29th Congress of the International Council of the Aeronautical Sciences
St. Petersburg, Russia; September 7-12, 2014

RESEARCH ON FLYING-PYLON TECHNOLOGY

Jiang Hanjie, Duan Zhuoyi, Pu Hongbin
The First Aircraft Institute, Aviation Industry Corporation of China
Xi'an, Shan'xi Province, China, 710089
Keywords: ***UAV, RATTLRS, Flying-Pylon, PESID***

Abstract

Whether military aircrafts, or commercial aircrafts, their basic properties in common is air conveyance. We regard them as flight vehicles with different kinds of payloads on different purpose. In traditional aircraft design, the technical indicators of basic configurations of the flying platform are adopted as the main issues and criterion. The Platform-External Stores Integrated Design (PESID) proposed in this paper regards the airplane performance indicators of common mission configurations as the main criterion in conceptual design. The PESID idea is an extension of the control configured vehicle (CCV) and integrated avionics, etc.

The Flying-Pylon is a highly integrated product of the physical units and software between the load-bearing aircraft and the mounted equipments or sub-aircrafts, which will not only improve the flight performances of the mission system under common mission configuration but also reduce the life-cycle cost of the flight platform by integrated design of the aerodynamic configuration, propulsion system, fuel system and avionics system.

In this paper, the concept of Flying-Pylon is proposed after PESID, which can contribute fresh and unique ideas for the design of flight platforms in the future. Several kinds of Flying-Pylon vehicles are also introduced to enrich people's imagination of this technology. Meanwhile, in order to provide a quantized acquaintance of Flying-Pylon, these vehicles are evaluated and compared to a common design. The paper is divided into three sections:

1) A brief introduction of the Flying-Pylon idea
This paper has presented the progress of PESID idea and its meanings. Furthermore, the Flying-Pylon is briefly introduced.
2) Research of Flying-Pylon design
This paper indicates the main contents and design method of Flying-Pylons. The key techniques of the platform design are illustrated and analyzed. Based on the integration approach of various software and hardware, several kinds of Flying-Pylon vehicles are designed as lively cases.
3) Performance evaluation
Finally, the paper chooses three kinds of the Flying-Pylon carrying platforms presented above with analysis and evaluation.
It is demonstrated that the Flying-Pylon design method could be really smart and effective.

1 Platform-External Stores Integrated Design (PESID) and Flying-Pylon

As we all know, during the last few decades, we have successfully put multiform modern equipments and weapons on the planes. However, for the coming decades the task we will be faced maybe is making the equipments and weapons well mounted while the changes hard to be told by air flow, radars and dollars. Since the flight control system, the mission system and the structural arrangement are highly associated with the configuration of the flight vehicles, a highly integrated design is needed between the platforms and the external stores.

1.1 PESID

The Platform-External Stores Integrated Design (PESID) idea proposed in this paper regards the

airplane performance indicators in common mission configuration as the main criterion in conceptual design. The idea contains two main parts.

Firstly, the classical serialization and modification experience can be taken into account adequately in the design of initial flying platform. By this way, the initial flying platform will be much more adaptable with the posterior projects.

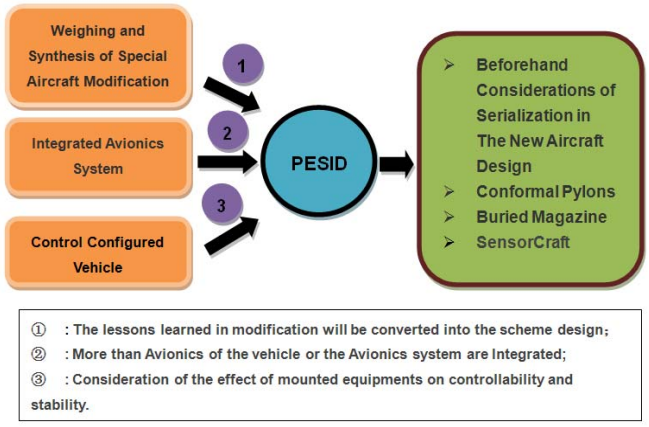

Fig.1 The Progress of PESID

The main reason for action is that we have already been walking on this way for a long time. The Y-8 series developed more than a dozen of modified types[1]. Not only the modification of Boeing or Airbus jets but also the development of the F-18 series and the development in the JSF program indicate a great benefit in cost control and logistics improvement. The adaptability in this paper is beforehand considerations of serialization and modification in the new initial platform design indeed.

