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NATIONAL AERONAUTICAL LABORATORY
POST BAG No. 1779, BANGALORE 560 017 INDIA

PROF. R. B. DAMANIA
ASST. DIRECTOR

Ref. FEL/109

Date: 4 February 1988

Prof.Satish Dhawan
Senior Advisor, Department of Space
ISRO Headquarters
Cauvery Bhavan, District Office Road
BANGALORE-560 009

Dear Prof.Dhawan:

Further to our telephonic conversation on February 3, 1988 I am enclosing herewith two notes.

1. A note showing the linear distance coverage, for remote sensing, with NAL's Light Canard Research Aircraft. This note shows that, depending upon speed, carriage of observer, the linear distance covered will be in the range of 400 km to 2700 km.

2. A small note I had written ~~two~~ three? years ago containing suggestions on the use of light aircraft for remote sensing.

With warm regards,

Yours sincerely,

R.B.Damania

(R.B.DAMANIA)

Encl: as above

Low-cost Remote Sensing Over Small Areas

1. Introduction

India is poised for making significant strides in the field of Remote Sensing. The resulting benefits to the country's agricultural and mineral outputs, urban and rural developments etc. are numerous and there is sufficient appreciation for these aspects so that they need not be covered in this report. The Indian Space Research Organisation is about to launch its own Remote Sensing Satellite which will provide coast to coast coverage at any time of the year. The National Remote Sensing Agency has acquired the facilities and expertise for aerial coverage over large tracts of land and water. Both the above organisations have a well established data acquisition and interpretation system.

At the lower end of the scale, when a smaller area is to be surveyed quickly and in a cost-effective manner, we do have some problems. This note addresses this area of operation. Various alternatives are considered and suggestions are offered.

2. Scale of Operations

The following is a very rough demarcation of the types of platforms used for various types of operations :

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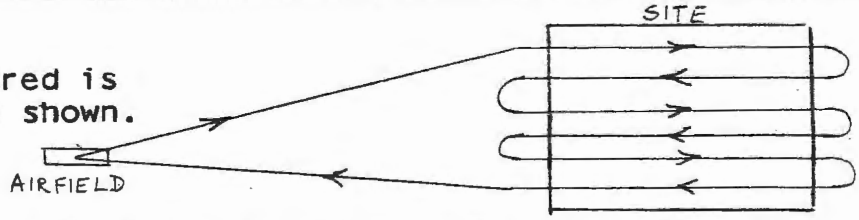
NAL's LIGHT CANARD RESEARCH AIRCRAFT

Typical weights/payloads/ranges for remote sensing operations

Operating Condition	Empty Weight Kg	Cameras Tracking Device & Associated Equipments Kg	Pilot Kg	Observer Kg	Fuel Kg	AUW Kg
1 Pilot + Observer with 600 kg AUW giving total distance cover of 400 km (at 275 Kmph) to 600 Km (at 230 Kmph)	418	12	65	65	49	600
2 Pilot alone with 600 Kg AUW giving total distance cover of 1400 to 2300 Km.	418	12	65	-	105	600
3 Pilot alone with full fuel with weight in excess of AUW giving total distance cover of 1800 to 2700 km.	418	12	65	-	140	635
4 Pilot + Observer with max. excess weight giving to tal distance cover of 1200 to 2000 km.	418	12	65	65	90	650

Note: 1. Distance covered is total path as shown.



2. Min. reserve is included in all calculations.

3. Long duration flights may subject the Pilot and observer to excessive mental stresses for this type of flying. Hence large areas should be suitably divided into smaller areas for coverage during each flight.

4. AUW = All Up Weight = 600 kg for normal op-erations
   = 650 kg with restrictions

Area / Type of remote survey	$>10^6$ Sq.Km	10^3 to 10^6 Sq.Km	10 to 10^3 Sq.Km	$<$ 10 Sq.Km
Aerial Photography (IR, B&W, Etc.)	Satellite	Transport Aircraft	Light Aircraft (500 to 1000 Kg)	Balloons or Micro-Light Aircraft (200 to 400 Kg)
Multi-Spectral Scanning	Satellite	Transport Aircraft	Light Aircraft (1000 to 2000 Kg)	Light Aircraft (1000 to 2000 Kg)
Radiological Scanning	Satellite	Transport Aircraft	Light Aircraft (1000 to 2000 Kg)	Light Aircraft (1000 to 2000 Kg)

The Balloons, Micro-Light and Light Airplanes offer cost-effective alternatives to larger aircraft and satellites, when the scale of operation is small.

3. Choice of Platform

The relative merits and demerits of the lighter-than-air balloon, micro-light aircraft and light-aircraft are as follows :

Balloons : There are lighter-than-air vehicles which can be either rigid or collapsible and use Helium or Hydrogen or a combination of the two. Hot-air balloons may not offer a viable alternative since they are difficult to position, and have very stringent weather limitations.

Balloons may offer a cost-effective solution for small area surveys where accurate tracking is not essential. In high-altitude coverage over a small area, the balloon may be the best choice of Platform.

The effect of strong and gusty winds on balloons may overcome by mounting cameras on an independently stabilised platform.

However, the balloon is not the ideal choice where an area is to be covered by several passes with adequate overlaps in the direction-of-flight as well as laterally. A balloon compares unfavourably with the light aircraft in tracking accuracy.

The cost of the baloon is difficult to estimate without a detailed study. This type of vehicle has not been developed in the country upto upto now and hence a costly design and development program may be required.

