

# **Eurofighter – Pilotenunterstützung**

- Automatic Low Speed Recovery (ALSR)**
- Disorientation Recovery (DRF)**
- Automatic Ground Collision Avoidance (AGCAS)**

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**DGLR Workshop “Pilotenunterstützungssysteme”**

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# Introduction – Eurofighter from an FCS Point of View

- Thrust-to-Weight-Ratio  $> 1$
- Single Seat Cockpit
- Carefree Handling
- Highly Unstable
- Delta-Canard
- Swing Role



**But: Why Autonomy?**  
**It's a manned aircraft!**

Autonomie von Fahrzeugen oder Robotern: „die Fähigkeit technischer Geräte, sich selbstständig bewegen und agieren zu können“ (Wikipedia)



Käfer-autonom-fahrend.MOV



# Autonomous Control Levels (ACLs – one possible metric)

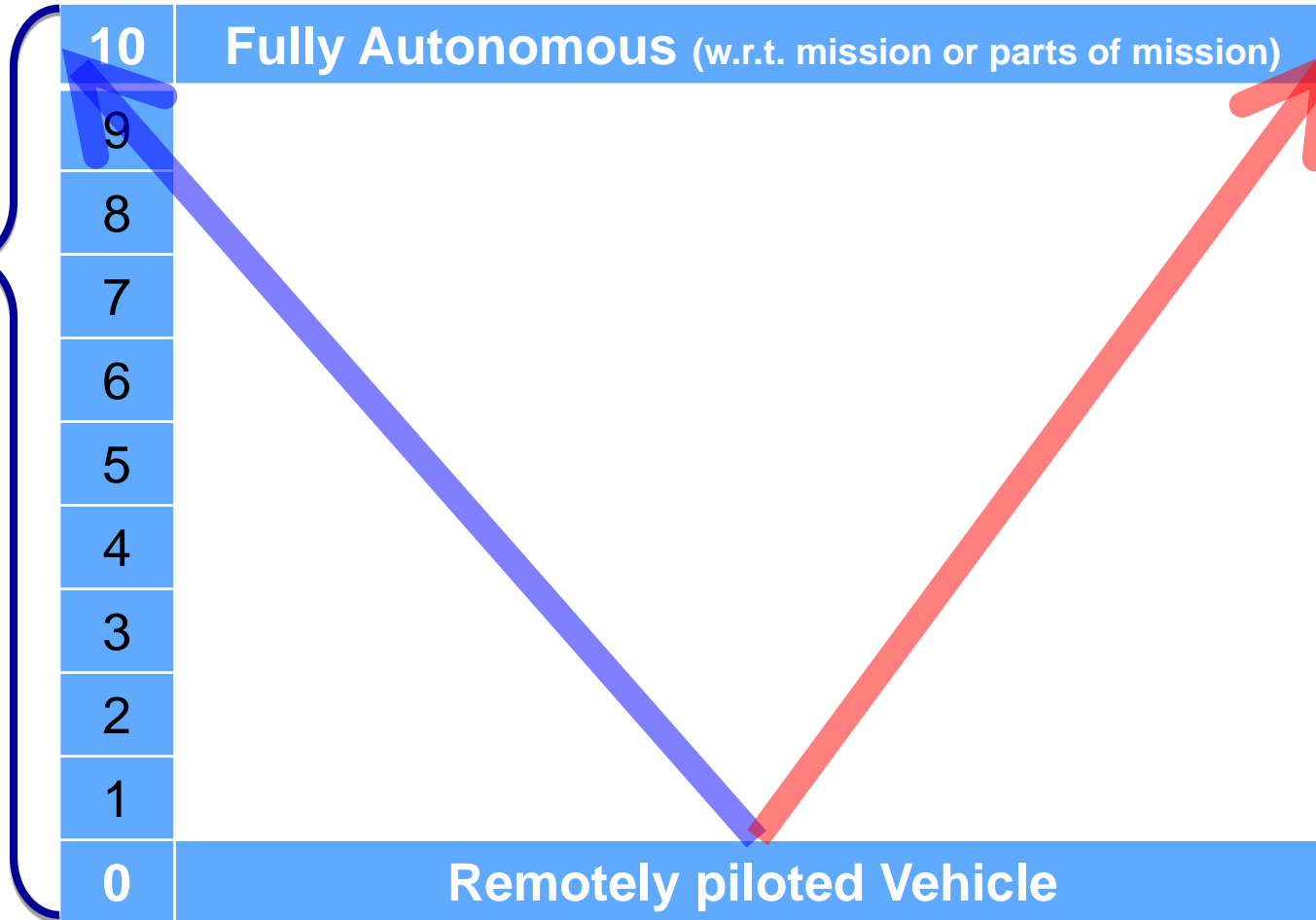
Im Systemkontext „Flugzeug“ wirkt auch ein bemanntes Flugzeug nach außen hin „autonom“!



