AAIU Report No:- **1998- 017**
AAIU File No: **1996-0072**
Published: **26/11/1998**

Type of Aircraft:	Home-design Model Aircraft
Registration:	Nil
No & Type of Engines:	One Titan 23 cc spark ignition
Owner:	Private
Year of Manufacture:	1996
Crew:	Nil
Persons on Board:	Nil
Injuries:	None
Location:	Dublin Airport
Type of Flight:	Private
Date & Time (UTC):	7th. December 1996, 1418 hrs.
Information Source:	Field Investigation

Synopsis

The model was flying circuits at a registered aeromodel site in the Phoenix Park in Dublin. After a take-off, which followed a normal circuit, command of the model was lost. The model then flew off in a North-east direction. When its fuel was exhausted, the model glided to earth, and landed on the new link taxi-way near the threshold of Runway 28 at Dublin Airport.

The report finds that the probable cause of the loss of command was the exhaustion of the receiver battery.

1. Factual Information

1.1 History of the Flight

The owner took the model to the registered model aeroplane flying site at the "15 Acres" in the Phoenix Park, Dublin, on the morning of the incident, having charged the transmitter and received batteries the previous evening.

He then completed approximately one hour's flying without incident. About one hour after the initial flying session he again launched the model, at approximately 13.50 hours, having refilled the fuel tank. It can not be verified if the receiver was turned off between these flying sessions. He completed a number of circuits over a period of approximately 10 minutes. Three other models were also airborne at the same time. On the final circuit, the model performed a normal roller landing. Immediately after take-off, the owner found he had no control of the model. The model continued to climb in a North-easterly direction, and would not respond to control inputs. The owner obtained another transmitter and changed the frequency to that of the model, but still could not command the model. The model then disappeared from sight. A search was made of the Phoenix Park, but nothing was found. At the time when command was lost, and subsequently, none of the other models that were airborne, and operating on the 35 MHz frequency band, experienced any control problems.

At approximately 14.18 hours the pilot of a B737, taxing for take-off at Dublin Airport, observed a model aircraft apparently parked on the new link taxi-way near the threshold of Runway 28. He reported its presence to ATC, and airport security personnel removed the model to the airport fire station. The AAIU was notified, and the model was inspected by an AAIU Inspector at 17.00 hours. The receiver battery appeared to be exhausted and the fuel tank was empty.

1.2 Injuries to persons

Nil.

1.3 Damage to Aircraft

The propeller had lost one blade and there was also damage to the engine and lower side of the nose. There was evidence of wingtip ground contact by the right wing, and there were cracks in the lower fuselage near the undercarriage area, consistent with a heavy landing. Propeller fragments were found in the landing area.

1.4 Other Damage

Nil.

1.5 Personnel Information

The owner had 17 years experience in building and flying model aircraft. He had been a member of the Model Aeronautics Council of Ireland (M.A.C.I.) since 6 June 1991. He has held a M.A.C.I. "A Certificate" for fixed wing models since 1995.

Age:- 32

The owner possessed a valid permit from the Department of Transport, Energy and Communications for operation of the transmitter used to control the model.

1.6 Aircraft Information

1.6.1 General Information

The model was built to the owner's own design, and was built by him.

Date of Manufacture:-	1996
Total Flying Time:-	6 hours approximately
Wing Span:-	3.0 meters
Fuselage Length:-	1.8 meters
Weight (empty, zero fuel):-	6.8 kg
Engine:-	Zenoah Titan 23 cc 2-stroke spark ignition, producing 1.8 HP at 10,000 RPM
Propeller:-	"Super" 16" diameter, 8" pitch. (40 cm diameter, 20 cm pitch) of Nylon construction
Fuel Capacity:-	½ litre
Fuel Type:-	Petrol-oil mixture
Radio Control Equipment:-	
Transmitter:-	Futaba FP-T6NFK Challenger FM operating on 35.060 MHz
Receiver: -	Futaba 9 Channel, Part No. FP-R128D F (FM)
Receiver Battery -	Ripmax Sanyo NICAD Part No. 0-4 N0600 AAW Rating: 600 mAhr
Servos -	Four Futaba FP-S148 (indirect drive) used on rudder, throttle and each aileron One Futaba S9001, (coreless motor) used on the elevator

