



ROYAL INSTITUTE OF TECHNOLOGY
SCHOOL OF ENGINEERING SCIENCES

Flight Mechanics

Project Work Part I

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Listings

1 Abstract

This is the report for the performance analysis project in the *Flight Mechanics* course offered by the School of Engineering Sciences at KTH. The report was written using the *Vim* Editor and the \LaTeX typesetting system. For the coding part the *Matlab* technical computing language was used.

2 Introduction

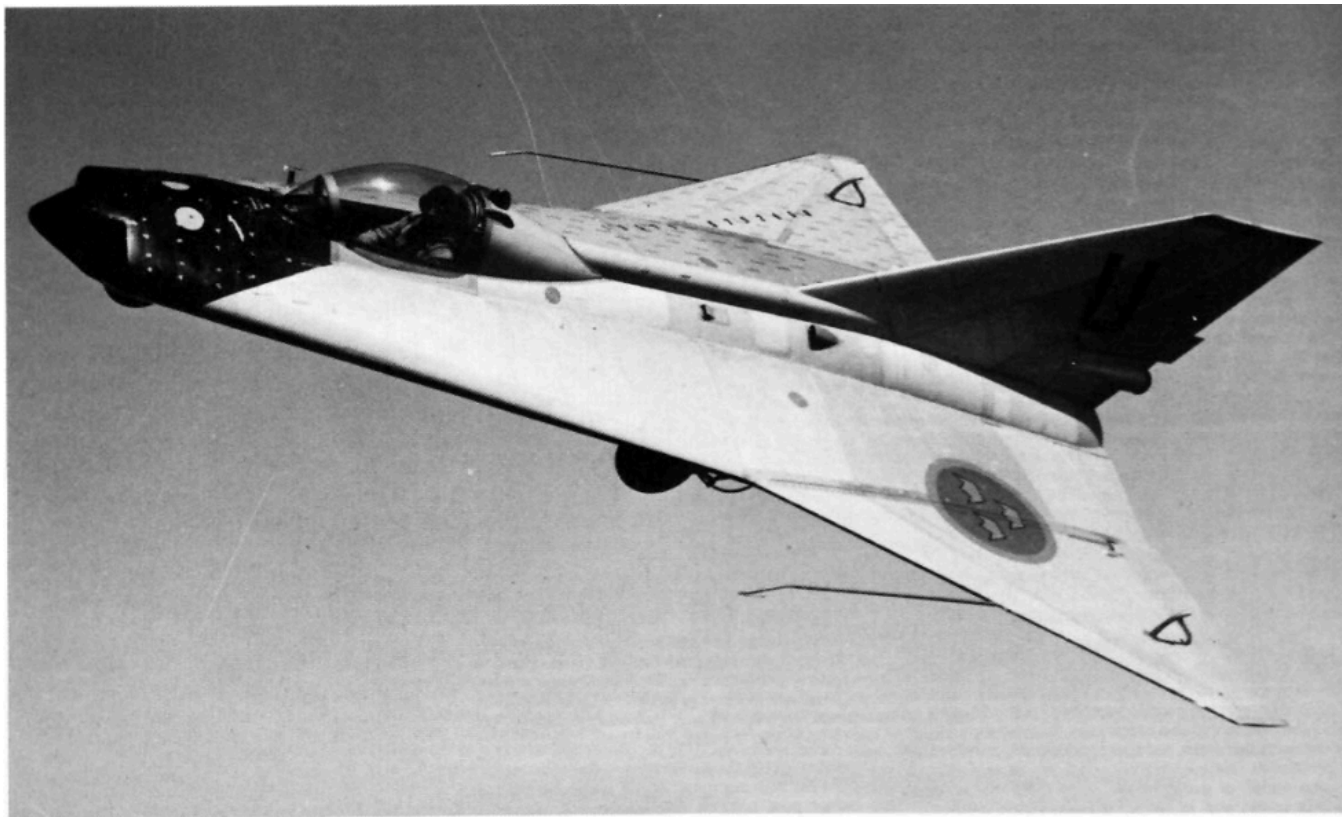
2.1 General Characteristics

As the jet era started, Sweden foresaw the need for a jet fighter that could intercept bombers at high altitude and also successfully engage fighters. Although other interceptors such as the US Air Force's F-104 Starfighter were being conceived during the same period, Saab's "Draken" would have to undertake a combat role unique to Sweden. Other demanding requirements were the capability to operate from reinforced public roads used as part of wartime airbases, and for refuelling/rearming to be carried out in no more than ten minutes, by conscripts with minimal training. **In September 1949, the Swedish Defence Material Administration issued a request for a fighter/interceptor aircraft, and work began at Saab the same year**

Regarding the aerodynamic design of the J35 Draken the two major options were swept wings and delta wings. The question was quickly resolved by the initial studies which had called for the exploration of a swept wing configuration. In short order it was determined that in consideration of all other parameters placed upon the design, the swept wing's aerodynamic drag at high Mach numbers was too high, and its configuration requirements dictated that the fuselage have insufficient volume for equipment, fuel and armament. The Delta wing on the other hand showed great promise following initial tunnel tests. The pure delta soon was ruled out, however, as it suffered from center of gravity and center of pressure anomalies that were difficult to alleviate. A derivative, however, often referred to as *the double delta*, proved much more flexible. In general the double delta was found to offer the attributes of:

- reduced frontal area while permitting optimal wing area
- More favorable wing sweep angles on the center wing section
- Center of gravity and center of pressure being closer to each other
- More favorable area distribution
- Low supersonic drag
- Favorable low speed drag
- Strong and stiff fail safe structure
- Being able to place the air intakes farther forward

The double-delta configuration was first tested on the SAAB 210 which first flew on 21 January 1952.



The SAAB 210 was the first full-scale double-delta wing aircraft ever to fly and was a sensibly executed aerodynamic testbed for the forthcoming SAAB 35 fighter. Several different intake configurations eventually were tested on this aircraft, these helping SAAB settle on the definitive layout that would become so characteristic of the entire "Draken" family. The landing gear were not fully retractable on the SAAB 210 and were, in fact, partially exposed in flight.