Manned



Unmanned



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# Autonomous Control Levels in the Eurofighter (one possible metric)

Still most autonomous “computer” on the market !

→ Today’s optimum: smart combination brain & computer



**Manned**

Human Brain  
(supported  
by the FCC)



10	Fully Autonomous (w.r.t. mission or parts of mission)
9	Battlespace Swarm Cognizance
8	Battlespace Cognizance
7	Battlespace Knowledge
6	Real-Time Multi-Vehicle Cooperation
5	Real-Time Multi-Vehicle Coordination
4	Fault / Event Adaptive Vehicle
3	Robust Response to Real Time Faults/Events
2	Changeable Mission
1	Execute Preplanned Mission
0	Remotely piloted Vehicle

Increasing  
Certification  
Effort

Automatic &  
Autonomous  
Functions  
in the  
Eurofighter

# Automatic & Autonomous Functions in the Eurofighter

- Envelope protection (i.e. aircraft + pilot)
- Workload reduction
  - to allow pilot to concentrate on most complex tasks
  - to support pilot in fulfilling the mission

Altitude



Limited mainly by Power

Typical H-M-flight envelope

ALSR  
Low Speed Warning (LSW)

- Basic Autopilot Modes
- Autothrottle Modes
- Carefree Handling
- **Disorientation Recovery (DRF)**
- Route Mode
- Auto Attack
- Auto Combat Air Patrol
- Auto Approach

HSW  
MSW

GPW (+AGCAS)

High Speed Warning (HSW)

Topics of following presentation !

Mach

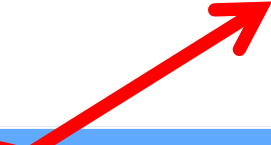
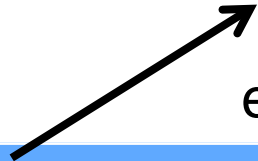
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# Autonomous Control Levels in the Eurofighter (US Navy metric)

“System requires no human intervention to perform any of its designed activities across all planned ranges of environmental conditions”

Topics of following presentations !

5	Fully “autonomous”	ALSR	
4	Mixed initiative	DRF + AGCAS	
3	Human supervised	TRK, CAP, APP, ATK	
2	Human delegated	Basic Autopilot + Autothrottle modes	
1	Human assisted	Carefree (CFH), LSW, HSW, GPW	
0	Human operated		



