TWO DECADES OF DEVELOPMENT IN THE DESIGN & CONSTRUCTION OF PERSONAL COMMUTOR AIRCRAFT IN SRI LANKA; FIXED AND ROTARY WINGED

by
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[This paper - which will be illustrated through video and slides - provides some of the thinking and experience behind the range of aircraft which were thus developed, built and successfully flown.]

The Dutch introduced us to canal transportation as an alternative to conveyance by horse - or bullock - drawn carriage. Barge transport on these canals was primarily muscle-powered, either animal or human; and very occasionally by the wind. Communication for centuries been appreciated as an essential pre-requisite to all forms of social development whether for trade or any other social function.

The British were great road-builders; probably a heritage from their Roman period. They greatly improved upon these skills during their own industrial age which pioneered, both at home and in their colonies abroad as in Ceylon (then) the rail-road, and carriages drawn thereon by the 'iron horse' and fuelled by coal (imported) and wood (our own). The iron and coal were mined from the bowels of THEIR own soils. That our current vehicular transportation system is still almost totally dependent upon imported vehicles operating on imported (tarred) road and using imported fuels is - in my opinion - a sad reflection upon the standards of engineering and entrepreneurial competence now prevailing in Sri Lanka! That the internal-combustion engine should replace the external-combustion engine was a technology acceptable in a country where oil bubbled out of the ground. That we ourselves should still be tied to a transportation technology which requires fuelling from half-way across the world... is disgraceful!

Airstrips, airports and landing

World-War II (early '40s) saw considerable aviation activity over Sri Lanka with British air-bases established at strategic locations throughout the country in Jaffna, Sigiriya, Trincomalee, Puttalam, Negombo, Katukurunda, and Koggala. These were supplemented a.i. (after independence) by airfields at Vavunia, Anuradhapura, Wirawila, Ampara, and Batticaloa, to service development programs extending into the lesser-populated 'dry-zone' regions of the country. That there were also active airstrips - used during the war - at Kandy, Kurunegala and in the heart of Colombo (where the Independence Hall now stands) is now barely remembered!

More air-strips (Dchiattakandiya, Welioya, Mahiyangana, and Moneragala are also under consideration) are planned for the newly developed regions of the Mahaweli valley and will greatly facilitate commuter travel to these otherwise still-remote parts of the country. We shall, hopefully, soon see a revival of the regular internal air-services with which the northern and more remote regions of the east and south-east were served during the 1960's.

Flight by helicopter was unknown, hitherto, prior to the '50s. Air-transportation was therefore very dependent upon the air-stripe - and later the air-port...... the place at which the aircraft made contact with the earth. There is occasional speculation whether the name Va-riya-pola might suggest a

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Becoming very concerned with the 'sustainability' of tropical farming systems, he served several years in research with the International Agricultural Research Institutes but still maintained a very deep interest in his 'first love' for aviation, and in the design and development of (often very unusual) aircraft many of which he then built and flew; earlier on an experimental basis and later for regular personal commuting. He has received seven 'Outstanding Individual Achievement' awards from the Experimental Aircraft Association for aircraft thus constructed.
landing field for air-borne vehicles as far back in (mythical?) history as the Dhandu-monara.

Significant, however, is the fact that air-transportation has been very dependent upon locations suitable for the flying vehicle to make contact with land, this being a vital component in the design of such machines which invariably had to compromise between the ability to:

a. fly as fast as possible - and for least possible cost!
b. fly as slow as possible, - as also when landing.
c. maneuver both in the air as well as on land (or/and on the water!)
d. carry considerable extra fuel for flight to locations at which safe contact with land could be achieved.

**Adopting Compromise!**

Nearly all engineering design - and development therefrom - evolves through compromise; compromise between such diverse factors as funds, materials, technology, skills, markets, climate, location, ... to name just a few. When we ADOPT (versus ADAPT) a technology we then accept the factors of compromise which OTHERS find most suited to THEIR circumstances. While this might be acceptable as a temporary expedient and until OUR OWN technologies are developed for propriety to OUR OWN circumstances, ... there is often a tendency to let the case of the adopted technology to prevail; thus saddling future generations with the laze and incompetence of the present!

