SOUTHEAST ASIA AVIATION SAFETY CONFERENCE
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Deep Dive into Recovery Techniques from Vortex Ring State

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Content

- Introduction
- Motivation – Why resume a decade old discussion with vigor?
- Latest flight physical insights – Flight test and numerical studies
- Comparison with other studies
- Conclusions and recommendations

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Introduction

Accident of BK 117 B-2 in New Zealand (September 2023)

- **Collision with terrain** during HEMS winch extraction mission.
- Tail- & orographic upwind during approach led to **entry into Vortex Ring State**
- **Recovery attempts by the pilot**
    1. Pilot **attempted recovery** by initially applying the Traditional recovery technique.
    2. Pilot switched to Vuichard technique upon realizing of **insufficient available height**
- Outcome: Severe damage to the helicopter, no injuries to occupants.

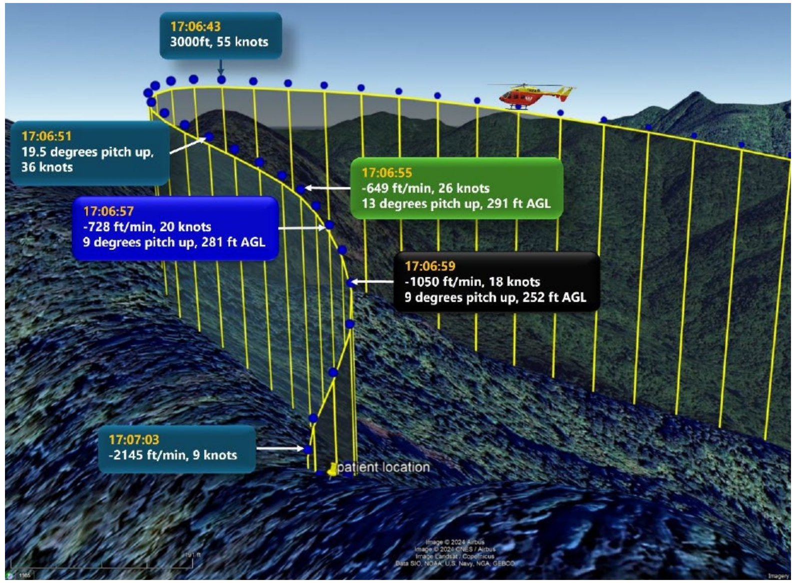
➢ Knowledge about the different ‘competing’ recoveries contributed to the inability to recover

Key Questions:

→ What is Vortex Ring State?

→ Which recovery method is best in context of the specific circumstances?

→ How can VRS recovery be standardized to avoid confusion?



Images from TAIC Final Report AO-2023-010, see: https://www.taic.org.nz/inquiry/ao-2023-010

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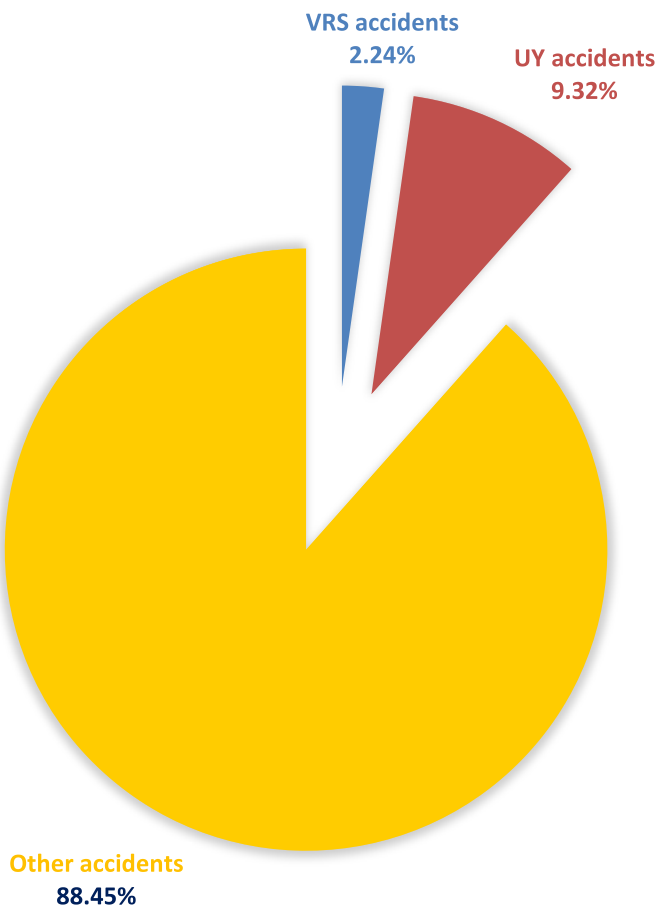
Motivation – why resume a decade old discussion with vigor?

VRS & UY Airbus Helicopters‘ fleet accidents 2013-2023



Motivation – why resume a decade old discussion with vigor?

- VRS is one of the frequent reasons for helicopter accidents
- Recovery techniques - to be re-addressed and improved

➢ *Many incorrect descriptions, misconceptions, misunderstandings based on incorrectassumptions still exist*

➢ Issue became in the focus of VAST Technology Team and was subject to an EASA Research project EASA.2022.C11

Vortex Ring State - Basics

Flow patterns in hover and during descent without forward speed:

In hover (HOGE) or slow forward flight:
Undisturbed downward airflow induced through the rotor disk, lift is the opposite momentum

At moderate rate of descent – incipient VRS:
Helicopter enters ist own downwash. Recirculation of the downwash start, downwash is impaired – loss of lift

At increased rate of descent – full VRS:
Downwash is fully recirculated around the main rotor, no more lift is created

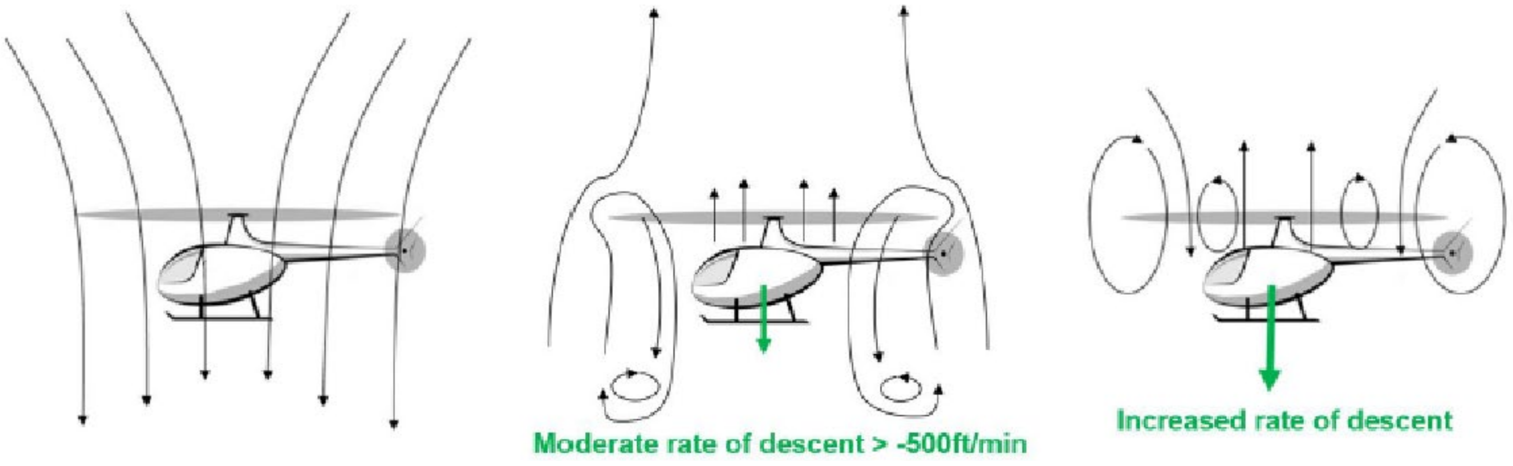
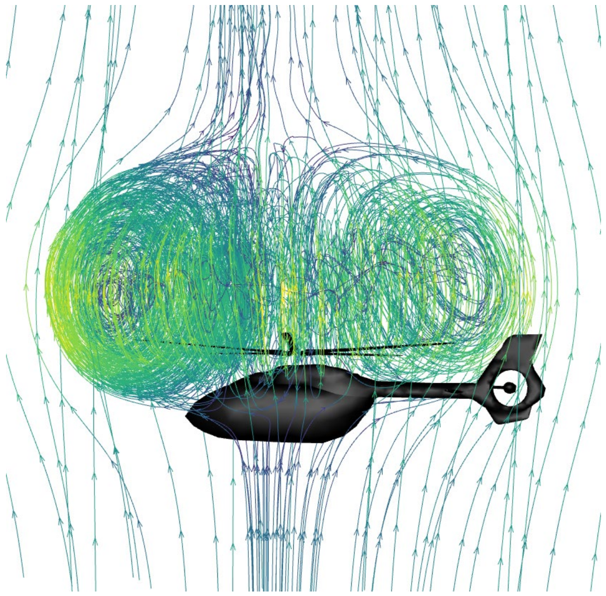


Illustration from RESEARCH PROJECT, EASA.2022.C11, D-1.1 VRS KNOWLEDGE REPORT

Vortex Ring State - Basics

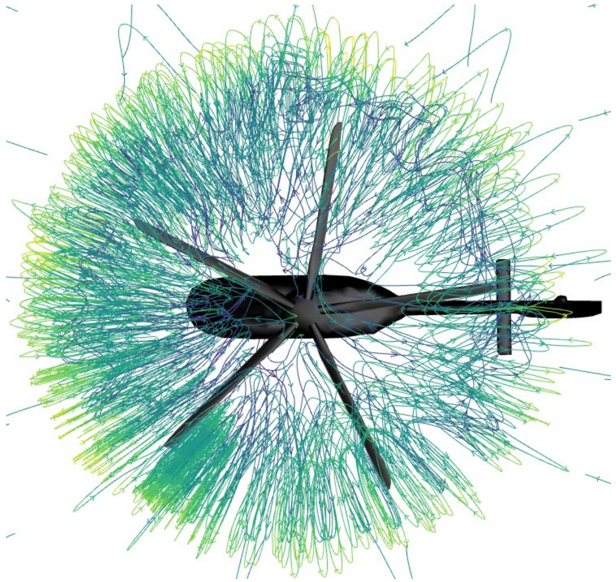
What is VRS ?

- Donut-shaped flow phenomenon around rotor blades
- Air flows upwards around rotor disk & is re-ingested into rotor from above, forming recirculation pattern
- Loss of lift leads to rapid downwards acceleration



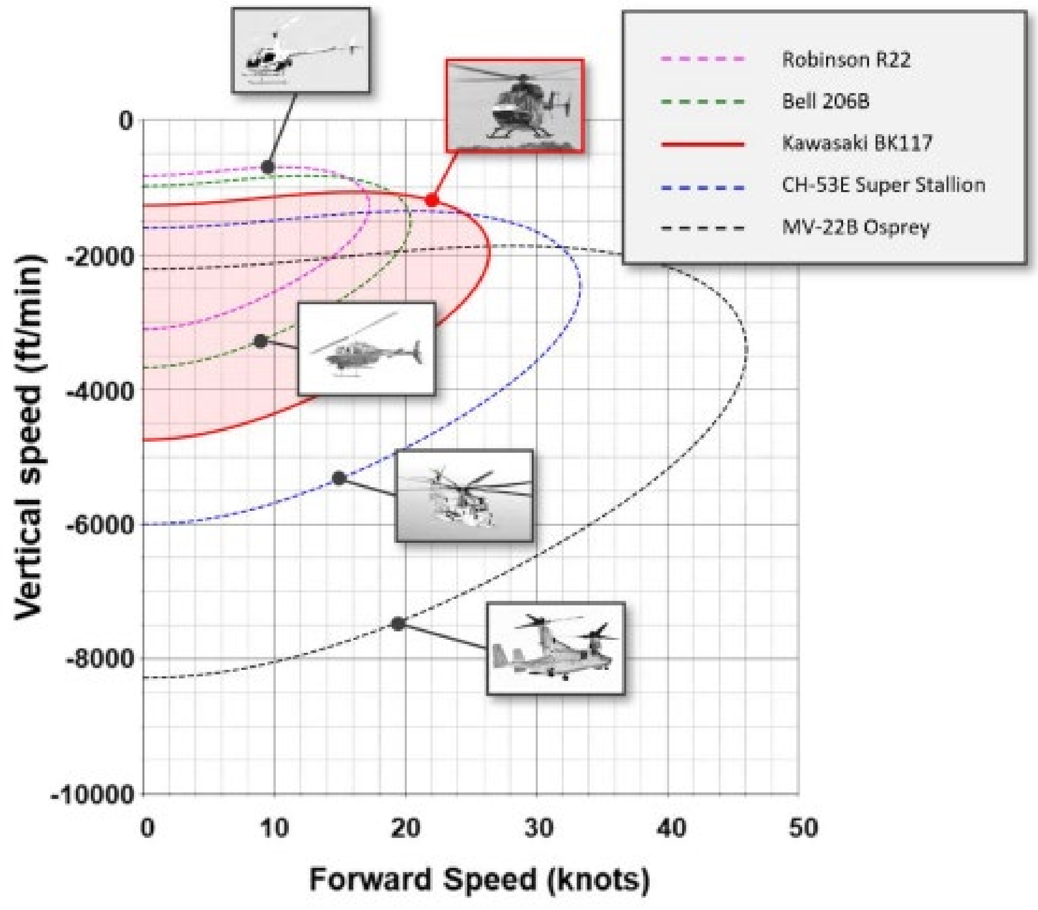
Three conditions are necessary for VRS:

- Powered flight (not in autorotation, > 20% power applied)
- Low forward airspeed (app. 20kts)
- Significant Rate of Descent (>300 ft/min)



Vortex Ring State - Basics

VRS domain:



(Credit: Dr Richard E. Brown, Sophrodyne Aerospace)

VRS domain for various helicopter types

Model used: Newman & Perry

- ➢Heavier helicopter/higher disc loading shifts domain downward
- ➢ Heavier helicopter/higher disc loading increase area of VRS domain
- ➢Autorotation starts below the lower boundary of the VRS domain

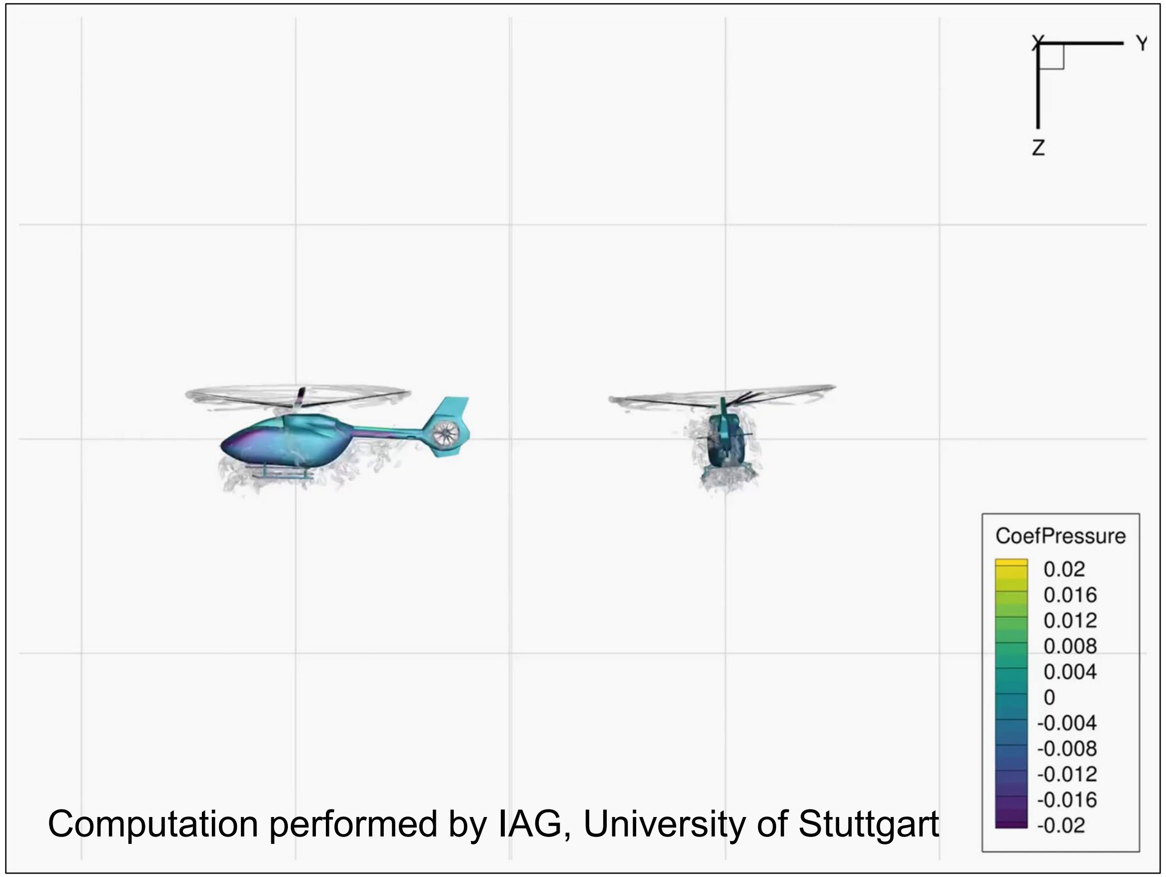
Vortex Ring State - Basics

VRS – Fligh Physical Cues

- Thrust fluctuation
- Torque fluctuation
- Blade flapping fluctuation
- Loss of control effectiveness
- Erratic fuselage movements (pitch, roll and yaw)
- Vibrations
- Sudden and uncontrolled increase of the rate of descent
- Loss of collective effectiveness (in full VRS)

Severity of symptoms depend on helicopter type and configuration, VRS entry ad VRS state

VRS entry – full CFD simulation (University of Stuttgart, IAG)



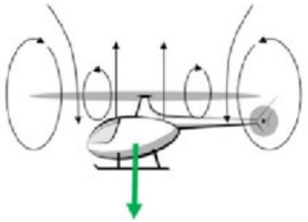
<u>Before we continue – basic advice for VRS handling</u>

- ***Best is to recognize and avoid VRS domain***
- ***At the latest, detect the first flight physical cues for VRS entry and take immediate recovery action***

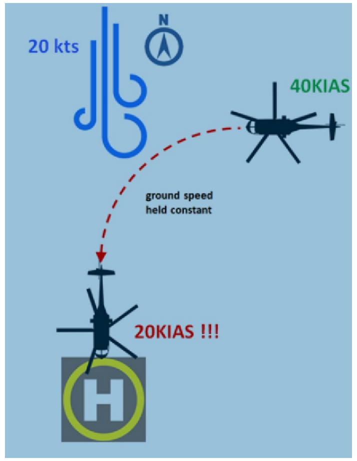
Vortex Ring State - Basics

VRS – Entries

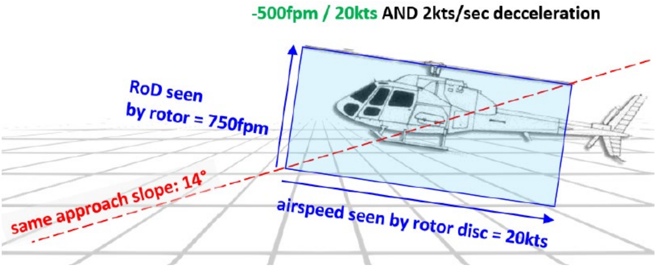
- Entry from hover by gradually increasing rate of descent



- Entry into VRS domain during tail wind approach (lower TAS than perceived by observed GS)

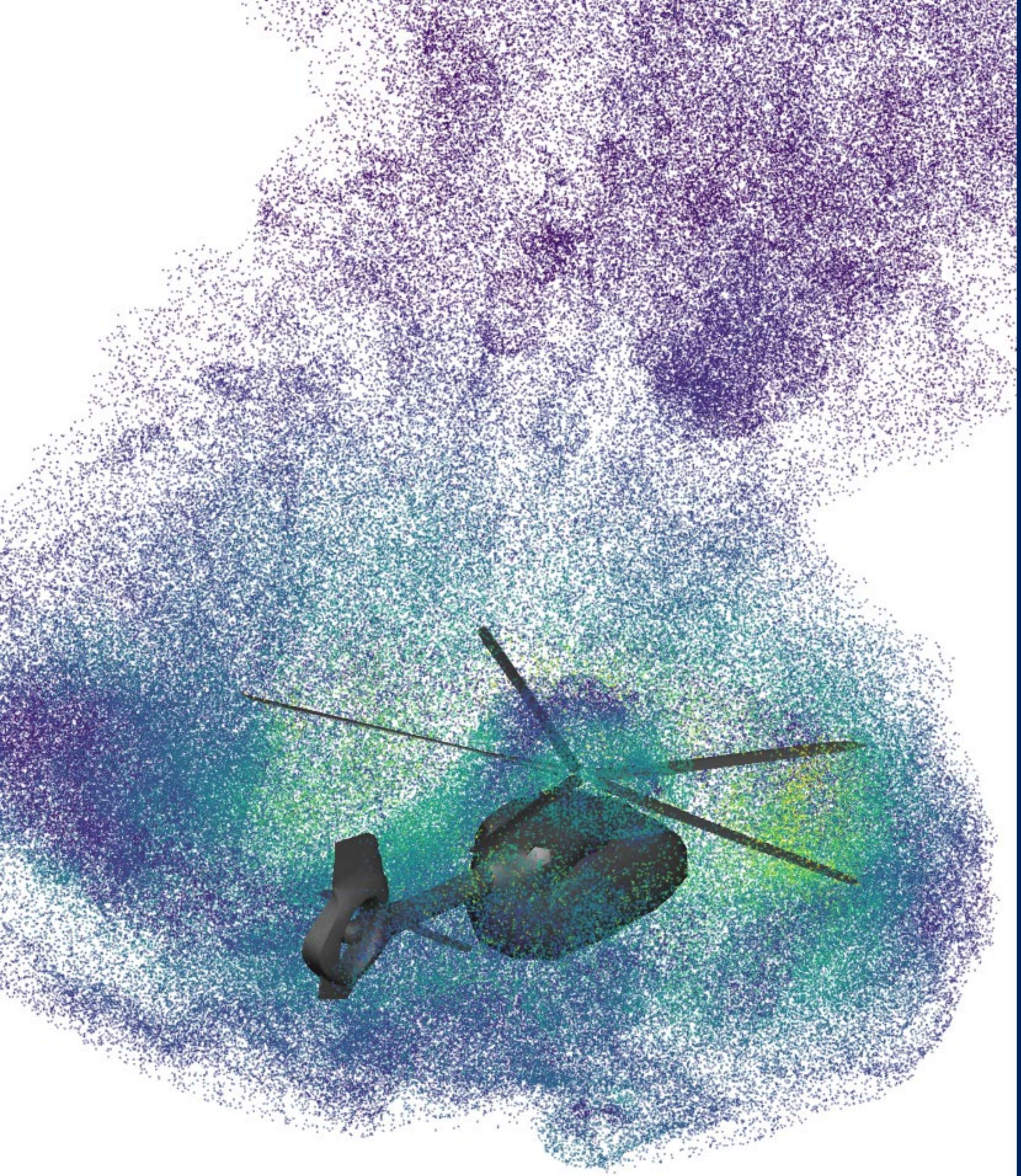


- Entry into VRS domain during deceleration / nose up



Other mission related scenarios:

