OPEN SKIES WORKING PAPER

• SENSORS AND PLATFORMS •

ARMS CONTROL AND DISARMAMENT DIVISION
EXTERNAL AFFAIRS AND INTERNATIONAL TRADE CANADA
OTTAWA, ONTARIO, CANADA

21 NOVEMBER, 1989

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CONTENTS

1 INTRODUCTION

Sophisticated military aerial reconnaissance systems will not be required to participate in Open Skies. Civilian systems have the ability to produce valuable data when operated under the cooperative measures envisioned for the Open Skies regime.

All of the imagery used for this report has been collected using civilian sensor systems. All cost figures are given in US dollars. The figures are approximate and provided for general comparison purposes only.

2 THE SENSORS

It should be possible to use exclusively off-the-shelf, commercially-available sensors for Open Skies. Sensors for Open Skies will include photographic cameras, thermal infrared systems and imaging radars. Table 1 outlines some of the main features of each type of sensor.

Photographic systems will be the primary sensor. They can provide fine spatial resolution but have limited spectral characteristics.[1] They require photographic processing and therefore cannot provide real-time data. Finally, they are restricted to daytime use.

Thermal infrared systems produce images by sensing radiation which is emitted by all surfaces according to their temperatures. They can be used during the night as well as the day, and are better than photographic systems for penetrating haze and smog.

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[1] Spatial resolution defines the minimum sized object on the earth's surface which is "seen" by the sensor as being separate from its surroundings. The spectral characteristics of a sensor refers to what wavelengths of electromagnetic radiation the sensor is sensitive to and how finely it can distinguish between different wavelengths.

Neither of the above sensors are able to penetrate cloud cover. Radar imagery may be acquired regardless of cloud cover. This may be particularly important in the European context. It can also be used during the daytime or at night. However, radar imagery is incapable of recording fine spatial detail.

2.1 Photographic systems

Aerial photographs may be categorized into a number of different types: vertical, oblique, multi-frame and panoramic.

Vertical photography

Vertical photographs are the most common form of aerial photograph. They are taken with the camera pointed vertically downward, looking directly beneath the aircraft. Figure 1 shows a portion of a typical vertical aerial photograph of an airfield. Several different kinds of aircraft can be distinguished.

Area coverage is achieved by taking successive overlapping photographs, as shown in Figure 2, and by using parallel flight lines as shown in Figure 3. Photographs are typically flown with sixty or more percent forward overlap between successive photographs. Two successive photographs can be viewed through a stereoscope (Figures 4 and 5) to provide a three-dimensional view, or "stereo model," of the scene. Stereo viewing of photographs allows interpreters to measure the heights of objects.

The detail that can be interpreted from an aerial photograph is, in part, determined by its photographic scale. The scale of a photograph is usually expressed as a representative fraction, such as 1:10,000 or 1:20,000. A 1:10,000-scale photograph has a larger scale than a 1:20,000-scale photo. Objects appear larger, thereby providing more detail, in the 1:10,000 photo than they do at the 1:20,000 scale. Figure 6 shows aerial photographs of the same area at scales of 1:40,000, 1:20,000, 1:10,000 and 1:5,000.

The scale of a photograph is determined by the flying height of the aircraft when the photo is taken and the focal length of the lens used to take the photograph. The same scale can be achieved from a number of flying heights. For example, a photograph taken with a 6-inch lens from 3,000 feet above ground will have the same approximate scale as one taken at 6,000 feet using a 12-inch lens. However, the two photos will <u>not</u> be the same. In the photograph taken from 3,000 feet, tall objects such as office buildings will "lean over" near the edges of the photo, whereas in the photograph taken from 6,000 feet they will appear to stand upright. An interpreter might want buildings to "lean over" since it allows their sides to be examined and permits accurate height measurements to be made of the buildings. An interpreter could also need photographs in which buildings do not "lean," so that ground areas between the buildings will be visible. Parameters such as the focal length of the lens and flying height of the aircraft must be carefully selected to meet the interpretation requirements for each individual mission.

Cameras used to take vertical aerial photographs include aerial survey cameras such as in Figure 7. This kind of camera is used to acquire photographs for map-making and other commercial applications. A camera of this type would cost about $300,000 to buy.[1] Otherwise, a commercial aerial survey company might be contracted to acquire the required photography. The approximate cost to have photography taken on a commercial basis ranges from about $4,000 to $5,000 per

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[1] Dieter Zeuner, Wild Heerbrugg Canada Ltd. Personal communication.

day excluding the cost of ferrying the aircraft to the site and depending upon the area to be photographed.[1]

The Vinten Type 1360 camera shown in Figure 8 is an example of a relatively low-cost camera which has been designed specifically for low-level reconnaissance and would be quite suitable for Open Skies missions. It does not have the metric accuracy of an aerial survey camera. However, many reconnaissance missions would not require metric accuracy. These types of cameras are also less expensive than metric survey cameras. A Vinten Type 1360 camera system, complete with a 3 or 6 inch lens, control unit and two film magazines would cost approximately $33,000.[2]

Oblique photography

Oblique photographs may be simply defined as those which are intentionally not vertical. Cameras will typically be pointed to either side of the aircraft's path or looking forward for oblique photography. Oblique photographs provide the potential advantage of recording large areas in a single photograph. They also allow photography to be acquired without directly overflying a target. They have the disadvantage of variations in scale from the foreground to the background of the photograph, making measurements more difficult.

Cameras such as the Vinten Type 1360 shown in Figure 8 can be used for oblique as well as vertical photography. There are also hand-held cameras specifically designed to acquire high quality oblique photographs such as the Linhof aero Technica 45 EL camera shown in Figure 9. A complete Linhof aero Technica 45 EL camera, with one lens, film magazine, viewfinder and power pack, can be purchased for about

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1 Robert Fowler, Kenting Earth Sciences Ltd. Personal communication.
2 Jeffrey Paine, Vinten Military Systems Ltd. Personal communication.

$20,000.[1] Cameras such as these can acquire high quality oblique photographs from ranges of up to several kilometres which would be useful in an Open Skies context (Figure 10).

Specialized long-range oblique photography (LOROP) systems may be used to take oblique photographs from distances as much as 200 kilometres away from the target. These systems can acquire superb photographs with very fine spatial detail. However, LOROP systems might not be required or appropriate for Open Skies under normal circumstances:

- Overflights under Open Skies are to be conducted with the permission of the underlying State. The stand-off distances made possible with these sophisticated systems might not actually be required very often for Open Skies.
- Aircraft to be used for Open Skies may be subject to inspection by personnel of the underlying State and those personnel may accompany the aircraft during the overflight. LOROP systems make use of sensitive technology which could be compromised if they were used for Open Skies.
- a LOROP system can cost as much as $1 million with installation in an aircraft.

Multilens and panoramic systems

Military reconnaissance requirements have led to aerial cameras which are intended to provide coverage of a large area with only one overpass of the aircraft. These include panoramic and multilens systems. Panoramic systems provide horizon-to-horizon coverage with very fine detail. These camera systems produce characteristically distorted photos which make measurements from the photographs more difficult, but which does not seriously hinder an interpreter's ability to identify targets. Along-track frames of multilens

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[1] Horst L. Pientka, Linhof Präzisions-Kamera-Werke GMBH. Personal communication.

photography can be viewed with a stereoscope in the same way as normal vertical photographs.

Aerial films

Commercially-available aerial photographic film would be suitable for Open Skies missions. Specialized reconnaissance films are able to record finer spatial detail than their commercial counterparts. This is required for high-altitude reconnaissance but should not be necessary for Open Skies.

There are four main types of film which are used commercially for aerial photography. The "standard" aerial survey film is panchromatic film. This is a black and white film which has been manufactured to have a sensitivity similar to that of the human eye. High speed infrared film is also a black and white film, but it is sensitive to near-infrared wavelengths of light. It is useful for taking photographs when there is alot of atmospheric haze. Colour film is available which is sensitive to blue, green and red light and produces photographs showing features in about the same colours that the human eye would see. Colour infrared or "camouflage detection" film is sensitive to green, red and near-infrared wavelengths of light. Using this film, vegetation appears red and bare ground appears cyan. The film was originally developed to assist in the recognition of camouflaged equipment. Vehicles which have been camouflaged to visually appear like vegetation will not appear red on the film unless the camouflage material has been manufactured to simulate the high near-infrared reflectance of vegetation (Figure 11).

2.2 Thermal infrared systems

Thermal infrared systems use electronic detectors to sense thermal infrared radiation or "heat radiation." Thermal systems can sense thermal radiation which is emitted by all surfaces at all times, rather than depending upon sunlight as a light source. For this reason, thermal systems can be used during the day or night. Thermal infrared radiation does not penetrate cloud cover, so thermal systems must be used under clear sky conditions or, sometimes, thermal imagery can be acquired by flying underneath an evenly overcast sky.

Aerial thermal infrared reconnaissance can be done using thermal infrared linescanners (IRLS) or forward-looking infrared (FLIR) systems. The two kinds of sensors are intended for different missions. Table 2 contrasts selection criteria for the two sensors.