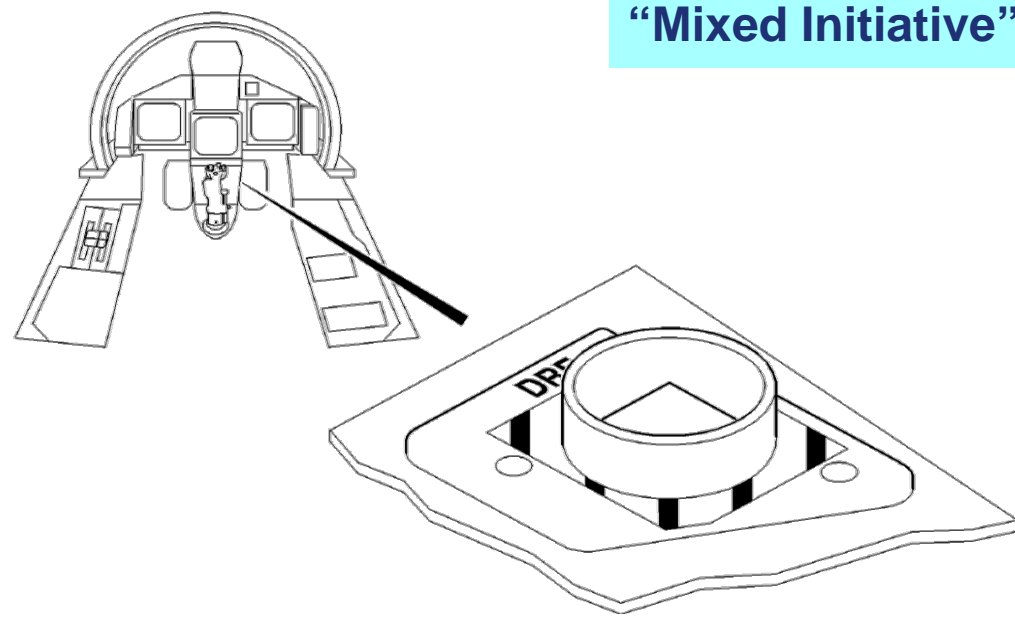
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# 1 – Disorientation Recovery Function (DRF)

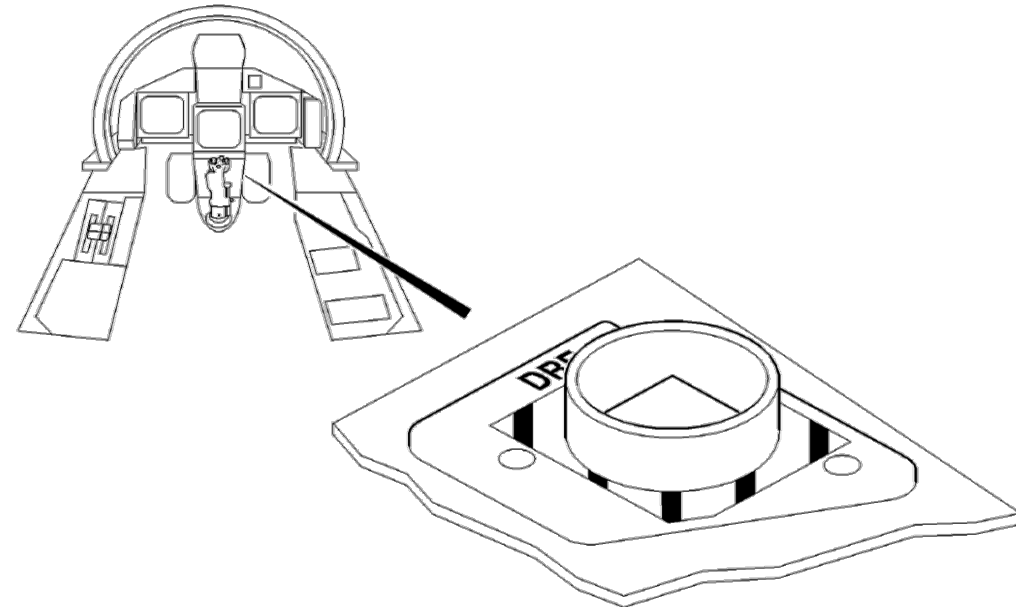
“Mixed Initiative”