- Combination of tail wind approach and deceleration
- Updrafts / orographic winds causing upward flow without rate of descent



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VRS Study – work scope at AH

- Flight tests performed at AH with BK117 – D3
- Two Master Thesis performed for numerical simulation of VRS phenomena and exit maneuvers at AHD
- Close interaction with the FAA Aviation Research Division and other manufacturers (Bell, Leonardo, Robinson, Sikorsky) and resarch institutions (ONERA, DLR, Sophrodyne, University of Stuttgart)

Numerical tools used

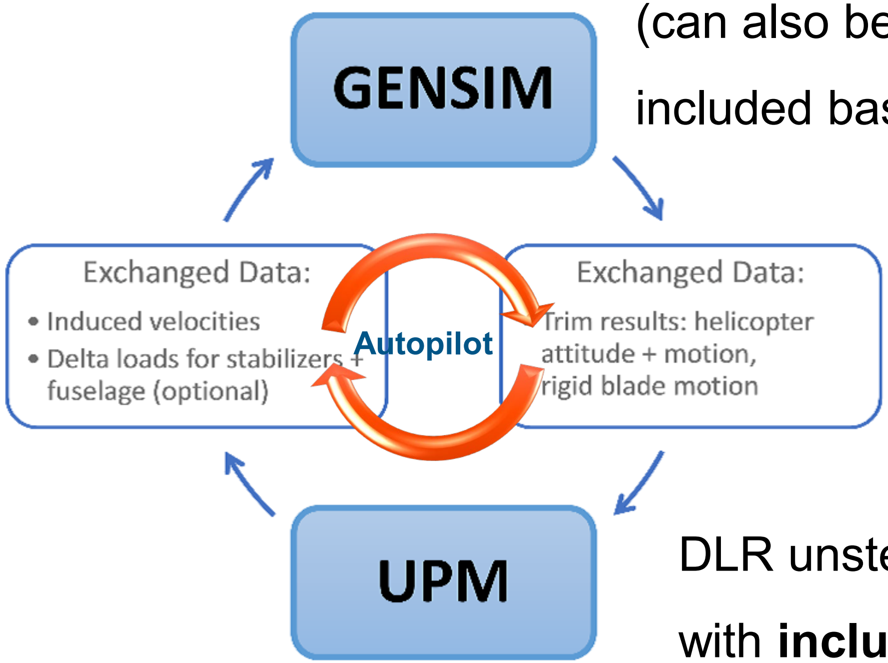
Implemented wrap-around autopilot to replicate realistic pilot control inputs

- Maneuver-sequence-based simulation
- Separate cascaded PI(D)-controllers for each axis

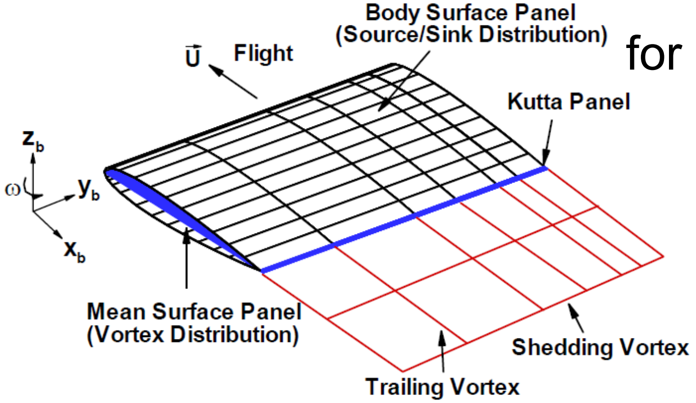
→ Autopilot enables simulation of maneuvers

Autopilot adjusted to simulate human pilot inputs

AH flight mechanic, 6 DOF code (can also be run stand-alone with a included basic aerodynamic modelling)



DLR unsteady panel method, with **inclusion of vortex interaction** for sophisitcated flow simulation



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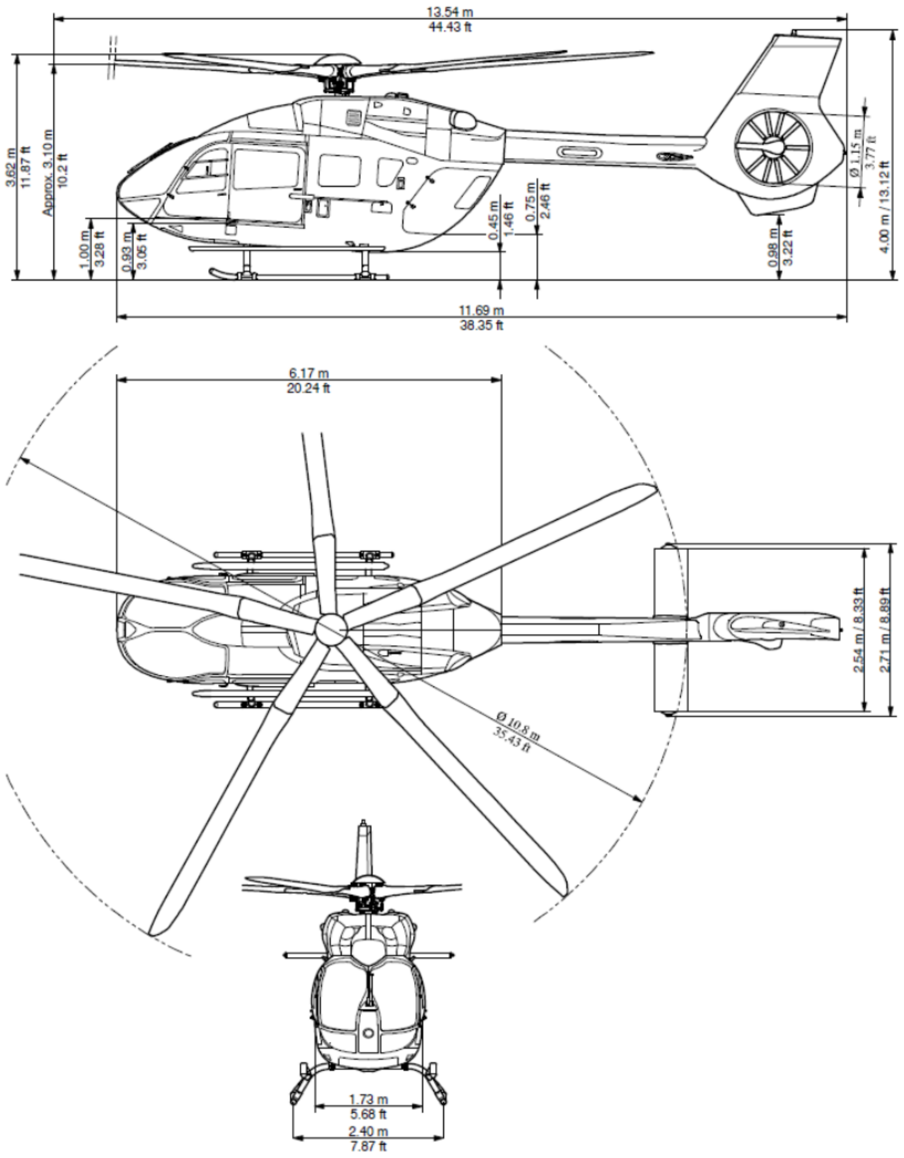
Simulation Setup

- **Helicopter type used for simulation:**

  BK 117 D-3

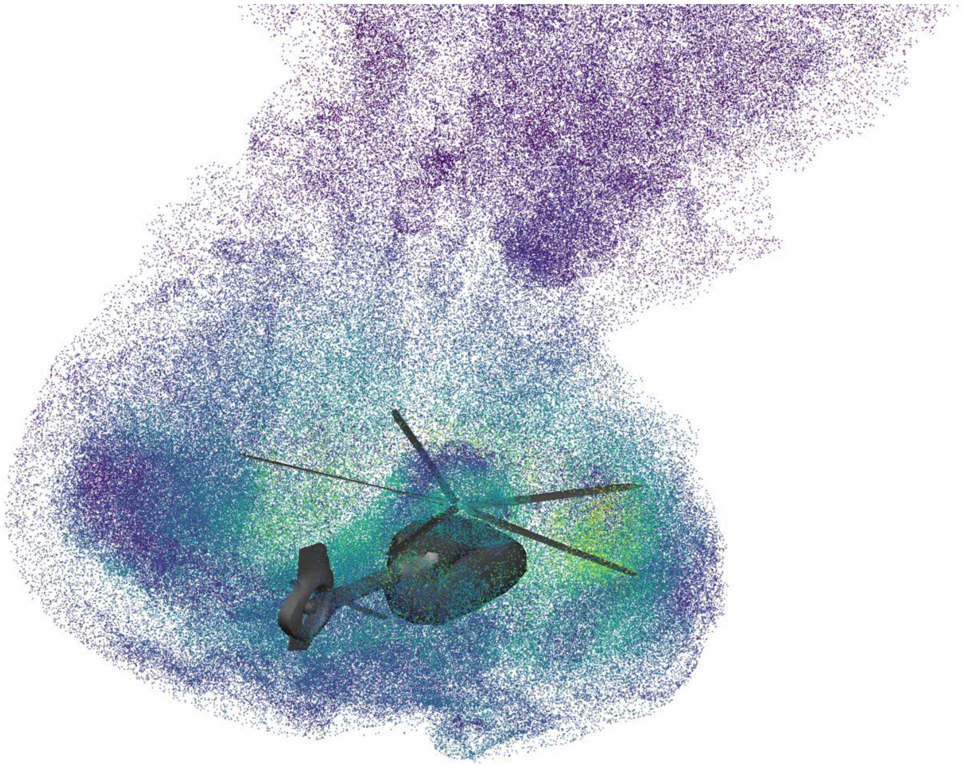
  - Medium-sized twin-engine helicopter
  - 5-bladed rotor & Fenestron
  - Empty weight: 1985 kg
  - Maximum take-off weight: 3800 kg

- **Flight conditions:**
  - Helicopter mass: 3085 kg
  - Density altitude: 6800 ft



Latest flight physical insights – flight test and numerical studies

Validation of simulation chain and results

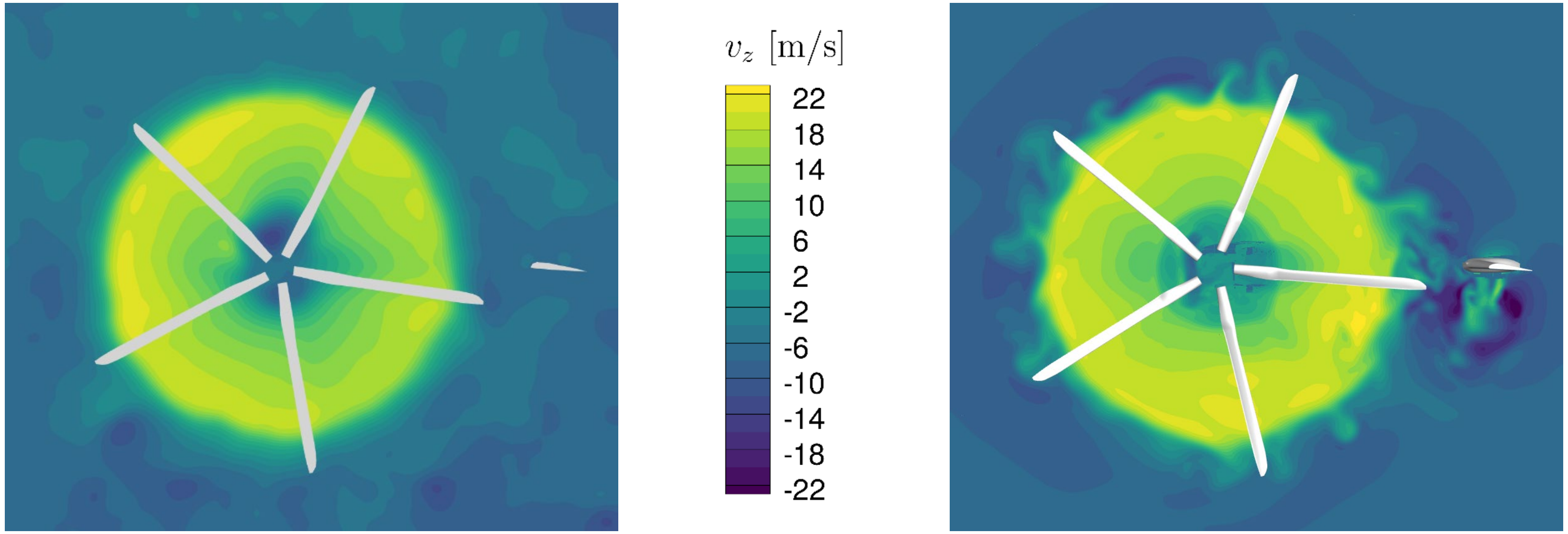


Validation: Comparison to CFD Simulation

- CFD simulation with same parameters and control inputs carried out by Institute of Aerodynamics and Gas Dynamics (IAG) of University of Stuttgart
- Distribution of vertical velocity v_z below rotor shows good agreement, but more refined flow patterns in CFD results

UPM simulation at 7 m/s

CFD simulation at 7 m/s



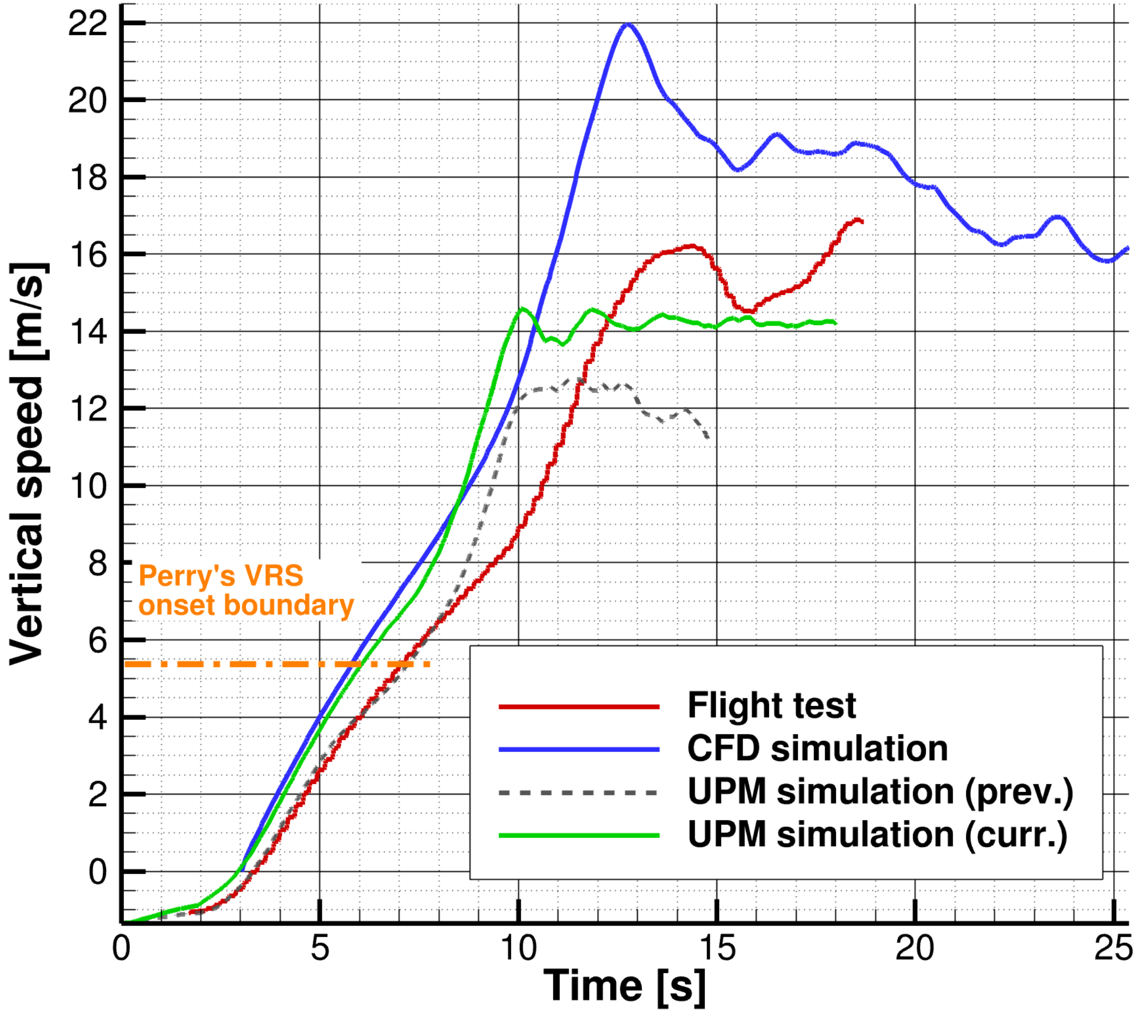
Validation: Comparison of VRS Onset to Flight Test & CFD

- Control input in flight test and simulations:

  Collective stick decrease by 10.5% lever travel from

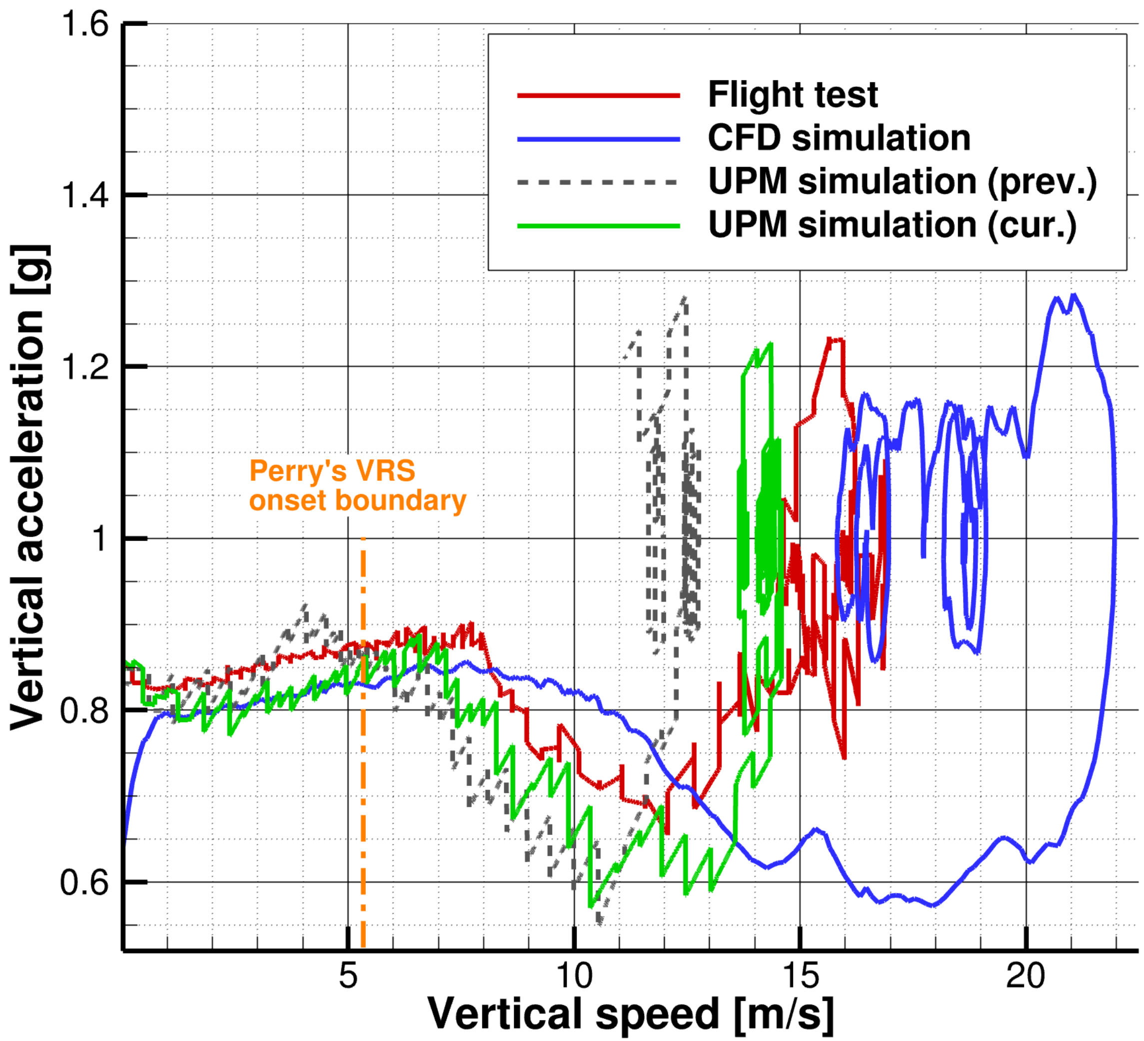
  slight climb condition in hover

→Good agreement of calculations with flight test data



Validation: Comparison of VRS Onset to Flight Test & CFD

- Plot of vertical acceleration with respect to vertical speed shows VRS onset behavior
- Qualitatively similar progression of vertical acceleration in time:
  - Sudden increase in downward acceleration in flight test also appears in UPM simulation, less abrupt in CFD results
  - Equilibrium point reached with similar spiral shape



