Perception and Visual Design
Uppsala University

Visualization for an IRST System

Disclaimer:
All information and assumptions stated in this document are fictitious and does not relate to Gripen or any of Saabs other products. All proposals are done by the students and does not in any way relate to Gripen.

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1. Introduction

This project is done by students of the master program in Human-Computer Interaction at Uppsala University as a university project in the course Perception and Visual Design taught by professor Mats Lind. The project is a collaboration between Uppsala University and Saab and took place in October 2008.

1.1 Goal of the Project

The goal of the project is to develop/design a visualization to be used in the cockpit of the fighter jet JAS 39 Gripen. The visualization will be based on data given by an infrared search and track (IRST) camera positioned on the airplane. The task is to visualize objects in air space where the camera can be directed. The scenario in which the visualization is to be used concerns surveillance of air space. The main task in surveillance of air space is to identify objects to get a better situation awareness.

The IRST camera is not in use today. The main purpose of using the camera, instead of the radar, is to be able to see beyond human visual range without giving away your own position.
Saab contacted us to get another point of view for how this visualization can be done. We have because of this not been looking at other visualizations already in use. Our proposal will instead be based on the theory taught in the course.

1.2 Acknowledgments

We would like to thank Jens Alfredson and Krister Stenberg at Saab who contacted professor Lind with the proposal of a collaboration and also helped us with this project.

1.3 Project Schedule

The project started on the first of October in 2008 when the first meeting with Jens Alfredson and Krister Stenberg at Saab in Linköping was held. The deadline of the project was one month later.

2. Background Information

2.1 Saab

"Saab serves the global market with world-leading products, services and solutions ranging from military defense to civil security. Saab has 13,700 employees. Annual sales are SEK 23 billion (€2.5 billion). Research and development corresponds to about 20 percent of annual sales. Saab is currently a major supplier of defense materiel at a high system level in Sweden/Nordic region, South Africa and Australia. Further investments in Gripen’s development have already been approved and will remain a priority."

"Gripen is the first of the new generation, multi-role combat aircraft to enter service. Using the latest available technology it is capable of performing an extensive range of air-to-air and air-to-surface operational missions and employs the latest weapons. Gripen is in service with the Swedish, Czech Republic and Hungarian Air Forces and has also been ordered by South Africa and Thailand.

The UK Empire Test Pilots' School (ETPS) is also operating Gripen as its advanced fast jet platform for test pilots worldwide."
(Web reference 1 and 2)

2.2 The Gripen Cockpit

In the cockpit of the Gripen fighter there are two main areas in which the pilot sees information, the head up display and the head down displays. The head up display is the display on the top of image 1, with the green arrows, situated in the middle of the windshield. The head down displays are the three screens in the middle of image 1. The head down displays are used for displaying information about the airplane itself, tactical information and radar information. Our project only concerns a visualization to be presented on one head down display that is completely separated from the other displays.

Image 1. The cockpit of the Saab Gripen fighter jet.

2.3 Infra-Red Search and Track

"IRST is a passive, long-wave infra-red sensor system that enables long-range detection and track of enemy airborne threats and targets under normal and electronic attack environments." (Web Reference 3) The fact that the IRST is passively looking for targets, all objects in air space, instead of actively sending a signal makes it undetectable. A radar actively sends a signals that bounces on targets, these signals can then be read by the target and used to localize the sender. If the IRST is used instead it only "looks" at the surroundings for the heat radiated by targets. Hence the fighter jet is more difficult to detect.

The IRST has a specific field of regard (FOR), which is the complete scope in which the camera can be directed in relation to the airplane. The field of view (FOV) is the exact location in which the camera is directed, hence the FOV is smaller then and located within the FOR. To scan the complete FOR the camera starts at the upper most left hand corner and completes a sweep to the upper most right hand corner of the FOR. It then moves down to the "next line" of the FOR and makes a sweep in the opposite direction, this is then repeated until the complete FOR is scanned. The camera can be directed to look at any position within the FOR and thereby get more precise data concerning the specific FOV.

2.3.1 IRST Limitations and Capabilities

As described earlier, the IRST provides an overview of targets within the Field of Regard. However there are some limitations to the IRST that need to be considered when creating the visualization. The main limitations of the IRST are the following:

<u>Distance is not derivable by the intensity of infrared radiation</u>

The IRST system is only capable of receiving infrared radiation intensity which means that the distance to a target cannot be exactly calculated. The IRST can only register a direction from where infrared radiation is coming. For example, a big bomber airplane produces more infrared radiation than an F16. But if the bomber is located at a distance of 25 km and the F16 at a distance of 10 km the infrared radiation received by the IRST system could be of the same strength due to distance differences. This means that the IRST cannot make any assumptions of the distance to targets by itself. The target will be located on a "direction line" in which the camera detects infrared radiation but in which the distance cannot be calculated.

