Flight testing the Saab 35 Draken

Göte Marcusson 2 March 2009

Flight testing the Saab 35 Draken

- **Saab jet aircraft developement before a/c 35 Draken**
- **Draken development process from a flight testing perspective**
- **Draken Flight characteristics and Handling qualities**
- **Flight test procedures and the how the test engineer interacts with the test pilot**
- **Cooper-Harper rating, what it is and how does it i work, ever used on 35?**
- **Superstall and spin testing, Superstall characteristics**

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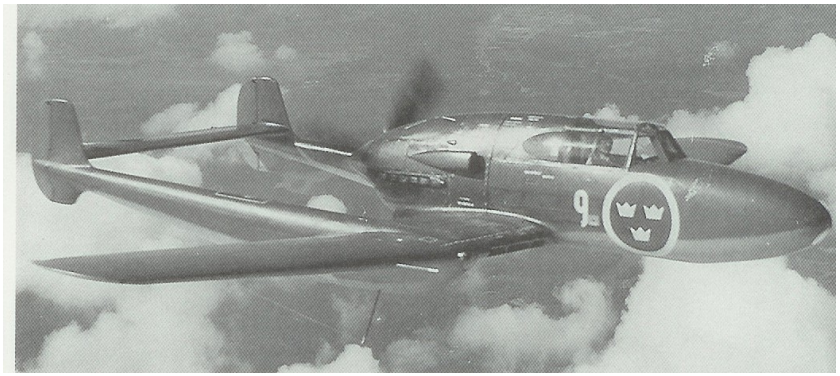
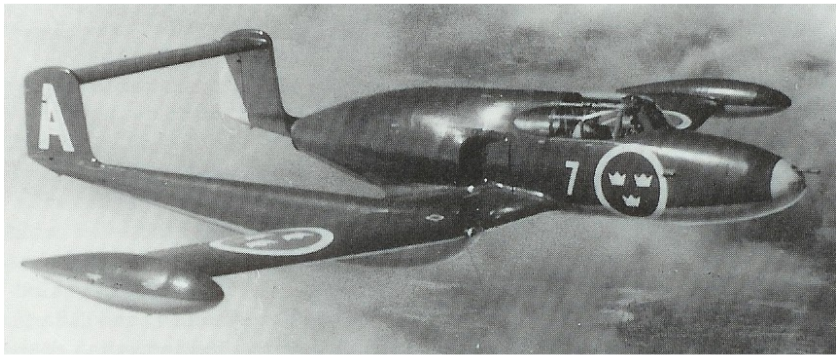
Flight testing the Saab 35 Draken

- **Saab jet aircraft developement before a/c 35 Draken**

a) Aircraft 21



J21A
Fighter aircraft
Piston engined
Maiden Flight
30 July 1943



J21R
Strike aircraft
Jet engined
Maiden Flight
?? March 1947

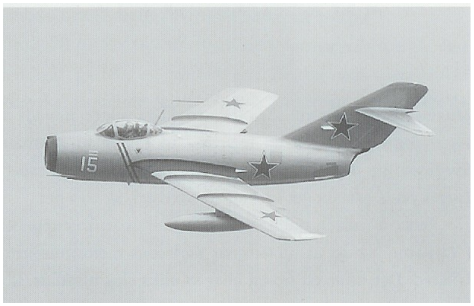
Flight testing the Saab 35 Draken

- **Saab jet aircraft developement before a/c 35 Draken**

b) Aircraft 29 Tunnan (Fighter aircraft)

Maiden Flight 1.th September 1948

Mig 15



F86 Sabre

Flight testing the Saab 35 Draken

- **Saab jet aircraft developement before a/c 35 Draken**

b) Aircraft 29 Tunnan (Fighter aircraft)

Techology wing demonstrator Aircraft 29 - Saab 201
½ Scale wing. Wing sweep 25o
Maiden Flight 29August 1946

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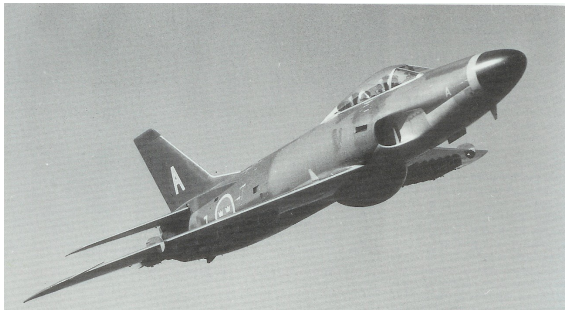
Flight testing the Saab 35 Draken

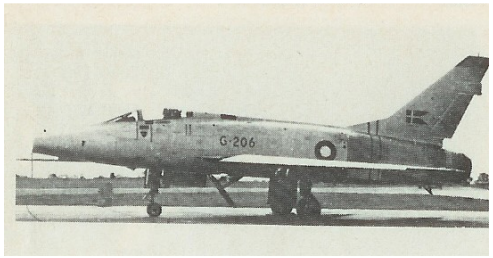
- **Saab jet aircraft developement before a/c 35 Draken**

c) Aircraft 32 Lansen (Strike aircraft)

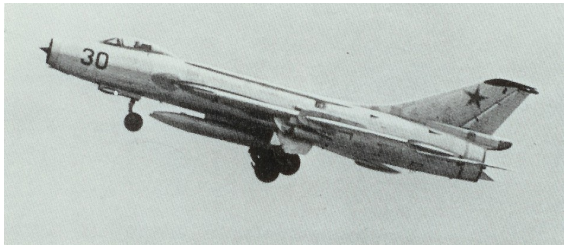
Maiden Flight 3.th November 1952



F100 Super Saber



SU7 Fitter



Flight testing the Saab 35 Draken

- **Saab jet aircraft developement before a/c 35 Draken**

c) Aircraft 32 Lansen (Strike aircraft)

Techology wing demonstrator Aircraft 32 - Saab 202
½ Scale wing. Wing sweep 40o
Maiden Flight 1.th March 1950

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Flight testing the Saab 35 Draken

2. Draken development process from a flight testing perspective

Maiden Flight 25.th October 1955

F102

Mig 21

Mirage III

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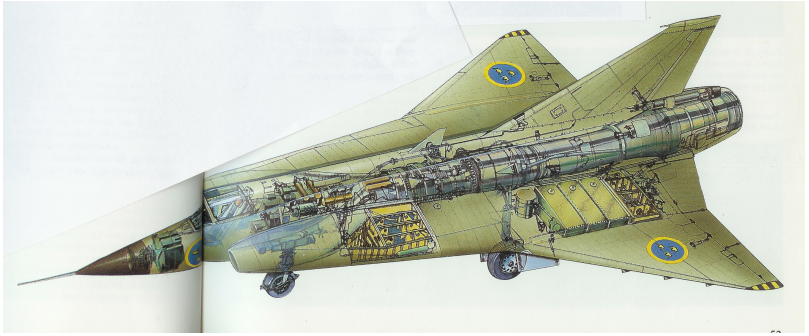
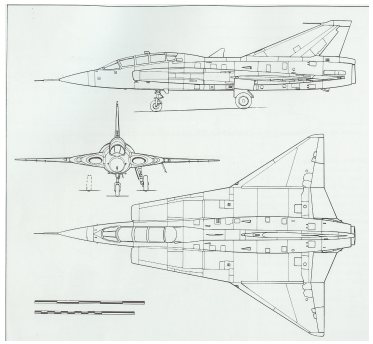
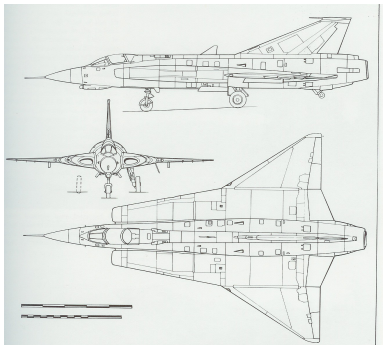
Flight testing the Saab 35 Draken

2. Draken development process from a flight testing perspective







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Flight testing the Saab 35 Draken

2. Draken development process from a flight testing perspective

- Swedish Air Force requirement
- Wind tunnel studies and tests of double delta wing design
- Questions (design vs requirements)
- Technology demonstrator Saab 210
- Draken protortypes
  - 35-1(A) 1.st Flight 1955-1025 to
  - 35-2 maiden flight 23.th March 1956
  - 35-3 maiden flight 13.th September 1956
  - 35-4 maiden flight 3.th July 1958
  - 35-5 maiden flight 15.th February 1958
  - 35-6 (D) maiden flight 19.th January 1961
  - 35-7 (F) maiden flight 1.th October 1962
  - 35-8 maiden flight 16.th November 1962
  - 35-9 (F) maiden flight 18.th June 1963
  - 35-10 maiden flight 22.th December 1961
  - 35-11(B) maiden flight 29.th November 1959
  - 35-12 (D/F) maiden flight 9.th February 1962
  - 35-13(D) 1.st Flight 1960-12-27

Flight testing the Saab 35 Draken

2. Draken development process from a flight testing perspective

Swedish Air Force requirement

Swedish Air Force requirement was a Fighter aircraft capable to handle the threat from Bomber aircraft at M<1 on Altitude 11 km (36.000 ft). That required capabilities:

- **For M>1,5 at Altitude 11 km (36.000 ft)**
- **To fly at M<1 at altitude 15 km (50.000 ft)**
- **Take-off and landing at Swedish Air Force bases**

Flight testing the Saab 35 Draken

2. Draken development process from a flight testing perspective

Wind tunnel studies and tests

Wind tunnel studies and tests of double delta wing design started 1949

- **Inner wing sweeep angle 80 degrees**
  - **Low relative thickness 4 % (12-8%)**
  - **For low supersonic drag**
- **Outer wing sweeep angle 56 degrees**
  - **For subsonic at altitude 15 km (50.000 ft)**
  - **For good low speed handling qualities**

Flight testing the Saab 35 Draken

- **Draken development process from a flight testing perspective**

Questions (design vs requirements)

Was it possible to get low supersonic drag?
Was the available engine (STALGlan T=5.000 kp) sufficient for M>1?
- **Developement of STAL Glan stopped August 1952**

Switch to Rolls Royce Avon 100 for 35 -1, -2 and -3
- **RM5A gave M>1,6 (3459kp / 4695 kp)**

Switch to Rolls Royce Avon 200 for 35 A-C
- **RM6B gave M>1,8 (4750kp / 6340 kp)**

Switch to Rolls Royce Avon 300 for 35 D-F and 35J
- **RM6C gave M>2 (5800kp / 8000 kp)**

Was it possible to land at Swedish Air Force bases?
Requires a Technology demonstrator!