Validation: Flow patterns

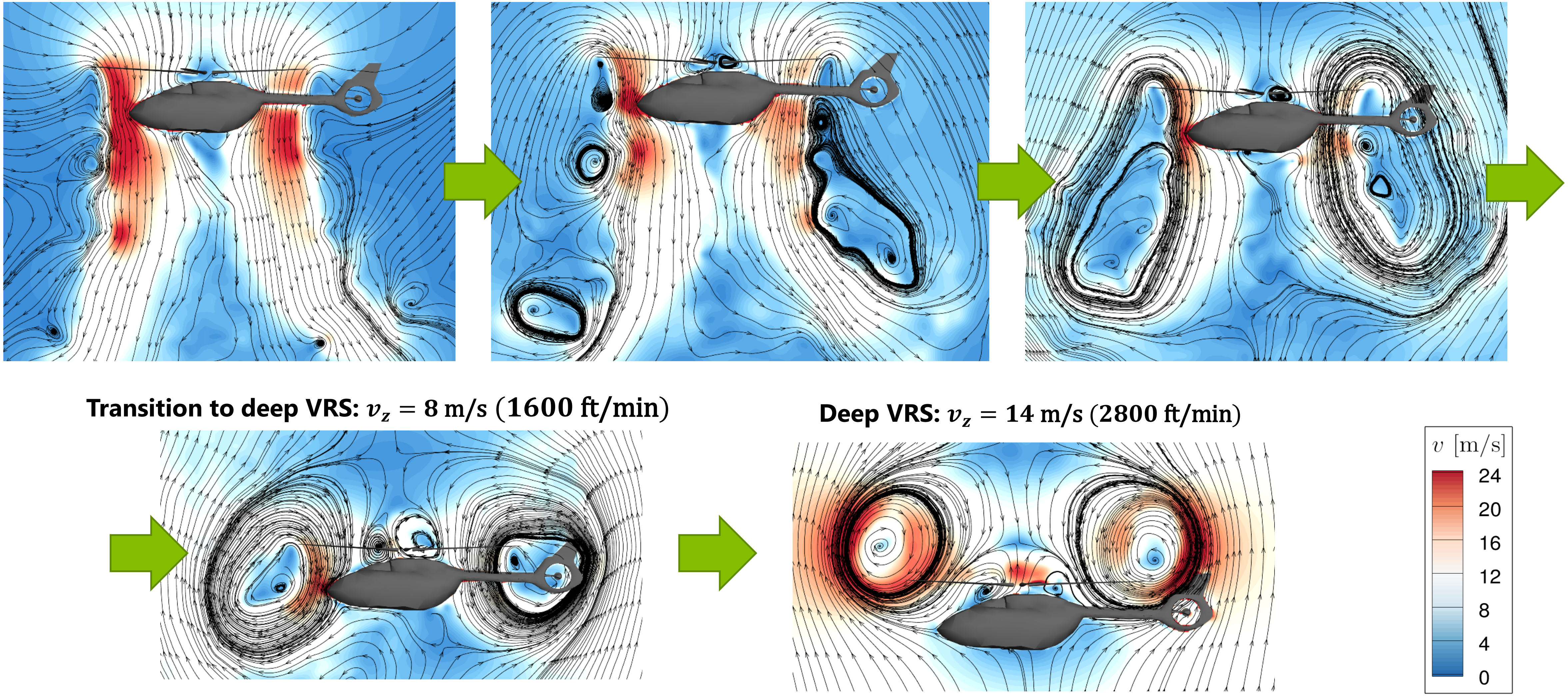
Slow climb: $v_z = -1\ \mathrm{m/s}$

Fast descent: $v_z = 2\ \mathrm{m/s}\ (400\ \mathrm{ft/min})$

Incip. VRS: $v_z = 5\ \mathrm{m/s}\ (1000\ \mathrm{ft/min})$

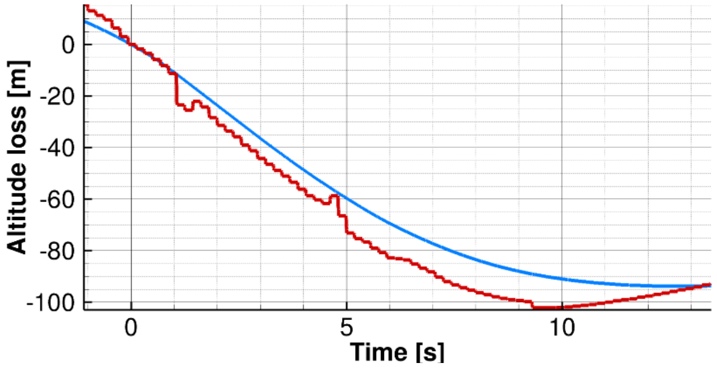
Transition to deep VRS: $v_z = 8\ \mathrm{m/s}\ (1600\ \mathrm{ft/min})$

Deep VRS: $v_z = 14\ \mathrm{m/s}\ (2800\ \mathrm{ft/min})$

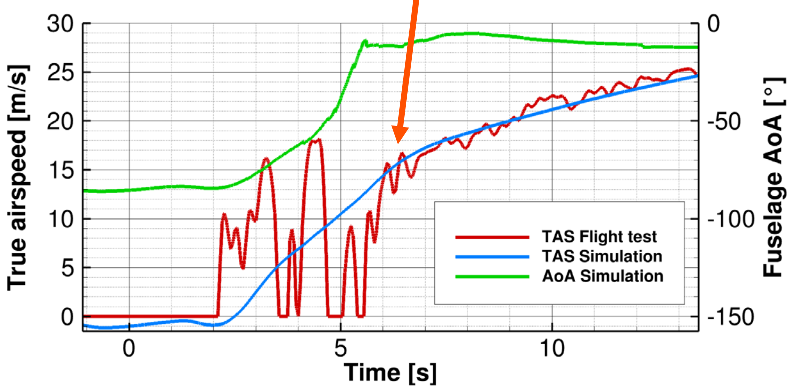


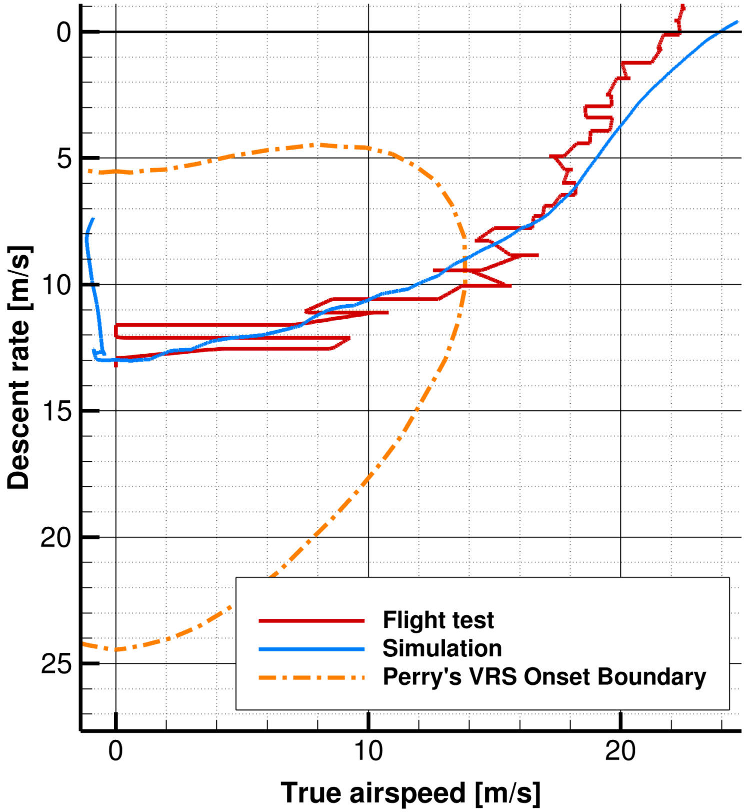
Validation: Comparison to Flight Test Maneuver – Power-Assisted

- Altitude loss similar (8% deviation)
- Airspeed curve shows that flight instruments are not reliable below 15 m/s
- Good match of flight path in VRS regime



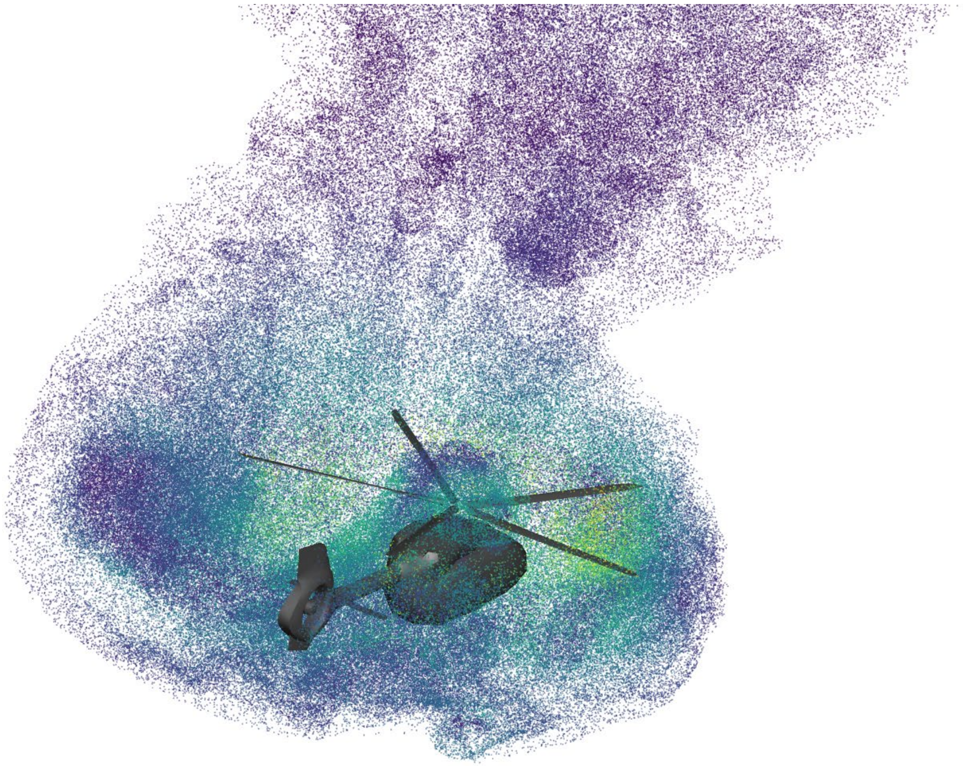
Reliable airspeed indication only above 15 m/s (29 kts)





Latest flight physical insights – flight test and numerical studies

Assessment of different recovery techniques



VRS Recovery Techniques investigated here: Overview

- Recovery strategies differ in recovery direction and collective input

FAA-Definition of „Traditional Recovery“ → Traditional, Constant-Power

Recovery strategies proposed by Airbus Helicopters SIN 3463-S-00 → Constant-Power, Power-Assisted, Pull Collective

„Vuichard Recovery“ according to FAA data → Vuichard

Traditional	Constant-Power	Power-Assisted	Pull Collective	Vuichard
• Pitch down (forward) • **Lower** Collective	• Pitch down (forward) • **Constant** collective	• Pitch down (forward) • **Increase** Collective	• **Increase** Collective ... to stop descent	• Roll left/right***** • **Increase** Collective
• Wait until airspeed indication (i.e. clear of vortex ring)	• Wait until airspeed indication	• Wait until airspeed indication		• Immediate, or short delay for 0.5 s
• Pitch up • **Increase collective** ... to stop descent	• Pitch up • **Increase collective** ... to stop descent	• Pitch up ... to stop descent		• Roll back to neutral ... to stop descent

***** *In direction of tail rotor thrust*

← Constant or decreases collective pitch | Increased collective pitch →

- Same amount of collective stick input used for all simulations, representative to average helicopter

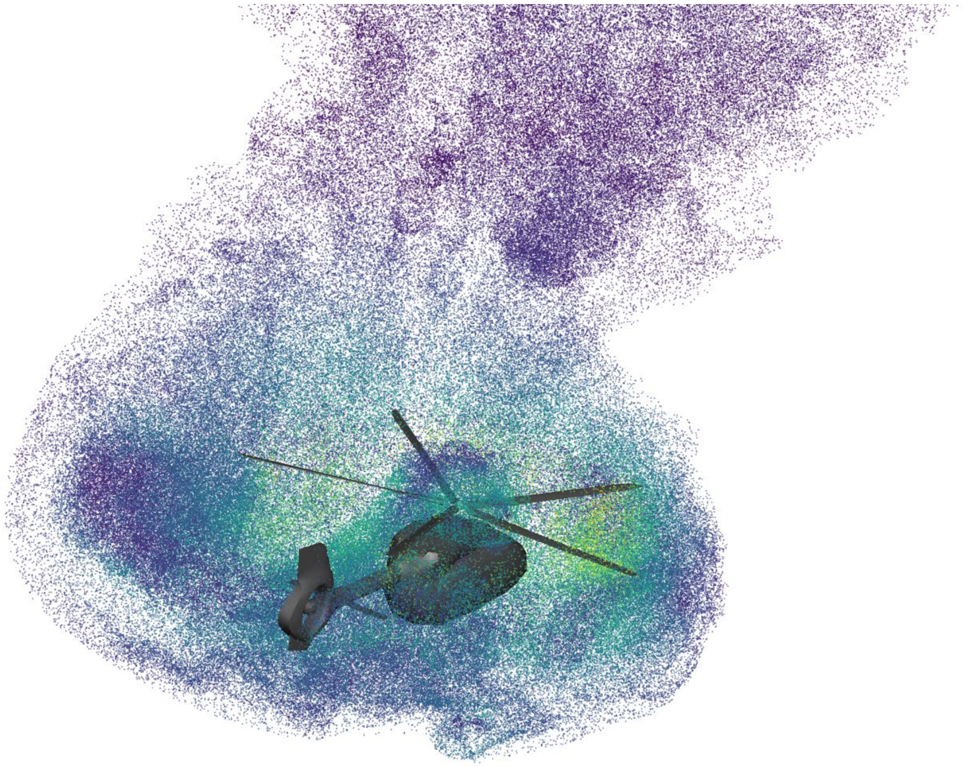
Traditional VRS Recovery FAA Helicopter Handbook

Quote from FAA Helicopter Flying Handbook (2019), Section on VRS Recovery Techniques:

"When recovering from a vortex ring state condition, the pilot tends first to try to stop the descent by ***increasing collective pitch****. However, this only results in* ***increasing the stalled area of the rotor, thereby increasing the rate of descent****. Since inboard portions of the blades are stalled, cyclic control may be limited. The* ***traditional recovery*** *is accomplished by increasing airspeed,* ***and/or partially lowering collective*** *to exit the vortex….. "*

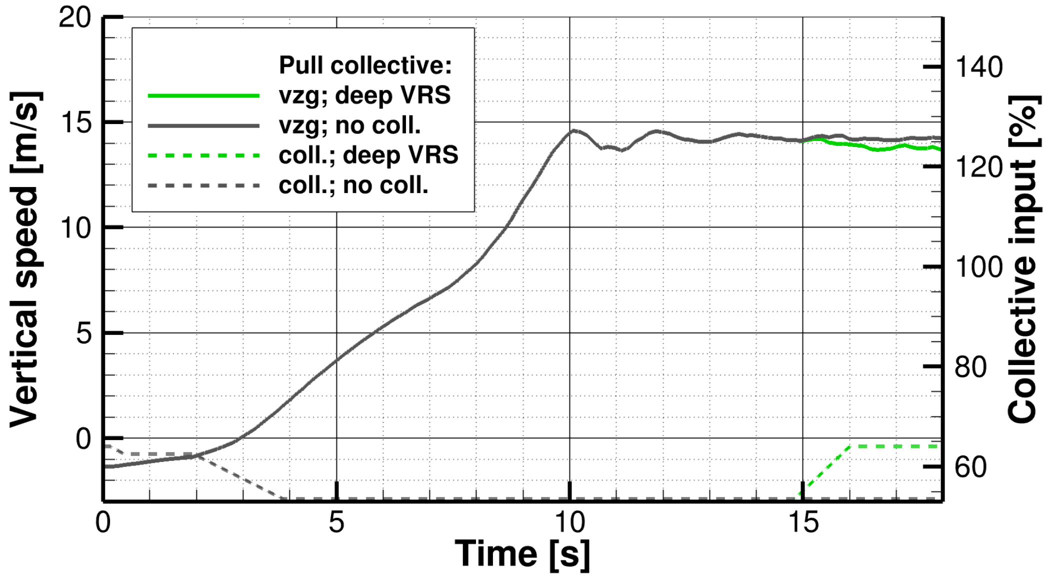
Latest flight physical insights – flight test and numerical studies

Effect of pulling collective

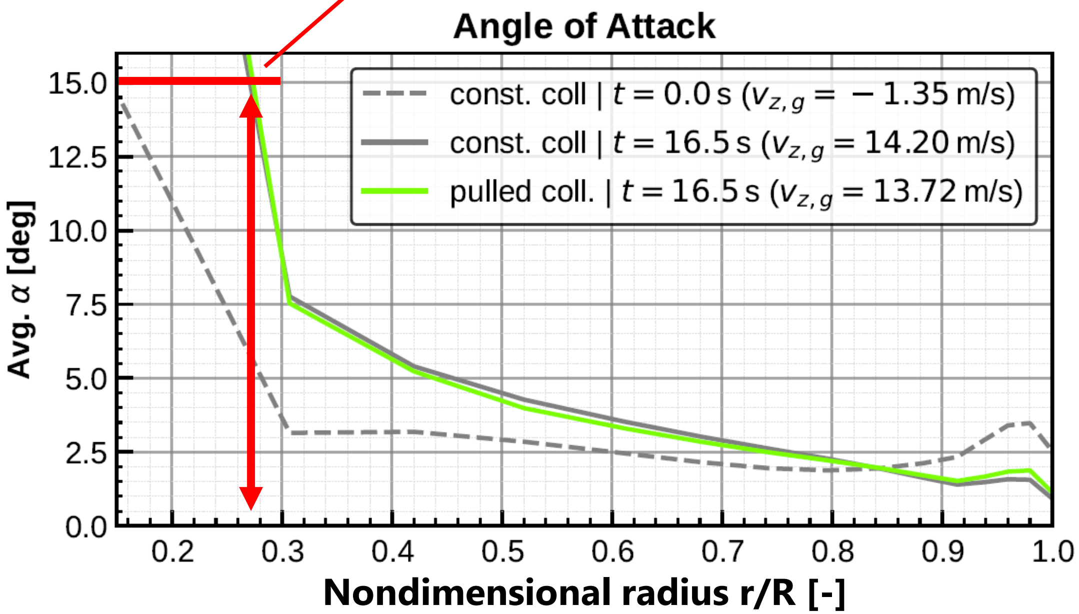


VRS Recovery Techniques: Pull Collective

→ Investigation: Pulled collective stick in deep VRS by 10.5%



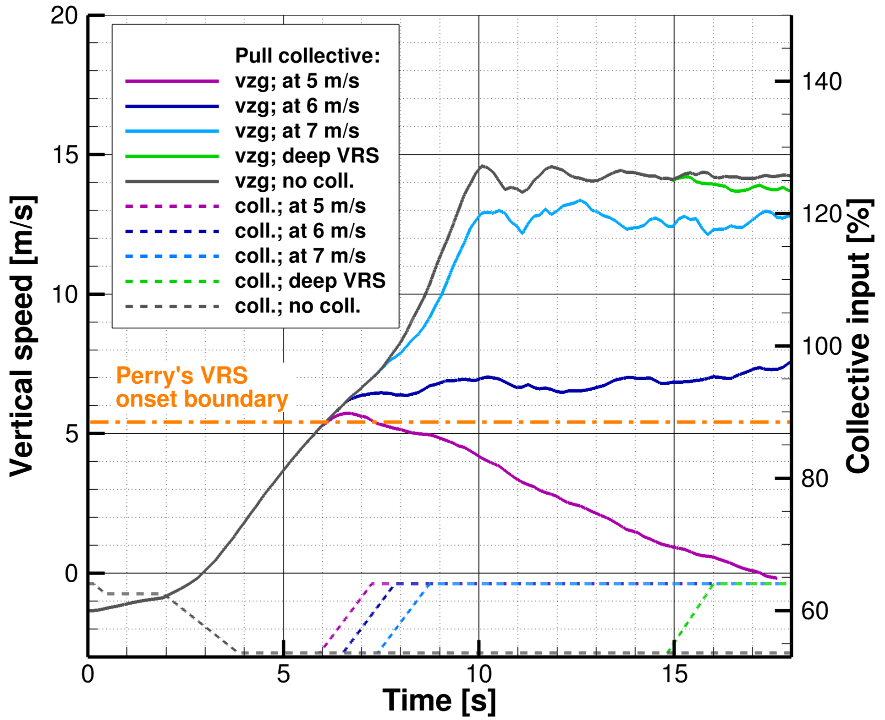
Approximate radial stall position at 27.5% of radius

