Safety analysis of SNI Aircraft and Rotorcraft IFR operations at airport

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Innovation takes off

GARDEN

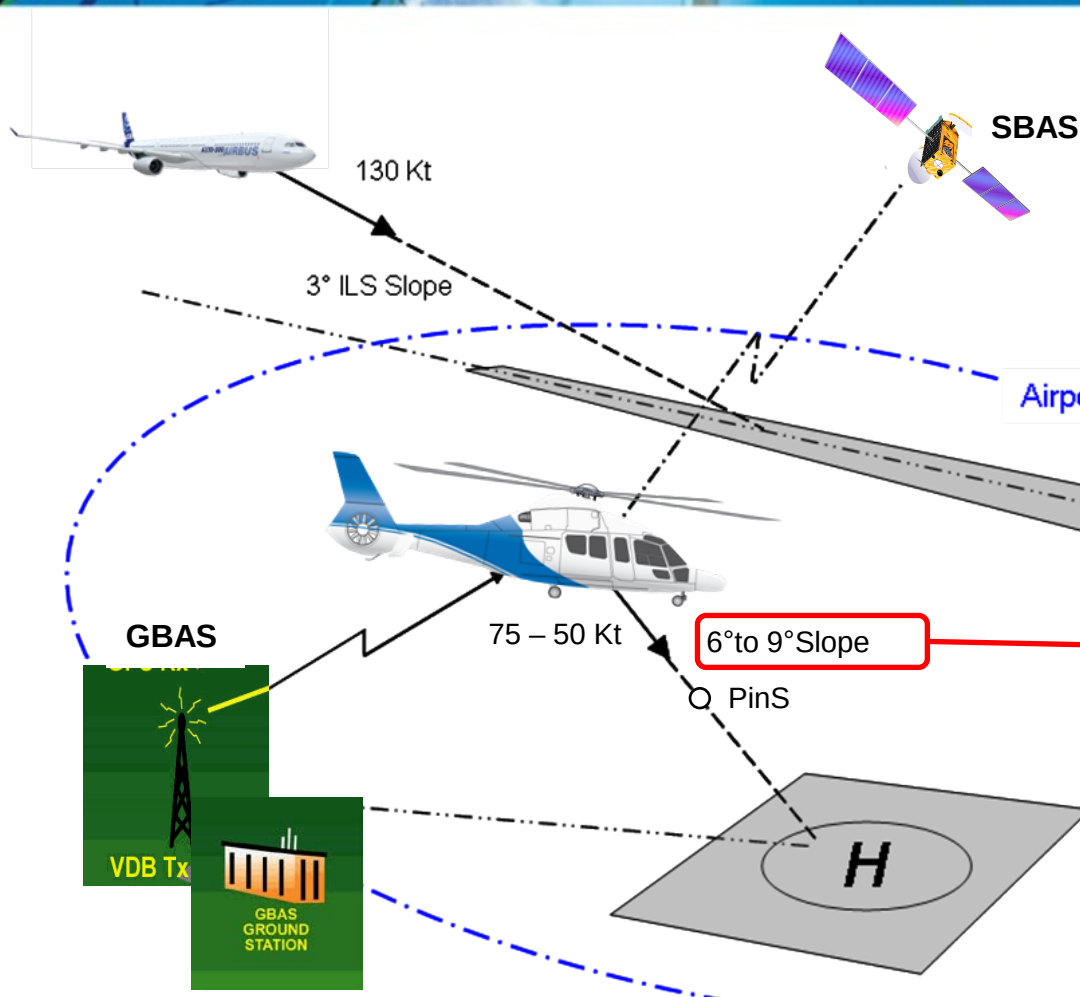
Green Rotorcraft

Summary

- Overview of SNI (*) concept
- The GARDEN CleanSky project
- Environment Friendly SNI procedures
- Safety analysis
- Operational issues
- Concluding remarks