FLIRs produce thermal images in a framed format, similar to that of a video camera (Figure 12). FLIR systems which are designed for reconnaissance missions have a sensor head mounted beneath the aircraft (Figure 13) which is pointed toward targets of interest by an operator inside the aircraft using a video display with a set of controls. A FLIR such as the Honeywell system shown in Figure 13 will cost approximately $450,000.[1]

Infrared linescanners use a rotating mirror with optics to direct radiation from a small ground surface area to a detector or detector array. The mirror rotates perpendicular to the line of flight so that with each cycle, a strip of ground normal to the flight direction is covered (Figure 14). The forward motion of the aircraft causes successive scan lines to cover adjacent strips on the ground, creating a two-dimensional image such as the one shown in Figure 15. The data may be displayed in near-real time on a display screen or on dry silver paper for the use of the sensor operator during the overflight. However, the data will likely be recorded on magnetic tape, or a similar storage medium, and

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[1] Jeff Tracey, Intera Technologies Ltd. Personal communication.

then processed after the aircraft has returned to base to provide the actual interpretable product.

A thermal infrared linescanner such as the one shown in Figure 16 would cost approximately $500,000 to purchase.[1] However, a service to acquire and produce the required imagery could also be contracted from commercial remote sensing firms for about $8,000 to $9,000 per day.[2]

2.3 Radar systems

Radar, an acronym for radio detection and ranging, is an "active sensor" which transmits short pulses of microwave energy and then records the echoes received back in their order of arrival. Airborne radars are called side-looking airborne radars (SLAR). SLARs produce continuous strips of imagery of the terrain adjacent to the flight path of the aircraft (Figure 17).

There are two main types of SLAR. Real aperture, or "brute force," radars (RAR) require a physically-large antenna to achieve any reasonable amount of spatial detail in the resulting images. Synthetic aperture radars (SAR) achieve better spatial detail without having to use a large antennae by using the forward motion of the aircraft to create the effect of an antenna hundreds of metres long.

Radar systems can acquire imagery through almost any atmospheric conditions: haze, smoke, cloud cover, or even light rain and snow. The ability of imaging radars to operate under just about any weather conditions suitable for flying means that coverage at a particular time, such as to monitor a military exercise, or of areas which are perpetually cloud covered can be relied upon with more

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1 *Ibid.*
2 *Ibid.*

certainty. Furthermore, radar can be used during the day or night because it is an active sensor, providing its own illumination.

Radars use radiation with wavelengths roughly two orders of magnitude longer than those used by photographic and thermal infrared systems. The long wavelength radiation provides imaging radars with their all-weather capability. It also means that the spatial detail which can be recorded is much less than that which can be recorded with optical sensors.

To the uninitiated, radar imagery may appear to be similar to black and white aerial photographs. However, the physical reasons for tones, textures and other features in radar images can be radically different than those for conventional photographs. Figure 18 shows a radar image of a military airfield. Some aircraft are visible on the tarmac as nicely aligned, bright "blobs." Figure 19 shows a radar image of some tethered destroyers (near the bottom of the image) and an urban area with residential neighbourhoods, commercial and industrial areas and an airport.

Airborne synthetic aperture radars are very expensive. A commercial system will cost about $5 million to $6 million. A SAR with a ground receiving station for real-time delivery of data will cost from $8 million to $10 million. Airborne acquisition of SAR imagery can also be contracted for about $15,000 to $20,000 per day, assuming a 3 person crew flying in a SAR-equipped Cessna Conquest.[1]

3 THE PLATFORMS

A wide range of aircraft may be used as reconnaissance platforms. Many of these, however, will not be well suited to the Open Skies context. Special-purpose military

[1] *Ibid.*

reconnaissance aircraft, of either the strategic or tactical variety, will not be necessary and may not be appropriate for Open Skies. Civilian aircraft may be more suited to the task. Open Skies aircraft may often have to transit long distances within a reasonable period of time. This consideration may often rule out the use of smaller, piston-engined aircraft. At the same time, the cost to operate Open Skies aircraft cannot be prohibitively expensive.

A suitable aircraft for Open Skies operations should include:[1]

- sufficient payload to provide for the required sensors, processing equipment and storage;
- good range capability with the payload, ensuring large coverage per sortie;
- broad range of operating altitudes without adverse operational or economic effects;
- ability to transport passengers (for example, observers for the underlying State) without loss of surveillance capability;
- ability to operate from a majority of airfields; and
- low operating costs coupled with high dispatch reliability.

Table 3 outlines the performance characteristics for a number of potential aircraft, including a Cessna 441 Conquest, de Havilland Dash 8 300, Lockheed C-130 and Canadair Challenger 600. Table 4 compares operating costs for the aircraft in 1985 US dollars. Photographs of the aircraft are provided in Figures 20, 21, 23 and 24. These aircraft are being used as representatives of categories of aircraft. Their selection for this discussion does not constitute an endorsement of these particular aircraft.

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[1] Adapted from: Airborne Remote Sensing for C.F.E. Verification: The Platform. Boeing Canada, de Havilland Division. Report SER-8-2295. June, 1989. p. 7.

The Cessna Conquest provides a cost-effective remote sensing platform. It would be capable of operating with a crew of three with aerial cameras and a thermal linescanner, or with a synthetic aperture radar by itself. These would be reasonable sensor configurations since nighttime thermal imagery will often be complemented with daytime photography to assist in the interpretation. SAR imagery is typically acquired as a stand-alone product, particularly if the target area is perpetually cloud-covered. The particular Conquest shown in Figure 20 has been equipped with a SAR. An aircraft such as this would cost about $3 million when new.[1]

A de Havilland Dash 8 Series 300 would serve as a good general-purpose platform. It has enough room for a comprehensive suite of sensors and associated equipment while retaining an ability to transport inspection teams as well. It provides a range in excess of 2,000 nautical miles. Figure 22 illustrates the ferry distances and times which would be required by aircraft operating out of Stockholm and Zurich to cover the "Atlantic to the Urals" area in Europe. Short field capability ensures that the aircraft would be able to operate from the vast majority of European airfields. A Dash 8 Series 300 would cost about $11 million to purchase.[2]

The Canadair Challenger is a jet rather than turbo-prop aircraft. It would be capable of transitting long distances quickly. Like the Dash 8, it would be capable of carrying a full suite of sensors and passengers. However, executive jets such as the Challenger have a number of disadvantages. They have relatively high stall speeds, restricting their ability to acquire large-scale imagery. They have higher purchase and operating costs. The purchase price for a

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[1] Ken Wilson, Ken Wilson Aircraft Sales. Personal communication.
[2] <u>Airborne Remote Sensing for C.F.E. Verification: The Platform</u>. op. cit., p. 23.

Challenger 601 is $16 million[1] and it costs over twice as much to operate as the Dash 8, and three times as much as the Conquest (Table 4).

The Lockheed C-130 is a large transport aircraft. An aircraft such as this would be needlessly expensive to purchase. A new, ready-to-fly C-130 will cost over $20 million.[2] It is also very expensive to operate: more than six times as expensive as the Dash 8 and almost ten times more expensive than the Conquest (Table 4).

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1 George LaForme, Canadair, a Division of Bombardier Inc. Personal communication.

2 Anne Oakes, Lockheed Canada Ltd. Personal communication.

4 TABLES

Table 1. Remote sensors for an Open Skies regime.

SENSOR	FEATURES
Photography	Fine spatial resolution daytime, clear skies film requires processing
Thermal infrared	fair spatial resolution night or day, clear skies useful to detect human activity can provide real-time data
Radar	poor spatial resolution night or day, all weather

Table 2. Criteria for selection of infrared sensor for reconnaissance mission.[1]

IRLS Selection Criteria	FLIR Selection Criteria
• hard copy imagery required	• real time imagery required
• image mensuration and analysis required	• image mensuration and analysis not required
• wide field-of-view across track, continuously-mapped imagery desired	• narrow field-of-view providing details of selected areas desired
• operator has little or no control over pointing of the sensor	• operator has full control over pointing of the sensor
• sensor operation may impose velocity/height restrictions on aircraft	• sensor operation will not impose velocity/height restrictions on aircraft

[1] Noel, William T. 1976. "Utilization of IR Imagery in Tactical Reconnaissance." IN: Shea, E. (editor) Aerial Reconnaissance Systems - Pods/Aircraft. SPIE Vol. 79. pp. 99-100.

Table 3. Performance characteristics for selected aircraft.[1]

	Cessna Conquest[2]	Dash 8 Series 300	Canadair Challenger	Lockheed C-130
Max. Gross Weight (lbs.)	10,800	39,000	41,100	155,000
Max. Payload (lbs.)	2,450	11,800	7,830	50,760
Payload with Max. Fuel (lbs.)[3]	1,500	9,122	5,375	33,000
Maximum Ceiling (feet)[4]	35,000	25,000	41,000	23,000
Maximum Cruise (knots)[5]	287	266	443	327
Maximum Range (nautical miles)[6]	2,100	2,500	3,040	3,300
Maximum Endurance (hours)[6]	7.3	9.4	6.8	12.0
Max. Range @ 5,000 ft. (n. mi.)	866	1,273	1,490	1,664
Take-off dist. @ Sea Level (ft.)	2,465	3,700	5,750	6,000

[1] Intera Technologies Ltd. "A comparison of the capabilities and costs of aircraft for an iceberg radar surveillance role." IN: CANPOLAR Consultants Ltd. Iceberg detection by airborne radar: Technology review and proposed field program. Environmental Studies Revolving Funds Report No. 045. September, 1986. p. 231.