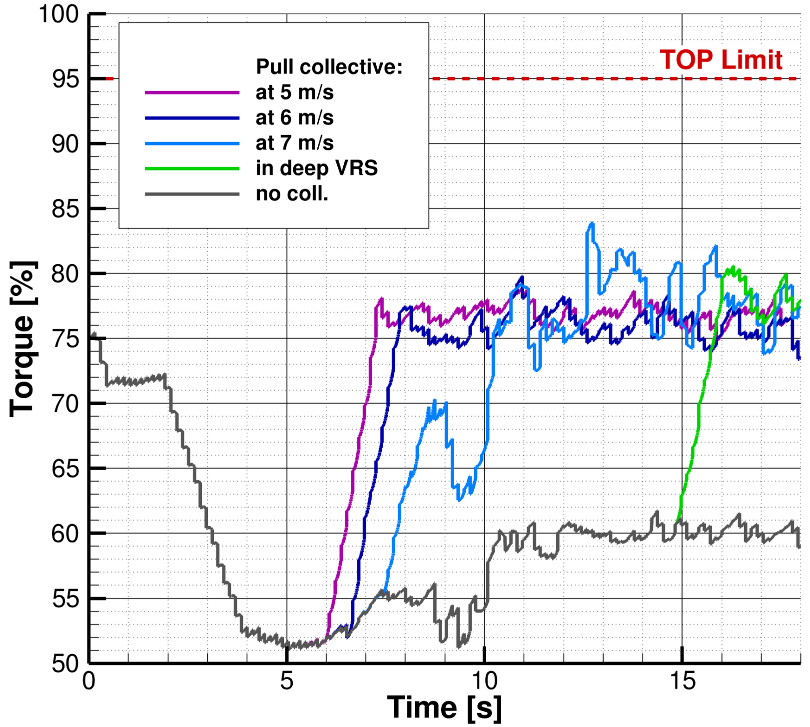


→ Slight decrease in descent rate, no significant change in stall area of blade section

VRS Recovery Techniques: Pull Collective

- Pulled collective stick at different times by 10.5% of collective lever travel



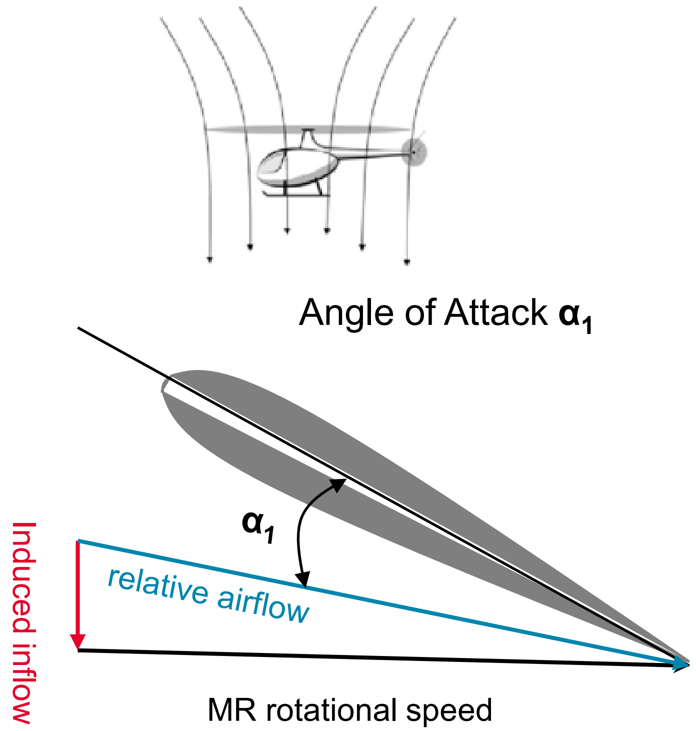


→Large power margin still available on the BK 117 D3, but…

→Torque increase chosen to represent helicopters with less power available

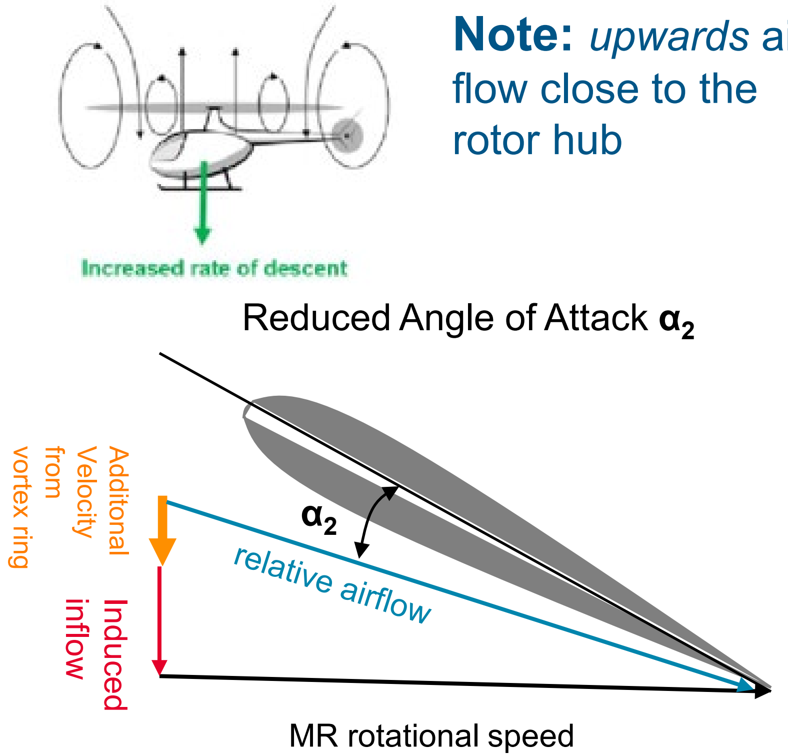
Vortex Ring State - Effect of VRS on angle of attack of the MR blades

Schematic depiction, cross-sectional view of a MR blade at an outward position



Cross-sectional view of a MR blade

Add induced velocity from vortex ring



Note: *upwards* air flow close to the rotor hub

$$\alpha_2 < \alpha_1$$

Less thrust for same collective pitch, higher stall margin

- **Increasing collective increases α / lift**

Pulling Collective in VRS recovery - Conclusion

- Pulling collective in VRS always provides lift and **decreases** descent rate
- Pulling collective always **decreases the loss of height** during VRS recoveries

Side note: VRS Avoidance and Detection system

- VRS prediction system as avialable on AH helicopters (H135, H145, H160, H175) equipped with HELIONIX:
  - Upon pre-vortex caution, **pulling collectve** an/or forward fly-away will help to **avoid** VRS

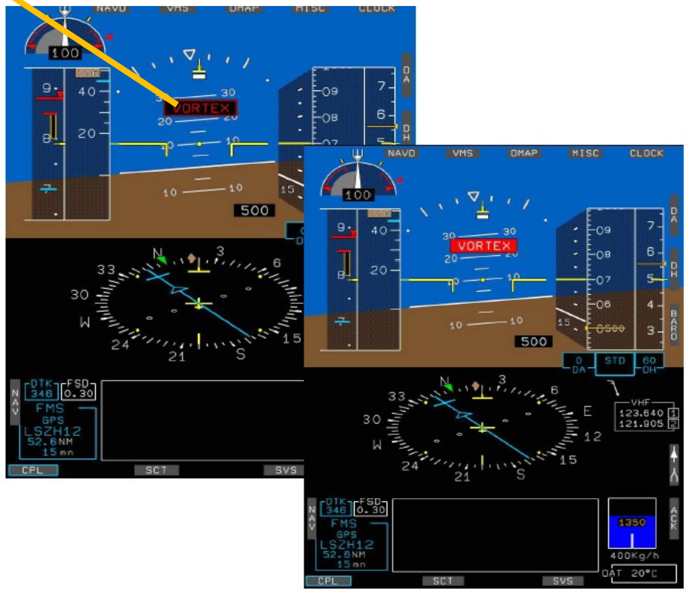
Avoidance: Pre-Vortex condition:

VORTEX Constant amber msg

+ aural alert ‚CHECK POWER‘ every 3s

Possible Vortex condition:

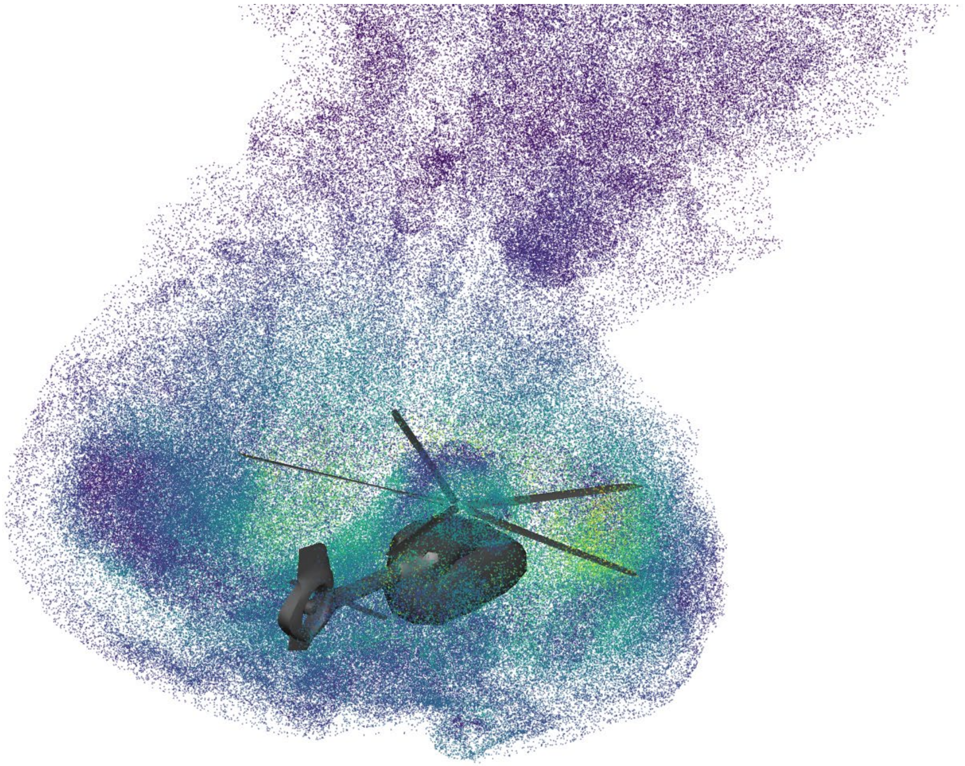
VORTEX Flashing VORTEX Flashing red



+ aural alert ‚VORTEX‘ every 3s

Latest flight physical insights – flight test and numerical studies

Power assisted recovery – parametric study for deep VRS



Power assisted recovery – parametric study for deep VRS

Power assisted recovery:

Power-Assisted

- Pitch down (forward)
- **Increase** Collective

- Wait until airspeed indication

- Pitch up

… to stop descent

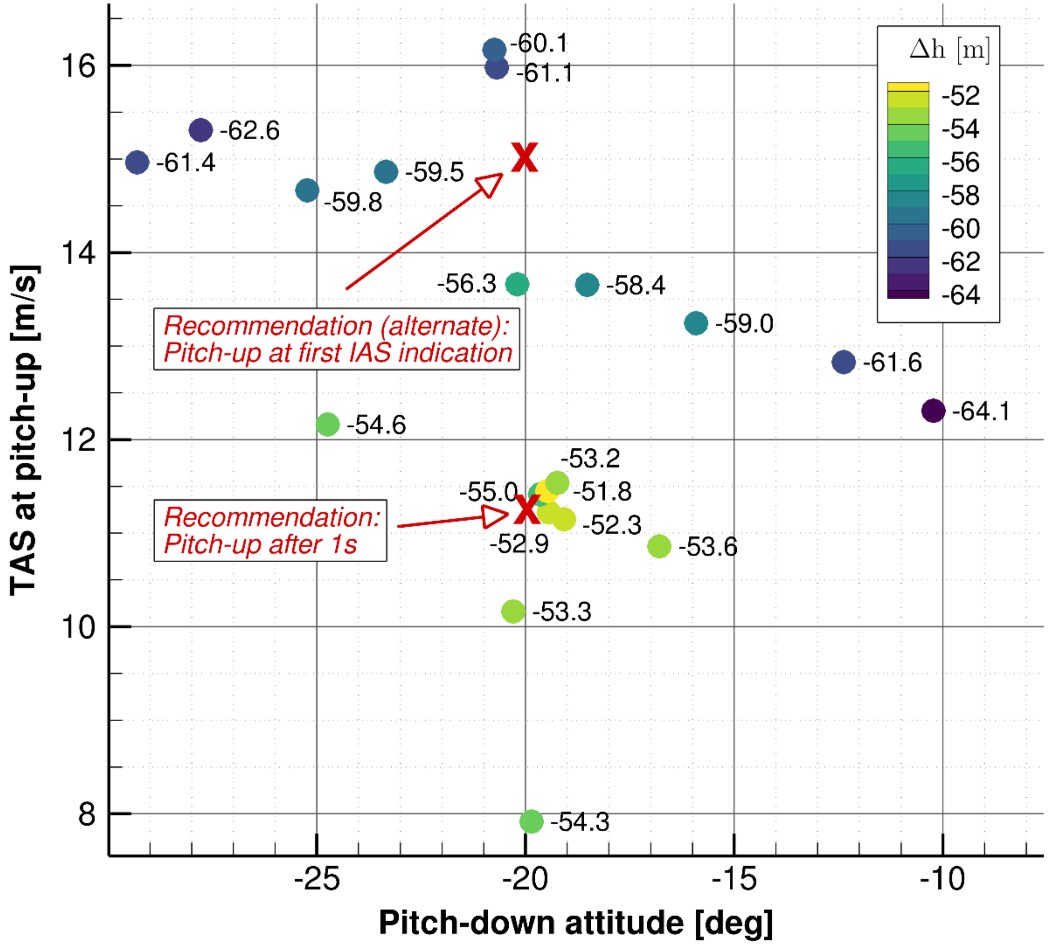
Parameter variations to check resilience of the methode:

- Recoveries initatied in deep VRS at different times (fluctuations in descent rate)
- Various pitch-down attitudes
- Various airspeeds at pitch up
- Various times holding the pitch down attitude

VRS Recovery Techniques: Power-Assisted

VRS Recovery Techniques: Power-Assisted (Deep VRS)

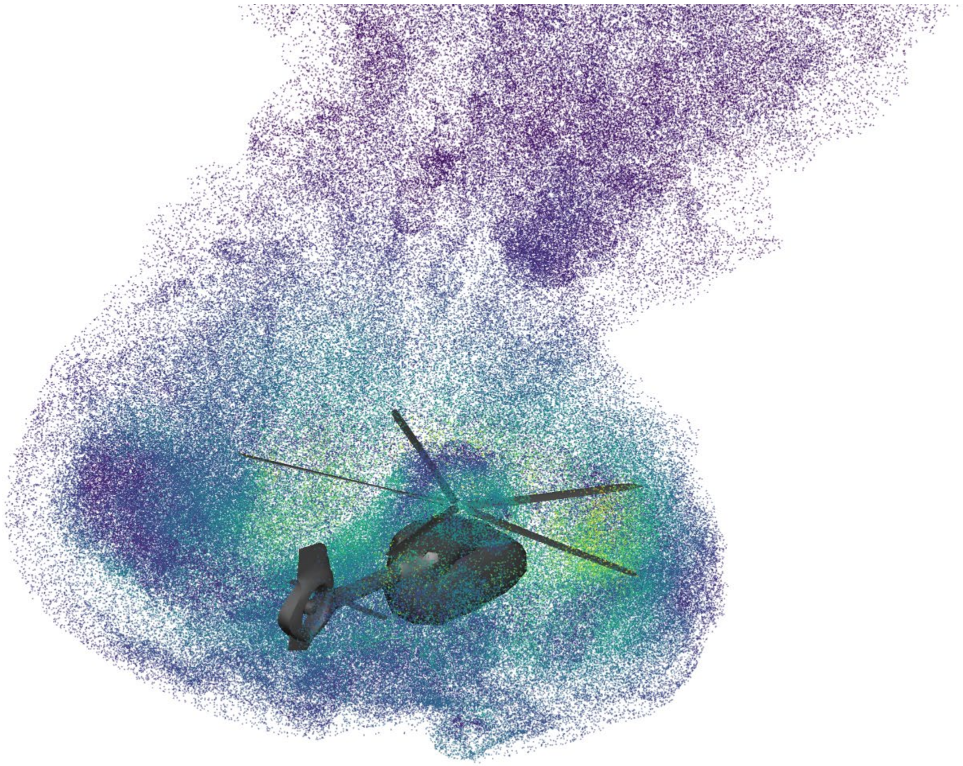
- Variation of minimum pitch attitude
  - *No significant impact on recovery performance for* $\theta_{min} < -15°$
- Variation of TAS at pitch-up
  - *Early pitch-up decreases height loss by ~12%*



→ Power-Assisted technique is very robust

Latest flight physical insights – flight test and numerical studies

Vuichard recovery – parametric study for deep VRS

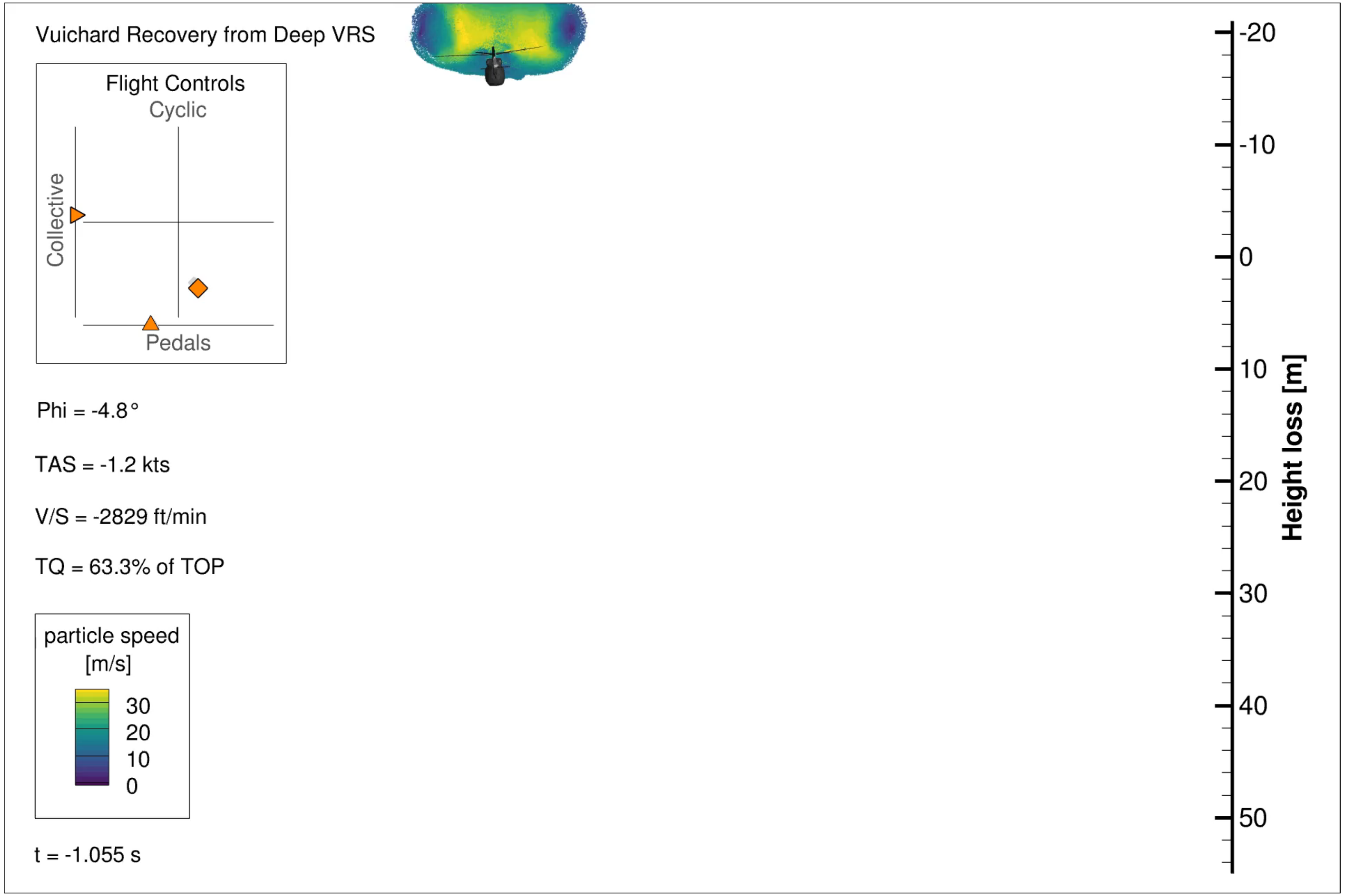


Vuichard Recovery- FAA Helicopter Handbook

Quote from FAA Helicopter Flying Handbook (2019), Section on VRS Recovery Techniques:

" In most helicopters, lateral cyclic thrust combined with an increase in power and lateral antitorque thrust will produce the ***quickest exit*** *from the hazard. This technique, known as the Vuichard Recovery (named after the Swiss examiner from the Federal Office of Civil Aviation who developed it)* ***recovers by eliminating the descent rate as opposed to exiting the vortex".***