1.6.2 General Description

The model was designed and built by the owner. The model featured a high wing configuration, nose mounted engine and tail wheel undercarriage, and generally resembled a Piper Cub. The model was constructed of balsa, ply and spruce, and was fabric covered. The fuselage consisted of a rectangular section ply covered box. The wings featured a main spar and a ply leading edge torsion box. The ribs to the rear of the main spar were fabric covered. The wing struts were aluminium tubing and the undercarriage was spring steel

The model featured an equipment bay, 28 cm long by 13 cm wide by 28 cm high. This bay was designed to carry a camera or a camcorder. The weight capacity of the bay payload had not been determined, but given the low wing loading of the model, it could have been of the order of 2 to 4 Kg. The bay was empty on this flight.

The model featured standard control, i.e. aileron, rudder and elevator. Each aileron had its own servo, which was mounted in the wing forward of the aileron, and activated the aileron by a push rod, and was connected to the receiver by a long lead. The rudder was connected to the arm of it's servo by twin cables. The elevators on either side of the fin were not interconnected, but each was connected directly to the elevator servo arm by a closed loop cable system. The throttle was operated by the fifth servo, mounted near the firewall.

1.6.3 Radio equipment

The radio control equipment was FM (frequency modulated) type. The model was not equipped with a fail-safe device nor a receiver battery back-up device.

1.6.4 Markings

The model carried the marking "EI-2352" in black lettering, approx. 100 mm high, on either side of the rear fuselage. This number is not a national registration, but is the modeller's own M.A.C.I. number.

1.7 Meteorological Information

Wind	5 kts SW
Visibility	Good

No significant weather

1.8 Aids to Navigation

Not applicable.

1.9 Communications

Not applicable.

1.10 Aerodrome Information

The model was being operated in a very large open area in a very large public park. The site is a registered aeromodel site. The site is located 7.7 km from the nearest boundary of Dublin Airport and 9.4 km from the point where the model finally landed.

1.11 Flight Recorder

Not applicable.

1.12 Wreckage and Impact Information

Impact marks on the taxi-way indicated that the model had arrived from a NNE direction, and landed heavily striking the ground with its nose and right wing tip. It ran on for approximately 10 meters before coming to rest on its undercarriage.

1.13 Medical and Pathological Information

Not applicable.

1.14 Fire

There was no fire.

1.15 Survival Aspects

Not applicable.

1.16 Tests and Research

1.16.1 When the model was first inspected at Dublin Airport, switching on and off the main switch had no effect.

1.16.2 When the receiver battery was re-charged, the model was tested with its own transmitter. The standard range check, i.e. full functioning of all servos at 50 meters range with the transmitter aerial retracted, was found to be satisfactory.

1.16.3 With the model held vertical by its nose, i.e. no load on any of the servos, a current drain of 98 mA was noted. However, with the model in a level attitude, a current drain of 133 mA was noted. In this horizontal configuration a significant constant hum could be heard from the elevator servo.

1.16.4 The receiver was then left on, and after a period of 1 hr 50 minutes, with just occasional use of the servos, the elevator and rudder made an un-commanded movement to full deflection, and it was found that transmitter signals had no longer had any effect on the model. The force required to then centralise the control surfaces was small, and was well below the aerodynamic loads which normal flying speed would have exerted in the deflected control surfaces. The receiver battery was tested and found to be discharged.

1.16.5 With the receiver battery again re-charged, it was found that peak battery loads for servo full deflection was generally of the order 200 to 250 mA. However, full-up elevator required a peak loads of approx. 500 mA. This was with the model in a static condition. It was not possible to measure the peak loads that would have been encountered in flight, which would have been higher than the static load, due to aerodynamic forces on the control surfaces.