<u>One or more targets can be present in the same elevation and azimuth angle</u>

To the IRST camera a situation in which only one target is present in a certain direction will not differ from a situation where multiple targets are present in the same direction. Since the IRST only registers that there is an amount of heat coming from a point in space it is not capable of discriminating different targets in the same direction. The camera will only receive more infrared radiation if there are more targets, producing more heat, in the same direction.

<u>Triangulation accuracy of the position and distance of a target</u>

Using one IRST system in determining the distance to a target is not possible, due to the limit of only detecting the direction of infrared radiation. However, using two IRST systems and triangulation makes it possible to determine a better approximation of the position of a target. Based on the two angles of the different direction lines from the IRST systems to the target and the distance between the IRST systems, the distance to the target can be determined. But this situation is only applicable if the infrared radiation is received from the same target on both IRST direction lines. If there are multiple targets present at the same direction line of one of the two IRST systems triangulation is not applicable. This is since the uncertainty of seeing the same target is too complex.

Targets moving out and coming back into the Field of Regard or Field of View
If a target is moving out of the FOR or the FOV the uncertainty of where the target is located will grow. An earlier identified target might not be located in the same direction if the FOV is not scanning that part of the FOR, the target can change it's position before it is imaged the next time. A target leaving and coming back into the FOR cannot be identified as the same target, there is no way of being certain that it is the exact same target that reappeared.

Narrowing the FOV increases uncertainty of targets
Sweeping or scanning the whole FOR will give an overview of targets with an uncertainty that is higher than an overview of targets coming from a sweep of the FOV, narrowing the FOV results in more accurate measurements. This is due to the amount of sweeps that can be made in a certain time frame.

Field of Regard is limited by the nose
The IRST System cannot make a complete sweep of the FOR since the nose of the airplane is located within the FOR.

3. Technical Specifications

3.1 Technical Specification of the Head Down Display

Size	8" x 6"
Resolution	800 x 600
Soft keys button	20 (7 on each side, and 6 below)
Distance to screen	Arms length ≈ 1 meter

3.2 Technical Specification of the IRST camera

Maximum range	25 km
Field of regard	Azimuth: +/- 100 degrees Elevation: +/- 50 degrees
Field of view	Azimuth: 25 degrees Elevation: 25 degrees
Ways of changing the direction	Joystick Head movement

4. Visualization proposals

In agreement with Saab we are supposed to include the following in our visualization for the IRST camera.

- **Show targets (up to five):** Targets (i.e. heating elements in the air space) should somehow be visualized.
- **Show field of view (FOV), instantaneous position of sweep:** The instantaneous position that the IRST sensor is currently sweeping should be indicated.
- **Show field of regard (FOR):** The FOR of the IRST should be visualized.
- **Show side angle and height angle:** The side angle and height angle of targets in relation to our airplane should be visualized on the screen.
- **Show direction of targets (where they are moving to):** The direction of targets might be indicated and visualized.
- **Show strength of signal from targets:** The strength of heating from targets that the IR sensor has been perceived should be visualized; targets that have strong heat will be distinguished from weaker ones.
- **Discriminate between selected and non selected targets:** Selected targets (i.e. targets that the pilot actively is following) should be discriminated against non selected targets (i.e. targets that are only "observed" in space).
- **Show longitude and latitude if data is triangulated:** If a pilot shares data with wing mates, it gives the possibility to calculate the position (i.e. longitude, latitude and height) of a target. However, the position is not exact.
- **Show information shared with wing mates:** Information that has been sent from one or several wing mates should somehow be visualized.
- **Show previous measurements of targets out of FOV or FOR:** If a target moves out of the FOV or FOR, previous measurements (e.g. size of the heating element and direction) should be visualized for a limited time. When that time has expired, the certainty of the data is no longer valid and should therefore not be shown any more.
- **Show time since last sweep of targets:** Since the direction (i.e. the side angle and height angle) accuracy of a heating object will be less certain as time goes by before a new sweep is conducted, the time since the last sweep must somehow be shown/visualized.

