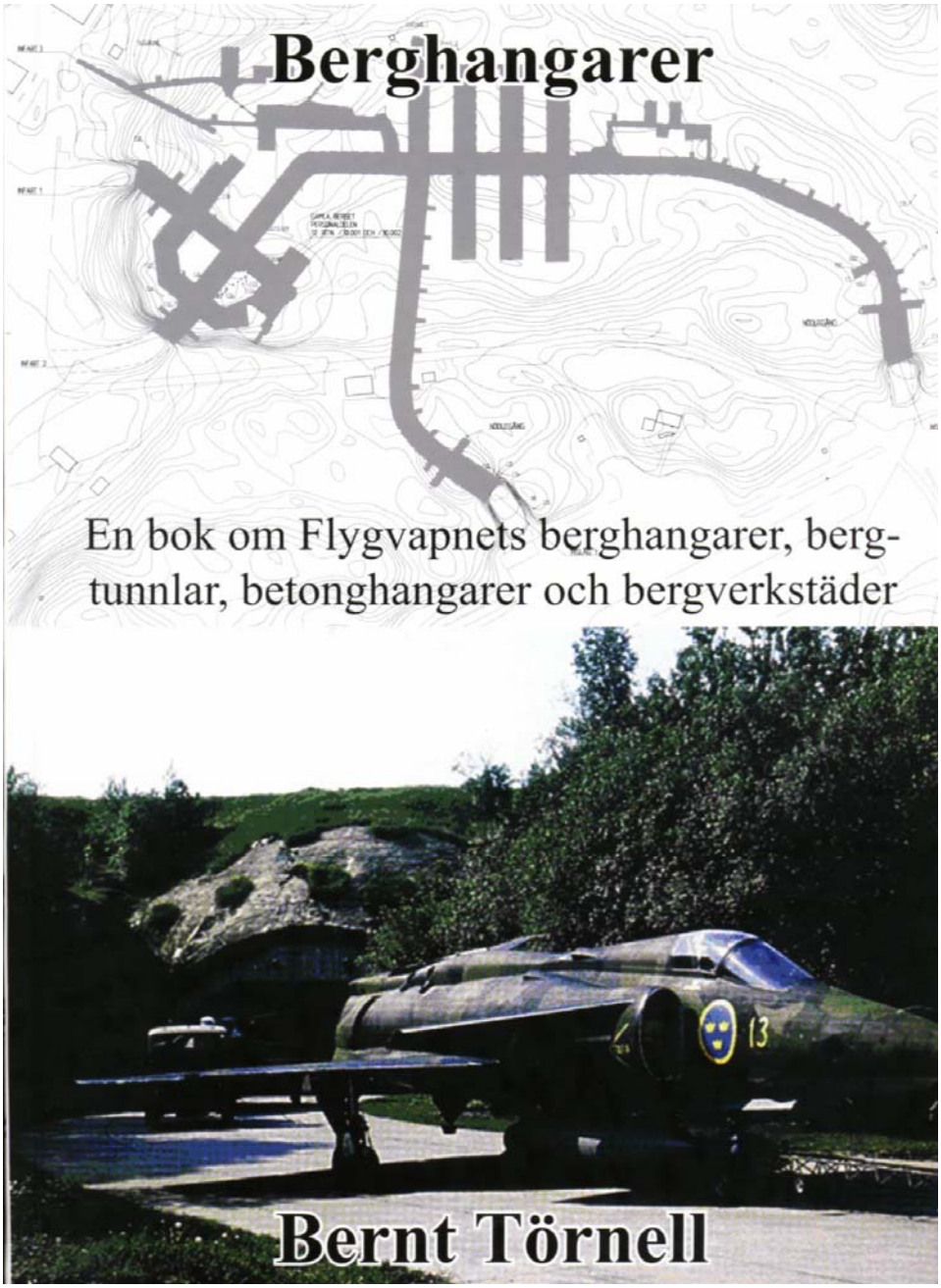
Summary of the book
"Mountain Hangers - The Royal Swedish Air Force mountain hangers, mountain tunnels, concrete hangers and mountain repair sites".
/Author: Bernt Törnell.



(The original title "Berghangarer - Flygvapnets berghangarer, bergtunnlar, betonghangarer och bergverkstäder", ISBN 978-91-977297-1-0)

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This is a summary of the book about the mountain aircraft sites or aircraft caverns used by the Swedish Air Force. In addition there are Chapters on Hardened Aircraft Shelters (HAS) and mountain aircraft plants.

Every chapter below contains a brief summary of the Swedish text. The photos in the book are titled and linked to the accompanying text.

Bernt Törnell (pictured in a Hawker Hunter on page 1), the author of the book, is a retired officer (Major) in the Swedish Air Force. He has previously published a book on military air surveillance in Sweden, with the title: "Spaning mot skyn", more information at his homepages **www.luftbevakning.se** and at **www.flygbas.se**.

Lars A. Hansson met the author in 2007 during a visit to the mountain hanger at Säve they have also corresponded on the internet. Bernt has designed the layout of the book himself and has included numerous photos. The book is privately published.

Introduction **(Page 3-pp.)**

The cover photo shows two SF 37 Viggen aircraft being towed out of the mountain hanger at F 13 Norrköping. Note that the tail is tilted, to ease transportation within the mountain.

Page 3 shows a typical scene from the days of the Second World War. The pilot Gösta Åhlberg awaits the call for a new mission close to his aeroplane. There is no protection for the pilot or the aircraft in sight.