Flight testing the Saab 35 Draken

2. Draken development process from a flight testing perspective

Technology demonstrator Draken Saab 210 A & B

Scope of test:

- **Low Speed Characteristics**
  - **Vmax=555 km/h (300kts)**
  - **Altmax= 4.000 m (13.200 ft)**

Decision April 1950 to develop Saab210

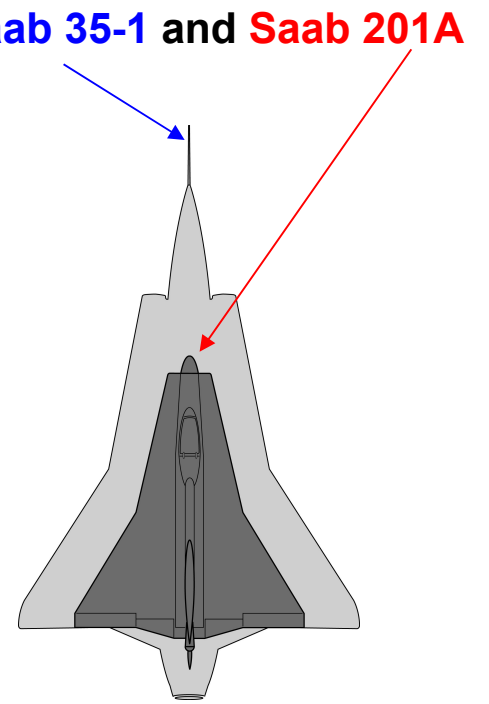
Roll-out 1 November 1951

Maiden Flight 210A 21 Januari 1952

Flight testing the Saab 35 Draken

2. Draken development process from a flight testing perspective

Technology demonstrator Draken Saab 210 A & B



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Flight testing the Saab 35 Draken

2. Draken development process from a flight testing perspective

Technology demonstrator Draken Saab 210 A & B

Data	210A&B	J35-1
Span:	6,35 m (21 ft)	9,4 m (31 ft)
Length:	8,8 m (29 ft)	15,4 m (51 ft)
Wing aerea:	24,2 m2 (264 ft2)	50 m2 (545 ft2)
Take-off weight:	1.775 kg	9.000 kg
Wing sweep angel:		
• Inner	77o	80o
• Outer	60o	60o

Remarks:

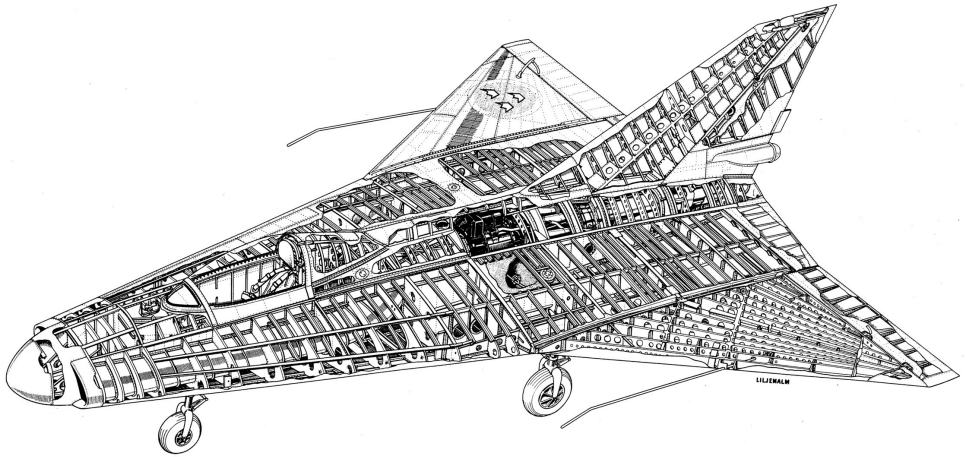
Different mod status of Saab 210:

- **Saab 210A (Air intakes far forward - Initially)**
- **Saab 210B (Air intakes production 35 like - Later on)**

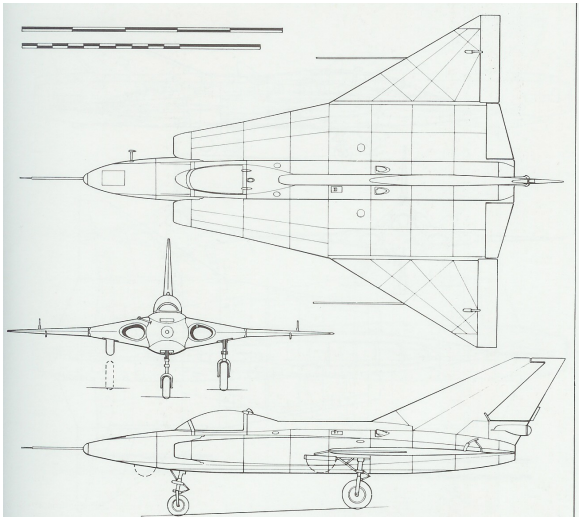
Flight testing the Saab 35 Draken

2. Draken development process from a flight testing perspective

Technology demonstrator Draken Saab 210 A & B



Saab 210A



Saab 210B

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Flight testing the Saab 35 Draken

2. Draken development process from a flight testing perspective

Technology demonstrator Draken Saab 210 A & B

Saab 210 A

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Flight testing the Saab 35 Draken

2. Draken development process from a flight testing perspective

Technology demonstrator Draken Saab 210 A & B

Saab 210 A
Maiden Flight 21 Januari 1952

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Flight testing the Saab 35 Draken

2. Draken development process from a flight testing perspective

Technology demonstrator Draken Saab 210 A & B

Saab 210 B

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Flight testing the Saab 35 Draken

2. Draken development process from a flight testing perspective

Technology demonstrator Draken Saab 210 A & B

Test equipment onboard

- **Photo panel to record**
  - **Airspeed**
  - **Altitude**
  - **Etc**
- **Oscillograph (12 channels) to record**
  - **Angles**
  - **Angle rate**
  - **Rudder moment**
- **String recording equipment to record**
  - **Pilots comments**

Flight testing the Saab 35 Draken

2. Draken development process from a flight testing perspective

Technology demonstrator Draken Saab 210 A & B

Step by step envelope expansion

- **Envelope**
  - **Vmax 555 km/t (300 kts)**
  - **Max alt 4 km (13.200 ft)**
- **Flying Qualities at**
  - **Medium airspeed**
  - **Low airspeed**
  - **Landing**
  - **High airspeed (540 km/h, 290 kts)**

Flight testing the Saab 35 Draken

2. Draken development process from a flight testing perspective

Technology demonstrator Draken Saab 210 A & B

Main flight test results

- **Nose wheel lift off** **125 km/h (68 kts)**
- **Lift off** **180 km/h (97 kts)**
- **Max speed** **555 km/h (300 kts)**
- **Approach speed** **250 km/h (135 kts)**
- **Landing speed** **190 km/h (103 kts)**
- **Landing roll - no shute** **300 m (990 ft)**
- **Landing roll - shute** **200 m (660 ft)**
- **Easy to land**
- **God low- and medium speed handling quailties**

Flight testing the Saab 35 Draken

2. Draken development process from a flight testing perspective

Technology demonstrator Draken Saab 210 A & B

Inadvertent pitch-up to 90o AoA (23.March 1953)

- **When testing control effectiveness at very low speed**
- **The first known superstall in th world**
- **Entry: Alt~2000m (6500 ft), Vi~105 km/h (57kts)**
- **Pitch oscillation**
- **Throttle pull-back from 14.500 to 12.000 rpm**
- **Full throttle (16.000 rpm) and full stick forward was applied at the point of max oscillation (most nose-down attitude and highest speed)**
- **Recovery. Pull-up at Vi = 280 km/h (150 kts)**
- **The pull-up was concluded at an altitude of about 150 m (500 ft)**
- **Lesson learned**
  - **The pitch-up occurred very quickly**
  - **Somewhere between 105 and 100 km/h (57 and 54 kts) at CL~1,2**

Flight testing the Saab 35 Draken

2. Draken development process from a flight testing perspective

Technology demonstrator Draken Saab 210 A & B

Summing up

- **Saab 210 proved that the concept was right**
  - **The double delta design worked**
- **Maiden Flight** **21 Januari 1952**
- **Superstall** **23 March 1953**
- **Last Flight** **25 October 1956**
  - **One year after Draken Maiden Flight 25 October 1955**
  - **One year overlap**
- **Total test flights:**
  - **887**
  - **286 flight hours**

Flight testing the Saab 35 Draken

2. Draken development process from a flight testing perspective

Saab 35 Draken

Decision early 1952 to develop Saab Project 1250 (Draken)

Decision April 1952 to develop three prototypes (35-1, 35-2, 35-3)

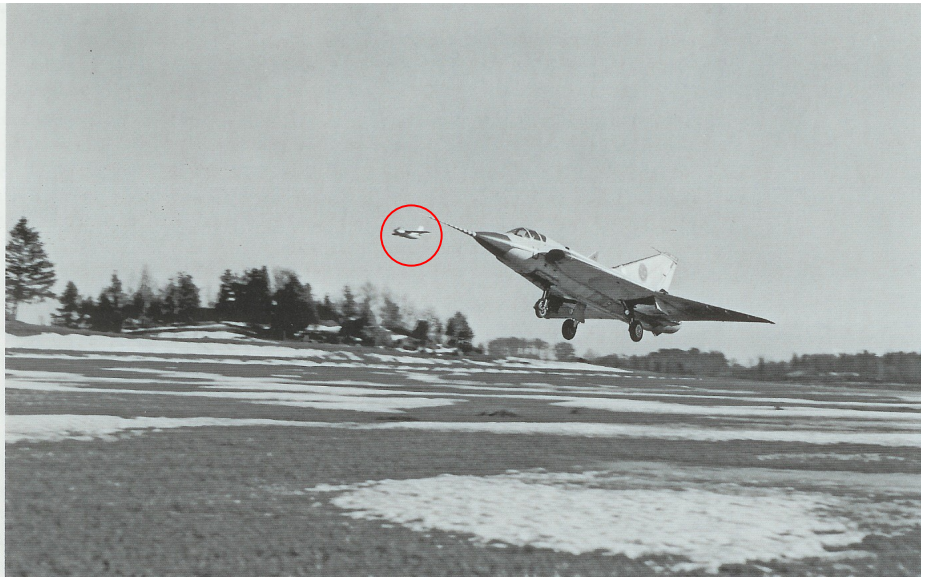
Scope of test: To prove the Swedish Air Force Requirements:

