Infrared Activities in the Netherlands

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1. Introduction

This presentation summarizes the infrared activities in the Netherlands during the past 30 years and indicates the directions for future work. The capabilities of infrared technology, being passive and useful for night vision applications were envisaged for a long time in our country. The dependence on the military market however made the progress slow, but this time was used properly by the research scientists to fully explore the problem areas.

In the Netherlands the research work started with Lead Sulphide detector work with the applications of heat seeking missiles against ships. This work was done at the Physics Laboratory TNO in The Hague. After some years the work proceeded towards Indium Antimonide with sensitivity in the 3-5 μm band. The first experimental scanners were developed in 1962 with such a detector.

Soon airborne use of IR scanners resulted in the first Netherlands commercial line scanning project: The Orpheus scanner of Oldelft, developed for the F104 reconnaissance pod. With this device many reconnaissance missions have been carried out by the Royal Netherlands Air Force. A number of these missions were including special targets under camouflage, another TNO research item.

For Naval applications Infrared Search and Track models have been developed in cooperation with Philips USFA. These systems have to detect and track point targets in the air from ships or from shore based positions.

Around 1976 the Royal Netherlands Army got interested in thermal imaging from tanks. Development of prototypes for thermal imagers started 1968 at TNO before the industry was involved in 1976. At Philips USFA the first prototype was ready in 1979. It took 6 more years to achieve a level of performance, competative with other imagers on the market. In the meantime Oldelft started a licence manufacturing of thermal imagers for similar applications.

At TNO, work continued on signatures, propagation countermeasures and sensors. Improved performance of components made a need for increased resolution and sensitivity in the research programmes. Many of the instruments had to be built in house as they were not available according to the specifications needed.

Due to international cooperation on a bilateral or trilateral basis and on the cooperative efforts in NATO the research and development activities in the Netherlands could be tuned to activities in the other nations. Exchange of information and components as well as common projects have led to successful progress in all research areas.

2. IR signature work

This work has taken most of the time because of the complexity of the signature. IR contrast is formed by reflectance and temperature at the surface. Thus the heat balance, determined by heat transfer phenomena has to be taken into account. IR physicists could be heat transfer specialists.

Furthermore the reflectance has to be studied in a much broader spectral area than in the case of visual contrast. Infrared sky is refected by the surfaces under investigation. Weather influence on the IR contrast is tremendous. Therefore the signature is a matter of statistics which makes the task for Operational Research people very difficult.

Signatures have been measured of ships, sea backgrounds, terrain, vehicles, buildings, aircraft and sky backgrounds. Of great healp in this effort was the installation of temperature sensors, mounted on the surfaces. In most cases the meteorological data have been measured as extensive as possible.

Modelling exercises have led to very complex models for ships and aircraft because of the dependence of apparent temperature of aspect angle to a specific surface area. The most simple model was the asphalt model, which could be made in close agreement with measurements. The most complex model is the plume radiance model beause of the interaction of line emission by the hot gases of a plume and line absorption by the atmospheric gases.

3. IR Backgrounds

Sea backgrounds are under investigation in one of the NATO groups. To measure the absolute apparent sea temperature in a certain direction is not so simple, as radiance is partly reflected sky radiance. Also it is impossible to measure the real sea surface temperature. The spectral band should be defined carefully. Wave structures should be known precisely. Very interesting is the case of solar glint in the shorter IR spectral bands.

Sky backgrounds are of interest in heat transfer calculations of terrestrial surfaces. For this purpose a rough IR sky radiance distribution has to be known. At TNO a lot of measurements have been taken for this application. Sky backgrounds are also important for the point target detection capabilities. These background measurements are taken with much higher resolution and sensitivity. Here spectral bands and sky elevation are important for the values of the fluctuations. Exchanges of such data with other nations have been undertaken. The data are of a statistical nature, dependent upon the weather situation.

Terrain backgrounds are the most complicated because of the variability of materials and humidity influence. Here statistical data have been gathered for numerous materials, nevertheless the general feeling is that more data are needed, especially for the application of autonomous sensors with focal plane arrays. Both 3-5 μm and 8-14 μm wavebands are of importance. A new measurement programme on this topic has been started in 1987.

4. IR Measurement Equipment

The Physics and Electronics Laboratory is specialized in the development of special IR measuring equipment. Following are some examples:

- Fast Filter Wheel Spectrometers for bands from 0,7 μm to 14 μm with a speed up to 5 spectra per second.
- Reflectometers with hemispheric irradiance and hemispheric measurement.
- Radiometers for fast phenomena simultaneously in many spectral bands. Also radiometers for slow phenomena, measuring absolute and calibrated.
- Scanning radiometers, to be mounted at platforms in order to obtain systematic data of extended sources.
- Radiometric scanners for making imagery of targets and backgrounds with many pixels per picture. Data transfer to standard NATO format.
- Calibrated sources for point source and extended source applications.
- Transmissometry equipment for multipath and multispectral applications in one installation.
- Fast absolute humidity measurement device.
- Airborne sensors with high thermal resolution and in many spectral bands, measuring reflectance of terrain materials.
- Differential Infrared Absorption Scanner to measure toxic gases in halls.

