

Flight Testing of “Möwe” Human Powered Aircraft and Analysis of the Data from the Data Logging System

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Introduction

This paper presents some information about Japanese efforts in human powered flight. In Japan, Nihon University started to study Human Powered Aircraft (HPA) first. The history of human powered flight at Nihon University is introduced, and a student group which took over the HPA project from Nihon University is also introduced. Additionally, some information about the YURI human powered helicopter, which was developed at Nihon University, is presented. Next, there is a unique competition for HPA and ultra light gliders, and the details and some problems of the competition are discussed.

The history of human powered flight at Nihon University

After the announcement of the Kremer competition about flight around a figure eight, in 1963, Professor HIDEMASA KIMURA started some basic research into human powered flight for an undergraduate study at Nihon University. 3 years later, in 1966, the research produced LINNET 1, which has a cantilever 22.3 m wing and 2.7 m propeller, and the empty weight is 50.6 kilograms. In same year, on the 26th of February, it flew for the first time - of course, this flight was the first human powered flight in Japan - and its best flight was 43 meters, but SUMPAC had already flown in Britain 5 years before. This LINNET series lasted until LINNET 4.

After SUMPAC flew, there were a lot of human powered aircraft built, but until the middle of the 70's, just a few aircraft could fly over 1000 meters. It was far from the requirements of the competition. At Nihon University, too, some aircraft were built and tested after LINNET, but still it was difficult to fulfill the requirements. However in 1976, STORK 'A' was built. At first, it only flew about 600 meters, but some improvements were made and then it was named STORK 'B'. On the 24th of November 1976, its 2093-meter flight set the record. In those days, the record was 1239 meters, set by JUPITER, which was made in England, in 1971. Therefore the Nihon University human powered aircraft team were convinced that they were closer to winning the competition. However, when the Nihon University team were trying making a circular flight with great hope, the news that Mr. Paul MacCready's GOSSAMER CONDOR 2 had achieved the figure eight flight came to them. It was a great disappointment to everyone concerned at that time. After that, despite the discouragement, Nihon University continued some human powered aircraft projects, and when Professor KIMURA retired, the responsibility of heading the projects was handed over to Professor AKIRA NAITO, who has recently been making a human powered Helicopter for the Sikorsky Prize, offered by American Helicopter Association.

Under NAITO's guidance, 2 series and 5 aircraft were built and tested, then, as soon as NAITO retired, the human powered aircraft projects at Nihon University was handed over to a student group.

At present, two human powered aircraft activities are going on at Nihon University. One is being carried out by a student group participating in the Japan International Birdman Rally (JIBR) and setting a new Japanese FAI record for long distance flight of human powered aircraft. This

student group is named NASG (Nihon Univ. Aeronautics Student Group). The other activity is cooperating to develop NAITO's human powered helicopter as an undergraduate study.

Next, I will introduce the student group. Actually I am a member of this group. Afterwards, I would like to talk about NAITO's helicopter.

Nihon Univ. Aeronautics Student Group (NASG)

This group, NASG, is a club run by the student at Nihon University. Originally NASG dealt with anything concerned with aircraft, but since it took on the task of the development of human powered aircraft, its main purpose has become to make and develop human powered aircraft. This group makes one or two aircraft every year, and has been taking part in the Japan International Birdman Rally since it started and we have had good results including winning the first prize 4 times. We also try to set a new FAI record; actually in 1990 we set the record for the longest distance and duration. This year, we will make our 20th human powered aircraft. NASG now has about 40 members, and they work in Nihon University's hangar after school. The work lasts till late quite often, so you would find our hangar brightly lit, even if it were midnight. The relationship between Nihon University and NASG is quite good, but strictly speaking NASG is just one of a lot of student clubs in the university, and for this reason they can't offer money. Instead, NASG is allowed to use the facilities relatively freely. The members finance the project themselves, but recently the cost has been getting higher. It has imposed a burden on the members. However, we have solved this problem partly by establishing a good partnership with material suppliers. NASG's members have to organise everything, team building and finance or designing, making and testing aircraft. However, for a long time, NASG has been maintained a high level of motivation and result. Possibly the independent organisation by students is one of the keys to it, even though there have been uneven levels of student ability.

The Japan International Birdman Rally (JIBR)

This competition, which is unique in having been held annually for a long time, is for handmade ultra light aircraft without motors and is held on Lake Biwa by YOMIURI Television co. ltd. It started in 1977. Every year it is broadcast on television, and the program is well known in Japan. Therefore this competition is very attractive for entrants, and there are over 100 applications to the broadcasting company every year, which are reduced by a panel of experts to a shortlist of about 50. This competition is concerned with flight distance, and the rules for aircraft are broadly on the FAI rules. It has two categories, one is for human powered aircraft and the other is for gliders. For each winner, a prize of about 5000 pounds is awarded. The entrants could be divided into two groups, university student groups and groups of fellow workers from companies which are sometimes not concerned with aviation. Actually, the numbers of these two groups of entrants are roughly equal. All aircraft take off from a platform which is about 10 meters above the water, and most of them land in the water, so the aircraft will be broken when they are collected. Therefore there are some arguments about it. However, thanks to the fact that the aircraft land in the water, there has not been a fatal injury, and we should not forget that some scenes of aircraft breaking up make the program funny and attract the viewers. So most entrants sportingly understand it, but some problems are still left. Because the aircraft breaks every year, we can't develop it continuously, even though continuous development is most important in engineering. In spite of these problems the flight distance record has been getting longer every rally. At last, in 1996 the record was approaching 10 kilometers (actually 9761m). Considering the fact that MIT's DAEDALUS flew 116 kilometers in 1988, it was not surprising. However the conditions in the Birdman Rally are hard enough. It is held in summer, so the temperature of the

cockpit easily climbs up to over 30 degrees, and you can imagine how difficult it is to continue pedaling inside. On the other hand, the wind is often high in this season and it has been found that the direction is variable above the lake, so these factors make the flight difficult. We are forced to find some other way of development to settle these matters. From this year, because last year the Japan International Birdman Rally cancelled owing to stormy weather, we will have a new category of “challenge”, which is concerned with uniquely configured aircraft. This new turn of the competition will be worth seeing. The Japan International Birdman Rally is going from strength to strength, both as a form of entertainment and as a focus for serious academic work.

YURI human powered helicopter

YURI is a human powered helicopter series, which is produced by Professor AKIRA NAITO, who is retired from Nihon University. The honor of the first verified flight was taken by Da Vinci 3, which was made by the California Polytechnic State University group, but YURI 1 has the record of the longest duration. The officially verified duration time is 19.46 seconds and the highest altitude is 22 centimeters, but at the AIAA International Symposium of Human Powered Flight, Seattle, 1994, when it gave a demonstration flight, it succeeded in flying for 24 seconds in front of a lot of spectators. YURI was applauded by the people there. To achieve the Sikorsky Prize, it has to fly up to 3 meters once and continue flying for 1 minute. At present it is difficult to achieve, but now YURI 2 is being developed at Nihon University, it is expected to gain the prize.

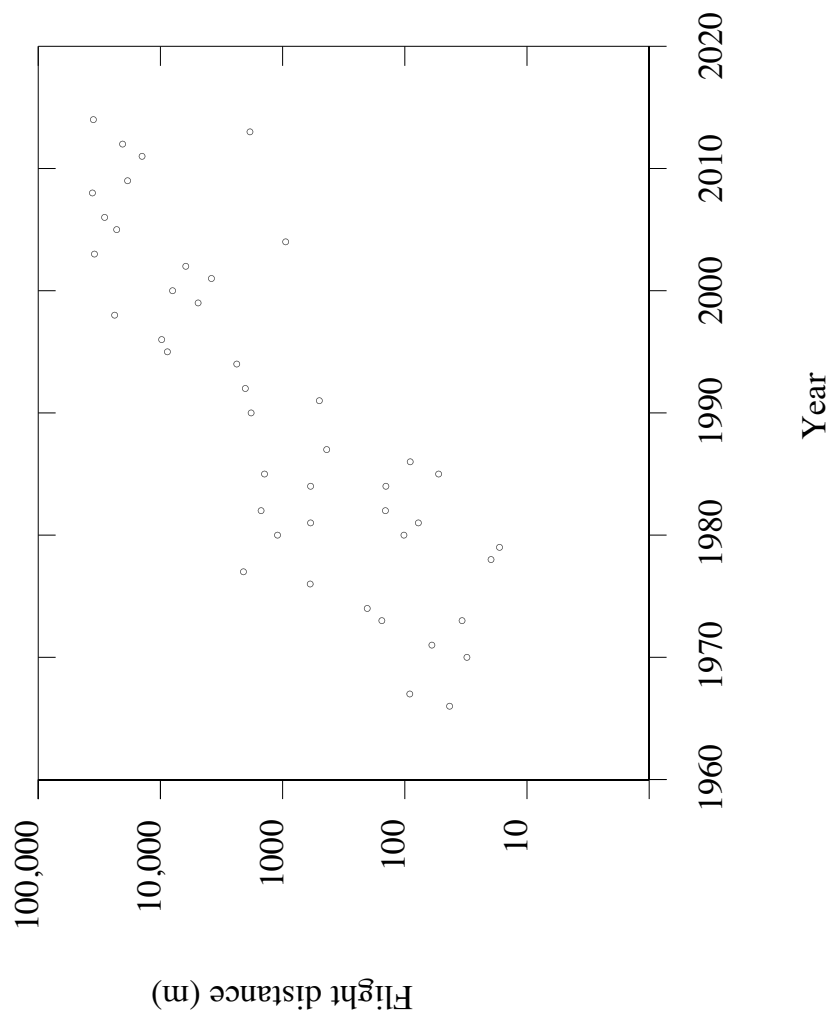
Conclusion

In Japan, considering the small area of the islands and the scarcity of level ground, a lot of human powered flight activities are going on. A lot of teams suffer from lack of airfields to do flight tests. So some kinds of methods or instruments to investigate the aircraft performance, which is very difficult to estimate particularly when the airfield is short, will appear.

In the Japan International Birdman Rally, the entrants aim to land on the opposite shore rather than extend the flight distance by using a following wind. Actually judging by the trend in the results, it could be achieved in a few years. Then some systems or instruments, which enable human powered flight to be a common sky sport, will be applied. At Nihon University, human powered flight activities will continue. NASG will continue to develop human powered aircraft to participate in the Japan International Birdman Rally while also trying to find the way to make the aircraft fly more easily. Human powered helicopter YURI series will also be developed and improved at Nihon University. Both activities will share the technics each other.

In the design state, the problems faced by engineers are relatively simple and solving them is “moderately” difficult, so an activity to make human powered aircraft is suitable for university students to learn engineering, management and teamwork. However as we can see from the fact that a lot of projects have collapsed halfway through, it has to be considered carefully before it is undertaken.