5. Method

5.1 The Strategy

Since this was a new area for all the members of the group, we had to understand more about some basics of the world of fighter jets. Therefore, a meeting to clarify the task was scheduled with Saab in Linköping. After the meeting we identified the objectives of the IRST system and the pilot’s primary goals. After this we identified the tasks we thought were relevant. After receiving an "OK" from Jens Alfredson at Saab we started to work on the project.

5.2 Interview

We scheduled several meetings with an ex fighter pilot, where he clarified the goals of a pilot while using similar systems. The pilot also answered basic questions regarding fighter planes. During these interviews and meetings we also got feedback on our ideas for the visualization,

5.3 Course Material

The course book (Ware, 2004) was very helpful especially on the design part, we used it for many concepts such as colours, glyphs, fading etc.

5.4 Tutoring

We scheduled several meetings with professor Lind, where he guided us mostly on the design part and gave important feedback regarding our ideas.

6. Result

6.1 Assumptions

Since all details of the IRST system could not be revealed due to time and practical constraints, several assumptions were made. These are presented below.

6.1.2. Technical Assumptions

- **High-resolution display with good colour accuracy:** It is presumed that the display is of high resolution and that it has good colour accuracy.
- **A complete sweep takes 8 second:** In our design, we presume that a complete sweep of the FOR takes approximately 8 seconds.
- **High-resolution infrared camera:** In the design for the FOV-view we presume that the infrared sensor has more pixels than is possible to display in the designated areas in both our FOR and FOV views. This means that it is possible to zoom in (digitally) on a target to see more details in the actual sensor image. We propose this digital zoom capability to be presented to the user in the FOV display area.

6.1.3 Pilot Assumptions

- **A pilot is able to learn how to use visual codes in new ways:** In the colour choice to discriminate between selected and non-selected targets, the colour normally understood as a "warning" colour in the Western world has been used for indicating non-selected targets (consult the Glyph chapter below for more information). The choice to use a colour "against the convention" will only work if a pilot is able to re-learn the meaning of the colour. It is presumed that the training of a pilot can re-learn the meaning of the colour.

- **A pilot is used to abstract visualizations:** We assume that pilots are used to and capable of dealing with very abstract visualizations of how the physical world works. This is both due to training and experience.

6.2 An Overview of the Solution

In image 2, an overview of the result is presented. The top part of the display consists of the view we call the Field of Regard (FOR) view. This is the view that shows the complete field the IRST system is able to sweep. The bottom part of the display is used for showing the Field of View (FOV) view, i.e. a single picture that the camera takes. As explained later in the document, this part can be used when a target is locked and the pilot wants to get a more detailed image of a heating element.

6.2.1 The Analogue Concept

In our interviews with the fighter pilot, he several times made complaints about the modern digital radar system used on modern fighter airplanes. Before the introduction of the digital radar, an analogue radar system was used. With this radar, the pilot saw what the radar detected. With the new digitalized radar systems, a computer decides what should be displayed or not. For the pilot, it is then difficult to obtain a mental model of how the digital radar works. One example the pilot mentioned, was that it is difficult to know how strong an echo is before an icon is displayed on the radar screen. In the old system the brightness of the visual signal (the echo on the radar scope) was proportional to the reflectivity of the radar signal from whatever target it hit. The modern way of just showing or not showing a target in effect transforms a continuous information source to binary one.

One could argue that the binary display reduces the cognitive load on the pilot, of course, and that therefore this is a good thing. However, this may not be true since the decision by the computer system will, for logical reasons, be in error at certain times, especially at low signal levels.

Depending on how the decision criteria are set, it will in situations with a low signal make either a type I or a type II error (i.e. decide that there is another aircraft where in fact it isn't or that there isn't another aircraft where in fact there is). That the system sometimes makes errors will certainly be noticed by experienced pilots and therefore they will in many instances have to use cognitive resources to handle the uncertainty introduced by the computer system.

The pilot described this problem domain as "the digital vs. the analogue" way of presenting information. In analogue systems, the pilot is given the "raw" data and based on his knowledge and prior experience, he makes conclusions. In digital systems, algorithms decide what to show and when to show it.

The "analogue concept", i.e. to display data as natural as possible, was therefore something we decided should guide our visualization. As an example, the amount of the heat transmitted from an object will decide the size of the icon on the display. Thus, the pilot will be able to see how strong a signal is, not just that there is some signal.