# 1) Disorientation Recovery Function – Introduction

## Why DRF?

- Several accidents with CFIT
- Loss of spatial orientation also happens to experienced pilots:
  - extreme manoeuvres
  - IFR-Conditions
  - Display-failures



## What is DRF?

- A manually activated function (→ DRF Button):
  - to automatically recover the A/C
  - from any flight attitude / altitude / airspeed
  - with minimum height loss
  - to a safe, wings-level, slightly climbing flight condition



# 1) Disorientation Recovery Function – Overview

## What does DRF do?

- DRF takes command authority from the pilot
- To regain control: pilot can only press ICO-Button anytime.
- ALSR has priority over DRF (“standby”)

## What does DRF not do?

- There is no automatic trigger
- It is not primarily a ground avoidance function (but minimized height loss)

## What do the pilots say? (in service since 2005)

- “... enhancing feature of the aircraft which can increase flight safety significantly if the operationally pilots are urged and trained to use it.”



# 1) Summary: Disorientation Recovery Function (DRF)

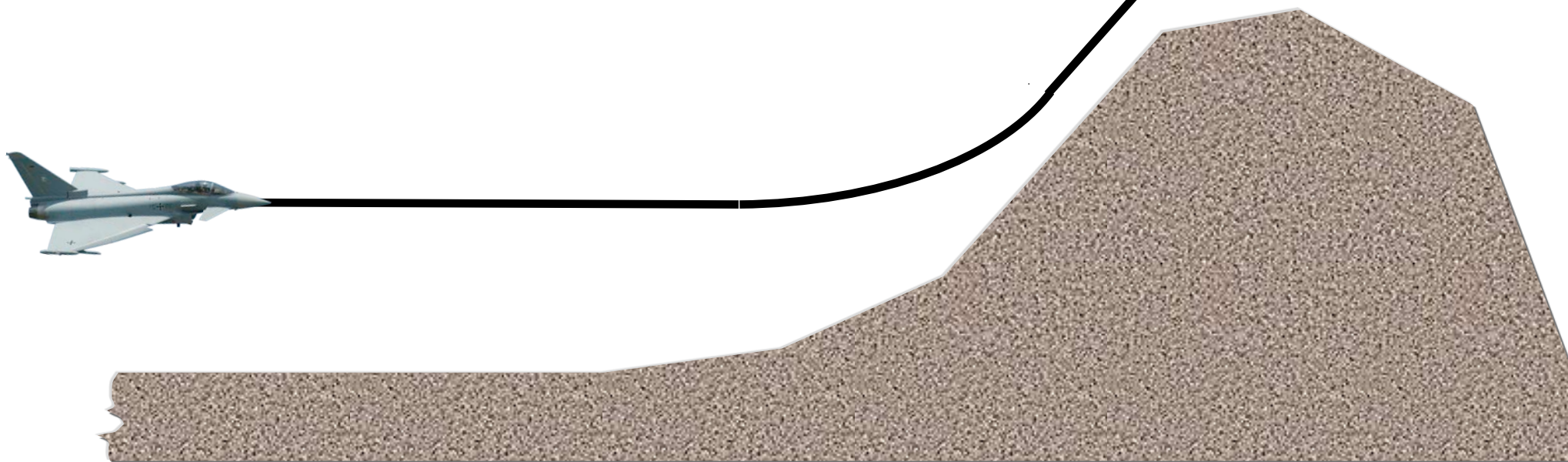
...Increasing Autonomy Level...