Aeroplanes are always vulnerable on the ground during wartime along with the maintenance crew and pilots. During the early days of the cold war propeller aircraft were replaced with jets. These required even longer runways and became harder to disguise from an attacker. The threat from nuclear explosions had also arrived.

There are a number different ways to protect aeroplane units on the ground:

• Protect them in fortified bunkers/shelters
• Provide ground defence
• To spread them out over a large area
• Hide them with camouflage
• Use of decoys
• Be ready in the air (having aircraft in the air above the base at all times)

The idea to protect the air force probably arose from the long-used idea in Sweden, to centralise defence in large mountain fortresses in the middle of the country. Although this was scrapped in the 20th century, the idea to protect pilots, crew and aircraft remained.

Page 4 has a photo on one of the mountain hangers at the air force wing ("flygflottilj"), F 18 outside Stockholm.

Sweden wasn't able to study foreign sites in the 1930's when the study started, but looked at the international development of fortification. The first mountain hanger in Sweden looked very much like the top most picture in the American magazine from 1937.

According to all reliable sources the first mountain hangers in the world were constructed on the Italian island of Pantelleria during the 1930's. This island was declared prohibited to foreigners in 1926 when construction work began to fortify the island. In the middle of the 1930's the air force base Marghana went into service with a mountain hanger close by. Pictures from outside and inside are on page 5. The 1570 meter runway was extended during the cold war and as a result of this work it is thought that the mountain hangers were destroyed. The mountain hanger was approximately 350 meters long and fully equipped with generators, a well and maintenance areas for up to 80 aircraft.

Switzerland also strengthened their central defence system during the Second World War and later in the Cold war. At some ten air bases, mountain tunnels were built to protect Hawker Hunter jet aircraft and earlier Swiss Messerschmitt Bf-109 and Morane-Saulnier D-3800/D-3801 Aeroplanes. The tunnels were basic structures without the facilities of the conventional hangers and were used purely to protect the aircraft. The tunnels were constantly upgraded during the cold war, gaining hanger status.

No other countries are known to have built tunnels or hangers during the Second World War. However, mountain factories were built towards the end of the war in Germany. (Picture from V1/V2 factory on page 6.).

Concrete hangers were also built in Japan (picture).

Fortifications at war time air bases **(Page 7-pp.)**

In the light of a possible German invasion of Sweden during the war a massive extension of the Swedish wartime bases were made. The usual protection was open areas with camouflage for aircraft, shelters for ammunition, personnel and bunkers for ground defence purposes.
Picture on the page 7 shows a typical wartime air base with a standard hanger.

The following types of protected sites were used in Sweden during the Cold war.

Mountain hanger is a fortified site at an airbase that can be used for service, maintenance and storage. At some airbases they were built instead of large hangers above ground. They were used in both peacetime and wartime. It was planned to have mountain hangers at reserve wartime bases as well, especially at places where there was a suitable mountain close to the airfield.

Picture from the old mountain hanger at F 9 Göteborg 1948.

Concrete hangers, also called caverns or dens. They had a concrete floor and a cast concrete structure. At one end they had a hanger door and the other end was covered with earth.

Picture from F 16 Uppsala 1943.

Mountain tunnel is a fortified tunnel used at reserve wartime bases, only to store aircraft. This system was introduced with the Base-90 system in the 1980’s.

Picture from the Fällfors base in 2008.

Mountain workshop is also a fortified site but only used for larger maintenance, modifications and storage of spare parts. Outside the air force a mountain factory also could be used solely for production of aeroplanes.

Picture from Arboga 1946.

The Swedish Air Force first mountain hanger and workshop **(Page 9-pp.)**

Page 9 photo from the old hanger at F 9 Göteborg during the Second World War. The fighter aircraft are Fiat C.R.42 "Falco" in Sweden J 11.

In 1936 the government decided to spend more money on the air force but it was still considered that fighters wouldn't play a significant role in war time and the focus was put on bombers.

Sweden got a new supreme commander in 1940, he put more emphasis into protection of aircraft and production facilities. It was decided that aircraft production should use two mountain factories, in Trollhättan and Linköping.

Discussions on protecting fighter aircraft and their personnel soon grew stronger. A fighter with its more limited range than for instance bombers couldn't regroup to another part of the country and needed better protection.
After the break out of the Second World War the Swedish government decided to add two fighter wings, F 9 in Göteborg and F 10 outside Malmö. A Swedish air force wing ("flygflottilj") normally comprised of three flying squadrons ("divisioner"). It was soon decided that he facilities at F 9 were best suited to have a mountain hanger and work began in 1941. It took two year to finish the 8000 square meter hanger. Three of four hanger entrances can clearly be seen on page 10.

During the building of the F 9 mountain hanger the second wartime site was started. In Arboga the central workshop (CVA) were moved below ground together with the air force central storage (CFA). Preparations started in 1942 and the site was operational in October 1944. Picture show Arboga in 1945.

Planning for a large extension of mountain and concrete hangers **(Page 12 -pp.)**

During the winter 1945/46 a large survey of possible locations for aircraft shelters was carried out. The study was made at air force wings, frontline bases, training bases, civil airports and airstrips at the central workshop.

The report was handed over to the supreme commander in spring 1946. At places with a good mountain to build in, mountain hangers were suggested. It should be large enough to house all of the aircraft at the base. If a concrete hanger system was to be used, nine of them would be required.