[2] Single-pilot, one operator. All others assume two pilots, one operator.

[3] Payload refers to the equipment payload available plus three or two man crew as required.

[4] Maximum ceiling is close to the optimum performance ceiling except for jets which have approximately 39,000 ft ceiling for optimum performance.

[5] Refered to optimum altitude. Will be slower at lower altitude.

[6] Assumes maximum fuel load at takeoff, VFR conditions. Reserve not included.

Table 4. Cost comparisons in 1985 $US[1] for selected aircraft.[2]

	Cessna Conquest[3]	Dash 8 Series 300	Canadair Challenger	Lockheed C-130
Specific Range (nm/lb fuel)	0.67	0.44	0.18	0.08
Operating cost @ optimum altitude[4]				
$/hr	285	404	978	~ 2550
$/nm	1.00	1.52	2.21	7.80
Operating cost @ 5000 ft altitude[4] [5]				
$/hr	430	625	1515	3953
$/nm	1.62	2.37	3.42	12.09

[1] Original figures were provided in 1985 Canadian dollars. These were converted to US dollars using the conversion $1 CDN = $0.85 US.

[2] Intera Technologies Ltd., op. cit., p. 232.

[3] Single-pilot, one operator. All others assume two pilots, one operator.

[4] Operating costs include fuel and engine maintenance but do not include crew costs.

[5] Derived by assuming 100% fuel flow increase at 5,000 feet from optimum cruise. Manufacturers do not provide full performance curves versus altitude.

5 FIGURES

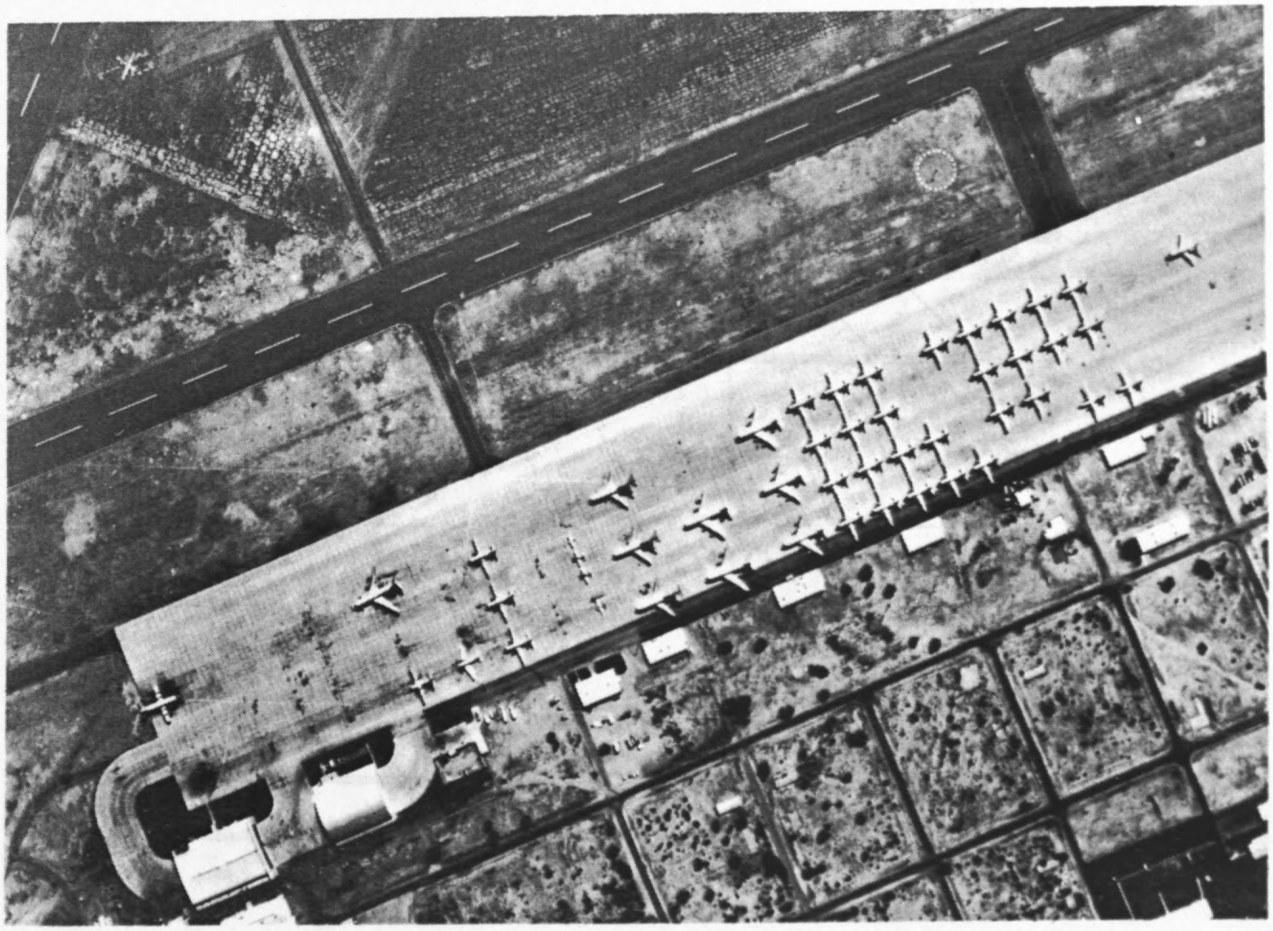

Figure 1. Typical vertical panchromatic aerial photograph of an airfield. Several different kinds of aircraft can be distinguished. (Courtesy of Intera Technologies Ltd.)

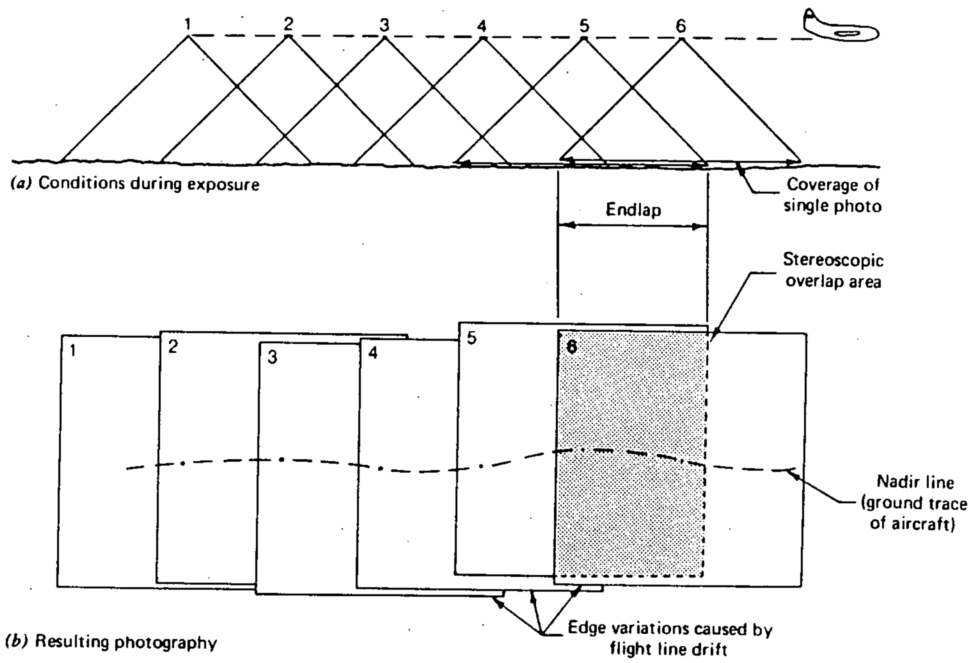

Figure 2. Acquisition of overlapping photographic coverage along a flight strip to provide stereoscopic coverage. (Source: Lillesand, Thomas M. and Ralph W. Kiefer. Remote Sensing and Image Interpretation. John Wiley & Sons. New York. p. 78.)