- **To fly M>1,5 at Altitude 11 km (36.000 ft)**
- **To fly at M<1 at altitude 15 km (50.000 ft)**
- **To take-off and land at Swedish Air Force bases**

Flight testing the Saab 35 Draken

- **Draken development process from a flight testing perspective**

Draken Saab 35-1



Maiden Flight 25.th October 1955
Chase aircraft J29 Tunnan

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Flight testing the Saab 35 Draken

- **Draken development process from a flight testing perspective**

Saab 35 Draken

Prototype aircraft 35 Draken

J35-1 Maiden flight 25.th October 1955

- **Subsonic testing (no afterburner)**
- **FQ and performance M<1 to landing speed**
- **M>1 in shallow dive**

35-2 Maiden flight 23.th March 1956

- **M>1 during climb**
- **FQ and performance M>1**

35-3 Maiden flight 13.th September 1956

- **FQ and performance M>1**

J35-4 Maiden flight 3.th July 1958

- **M>2 level fight 14 February 1960**

Flight testing the Saab 35 Draken

2. Draken development process from a flight testing perspective

Saab 35 Draken

Step by step envelope expansion

FQ and performance at

- **Medium airspeed and altitude**
- **Low airspeed at medium and low altitude**
- **Landing**
- **High subsonic airspeed / high altitude**
- **High supersonic airspeed / high altitude**

Flight testing the Saab 35 Draken

- **Draken development process from a flight testing perspective**

Saab 35 Draken

Test equipment onboard

- **Photo panel to record**
  - **Airspeed**
  - **Altitude**
  - **Etc**
- **Oscillograph (12 channels) to record**
  - **Angles**
  - **Angle rate**
  - **Rudder moment**
- **String recording equipment to record**
  - **Pilots comments**

Flight testing the Saab 35 Draken

- **Draken development process from a flight testing perspective**

Saab 35 Draken

Problems

Wheels-up-landing April 1956

- **35-2 Wheels-up-landing at Saab early April**
  - **Pilot error**
  - **Test Pilot 1 hurt in his spinal column**
    - **Fit for flight within 6 weeks**
  - **Aircraft damaged – Ready for flight in July**

- **35-1 Wheels-up-landing at F3 late April**
  - **Landing gear malfunction**
  - **Test Pilot 2 hurt in his spinal column**
    - **Fit for flight within 6 weeks**
  - **Aircraft damaged – Ready for flight in July**

Flight testing the Saab 35 Draken

2. Draken development process from a flight testing perspective

Saab 35 Draken

Problems

Superstall 7th. June 1960 at F13 (conversion training)

- **J 35A (35.018)**
- **Pilot made a split-S-manouver**
- **The aircraft made a rapid pitch-up**
- **Oscillated i pitch, wings level, low airspeed, high sink rate (Later defined as superstall)**
- **He was not able to recover, tried to eject**
- **The ejection seat malfuntioned, pilot was killed**
- **The Draken Spin flight test program accelerated**
  - **First test flight 25 March 1961 (see para 6a)**

Flight testing the Saab 35 Draken

2. Draken development process from a flight testing perspective

Saab 35 Draken

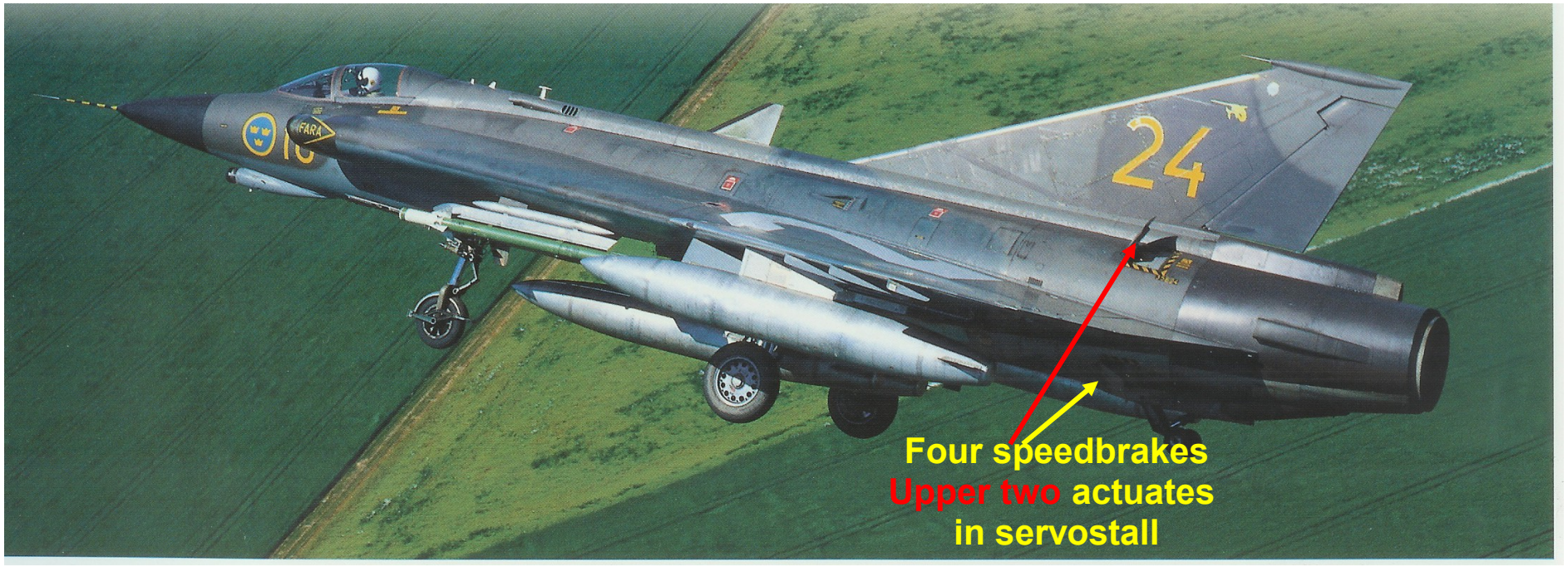
Problems
Wing hydraulic servo stall

- **In the later version production versions of Draken J35D and J35F, with increased weight and a more forward center of gravity, servostall occured at transonic speed, that made it difficult to pull out from a dive**

- **It was qured by a flight control system modification. It worked so that when servo stall occured during a pull up at high speed, the system automtically initiatied the upper two air brakes as manuvering flaps, which restored the manuverability**

Flight testing the Saab 35 Draken

Saab J35J Draken



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Flight testing the Saab 35 Draken

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- **Superstall and spin testing, Superstall characteristics**

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Flight testing the Saab 35 Draken

- **Draken development process from a flight testing perspective**

Flight characteristics

A very good Fighter aircraft ”A pilots aircraft”

- **Good flying characteristics**
- **Fast M2+**
- **Good instatanious turning performance**
- **Fair steady state turning performance**
- **Very good rolling performance**
- **Fair landing performance**

Flight testing the Saab 35 Draken

3. Draken Flight characteristics and Handling qualities

Handling qualities

Good handling qualities

Initially a little sensitive in pitch

That was later qured by a modified gearing in the control stick

- **Lower elevon deflection for a certain stick input around neutral trim, than the earlier linear gearing**

Flight testing the Saab 35 Draken

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Flight testing the Saab 35 Draken

4. Flight test procedures and the how the test engineer interacts with the test pilot

Flight test procedures

Create a master test plan for *performance* and *flying qualites* with special focus on the two new aereas, compared with Saab flight test of the earlier subsonic aircraft

- **Draken was predicted to be capable to fly up to M=2**
- **How the double-delta design would behave during landing**

Flight testing the Saab 35 Draken

4. Flight test procedures and the how the test engineer interacts with the test pilot

Flight test procedures

A detailed test plan for each test flight is worked out by the *flight test engineer*, in co-operation with the *test pilot*

Those detailed test plans sometimes have to be adjusted, depending on the fall-out of the privious tes

Flight testing the Saab 35 Draken

- **Saab jet aircraft developement before a/c 35 Draken**
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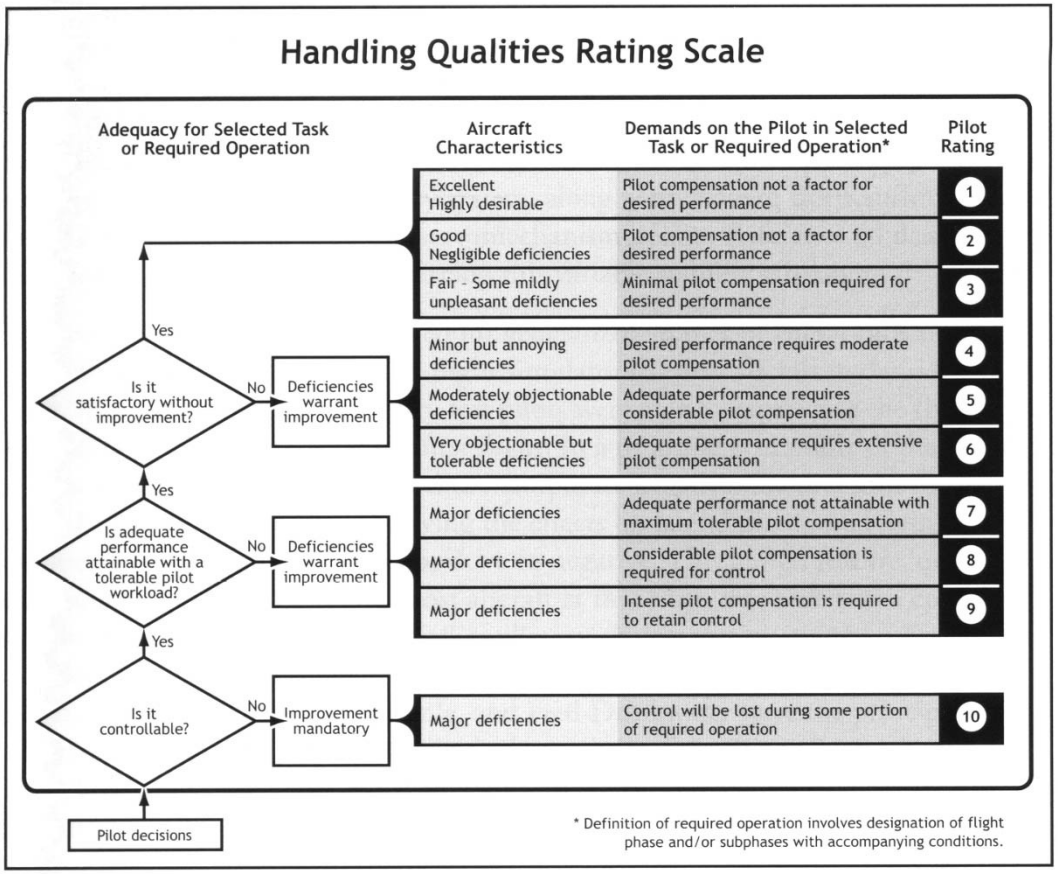
Flight testing the Saab 35 Draken