These are loose definitions! Distinctions between "microlights" and "ultralights" are now possibly formally defined.

Micro-light Aircraft : Airplanes with a max weight in the region of 200 to 400 Kg are known as micro-light aircraft (sometimes also called Ultra-Light aircraft). These are usually single-seat aircraft powered by small piston-engines mostly in the 20 to 50 HP range. A large number of ultra-lights have an open cockpit. The airframe is simple and easy to build with only basic workshop facilities. Costs are usually in the range of Rs.50,000 to Rs.1,50,000. The engine, most of the components and some of the raw materials have to be imported.

These aircraft are also very inexpensive to operate and it is expected that a large number of them will be flying in India in the not-too-distant future.

These aircraft would offer the most cost-effective approach where a single-shot, low-scale aerial photograph is required. If the area to be covered requires about 8 to 10 frames, ultra-light aircraft may offer a viable alternative.

These aircraft do not have certified engines and hence Civil Air-worthiness Authorities in India may restrict their flights over populated areas. There is thus a doubt about their use for urban area coverage.

It will be difficult to use these aircraft for an area coverage involving accurate tracking.

Light Aircraft : The term 'light aircraft' can cover a rather wide weight-range. Light single-engined aircraft are usually in the weight range of 500 to 1500 Kg. Light twin-engined aircraft are usually in the weight range of 2000 to 3000 Kg. If these twins are pressurized and equipped with expensive avionics, their cost can exceed two crore of rupees. Several light single-engined two-seat aircraft are being used by Flying Clubs and Flying Schools in large cities all over India. The use of these available light aircraft should also be seriously considered.

Light two-seat aircraft used for ab-initio training or sport can be cost effective platforms for remote sensing operations involving the use of aerial photography cameras (one to four in number). The weight of the camera installation, with its control, timers, spare magazines, etc. will usually be within the baggage carrying limit of these aircraft. These aircraft can be flown over distances of 300 to 500 Km and possibly more if the Pilot flies alone. It is necessary to operate these aircraft from a landing area which is relatively close to the area under survey.

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Minor modifications can be made in these aircraft to install the cameras and provide suitable openings in the fuselage bottom. These modifications require the approval of the DGCA.

It is not possible to carry a remote sensing payload in excess of 30 to 50 Kg if an observer is on-board. This can be increased to 80 to 100 Kg if the Pilot flies alone. Hence, equipment like the Multi-Spectral-Scanner, cannot be installed on these aircraft.

If the survey area requires to be covered by a grid with several passes, it is essential to provide the Pilot (or the observer) with an aid for tracking. The simplest form of this aid would be a sighting hole in the fuselage, adjoining the seat, with a cross wire. However, if the aircraft is to be used for serious aerial photography work, or if the survey area is relatively large (> 100 sq.km), it is essential to have an optical sighting device. The author has the experience of carrying out several remote sensing operations with light aircraft, and feels that this is an essential requirement.

4. Cost Estimates

Typical costs for acquiring the aircraft are as follows :

Balloon	...	To be determined
Micro-Light Aircraft	...	Rs. 1,00,000
Light Single-Engined Aircraft	...	Rs.10,00,000
Single or Light Twin To carry MSS (non-pressurised)	...	Rs 80,00,000

Operating costs fluctuate rather wildly depending upon the choice of aircraft, the nature of overheads, annual utilization, the organisation which is responsible for maintenance, if depreciation is to be included etc.

On one end of the scale, we can have an aircraft which is acquired and operated solely for remote sensing. A separate flying and maintenance crew is hired. This would be cost-effective only if the utilisation is of the order of at least 400 hours per year, which is not very likely.

At the other end of the scale, we can have a micro-light or light aircraft /which is acquired by a Flying Club/School and also used for training or sport flying. It would be maintained and flown by the personnel of the Flying Club/School. This appears to be the only practical approach which will also be cost-effective. The operating cost would therefore be a matter of negotiation with the agency which is operating and maintaining the aircraft.

In terms of fuel consumed, the costs for the various aircraft would be roughly as follows: (Cost of fuel per Km flown)

Microlight Aircraft	....	Rs.1.50
Light Aircraf	....	Rs.1.50
Single or Light Twin To Carry MSS	....	Rs.3.50

The suggestion of the author is that a light aircraft should be made available to each Flying Club/School which is willing to take up local remote sensing projects. The Flying Club/School will be responsible for maintenance and operation of this aircraft. This aircraft should be available for remote sensing operations as and when required by a user/coordinating agency. A fixed hourly flying cost can be paid to the Flying Club/School for remote sensing operations. Typically, these costs would be of the following magnitude :

Microlight Aircraft	...	Rs.200 per hour
Light Aircraft	...	Rs.500 per hour
Single or Light Twin To Carry MSS	...	Rs.4500 per hour

It may be noted that the operating cost per Sq.Km. of area surveyed would be in the following ratio :

Ultra-Light Aircraft	...	X Rupees/Sq.Km.
Light Aircraft	...	X Rupees/Sq.Km.
Single or Light Twin To Carry MSS	...	6X Rupees/Sq.Km.

It may also be noted that there will be very few Flying Clubs/ Schools which will be able to find adequate utilisation for the larger single engined or light twin aircraft which is required to carry the M.S.S. In fact, this arrangement may not be practical since it is difficult to remove and reinstall the MSS if the aircraft is to be used for other purposes.

Prof. R.B. Damania
Scientist
National Aeronautical Laboratory

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