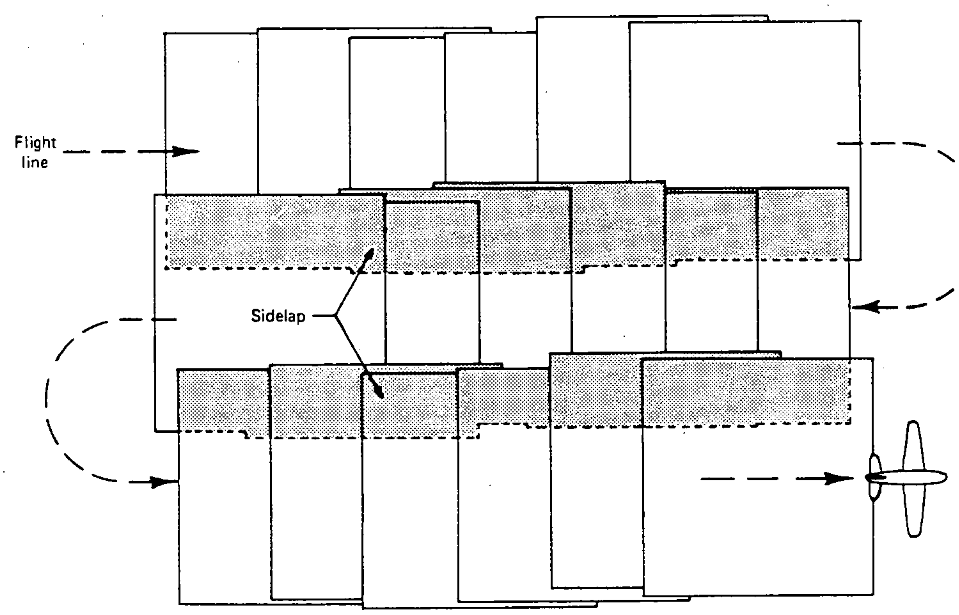

Figure 3. The use of sidelap between adjacent flight lines to obtain contiguous coverage of a project area. (Source: Lillesand and Kiefer, op. cit., p. 80.)

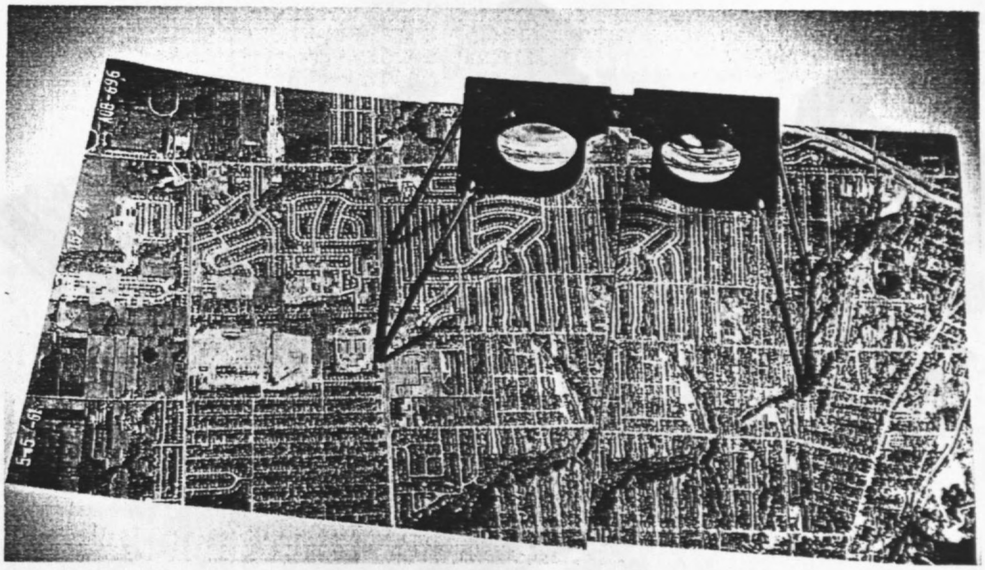

Figure 4. A simple "pocket" stereoscope. (Source: Lillesand and Kiefer, op. cit., p. 103.)

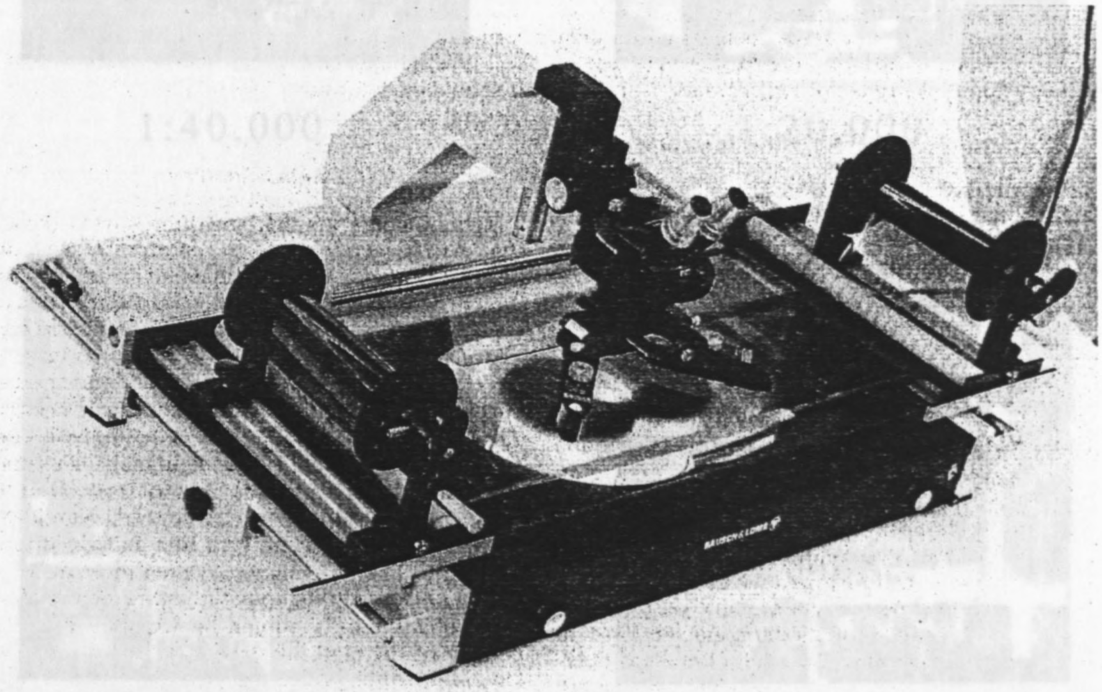

Figure 5. Bausch & Lomb Zoom stereoscope mounted on a high intensity light table for viewing transparency roll film. (Source: Colwell, Robert N. (editor-in-chief). 1983. Manual of Remote Sensing. 2nd Edition. Volume 1: Theory, Instruments and Techniques. American Society of Photogrammetry. Falls Church, VA. p. 1016.)

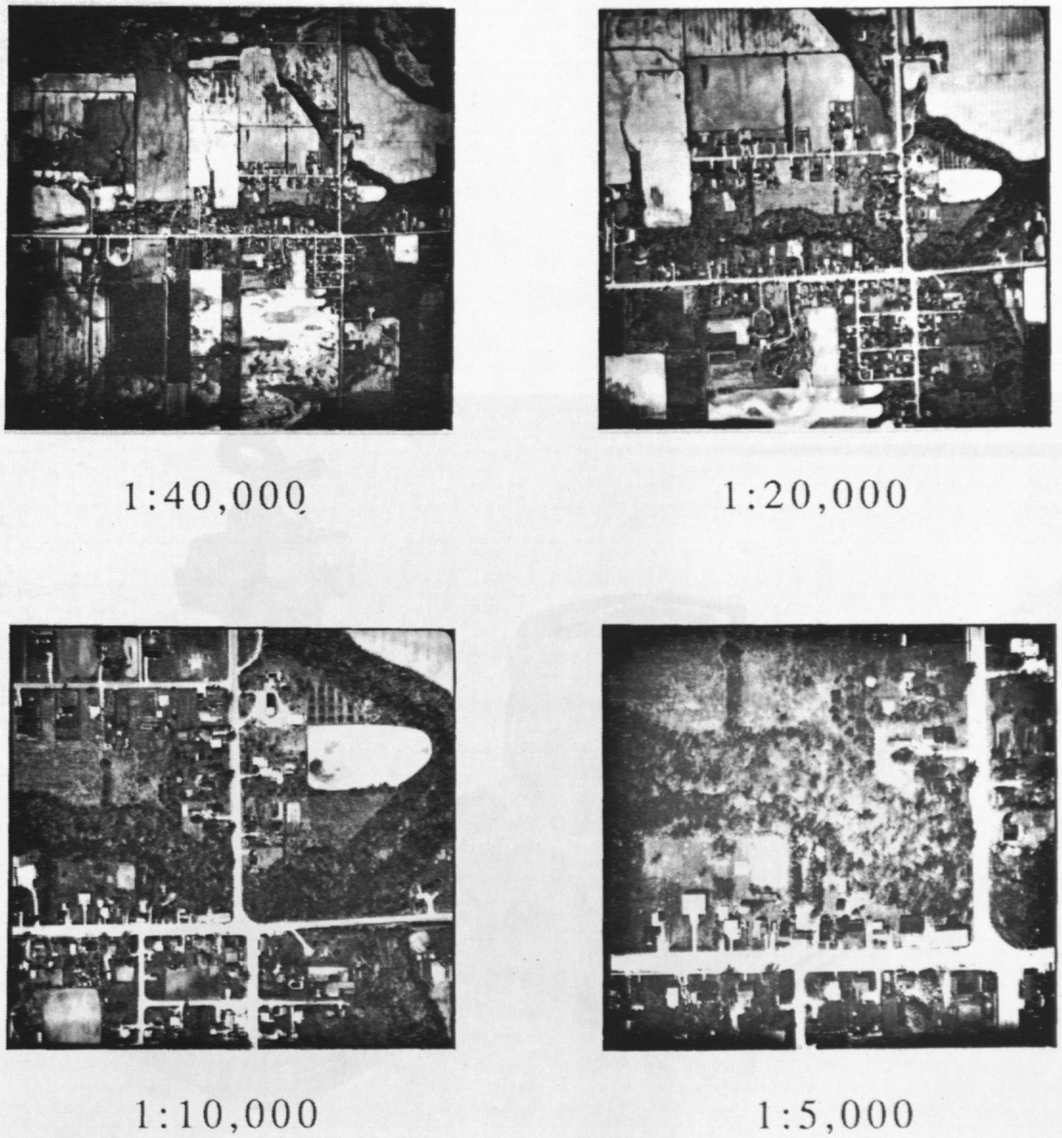

Figure 6. Aerial photography at different scales:

(a) 1:5,000 (largest scale)

(b) 1:10,000

(c) 1:20,000

(d) 1:40,000 (smallest scale)

Notice the extent to which small detail can be interpreted at each scale. Also take note of the relationship between the total area recorded in each photograph and its photographic scale. (Courtesy of E.M. Senese, Ontario Centre for Remote Sensing.)