The development of these instruments has been possible thanks to the availability of an excellent mechanical and electronical workshop, optical components being manufactured at the Naval Optical Workshop in Wassenaar.

5. Propagation Studies

The use of infrared in many applications has been going slow due to the limited performance in poor weather. Statistical data have been gathered upon transmission through fog, snow and rain for all kinds of ranges. An example is the NATO-OPAQUE project.

Measurements have been carried out over long paths at low altitude above the sea in order to study the effect of aerosoles in different sea states.

In present days the LOWTRAN transmission models are used in many low resolution applications for transmisson- and emission calculations. Effort is however spent on high resolution effects, related to the before mentioned plume-work.

Another effort in the propagation area is the work on turbulence, causing point source radiance fluctuations. C_N value measurements are correlated to the fluctuations in point source radiance. Effects of weather are taken into account.

6. Civil work

In the Netherlands, thermal imagers have been used for many years in geological applications. The possibility to detect temperature differences have been used to determine soil effects in all kinds of locations in the Netherlands and outside. The International Training Center in Enschede is flying with a 2-color IR scanner from TNO for studying water exhaust at power stations, water leakage below dikes, pipelines etc.

Vegetation studies imply thermal effects on leaves as sunradiation and water transport change. At the Agricultural University in Wageningen a number of these studies have been undertaken.

Heat conservation in building is another example of application of thermal IR. In an easy way the leakage-points can be found and protective countermeasures can be advised. At some of the universities the medical thermo-graphy has reached a sophisticated status.

The ministry of waterworks has shown a lot of interest in infrared surveillance at sea and from satellites. Finally the Netherlands Police operates with a modern thermal imager from a helicopter for patrol operations in darkness.

7. Sensor Studies

These studies have been carried out mainly at the Physics and Electronics Laboratory TNO. Many problems have been studied of technical and theoretical nature. Experiments on detector performance, optical components, scanning mechanisms, coolers, electronic components and displays have led to an optimized technology for all kinds of sensors.

These sensors may be of an imaging nature with observers, autonomous with automatic data interpretation by means of complex signal processors or simply recording sensors. An example of an automatic sensor is the work on fire detection, started recently at TNO. Another class of sensors is the class of the warning receivers, receiving launch flashes, enemy sensor-emission or other simple event phenomena.

A lot of time is spent in optimization of these sensors, proper selection of spectral bands, based upon careful study of the signatures, available from previously mentioned signature work. Optimization means reduction of false alarms to a minimum level and increasing the detection ranges with the smallest device possible for the lowest price.

Experimental sensors have been built for all kinds of applications: thermal imagers, trackers, warning receivers, automatic sensors. Therefore based upon this experience, TNO can give a proper advise to the Armed Forces in the acquisition process of IR materials.

Resolution studies have been carried out to convert the military requirements, written in terms of detection/recognition ranges into system parameters. A measurement set-up has been built to measure the system performance of thermal imagers. Recently a project has been started to meaure the commonly used MRTD value in an automatic fast way.

8. IR countermeasure

This work is generally of a classified nature, so the information given can only be of a general nature. Work has been spent to reduce the thermal contrast of targets by means of cooling techniques, screening, and low-emissive-paints.

Other work incorporates the use of decoys as in the aircraft situations. Measurements with seekers have been done to study the performance of the flares in different aspect angles.

The last years a lot of effort has been spent on the study of the effect of screening smokes. At TNO a multipath, multispectral transmissometer has been developed to evaluate effectively and fast the performance of a screening smoke in a battlefield.

Also recently studies have been started on the effect of emissive sources on thermal imagers; these sources can be fires in a battlefield, gun flashes or lasers.

9. New directions

The future activities will incorporate work on focal plane arrays for several applications: (autonomous) imagers and search equipment. The use of fast computing elements will further be introduced to automatically detect targets in more and more complex backgrounds.

Higher spectral resolution effects in certain spectral bands will further be studied in order to find new applications. Multispectral work will lead to more sophistication in discriminating targets from backgrounds. The work on automatic warning receivers will be continued and will lead to new applications of military interest.

On the civil side applications will be studied with the new sensors with higher resolution and with better calibration techniques. The installation in airborne platforms will lead to possibilities in third world nations to find resources.

10. Conclusions

Thanks to the military interest on infrared in the Netherlands, the technology base has been built up to a reasonable level. In this process the NATO contacts have been profitable for the research institutes involved in the research and development.

On the other hand the Netherlands industries Oldelft and Philips-USFA have shown to be able to develop IR systems competative on the international market.

Finally on the civil side several universities and institutes have been active in the field of infrared for a very long time. In conclusion one can state that infrared in the Netherlands is a living technology, of which the activities will continue for many years.