The endeavours which are described further on in this paper may be viewed in the context of a personal endeavour to rise above the luxury of merely accepting what is 'available' and to search beyond towards the 'achievable' ... towards achieving a compromise more appropriate to our own means and circumstances.

**Recent History**

During WW-II the British very ingeniously made use of their (primarily naval) development of the sea-plane - and of amphibious aircraft - to overcome a lack of wide-open spaces in the jungle-covered tropical terrain into which the war had moved. They operated many of their aircraft off the water - from lakes, estuaries, and lagoons - with which the tropics were blessed.

Aircraft have hitherto been developed mainly in the advanced countries of the temperature regions. Their design invariably incorporated such features of compromise as best suited their own terrain and operating conditions. Thus the design of commuter aircraft primarily featured cabins for protection against the temperate cold-weather, and wheels for landing on open farm-land areas. Floating hulls (or floats) were occasionally used, but to a far lesser extent, and only for very occasional operation over sea or lake-covered terrain. The range of commuter aircraft for use in the less developed countries such as Sri Lanka has invariably had to accept the design compromises derived for the temperate countries in which they were manufactured.

A fresh look was sought into the history and development of aviation from it's inception and in it's various configurations and adaptations, for such revised compromise as may better suit the propriety in needs of a small country such as ours. Flapping-wings, rotary-wings, fixed-wings have each been experimented with, first in model form and controlled by radio, and then - where promising - in full size. Likewise, promising configurations were tried both as models and later as man-carrying aircraft. Configurations such as the elevator located behind the wings (as developed by Blériot... and even earlier by birds!) as well as the elevator located ahead of the wings (as developed by the Wright Brothers, ... and how 'right' they have proven to be!). Amphibious air-craft for operation off the land as well as off the water. Aircraft which could easily be road-transported (on a trailer towed behind a car as well as those which could be folded and placed on top!) ... aircraft which could be 'motorized' on the road after landing.

The technology of ballooning - now 200 years old - was also investigated, personally, for propriety in the Sri Lanka context. While the modern hot-air (propane-gas fired) balloon exhibits excellent control over altitude, there is minimal control as regards direction of travel this being in whatever direction the wind is blowing at the altitude in which the balloonist happens to be. While being delightfully adventurous for flight over an open country-side (the balloonist never quite knows where he will land) the balloon could be positively disastrous when landing on tropical tree-covered Sri Lanka!

Gliding and hang-glding were also (personally) investigated, and while being a delightful recreation over open countryside, is likewise highly inappropriate over tree-covered terrain as is most of Sri Lanka; or for specific transportation from, say, point 'A' to point 'B'. It is an interesting anomaly that in ballooning one has control over altitude but not over direction of travel. However, in gliding one has control over direction but no control over altitude. Commuter aviation needs control over both altitude as well as direction!

A summary of these experiments will bear quick illustration by slide and video during the 'seminar' to accompany this 'paper'. The ability for an engineer to design and thus describe his concept; then to construct it with optimal craft skills; and then also to conduct all the
testing and evaluation necessary for 'proving' his concept cannot be over-emphasised. However, as the renowned aircraft designer and constructor Sir Geoffrey de Havilland has explained; ".... in the case of an aircraft this process can very quickly eliminate the bad designer!"

Rotary-wings

The development of the helicopter in Europe and America was primarily to resolve the operational problems of standard fixed-wing aircraft which needed such 'wide-open-spaces' from which to achieve the speeds necessary for take-off and landing. The larger the aircraft the higher the take-off speed (usually) and correspondingly larger airports (now with two-mile-long runways, located further and further apart) at which the transition from stationary to flying speed could be achieved. The dream of VTOL (Vertical Take-Off-and-Landing) thus held promise of an aerial transportation system sans the hassle of the airport!.... the personal aerial-automobile, perhaps!... A 'chopper' in every garage!