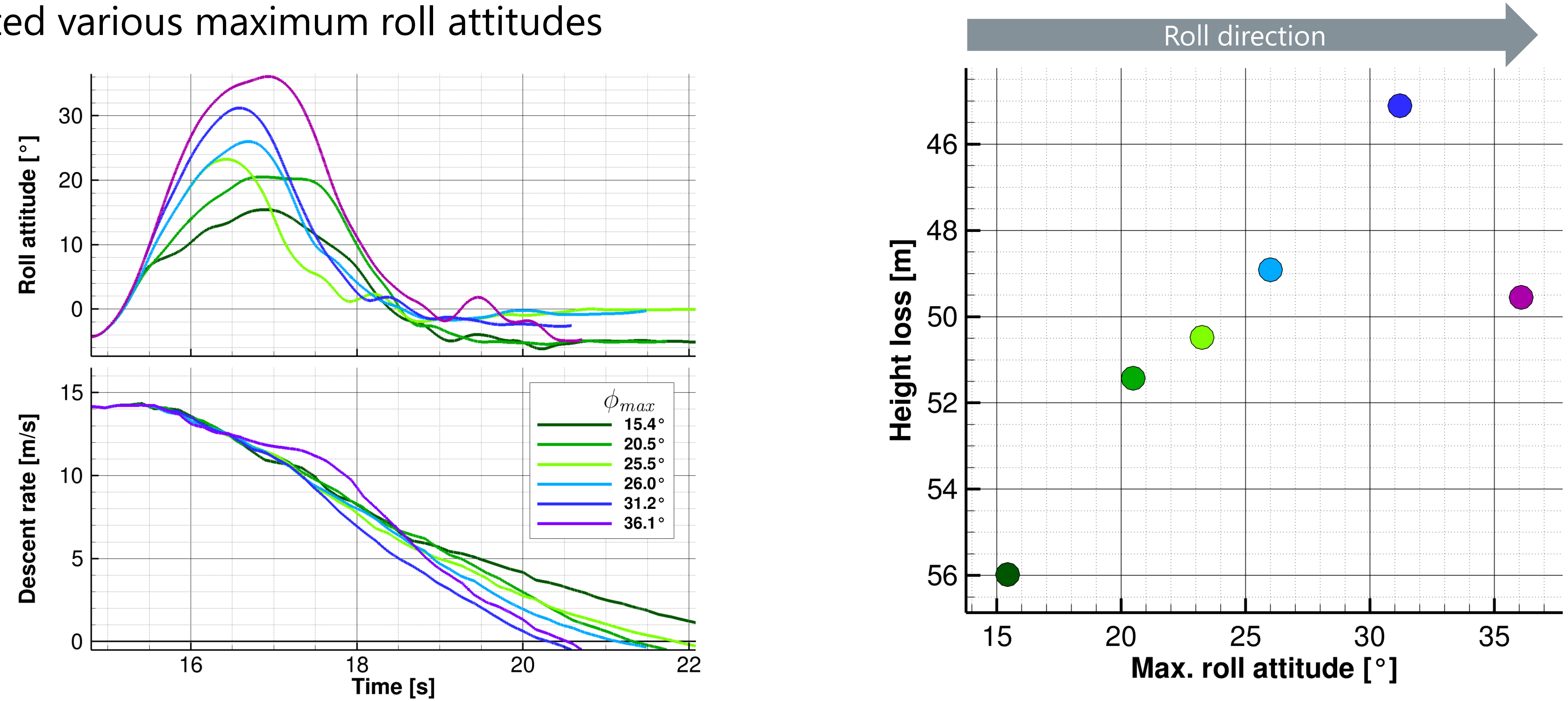
VRS Recovery Techniques: Vuichard



During the Vuichard recovery, the helicopter also **exits** the VRS

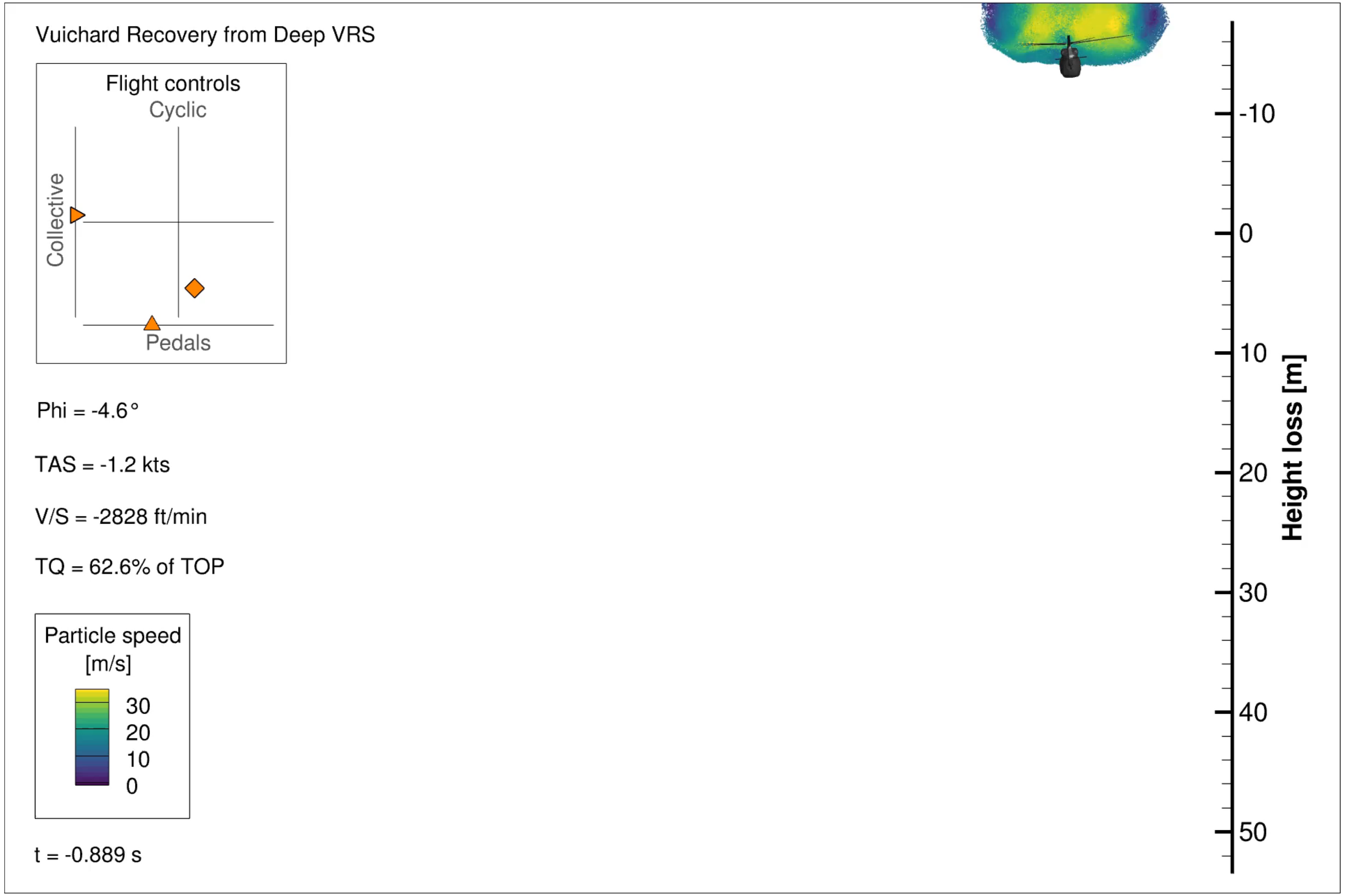
VRS Recovery Techniques: Vuichard (Deep VRS)

- Tested various maximum roll attitudes



→ Height loss minimal for $\phi_{max} \approx 30°$, relatively robust; recommendation: 25°

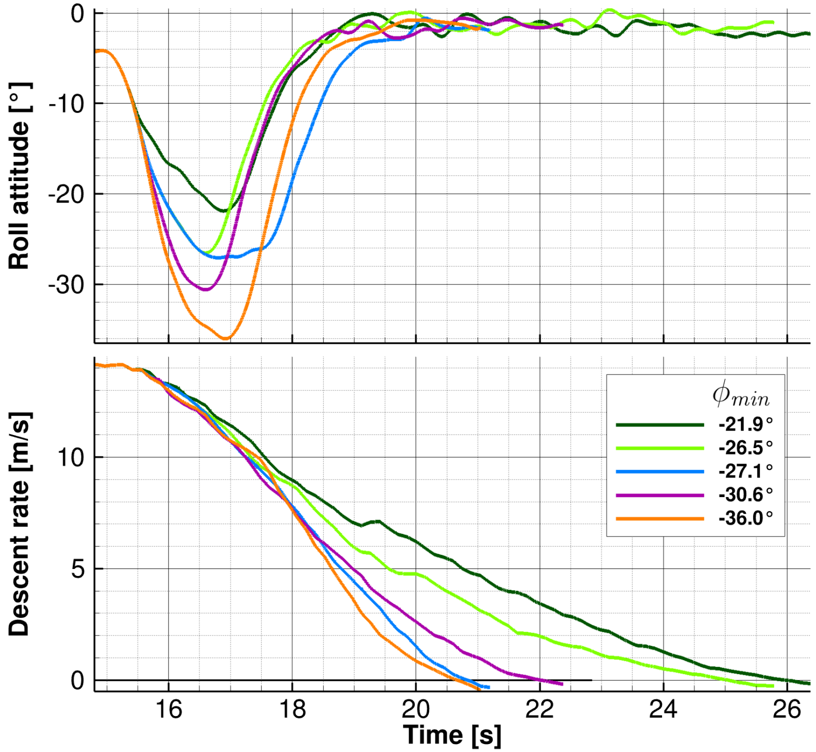
What happens if Vuichard is Executed in Wrong Direction? (Deep VRS)

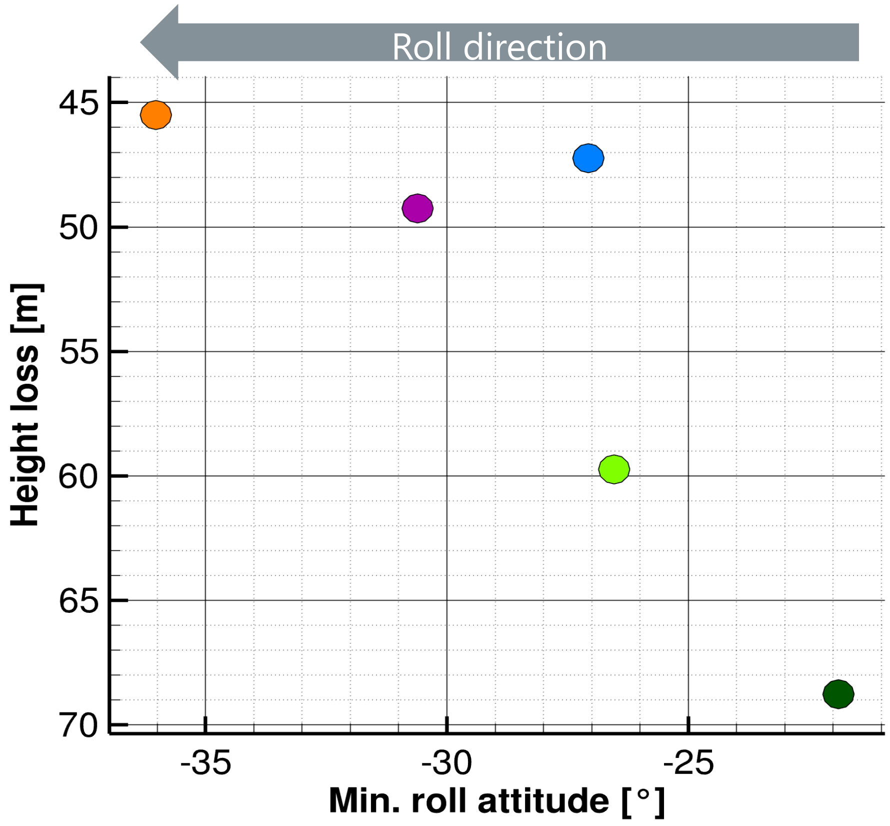


Confirmation of result: the helicopter also **exits** the VRS

What happens if Vuichard is Executed in Wrong Direction? (Deep VRS)

- Tested multiple roll attitudes and time of holding the minimum attitude



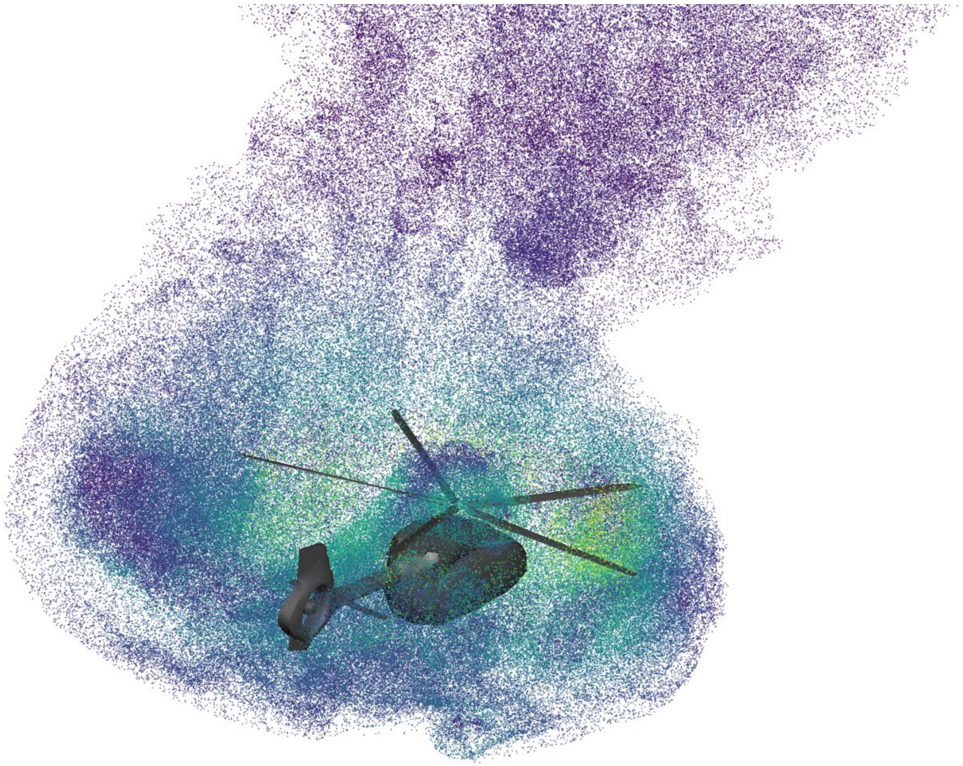


→ Recovery possible, similar height loss to normal Vuichard

→ Lowest height loss for large roll attitudes or when holding the maximum roll attitude for one second

Latest flight physical insights – flight test and numerical studies

Case of no Power Margin available
-Vuichard vs. Power Assisted Recovery

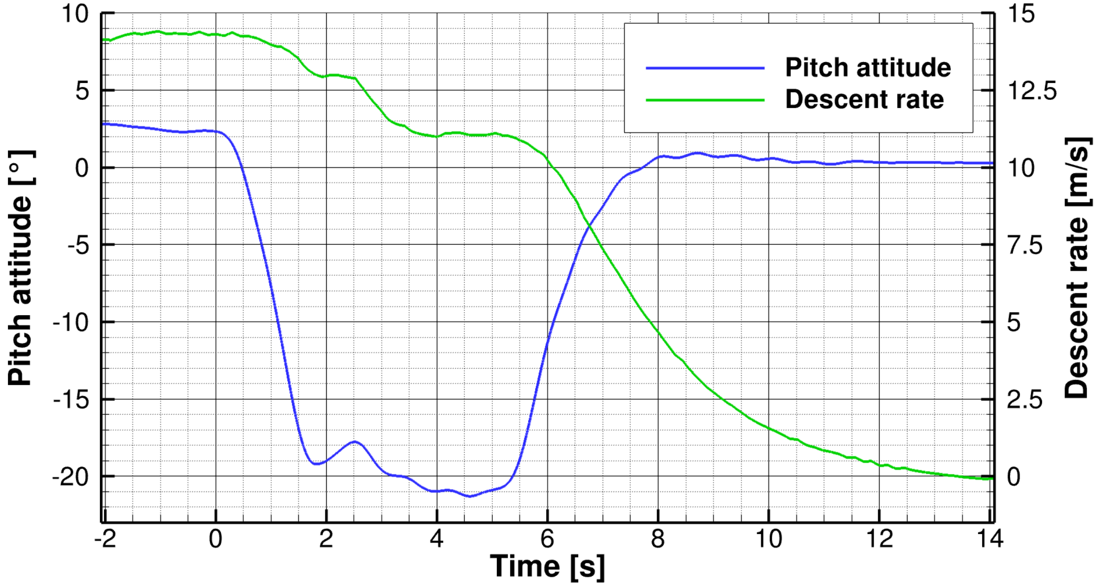


What Happens if no Power Margin is Available?

- Possible scenario: No power margin due to high density altitude and/or operation close to MTOW

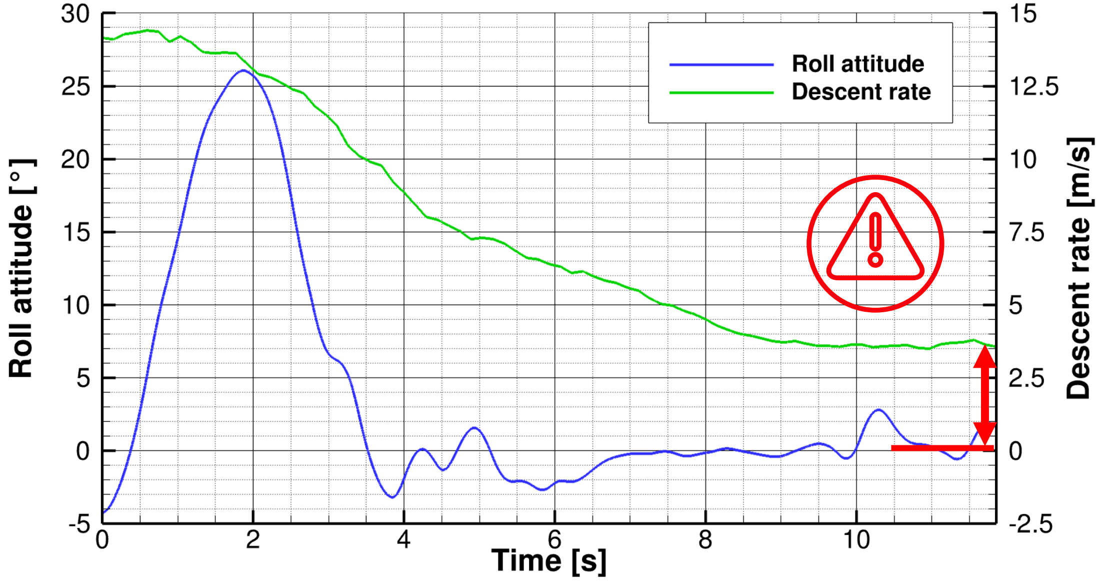
→ Collective stick cannot be pulled

Forward recovery without collective:



→ Successfully recovered

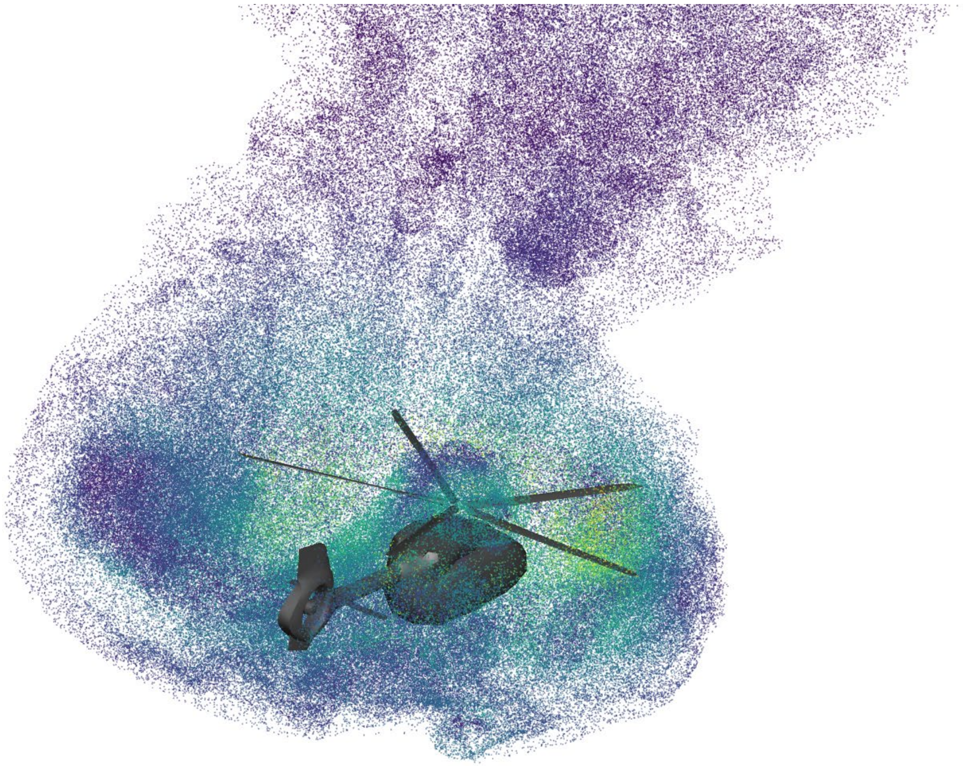
Vuichard recovery without collective:



→ **Failed to recover,** end point close to VRS domain with minimal horizontal velocity

Latest flight physical insights – flight test and numerical studies

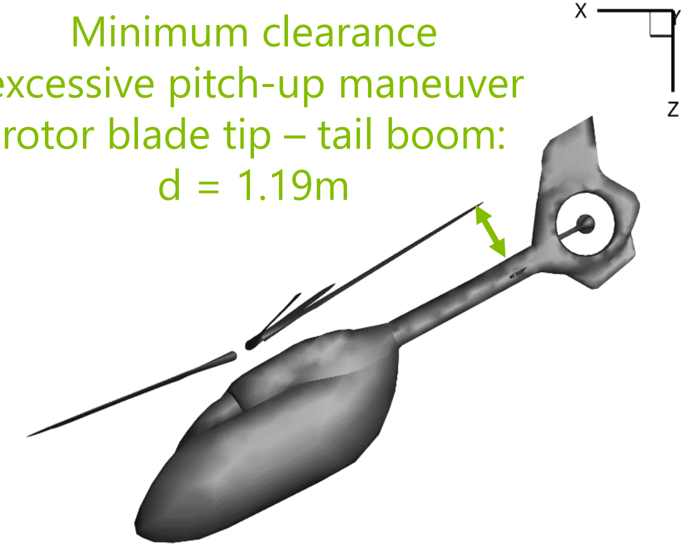
Considerations of loads and main rotor – fuselage clearance



Tail Boom Clearance of Main Rotor & Mast Bending Moment

- Power-Assisted recovery maneuver with excessive pitch-up motion (39°/s)
  - → Tail boom clearance still 1.19m (see screenshot)
  - → Maximum mast bending moment **45.6%**
    - *(during recommended execution < **41.8%**)*
- Vuichard recovery maneuvers with non-excessive control movement
  - → Most recoveries: mast bending moment in **yellow** range
  - → Maximum mast bending moment of **68.4%** during one maneuver

Minimum clearance excessive pitch-up maneuver rotor blade tip – tail boom: d = 1.19m