	DRF	
<b>Autonomy Level</b>	Mixed Initiative	
<b>Who activates it?</b>	Pilot	
<b>Who deactivates it?</b>	FCS or Pilot	
<b>Aut. flying time</b>	Max. 15s	
<b>Pre-Warning?</b>	No	
<b>Pilot Interaction</b>	Very limited (pilot can only select reheat)	
<b>In service</b>	Yes (since 2005)	
<b>Motivation</b>	Protection against A/C loss in case of <u>detected</u> loss of spatial orientation or situational awareness	
<b>Description</b>	<ul style="list-style-type: none"> <li>• Pilot presses DRF button</li> <li>• DRF controls Pitch- and Roll-axis and Thrust to recover attitude</li> <li>• A/C finally in wings level slightly climbing flight</li> </ul>	

# 2 – Automatic Ground Collision Avoidance System (AGCAS)

“Mixed Initiative”



## 2) Why Automatic Ground Collision Avoidance System (AGCAS)?

### US study:

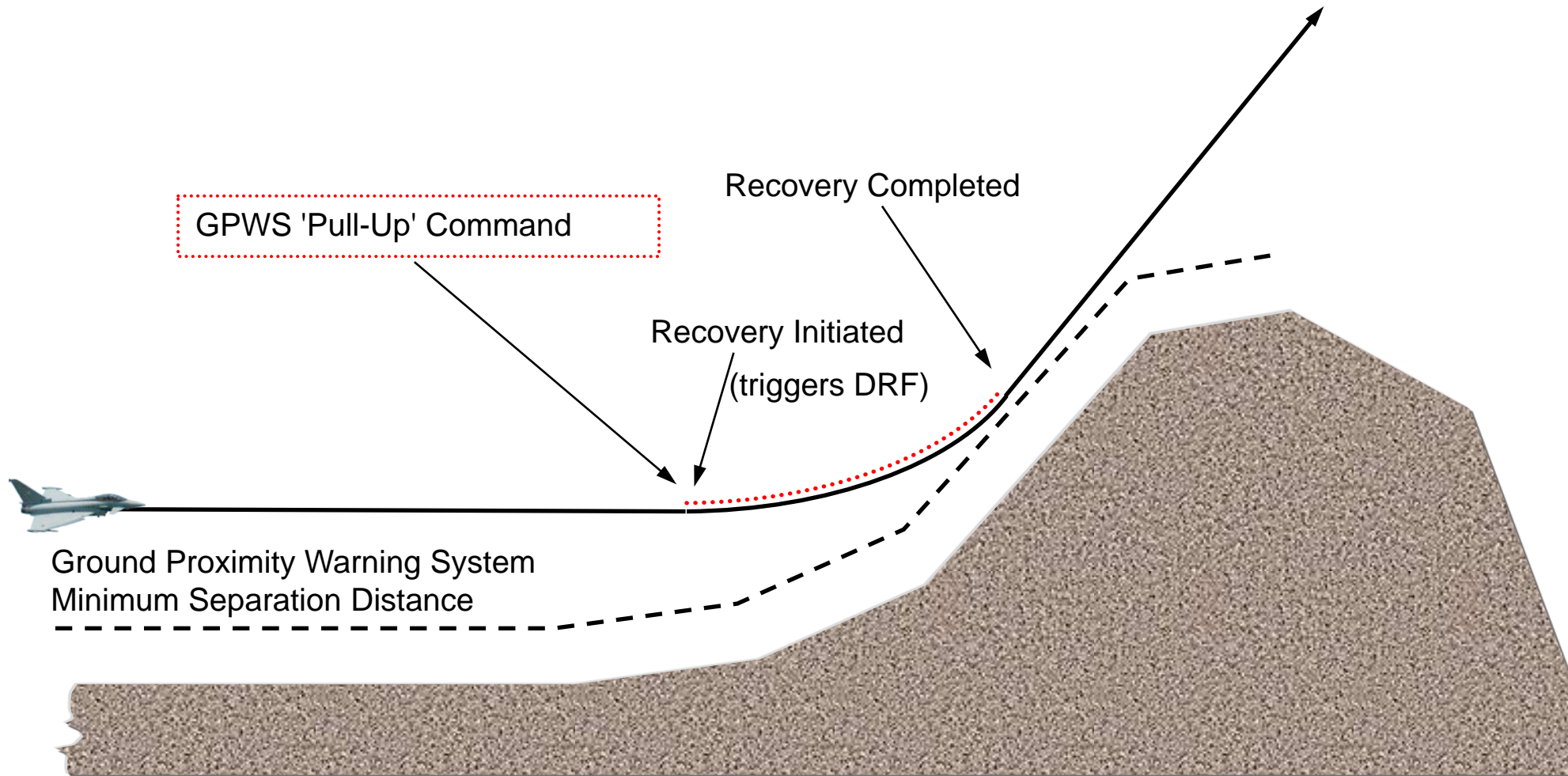
- collision avoidance on F-16, F/A-18, F-22 would save:
  - 78 pilot lives
  - 136 aircraft losses
  - 6.7 billion dollars