Japanese human powered aircraft distance records



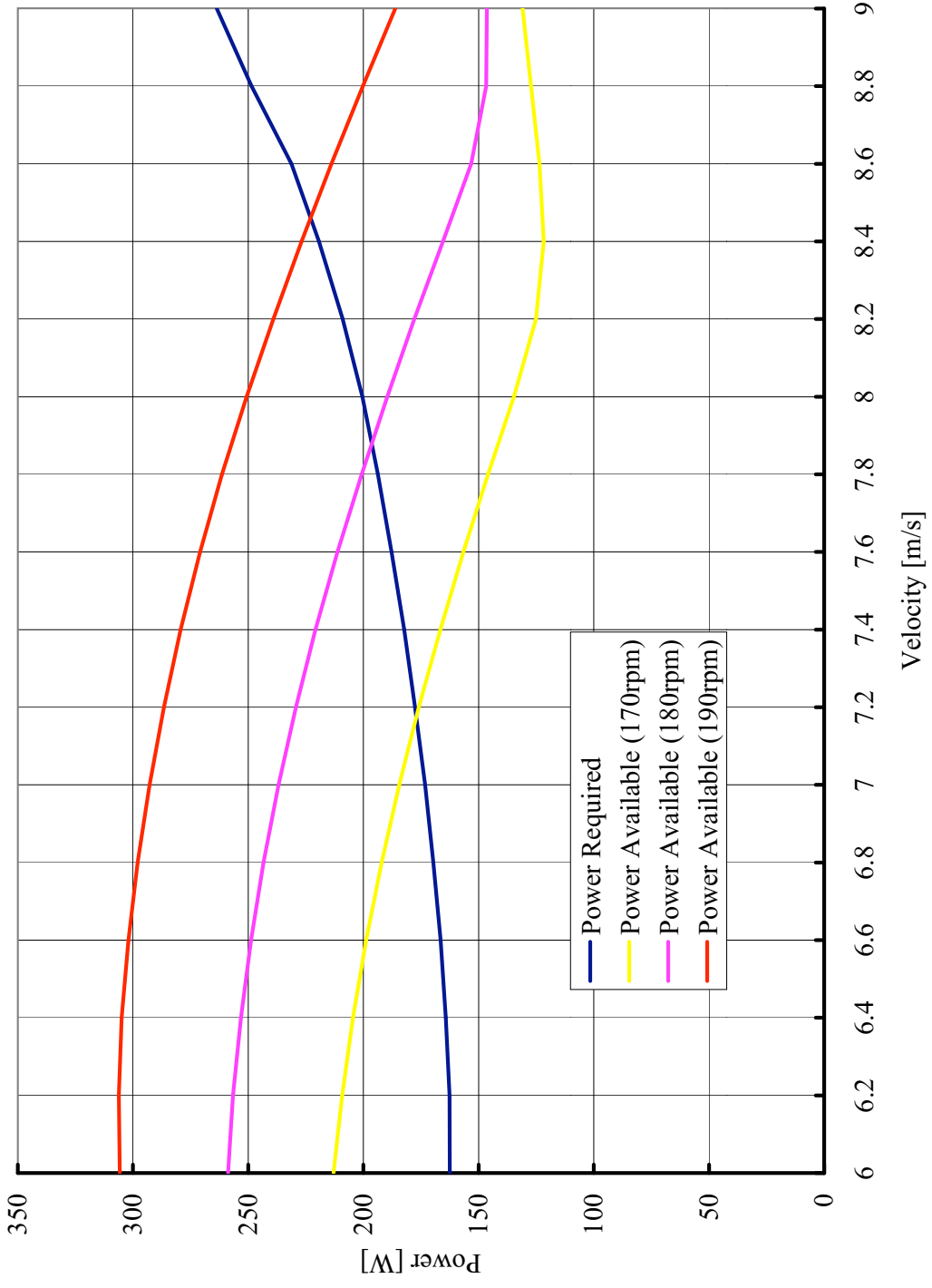
Flight research with the M \ddot{o} we 13 Human Powered Aircraft

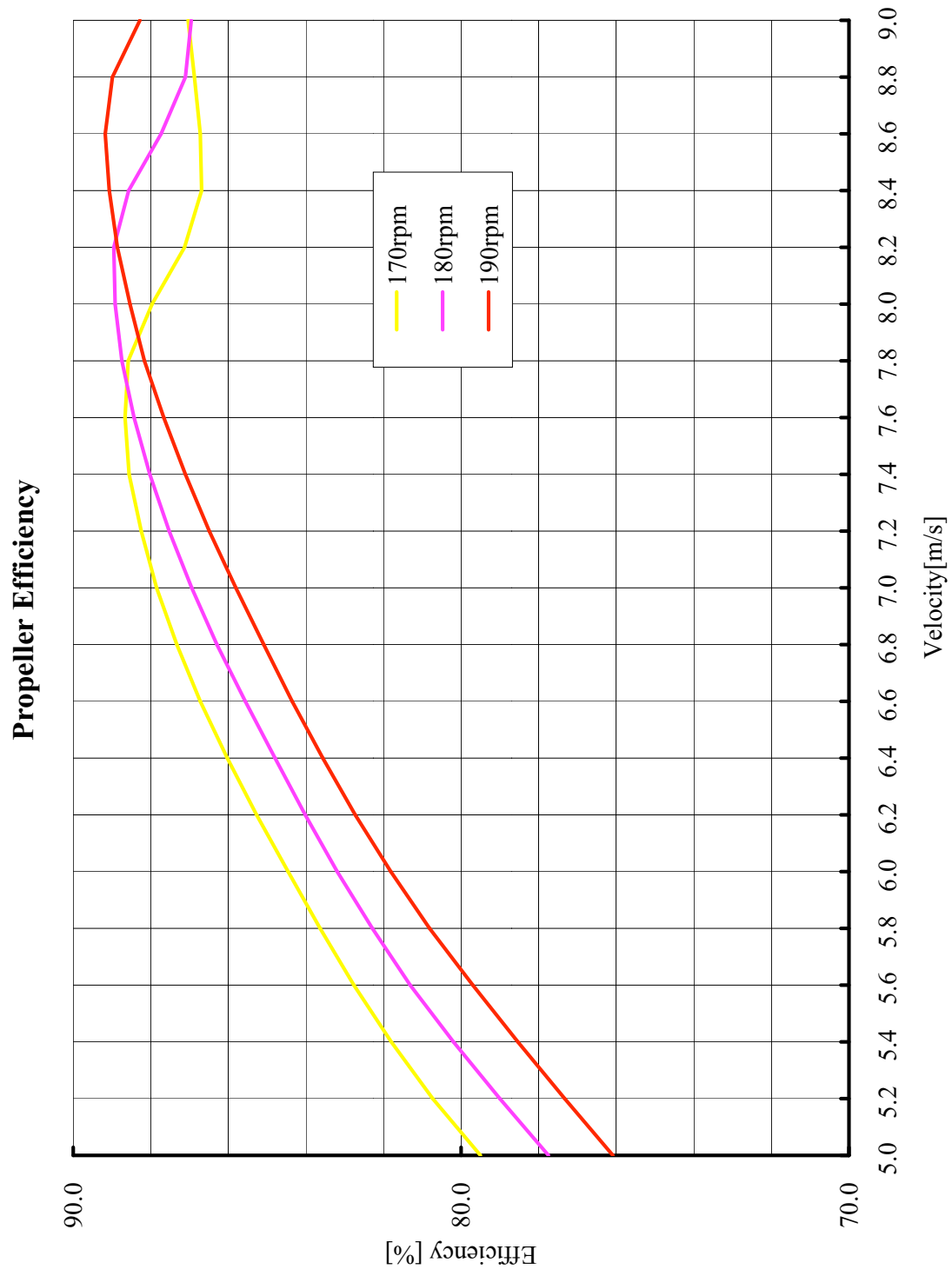
The aircraft was instrumented and the following data logged: Airspeed, altitude, propeller rpm, power, using strain gauges on the driveshaft, control input, sideslip and angle of attack. These were used to calculate power and power compensated for changes in energy due to changes in altitude and airspeed. This is described in detail in Sullivan et al. [1]. The gradient of the compensated energy curve then corresponds to aircraft power. Three points derived from the following flight data for two test flights are plotted with the theoretical power polar calculated by the NSAG and two additional theoretical polars calculated by McIntyre for M \ddot{o} we 13 flying in and out of ground effect.

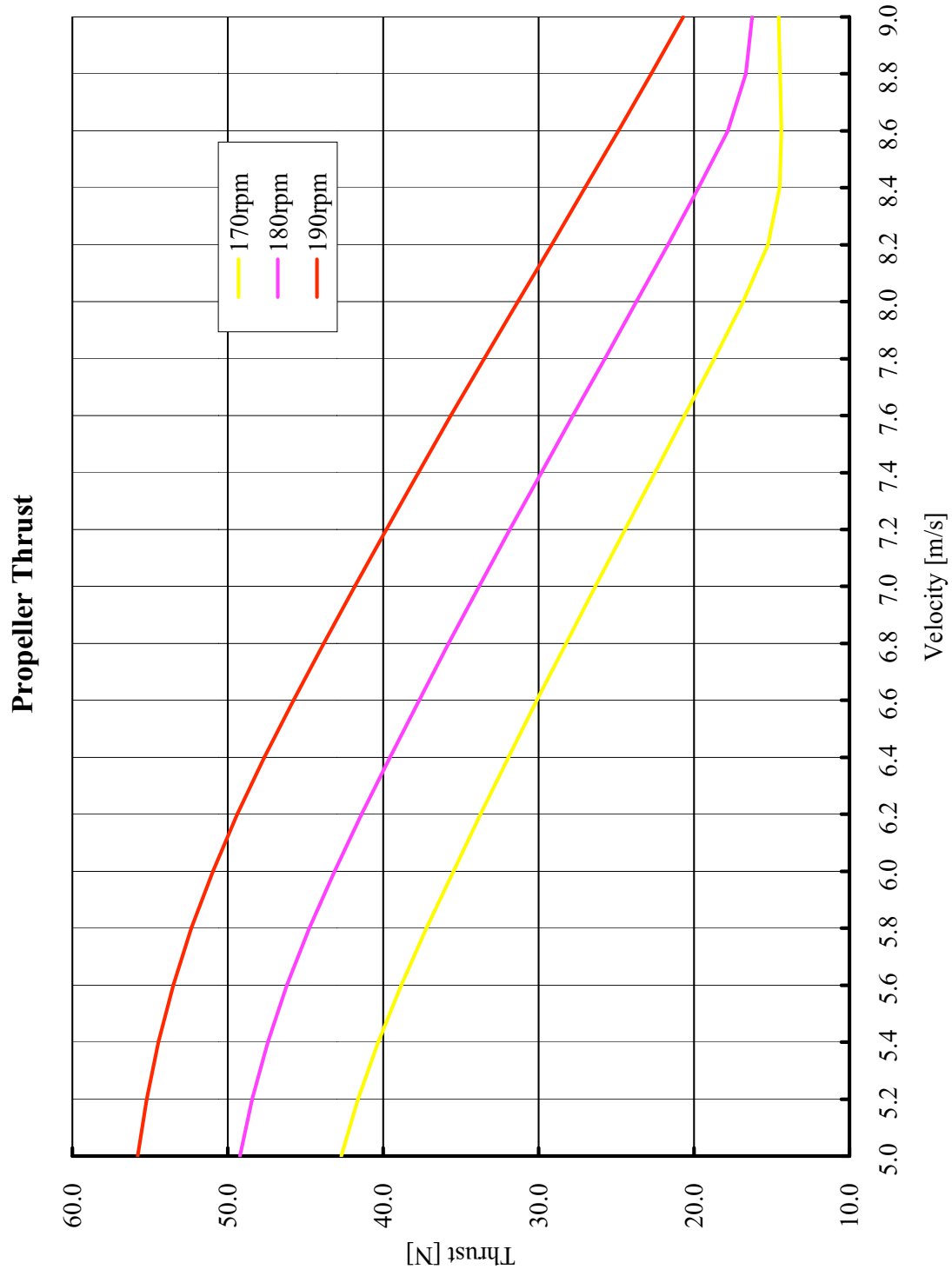
References

1. Sullivan, R.B., and Zerweckh, S.H., Flight Test Results for the Daedalus and Light Eagle Human-powered Aircraft, NASA Grant Report, October 1988.