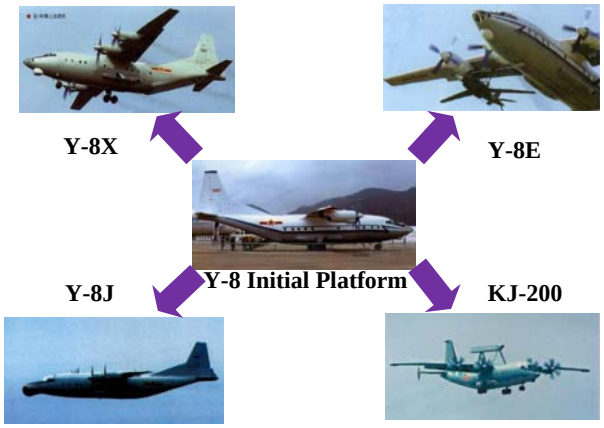

Fig.2 The Y-8 Series

These considerations are mainly about the configuration design, the structural arrangement and the flight quality, which are divided into three classes: safety, economical efficiency and performance improvement.

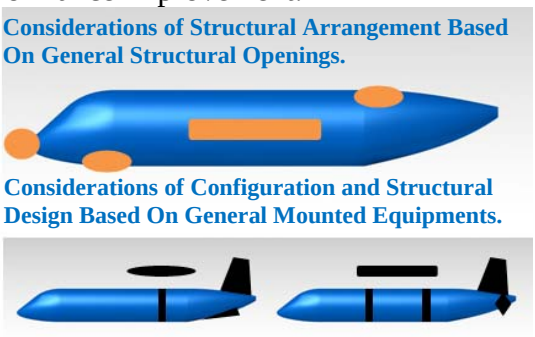

Fig.3 Beforehand Considerations of Serialization and Modification

Secondly, PESID regards the airplane performance indicators in common mission configuration as the main criterion in conceptual design. The integrated design of configuration, propulsion &fuel system and avionics system can improve the performance and reduce the cost.

Fig.4 Conformal Fuel Tanks and Sensor Crafts

Like the first part, the integrated idea is not a new one either. The Conformal Fuel Tank, the Conformal Pylon and even the Control Configured Vehicle[2] are the techniques familiar to aircraft designers that focus on the aerodynamic configurations. For avionics system, the advanced Integrated Avionics System is on the table. However, the Sensor Craft may be the farthest on the way so far[3].

If we focus on the Integration of hardware and software, the platform can be simple. In other words, the mission system combined by the platform and the external stores will be full-function before the mission is done. After that, some of the functions maybe not maintained as the platform does not have or need it.

Obviously these two parts each correspond with the two main conceptual design directions,

the common platform for multi-missions development, like the JSF program, and the customization for specific tasks.

1.2 Flying-Pylon Technology

Just as its name implies, Flying-Pylon is a new concept of UAV, which is a kind of airborne weapons deliver system. Which distinguishes Flying-Pylon from common UCAVs is that Flying-Pylons are designed for certain airborne weapons. Of course, the combination is not only one result and each type has its own strong suit.

1.3 RATTLRS

The Lockheed Martin RATTLRS (Revolutionary Approach to Time Critical Long Range Strike) is an advanced cruise missile concept demonstration funded by the US Navy. The engine of RATTLRS is Rolls Royce YJ102R turbojet, which is inherited from Blackbird (SR-71)[4].

Fig.5 RATTLRS Launched By the F/A-18

An initial concept of Flying-Pylon combined with 2 RATTLRS missiles, equipped in both sides, is shown in Fig.6. Like the F/A-18 fighters and maybe the potential client X-47B, the Flying-Pylon can also take 2 missiles, while the size of which is much more tiny, as shown in Fig.7. It is a visualized introduction of Flying-Pylon for RATTLRS.

