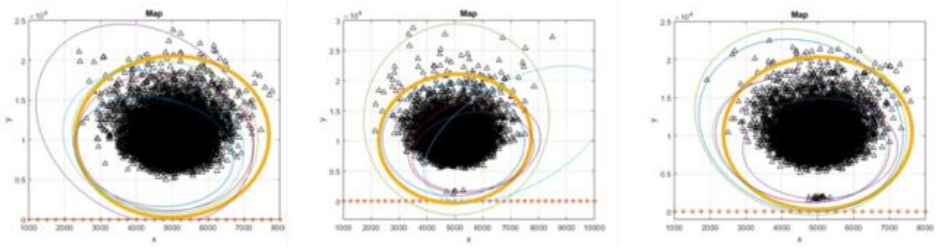
Scenarios simulated:

- Distance-based.
  - Straight and curve trajectories between aircraft and source.
- Power-based.
  - Straight trajectory, varing power of source.



Statistics:

- Bias. $\varepsilon_{bias} = \|E\{\hat{p}\} - \vec{p}\|$
- RMSE. $\varepsilon_{RMSE} = \sqrt{\mathrm{E}\{\|\hat{p} - \vec{p}\|^2\}}$
- Error ellipse area.
  - Area of the error ellipses for a 95% probability.
- Error ellipse true probability.
  - For 1e3 simulations, probability that the estimated position for all simulations is contained by the 95% error ellipse of each simulation.



2.1 Localization

Problem resolution (methods):

- LSE (Least Square Estimation)
    - Prefered if unknow the distribution nature of the noise (**w[n]**)
- MLE (Maximum Likelihood Estimation)
    - Prefered if known noise PDF (**w[n]**)

Solving the equations:

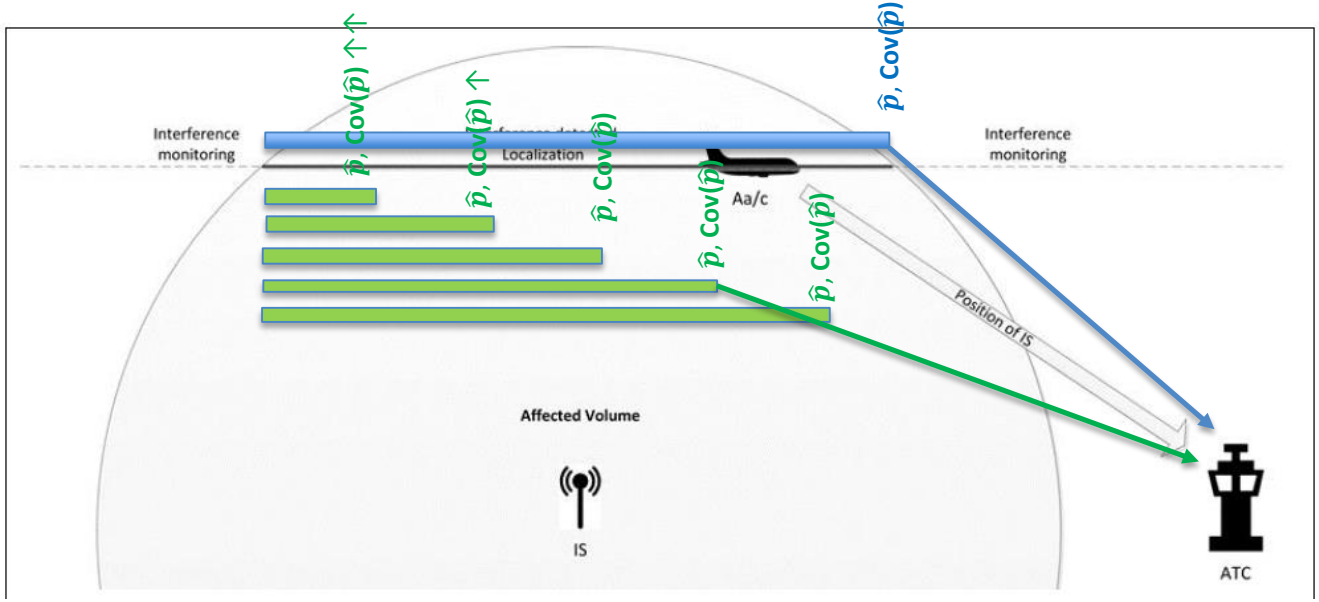
- Linear algorithm (Stansfield Estimator)
- Initial guess linear + Non-linear algorithms:
    - Steepest descent
    - Newton-Rapson
    - Gauss-Newton
    - Levenberg-Marquard (LM)
    - An ad-hoc hybrid method has been defined