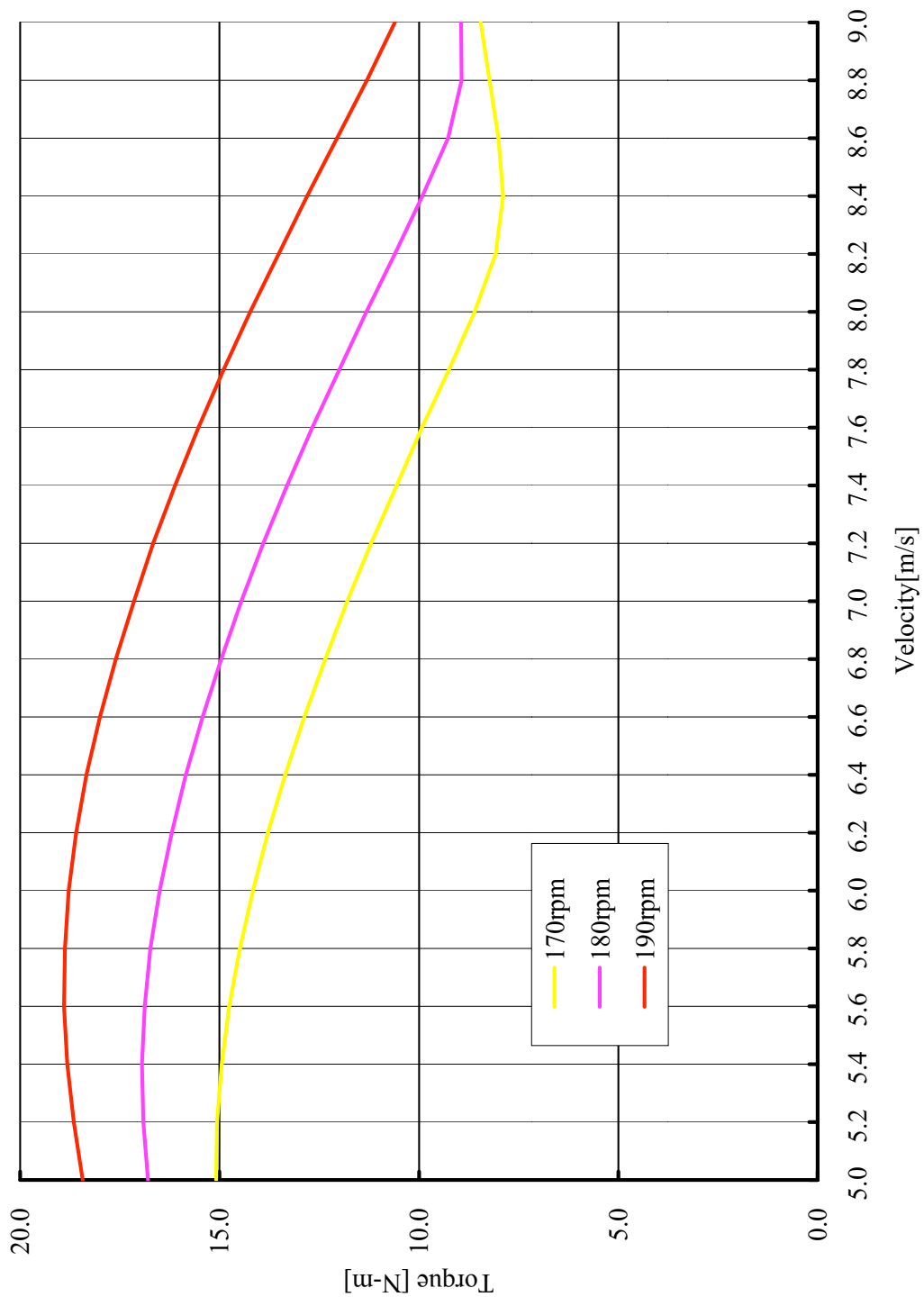
Mowe 13 Power





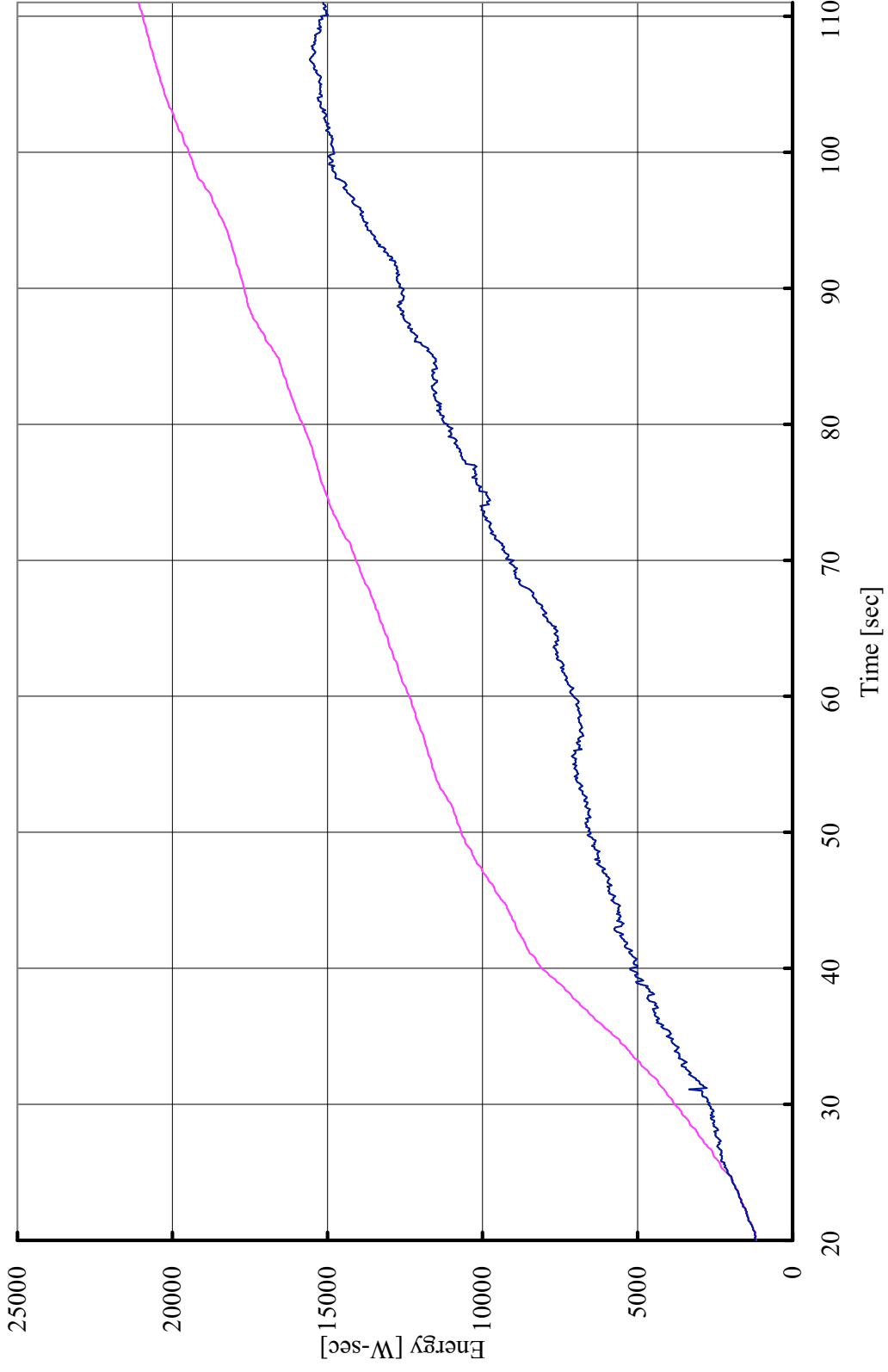


Propeller Torque

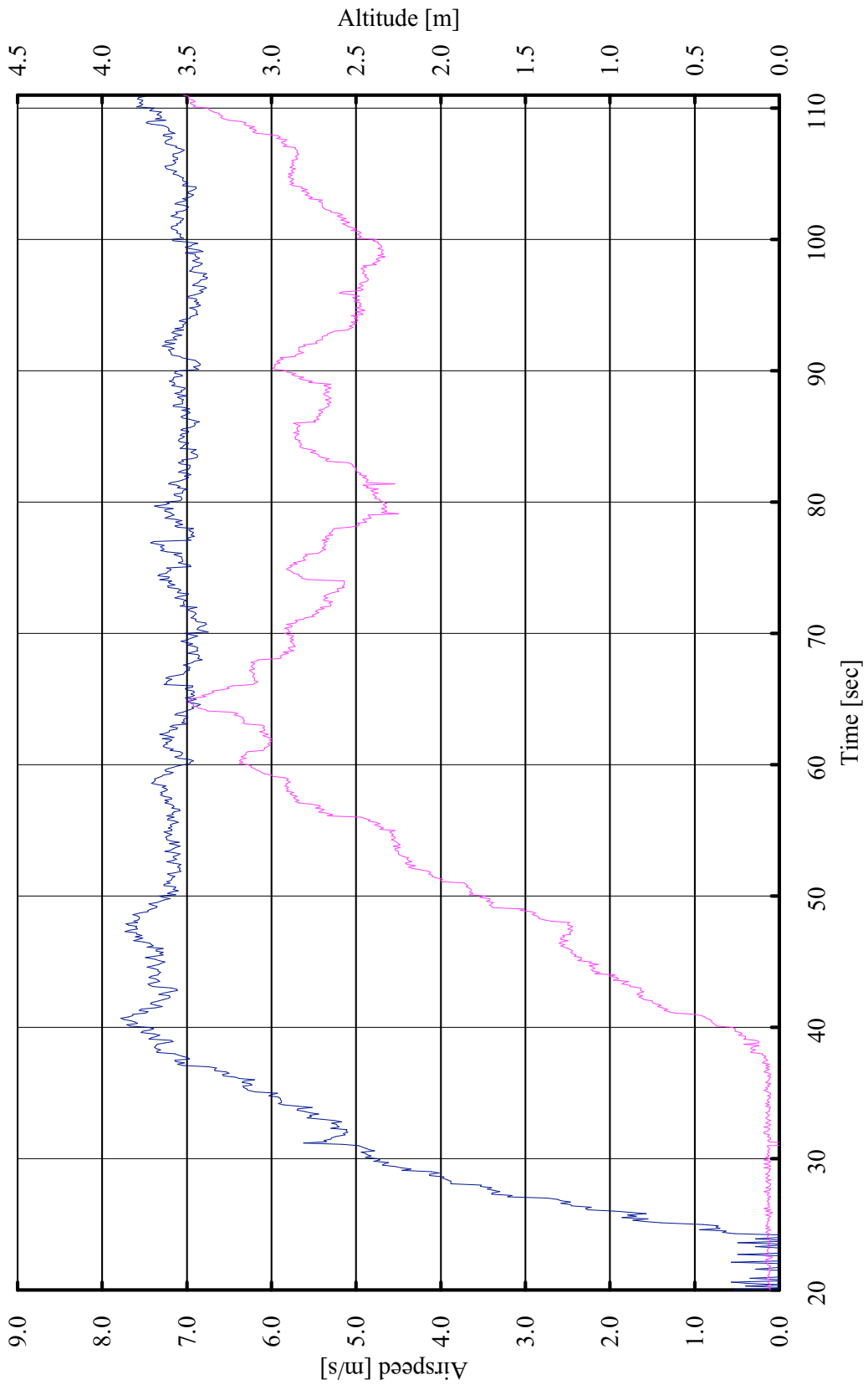


Data from flight 07140529

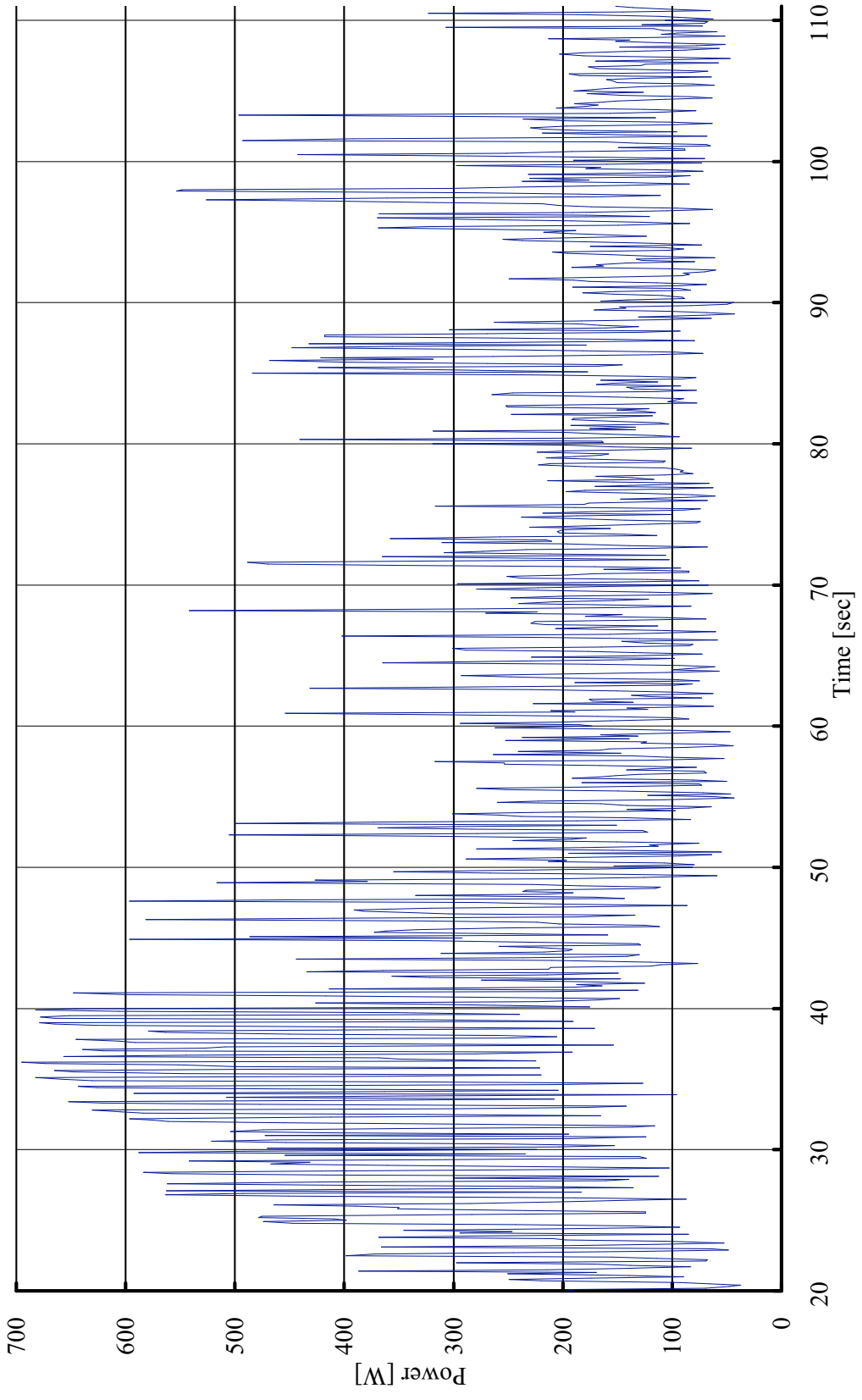