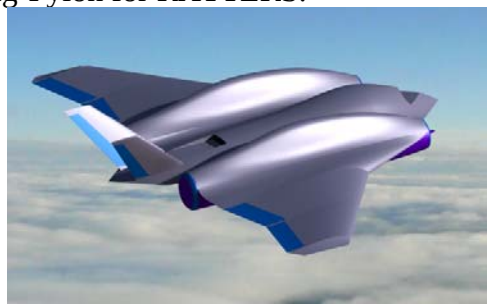

Fig.6 Initial Concept of Flying-Pylon

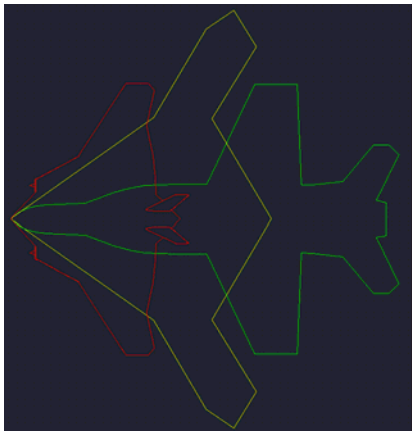

Fig.7 Outline Comparison of Typical Vehicles

2 The Design Rules

Design rules are necessary since the Flying-Pylons are not normal UCAVs, and the rules can be helpful to make the outline of the strange pylons to be clear.

2.1 Propulsion System Integration

The turbojet engine is chosen for the supersonic cruise missiles and the engine of Flying-Pylons can be the same or not, but the fuel for each must be the same. Before the combination get to the combination region, the power is contributed by the missile's engine alone or together.

The first rule is the key part of Flying-Pylon design. Taking fully use of the supersonic cruise missile engine can fix the thrust requirement of the combination. Furthermore, after the missile is launched, as the weight loss from fuel burning and the entire launched missiles, a much smaller thrust is enough. Of course the range and the endurance can be improved with a smaller fuel burning speed. By this way, the platform weight is smaller with a smaller engine in it. When the engine is 1kg heavier, the gross weight of a subsonic aircraft will add about 4~5kg, and for a supersonic aircraft, the number will be 6~10[5].

2.2 Fuel System Integration

As the fuel for the Flying-Pylon can be also used by the missile engine, the missile engine uses the fuel in the fuel tanks inside Flying-Pylon before it is launched. This process

is just like the auxiliary fuel tank but in opposite direction with the same installation.

The second rule will keep the cruise missile intact before it is launched. Although the traditional engines of cruise missiles are used for once, but for Flying-Pylons the engines should work longer or even time and time again. However, the engines will not be the problem.

2.3 Integration Design of Configuration

The combination of the Flying-Pylon weapon system should be small in size, flexible enough and cheap. The Flying-Pylon is designed for a certain supersonic cruise missile, based on the missile's parameters.

The third rule guarantees the advantages of Flying-Pylons in performance and cost control. The embedded elastic tank is used in modern stealth UAVs. However, hanging the missiles inside the body makes the platform bigger. Hence the increase of weight and size will cut down the profit of the combination. Therefore, the Flying-Pylon will equip semi-sunk mount to fit the requirements.

3 Flying-Pylon Design

The concept of Flying-Pylon is more clear now, so as to the design rules. However, the design of Flying-Pylons should be based on the performance optimization according to the mission requirements.

The supersonic cruise missile is a kind of high speed and powerful weapon, and the combination with Flying-Pylons will provide two kinds of tactics weapon systems as the tool to attack or defense. The difference depends on the cruise speed of the Flying-Pylons.

3.1 Cruise in Supersonic Speed

As the speed from taking-off to battle field is supersonic, the weapon system will be like this:

- Quick reaction capability
- Outstanding penetration ability

This kind of weapon can be used to attack the target with anti-air capability or far from the battle line.