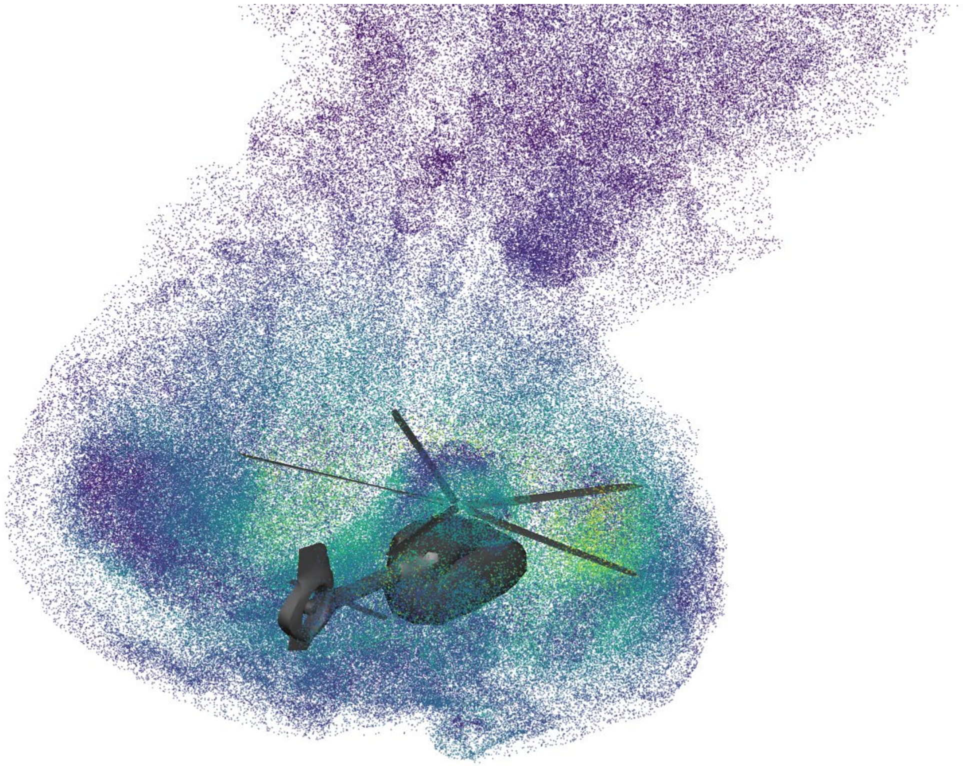
Potential risk, to be investigated:

- Offloaded rotor in traditional recovery (free teetering rotor):
  - → Simulation data suggests proximity to 0.5g-criterion

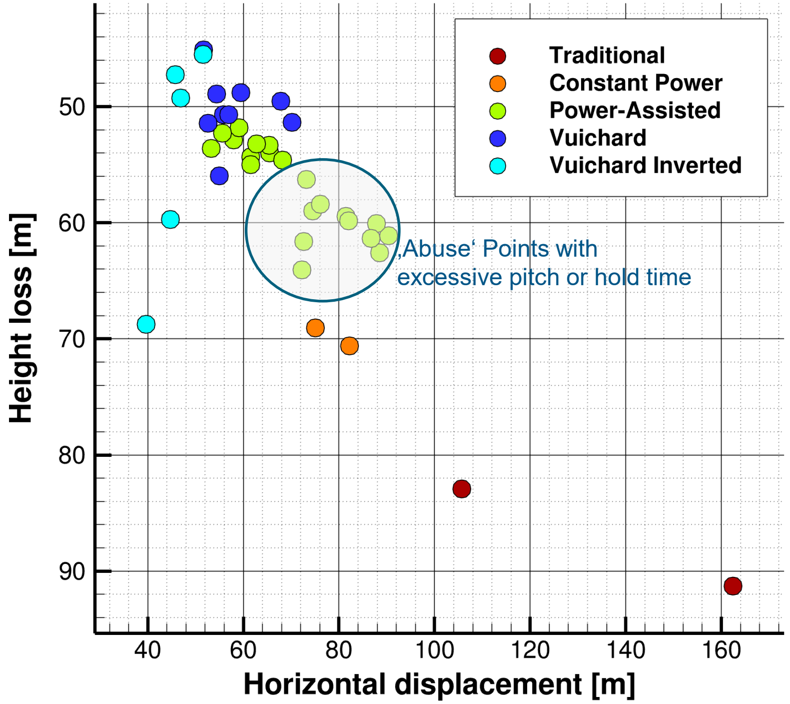
Mast bending moment limits		
Green	*0% – 54%*	
Yellow	*54% – 68%*	*Caution*
Red	*> 68%*	*Conditional maintenance inspection required*

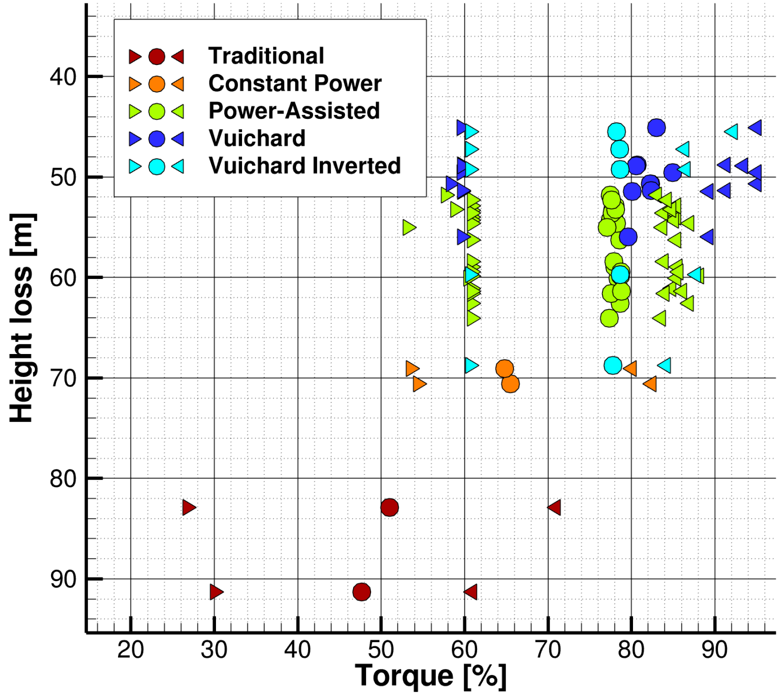
Latest flight physical insights – flight test and numerical studies

Comparison of VRS recovery methods (Deep VRS)



Comparison of recovery methods



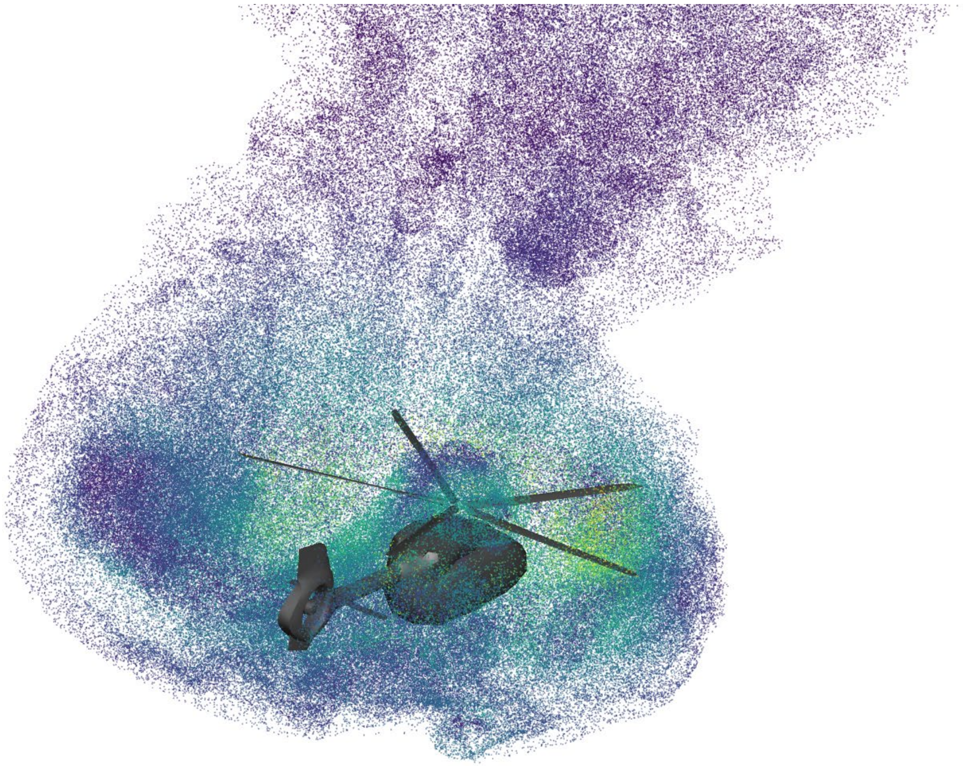


- Lowest height loss for Vuichard & inverted Vuichard; slightly more height loss with Power-Assisted
- Excessive height loss & horizontal displacement for Traditional recovery technique
- Power assisted & traditional recovery require low level of piloting skill, are intuitive
- Vuichard & inverted Vuichard recoveries require high level of piloting skill / simultanious inputs roll, pitch & yaw
- Higher mean & maximum torque for normal Vuichard compared to Power-Assisted

Latest flight physical insights – flight test and numerical studies

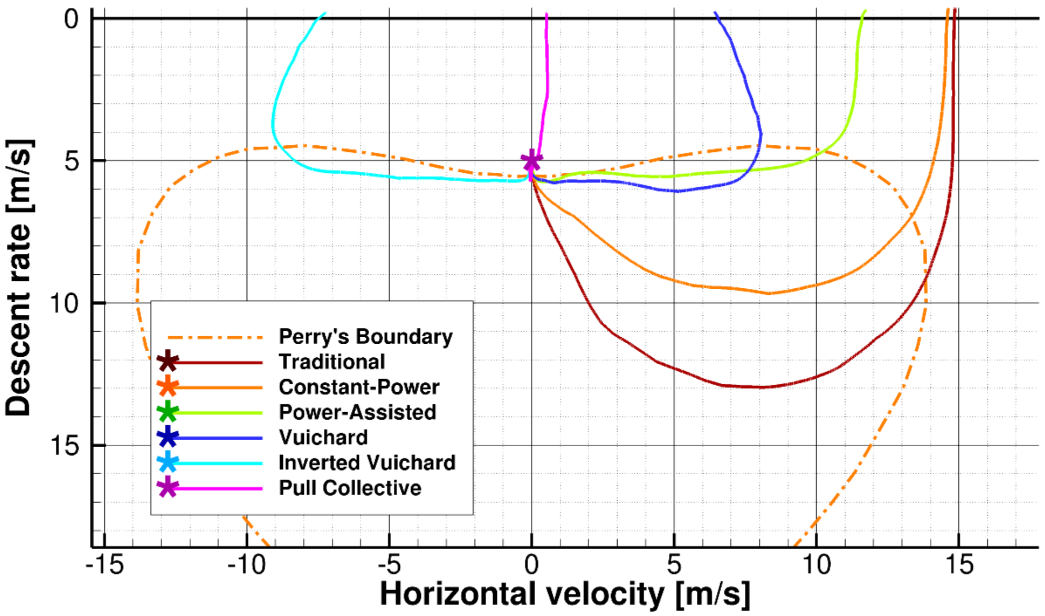
Comparison of VRS recovery methods (Incipient VRS)

-*Most frequently encountered case in real flight ops!*

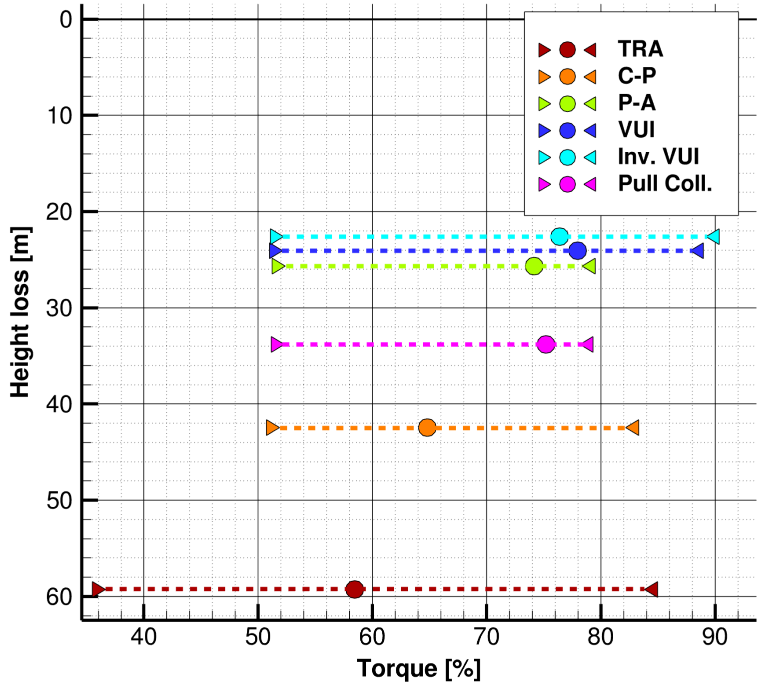


Comparative Analysis: Incipient VRS

Speed domain diagram:



Torque vs. height loss:



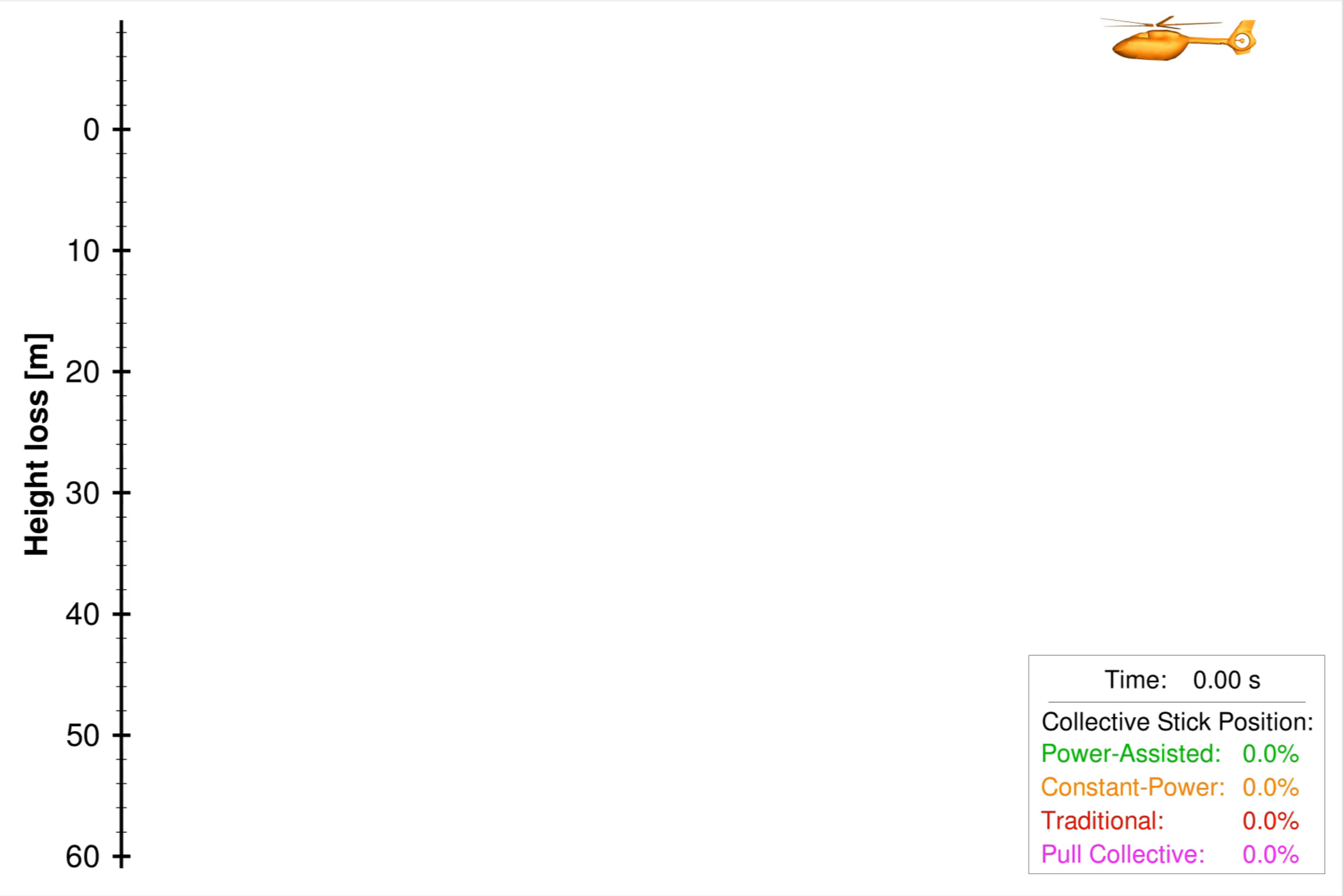
→ Power assisted, Vuichard and inverted Vuichard with very similar height losses and recovery times

→ Not increasing collective stick (or even lowering it) leads to significant increase in height loss

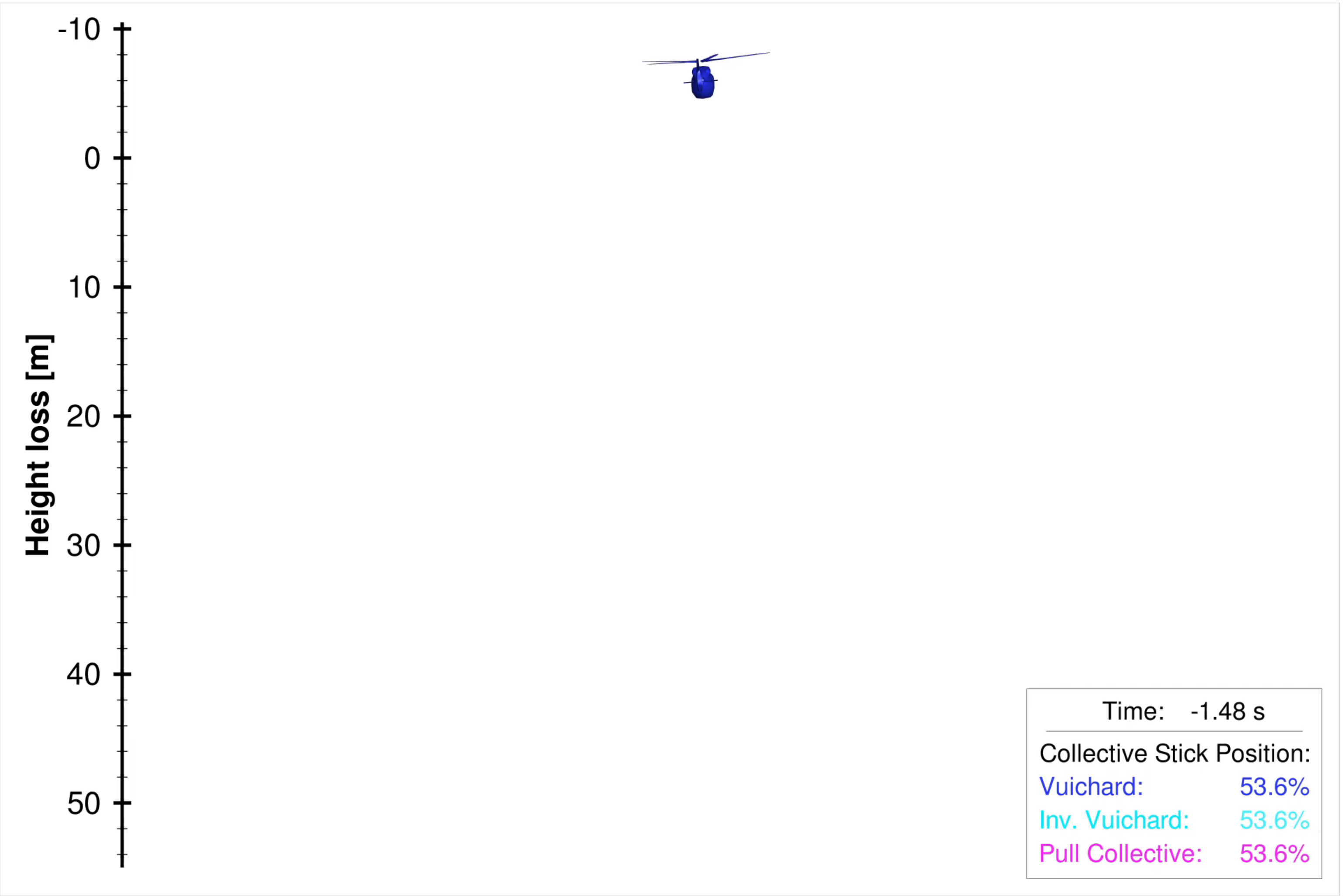
→ Pulling collective alone is more effective than Constant-Power and Traditional recovery

→ Vuichard good in height loss, but also increased torque – Inverted Vuichard better with lower average torque