Regrettably, the standard helicopters have proven VERY much more complex and expensive than fixed-wing aircraft of comparable carrying capacity and range, by a factor of about four. They are also that much more difficult to fly being somewhat unstable machines.... about as 'tricky' as balancing one billiard ball on top of another!

Design Parameters

What then were the chances for developing a means for practical aerial transportation over tree and forest-covered Sri Lanka?... for commuting above the hassle and constraints of road and rail?

Broad design parameters had first to be explored. These were based on some forty years of practical aviation experience with building and flying a range of conventional as well as non-conventional light aircraft under both tropical as well as temperate weather conditions.

As initial consideration must necessarily be for 'purchasability', a target was established at no more than the local cost of a medium-sized automobile with carrying capacity around that of a medium-sized two-place motor-cycle. This would limit engine size to 750 cc or about 90 h.p. and fuel consumption (at cruise speed of about 120 km/h) to around 20 litres per hour. A reasonable operating range of about 400 km was estimated as about 4 hours of flying on a tank-full (80 litres) of fuel.

The next question was whether the two-place 'aerial-motor-cycle' would house it's crew in a cabin or 'open' at it's typical operating altitude of between 4000 and 7000 feet (in 'natural' air-conditioning!) Considering that a cabin aircraft would cost about 50% more than the price of an equivalent 'open' aircraft, with corresponding increases in weight and time to build, an open aircraft appeared a reasonable compromise for use in the more congenial climate of the tropics. One could avoid and fly around a storm, but during winter months in a temperate country there is no way to avoid the cold except enclosed inside a cabin! The 'open aircraf' would still need to be adequately 'streamlined' for minimising power otherwise wasted combating wind-resistance (or 'drag') at the cruising speeds envisaged. Remember, while 'drag' increases by the square of the speed, the power needed to overcome drag then increases by the cube of the speed! (A 2-X (two-times) increase in speed (say from 50 to 100 mph) requires a 3-X increase in power just to overcome the 4-X increase in drag!)

Fixed or Rotary wings (gyro-planes)?

The carrying capability of an aircraft is necessarily dependent upon it's wings; whether fixed or rotating. The larger the wings the greater the carrying capacity (lower wing - or disc-loading) and lower the landing speed but higher the drag and cost! Rotating wings (blades) are, however, usually lower in cost to build; are stronger for their weight, being supported by centrifugal forces instead of by struts, but are usually more complex to design as well as to drive and control in helicopter configuration. The remarkable facility of the gyro-plane, however, to land within a very limited space has merited further 'hands-on' study. These experiments conducted over a number of years with this particular rotary-wing configuration will be summarised below and demonstrated through video.

Two main types of gyro-craft exist. One, the helicopter has it's rotor driven by the engine to pull the air downwards in great volumes and 'cushion' the weight of the machine on this mass of air. Forward motion is achieved by 'cyclic-control' of the pitch (or angle) of the blades as they rotate to reduce lift when in the forward position and increase lift in the rearward position, thus tipping the aircraft forward on its air-cushion. The pilot has the tricky job always of coping with the gyroscopic forces produced by the rotating mass of blades above him; compensating for the torque from the (engine-driven) rotor with the assistance of another variable-pitch propeller at the rear, and all the time preventing the machine from sliding off it's air-cushion during hover! These problems ease somewhat during forward flight. The drive mechanism necessary to achieve hover capability is necessarily very complex and demanding of great skill in construction, and great concentration during flight.

The autogyro, was invented by a Spaniard de la Cierva in the 1920s. Curiously, it preceded the helicopter and was
much more simple in design. It’s rotor was not coupled to the engine during flight but was rotated automatically (hence ‘autogyro’) by the flow of the air from below and through the rotor as the craft was propelled through the air by a standard engine and propeller. While the autogyro would not hover stationary it could fly extra-ordinarily slowly and land within a very confined space. It did, however, require a very short take-off run in which to speed up it’s rotor to auto-rotational speed (the speed at which it would thereafter continue rotating automatically while in flight).