(*) SNI: Simultaneous Non Interfering

Overview of SNI concept



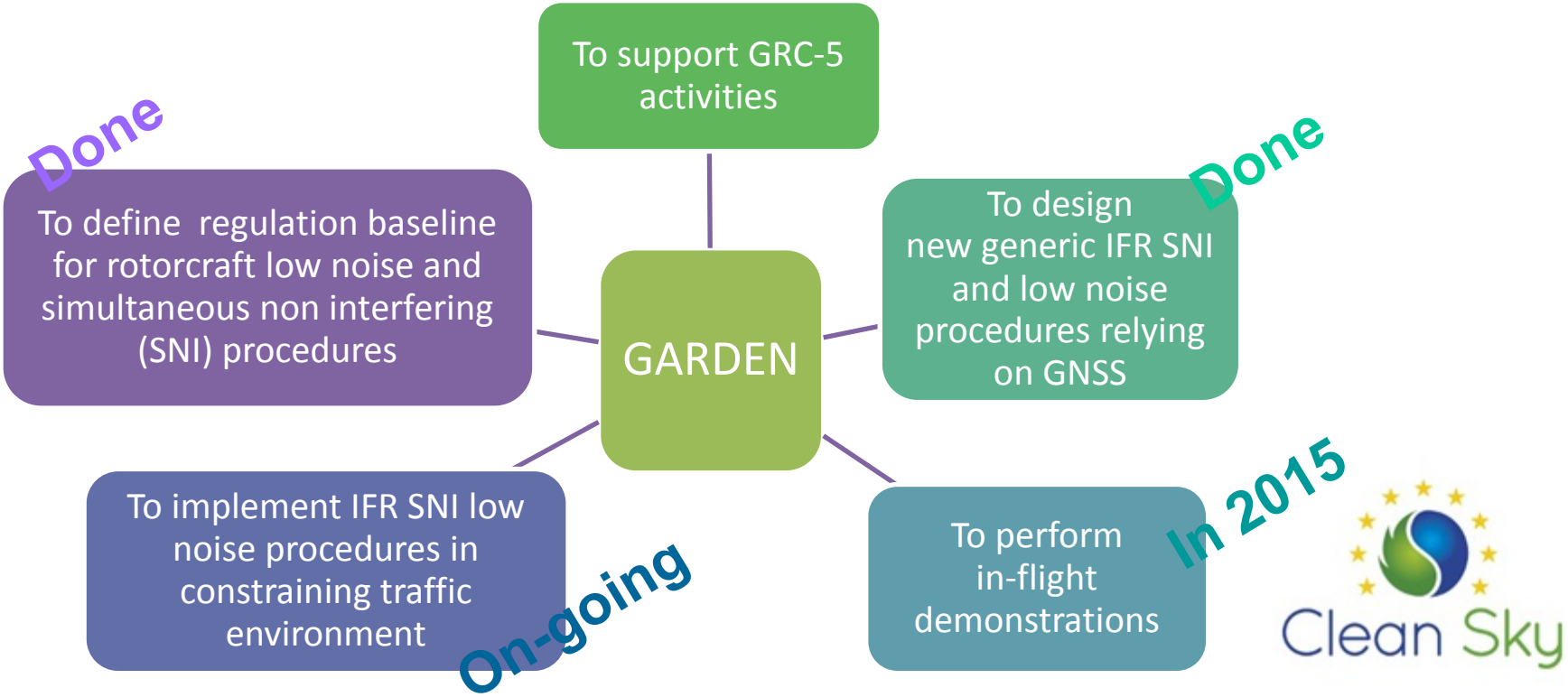
Rotorcraft-specific IFR approach

- "Point-in-Space" type (VFR FATO)
- Steep final segment
  - ⇨ Noise abatement
  - ⇨ Vertical separation