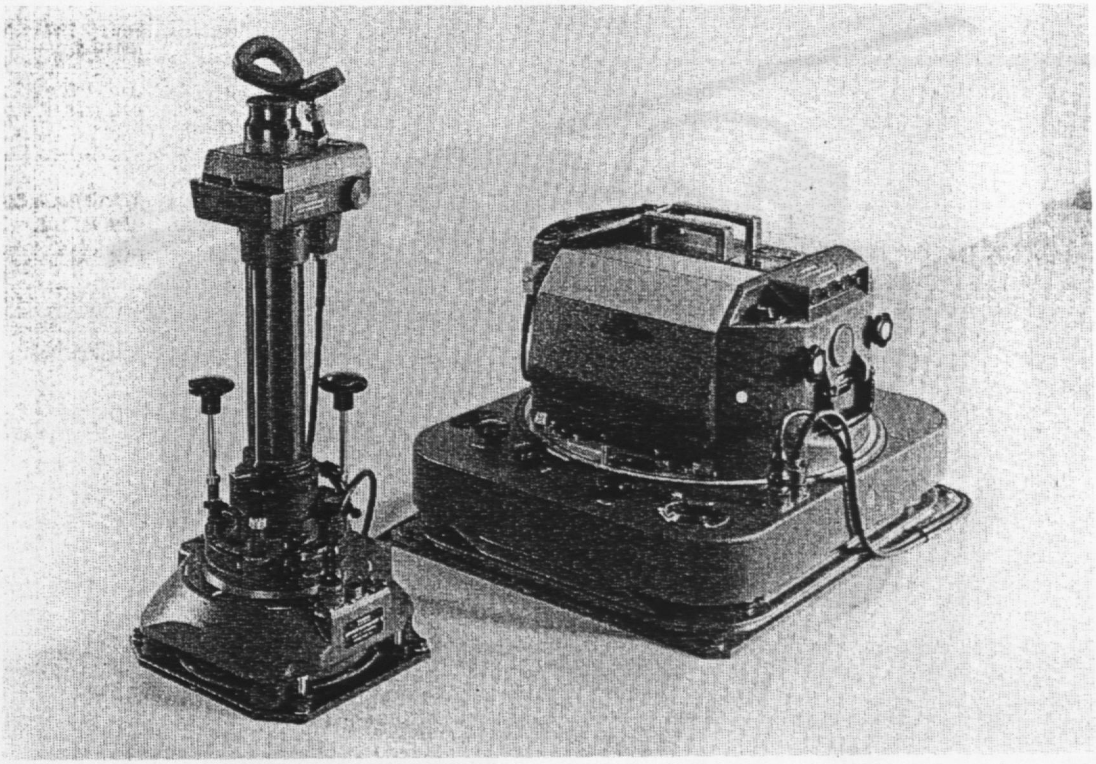

Figure 7. The Wild AVIOPHOT RC20 Aerial Camera System with camera (right) and navigation sight (left). (Courtesy of Wild Heerbrugg Ltd.)

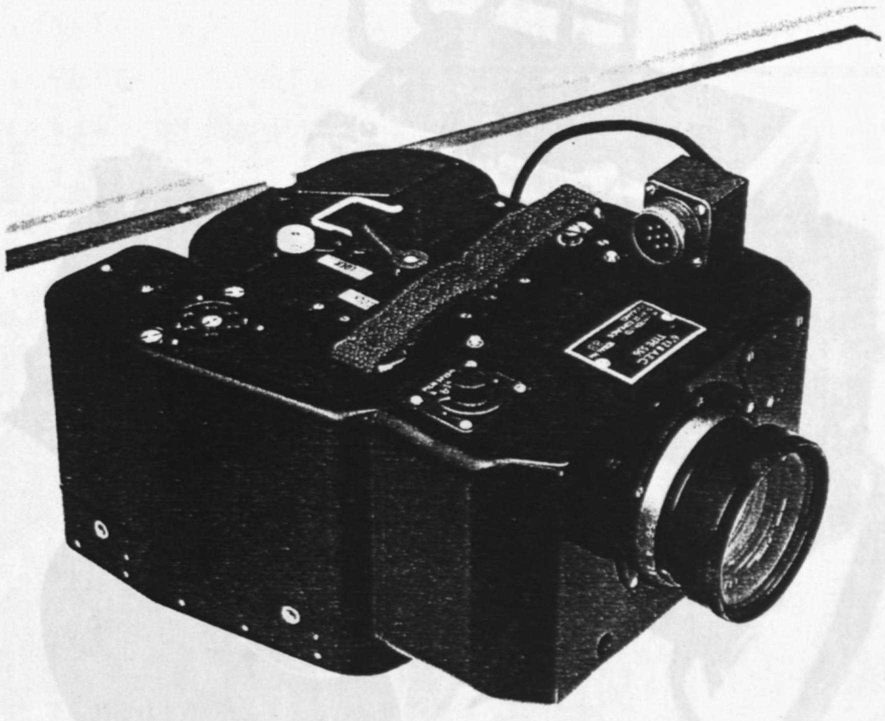

Figure 8. The Vinten Type 1360 reconnaissance camera complete with automatic exposure control and 6 inch lens. The film magazine holds 500 exposures on 70 mm film. (Source: Graham, Ron and Roger E. Read. 1986. Manual of Aerial Photography. Focal Press. London. p. 44.)

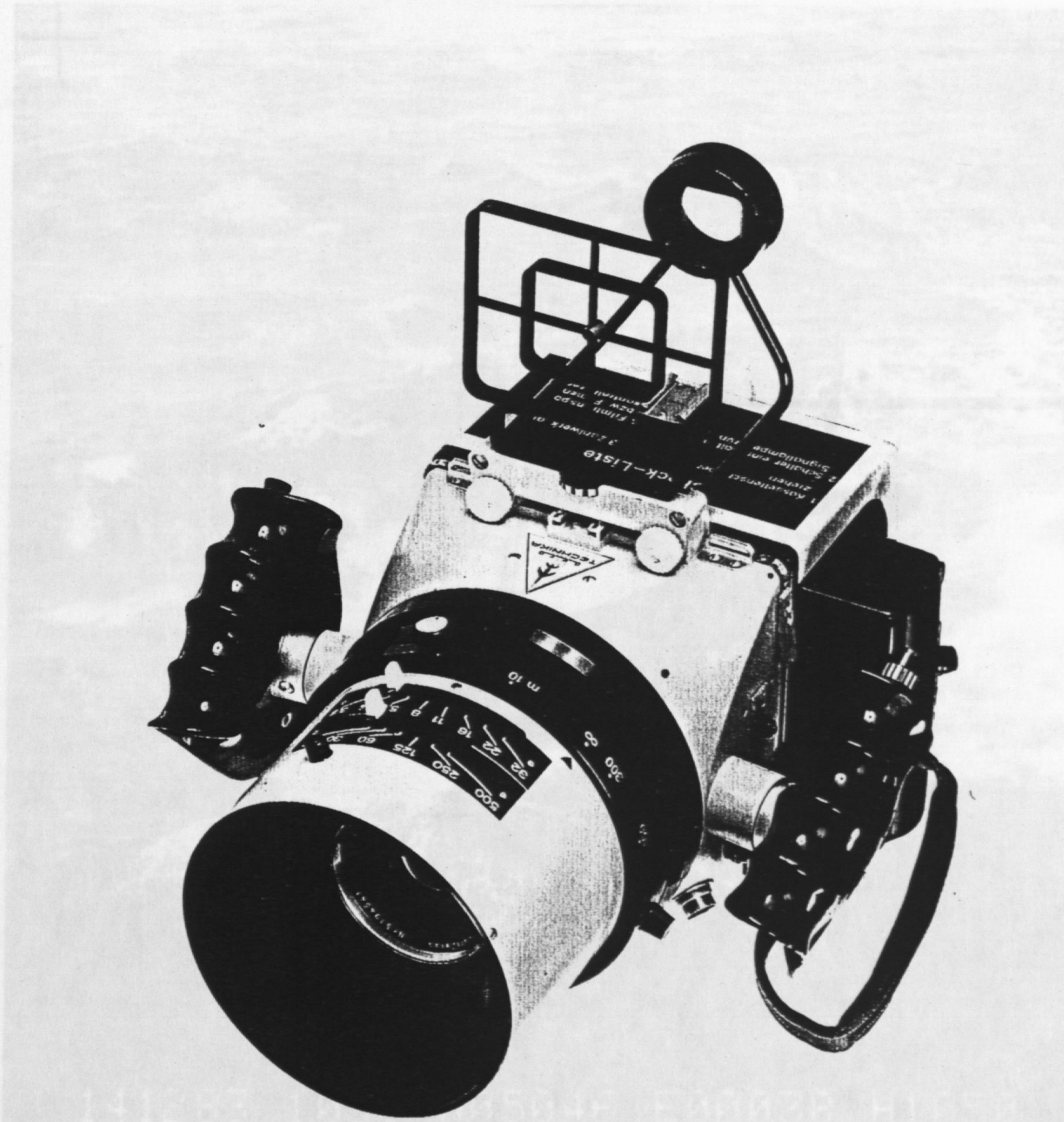

Figure 9. The Linhof aero Technica 45 EL 9 × 12 cm format hand-held aerial camera. (Courtesy of Linhof Präzisions Kamera Werke GMBH)