The subsequent development of the helicopter by Sikorsky for stationary hover; and for both vertical take-off and landing capability, obscured the autogyro despite the remarkable simplicity and lower costs for the latter. Isolated development of the autogyro still took place in the 1930s by Pitcairn in the USA, by the German navy during World-War II (as a quickly stowable spotting aircraft for carrying within a submarine and which was towed behind and above the submarine like a kite); and later, in the 1940s, by Rev. Igor Bensen also in the USA. The latter included many of the features developed by the Germans but had significantly simplified the design first as a towed ‘gyro-glider’ and subsequently as a powered gyro-craft which was appropriately dubbed a ‘gyrocopter’. The two-bladed rotor had it’s blades fixed in auto-rotating pitch thus greatly simplifying the design.

A version of this ‘gyrocopter’ then underwent further development in Britain in the skilled hands of Wing-Commander Ken Wallis, one of these machines undergoing extensive further development trials in Sri Lanka in the late 1960s with a remarkable pre-rotator mechanism constructed from bicycle gears and automobile ‘Bendix’ drive to spin-up the rotor prior to take off. This greatly reduced it’s take-off run to a few hundred feet while still retaining the ability of an ‘almost-hover’, near-stationary landing. .... not quite helicopter performance but still achieved at remarkably lower cost (about 1/10th the cost of the latter) and with very great simplicity in design and construction technology.

Most remarkable, however, is the case with which the autogyro could be flown by anyone with standard fixed-wing aircraft piloting capability. However, further ‘dual’ training enables him to more fully exploit the wide range of additional flying characteristics of this remarkable craft which were demonstrated several years ago during the filming in Japan of the James Bond movie YOU ONLY LIVE TWICE.

Fixed wing trials

During the early ‘80s a new aviation development showed promise in the USA and ‘ultralight’ aircraft swept into quick popularity, also in Europe as ‘microlight’ aircraft. These developed as an (engine-powered) spin-off from ‘hang-glider’ technology and also utilised construction techniques from the international sport of yacht-racing. Several models of these designs were constructed and flown experimentally in Sri Lanka under the careful scrutiny of our Department of Civil Aviation. The opportunity was also taken to experiment with a range of landing systems as alternative to operation off standard airports. One model (mentioned earlier) which was designed to be collapsible and ‘car-toppable’ was taken all over the country to fly off the water from lakes and reservoirs. Excellent pictures were taken from the air at very close proximity of Sri Padh. Dual-control versions of these were subsequently built locally with facilities for flight training, in addition to VHF-communications-radio, inter-com and radio-location.

It is seldom appreciated that the brilliance of the Wright brothers extended not only to construction of the first fully controllable aircraft but that they taught themselves to control and fly their machine. It is now known that several earlier designs of aircraft ‘might’ have flown, had the art of controlling a flying machine been known at that time! The experiments conducted locally also included programs in flight-training with these aircraft to ascertain what problems might be encountered with, say, hundreds (or thousands) of these aircraft (flying at speeds of around 100-mph or more) in the skies over Sri Lanka. The ability also to fly slow (even down to 25 mph) was seen as a tremendous feature for safety; a feature not pertaining to conventional light ‘commuter’ aircraft from the developed countries, very few of which can keep airborne at speeds below 50 mph.

One here comes across another anomaly in design for flight. A fast aircraft finds it complicated and expensive to adapt to slow-speed flight. Likewise an aircraft designed for slow speeds adapts with difficulty to high-speed flight. Birds and insects have similar problems adapting to ‘speed-range’. A speed-range of 1:2 in an aircraft (say, 50-100 mph) is comparatively easy. A speed range of 1:3 (say, 50-150 mph) is difficult to achieve at low cost.... quite a challenge! Collision with birds is yet another consideration!