**Compensated Energy Time History
Flight No. 07140529**



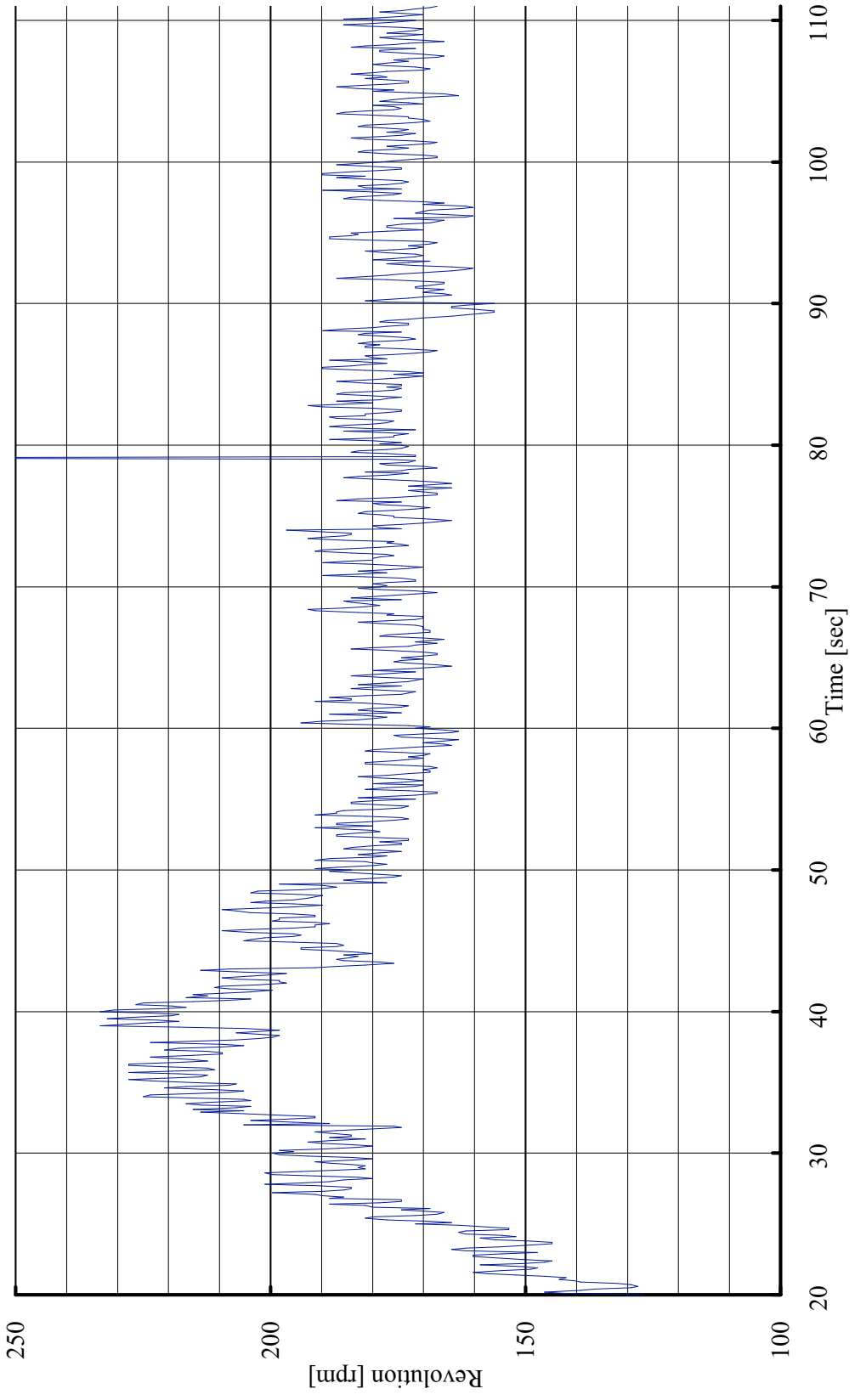
Airspeed and Altitude
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Pilot Power Output
Flight No. 07140529