The shelters should be able withstand a direct hit from a 500 kg bomb and the larger mountain hangers a 1000 kg bomb. It was also stated, in principle the sites should be both nuclear and gas proof (NBC). This was not going to be possible in all areas but as a minimum the staff areas inside should be NBC proof.

This was a large extension of the shelter infrastructure in Sweden. Twenty mountain hangers and eighteen sites with concrete hangers for a total budget of 305 million Swedish Kronor (SEK). (In today's terms some 600 million euros).

The report stated two different kinds of aircraft being located in the sites. The smaller fighter aeroplane the SAAB J 21 (pictured) with a span width of 13 meters and the larger bomber the SAAB B 18 at 17 meters.

Forty-five aircraft (three Swedish divisions) of B 18's would require a minimum of 70 000 square meters and the smaller J 21 30 000 square meters of space. The Staff areas are in addition to this comprising of dormitories, office blocks etc.

One top of page 13 the report states the extension of mountain ("Berg") and concrete ("Betong") at the air wings (abbreviation and city/name to the left). It also states aircraft types and numbers.

“Vid fältet” is at the field and a number states how far from the air base perimeter the hanger was planned. The last column is approximate space needed. “Befintlig” is already in use.

Table 2 is reserve wartime bases. Those were numbered “Fält/field and a number” the other information is the same as above.

Table 3 is the proposed works at civil airports, training airports and at the central workshop. Note a) states that an additional mountain hanger should be built for the air force close to the central workshop mountain in Arboga.

Search for suitable sites for mountain hangers **(Page 14-pp.)**

Mountain hangers should be located between five hundred and one thousand five hundred meters from the runway, in exceptional circumstances three thousand meters may be acceptable.

Pictures on pages 14 and 15 shows the proposed sites at F 1 Västerås, F 13 Nyköping (nowadays Stockholm/Skavsta) and F 15 in Söderhamn. None of these were built.

1948 building plan **(Page 16-pp.)**

The 1948 plan took the 1946 survey into account. However costs had risen during this time and a new stronger air force had to be taken into account. The 1948 government had approved a 50% increase to the air force and also had plans for a further increase to the air force. This was taken into account in the 1948 plan and some mountain and concrete hangers were made larger. At the same time 14 air fields were deleted from the list and seven were reduced in size. In general the smaller J 21 aircraft was made the default aeroplane type for the hangers.

Differences between the 1946 and 1948 plans:

- Mountain hangers at F 8, F 9, F 11, F 13, F 15, F 16, F 18, field 30, 31, 32 and 37. These were planned to be increased from 45 to 65 aircraft.

- Concrete hangers at F 3, F 12, F 21, field 28 and Hagshult. The protection level was brought down to protect from splinter and firearms, And increased from 45 to 65 aircraft.

- Other areas within the hangers, like ammunition, fuel and dormitories, were increased in size in proportion to the increase of aircraft.

- A total of 14 airfields were taken out in this plan. They were F 5, F 6, Field 1, 10, 12, 14, 19, 24, 29, Arboga, Boden, Bromma, Norrköping/Kungsängen and Rinkaby.

Picture on page 16 shows the building of the old hanger at Tullinge. On page 17 two further pictures from the Tullinge: Winter 1951/52, with a J28 Vampire fighter being pulled out, for engine starting. This problem was solved on the lower picture from around 1953, when a truck is being used to tow the aircraft.

Building planning after 1948 **(Page 18-pp.)**

The change from propeller to jet aircraft made the movement of aircraft inside the hangers

easier as the modern aircraft had a front wheel that could be attached to a towing rod. The aircraft could be loaded and ready with both fuel and ammunition within the hanger and attached to the towing truck. This increased the efficiency within the hangers and allowed the storage of more aircraft.

With the arrival of the nuclear threat all mountain hangers except the old hanger at Säve and the mountain hanger at Arboga were equipped with blast doors. These were installed after the sites were finished and were made of concrete with a weight of some 90 tons.

The blast doors in the hangers were found to be unpractical. The doors took up to a minute to open, a long time for a fighter plan to be stuck inside if the airfield was under attack. It was also noted that the doors could not be proven to be fail-safe, there was a possibility of the doors malfunctioning and blocking the exits. Despite blast doors, “dog leg” entrances and the protection of up to thirty meters of granite, no mountain hanger could be approved to withstand a 1 Megaton nuclear explosion.

In a 1953 report, 49 fields were proposed for upgrade to the new Base-60 system. The building of mountain hangers should be completed at F 8, F 9, F 13, F 16 and F 18. The planned hanger at F 17 Ronneby remained as a priority hanger for production.

To increase the protection for aircraft at the Base-60 systems there was a proposal for 250 concrete shelters at 96 deployment areas.

Pictures on page 19 shows a division of J 29 fighters from F 13 being refuelled at F 18 during a practice in the 1950’s. With a time limit set to 10 minutes it was impossible for aircraft from another wing to use the mountain hangers for refuelling and rearming.

The lower pictures shows pilots in J 29 aircraft inside a mountain hanger. The pilots took two hour shifts waiting in the aircraft for order to start.

What became of all the plans? **(Page 20-pp.)**

The old hanger at Säve and the mountain workshop at Arboga were ready during the war. The first postwar site was built during 1947-1949 at Tullinge. It resembled the Säve facility, with some improvements. It was planned from the start that the mountain at Tullinge would be expanded. This work was started during the 1950’s and the tunnels were built but newer completed. The hangers were built between 1954 and 1957.