Figure 2.1: SAAB 210

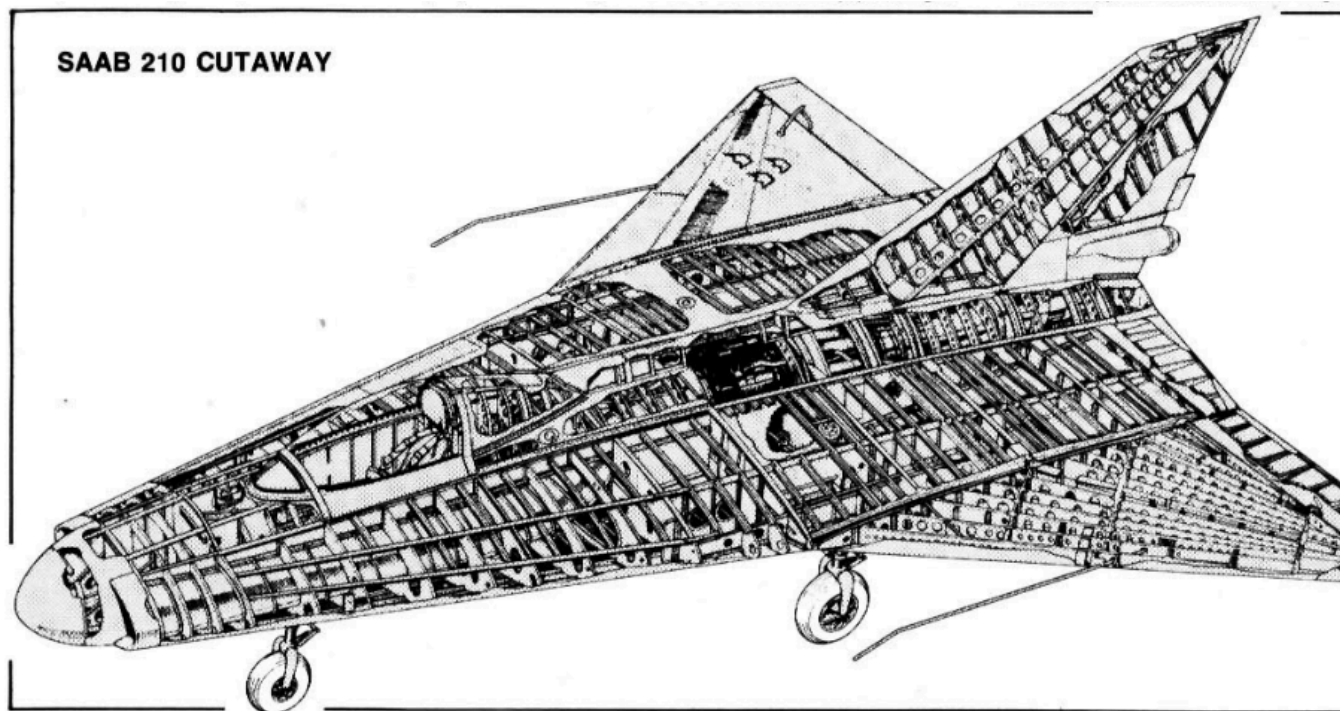


Figure 2.2: Cutaway design of SAAB 210

2.2 Basic Versions

Below are the major versions of J35 Draken which were manufactured from 1955 to 1974 by Saab.

2.2.1 J35A

- First flew on 1958
- Total Production: 90
- Delivered from 1959 to 1961



Figure 2.3: J35A

2.2.2 J35B

- First flew on 1959
- Total Production: 73
- Delivered from 1962 to 1963
- First truly operating interceptor version of J35 Draken