Clean Sky

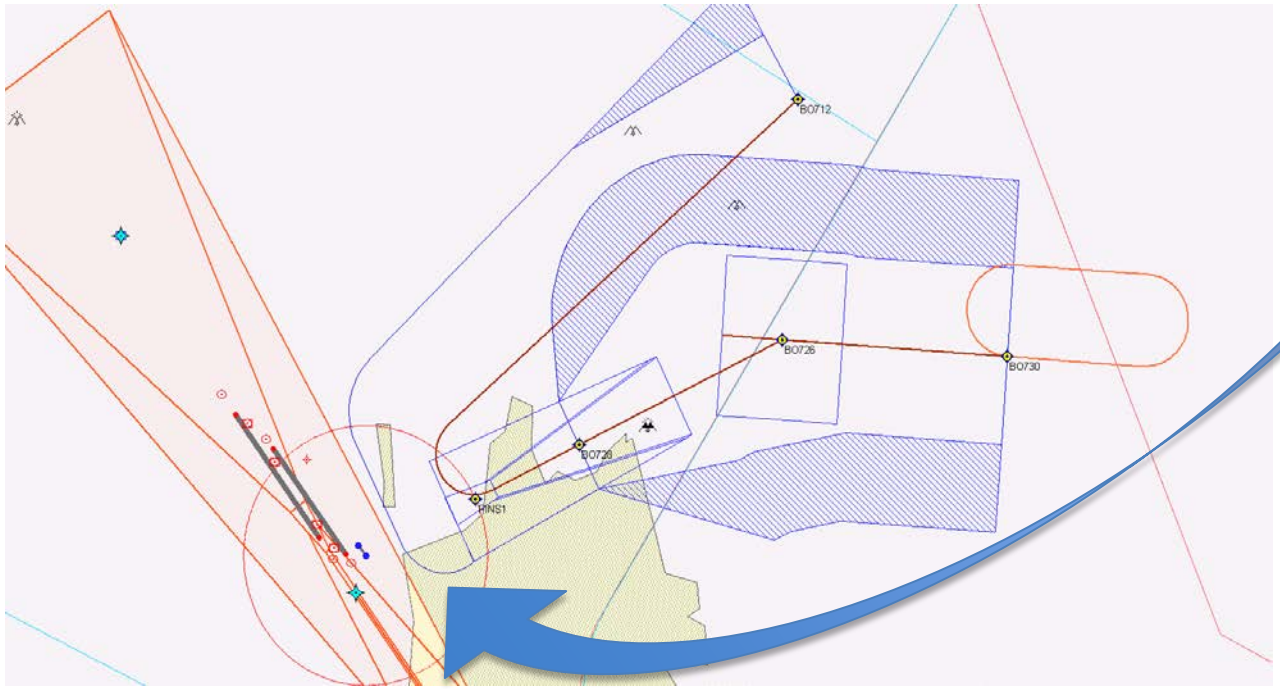
The GARDEN CleanSky project

- GNSS-based ATM for Rotorcraft to DEcrease Noise
  - Sponsored by CleanSky JU, 5 years duration (2010 ⇨2015)
  - Linked to CleanSky GRC-5 (Environment Friendly Flight Paths)
  - GRC-5 Topic Manager: Eurocopter
  - Consortium: Egis Avia (leader), French DGAC, CGX & Pildo Labs



Environment Friendly SNI procedures (1/3)

- 1st GARDEN case study: Fully SNI approaches
  - **Strategic separation**: Separation of rotorcraft and aircraft trajectories is based on non-interfering horizontal protection areas
  - **Visual segment not strategically separated**
    → visual separation required