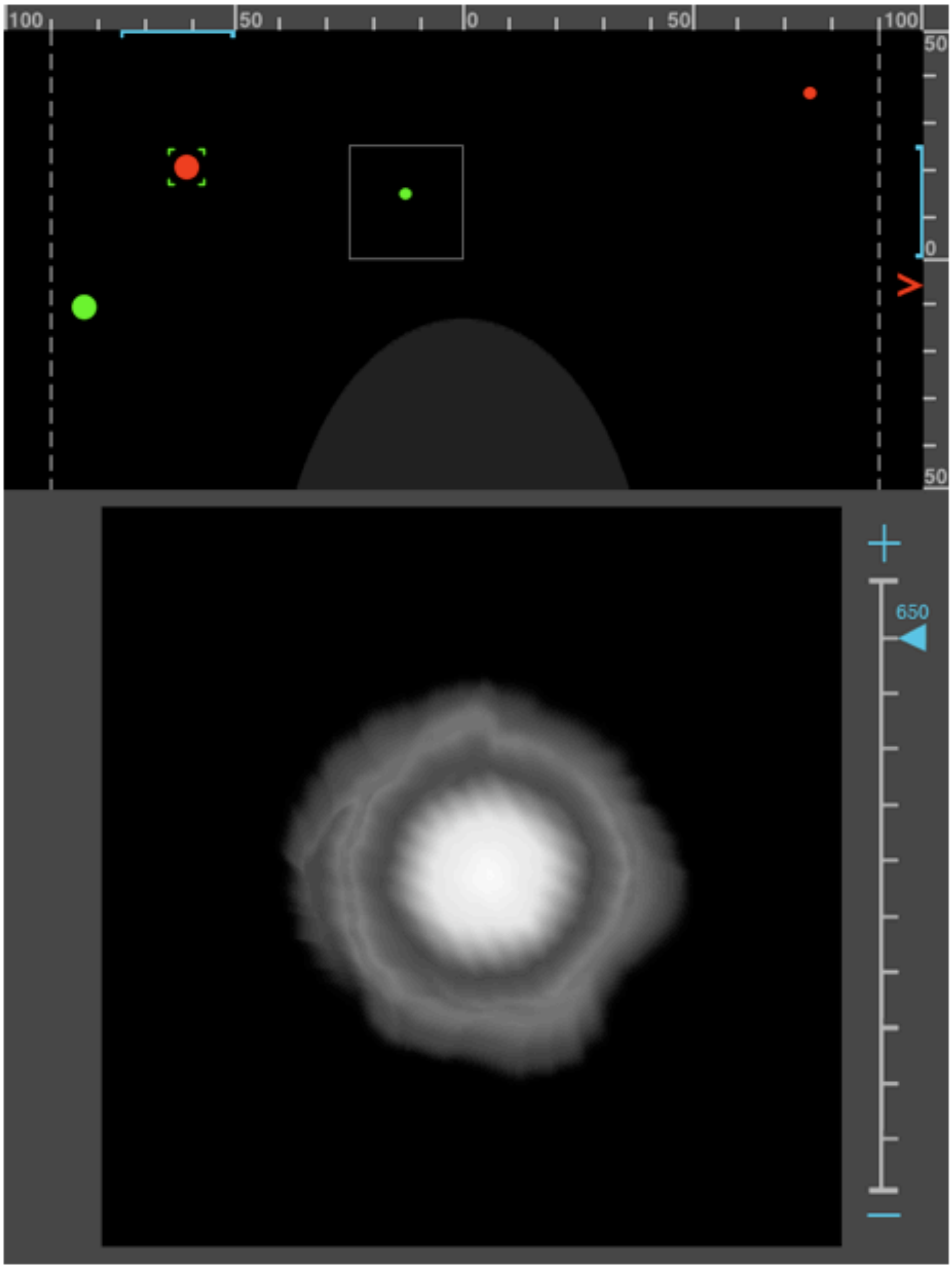

Image 2. An overview of the visualization with all "features" enabled.

6.2.2 Reasons Behind a Sensor View

A radar picture is showed in a "God's view", so why didn't we choose the same view for the IRST-system? The answer is quite simple: since an infrared camera only detects heat, it cannot calculate the distance to the heat element. The only exception is when triangulating is used, but then another airplane must send data and the distance figure is still very uncertain. There are then only two dimensions in which the area can be detected, the side angle and the height angle. This means that what we can visualize is only what's visible for the camera in this 2D-diemension. The sensor view is the simplest way for showing height angle and side angle.