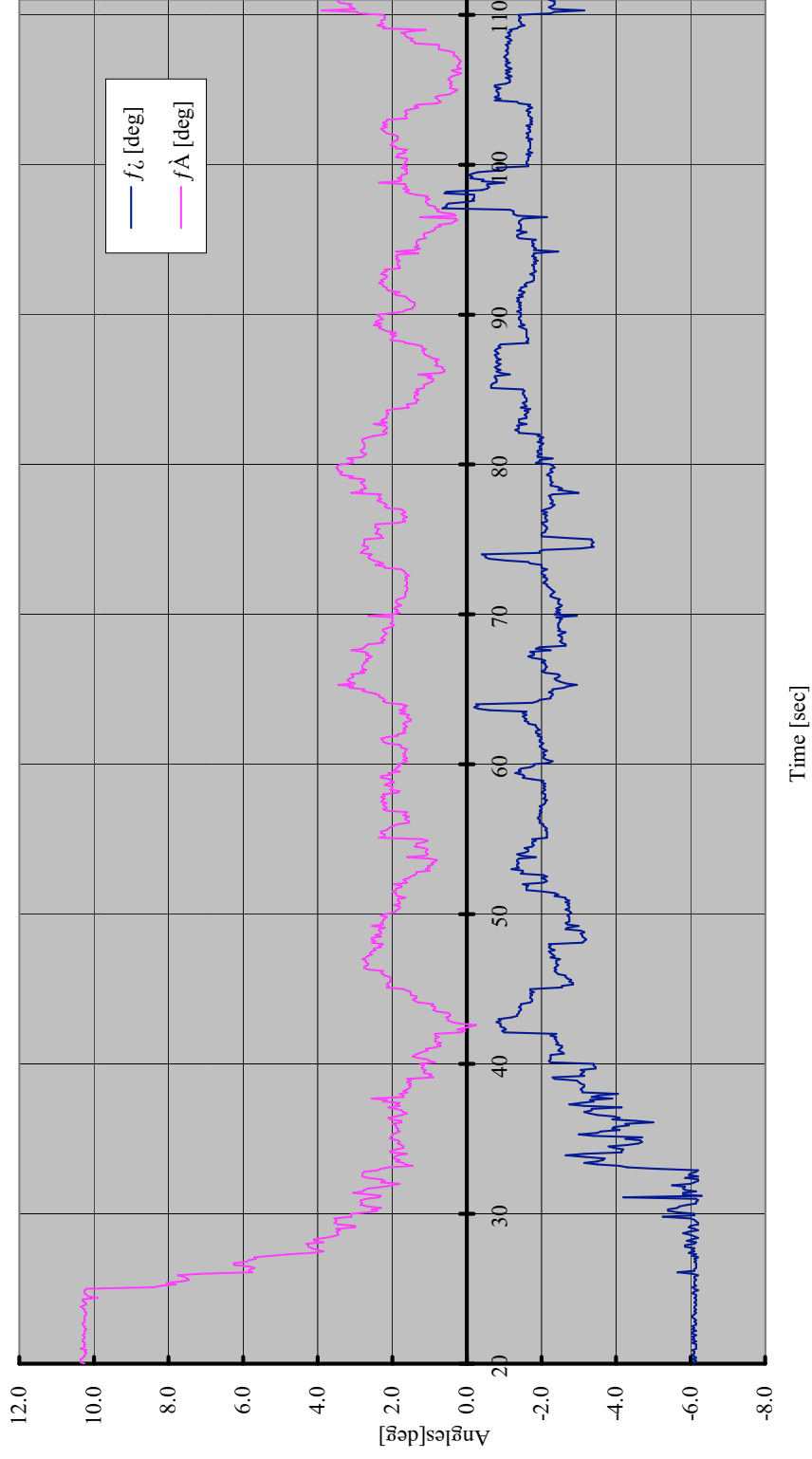


**Propeller Revolution
Flight No. 07140529**



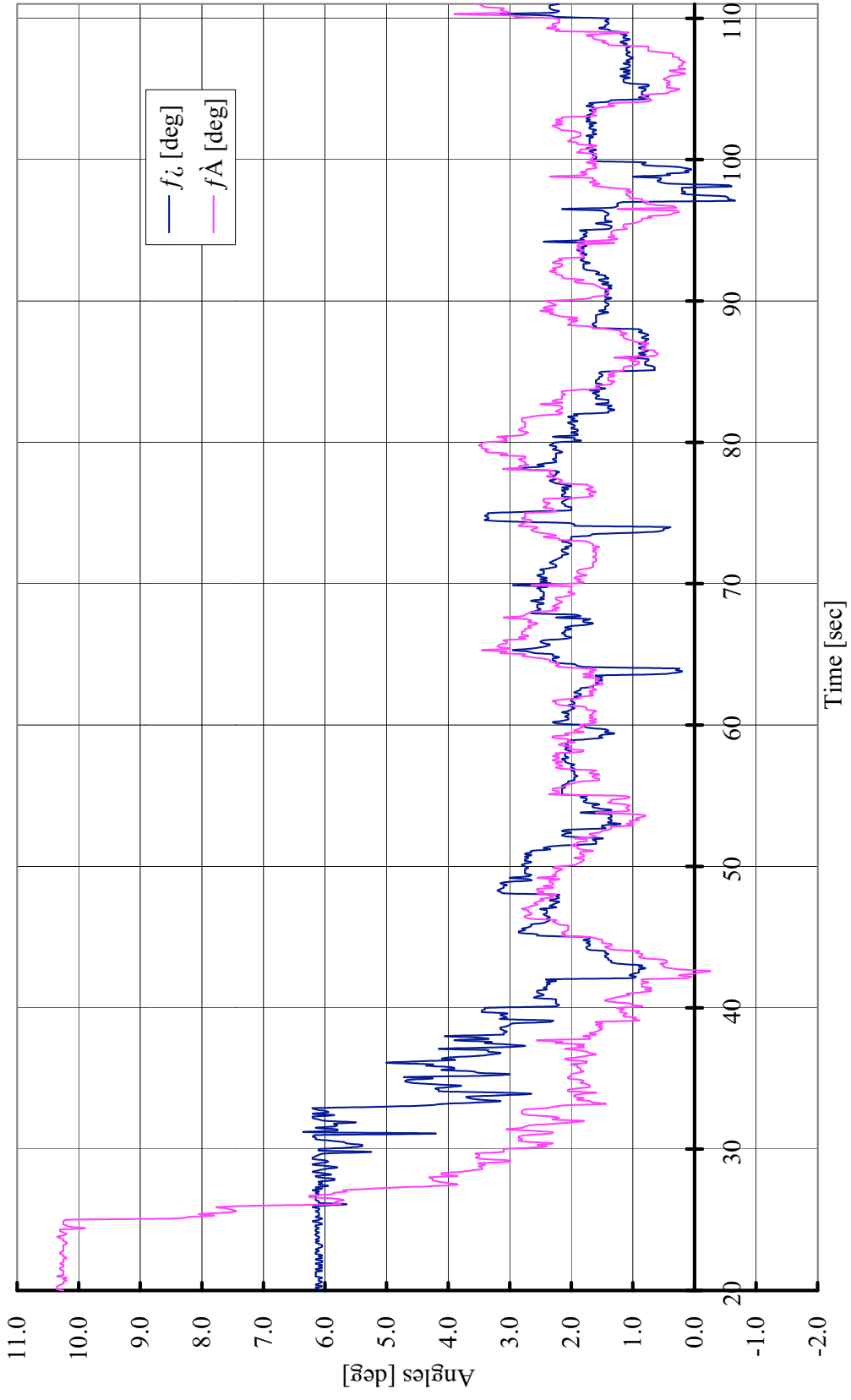
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Angle of Attack and Side Slip Angle
Flight No. 0714529