3.1.1 Disposable Flying-Pylon without Engine

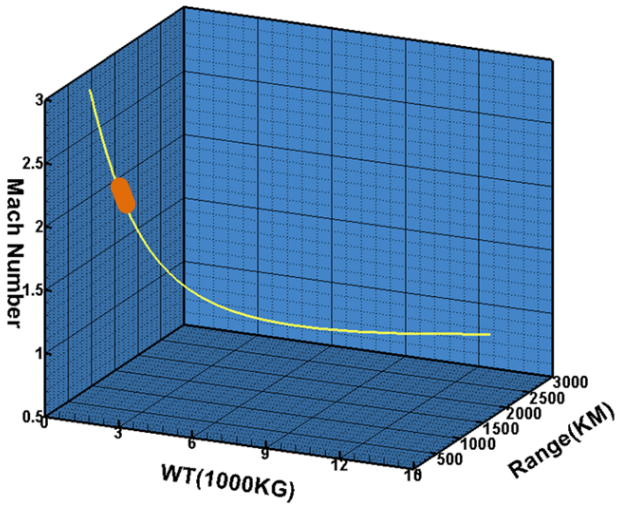

Fig.8 Design Parameters Selection of Disposable Flying-Pylon without Engine

Disposable Flying-Pylon without engine just like the glide wings for the bomb, but Flying-Pylon is not designed to improve the precision but to take more fuel for a longer range.

A line of Flying-Pylons to match the missile are calculated and presented in Fig.8. The "brown part" on the line is selected as the region for the disposable Flying-Pylon without engine.

In this region, the Flying-Pylon is used as a conformal fuel tank. The cruise speed of the combination is about Ma 2.0, and the gross weight is about1800kg. The design can increase about 700km of the range, thus it will support the weapon system attacking the target 1000km away in less than 25minutes.

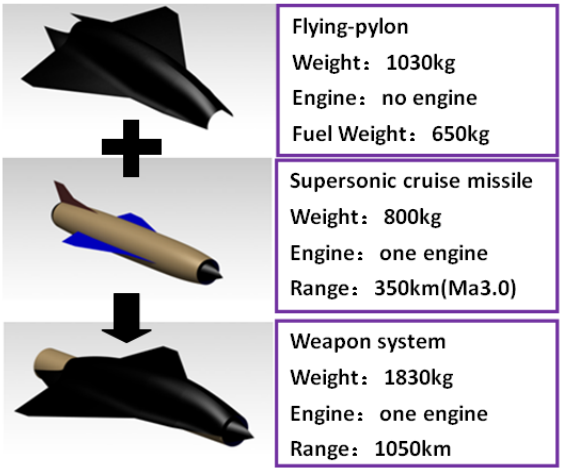

Fig.9 Disposable Flying-Pylon without Engine

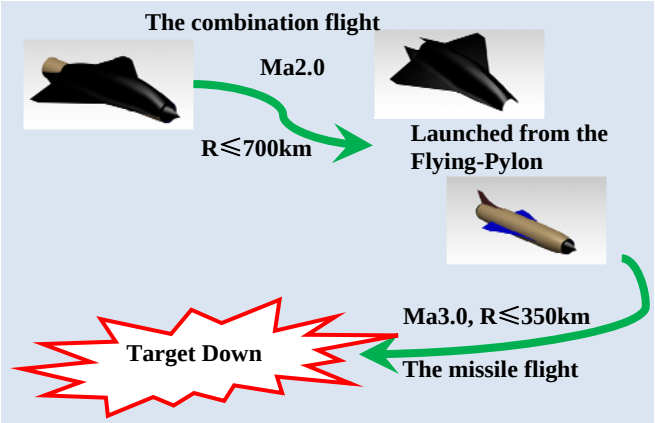

Fig.10 The Use-pattern of The Disposable Flying-Pylon without Engine

3.1.2 Disposable Flying-Pylon with An Engine

Disposable Flying-Pylon with one engine is actually an UAV which combines with the missile can not only improve the range but also implement other functions. The sample of this kind is shaped as an anti-radiation missile here. So the weapon system can take more fuel for a longer range and take the supersonic cruise missile as a "real" bait missile for the anti-radiation one. A Ma3.0 cruise missile is absolutely hard to be head off and the Flying-Pylon could be also afflictive as an anti-radiation missile after it.

The Flying-Pylons matching with the missile are calculated as presented in Fig.11. The "brown part" on the line is selected as the region for this kind of Flying-Pylons.