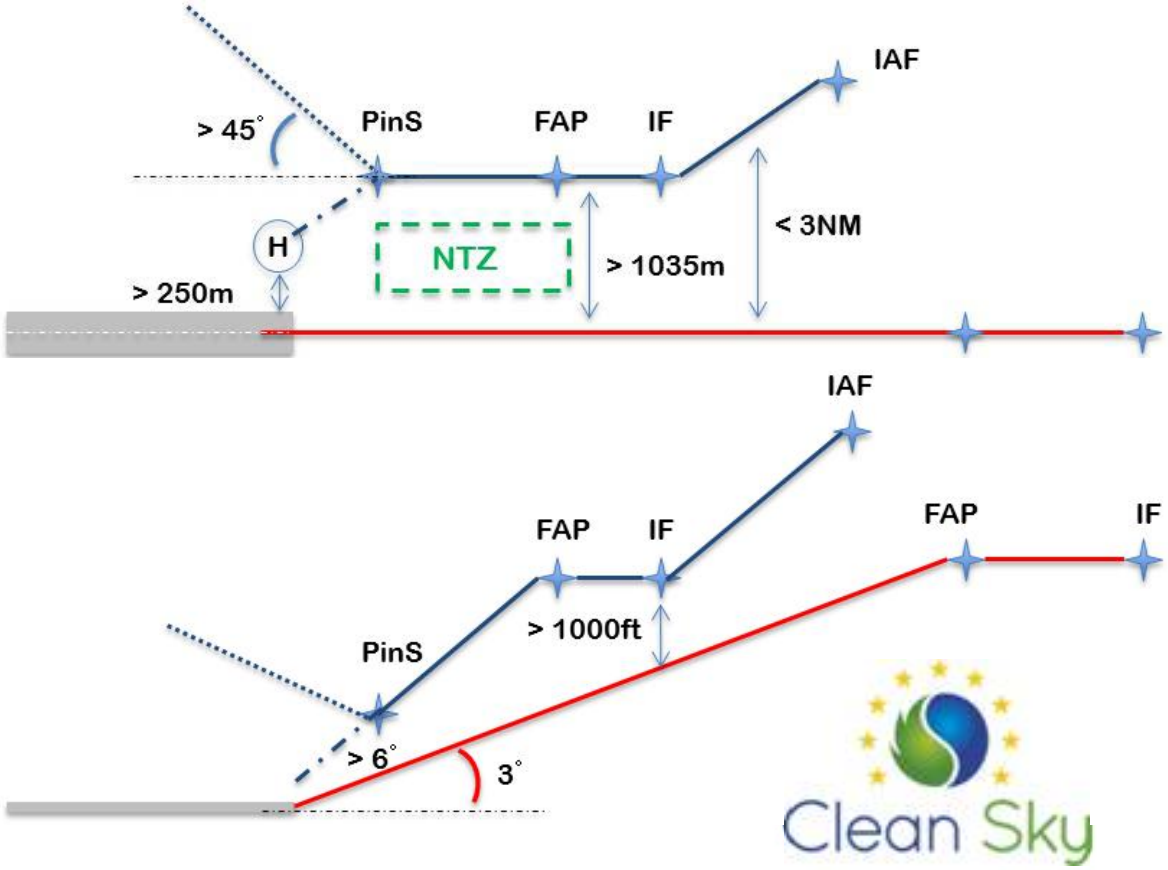
Controlled environment
(FATO at airport)
OR
Uncontrolled environment
(FATO away from airport)

Environment Friendly SNI procedures (2/3)

- 2nd GARDEN case study: SNI parallel approaches
  - No strategic separation → **radar environment with 1 ATCo,** but no radar vectoring required

- Need for **No Transgression Zone (NTZ)** and flight path monitoring by ATCo

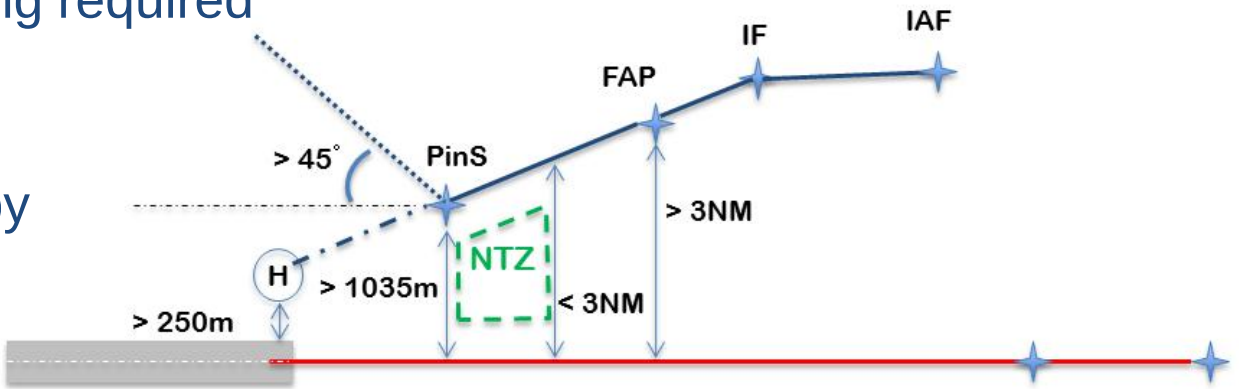
- **Required 1,000 ft vertical separation** ensured by procedure design