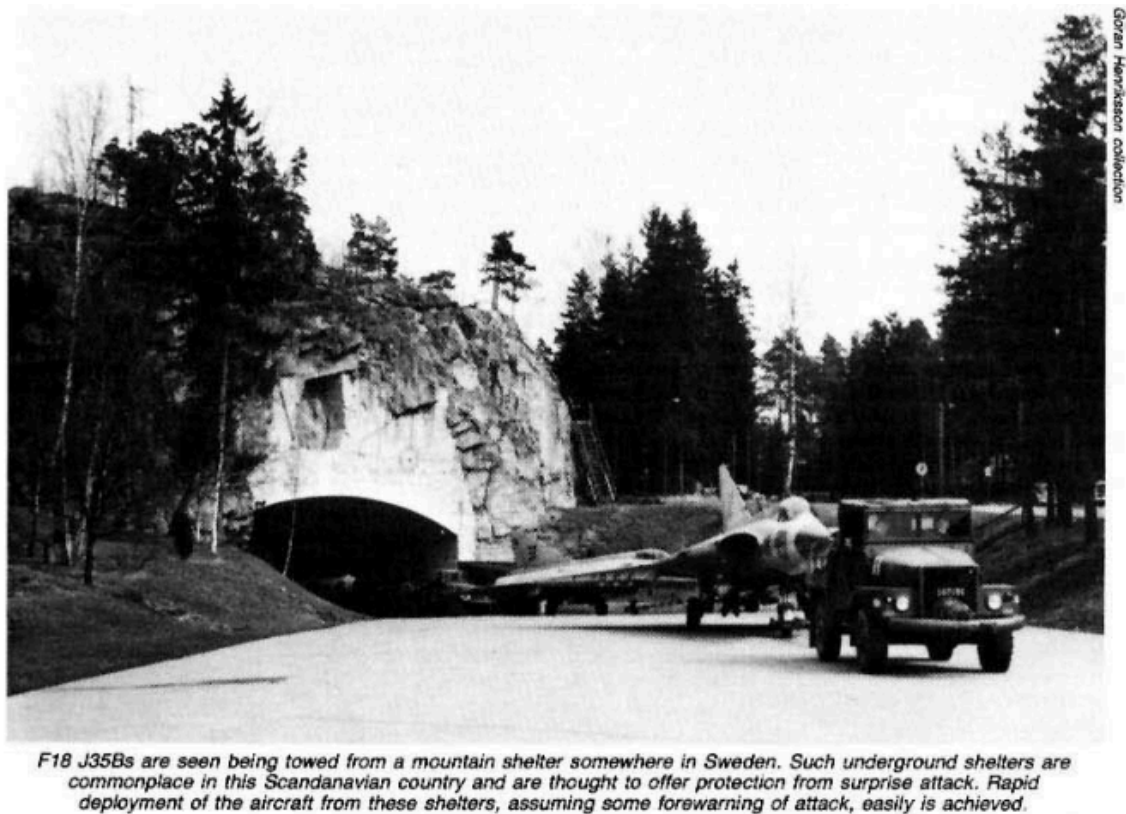


Figure 2.4: J35B carried out of sheltered area



Figure 2.5: J35B

2.2.3 Sk35C

- First flew on 1959
- Total Production: -
- Essentially 25 J35A with short tail sections rebuilt into a twin-seated trainer version

- To provide space for a second cockpit some equipment was relocated and the size of the forward fuel tank was reduced.
- Lacking the guns and radar of single-seater, the Sk35C nevertheless could be used for armament training with Sidewinder missiles and other external stores.



The prototype Sk35C two-seat trainer, 35800, flew for the first time on December 30, 1959, some four years after the first flight of the prototype "Draken". Changes to the airframe to accommodate the second seat were virtually non-existent.



Following its use as a prototype for the two-seat configuration, the first Sk35C, 35800, was used by the Swedish Air Force test center as a SAAB 05 air-to-ground missile testbed. Special markings and a modified back seat periscope were provided.

Figure 2.6: Sk35C

2.2.4 J35D

- First flew on 1960
- Total Production: 120
- Delivered from 1963 to 1964
- Fastest Draken version, capable of accelerating until out of fuel.
- Represented a marked improvement over earlier versions both in terms of performance and combat capabilities. The former was obtained by replacing the RM5B engine with RM5C (Avon-300 series) thus increasing the max thrust from 6.850 kgp to 7.750 kgp when using the afterburner.



An early J35D during armament tests with the Rb27-designated Swedish-built derivative of the Hughes AIM-4 "Falcon". This weapon proved to be decidedly ineffective when used by American aircraft during the air war over Vietnam.