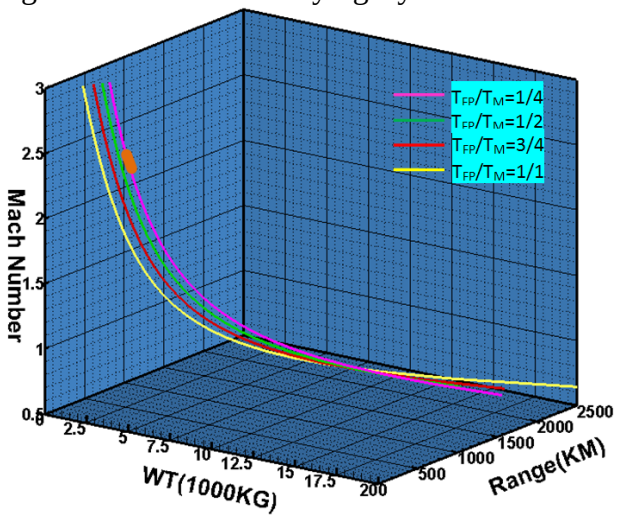

Fig.11 The Design and Parameters Selection of Disposable Flying-Pylon with One Engine

In this region, the Flying-Pylon is used as an anti-radiation missile. The cruise speed of the combination is about Ma 2.2, and the gross weight is about 1650kg. The design can add 420km to the range, thus it will support the weapon system attacking the target 680km away in about 17minutes.

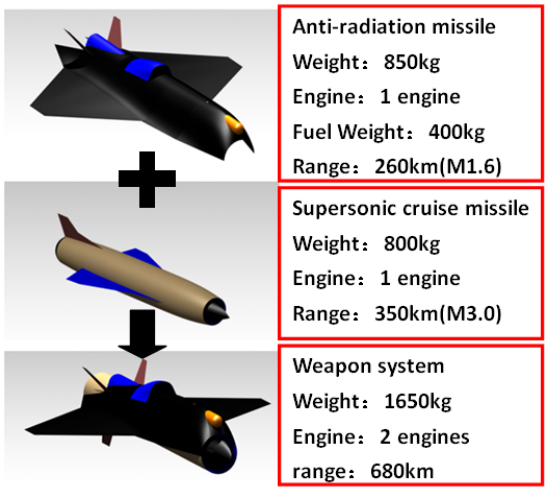

Fig.12 Disposable Flying-Pylon with An Engine

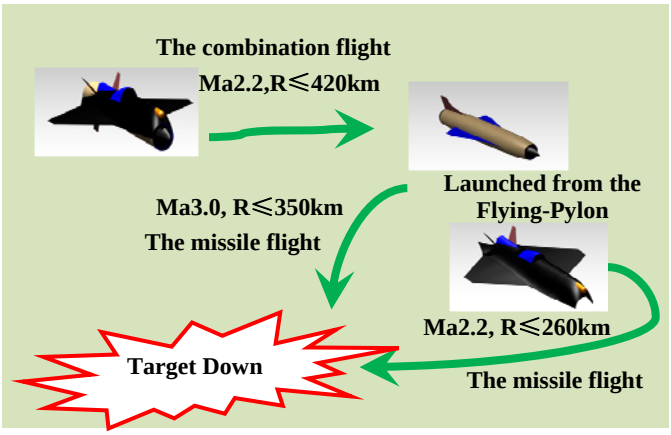

Fig.13 The Use-pattern of The Disposable Flying-Pylon with An Engine

3.2 Cruise in Subsonic Speed (Reusable Flying-Pylon)

As the speed from taking-off to battle field is subsonic, the weapon system will be like this:

- Adaptability for multi-missions
- Attack and defense
- Awareness of battle field state

This kind of weapon system can be used to patrol in sensitive region because it has a longer endurance and range.

Reusable Flying-Pylon is a kind of UAVs either. Hence the Flying-Pylon cruises below Ma 1.0, the sample of this kind is designed as a scout plane here. It can also improve the range

and implement other functions. However, the most important is that the system can wait quietly and take a shoot suddenly.

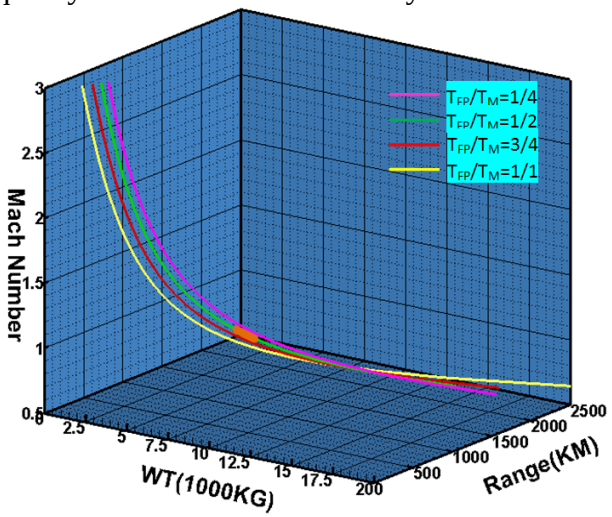

Fig.14 The Design and Parameters Selection of Reusable Flying-Pylon

The Flying-Pylons matching with the missile are calculated as presented in Fig.14. The “brown part” on the line is selected as the region for this kind of Flying-Pylons.