### Example (F-22, 16/11/2010, Alaska):

- *“... the cause of the mishap was the pilots failure to recognize and initiate a timely dive recovery due to channelized attention, breakdown of visual scan and unrecognized spatial disorientation.”*

## 2) Typical AGCAS Recovery Sequence



## 2) Summary Automatic Ground Collision Avoidance System

...Increasing Autonomy Level...

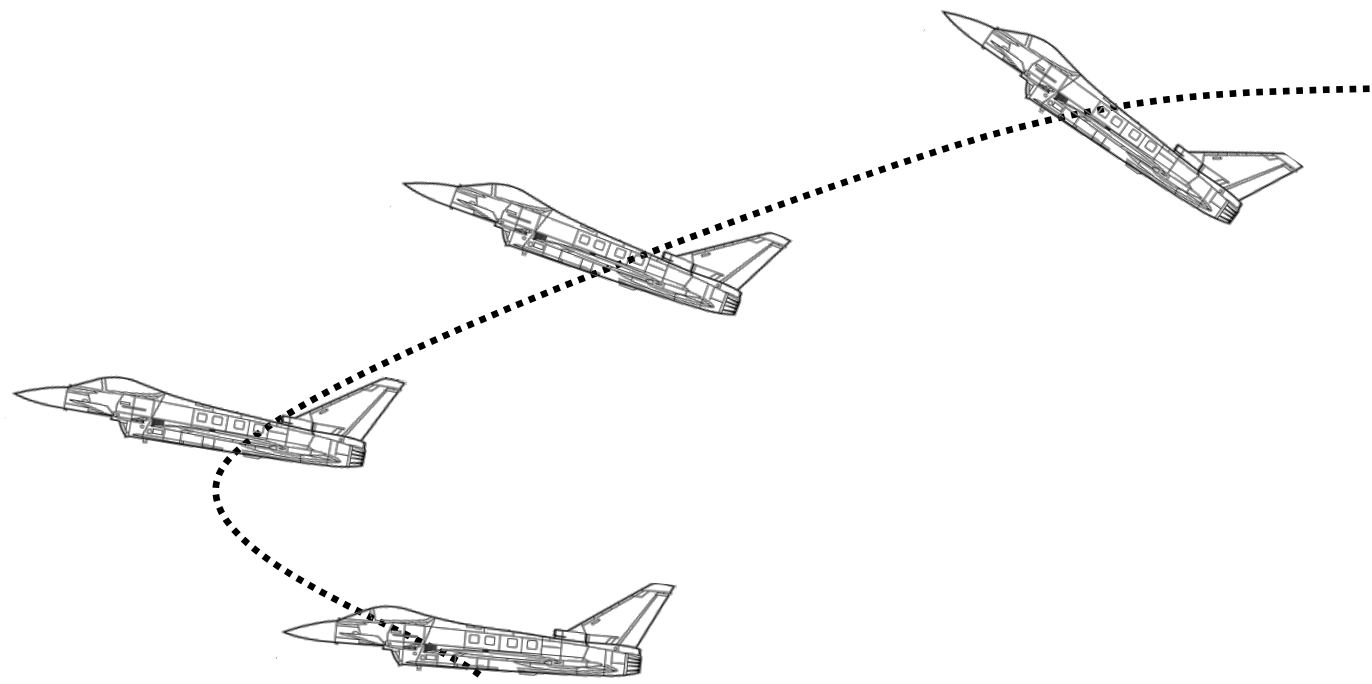


		AGCAS	
<b>Autonomy Level</b>	Mixed Initiative		
<b>Who activates it?</b>		FCS	
<b>Who deactivates it?</b>	FCS or Pilot		
<b>Aut. flying time</b>		Max. 20s	
<b>Pre-Warning?</b>		Yes	
<b>Pilot Interaction</b>	Very limited (pilot can only select reheat)		
<b>In service</b>		In development	
<b>Motivation</b>		Protection against A/C loss due to CFIT (Controlled Flight into Terrain)	