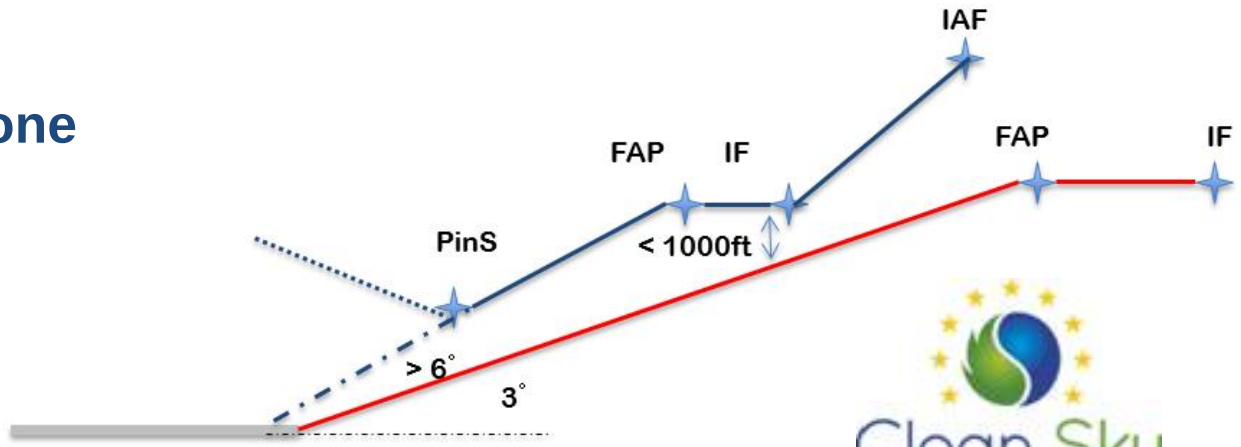
Environment Friendly SNI procedures (3/3)

- 3rd GARDEN case study: SNI converging approaches
  - No strategic separation → **radar environment with 1 ATCo,** but no radar vectoring required

- **Required 3NM radar separation** ensured by procedure design



- Need for **No Transgression Zone (NTZ)** and flight path monitoring by ATC



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Safety analysis: Objective and Scope

- Generic safety analysis of SNI aircraft-rotorcraft IFR operations based on GNSS
  - Focus on the safety impact on the ATM system (Mid-Air Collision risk) at a busy medium airport, like Toulouse-Blagnac
  - Based on operational model of SNI operations
- Approach procedures (for each SNI configuration)
  - Rotorcraft: Steep PinS LPV(*) (SBAS) or GLS (GBAS) approaches
  - Fixed-wing aircraft: LPV, GLS or ILS approaches
- Safety Workshop involving Air Traffic Controllers, procedure designers and rotorcraft operations experts
  - Validation of operational assumptions
  - Identification of hazards, causes/effects, occurrence/severity and mitigations means

(*) LPV: Localiser Performance with Vertical guidance

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Safety Analysis: Methodology

- EUROCONTROL Safety Assessment Methodology
- French ANSP (DGAC/DSNA) tool for hazard assessment

Operational Hazard (OH) :				
OH identification :		OH definition:		
Initial severity without external mitigation means				
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Initial frequency of occurrence without internal mitigation means				
☐ Ext. Rare	☐ Rare	☐ Occasional	☐ Likely	☐ Numerous
Corrected severity taking into account external the mitigation means				
☐ 1	☐ 2	☒ 3	☐ 4	☐ 5
Corrected frequency of occurrence taking into account the internal mitigation means				
☐ Ext. Rare	☒ Rare	☐ Occasional	☐ Likely	☐ Numerous
Detailed description of the operational hazard				
Causes description		Consequences description		
		Consequences without EMM: Consequences with EMM:		
Internal Mitigation Means (IMM)		External Mitigation Means (EMM)		
Assumptions: Safety requirements: Safety recommendations:		Assumptions: Safety requirements: Safety recommendations:		