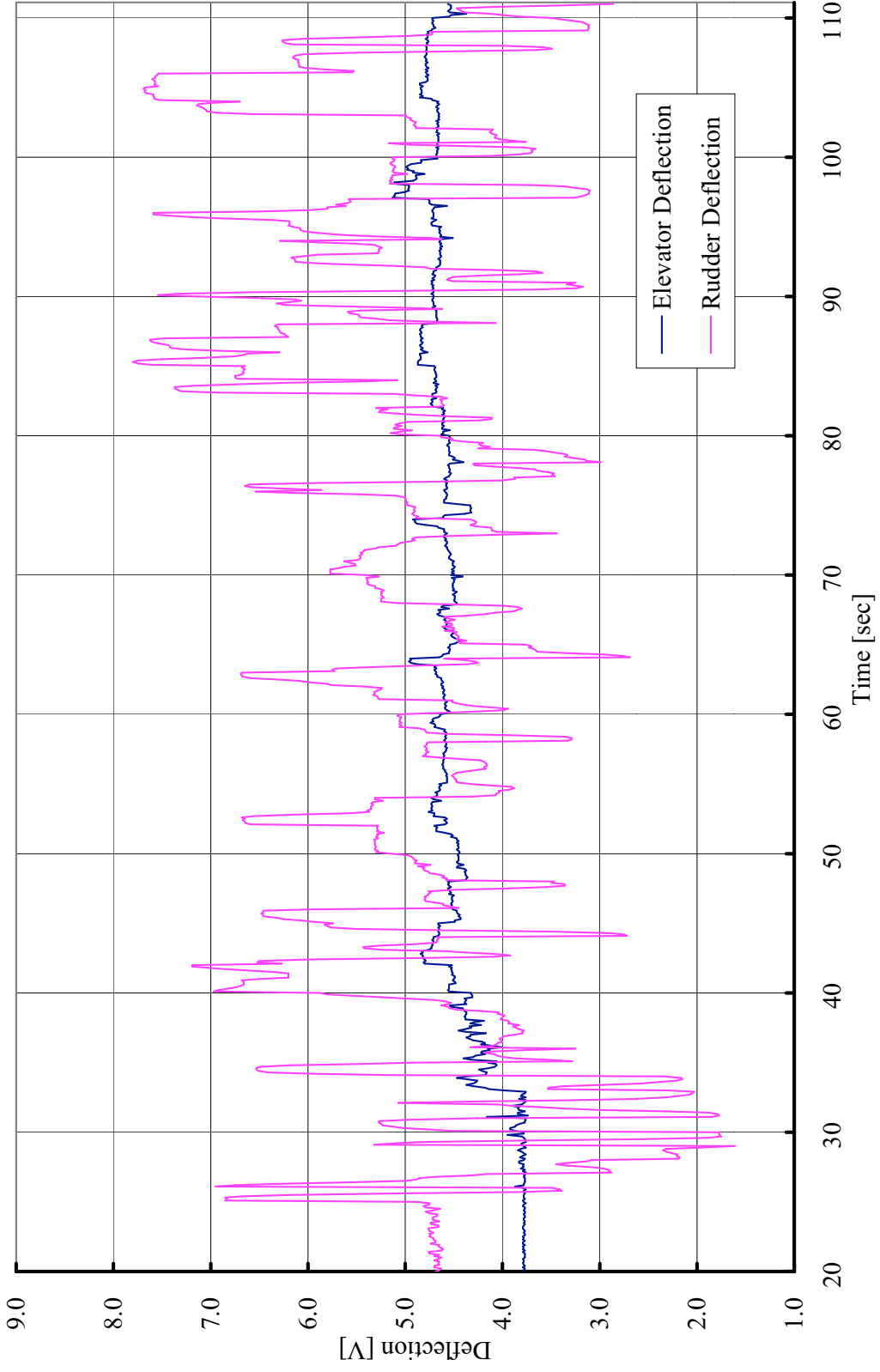


Angle of Attack and Side Slip Angle

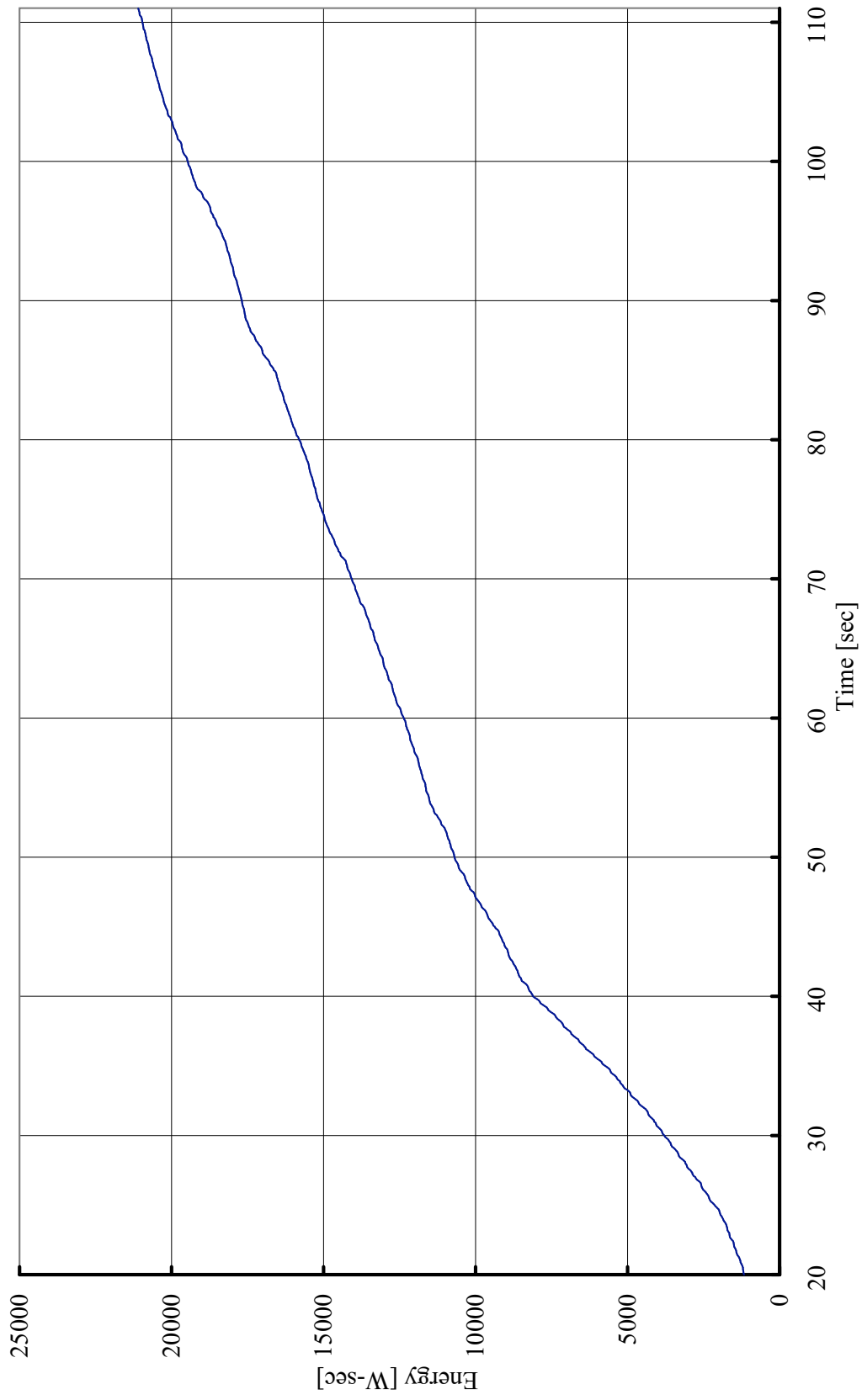
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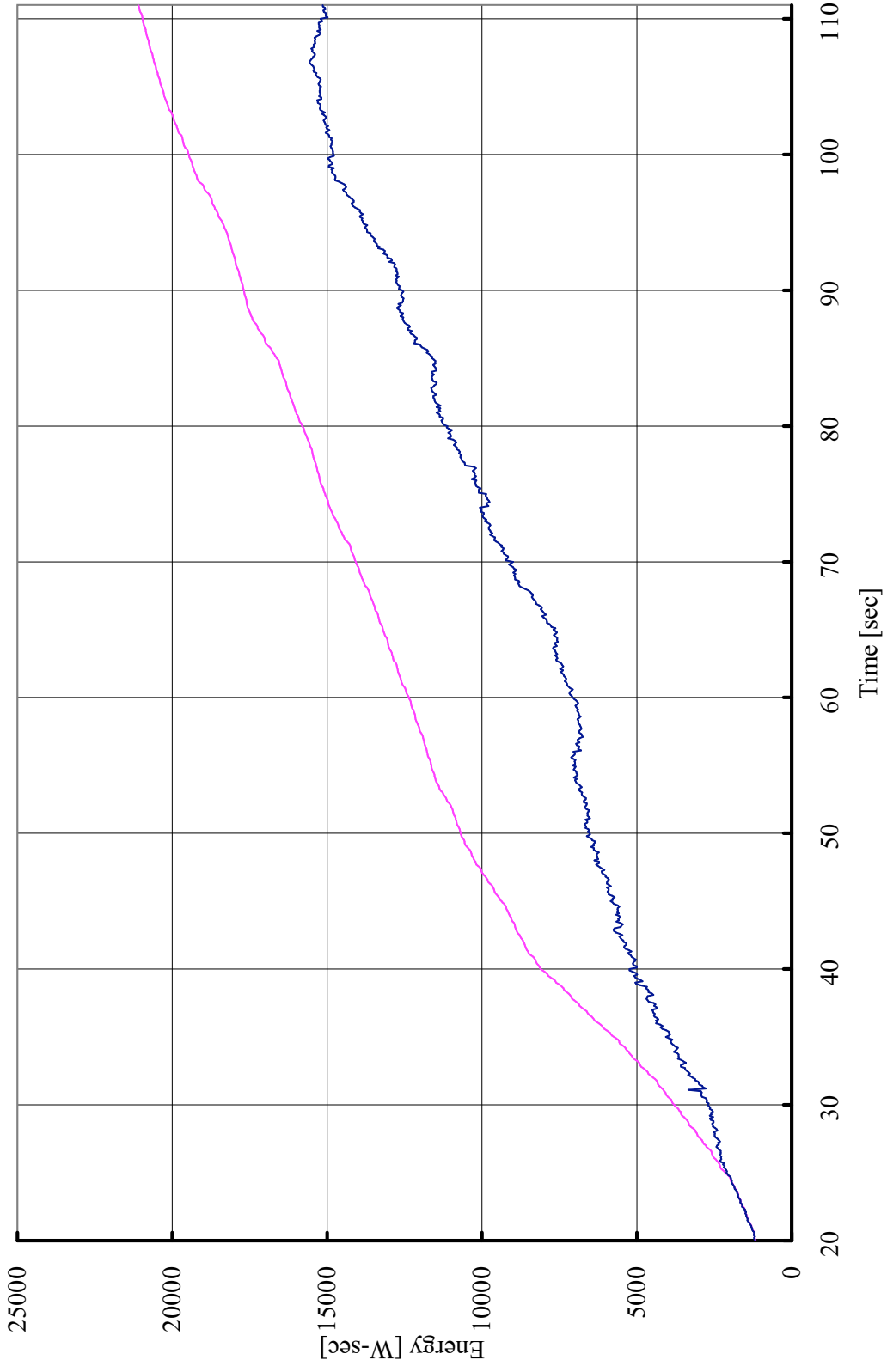
Pilot Control
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Uncompensated Energy Time History
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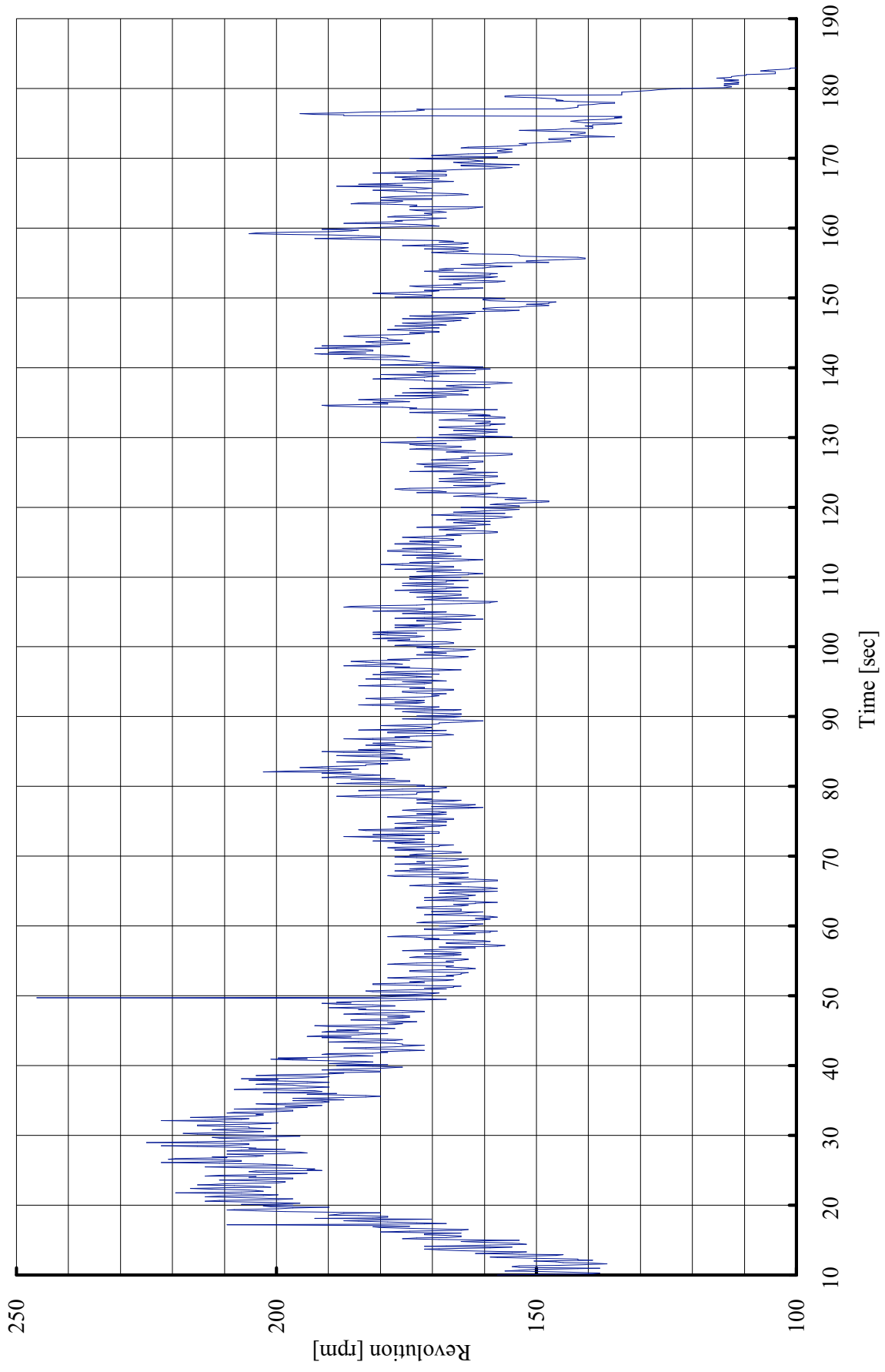