Comparative Analysis: Incipient VRS

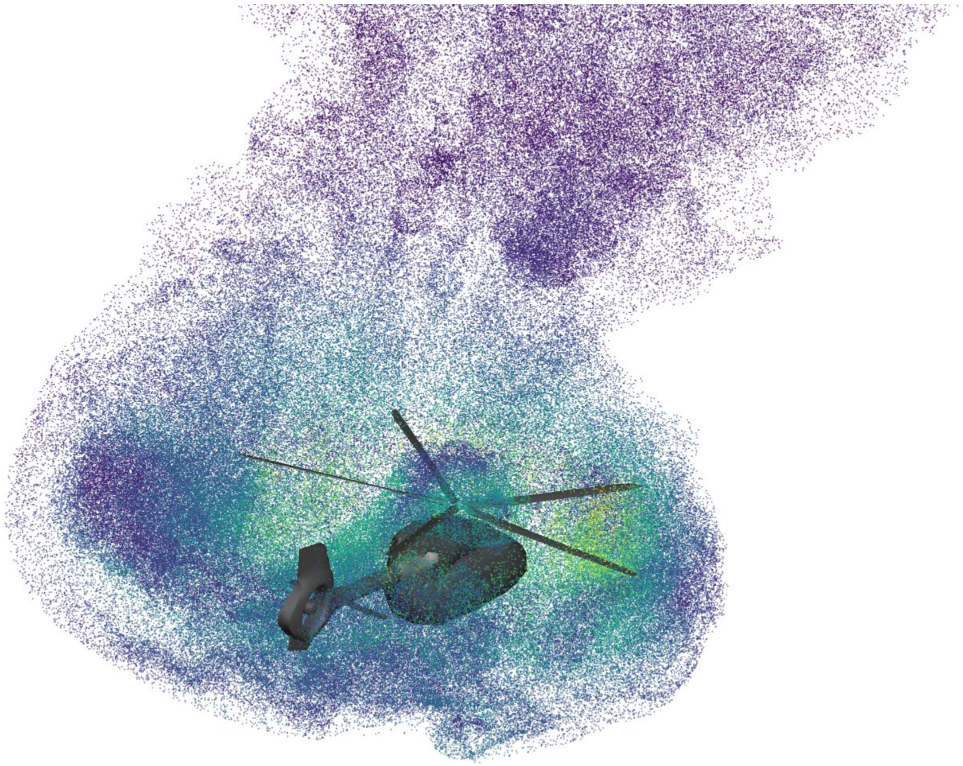


Comparative Analysis: Incipient VRS



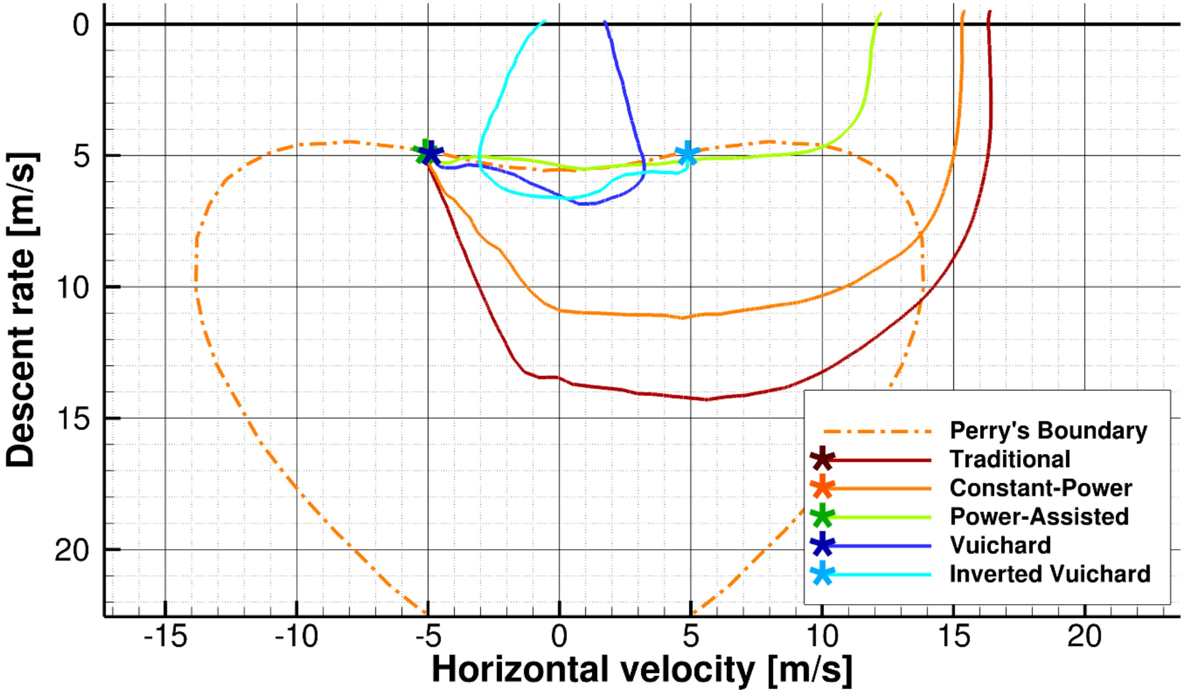
Latest flight physical insights – flight test and numerical studies

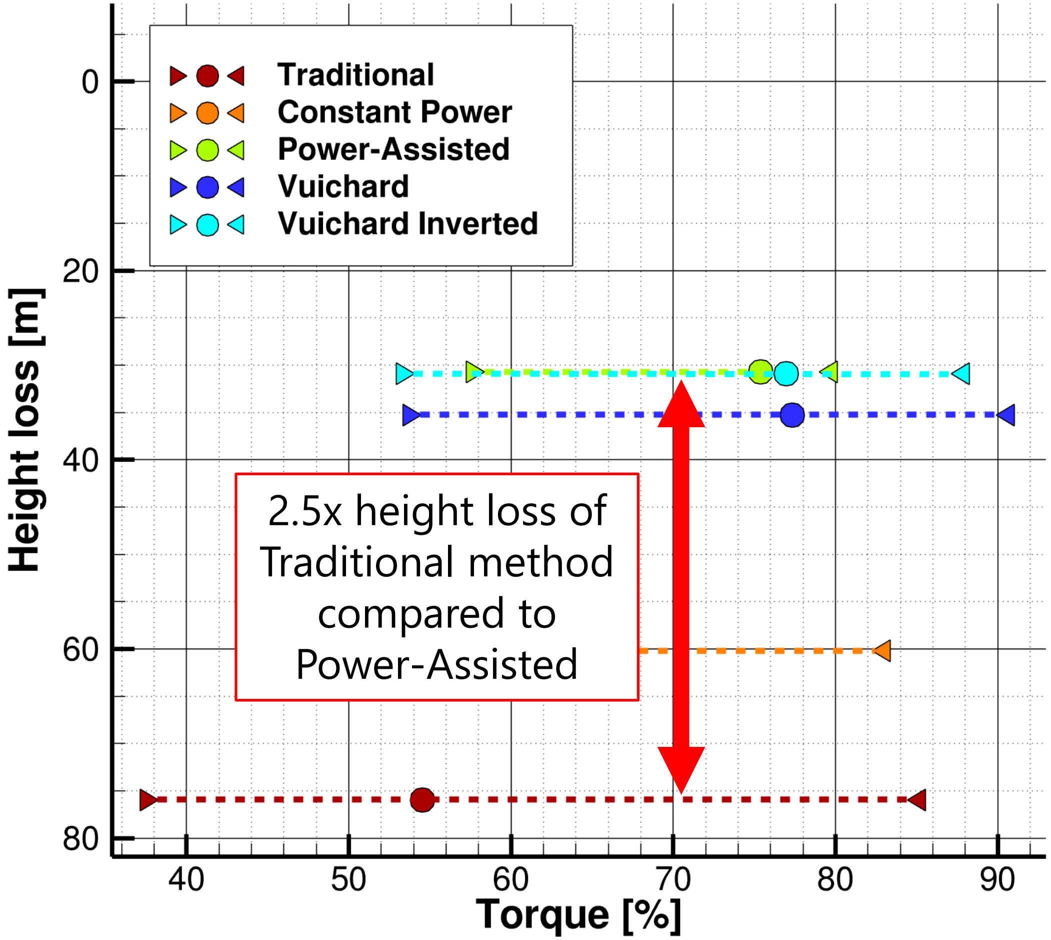
Recovery when hovering in wind



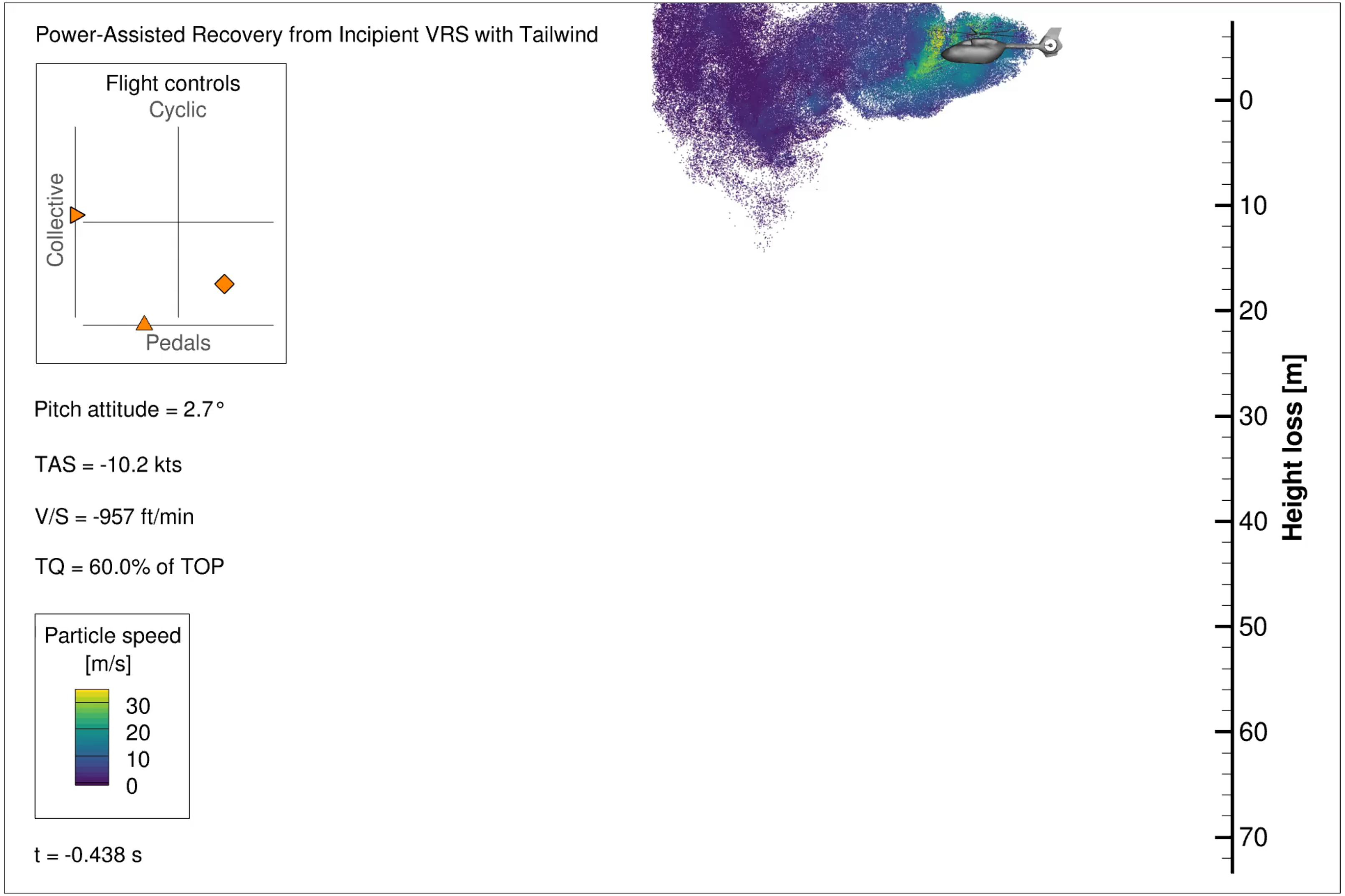
Comparative Analysis of Recovery Effectiveness: Incipient VRS with Wind

- 5 m/s wind from the adverse direction (tailwind for fwd recoveries, crosswind for Vuichard recoveries)
- Helicopter falls into deep VRS for Traditional Recovery
- Lower height loss with Power-Assisted recovery than Vuichard, as early roll-back decreases horizontal velocity.

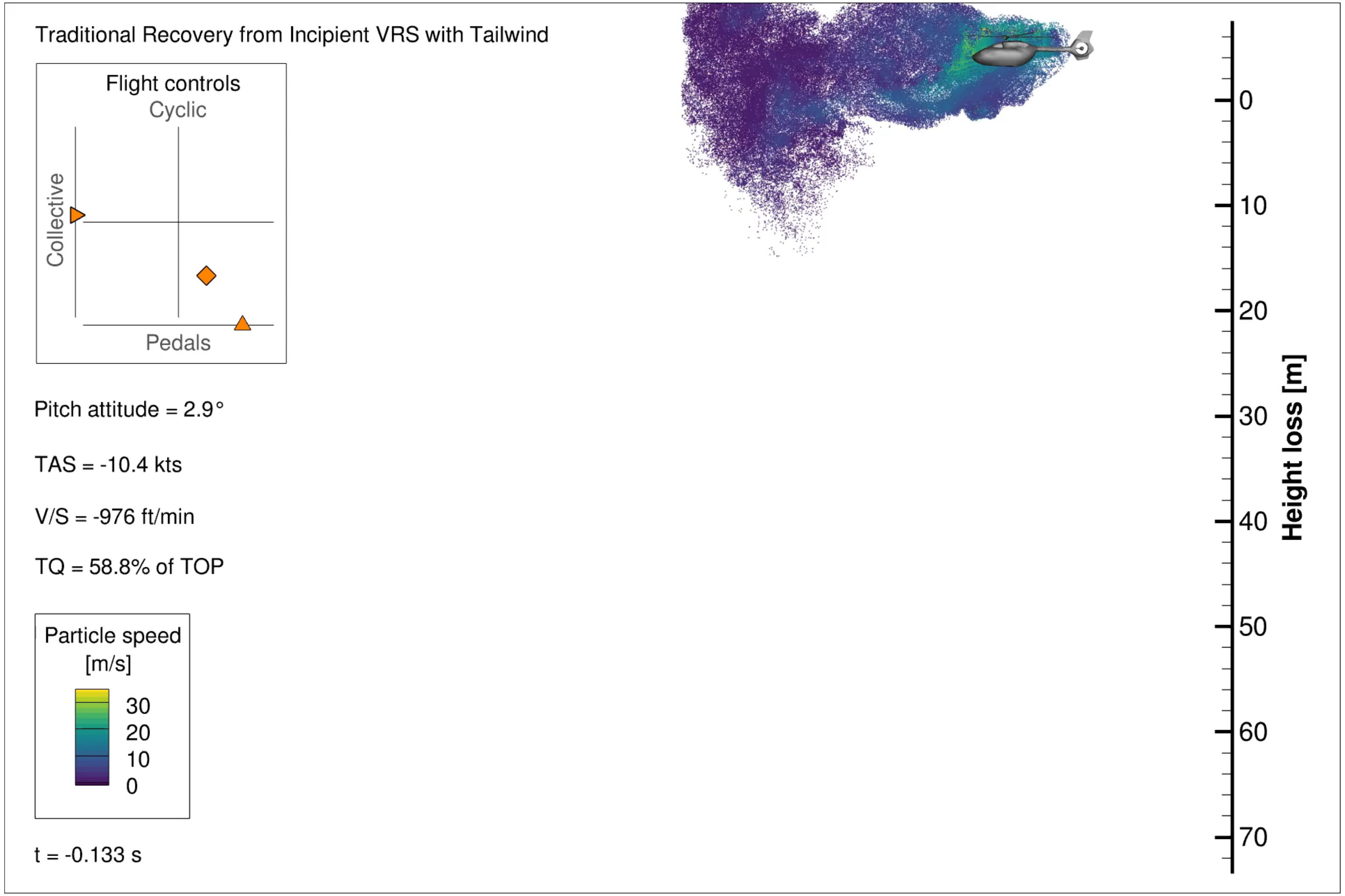




Comparative Analysis: Power-Assisted Recovery from Incipient VRS with Wind



Comparative Analysis: Traditional Recovery from Incipient VRS with Wind



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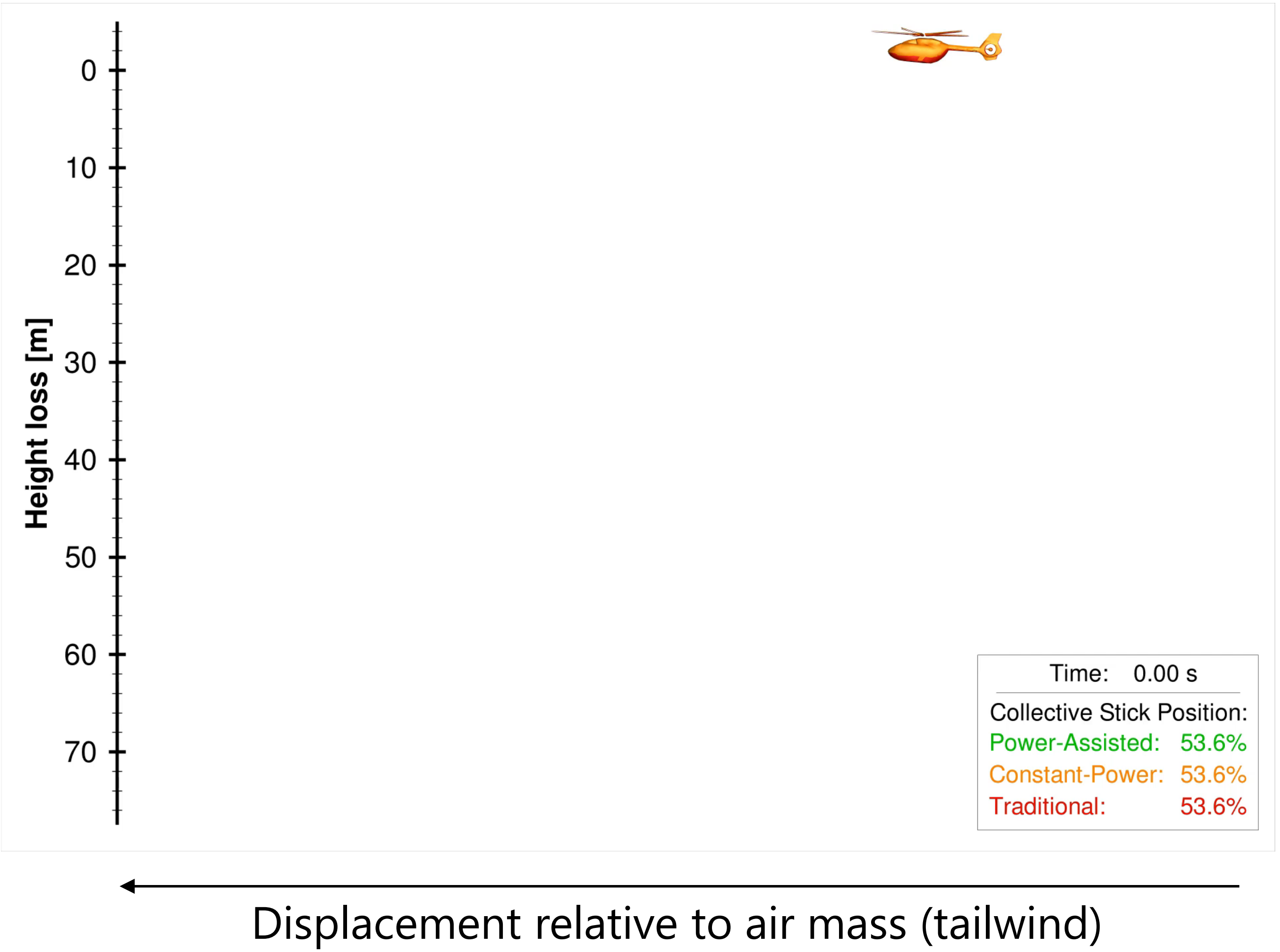
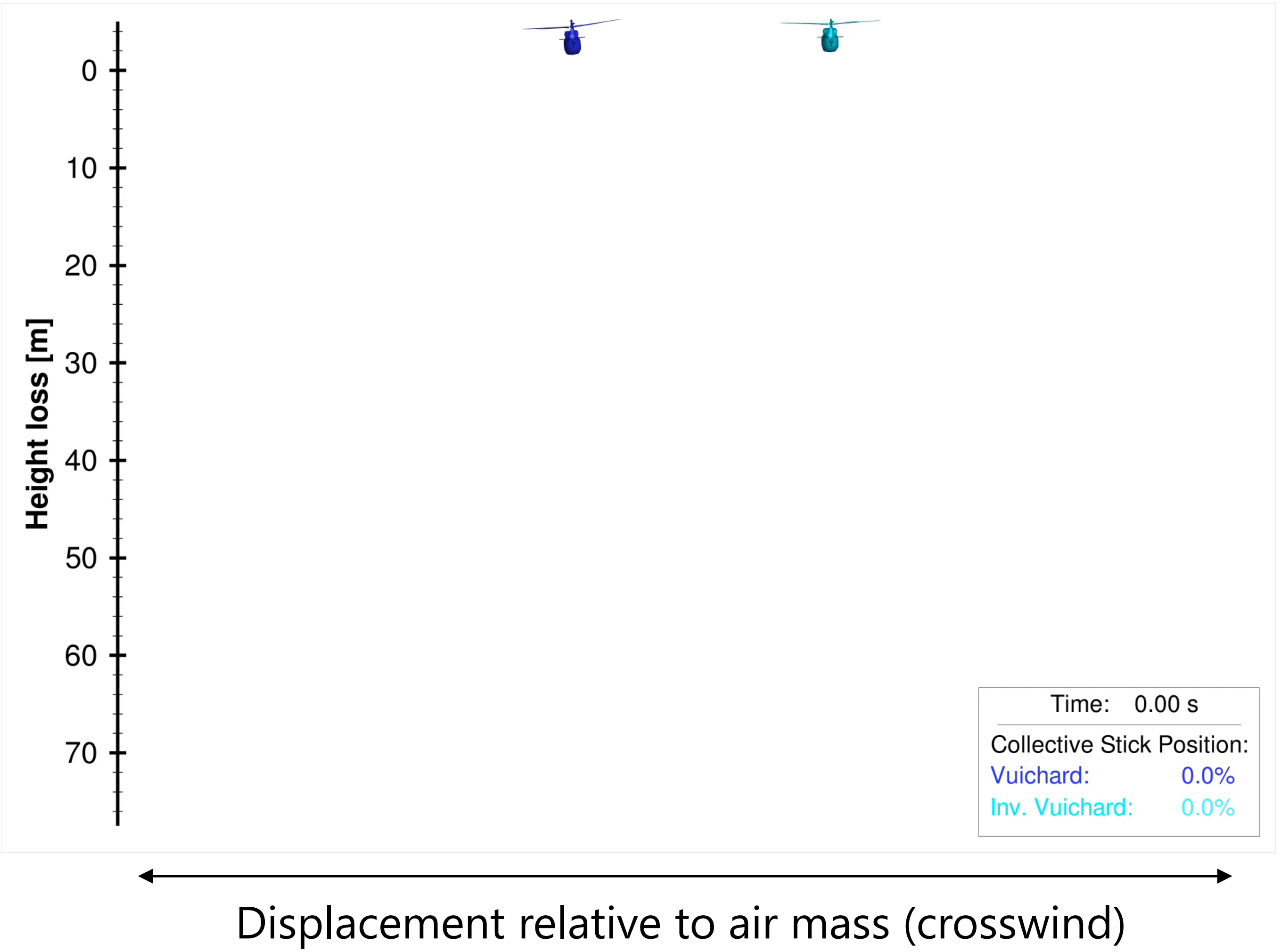
Comparative Analysis: Incipient VRS with 5 m/s Tailwind