1.Hazard Identification and description

2. Identification of the operational effects and of the **Initial Severity**

3. Identification of the EMM, of the operational effects and of the **Final Severity**

4. Identification of the causes and of the **Initial Frequency**

5. Identification of the IMM and of the **Final Frequency**

Safety Analysis: Main outcomes

- 14 Operational Hazards (OHs) with many common causes, but hazard effects depend on SNI configuration
  - Fully SNI configuration
    - A few Safety Requirements (SR) defined upstream of PinS (as strategic separation is ensured by design)
    - SR also needed to support separation on the visual segment (Pilot and ATC procedures)
  - SNI parallel and converging configurations
    - SR mainly defined to ensure separation along the FAS (ATC procedures)

OH Id	OH definition
OH1	The rotorcraft flies low when intercepting the final approach path
OH2	The aircraft intercepts the final segment from above
OH3	Lateral overshoot of the final approach segment by the rotorcraft during the interception prior the FAF
OH4 (Fully SNI)	The aircraft or rotorcraft laterally deviates from the final approach paths
OH4 bis (SNI parallel or conv)	The aircraft or rotorcraft penetrates the NTZ
OH5 (Fully SNI)	Both aircraft and rotorcraft deviate from the final approach paths
OH5 bis (SNI parallel or conv)	Both the aircraft and rotorcraft penetrate the NTZ
OH6 (Fully SNI)	Both aircraft and rotorcraft abort the final approach procedures simultaneously due to GNSS failure
OH6 bis (SNI parallel or conv)	Both aircraft and rotorcraft abort the final approach procedures simultaneously due to GNSS failure
OH7	The pilot of the aircraft is surprised to see rotorcraft so close (transition only)
OH8	Aircraft or rotorcraft destabilized by the adjacent traffic wake vortex
OH9	Rotorcraft deviates from visual approach path or aircraft deviates from final path
OH10	Failure to maintain own visual separation by Rotorcraft
OH11 (Fully SNI)	Failure to follow the first turn of the missed approach
OH11 bis (SNI parallel or conv)	Failure to follow the first turn of the missed approach
OH12 (SNI parallel or conv)	Nominal Interference of the missed approach with other trajectories
OH13 (SNI parallel or conv)	Untimely MSAW alert
OH14	Untimely aircraft TCAS alert
OH15 (SNI parallel or conv)	Untimely STCA alert

- SNI operations can be safely implemented, yet three operational issues require further investigation

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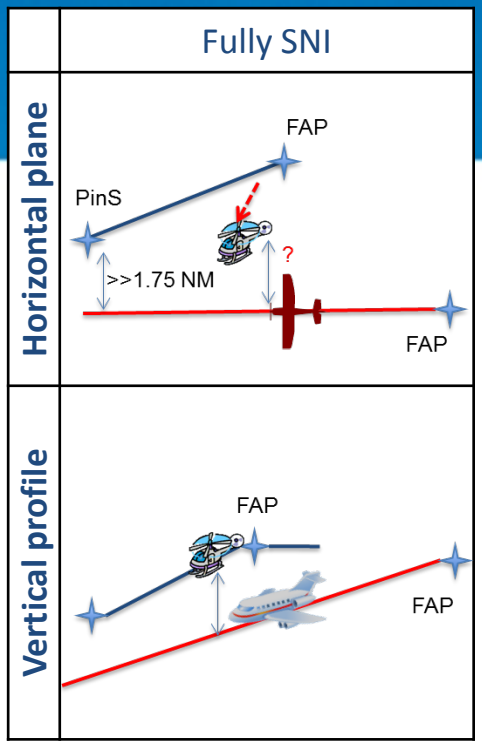
Safety Analysis: Example of OH