Figure 10. Oblique photograph taken using an Agiflite hand-held camera with time and position data in the margin, recorded at the time of exposure. (Courtesy of Negretti Aviation)

Figure 11. Colour infrared film can be useful to detect poorly camouflaged military equipment. The camouflage net in this photograph does not match the spectral characteristics of the surrounding vegetation, making it visible in the photo. (Courtesy of David Dorschner, Aerial Intelligence Specialists)

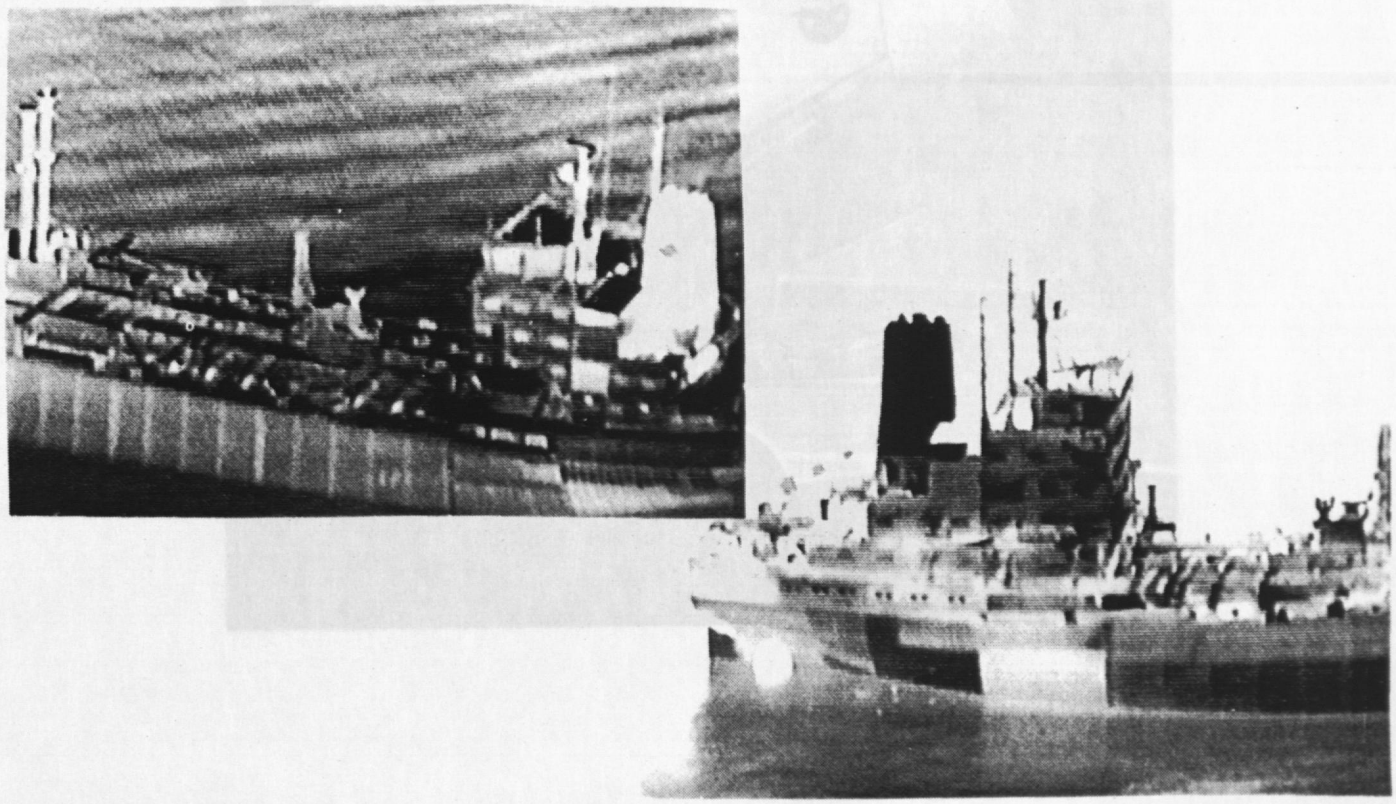

Figure 12. FLIR images of freighters. Notice the hot stack in the left image and the ability to "see through" the hulls because of differences in surface temperature resulting from the contents in the holds. (courtesy of David Dorschner, Aerial Intelligence Specialists)

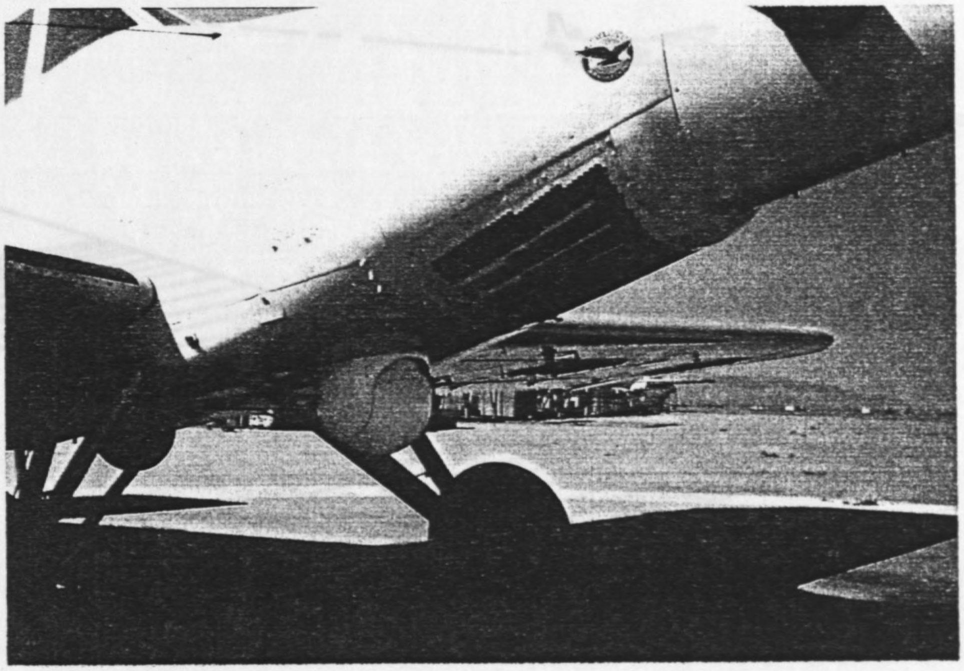

Figure 13. This gimballed FLIR mounted underneath the fuselage of an aircraft allows the operator to image terrain anywhere ahead, behind, to either side, and all angles below the aircraft. Most FLIR systems are used together with high resolution television displays to provide the pilot and system operator with real time data for navigation as well as surveillance. (Courtesy of David Dorschner, Aerial Intelligence Specialists)

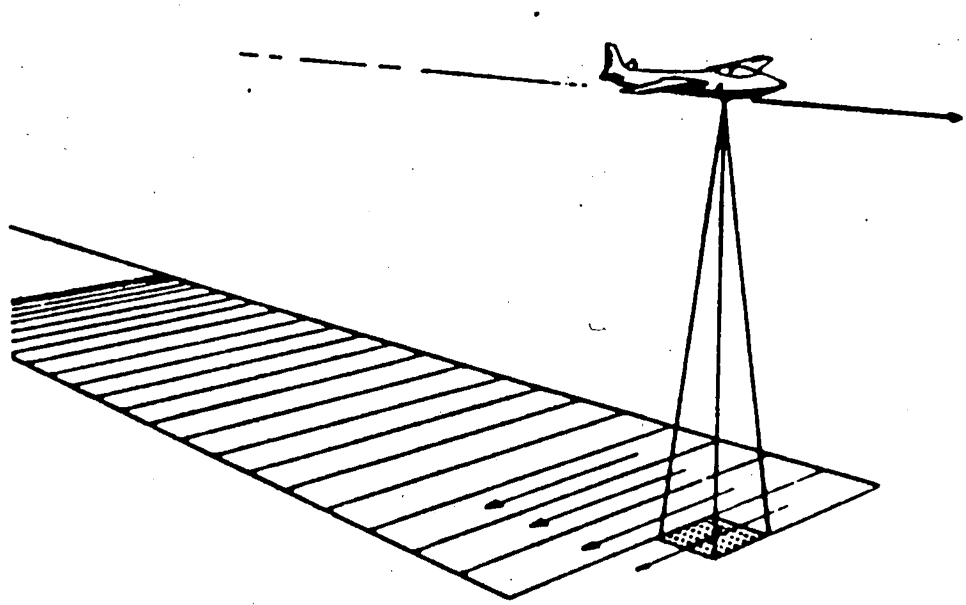

Figure 14. Operation of an airborne line scanner to produce contiguous imagery. Rotation of the mirror provides the across-track dimension of the image. The forward motion of the aircraft causes successive scan lines to cover adjacent strips on the ground, forming the second dimension of the image. (Source: Madding, Robert P. 1979. Thermographic instruments and systems. University of Wisconsin-Extension. Department of Engineering and Applied Science. p. 82.)