1.16.6 Tests were also conducted on the possibility of interference. A 35w signal was transmitted on 35.050 MHz, 10 meters from the model. The transmitter was located 10 meters further away. The effect of the interference signal was to cause the servos to oscillate over a significant arc, with corresponding oscillations of the control surfaces. However, the model's transmitter was still able to effect a significant level of control over the movements of the control surfaces.

1.17 Organisation and Management

1.17.1 The organising body for the sport in Ireland is the Model Aeronautical Council of Ireland (M.A.C.I.) Through M.A.C.I., registered sites are set up and M.A.C.I. provides a certificate scheme for rating operators of model aircraft and also provides an insurance scheme for modellers, to cover against third party claims. The owner was a member of M.A.C.I., and the model was insured under this scheme to a limit of £1,000,000.

1.18 Additional Information

1.18.1 IAA regulations

The only regulation in Ireland, laid down by the Irish Aviation Authority (IAA) specific to model aircraft, is that they must not operated within 5 km of an aerodrome or elsewhere not above 200 feet or not within 2 km of an aircraft in flight. At 9 registered sites, operations to 400 feet is permitted and at 28 sites operation to 600 feet is permitted. At these sites the increased altitude permission is limited to a 0.5 NM radius of the site. These regulation are published in AIP Ireland, reference ENR 5 - 23. The Phoenix Park site is one of those with a 600 foot permit. There are no regulations covering the size, weight, power or speed of radio control models.

Statutory Instrument (S.I.) No. 322 of 1996, under Regulation 3.(3), requires all aircraft except models with a wingspan less than 2 meters and gliders, to carry national registration marks. To receive such a registration marking the aircraft or model would have to be registered with the Irish Aviation Authority. The format of the registration is laid down as "EI-" followed by three letters.

1.18.2. Transmitter regulations

Operators of radio control equipment on the international frequency band for aeromodels, i.e. 35.10 to 35.25 MHz FM, are required to hold a valid permit from the Department of Transport, Energy and Communications, (later The Department of Public Enterprise) These permits have to be renewed annually.

1.18.3 UK Regulations

In the UK., the CAA have issued CAP 658, a guide to the safe flying of small (model) aircraft. This guide states the UK. restrictions on flying model aircraft and also lists additional restrictions on models weighing 7 to 20 kg and also above 20 kg.

Models weighing between 7 and 20 kg, are recommended to feature a fail-safe device.

Models above 20 kg are required to obtain an exemption certificate issued by the CAA.

These regulations are based solely on the weight of the model and do not consider size or engine power.

1.18.4 Guidelines

M.A.C.I. have not issued any guidelines specifically for large model aircraft.

In the UK., an organisation catering specifically for larger models, the Large Model Association, lays down recommendations for large models that are more than 8 ft (2.43m) wingspan, or 6 ft (1.83m) for a biplane, or weighing more than 5 kg. Their rules require the fitting of a fail-safe device, and recommends that large models be fitted with a battery of a least 1200 mAhr capacity.

1.18.5 Fail-safe Devices

These are devices, which can be fitted to radio control models, which will take a pre-determined action in the event of failure of the control system.

The more usual fail-safe is designed to close the throttle of the engine in the event of non-receipt of a signal from the transmitter by the receiver. When such a failure occurs the fail-safe device will close the throttle, causing the model to descend to earth. The device can be either an external device between the receiver and throttle servo, or in the case of some modern systems, it can be integrated in the receiver.

1.18.6 Receiver battery back-up devices

Receiver battery back-up devices, consisting of a second receiver battery, are commercially available. These devices detect a loss of power by the primary battery, and automatically switch the receiver to the standby battery.

Higher specification PCM (Pulse Control Modulation) radio control systems feature an integrated device which detects a drop in receiver battery voltage before it reaches a critical level, and automatically retards the throttle to the idle position, causing the model to glide to ground.

1.18.7 The technical support department of the European agents for Futaba equipment expressed the opinion that the elevator servo used on this model were considered marginal for this size of model.