In this region, the Flying-Pylon is used as an scout plane. The cruise speed of the combination is about Ma 0.75, and the gross weight is about8000kg. The design can increase about 1500km of the range, and 110minutes of the endurance, thus it will support the weapon system patrolling in the potential battle field which is about 1000km away from the coast or the base for about 50minutes. And once if the target is appeared， the supersonic cruise missile will be launched and get to the target in 5minutes. Then the Flying-Pylon will evaluate the hit in a minute and go back to the base.

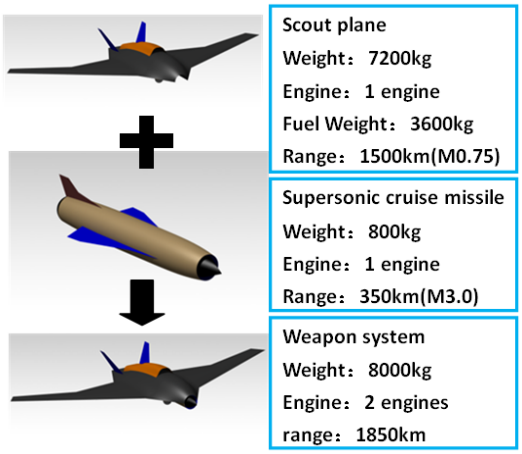

Fig.15 Reusable Flying-Pylon

Table.1 Comparison of Different Platforms

NO.	Platform	Wing Span/m	Gross Weight/kg	Combat Radius/km
1	F/A-18E/F	13.6	29900	1450
2	X47B	18.9	20215	2963
3	RFP	10.0	8000	1500

Table.1 shows the differences between 3 kinds of platforms.

Fig.16 The Use-pattern of Reusable Flying-Pylon

Table.2 Comparison of Two Concepts

Platform	Reusable Flying-Pylon	Traditional Concept	Benefit
Wing Span/m	10.0	10.0	-
Gross Weight/kg	8000	8000	-
Empty Weight/kg	3600	5000	28%
Combat Radius/km	1500	820	83%

A comparison between the traditional concept and reusable Flying-Pylon with same size and weight is shown in Table.2. The missile is mounted below fuselage of the traditional concept and the structural weight increment is mainly caused by the larger engine and landing gears. The comparison result is an initial one. The comprehensive benefit analysis will be done in latter work include aerodynamic performance and RCS either.

The three types of Flying-Pylons presented above are only the part of the iceberg out of water. This technology will bring you much more surprise beyond your imagination.

4 Conclusion

This paper made an introduction of an innovative concept for UCAV development, and the concept is named Flying-Pylon technology. This technology is the research into Platform-Hanging-Mount Integrated Design (PHMID) idea. The definition, the design rules and the samples are introduced to make the technology visualized. Three kinds of Flying-Pylons listed above are easy to be realized and really ingenious. And we hope this paper could bring something new to you.

References

[1] Tian Yi. The introduction of the Y-8 series and the development of special aircrafts. NAAS&INERTIAL TECHNOLOGY, No.88, pp 37-57, 2010.

[2] Sang Yusheng. The Control Configured Vehicle. Aviation Knowledge, No. 9, pp 12-14, 1998.

[3] Tan Jianmei, Zhang Ju and Yan Juan. Information-Centric Unmanned Aircraft System-a New Milestone in the Future Development of UAV. The 2th Conference of China Aviation Institute Youth Science and Technology, Vol.2, pp 166-172, 2008.

[4] Li Xiaoqiang, Wang Qiang. RATTLRS. GLOBAL MILITARY, No.137, pp 38-39, 2006.

[5] Lian Youchun, Wu Hu. Aviation Engine Principle. Northwestern Polytechnic University Press, 2005.

Contact Author Email Address

jianghanjie@163.com

Copyright Statement