At the end of the 1950’s the strategy was changed from mountain hangers to deployment of aircraft over large areas. The protection benefits of mountain hangers could not be balanced to the huge building costs.

A total of six hangers were built for the air force with an addition of the workshop mountain. See map and table on page 20!.

Pictures on page 21 shows the new mountain hanger at Säve with J 29’s ready to roll out and J 34’s at Tullinge.

Air defence centrals in connection to mountain hangers **(Page 22-pp.)**

Swedish air defence consisted of a number of air defence operations rooms that coordinated aircraft and air movements within its sector. The control of the aircraft has the abbreviation

“Stril” in Swedish. During the expansion of the air force in the 1950’s the Stril-50 system was launched, focusing on two operations rooms, O 2 and O 3 on the eastern coast of Sweden.

These very important operations rooms were to be highly protected and were co-located within the mountain hangers at F 16 Uppsala and F 18 Tullinge. Code named “Räven” (the Fox) and “Falken” (the Falcon) they went into operation in 1950 and 1951.

On top of the mountain, close to the operations rooms, a radar station called PJ 21/F (F – fixed) was built. It consisted of a surveillance radar PS 14/F and a height finding radar PH 13/F. The F 16 Uppsala radar site is pictured on page 23.

The air defence operations room at F 16 Uppsala was built as an expansion to the operational shelter at the air base. In this shelter the operations room for fighters (Fighter Control Centre, jaktcentral, jc) was already in use. For quick access to the below ground rooms a “fireman’s pole” was installed, A similar one at F 9 Säve is pictured on page 23.

The air defence operations room was enlarged, usually referred to as the “church” due to the size of the room. The room (picture on page 22 at F 18 Tullinge) consisted of two floors with glazed platforms for fighter, air surveillance and alarm command. The opposite wall contained maps and plans and on the floor, a big plotting table (pictured) for the sector.

The O 3 site at F 16 Uppsala became the first operations room to go live, starting in the summer of 1950. It was a rather small extension of the mountain structure. It was modernized over the years and used constantly for both peace time incident preparedness and training for war.

The O 2 at F 18 Tullinge was operational a year later and used for a training session during autumn 1951. This operations room was placed in the office area of the mountain hanger. Even though this site was considerably larger than the one O 3 it was found to be too small even before the building works were finished.

For the construction of the later operations rooms in sectors S 1, S 2, W2, O 1, W 5 and ÖN 3 the plan was to build the structure around the operations room, not fit that room into a finished or almost finished structure.

The operations room was built so as to be able to fit in the plotting table and its personnel. The platforms could seat 30 officials and a small number of observers.

The plan on page 24 shows the operations room at F 18 Tullinge with two platforms. After an initial exercise it was noted that with two floors some parts of the plotting table weren’t visible to all members of staff. The O 2 central was not rebuilt but for future sites it was noted that three platforms were needed. The size of the room inside the mountain to accept this should be 40 meters in length, 15.5 m width and with a height of 8.5 meters.

Most of the interior of these rooms were constructed of wood, so as to be able to rearrange the room easily. After a huge fire during the building of the W 2 “Swallow” in Göteborg extra emergency exits were installed.

The next system, Stril-60, saw the construction of a new site in the eastern part of Sweden. O 5, “The Puma” took over the work from O 2 and O 3 in 1965.

The photo on page 25 shows a view from inside O 2.

Adaption to new aircraft types **(Page 26-pp.)**

During the latter part of the 1950's, F 8 Barkarby and F 16 Tullinge were adapted to accept the J 34 Hawker Hunter. Tullinge was subsequently modified to take the J 35 SAAB Draken. F 13 Norrköping and F 18 Uppsala hangers were built to host the J 35 SAAB Draken and later adapted to fit the JA 37 SAAB Viggen. F 13 was also adapted a second time to fit the JAS 39 Gripen. This was done in 1991 and the F 13 wing, together with the mountain, was decommissioned in 1992.

The air force Hawker Hunter wings decreased in numbers and as the mountain hangers were used mainly as facilities for these wings, the interest in the hangers also decreased. F 8 Barkarby was decommissioned in 1962, F 9 Göteborg 1969, F 18 Tullinge 1974, F 13 Norrköping 1992 and F 18 Uppsala in 2003.

After the wings were disbanded and vacated the hangers, they were used as a storage area for the Swedish military as a whole.

Pictures: J 34 Hawker Hunters inside F 18. SAAB Draken J 35 is being towed out of the F 18 hanger. (Compare with the picture on page 4). A JA 37 is being towed into the mountain at Uppsala.

The structure of the mountain hangers **(Page 27-pp.)**

The picture shows the top of the F 13 Norrköping mountain with the ventilation shafts and a defence position in the background.

There are subtle differences between each of the mountain hangers. There was a standard hanger and maintenance facility below ground and all were built to fit the local mountain structure. They were built over a number of years so both knowledge from previous buildings and changes in the demands of the air force made them differ.

There are three major types:

Cat. 1 (Page 28-29) – Old structure

This is the old mountain hanger at F 9 Göteborg. From top; Entrance 1 is the standard entrance. Both entrance 2 and 3 have been rebuilt with smaller entrances. The hanger has an area of 8000 m2. There is about eight meters of overhead cover from the mountain above. The doors are made of reinforced wood. Page 29, The Black and white photograph shows the old Hunter operations room at F 9.
The eastern part of the hanger area contains offices etc. Towards the emergency exit there are facilities for air filtration, generators. Natural ventilation is used. There is no sprinkler system for fire extinguishing.