5. Cooper-Harper rating, what it is and how does it i work, ever used on 35?

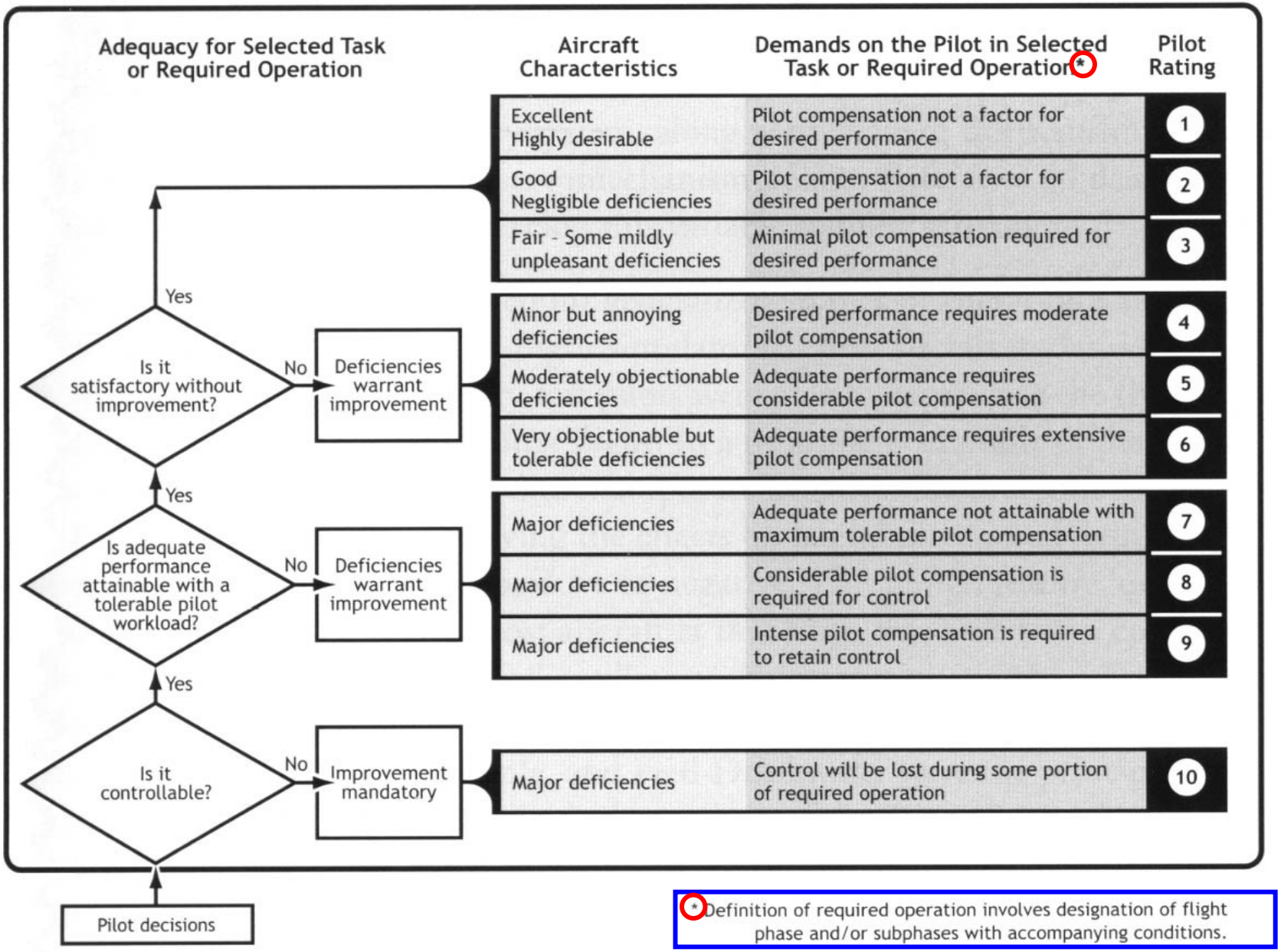


Cooper-Harper Ref NASA TNO-5153

The Cooper-Harper handling qualities rating scale gives the test pilot guidance how to grade an aircraft handling qualities from

- **CH 1 Excellent down to**
- **CH 10 Major deficiencies**

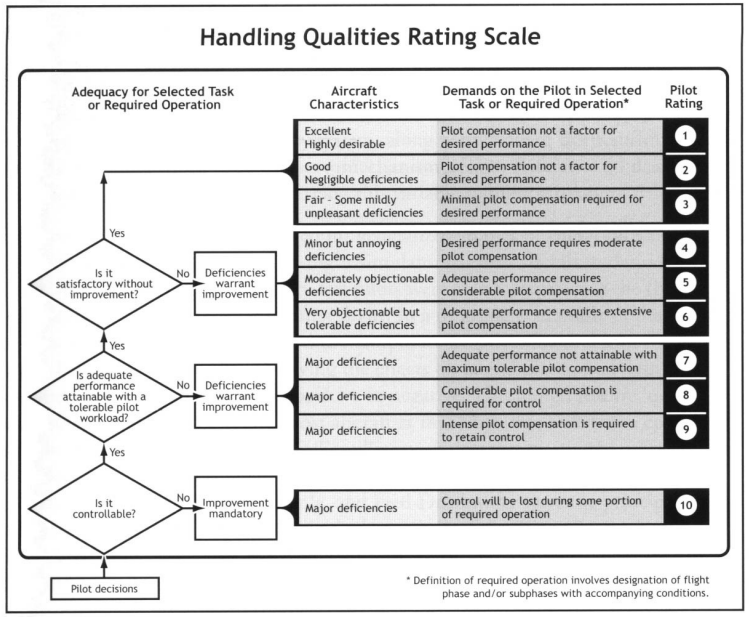
Handling Qualities Rating Scale



Flight testing the Saab 35 Draken

5. Cooper-Harper rating, what it is and how does it i work, ever used on 35?

The Cooper-Harper handling qualities rating scale was not used at Saab during Draken Flight Test



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Flight testing the Saab 35 Draken

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Flight testing the Saab 35 Draken

6. Superstall and spin testing, Superstall characteristics

a) **Saab Spin Trials with 35 Draken**

b) **FC complementary Spin Trials with 35 Draken**

Saab Spin Trials with 35 Draken was running 1955 to 1963

- **Vindtunnel tests 1955-58**
- **Model tests 1958-1961**
  - **RAE 1958-60**
  - **Saab 1961**
- **Full scale flight tests 1961-63**
  - **Test aircraftfpl**
  - **Production aircraft**