Figure 2.7: J35D

2.2.5 S35E

- Total Production: 60



The prototype S35E, 35901, during an early test flight over Linköping and generally sans all markings with the exception of the Swedish insignia on the forward fuselage. The S35E was based on the improved J35D airframe and powerplant.

Figure 2.8: J35E



Figure 2.9: J35E nose view

2.2.6 S35F



Figure 2.10: J35F



Figure 2.11: J35F landing

2.2.7 S35H

Version of J35 which was supposed to be sold to Switzerland by SAAB. During 1960 it was evaluated thoroughly in Switzerland with generally favorable results. The J35H was not however the only aircraft considered and in the end the Schweizerische Fliegertruppe concluded that a slightly modified version of Dassault Mirage III was more ideally suited.

2.2.8 SAAB 35XD

- Company designation in which X stood for export and D for Denmark
- In 1968 The Danish Government ordered 20 single seated 3 two seated trainers 23 photo-reconnaissance aircrafts in a follow up order. Finally the Danes revised their offer for 20 single seat 20 reconnaissance aircrafts and 11 two-seat trainers.

2.2.9 SAAB 35XS

- Export version for Suomi or Finland
- Ordered during 1970 by Finland

3 Static Performance

3.1 Excess Thrust

3.2 SEP Graph

3.3 Maximum altitude

3.4 Maximum Mach number

4 Minimum time to climb

4.1 Computing $\gamma(t)$ - minimum time to climb

4.2 Trajectory for maximum Mach number in minimum time

4.3 Trajectory for maximum altitude in minimum time

References

- [1] Robert Dorr, Rene Francillon, and Jay Miller. *Aerofax Minigraph 12, Saab J35 Draken*. Aerofax Inc., 1987.