Cat. 2 (Page 30-33) – Combination of old and new structure

The hanger area in the earlier part of F 18 Tullinge, is mostly built above ground. The protected overhead cover is between 12 and 14 meters. It is of similar construction to F 9 Säve hanger but with a little smaller hanger area and only two entrances. The office and technical area has been moved towards the back of the structure.

The red line in the plan on page 30 shows the camera views.

Page 31 shows parts of the office and technical area with offices, quarters, workshops, dormitories and map rooms spread over two floors. The largest room is the old air defence operations room “the Falcon”, pictured top right.

Page 32 – The F 18 facility was to be built in three stages. The first part was ready in 1950 and the mountain was blasted for stage two and three. The two later stages were planned as a modern hanger with a much higher protection level. This works were halted in 1958 and the tunnels were left in an unfinished condition. The costs for upgrade of the earlier areas to a nuclear protected level were too high and at the same time the need for storage of aircraft had decreased at F 18.

The two left pictures of page 32 shows the area between the old and the new areas. The new area is some 8-10 meters below the older area, it was planned to combine the two areas. The plans called for a lift to transport aircraft between the two areas.

Page 33 The top photograph shows one of the two blast doors with the remains of a scrapped SAAB J 35 Draken. This has now been removed from within the hanger. The close up picture shows the lighting arrangements above the blast door.

Cat. 3 (Page 34-35) –Modern structure

Category 1 and 2 hangers couldn’t withstand a nuclear attack. Category 3 Hangers were built into mountains at much deeper levels. They would also host all of aircraft of the wing, with a minimum of 60 aircraft. All the facilities would be incorporated within the hanger, including a fuel depot for refuelling the aircraft. A category 3 hanger is 10-12 meters below the outside ground level, which equates to 20-25 meters of overhead cover. The size of the hanger varies between 22000 and 24000 m2.

This type of hanger is much more advanced that its predecessors. The hanger starts and ends with a 300 to 500 meter long descending tunnel. The central spine is in a horseshoe shape and from this there are a number of storage areas leading off to the sides. A one-way traffic system is used with turntables (pictured) to manoeuvre the aircraft into the storage areas. As can be seen on the plan of F 9, Port 1 is used for enter the hanger and Port 2 is used exit the hanger.

In the ramp up to Port 2 there are areas for refuelling the aircraft, electricity substations and ammunition storage areas in the wall to the side of the central spine. Automatic sprinklers have been installed. Air is forced into the hanger from the sides and is sucked out from both the top and bottom of the tunnels. In the middle of the F 9 structure there are dormitories and a operations room or command central (KC) (pictured) for the airfield.

Apart from the new mountain hanger at F 9 Säve, category 3 hangers were built at F 8 Barkarby, F 13 Norrköping and F 16 Uppsala. They are still in use by the Swedish military. The picture on page 36 shows the building of the F 14 mountain hanger in the 1950’s and the personnel entrance at F 16 Uppsala. The author’s bicycle is shown.

Preparation for war-time total destruction of the facilities **(Page 37.)**

As with some other public buildings, civil and military fortified sites, the mountain hangers had plans in place for their destruction if they should fall into enemy hands.
The entrance to the hangers would be destroyed with explosives smaller quantities of explosives would also be placed inside the hanger in strategic places. Pictured is one of the containers at the entrance to the old mountain hanger at Säve, used to store explosives for demolition of the entrance and the port. The plan is a demolition plan for an air surveillance

operations room in Uppsala.

Attempts to disguise mountain hangers **(Page 38-pp.)**

Attempts were made at F 9 Säve during the late 1950's to camouflage hanger entrances to prevent attacks from the air. If the project was proved to be successful it would be implemented at every mountain hanger in Sweden.

Focused on having the taxiway apparently passing the entrance to the hangers and having the entrances hidden. They would be hidden from optical observation but it was considered a too big challenge to have them disguised to photographic surveillance. This would probably be such a massive camouflage job, that it would hinder the normal operations at the hanger.

The major problem became to disguise the runways. Different kinds of paint, both black and green were tested unsuccessfully. The entrances were disguised to a good effort with camouflage; the problem here was that the opening in the camouflage for the aircraft to enter/exit was clearly visible (page 39 top). One solution was to disguise the entrance with dummy trees; this was dropped due to restricted access for the aircraft.

A survey was undertaken by SAAB A 32A Lansen aircraft from F 14 during a simulated attack. The attack was filmed and recording on both moving film and slides. The film and slides showed that the entrances could be seen from over 10 km away, both in a low level attack and a diving mission. There was plenty of time to aim the weapons and wait for the optimal moment to fire. The lower photograph on page 38 shows disguised entrances from a photo taken In 1960. The lower photograph on Page 39 is a photo taken by the navigator in one of the attacking A 32A Lansen aircraft. Note the surprised personnel on the ground. After the results were analysed the project to disguise mountain hangers was scrapped.

Usage of the mountain hangers **(Page 38-pp.)**

In 1962 a report was produced about the security in the mountain hangers. The report also lists the usage of the hangers and is therefore quoted here.

F 8 Barkarby – with the closing of the wing in may 1962 no aircraft are stored in the hanger. 20-25 J 34 Hawker Hunter's may be stored in the mountain, from F 18, from October 1962 to May 1963. SAAB J 35 Darken from F 18 will also be stored at F 8 due to the lack of space at F 18. Apart from the hanger area, there are two divisions of Bloodhound missiles at F 8.
Left, a wintertime picture shows F 8 in 1970, temperatures dropped to -32 Celsius this year.