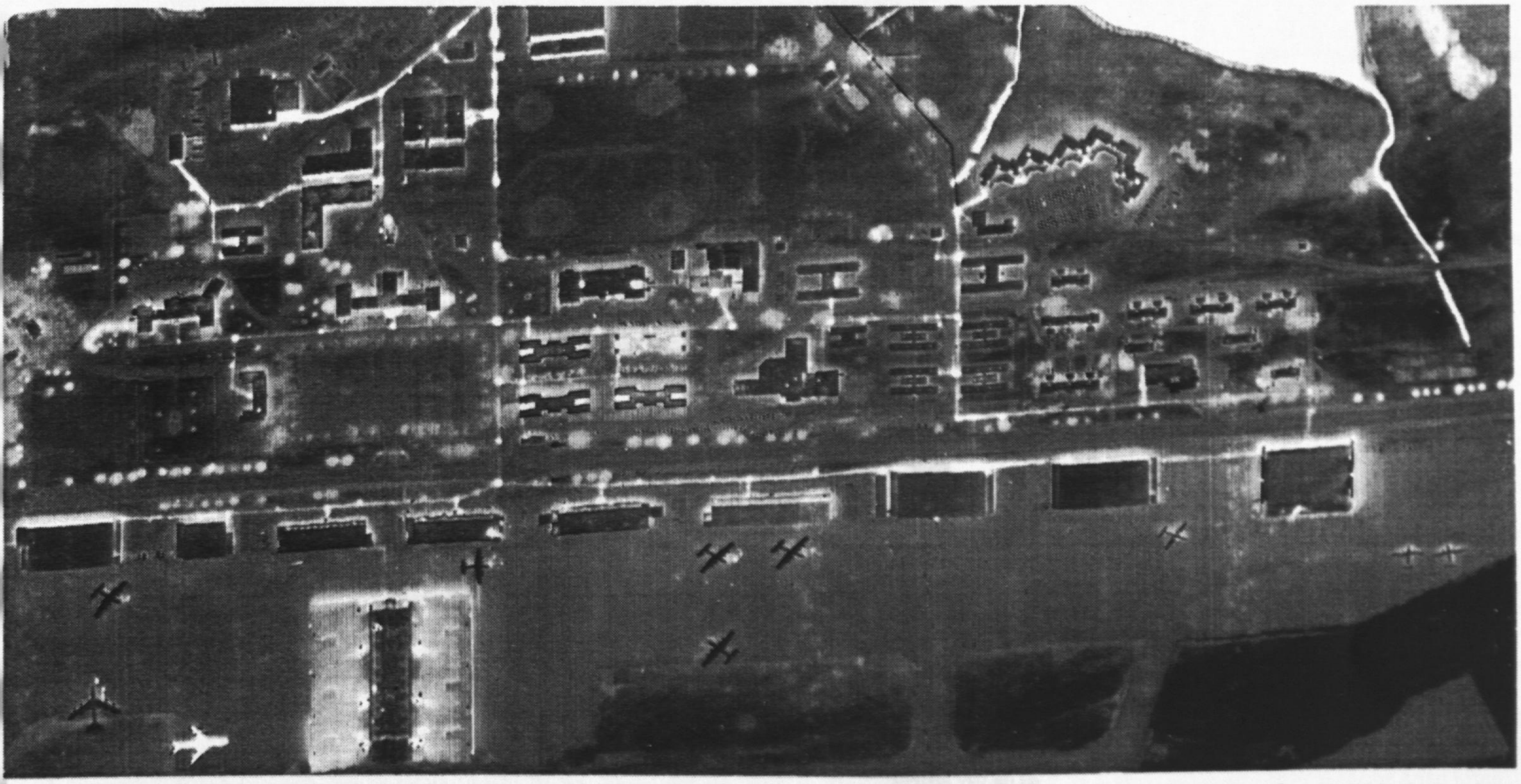

Figure 15. Thermal infrared linescan image of an airport. White is "hot" and black is "cold" in this image. The image was taken at night. Notice the "hot" buried steamlines and trees along the roadsides. Warm auxillary power units (APU's) can be seen near some of the aircraft. One aircraft appears anomalously warm compared to the others. It may have been parked inside the nearby hangar not long before the image was acquired. (Courtesy of Intera Technologies Ltd.)

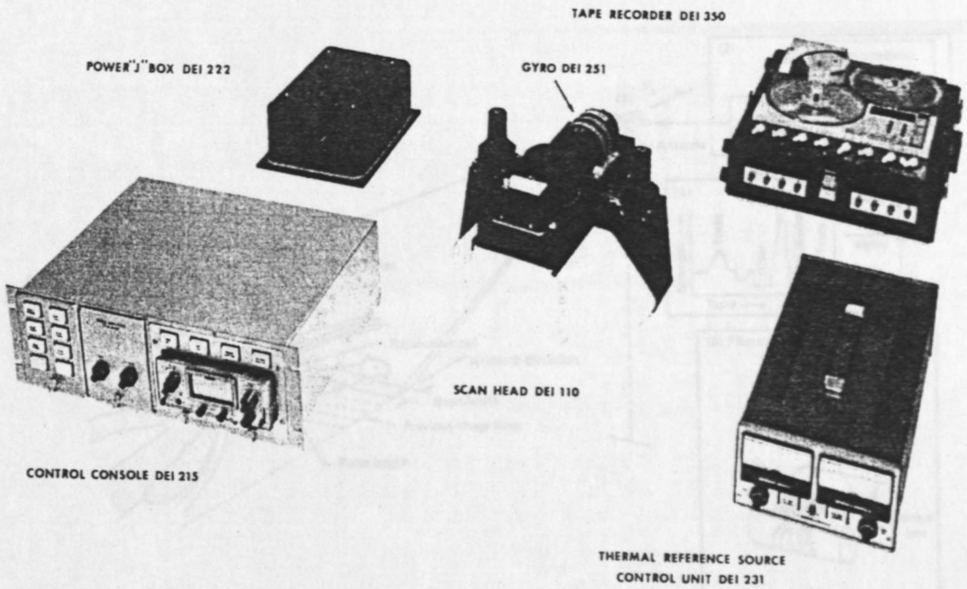

Figure 16. Thermal infrared linescanner system including the scan head, control console, blackbody reference source control unit, tape recorder and "J" box. (Source: Lillesand and Kiefer, op. cit., p. 402.)

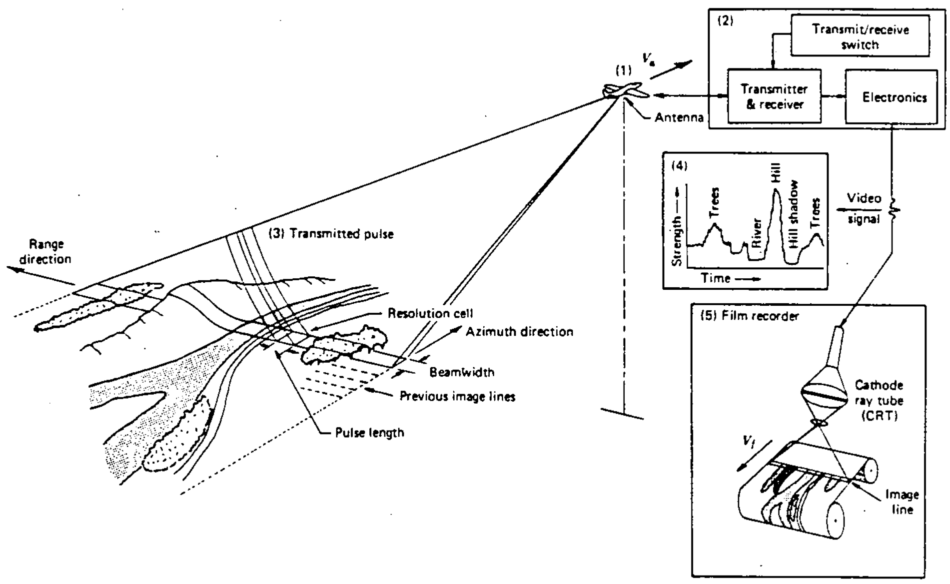

Figure 17. Operation of a real aperture side-looking airborne radar (SLAR). (Source: Lillesand and Kiefer, op. cit., p. 495.)