Flight testing the Saab 35 Draken

6. Superstall and spin testing, Superstall characteristics

a) Saab Spin Trials with 35 Draken

Vindtunnel tests 1955-58

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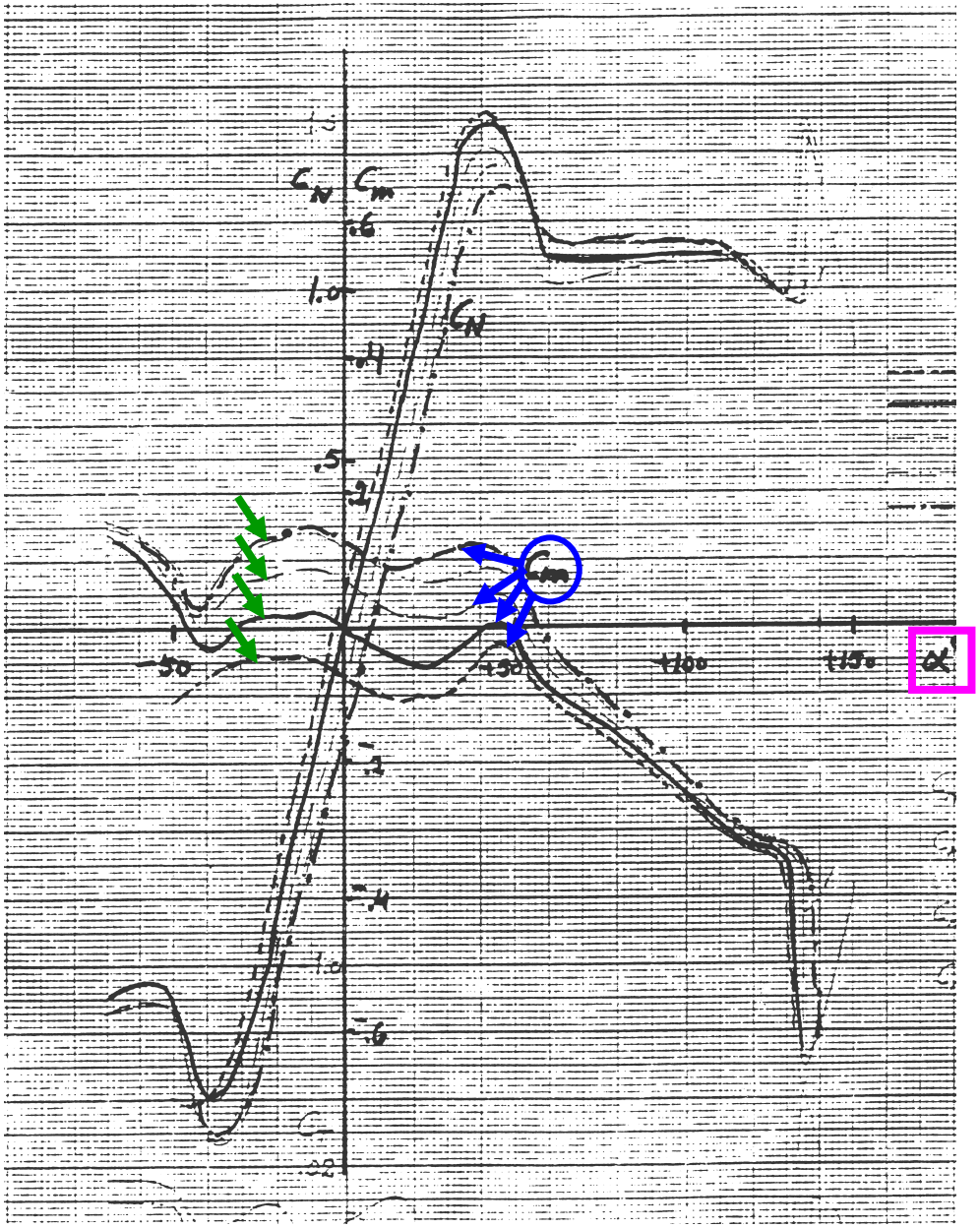
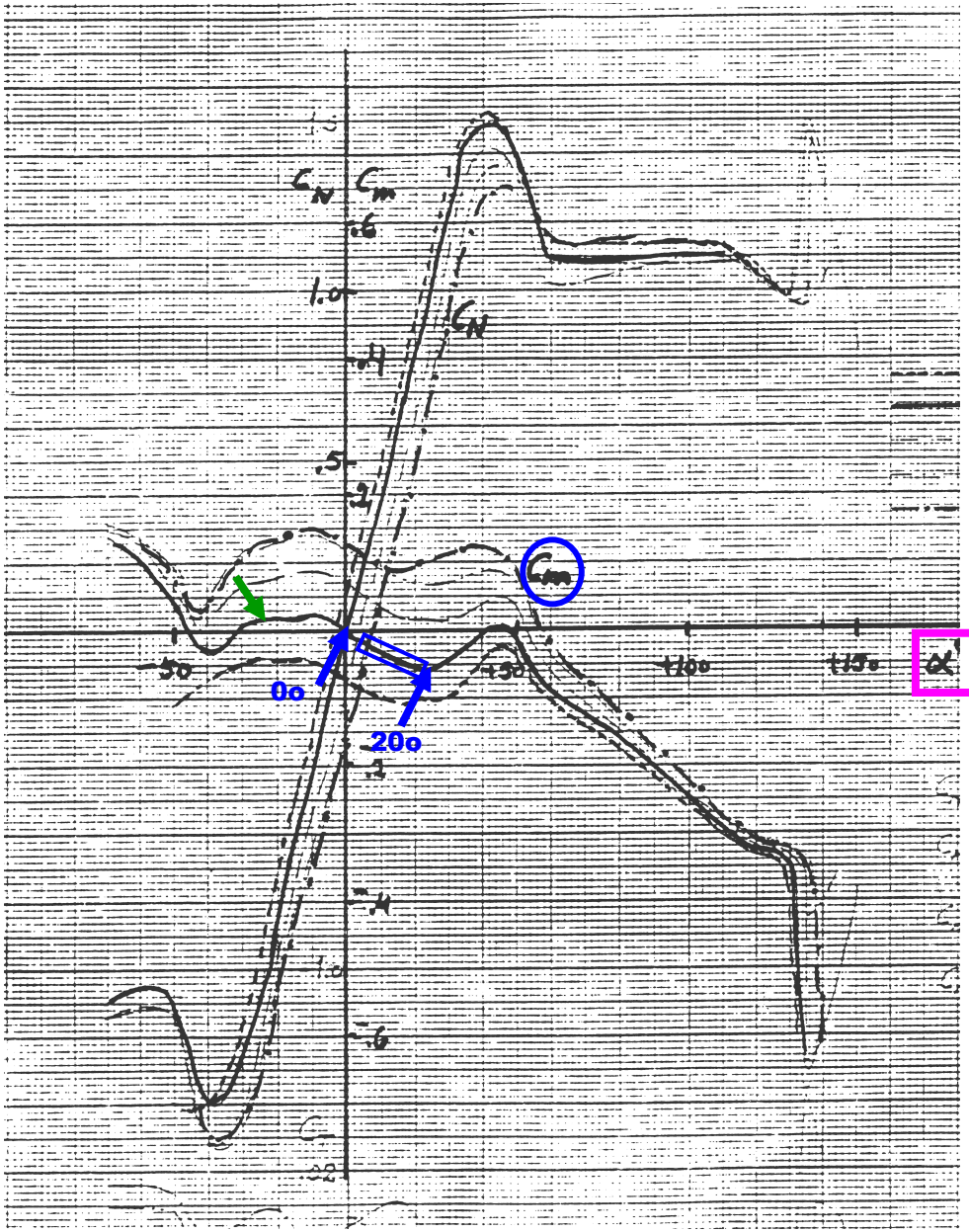