F 9 Säve – is used by a company each of SAAB J 29F Tunnan and Hawker Hunter J 34 (pictured below left from 1968). It also served as maintenance hanger for another company of J 29F's. After March 1963 the J 29 will be obsolete and there will be two companies of J 34 in the mountain. A company J 34 plus 5-7 Sk 16 school aircraft use the new mountain.
The Aerial photo shows the F 9 area.

F 13 Norrköping – Training with J 35 Darken is currently only carried out with two out of the three aircraft maintenance companies. These aircraft are stored in concrete hangers above ground. The third company is stored in the mountain hanger with 4-6 Sk 16 aircraft, due to a shortage of personnel.
Central maintenance of J 35's is carried out in the mountain hanger, as well as deep storage of aircraft. Pictures on page 41 show one of the entrances, the photos are taken from the same spot looking in both directions.

F 16 Uppsala – Like F 13 this wing has concrete hangers above ground, due to the distance from the airstrip to the mountain hanger, the concrete hangers are used to store aircraft that are in everyday use. The aircraft that are not in constant use or are being serviced are stored in the underground hanger. Page 42 has an aerial view of the F 16 field.

F 18 Tullinge – The newer area has not been completed. The tunnel system has been blasted but no further work has taken place. Two companies of J 34's are using the older area. One company is replacing its aircraft with J35's in October 1962 the other company will follow them in January 1963. After the change to J35 aircraft space in the already crowded hanger will be at a premium as the J 35 is a larger aircraft. The third company uses wooden hangers above ground. Storage of the six Sk 16 and a number of stored J 34's is outside in the open. (See picture). The last picture on page 42 shows movement of J 34 "Rudolf Gul Johan", an F 18, from the 3rd Squadron ("Division"), aircraft "J".

Wartime activity **(Page 43.)**

In addition to the aircraft used at the wings with mountain hangers, the fighter version of the Lansen (the J 32B) would be added in wartime. The mountain hangers would be used for the maintenance of aircraft and safe storage of aircraft in order to make them ready for action.

The strategy of having the aircraft at highest alert inside the mountain hangers changed to a storage role, the aircraft were towed to the end of the runway and prepared there. However, at many bases only two companies could be prepared at the end of the runway, the third needed to be below ground. To minimize the risk of spillage of fuel and the risk of fire all aircraft were equipped with a collection system attached to the underside of the aircraft.

Pictures show the towing of a J 29 Tunnan. The jeep carries a starting unit. The pilot is already in the cockpit. The lower picture was taken at a preparedness demonstration.

Sharing experiences with other countries **(Page 44-pp.)**

Study visits have occurred within the mountain hanger sphere to share knowledge. Some of the documented visits from abroad seem to have had an impact on the building of Swedish hangers.

Swiss fortifications visit in 1954

The Swiss passed on detailed information about the buildings of their mountain hangers. Special interest was taken in their experiments dealing with extinguishing of fire. The results showed that the primary risk of explosion came from the fast heating of ammunition and rockets on board the aeroplanes. If a aircraft was engulfed by fire from leaking fuel the fire must be put out within 30 seconds, otherwise the ammunition and rockets would explode. After many Swiss attempts the best solution was found to be a fast, aimed high-pressure water deluge system. The tunnels were divided into 15 meter sections with one aircraft in each. The sections were divided with fireproof curtains. Three sections could be deluge with water at the same time.

The Swedish protection system at this time relied on automatic foam alongside with manual extinguishing from fire points and fire extinguishers. The Swiss officers pointed out that ammunition and rockets are hidden under the wings of the aircraft and that a vertical foam is ineffective in extinguishing a fire.

The result was a system with directional foam sprinklers was installed in the Swedish hangers.

Picture shows the main control panel for the sprinkler system in a Swedish mountain hanger.

American visit in 1957

RAND (Research and new development) was a civil consultancy company that investigated how the U.S. could protect their aircraft and missiles on the ground. The group visited the mountains at F 8 and F 18 around Stockholm, as well as the concrete hangers at F 10 Ängelholm and a dispersed wartime base, adjacent to F 5 in Ljungbyhed.

The American view of the visit was not encouraging. They pointed out that the hanger doors should be better protected to withstand larger munitions. If they were thicker and had better seals they could also withstand nuclear attacks.

The dispersed base visited gave the group an example of extreme dispersal of aircraft over a vast area. They, as well as the Swedish Fortification Board (FortF) were sceptical as to the efficiency of this system.

The other shelters visited, both in wood and concrete, also produced a negative response. The group, as well as FortF, came to the conclusion that an aircraft could possibly be damaged to a greater extent inside the shelter as the aircraft could be thrown around inside due to the shock wave. Other options discussed were to either fasten the aircraft down or construct a concrete pit into which the aircraft could be lowered with vertical protection from large hydraulic doors.

The Second American visit in 1957

As a result of the previous US visit, Colonel William E Leonhard of the U.S. Air Force Ballistic Missiles Division (AFBMD) made a visit in November 1957. He wanted to gain experience of the techniques used in the construction of the mountain hangers, the installation of the blast doors, ventilation, air conditioning, heating systems and the personnel areas. He visited the F 8 and F 18 hangers as well as the civil shelter at Katarinaberget in central Stockholm and the Atlas Copco drilling centre also in Stockholm. Leonard gave some feedback on the last day of the visit; The number of entry points to a mountain hanger should face in the same direction and not as the F 18 Tullinge mountain was built. The impact of a strategic nuclear bomb over 1 M/ton would statistically damage the hanger less if all entrances were aligned in the same direction.