OH4: A/C or R/C laterally deviates from the FA path

- EMM – Assumptions
  - On-board detection of deviations with alert (RNP capability)
  - Recovery: missed approach (with strategic separation)
  - **No additional safety requirement needed**
- IMM – Assumptions
  - Pilot check of reference trajectory on Navigation Display
  - Crosswind effect considered in procedure design
- **IMM - Safety requirement**
  - For approaches with several minima only those with vertical guidance (LPV, ILS, GLS) can be cleared for SNI operations → **Shall** be stipulated on the approach chart and/or in the ATIS messages (if applicable)
- IMM - Safety recommendations
  - Simultaneous procedures **should not** be performed in high crosswind or very adverse meteorological conditions (e.g. whirling winds in case of thunderstorms)



Corrected severity: **Significant incident**

Corrected frequency of occurrence: **Rare**

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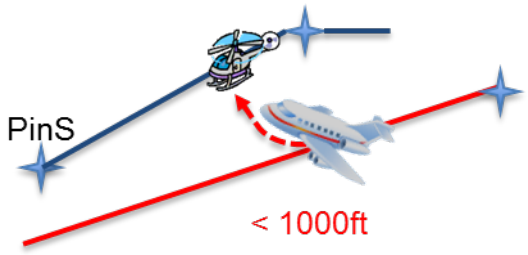
Ops Issue 1: “Break-Out” manoeuvre

- Required when one traffic (A/C or R/C) infringes NTZ
- A/C and R/C climb slope, speed and turn radius are different
  - ⇨ ATC instruction “**climb and turn**” (ICAO Doc. 4444) cannot be applied directly to the non-infringing traffic
- Which strategy to apply:
  - upstream IF when 1,000ft vertical separation not ensured?
  - along the FAS in case of crossing altitudes between A/C and R/C?



⇨ **Strategy depends on A/C – R/C sequence and altitudes**

- Possible solutions / further work
  - Define « break-out » procedures tailored to local environment (with specific information on AIP)
  - Revisit the current « break-out » procedures (e.g. Heading instructions) taking care of R/C flight characteristics

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Ops Issue 2: Separation in the visual segment

- Aircraft – Rotorcraft separation issue
  - Protection surfaces related to the **visual segment** of the PinS procedure are not used to ensure strategic separation
  - No ICAO criteria exist to define NTZ for dependent approaches (A/C final path and R/C visual path spaced by less than 1035m)
- Possible solutions
  - Visual A/C – R/C separation → mutual agreement required 
  - Consideration of special VFR flight → increased ATC workload 
  - **Reduction in separation minima in the vicinity of airports** → suitable for non-converging approaches to ensure separation between preceding A/C and R/C, but separation with succeeding A/C still to be ensured by ATC 
  - **Use of a geographical reference (FATO axis)** → suitable for converging approaches, facilitates visual acquisition of the R/C by ATCo 

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Ops Issue 3: Wake Vortex Encounters (WVE)

- Rotorcraft Wake: Not an issue for SNI operations
  - Strong effects only in hover or at very low speed
  - Negligible effects when distance is more than 3 x Rotor Diameter
- Airplane WVE: The risk is for Rotorcraft flying the visual segment (PinS ⇨ FATO), but mitigation means exist, e.g.:
  - Proceed beyond PinS only if visibility allows to see both the FATO and the preceding airplane approaching the runway, then ensure adequate spacing
  - Do not allow SNI operations at FATOs located close to runways when wind conditions are adverse (Runway ⇨ FATO crosswind)

Need to also take care of operational experience

No WVE recorded up to now at Nice airport in spite of 50,000 R/C movements per year (VFR SNI)

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Concluding Remarks

- SNI IFR operations improve **rotorcraft access to busy airports while reducing environmental impact**
- Rotorcraft-specific IFR approach procedures relying on GNSS guidance are key enablers
- Safety analysis using EUROCONTROL methodology shows there are **no blocking points for safe implementation**
- 3 operational issues would need further investigation, but solutions or (and) acceptable risk mitigation means already exist
- SNI concept is now considered in SESAR

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Thank you for your attention

Questions?

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