1.18.8 Dublin ATC subsequently reported that the model had not appeared on radar.

1.18.9 This model was not registered with the IAA, and did not carry any national registration markings.

1.19 Useful or Effective Investigation Techniques

Nil.

2. Analysis

2.1 Using data derived from the impact marks on the taxi way and marks on the model, the probable final flight path of the model is shown on Annex A. The final turn to the right was probably caused by the trim change when the engine stopped due to fuel exhaustion.

2.2 The receiver battery was found to be completely discharged on examination of the model, some 3½ hours after it took off on its flight. Furthermore, the radio command system was found to function correctly and effectively after the receiver battery was re-charged. No defect was found in the aircraft, its radio equipment or command transmitter that could explain a loss of control.

2.3 The model had completed a significant number of previous flights, including one hour's flying on the day of the incident, without any indication of control problems. The loss of command occurred at a relative close range between the model and the transmitter, well within the range of the equipment and much closer than the range envelope that had been previously flown successfully.

2.4 The fact that the model flew away smoothly after the loss of command, without twitching or violent manoeuvrings indicates that interference from other modellers, or other transmitters, was not a factor. For the same reason, there is no indication that jamming was a contributor to this incident. This evidence is further supported by the absence of any problems with the other models flying at the same time.

2.5 The failure of another transmitter, equipped with the appropriate 35.060 MHz crystal, to regain command of the model indicates that transmitter failure was not a factor.

2.6 The size of the receiver battery was small in relation to the model, and only half the minimum size recommended by the Large Model Association. Certain design features of the model, i.e. the absence of mass balancing on the ailerons, and even more so on the elevator, contributed to very heavy current drains on the receiver battery. The size of elevator servo used on the model could have resulted in a stalled, or near-stall, servo motor situation, which would significantly increase battery drain.

2.7 The owner had not performed any tests or calculations to determine receiver battery duration performance. However, there is no readily available method of determining such performance. The battery drain rate is determined by the basic receiver requirements, the static load on the servos, such as those caused by large control surfaces without mass balance, the aerodynamic loads on control surfaces in flight, and the rate and extent of control inputs. Battery duration is determined by the battery drain rate, the duration of flight, the battery initial charge state and the battery condition. Because of the variables involved, it is probably beyond the resource of an aeromodeller to accurately predict receiver battery duration.

2.8 Little or no warning is given of receiver NICAD battery run-down. This is because NICAD batteries maintain a very constant voltage through-out their charge life until near the end of that life, when a steep voltage fall-off occurs. The situation is aggravated by the sudden close-down of solid state devices, such as those found in modern radio control receivers, when the supply voltage drops to a critical threshold value. The only protection available to the modeller is to use a receiver battery with a very large margin of safety, to limit flying duration between re-chargings, and to use appropriate re-charging equipment and procedures to ensure optimum battery performance.

2.9 For the flight in question, the model had been flown for at least one hour followed by a period of approximately one hour on the ground. It is possible that the battery was left on for some or all of this period on the ground. There then followed a second period of flying, lasting approximately 10 minutes before command was lost. At this point it is probable that the receiver battery charge had fallen to a level below that required to maintain the receiver on line. The resultant close-down of the receiver would have resulted in a total loss of command of the model. A well-trimmed model would then continue in flight until its fuel was exhausted, when it would have glided back to ground.

2.10 The absence of a safety device resulted in a situation where the model could continue to fly away when command was lost. However, it is far from certain if many of the fail-safe devices on the market would have prevented this incident. Fail-safe devices are generally designed to activate when the signal from the transmitter to the receiver is no longer detected by the receiver. There is significant doubt if many of the available fail-safe devices would ensure appropriate safety action, i.e. closure of engine throttle, in the event of receiver battery failure. Because characteristics of NICAD batteries, as discussed above, the reliability of fail-safe devices in a battery exhaustion situation is far from guaranteed. The difficulty is that the fail-safe device must detect a reduction of battery performance and initiate the appropriate action, i.e. close the throttle servo, before the entire system goes off-line due to the deteriorating battery supply. Many fail-safe devices do not respond to the type of failure that occurred in this incident. A receiver battery back-up device would have ensured that command was retained in the event of battery exhaustion. The use PCM radio control equipment would have also prevented loss of command in this situation.