While ‘bird-strikes’ have sometimes been encountered by conventional aircraft flying at the lower altitudes over Sri
Lanka, the ability of our aircraft to fly slow when low has often been observed to enable birds to take avoiding action when on path of collision with us.

A range of construction technologies was also investigated. One utilised the well proven principles of the early Wright and Curtis aircraft with their bamboo spars replaced by test-proven duralumin tubing; with their piano-wire bracing replaced by multi-stranded stainless-steel cable and with their doped-cotton covering replaced by rip-stop Terylene. A range of new developments in light-weight (two-stroke) engines have also been experimented with and power-to-weight ratios down to one pound-per-horse-power and (dual capacitor) discharge ignition systems for even greater reliability. By comparison, standard 4-stroke aircraft engines weigh about three to four times as much for their weight, and thereby require proportionally heavier structure, dimensions, as well as operational costs!

The modern two-stroke engine is still a 'thirsty' machine, for all it's simplicity in design and greatly reduced number of moving parts. For the same power-output, the 2-stroke engine uses about 50% more fuel than it's 4-stroke counterpart! Once again the need arises to compromise on one's options!

**Which way for the future?**

That is a good question! Currently the autogyro holds most promise, also for several quite un-anticipated reasons!

a) It can (in an emergency such as an engine-failure) be landed safely and gently in a space as small as a school playground or rice-field liyadde. It can then be carried (weighing only 200 kgs.) to a road or onto a light lorry.

b) It is so compact (no out-stretched wings) that it can be 'motored' along the highway, taking up no more room than a 'Bajaj'. (It was recently landed quietly on the lawn of the Colombo town-hall, and then 'driven' along the main-road amidst other traffic, round a round-about and into the garage of a personal residence near by.... to prove a point!)

c) It has a remarkable range of speed from about 25 mph (nearly a fast 'jog') to cover 75 mph. with only a 500 cc. engine.

d) It has shown exceptional promise as a patrol aircraft for (traffic) police and coastal surveillance.

Further design-development is planned towards increasing engine-propeller thrust and thereby increasing load (passenger and fuel) carrying capacity. Development is also planned towards exploring the scope for amphibious operation of aircraft over Sri Lanka.

Yet another (unusual!) direction for development is currently under investigation. Using a 'flexible' wing, this suggests exciting new parameters for compromise and may (hopefully) be described at a future meeting of our Institution.
PHOTOGRAPH NO. 1

Experimental (open-frame) amphibious aircraft constructed in 1961 with elevator positioned ahead of the swept-back wings. This aircraft could be folded up and 'car-topped' for transport all over the country for trials off the water.

PHOTOGRAPH NO. 2

Taken during thirty-hour program of training in Australia in the piloting of hot-air balloons for evaluation thereof for applicability to Sri Lanka.
PHOTOGRAPH NO. 3

This locally constructed helicopter was powered by a 115 h.p. (Johnson) outboard motor and was not progressed beyond the stage of circuits around the (Ratmalana) airfield. It was difficult to fly and mechanically 'temperamental'!

PHOTOGRAPH NO. 4

This dual-controlled two-place (open) aircraft was constructed in 1985 and later further modified for operation off the water, too. It was very good as a training aircraft as well as for touring.
PHOTOGRAPH NO. 5

This dual-controlled cabin-aircraft was constructed in 1988 and is currently under evaluation. It will soon be fitted with an amphibious float landing system for further evaluation in this mode.

PHOTOGRAPH NO. 6

This single-seat autogyro was constructed over 20 years ago. While it flew delightfully, it suffered from the very limited dependability of the (90 h.p.) engine available at that time. (Frequent sudden silences!)

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PHOTOGRAPH NO. 7

This two-place autogyro was constructed in 1991 based on the experience gained 20 years earlier. Even with only 60 h.p. it flies well with one pilot but has limited performance with two. Further development is on-going towards an increase in propeller thrust for better two-place capability.