The “FortF” report made some proposals for future Swedish improvements:

a) The F 18 hanger would be reviewed with the new ideas suggested before the

construction work restarted. The cost to finish the hanger would come to 4 Million SEK and has been asked for in the 1958/59 budget, but would possibly not be granted.

b) Check the possibilities to upgrade already completed and nearly completed hangers.

c) Investigate the possibilities of increasing the level of protection for the battle control areas within the mountain hangers.

d) Make sites invisible to radar surveillance.

e) Concrete shelters at war time bases should not be built. The cost reduction should be transferred to improve ammunition and fuel depots.

Swedish visit to Switzerland 1962

Four Swedish fortifactors visited a Swiss mountain hanger built in 1958, fully self-sufficient for war time use. Mountain coverage was at least 100 meters increasing to over 450 meters above the main area. The upper part of the hanger housed dormitories, battle control and other services. The hanger could host 36 fighters, divided into two groups of 18 each.

Cranes in the roof could relocate the aircraft in the hanger and could also be used for storing aircraft in reserve (pictured on page 46).

Special emergency lamps drew the attention of the Swedes. They were a modified torch, mounted on the wall and attached to the power network inside the hanger. A rechargeable battery was maintained as long as the power was on, the lamp illuminated in a power cut. It then became a movable lamp. A sample was handed over and the picture shows a lamp installed in a Swedish hanger.

Hardened Aircraft Shelters, HAS **(Page 47.)**

These kinds of hangers had been built at F 16 Uppsala wing in 1942-44 as a compliment to the big wooden hangers already in use. 1946-54 saw construction at F 12 Kalmar, F 13 Norrköping and F 21 Luleå and a war time base at Vidsel. Although most planned for construction during the cold war were never built.

A cheaper version was built at some bases, for example, Field 1 at Sjöbo (pictured at the top of page 47 and 3D further down). This became the Swedish version of the NATO “HAS” – Hardened Aircraft Shelter.

The movement of aircraft was as tricky as in a mountain hanger. There was only one entrance and the aircraft could not enter the hanger under its own power. The hanger was covered with earth, for camouflage purpose. They were placed nearer to the runway.

Development of air bases within the new Wartime Airbase 1960 ("Bas 60") concept in the 1960´s and 70´s **(Page 48-pp.)**

In 1958 a decision was made to give the air force a larger part of the total budget for national defence. It was decided that a new air base system should be launched, to be called base 60. 31 additional bases should be built around Sweden, giving a total of 70 bases. A reserve strip would be added to all bases, making use of an ordinary road. A fortified command central (KC) would be built at every base and the main strip would be protected by tank-turrets built into fixed fortified units. Every base would have anti-aircraft protection provide by the army.

During planning of the new mountain hanger at F 9 Säve the eastern exit was constructed to have a connection to the road network. The picture on page 48 shows the exit to the left the runway and to the right the exit out to the new motorway E 6.

The other pictures on pages 48 & 49 show alternative kinds of aircraft protection for aircraft close to the end of runways. These shelters were built after the decision was made to have aircraft ready at the end of the runway, rather than in the mountain hangers. By this, the mountain hangers were reduced to being more of a storage area and in some cases they was used to prepare surveillance aircraft before a mission.

Base 90 tunnels **(Page 50-pp.)**

In the 1980's a new base system was launched, Base 90. The concept was to have a much larger base area around the main strip and also have additional runway capacity in the base area.

The picture on page 51 shows the Fällfors base from the air with the main runway (H) of 1990x35 meters. To the left of it is one of the three short runways (C) of 800x17 meters, inside the fenced area. To the south is D and north of the picture is runway B. Shown on page 53 is a taxiway 111 from runway H and B to the mountain hanger.

As a compliment to the command post of the Base 60 system a "BasC" (Airbase Control Centre) was also installed in a fortified bunker.

The map shows where mountain tunnels were planned, all at bases north of the Dalälven river. The idea of base 90 system with a large dispersal of aircraft and the function of a static tunnel is not a total match. The reason tunnels were planned in the northern part of Sweden is due purely to geographical conditions. At Fällfors a river cut across the base area to the east and as such the dispersal area was reduced, therefore a protected mountain tunnel was added.

A standard tunnel was developed for the purpose of protecting aircraft in reserve. It was developed for 10 fighters of type SAAB JA 37 Viggen. Its an unlined tunnel with a tarmac floor, concrete supports were added to the walls and roof to provide additional strength. The tunnel was not initially fenced and there were no gates at the entrances. Pictures on page 50 show one of the entrances during winter 2007-2008, with the camouflage installed in 1982 and with gates to prevent civilians entering. Below is a photo from an exercise at the base.

The first tunnels were ordered in 1978 for the base at Fällfors. It was ready in 1981 - 82 with a length of 150 meters, 20 m wide and 5 m high.

It was then used for ordinary exercises until 27 June 2006 when the Fällfors base was vacated by the Royal Swedish Air Force. In September 2007 the base area was sold to the Skellefteå community.