Comparative Analysis: Incipient VRS with Wind



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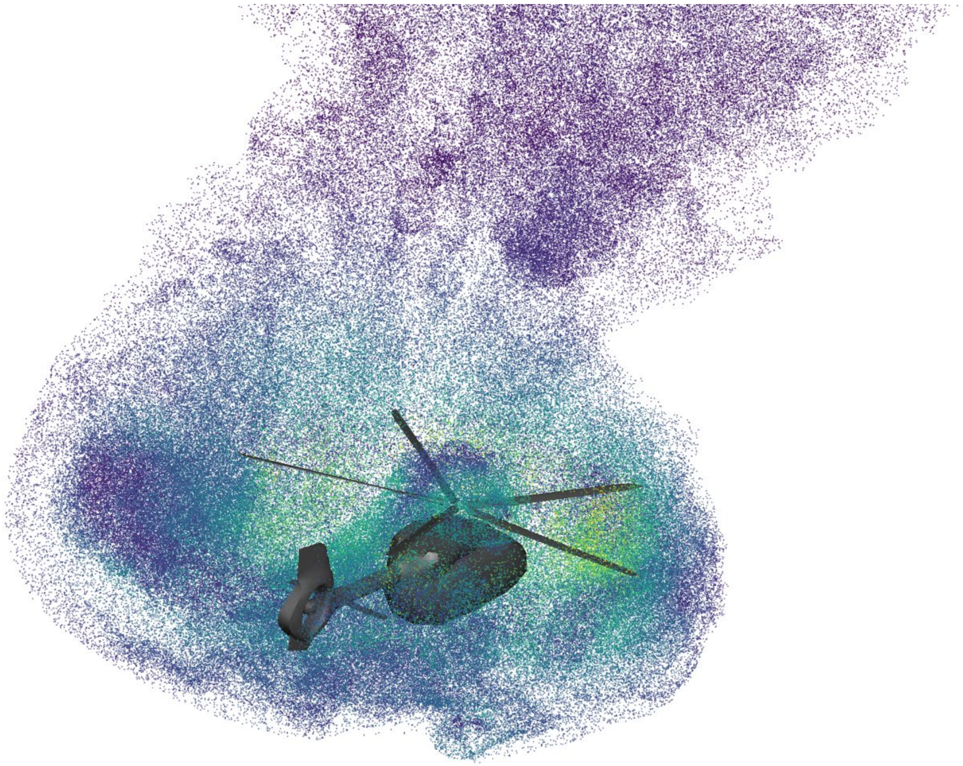
Comparison with Other Studies



Comperative Studies -1

- EASA launched the Helicopter Vortex-Ring-State Experimental Research project (EASA.2022.C11) in November 2022.
- This project was conducted under a contract between the EASA and ONERA/DGA-EV and was funded from the European Union's Horizon Europe research and innovation programme.
- Project included a flight test campaign
  – 177 recoveries performed (Various VRS entries, recoveries at various VRS stages)
  – Forward-, Vuichard-, Inverse Vuichard applied
- Reports available on EASA web site

Conclusions

This project is funded from the European Union's Horizon Europe research and innovation programme.

Recovery techniques

- On average, a slight increase of the performance could be seen with the Vuichard recovery manoeuvre at VRS onsets;
- In established VRS: no major differences on Fennec, Vuichard recovery is worse on Dauphin;
- Surprisingly, the inversed Vuichard recovery gave very interesting results and should be further investigated;

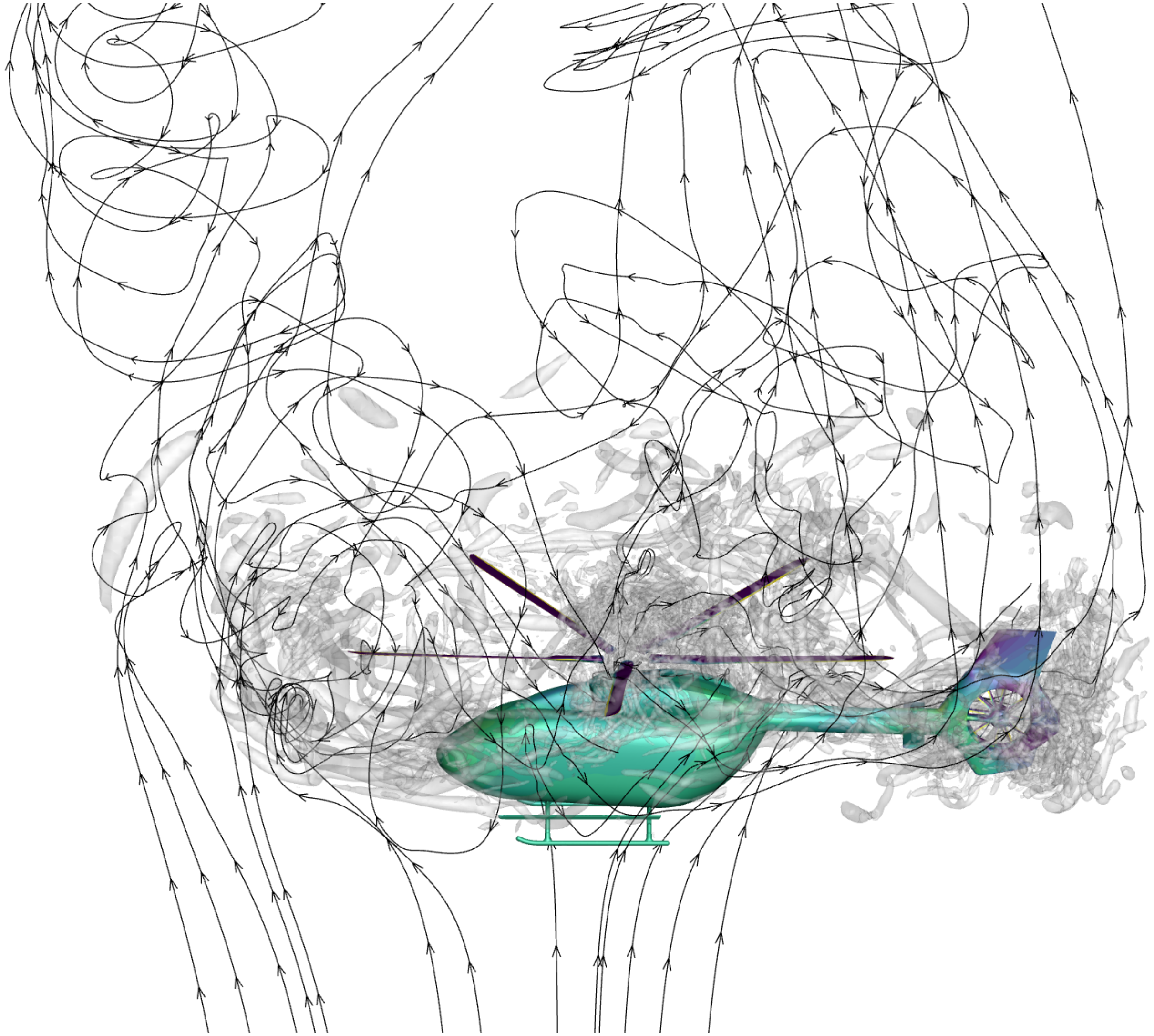
Pilot feedback:

- In general, the lateral motions of the Vuichard recoveries were also judged less “intuitive” than the forward motion by both test pilots, as their natural instinct (consistent with the emergency procedures in case of failure in hover) is to increase speed toward Vy by moving forward.

- Pilot workload has a major impact on recovery performance.
  ➔ Highly dependent on the helicopter, this criterion has to be always considered in the evaluations.

- **Depending on the helicopter, large and nasty parasitic effects can be faced during Vuichard recoveries, increasing the workload and the risk of exceeding aircraft limitations**
  ➔ Note that problematic to escape a VRS during an operational flight
  ➔ Could be damageable during numerous training flights

University of Stuttgart
Institut für Aerodynamik und Gasdynamik



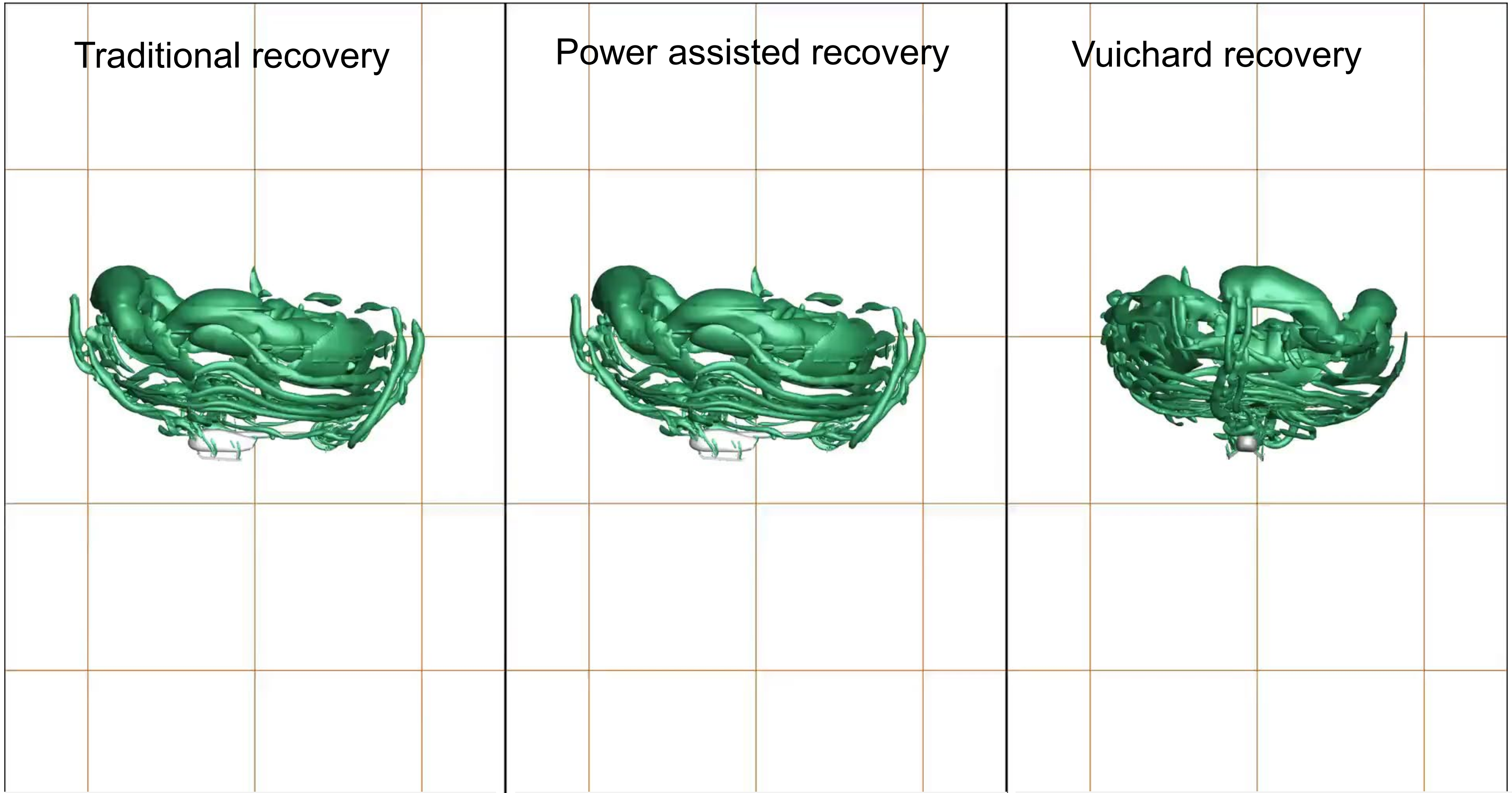
Comparative studies -2:

Full CFD simulation of deep VRS recovery for a R44

High Fidelity CFD Vortex Ring State Simulation at IAG

Manuel Keßler

VRS Evasive Maneuvers – R44, full VRS



Traditional recovery

-Height loss 54 m
-Zero descent rate after 4.6 s
-Forward speed 16 m/s
-Low level of blade flapping

Power assisted recovery

-Height loss 43 m
-Zero descent rate after 4.0 s
-Forward speed 11 m/s
-Low level of blade flapping

Vuichard recovery

-Height loss 36 m
-Zero descent rate after 3.9 s
-Excessive control movement-high pilot workload
-Considerable blade flapping

Comparative Studies 3:
Ph.D. Thesis at Georgia Tech,
performed at the FAA Research Center

- Objective 1: Develop and apply a method to assess the fidelity of flight simulators for VRS onset and entry
- Objective 2: Develop and apply a method to assess the fidelity of flight simulators for VRS recovery techniques
- Objective 3: Create a proof of concept for scenario-based training in flight simulators dedicated to VRS training and a framework for pilots' performance evaluation

INVESTIGATION INTO THE FIDELITY ASSESSMENT AND USE OF HELICOPTER FLIGHT SIMULATORS IN VORTEX RING STATE (VRS) ACCIDENT PREVENTION TRAINING

A Dissertation
Presented to
The Academic Faculty

By

Eleni Sotiropoulos-Georgiopoulos

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy in the
School of Engineering
Department of Aerospace Engineering

Georgia Institute of Technology

August 2025

Flight Simulation for VRS Training

Flight Simulation for VRS Training

Regulators and OEMs recommend:

- **Not** to **train in fully-developed VRS** in the actual helicopter
- The **use** of **synthetic training devices** to practice dangerous situations such as VRS encounters and recoveries in a safe environment

Flight Simulation and Modeling Goals

Recommendations and Goals:

- The use of **FSTDs** and the development of new training devices for **high-risk training** scenarios
- Risk of **negative pilot training** in helicopter simulators due to inaccurate flight dynamic models → **Need improved** physics-based **models** for various dangerous flight conditions

Scenario-Based Training (SBT)

Scenario-Based Training (SBT) incorporates traditional maneuvers into realistic scenarios

- Introduced **SBT** in aviation in the early 2000s, gradually incorporated into Practical Test Standards
- **SBT** is the most effective way to prepare pilots for making **safe decisions** during emergency or **abnormal situations**. This training is effective in both actual aircraft and simulators

R.Q. 3.1: Results Overview – H125 Simulator

	Steep approach	Steep approach IMC	Aerial Photography	Instructional Flight	Quick stops	Mountain Rescue
Pilot C		Power-Assisted Recovery			No VRS	
Pilot F	No VRS	No VRS	Traditional Recovery	Traditional Recovery	No VRS	Traditional Recovery
Pilot F2	No VRS	No VRS	No VRS	Traditional Recovery		Power-Assisted Recovery (diagonal)
Pilot G	Incipient VRS, increased collective	Recovered but reentered and crashed	No VRS	Traditional Recovery	No VRS	Power-Assisted Recovery (diagonal)
Pilot H	VRS encounter and crash		Traditional Recovery	Traditional Recovery	No VRS	No VRS
Pilot I	VRS encounter and crash	No VRS	Power-Assisted Recovery	Traditional Recovery	No VRS	Power-Assisted Recovery (diagonal)
Pilot J	Incipient VRS, increased collective	Power-Assisted Recovery (diagonal)	Power-Assisted Recovery (diagonal)	Power-Assisted Recovery (diagonal)		Power-Assisted Recovery (diagonal)

Extensive VRS Scenario Based study performed
-various pilots
-various scenarios

R.Q. 3.1:
SBT

R.Q. 3.1: Overall Results

Overall, the scenarios allowed us to trigger some VRS encounters and witness how pilots avoided them, recovered, or crashed.

Awareness

- Overall pilots were **aware of** the **risk** of VRS encounter in **steep descent** and **hover** conditions
- It did not prevent part of them from entering VRS in every scenario except the quickstops

Recovery

- Traditional Recovery:
  - **Intuitive reaction** of the pilots during the recovery **contradicted** description of the **technique**
- Vuichard Recovery:
  - **Half** of the pilots **had training** in the recovery but only **two attempted** to use it and **performed** it **incorrectly**
  - **Lack of proficiency** and **training** made it **unusable**

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Conclusions/Recommendation for Pilots: How to safely recover from VRS

Primary Training objective: Recognition and avoidance, therefore recovery latest during incipient VRS

AH recommends simulator training for VRS recoveries

If incipient VRS or full VRS state is entered:

- Use **available power** by applying collective in any case, as early as possible

  →Benefit:

  1. Already gain of thrust in VRS, contrary to present published theory
  2. Full thrust available as soon as clean air is reached

- **Recover forward**, pitch down to -20° and pitch back up at first airspeed indication (usually after 1-2 s)
- If obstacles or terrain prohibit forward recovery:
  - Vuichard recovery: Roll to any side to ±25° roll attitude while applying pedal to maintain heading, roll back after 1-2s

Next Steps

- Consistent & uniform recovery recommendations across manufacturers vital to avoid similar accidents
- Flight tests by other manufacturers important to verify similar behavior & recovery performance
- AH recommends revision of FAA Helicopter Flying Handbook to reflect latest knowledge

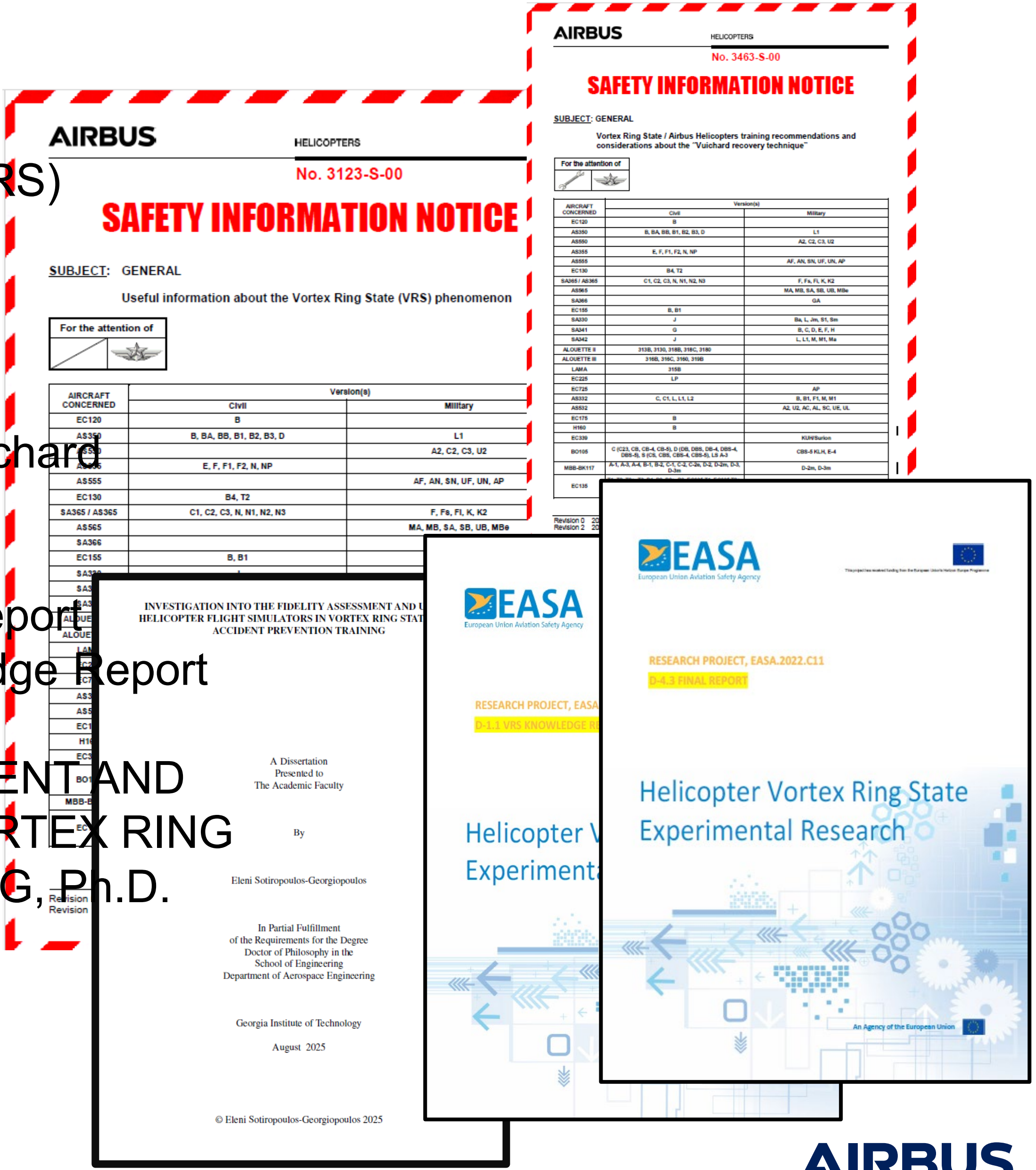
Sources

- Airbus Safety Information Notice SIN 3123-S-00 ‚Useful Information about the Vortex Ring State (VRS) phenomenon‘

- Airbus Safety Information Notice SIN 3463-S-00 ‚Vortex Ring State / Airbus Helicopters training recommendation and considerations about the Vuichard recovery technique‘

- EASA Research Project, EASA.2022.C11, Final Report
- EASA Research Project, EASA.2022.C11, Knowledge Report

- INVESTIGATION INTO THE FIDELITY ASSESSMENT AND USE HELICOPTER FLIGHT SIMULATORS IN VORTEX RING STATE (VRS) ACCIDENT PREVENTION TRAINING, Ph.D. Thesis Georgia Institute of Technologz




The End
Thank you for listening!