6.3 The Base Template

6.3.1 Main Colours

As presented in Image 2 above, we have chosen to use grey scale colours for the base of the display. The areas where the camera pictures are presented are visualized by black. For static information, i.e. the degree indicator in the FOR and the zoom in level indicator in the FOV, a grey colour with 75% more luminance than black is used.

Our arguments for this choice are that since all background information is in grey scale they are perceived as belonging together. Heating objects, which are coloured red and green, will also be seen as belonging together. They also use the chromatic channel, which make them “pop out”.

6.3.2. Field of Regard

<u>Degree Indicators</u>
The degree indicators show the degrees in the FOR. Because of the lack of space, we have chosen only to present degree numbers at some levels.

<u>Dashed Lines for Showing What’s Behind</u>
Dashed lines represent the border that indicates what’s in front or in line of the pilot and what is behind the pilot (10 degrees on both sides). The luminance has been set to 50% which makes the dashed lines not popping out to much but at the same time visible to the pilot.

<u>The Nose Area</u>
Since the nose of the airplane will cover some part of the FOR, that area has been indicated by an almost black colour (luminance 10%) to indicate that this area is out the FOR.

<u>Sweep Indicators</u>
To indicate where the current sweep is, and thus enhance the analogue feeling of knowing the state of the system, one indicator on the top and one on the right visualize the position of the infrared camera. These indicators are moved according to how the camera moves.

<u>Locked Area</u>
When a target has been locked, i.e. the infrared camera has been set to only follow a specific target, a square will indicate the locked area.

6.4 Field of View

We have chosen to visualize the field of view, when locked, in a separate part of the screen. This is due to the extra information available by looking at the exact heat signal of a certain object. We will not visualize the specific heating information in the FOR-view due to the unnecessary extra workload the pilot will be given. The FOR-view is an overview only used for seeing where targets are located. Extra information about the heat signal is, by our assumption, only relevant for target of interest, which then can be locked.

By visualizing the heat signal in this way the pilot can make assumptions based on his expert knowledge. The pilot might for example be able to make assumptions of what kind of target it is, how far away it is and where it is moving to in real world 3D-space.

We will in the FOV-view visualize an as exact copy of the heating as is possible. This can be done because we assume that the camera has a much higher resolution than the screen. Each pixel of the screen will be a representation of several pixels in the camera. The limitations of the visualization will then solely depend on the limitations of the screen, in which a clear representation is achievable.

The pixel relation between the screen and the camera also means that a digital zooming function can be created. The pilot will be able to zoom within the image to the degree in which a pixel on the screen is equal to a pixel from the camera.

Whether or not the zooming functionality will give the pilot extra information, or if it will be confusing is impossible for us to tell. But since we have the possibility to add this feature and since it might give the pilot better information this will be included in our presentation. This means that there still is a need for verifying weather of not the zoom function will add anything usable to the pilot.

There is also a problem of how the visualization initially will be configured. If the visualization starts at 25 by 25 degrees and the signal is larger or smaller than the cameras FOV, zooming needs to be done, if the heat signal will be shown as a whole. This can be done either by the pilot or by the system.

As a start we used a colour version of the heat signal, see image 3 left part. This image turned out to take to much attention of the viewer and we agreed that using a greyscale version would be better, see image 3 right part. The greyscale still show what's important, the difference in heating. The parts with the strongest heating signal will be brighter and the less heated parts will be darker. This gives the exact same information as the colour image, even though just one part of the low-level visual system is used. This means that since we do not stress the chromatic channel the greyscale will not take as much attention.