Page 53 shows a picture taken from the main runway with the mountain containing the tunnel in the distance. The map is from the original plans of the tunnel. When it was constructed it was known that it would be used as part of a test program and therefore some differences were introduced into the design. The two entrances have different designs so as to be able to test which design was best to protect the aircraft inside the tunnel. The left entrance also has a blast pocket to see if that was better than a 90-degree turn as the right entrance has. A side tunnel in the middle was also constructed to check if a aircraft inside this area is better protected than in the main tunnel.

Page 54; 1) The left hand, northerly, entrance with the dogleg entrance tunnel. 2) The tunnel showings its full extent, from north to south. 3) The Southerly entrance is angled directly into the main tunnel. 4) The side tunnel for one aircraft in the middle of the tunnel. 5) The Blast pocket at the northern entrance. 6) Both entrances are camouflaged and have gates. 7) The taxiway outside the mountain. Note the cleared area to the left. The plan was to construct a large earth revetment to protect the entrances from incoming rockets and missiles.

Blast tests at Fällfors aircraft tunnel **(Page 55-pp.)**

Tests were carried out during April to June 1983. The top picture shows the tunnel at the time of the tests and below is a diagram showing munitions trajectory for the test. Picture three shows an aerial bomb placed inside the tunnel entrance with plates and test objects outside. These

were used to collect splinter samples from the bomb during the tests.

The first part of the tests was carried out on the empty tunnel. 40 detonations were carried out with up to five detonations per day. 1950 kg 4200kg and 9100kg Prilit charges were used. TNT charges of 50 kg (84 charges) and 100 kg (2) were also used. Along with this 2 250 kg bomb and 1 500 kg bomb were also used.

Part two (page 56) consisted of 10 tests with two fully functional SAAB J 35 Draken aircraft. After one test the aircraft were transported to a test site (pictured) and the other aircraft was prepared for the next test. 12 100 kg Prilit charges and two bombs of each 250 kg (pictured) and 100 kg were used for these tests.

The aircraft was placed on scales, one under each wheel. At the detonation the wheels lifted from the ground, decreasing the pressure on the scales from 10 tons to one ton. High speed cameras were installed in the tunnel to photograph the event (pictured).
The results were better than expected. The visual damage was reduced to some cracked instrument glasses. The engine was restarted and found to work fine.

In a real situation the aircraft could be functional after some limited repairs, cleaning and a routine service.

The result of two month testing was as follows: The entrance tunnel could be of the simpler version that is the south without the angled entrance and the blast pocket. The side tunnel could also be deleted; the aircraft was safe in the main tunnel. As long as the detonation didn't "see" the aircraft it was safe. So if the bomb or missile didn't get past the 90 degree turn into the main tunnel the aircraft was very safe inside. All these tests were in vain, no more tunnels were built in the base 90 system.

Decommissioning of air bases and aircraft fortifications **(Page 57-pp.)**

The picture shows the former gate area of the F 18 wing at Tullinge airbase. The whole base area is now being converted to a new residential area. The future of the two mountain hangers has not yet been decided. The office block with the former air control centre has been demolished.

All Swedish hangers are still owned by the Fortification authorities with the exception of the Arboga mountain which is still in use and the New mountain hanger at Säve that has been converted into a museum (picture page 58)
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Development abroad **(Page 59-pp.)**

The majority of the development abroad took a different approach than in Sweden. Only Switzerland completed an expansion of mountain hangers during the cold war. The mountain tunnels were rebuilt into mountain hangers and some new hangers were built. The Meiringen mountain reopened in 2003 after a five year rebuild to allow the F/A-18 Hornet to fit into the mountain. This is the only active mountain hanger in Switzerland, the others have been placed in reserve.

Other countries that built a few mountain hangers were the former Yugoslavia, Taiwan, China, North Korea and Norway.

Pictures shows a Northrop F-5E Tiger and a Mirage IIIRS coming out of the Swiss mountain at Turtmann in 2003. The lower picture shows a F-5E crossing an ordinary road to get from the

mountain to the runway at Turtmann.

Mountain tunnels were made in a bigger number of countries. Albania, the former Yugoslavia, Iraq, Taiwan, China and Switzerland are examples of tunnels made to protect aircraft. It is still uncertain as the quantity of mountain hangers around the world.

The biggest mountain tunnel in Europe is in the former Yugoslavia. Close to Bihac in Bosnia Objekat 505 or Klek was built between 1957 and 1970. The site has tunnels spanning over 3,5 km with places for 80 MiG-21 aircraft separated into one surveillance and two fighter squadrons. The base has five runways and numerous taxi runways that link the runways, with the three entries to the tunnel system. It is stated that some 110 pilots and up to 1400 workers could be in the mountain at the same time.

After the fall of Yugoslavia there were attempts to blow up the tunnel and it is now in poor condition. Thieves have also looted the site of copper and other valuable items. The map shows the site and the three pictures on top row are from Klek. The two pictures below shows an Albanian tunnel close to Gjader.

The six-day war between Israel and Egypt saw a rethink of how to protect aircraft from a primary surprise attack from enemy aircraft. This evolved into an almost international standard of above ground concrete shelters close to the runways. NATO called them “HAS” – Hardened Aircraft Shelter – usually built to accept a single aircraft.

Pictures on page 61. Within the Warsaw pact a similar system was used, an A-10A Thunderbolt is pictured in front of an old hanger at the Rostock air base.

Picture below left shows reuse of an Iraqi shelter at Balad airbase. To the right see how aircraft are stored today, completely without any shelter. Compare this with the picture on page three 70 years before.

The last pages consist of abbreviations and notes of sources.

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