<b>Description</b>		<ul style="list-style-type: none"> <li>Existing GPWS triggers "PULL UP" warning</li> <li>If no pilot reaction:</li> <li>Activation of a modified DRF (controls Pitch- and Roll-axis and Thrust to avoid obstacle by wings-level pull manoeuvre)</li> </ul>	

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# 3 – Automatic Low Speed Recovery (ALSR)

“Autonomous”



### 3) Low Speed Flying – Candidate Solutions

1) **Open loop stable aircraft configuration** (example: F-18)

- Manually flown recovery manoeuvres
- Spin-trials
- However: departure risk remains



2) **Thrust vectoring** (examples: X31, F22, MiG29TV)

- Stabilisation and flight path changed by thrust forces
- Zero air speed possible



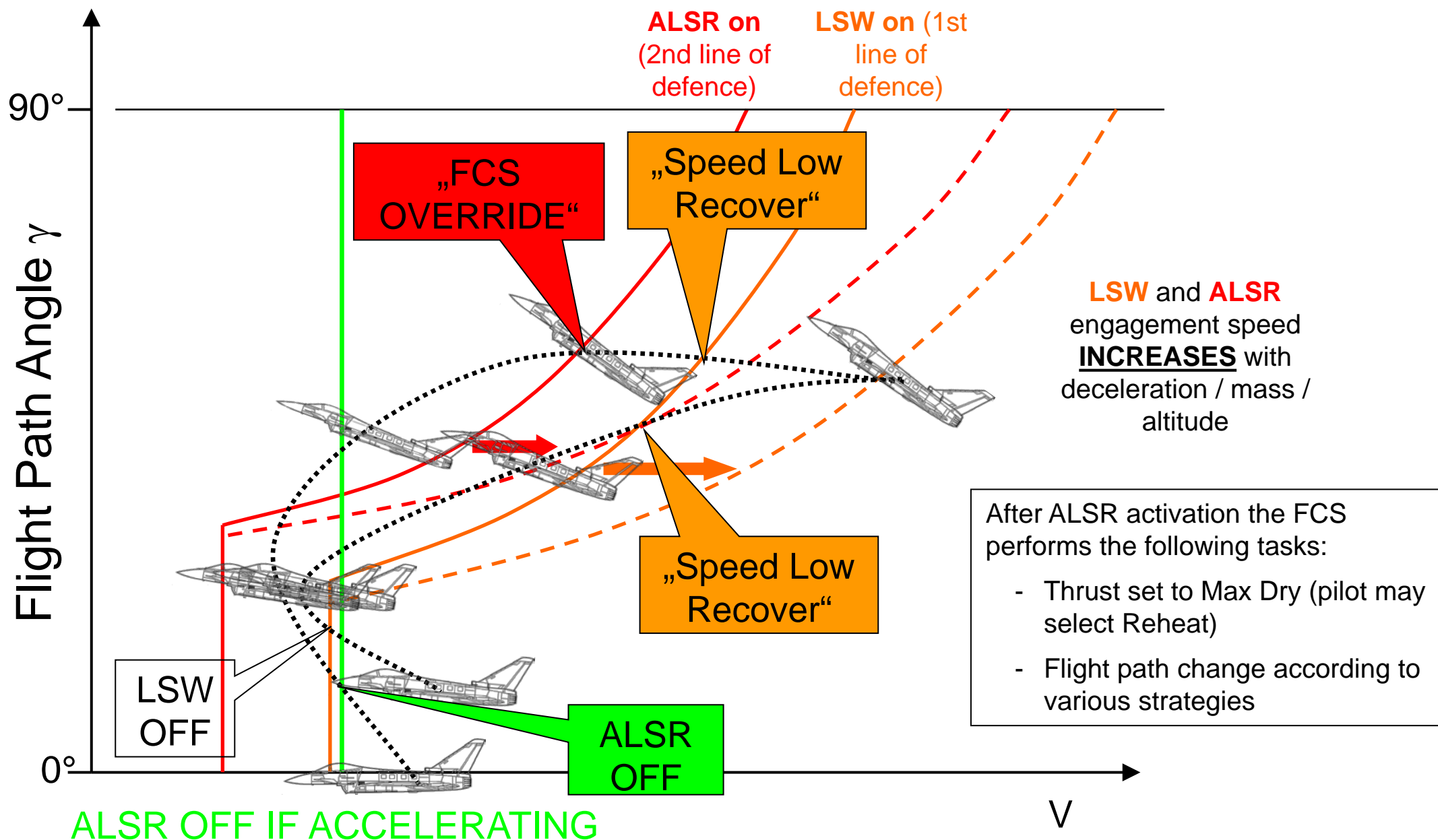
3) **FCS envelope protection** (example: Eurofighter)