Compensated Energy Time History
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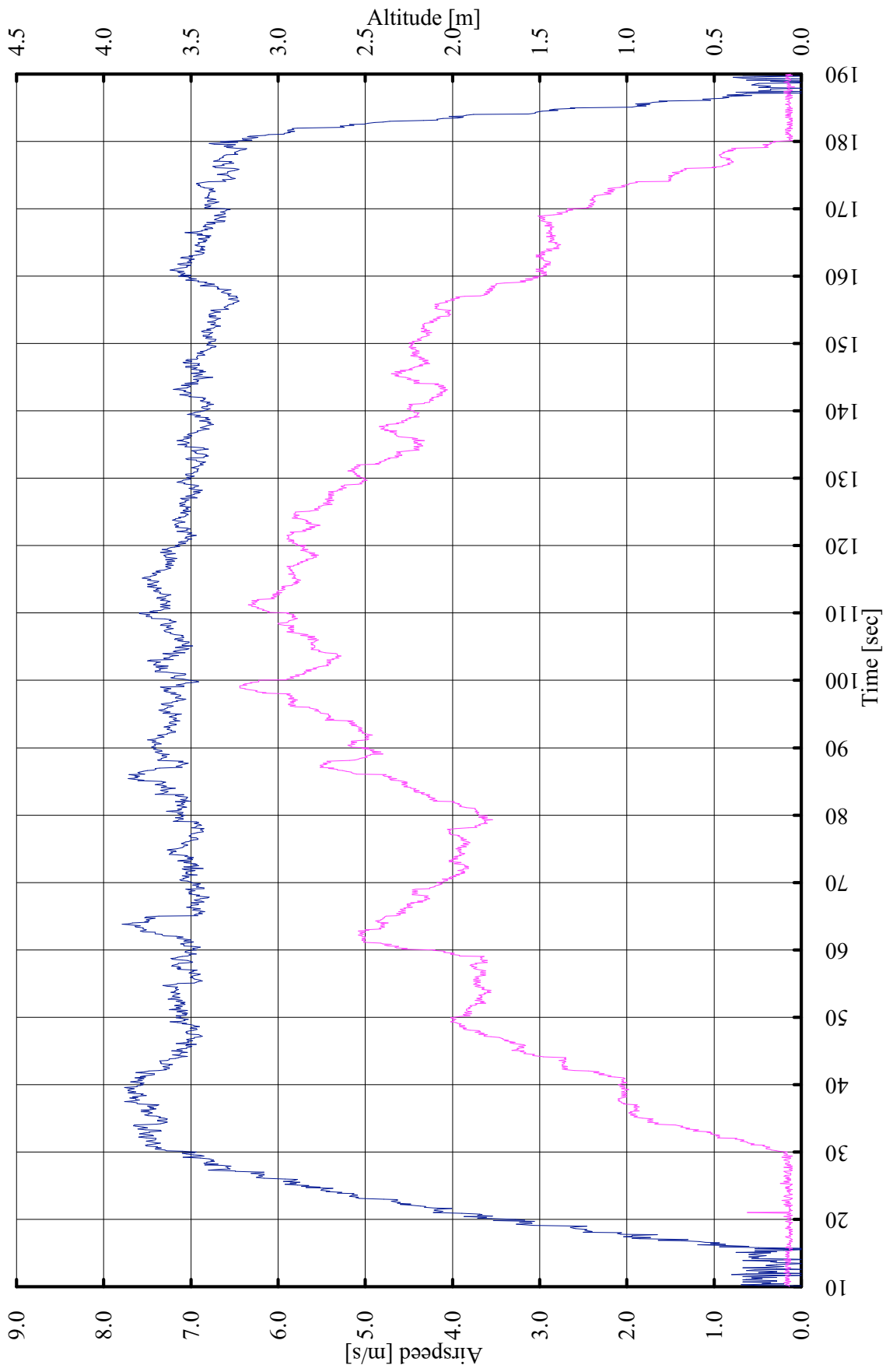


Data from flight 07130521

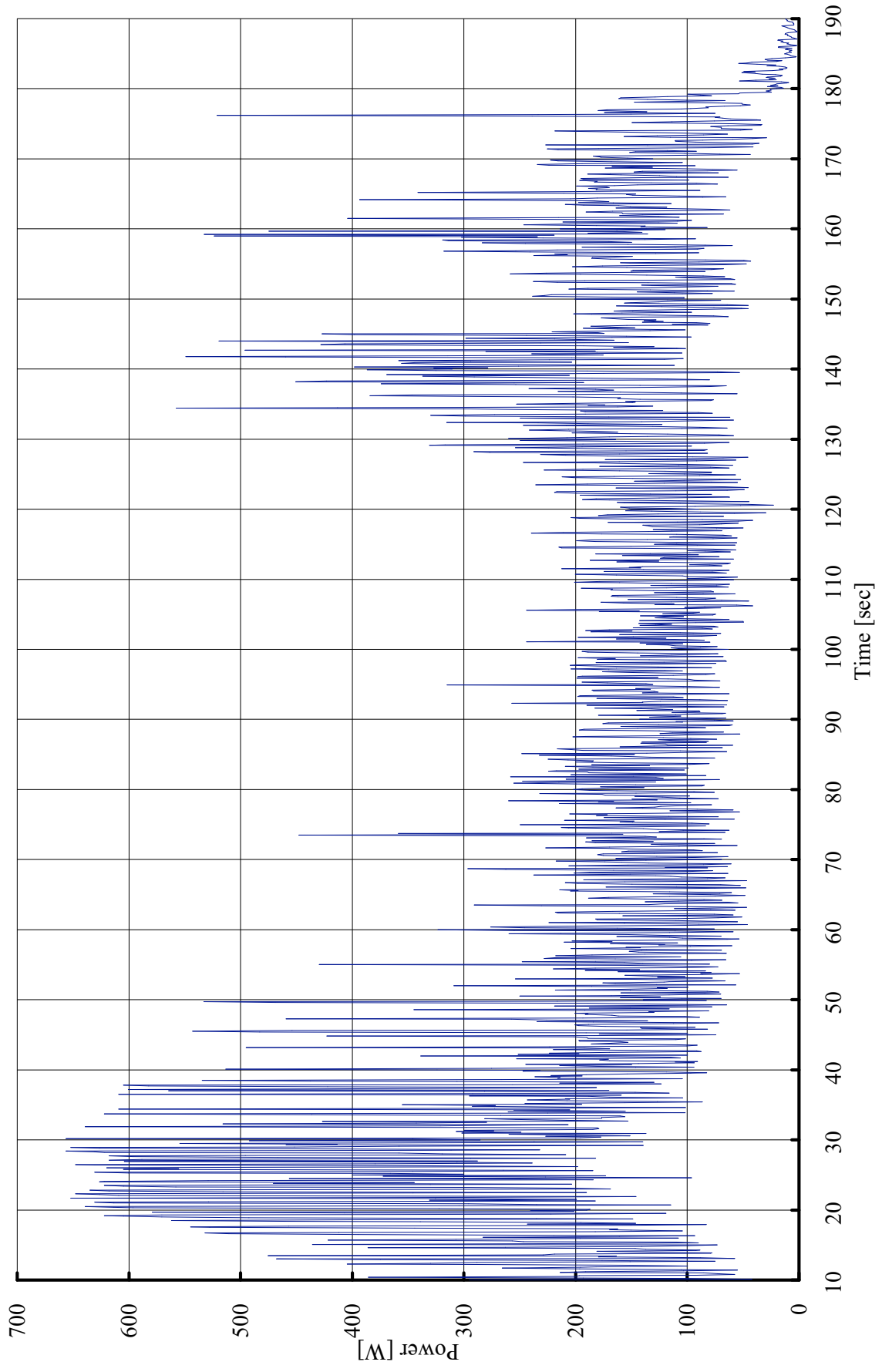
Propeller Revolution Time History
Flight No. 07130521



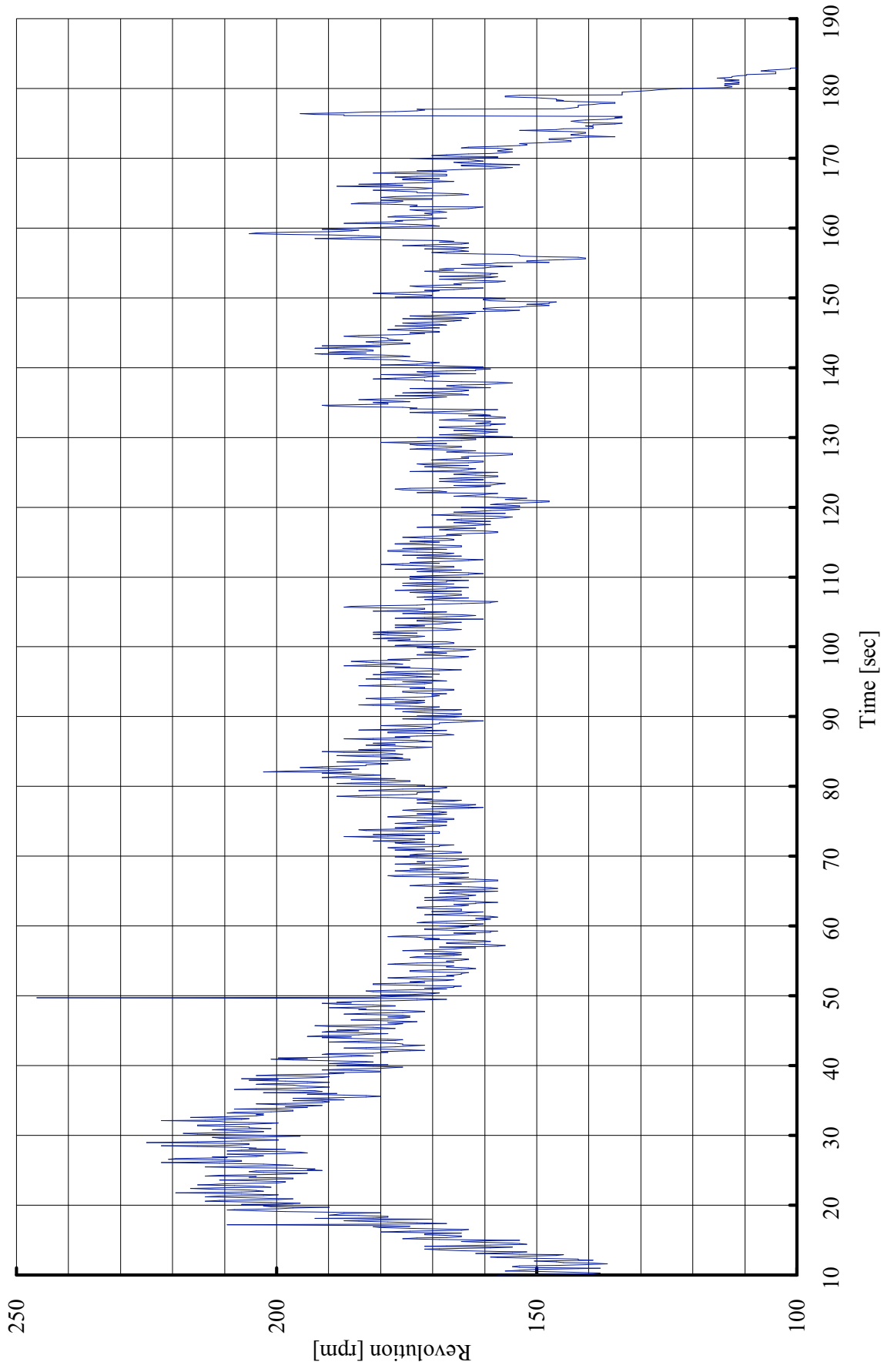
Airspeed and Altitude Time History
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Pilot Power Output Time History
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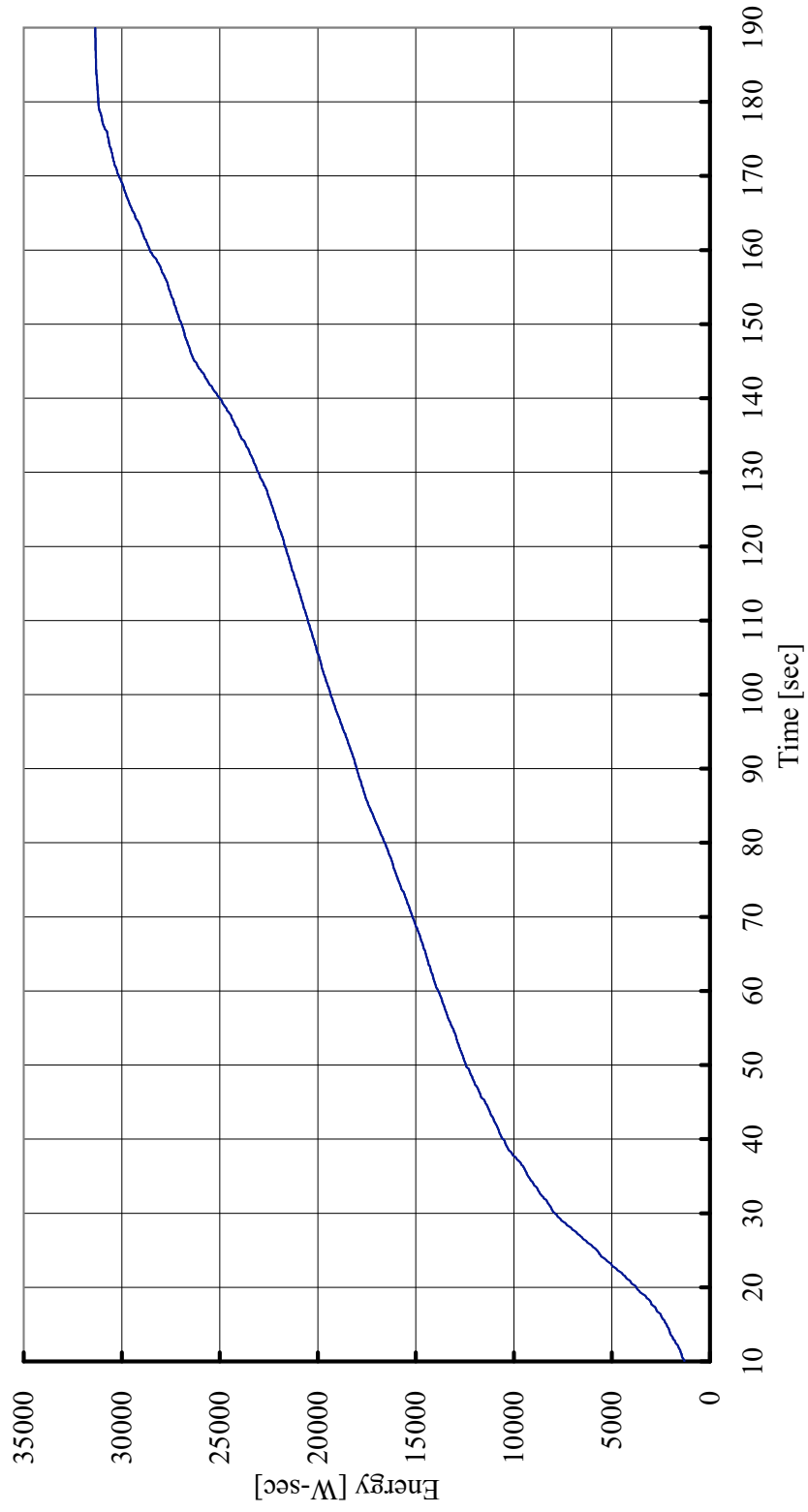