Vindtunnel tests 1955-58

Low speed aerodynamics

alfa 0° to +130°

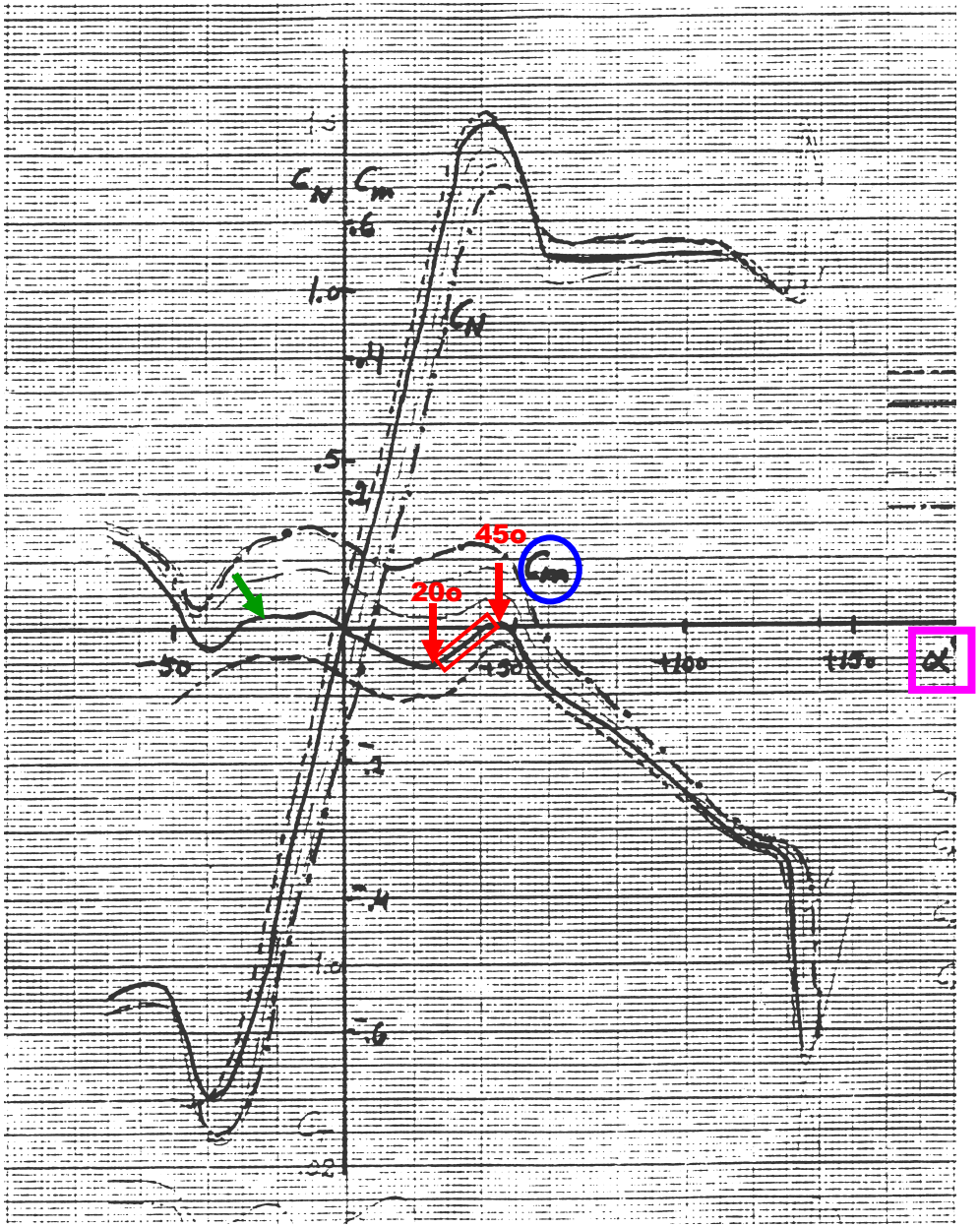
- **C_m vs AoA and c.g.**



Vindtunnel tests 1955-58

Low speed aerodynamics alfa 0° to+130°

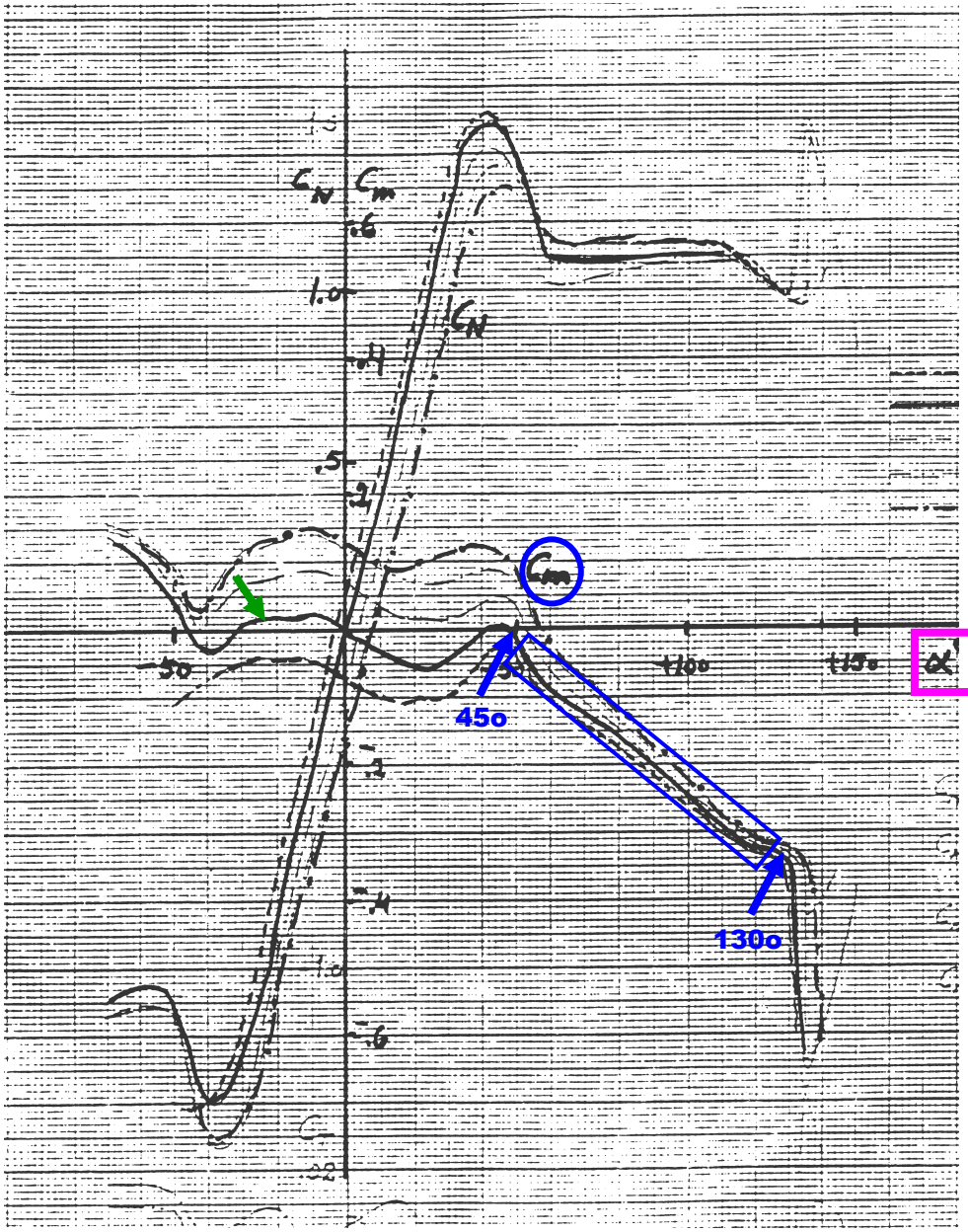
- **C_m vs AoA and c.g.**
  - **Stable for AoA 0-20°**



Vindtunnel tests 1955-58

Low speed aerodynamics alfa 0° to+130°

- **C_m vs AoA and c.g.**
  - **Stable for AoA 0-20°**
  - **Unstable in pitch for AoA20-45°**



Vindtunnel tests 1955-58

Low speed aerodynamics

alfa 0° to+130°

- **C_m vs AoA and c.g.**
  - **Stable for AoA 0-20°**
  - **Unstable in pitch for AoA 20-45°**
  - **Superstable for AoA > 45°**
    Superstall

Flight testing the Saab 35 Draken

6. Superstall and spin testing, Superstall characteristics

a) Saab Spin Trials with 35 Draken

Model tests 1958-1961

- **RAE 1958-60**
  - **Some 20 drops of a 35 Draken aircraft model (scale 1:6,5) from helicopter at Royal Aircraft Establishment**
  - **The drop test indicated a normal spin**
  - **That lead to the conclution to use stick forward and pro-spin ailrons for the recovery**

Flight testing the Saab 35 Draken

6. Superstall and spin testing, Superstall characteristics

a) Saab Spin Trials with 35 Draken

Model tests 1958-1961

- **Saab 1961**
  - **Complimentary drops of the 35 Draken aircraft model (scale 1:6,5) from a ballon at Flugebyn airfield Karlsborg, after recovery problems in the second full scale spin flight test in 35-2, 25 April 1961**
  - **The conclution was that neutral controls was enough for recovery**

Flight testing the Saab 35 Draken

6. Superstall and spin testing, Superstall characteristics

a) Saab Spin Trials with 35 Draken

Full scale Spin Trials with 35 Draken was running 1961 to 1963

- **Flight test from 25th. March 1961 to 1th. April 1963, with**
  - **35-2**
  - **35.027 (J35A)**
  - **35.800 (SK35C)**
  - **35-4 (J35D and J35F)**
  - **250 superstalls during 88 flights**

Flight testing the Saab 35 Draken

6. Superstall and spin testing, Superstall characteristics

a) Saab Spin Trials with 35 Draken

35-2 (25 March 1961 – June 1962)

- **Clean aircraft**
- **Specially equipped**
  - **Anti-spin shute**
  - **Cocpit**
  - **Registration equipment**

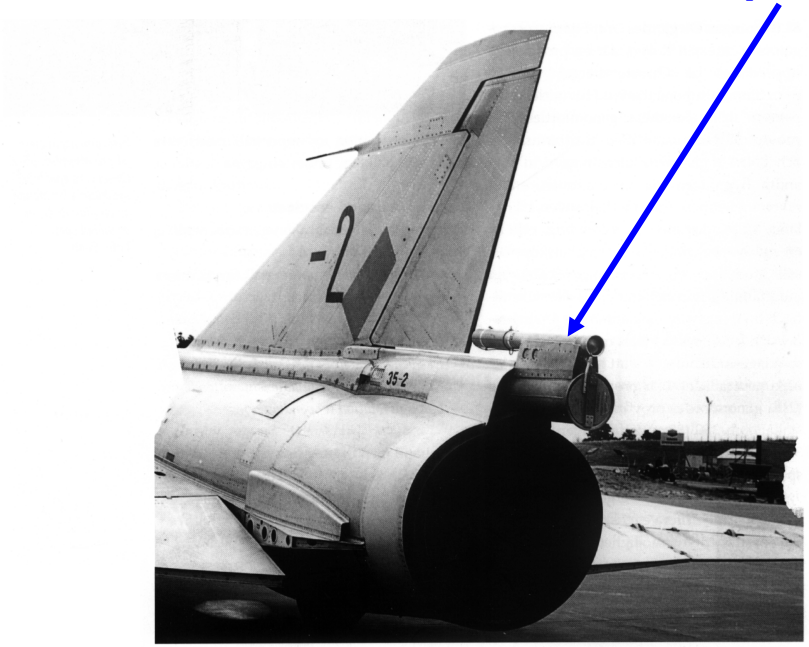
Flight testing the Saab 35 Draken

6. Superstall and spin testing, Superstall characteristics

a) Saab Spin Trials with 35 Draken

35-2

Anti-spin shute



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Flight testing the Saab 35 Draken

6. Superstall and spin testing, Superstall characteristics

a) Saab Spin Trials with 35 Draken

35-2
Cockpit

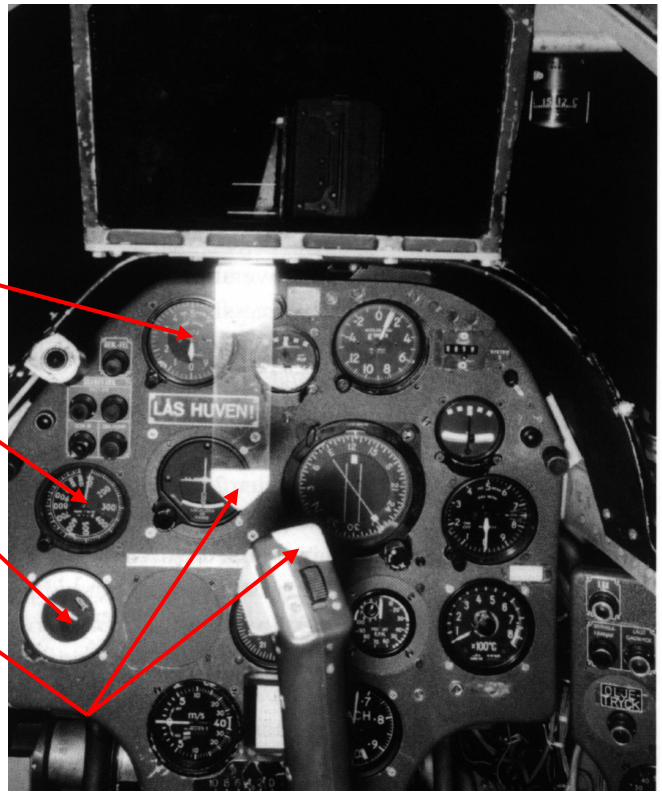
Altimeter
- **Red** below 3.000 m (10.000 ft)

Special calibrated IAS
- **Red** below 350 km/t (190 kts)

AoA indikator

Two indikator lamps for spin direction

Control stick lindikator
- After problems in spin test 1 och 2



Flight testing the Saab 35 Draken

6. Superstall and spin testing, Superstall characteristics

a) Saab Spin Trials with 35 Draken

35-2

Test equipment on-board

Photo panel to record

- **Airspeed**
- **Altitude**
- **Etc**

Oscillograph (12 channels) to record

- **Angles**
- **Angle rate**
- **Rudder moment**

String recording equipment to record

- **Pilots comments**

Flight testing the Saab 35 Draken

6. Superstall and spin testing, Superstall characteristics

a) Saab Spin Trials with 35 Draken

35-2

1.th Spinn test flight (1961-03-25)

- **Entry:**
  - **Vi=275 km/h Alt 12.000 m**
- **Result:**
  - **Pith-up, pitch oscillations (5 sec cycle), yaw**
- **Recovery controls:**
  - **In-spin-ailron, stick forward, rudder against rotation**
- **Result:**
  - **Recovered immediately, rapid roll during recovery**
- **Before 2.nd spin test flight**
  - **Analysies showed that in-spin-ailron gave the roll**