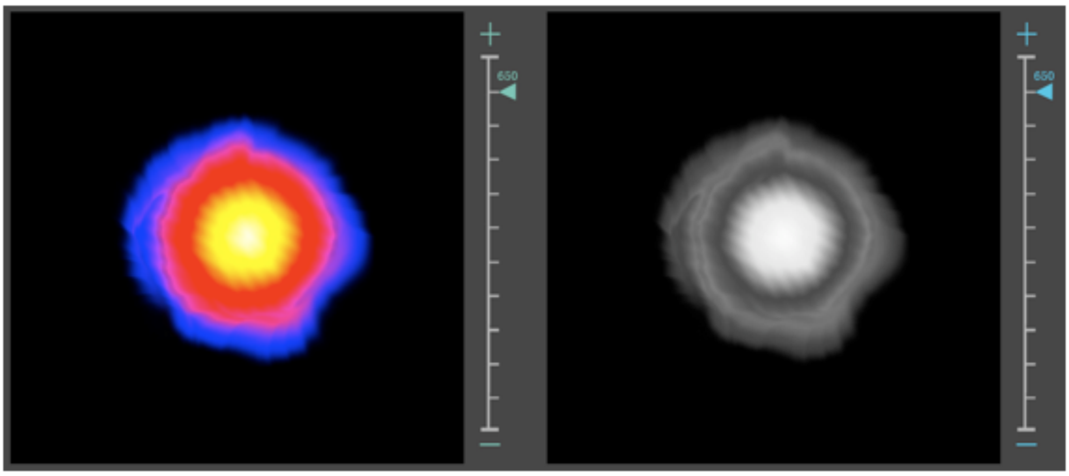

Image 3. Two examples of the heating signal in the FOV.

To make the different areas of our greyscale more differentiated from each other one can use the so-called edge enhancement technique (Ware, 2004, p. 77). This means that since our visual system enhance edges, areas that are hard to differentiate can be made distinct by adding an enhancement of the edge between them. This is done by making one of the areas darker and the other lighter close to the edge. As seen in image 4, the edge of the left circle is easier to perceive than the edge of the right one. This is due to the larger difference of luminance between the edge and the background used, even if there is no line drawn between them. This technique can be used at the intersections of differentiated heating areas to make their, sometimes small, differences more clearly distinct.

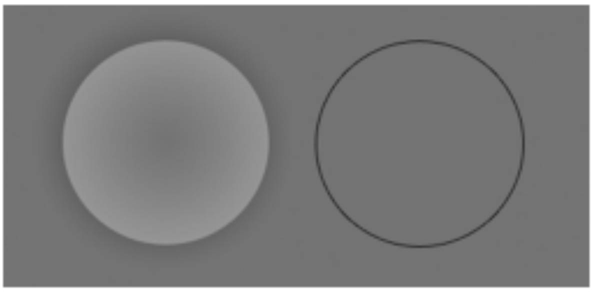

Image 4. Edge enhancement.

6.5 Glyphs

For the targets we have several different attributes to visualize, namely:

- If it is selected or not
- The amount of heat the target radiates
- The time since the target was last swept
- If the target is locked
- Which targets our wingmen have locked
- Uncertainty of targets
- Motion of targets

To do this there are two ways of representing the attributes visually. There is the “integral dimension” where different attributes are perceived as one and the “separable dimension where different attributes are easily separated. (Ware, 2004, p.177)

“If one wants people to respond holistically to a combination of two variables, using integral dimensions is better. If one wants people to respond analytically, making judgements on basis of different variables, using separable dimensions will be better.”(Ware, 2004, p. 179)

Integral dimension pairs	Red - Green	Yellow – Blue
	Red – Green	Black – White
	Shape Height	Shape Width
	Shape	Size
	Colour	Size
	Direction of motion	Shape
	Colour	Shape
	Colour	Direction of motion
Separable dimension pairs	x,y position	Size, shape or colour

Hence, since the target's different attributes do not depend on each other, the separable dimension will be the best choice.

Below is a list of some of these different ways of representing attributes. For example, to have a colour represent one target attribute and the shape another makes the attributes more separable then using the width and the height of a target. (Ware, 2004, p. 179)

There are also monotonic attributes which "naturally express relations such as greater than or less than. For representing simple quantity, a mapping to any of the following attributes will be effective: size, lightness (with dark background), darkness (with light background) and saturation/vividness of colours." (Ware, 2004, p. 182)

We have chosen to represent the different attributes of our targets according to these theories as follows.

6.5.1 Shape

A circle was the choice we used for visualizing targets; it can include three different parameters, size, colour and position.

It is easier to visualize targets using a circle glyph; the size, colour and position represent different information which is respectively strength of the signal, selected and non selected targets and finally the position of the targets.
This symbol doesn't resemble the other radar interfaces where they represent targets using an arrow, the line of the arrow shows the orientation which is not known in our case for the IRST system.

6.5.2 Colour – Selected or Non Selected Targets

As stated earlier in chapter 5.3.1, we used a black background where the camera pictures, which led us to choose green colour for the selected targets and red for the non-selected even though in many cultures red signify danger.

We based our findings on theories (Web reference 4) that green is more perceivable and attract more than red.

6.5.3 Fading – Time Since Last Sweep

Since the uncertainty of where a target is will increase when the camera is not pointed directly at the target and since we want the visualization to be an analogue representation of what the camera actually see this needs to be visualized. For example if the pilot locks the camera to follow a certain target, the other targets positioned wherever the camera is not directed can move without the IRST system recognizing it. This means that the uncertainty of where these targets are will grow as the time since they were last swept grows.