2.11 It is generally accepted, given the vastly increased reliability of modern radio control equipment, that receiver battery exhaustion or failure, or a wiring failure on the model, are the most common causes of loss of command of model aircraft.

2.12 This model was flown operated within the current IAA regulations, and guidelines issued by M.A.C.I.. As flown, i.e. with an empty payload bay, it was flown at a weight which would not have brought it within the CAP 658 regulations for large models.

2.13 M.A.C.I. has an excellent record in organising the safe pursuit of radio controlled aeromodelling, particularly in the areas of site registration, operator training programs and certification and the third party insurance scheme.

2.14.1 The requirement to register model aircraft with a wingspan over 2 meters is not generally known.

2.15 There are several developments in the aeromodelling field which are not covered by current regulations or guidelines. In addition to a increasing number of large models, there are also available very high speed models powered by miniature gas turbine engine. Some models are also equipped with autopilots, as a training aid. Such a device could exacerbate a loss of command problem in certain situations.

2.15 While they were not registration marks, the clear identification numbers carried on this model, in accordance with the M.A.C.I. guidelines, were of considerable assistance to this investigation.

3. Conclusions

3.1 The probable cause of this incident was the exhaustion of the receiver battery on the model, which was a result of an inappropriately small battery being used on the model, combined with design features which increased battery drain, i.e. absence of mass balancing on the elevator and ailerons, and heavily loaded small servos. (Causal Factor)

3.2 There is no evidence of any wilful wrongdoing by the owner. The fact that the model eventually landed in Dublin Airport was due to pure chance.

3.3 The loss of control did result in a situation where a potential hazard was posed to air traffic at Dublin Airport, and to people on the ground in a large residential area over which the model flew.

3.4 The regulations and guidelines governing the operation of models, especially those that are capable of posing a significant hazard to public safety require revision.

3.5 The absence of a suitable fail-safe device on this model contributed to the hazard posed by this model.

3.6 It is doubtful if many of the currently available fail-safe devices would have prevented this incident. However a receiver battery back-up device or PCM control equipment would, in all probability, have prevented the incident.

3.7 M.A.C.I. have played an important role in the self regulation of aeromodelling. This role should be encouraged. It would be counter-productive to safety if any new regulations had the effect of producing a proliferation of lone modellers operating outside the M.A.C.I scheme.

3.8 The model was required, by S.I. 322 of 1996, to be registered and to carry official registration marks. However this requirement is not generally known in model flying circles.

4. Safety Recommendations (SR)

4.1 Aeromodellers should ensure that models are fitted with receiver batteries of sufficient capacity to afford a large safety factor against battery exhaustion, that design features minimise battery drain and that adequately sized servos are used on larger models. **(SR 23 of 1998)**