Flight testing the Saab 35 Draken

6. Superstall and spin testing, Superstall characteristics

a) Saab Spin Trials with 35 Draken

35-2

2.nd Spinn test flight (1961-04-25 = + 1 month)

Entry:

- **Vi=275 km/h Alt 12.000 m**

Result:

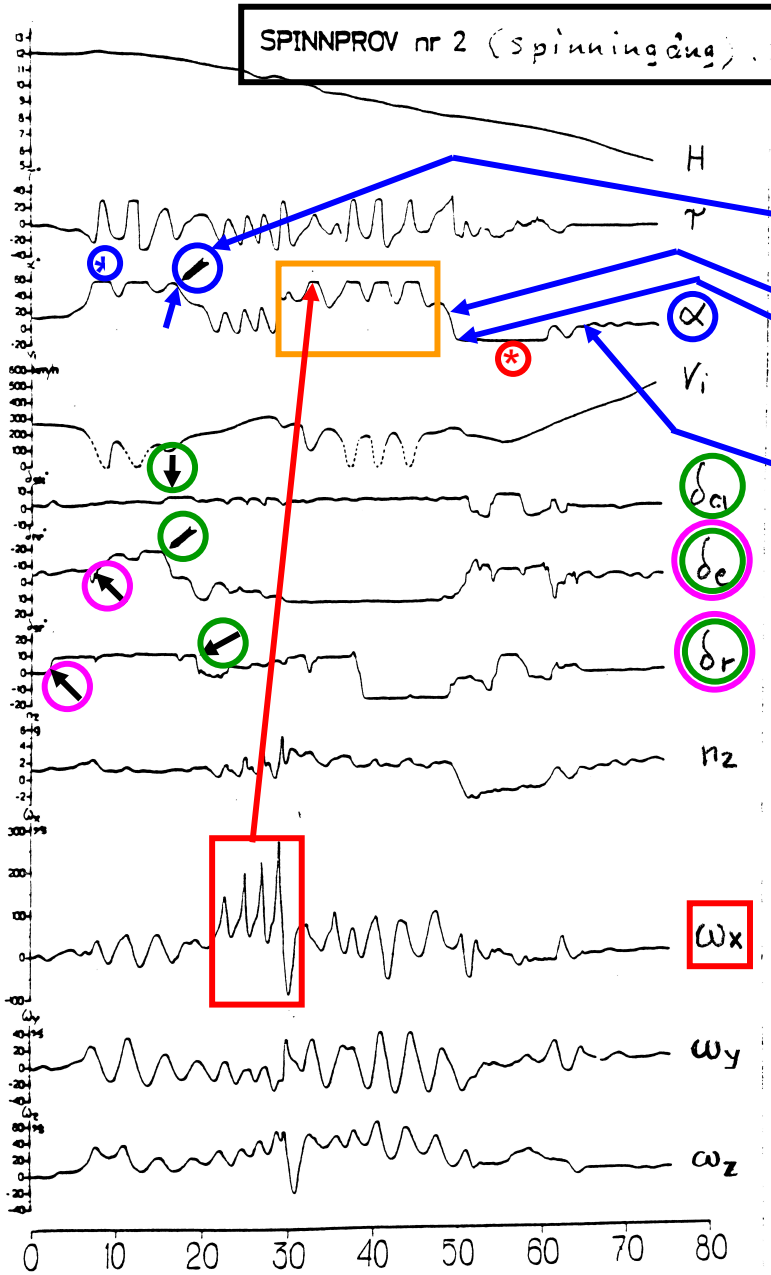
- **Pith-up, pitch oscillations (5 sec cycle), yaw**

Recovery controls:

- **In spin ailron, stick forward, rudder against rotation**

Result:

- **Recovered immediately, rapid divergent roll developed that lead to a new superstall, recovered, flipped over to an inverted super-stall, pilot activated the anti-spin shute, recovered succesfully**



- Entry ruddder initiated
- Recovery rudder initiated
- Alfa decreases
- Divergent roll
- New superstall
- Spontanious recovery
- Flipps over to inverterad ss
- Antispinshute out on A=8 km
- Aircraft recovers from ss

AoA-probe limited to the range +60° to -15°

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Flight testing the Saab 35 Draken

6. Superstall and spin testing, Superstall characteristics

a) Saab Spin Trials with 35 Draken

35-2

2.nd Spinn test flight (1961-04-25 = + 1 month)

Before 3.rd spin test flight

- **Simulations with 3 degres of freedom**
- **Further 35 model drops from ballon in Flugebyn Karlsborg**
- **Best means of recovery was stick fully forward, ailrons neutral**
- **Stick position indicator was added (helps pilot keep ailron neutral)**

Flight testing the Saab 35 Draken

6. Superstall and spin testing, Superstall characteristics

a) Saab Spin Trials with 35 Draken

35-2

3.rd Spinn test flight (1961-09-13 = + 4,5 month)

Entry:

- **Vi=275 km/h Alt 12.000 m**

Result:

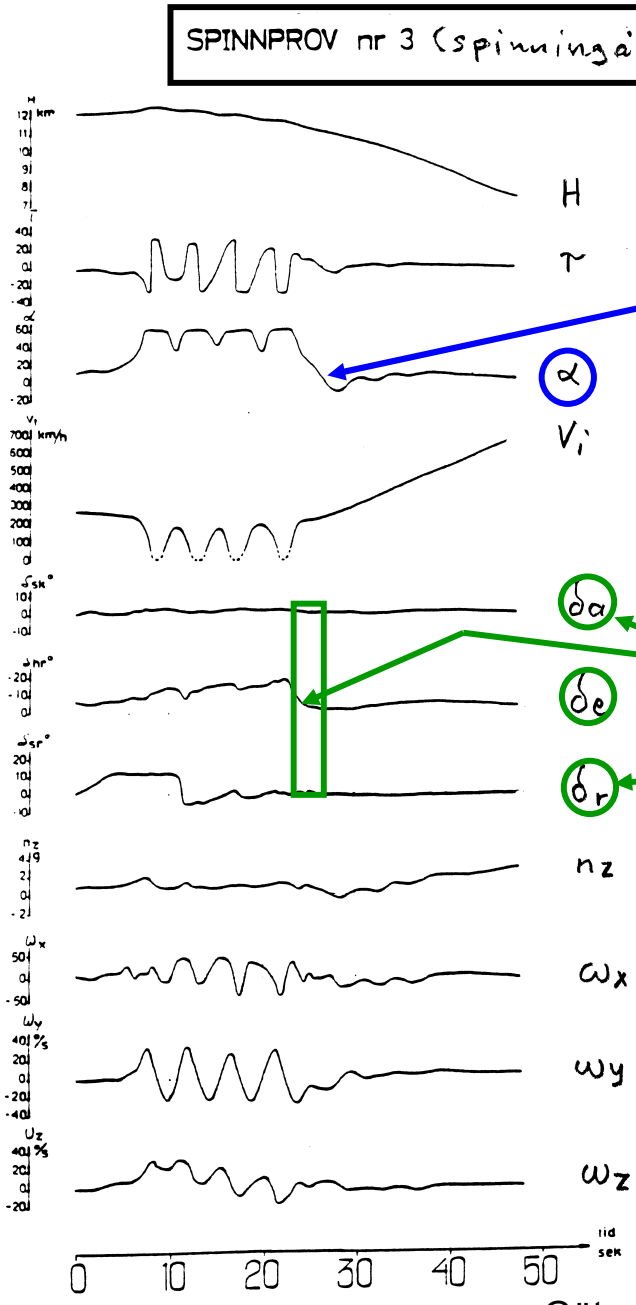
- **Pith-up, pitch oscillations (5 sec cycle), yaw**

Recovery controls:

- **Stick forward, ailron and rudder neutral**

Result:

- **Immediate recovery**



Immedate recovery

Recovery controls

- **Elevator fully forward**
- **Ailron and rudder neutral**

Flight testing the Saab 35 Draken

6. Superstall and spin testing, Superstall characteristics

a) Saab Spin Trials with 35 Draken

35.027 (J35A) (15 August 1962 – 14 December 1962)

35.027 with short tailpipe (J35A)

Scope of test

- **Assess recovery characteristics with production flight control system**
- **Assess characteristics compared to 35-2**

54 Superstalls

- **34 clean aircraft**
- **20 with 1 drop tank**

No specific spin test equipment, exept

- **Anti-spin-shute in drag shute compartement**

Flight testing the Saab 35 Draken

6. Superstall and spin testing, Superstall characteristics

a) Saab Spin Trials with 35 Draken

35.027 (J35A)

Superstall characteristics compard to 35-2

- **Softer pitch-up**
- **Quicker recovey**
- **Small delay in recovery with a drop tank**

Flight testing the Saab 35 Draken

6. Superstall and spin testing, Superstall characteristics

a) Saab Spin Trials with 35 Draken

35.800 (SK35C) (17 September 1962 –1 April 1963)

Scope of test

- **Assess characteristics compared to 35.027 (J35A)**
- **Assess possibilities for an instructor pilot in rear seat to demonstrate superstall for a student pilot in front seat**

82 Superstalls

- **17 clean aircraft**
- **37 with ventral fins under the outer wings**
  - **Ventral fins added after test flight 3**
- **28 with ventral finns and one drop tank**

Anti-spin-shut

- **Initially in drag shute compartement**
- **After test flight 3, same type of anti-spin-shute as in 35-2**

Flight testing the Saab 35 Draken

6. Superstall and spin testing, Superstall characteristics

a) Saab Spin Trials with 35 Draken

Saab SK 35C Draken

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Flight testing the Saab 35 Draken

6. Superstall and spin testing, Superstall characteristics

a) Saab Spin Trials with 35 Draken

35.800 (SK35C)
Superstall characteristics compared to 35.027 (J35A)

- **2.nd test flight**
  - **More yaw rotation**
  - **First recovery attempt failed**
  - **Second recovery attempt sussesful**
- **3.rd test flight**
  - **Recovery attempt failed**
  - **Anti-spin-shute activated (failed)**
  - **Spontaneous recovery**
  - **Heavy sideslip at recovery**