Propeller Revolution Time History
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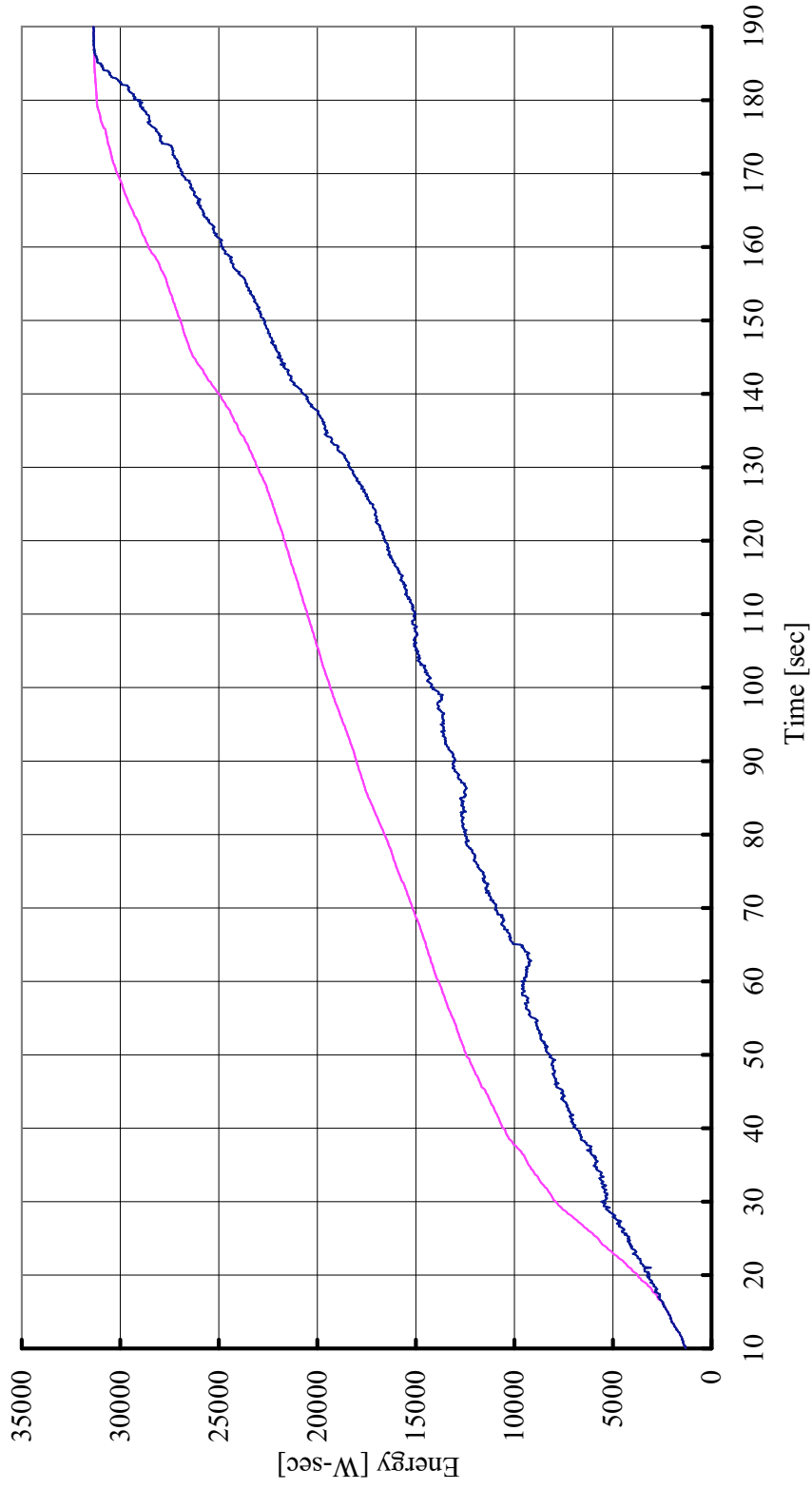


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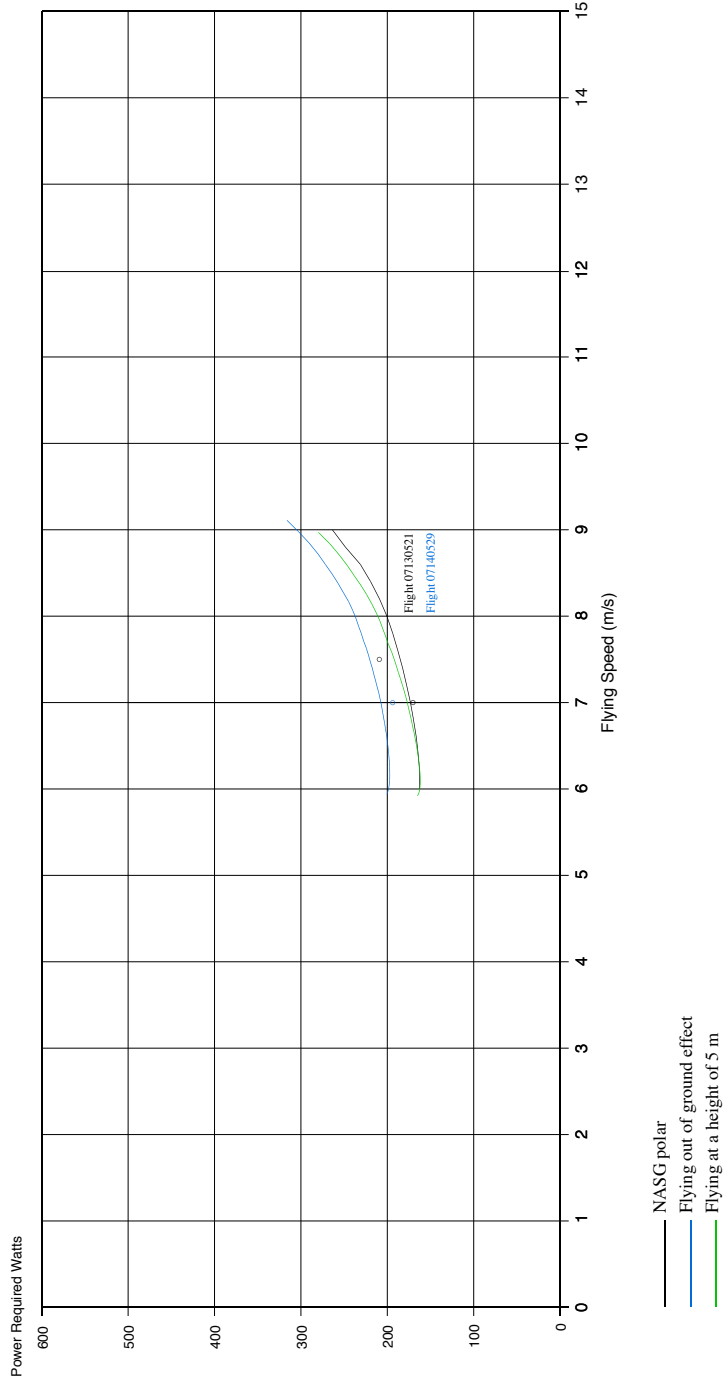
Uncompensated Energy Time History Flight No. 07130521



**Compensated Energy Time History
Flight No. 07130521**



Mowe 13 Power Polars



About the Author

TOSHINARI NOMURA has been studying aeronautical engineering at Nihon University. He has been involved with human powered flight since he started university, participating in the annual human powered aircraft projects. In 1996 he became the leader of the group, worked on the MÖWE 13 project, culminating in the 1996 Birdman Rally. He then handed over his responsibilities to his junior, and came to Britain to study English.