=> Selected method: MLE + LM

2.1 Localization

Techniques for 1 a/c. Detection & Autonomous Localization (D&AL):

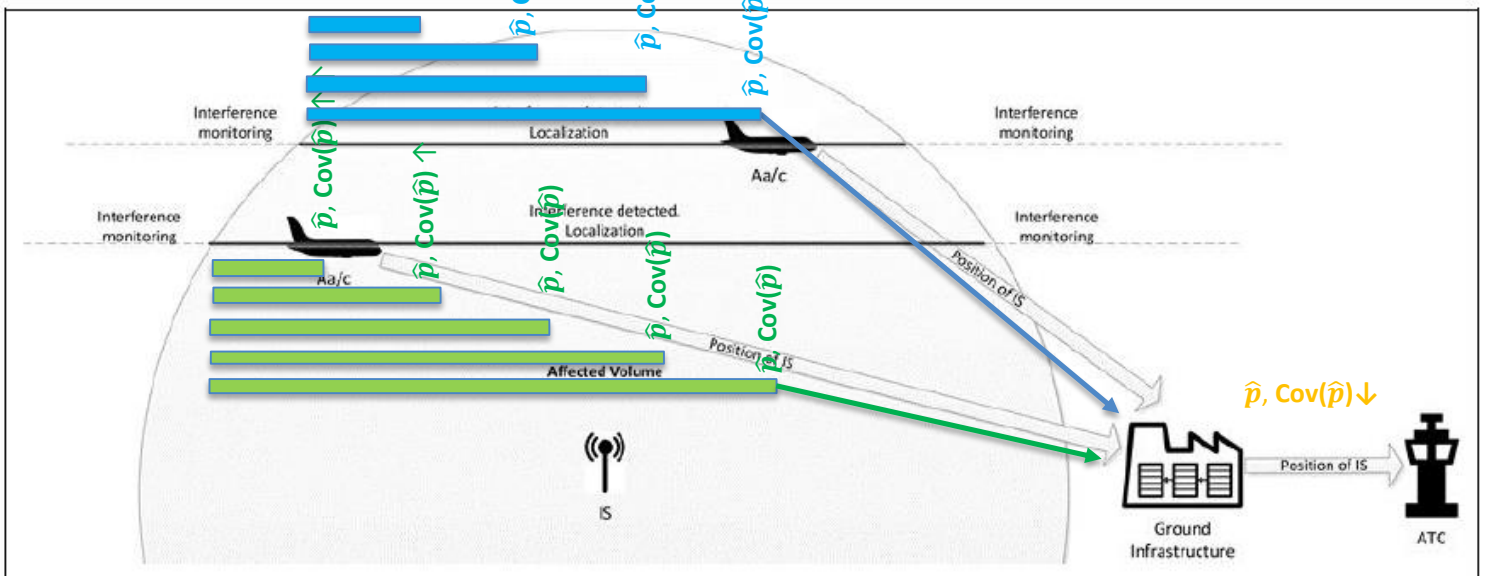
- Single-batch
  - Position estimated only once at the end of the affected volumen.
- Sequential (accumulative)
  - Position estimated at each interval (using previous azimuths).
  - Negligeble improvement in error ellipse area observed after crossing IS.



2.1 Localization

Techniques for +1 a/c. Detection & Collaborative Localization (D&CL):

- Sequential (accumulative)
  - Ground Infrastructure required:
    - combine estimated positions ($\hat{\boldsymbol{p}}$, $\hat{\boldsymbol{p}}$) from aircrafts.
  - TBD. Estimate source dynamics?



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3. Next Steps

GNSS Spoofing Monitoring

Objective:

- Study of algorithms for spoofing monitoring

A-PNT. 5G

Objective:

- Investigate the suitability of 5G-based positioning solutions as an alternative to GNSS-based navigation solutions in aviation, especially when taking off and landing.

3. Next Steps

Demonstrator. Field Experiments

Objective:

- Integrate the jamming and spoofing algorithms with the selected hardware into one single platform.
- Preparation and execution of an open-field test campaign.

GATEMAN

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