Flight testing the Saab 35 Draken

6. Superstall and spin testing, Superstall characteristics

a) Saab Spin Trials with 35 Draken

35.800 (SK35C)
Superstall characteristics compared to 35.027 (J35A)

- **Before 4.th. test flight**
  - **One ventral fin under each outer wing**
  - **Anti-spin-shute changed to 35-2 installation**

- **4.th test flight**
  - **Immediate recovery**

Flight testing the Saab 35 Draken

6. Superstall and spin testing, Superstall characteristics

a) Saab Spin Trials with 35 Draken

35.800 (SK35C)

Superstall characteristics compard to 35.027 (J35A)

- **After adding ventral fins, the 35.800 superstall- and recovery characrteristics became equal to 35.027 (J35A)**

Flight testing the Saab 35 Draken

6. Superstall and spin testing, Superstall characteristics

a) Saab Spin Trials with 35 Draken

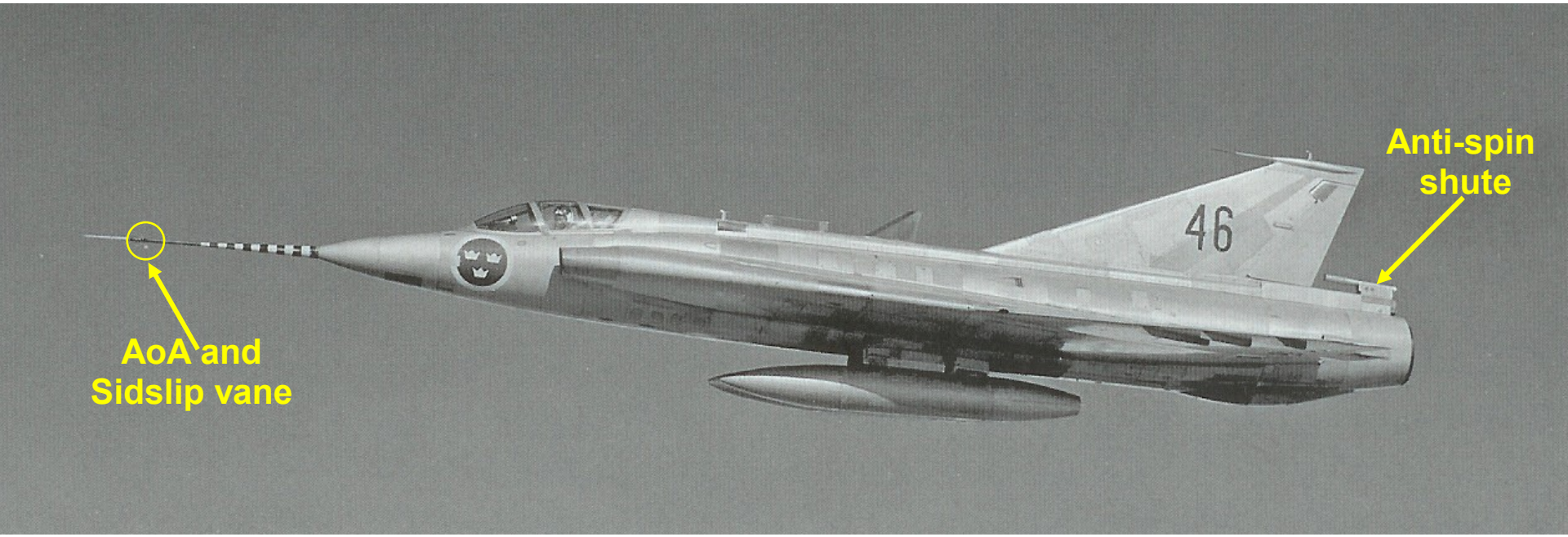
35-4 with long tailpipe (J35D and J35F)

Superstall characteristics compard to 35.027 (J35A)

- **A couple of test flights was performed**
- **The J35D and J35F superstall- and recovery characrteristics are equal to 35.027 (J35A)**

Flight testing the Saab 35 Draken

Saab 35-4 Draken



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Flight testing the Saab 35 Draken

6. Superstall and spin testing, Superstall characteristics

a) Saab Spin Trials with 35 Draken

Summing up – Draken Superstall Characterics

- **The Saab 35 Draken has, especially at high altitudes and low IAS, a weak stall warning and will due to a pitch-up at CL ~0,7 enter a stall. This pitch-up can during an accelerated stall be controlled by rapidly applying forward stick**

- **During such a stall entry, the load factor will rise some 70 %. Entering the stall, the aircraft may tumble but will always stabilize at approximitly 1 g after a few seconds**

- **This stalled condition does not meet the definition of conventional spin. Rather the aircraft is flying continually in a stalled condition, here termed superstall. The superstall can be either stable or pitching, with or without rotation**

Flight testing the Saab 35 Draken

6. Superstall and spin testing, Superstall characteristics

a) Saab Spin Trials with 35 Draken

Summing up – Draken Superstall Characterics (cont)

- **The recovery is quick if correct recovery action is applied. Rotation in yaw will delay recovery a few seconds. Repeted recovery action shall therefore not be made too soon (10-15 sec)**
- **No significant difference has been discovered due to c.g. position**
- **Wind tunnel tests through the AoA-range, free model spin tests as well as simulatilons have been of great help**
- **The ram air turbine (that normally gives emergency electricity and hudraulic pressure) is of no use as a stand-by system for the hydraulic pressure at the AoA occuring during superstall.**

Flight testing the Saab 35 Draken

6. Superstall and spin testing, Superstall characteristics

b) FC complementary Spin Trials with 35 Draken

FC complementary Spin Trials was running 1968 to 1974

Superstall demonstration program in SK35C 1968-1970

- **Develope a Superstall demo program**

Flight testing the Saab 35 Draken

6. Superstall and spin testing, Superstall characteristics

b) FC complementary Spin Trials with 35 Draken

FC complementary Spin Trials was running 1968 to 1974

Superstall demonstration program in SK35C 1968-1970

- **Develope a Superstall demo program**

Complementary test J35F characteristics vs SK35C 1973-1974

- **Clean aircraft**
- **Two drop tanks**

Flight testing the Saab 35 Draken

6. Superstall and spin testing, Superstall characteristics

b) FC complementary Spin Trials with 35 Draken

FC complementary Spin Trials was running 1968 to 1974

Superstall demonstration program in SK35C

- **Prepared a Superstall demo program 1969 to 1970 (2 flihts & 10 superstalls for each student)**
- **Teached five flight instructors at Draken central conversion unit at F16 Uppsala Mars 1970**

Flight testing the Saab 35 Draken

6. Superstall and spin testing, Superstall characteristics

b) FC complementary Spin Trials with 35 Draken

FC complementary Spin Trials was running 1968 to 1974

Superstall demonstration program in SK35C

- **Prepared a Superstall demo program 1969-1970 (2 flihts & 10 superstalls for each student)**
- **Teached five flight instructors at Draken central conversion unit at F16 Uppsala Mars 1970**

J35F Superstall characteristics vs SK35C 1973 to1974

- **Clean aircraft**
  - **More pitch oscillation (easier to recover)**
  - **Less yaw rotation**
- **Two drop tanks**
  - **Same yaw rotation**
  - **Yaw rotation easy to stop with in-spin-ailron**

Flight testing the Saab 35 Draken

6. Superstall and spin testing, Superstall characteristics

b) FC complementary Spin Trials with 35 Draken

FC Flight Test Videos

SS nr 1-AN 37 sek

- **Vertikal entry**
  - **Alt=12km/40.000ft**
  - **M=0,8**
- **Neutral controls on top**
- **The a/c recovered by itself**

Flight testing the Saab 35 Draken

6. Superstall and spin testing, Superstall characteristics

b) FC complementary Spin Trials with 35 Draken

FC Flight Test Videos

SS nr 2-AN 40 sek

- **Turn entry**
  - **Alt=12km/40.000ft**
  - **M=0,6**
- **Slow rotation in yaw**
- **Stick forward**
- **Immediate recovery**

Flight testing the Saab 35 Draken

6. Superstall and spin testing, Superstall characteristics

b) FC complementary Spin Trials with 35 Draken

FC Flight Test Videos

SS nr 3-AN 55 sek

- **Turn entry**
  - **Alt=12km/40.000ft**
  - **M=0,6**
- **Slow rotation in yaw**
- **Ailron against the yaw rotation increases rotation in yaw**
- **Stick forward**
- **Delayed recovery**

Flight testing the Saab 35 Draken

6. Superstall and spin testing, Superstall characteristics

b) FC complementary Spin Trials with 35 Draken

FC Flight Test Videos

SS nr 4-GM 55 sek

- **Level flight entry**
  - **Alt=12km/40.000ft**
  - **Vi=280 km/h (150 kts)**
- **Pitch oscillating superstall**
- **Stick forward when pitching forward**
- **Immediate recovery**

Flight testing the Saab 35 Draken

6. Superstall and spin testing, Superstall characteristics

b) FC complementary Spin Trials with 35 Draken

FC Flight Test Videos

SS nr 5-GM 20 sek

- **Turn entry**
  - **Alt=12km/40.000ft**
  - **M=0,6**
- **Pitch-up**
- **Stick immediately forward**
- **Immediate recovery**

Flight testing the Saab 35 Draken

6. Superstall and spin testing, Superstall characteristics

b) FC complementary Spin Trials with 35 Draken

FC Flight Test Videos

SS nr 6-GM 55 sek

- **Turn entry**
  - **Alt=12km/40.000ft**
  - **M=0,6**
- **Pitch-up**
- **Stick immediately forward and kept there for ~15 sec**
- **Departure with violent tumbling, engine flame-out due to large sideslip and AoA**
- **Stick fully aft and kept there for ~15 sec (a/c calmed down, erected with no pitch oscillation)**

Flight testing the Saab 35 Draken

6. Superstall and spin testing, Superstall characteristics

b) FC complementary Spin Trials with 35 Draken

FC Flight Test Videos

SS nr 6-GM 55 sek (cont)

- **Stick fully forward and kept there for ~15 sec (slow stick rate because hydraulic pressure became low due to the flame-out)**
- **Recovery after some hesitation**
- **Smooth pull-up**
- **Engine relight was successful during pull-up**

Flight testing the Saab 35 Draken

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Flight testing the Saab 35 Draken

Saab J35J Draken

Göte Marcusson 2 March 2009