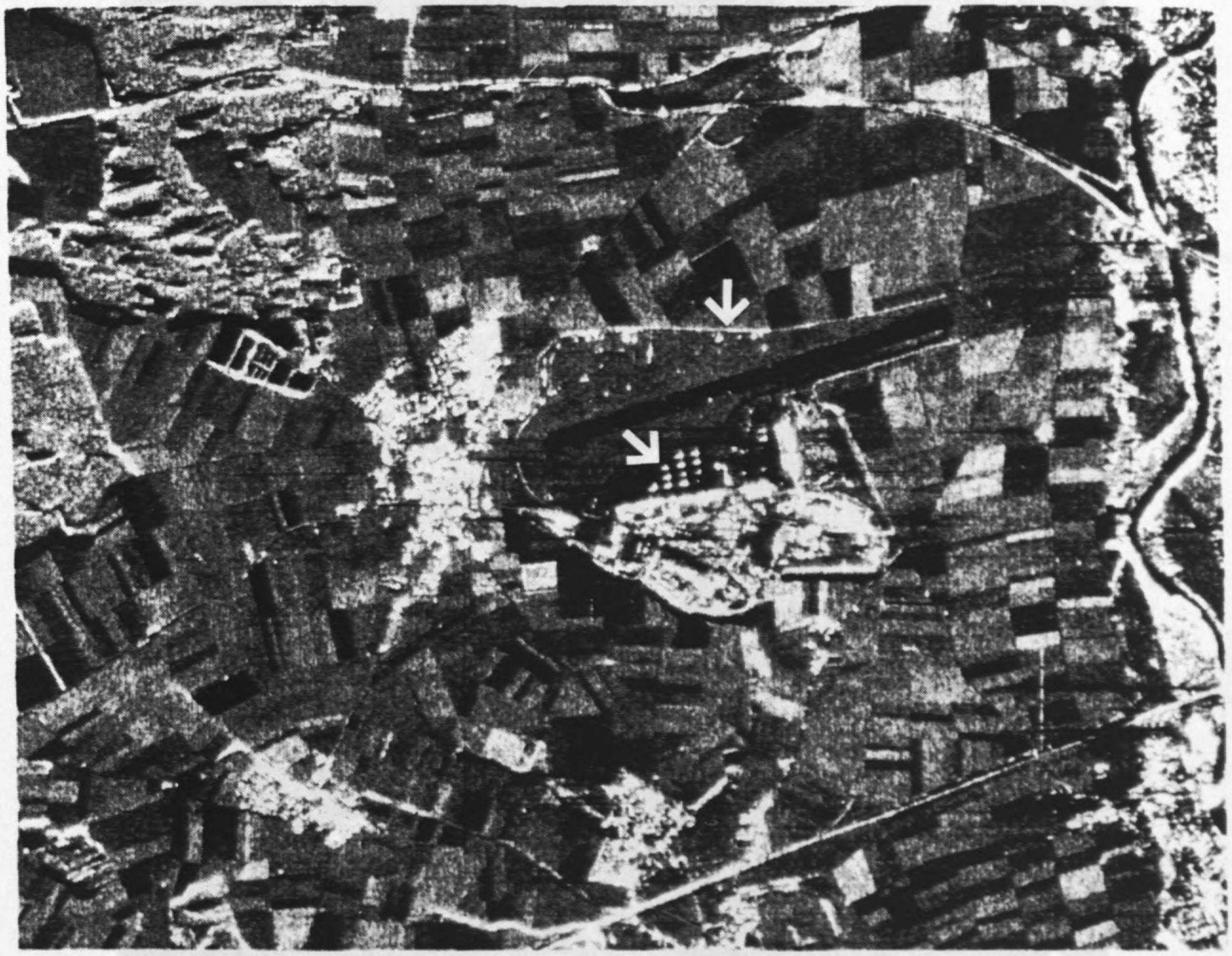

Figure 18. A radar image of an airfield. The image was acquired using a synthetic aperture radar with 1 metre × 1 metre resolution. Radar imagery is characterized by an overall speckly appearance with bright targets such as the aircraft indicated by one of the arrows. The asphalt runway and river (on the left) are areas of low return, and therefore appear dark. Perimeter fences (indicated by arrow) are evident as bright lines, particularly when oriented parallel to the line of flight. (Courtesy of Intera Technologies Ltd.)

Figure 19. The tethered destroyers seen as bright returns near the bottom of this SAR image are plainly visible but not necessarily easy to identify. Many common cultural features, such as roads, an airport, and housing subdivisions, are evident. (Courtesy of Intera Technologies Ltd.)

Figure 20. Twin-engined Cessna Conquest equipped with synthetic aperture radar. The Conquest is a cost-effective platform which delivers the altitude, range and speed capabilities required to operate a SAR. The aircraft would also make a good platform for an infrared linescanner or mapping camera. (Courtesy Intera Technologies Ltd.)

Figure 21. The de Havilland Dash 8 Series 300 provides a platform with room for 16 passengers or more as well as a full complement of sensors. Based from a central location in Europe, the Dash 8 could reach any target within the "Atlantic to the Urals" region within six hours without refueling. The Dash 8's airfield performance would permit operations from most airfields in Europe. (Courtesy of Boeing Canada, de Havilland Division)

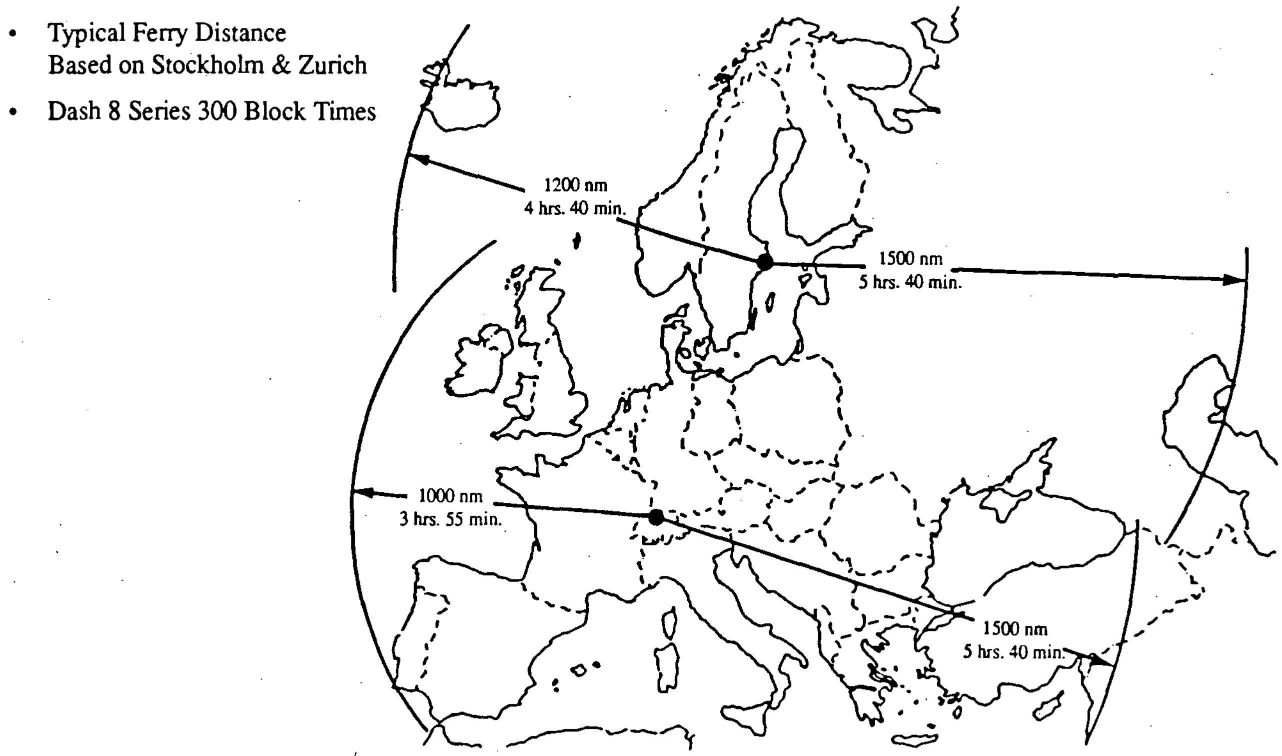

Figure 22. Typical ferry distances and times for Dash 8 Series 300 aircraft based out of Stockholm and Zurich. (Source: <u>Airborne Remote Sensing for C.F.E. Verification: The Platform</u>. op. cit., p. 15.)

Figure 23. Canadair Challenger 601. A jet aircraft such as the Challenger could be appropriate for Open Skies missions involving large transit distances. (Courtesy of Canadair, a Division of Bombardier Inc.)

Figure 24. Lockheed C130 Hercules. The C-130 was not intended or designed as a platform for remote sensors. It's high operating costs would make Open Skies operations needlessly expensive. (Photo source: Yenne, Bill (editor). 1987. Aircraft of the US Air Force and its NATO Allies. Gallery Books. New York. p. 49.)