To visualize this uncertainty we have chosen to use the fading of target icons. This is a monotonic effect to show that the certainty of the position decreases with time since the last time this target was sensed. Based on the colours we have select for active and non-active targets this means that the scale for the fading will go from red or green to black. An important aspect here is that the best way of creating a perceivable scale, independent of colours used, is done by increasing or decreasing the luminance. The luminance in such a scale will optimally begin at 100% and end at 0%. But since different screens will display the same colour with different luminance, this is something that needs to be calculated and set for the monitor used.

In our visualization we have chosen the colours red and green to represent active and non active targets. We will then be using red, with an RGB-value of (255,0,0), which is the purest red possible. If the screen then is set so that red has a luminance of 100% a fading to black, with luminance of 0%, will decrease the luminance at the same rate as the target will get closer and closer to disappearing on a black background. This can then easily be done by just decreasing the red RGB-value. The same reasoning is applicable for the green colour used.

An example of this fading is show in image 5, the RGB value continually decreases at the same time as the luminance from 255 and 100% to 0 respectively.

Image 5. Fading example.

6.5.4 Size – Strength of Heating Signal

The size of the circle glyph represents the heat signal radiated from targets. The pilot can also make assumptions based on his experience of differences between sizes of targets, one example could be that the system captures a strong heating area and shows a big circle on the interface, the pilot in this case based on his experience can know whether or not it is a big airplane or a close fighter jet.

We calculated the size of the circle glyph using the area instead of the radius. This is due the fact that we as humans will see a size differing on width and height of objects as larger than they are. For example a square that differs in both height and width will look four times as large in relation to the original square. A square with difference only depending on the area will look twice as large, see Image 6.

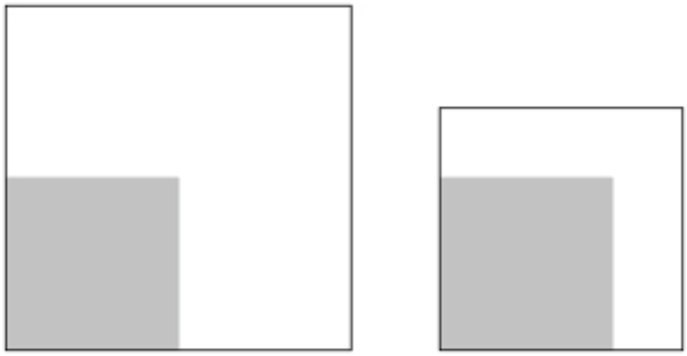

Image 6. Size example.

6.5.5 Enhanced Shape – Locked Targets

When the pilot locks on a certain target, a square will be drawn around the locked target. The square represents the FOV and shows where the IRST system is sweeping at that moment. When the locked target moves, the square also moves in the direction of the target. This results in a real-time representation of where the locked target is moving.

6.5.6 Wingmen Information

As described earlier, the green colour is used to show targets that are active or selected by the pilot itself. To show that a certain target is locked by another pilot we choose to show 4 green borders around a target. Since green is used for selected targets and consistency in colour usage is important, we also used green to show locking by other pilots. The 4 green borders represent a focus on the target in the form of a square.

6.5.7 Uncertainty

First we thought that there was a need of a separate visualization for the uncertainty of the targets at large. But since the possible uncertainties only grow whenever a target is not swept it will grow at the same rate as the time passed since the target was sensed the previous time. Even if the pilot lock on a target and thereby get more accurate information about this target's position and heating signal the only way the uncertainty can grow is due to not acquiring more information, which always is due to not sweeping an area and hence only depends on the time since last sweep.

6.5.8 Motion

We were early in the project thinking of giving a visualization for how the targets move, and where they probably will be after a given time has passed, but by e-mail contact with Jens Alfredson we were told that the speed of targets cannot be calculated and thereby the time for a target to move from one point to another cannot be calculated.

Instead, we have decided to show the motion by showing a small trace in the fading. A complete sweep takes 8 seconds and we have chosen the fading to go on for 10 seconds. This means that when the target is found and visualized the next time, the old place of the target will be shown for two seconds. This means that it's up to the pilot to make assumptions about whether or not it is the same target as before. We also know that this function can enhance screen clutter, but since the pilot works with surveillance there are assumingly not enough targets to make the screen non readable. This function can hence also be argued to be optional by the pilot from scenario to scenario.