- Minimum speed will always be ensured
- Accurate sensors (ADS, attitude, ...) required





### 3) Low Speed Warning / ALSR – Activation & De-Activation



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# Summary

...Increasing Autonomy Level...



	DRF	AGCAS	ALSR
<b>Autonomy Level</b>	Mixed Initiative		Autonomous
<b>Who activates it?</b>	Pilot	FCS	FCS
<b>Who deactivates it?</b>	FCS or Pilot		FCS
<b>Aut. flying time</b>	Max. 15s	Max. 20s	Max. 30s
<b>Pre-Warning?</b>	No	Yes	
<b>Pilot Interaction</b>	Very limited (pilot can only select reheat)		
<b>In service</b>	Yes (since 2005)	In development	Yes (since 2004)
<b>Motivation</b>	Protection against A/C loss in case of <u>detected</u> loss of spatial orientation or situational awareness	Protection against A/C loss due to CFIT (Controlled Flight into Terrain)	Protection against A/C loss due to loss of control at very low speed
<b>Description</b>	<ul style="list-style-type: none"> <li>• Pilot presses DRF button</li> <li>• DRF controls Pitch- and Roll-axis and Thrust to recover attitude</li> <li>• A/C finally in wings level slightly climbing flight</li> </ul>	<ul style="list-style-type: none"> <li>• Existing GPWS triggers "PULL UP" warning</li> </ul> If no pilot reaction: <ul style="list-style-type: none"> <li>• Activation of a modified DRF (controls Pitch- and Roll-axis and Thrust to avoid obstacle by wings-level pull manoeuvre)</li> </ul>	<ul style="list-style-type: none"> <li>• "SPEED LOW RECOVER" warning</li> </ul> If no pilot reaction: <ul style="list-style-type: none"> <li>• ALSR controls Pitch- and Roll-axis and Thrust to recover airspeed</li> <li>• Deactivates when out of low speed situation</li> </ul>

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# Fragen?



## ***Eurofighter – Pilotenunterstützung (ALSR / DRF / AGCAS)***

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**Vielen Dank für Ihre Aufmerksamkeit !**