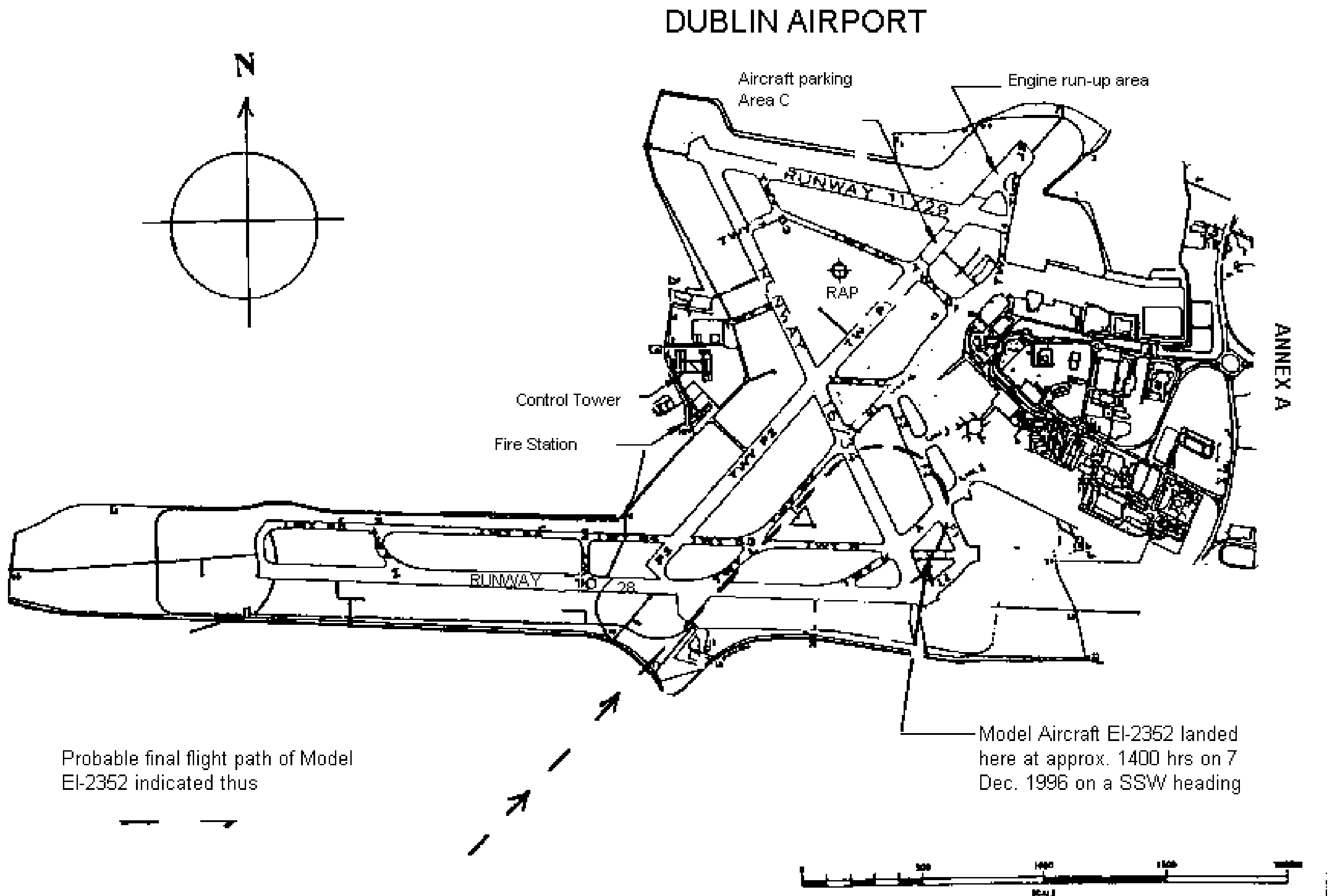
4.2 The use of receiver battery back-up devices, or PCM control equipment, in addition to fail safe devices, should be considered by aeromodellers, especially those operating models with the capacity to pose a significant public safety hazard. **(SR 24 of 1998)**

4.3 Manufacturers and suppliers of radio command equipment should consider a pro-active policy to encourage modellers to use equipment that will prevent loss of command situations. **(SR 25 of 1998)**

4.4 The IAA and M.A.C.I. should jointly review the regulations and guidelines covering the operation of aeromodels that have the potential to pose a hazard to public safety. Specifically, the provision of adequate fail-safe devices on certain models categories should be considered. **(SR 26 of 1998)**

4.5 The matter of registration and marking of model aircraft above 2 metre wingspan merits further consideration and discussion by the IAA and M.A.C.I. **(SR 27 of 1998)**

ANNEX A



DUBLIN AIRPORT
N
Aircraft parking
Area C
Engine run-up area
RUNWAY 11X29
RAP
Control Tower
Fire Station
RUNWAY 10 28
Model Aircraft EI-2352 landed here at approx. 1400 hrs on 7 Dec. 1996 on a SSW heading
Probable final flight path of Model EI-2352 indicated thus