6.5.9 Arrows for Showing When An Object Has Left the FOR

If a target moves out of the FOR an arrow will appear, the arrow will stay two seconds and then fade out in one second. If the same target during this time enters the FOR it is up to the pilot's knowledge of the situation to make an assumption of if it is the same target or not.
The arrow will appear at the point on the edge of the FOR that is closest to where it was last seen. The arrows will be either red or green relative to what colour the target that disappeared had.

6.6 Miscellaneous

6.6.1 Triangulation

Triangulation accuracy of the position and distance of a target is explained in chapter 2.3.1 and discusses the possibilities of the IRST system regarding the position and distance of a target. Triangulation and position determination of a target can only occur when at least two IRST systems are used on different airplanes. We choose not to show any positions of targets on the IRST display we developed, since this could be better done on the tactical overview display, which is located in the middle of the cockpit. The IRST display serves the goal of showing a certain direction where the target can be with a lower accuracy than the tactical display. Therefore we choose to show a position of a target on this display when triangulation occurs.

Another reason for not displaying triangulation in our visualization is that we only show azimuth and elevation. Information for the triangulation is only relevant in a map-view, something already in use in the tactical display.

6.6.2 Turning Airplane

Since the information is inherently angular and that the pilot sometimes, when the other aircraft is within visible range, can compare what he or she sees with the sensor display, we propose a "track-up" display. That is, it uses gyro data and readjust continuously such that it corresponds to the aircraft position. Thus, when the airplane turns, the targets will move over the display in proportion to the amount of turn of the airplane.

Since we show the positions of targets statically we can just move all the icons on the display. The sweep of the camera will continue and the visualization will work as before with old targets in a new position.

Targets that when moved will appear behind the nose will be visualized as if the nose is transparent. We have chosen this design since the data otherwise will get lost. If targets move out of the FOR an arrow as described earlier will appear.

6.7 Examples

To better communicate how the system could like in a real world scenarios, we have created 3 scenarios that you can see on the movies you have received.

Below are the scripts for each scenario.

6.7.1 Scenario 1

The airplane is flying straight ahead, there are three non-selected targets, which have different sizes and the sweep is normal. The sweep will go on for around 30 seconds, and the position of the targets will be changed. After that, selecting two targets, change the colour of the target, wait for 10 seconds. Then two targets (ONE is selected) move out of FOR, two arrows shows. The time interval between those two targets will be about 5-10 seconds. After 2-3 seconds, three targets move in the FOR. The time interval between those two targets will be about 5-10 seconds. Another target moves into the nose area, an arrow shows. The wingman locked targets will be appeared; it will be pilot's non-selected target, the wingman's locked target will disappear if targets fade out or wingman de-select. Fly around for 10 seconds.

6.7.2 Scenario 2

The airplane is flying straight with two selected targets, and one non-selected target. The sweep will last for normal 20 seconds. A selected target is locked, which appears on the FOV. The targets that are outside of FOV will fade out in 10 seconds. The locked target will move around for about 30-40 seconds. At the same time, the locked target will be zoomed in & out in the FOV.

6.7.3 Scenario 3

The airplane is normally flying straight with three targets; two of them are selected for 10 seconds. Then the airplane is turning left, all the targets in the FOR will move to right in the same angle as airplane, and one target (not selected) will move into the nose area (50% transparency of target) and fade out in 8 seconds. One target (selected) moves out of the FOR and arrows will point that.

7. Discussion

We based most of our results on interviews with a fighter pilot, professor Lind, the Saab group team and last but not least, the course literature Information Visualization by Ware (2004). We used many iterations for our design based on input from professor Lind and the pilot we interviewed. It should be noted that we haven't made any user evaluations of the interface due to time and resource constraints. Hence, this idea should be regarded purely as a "design idea".

An arrow is shown for 2 seconds on the sides of the FOR to indicate that the target left the FOR. A possible situation that can occur is that a target enters the area, where an arrow shows that another target left the FOR. This means that the target will overlap the arrow either as an active or non-active target. If the arrow is red and the target is green or the other way around, this means that the arrow is hard to perceive since green and red are in the same chromatic channel. A solution to make both perceived good is to add a stroke or shadow to the target so that the edge of the target is emphasized and the difference between the target and arrow is perceived better.

8. References

8.1 Printed reference

Ware, Colin (2004), Information Visualization: Perception for Design, Morgan Kaufmann

8.2. Web references

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3: http://www.lockheedmartin.com/data/assets/IRST-Product_Card.pdf

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