APPLICATION OF RELIABILITY, MAINTAINABILITY AND SUPPORTABILITY CAD BASED ON DIGITAL PLATFORM

Wenjin Zhang, Yufeng Sun, Lin Ma, Dezhen Yang
Department of Engineering System of Engineering Technology Beihang University Beijing 100191, P.R. China

Abstract

After analyzing the application of reliability, maintainability and supportability(RMS) engineering and CAD in domestic and abroad, this paper put forward the application framework of reliability, maintainability and supportability CAD based on digital platform. And it discussed the application of traditional RMS design and analysis software, EDA-based performance and reliability integration, simulation-based RMS technology (demonstration and evaluation), while the application of virtual reality technique in equipment maintainability and PDM-based information system of equipment reliability, maintainability and supportability were also discussed in this paper.

1 General Introduction

With the development of complex equipment, the application of CAD was more and more extensive, like Boeing 777 which was designed no paper in Boeing. The same case happened with the development of weapon. It was further developed into PDM(Product Data Management) technology, which combined CAD data with CAM data, and CALS(Continuous Acquisition & Logistic Support) technology. These technique contained massive reliability maintainability supportability CAD software. During the process of their application, great economic benefits were obtained.

Although some development departments have used CAD in the development of arms equipment, many of them were computer-aided drawing processing systems but not the Process CAD System. Therefore, weapon development departments in China didn't bring more benefits from the overall application of CAD. The primarily national defense science and industry committee clearly stated that the same as performance of equipment, quality and reliability of equipment should be promoted. To match the development, reliability, safety, maintainability, testability and supportability ("Five Characters") design should be actually integrated into CAD concurrent design system.

Conclusions demonstrated that the "Five Characters" CAD software should be popularized and applied as soon as possible to satisfy the requirements in the development of new equipment. Under its help, designers can do specialized design and the "Five Characters" design simultaneously and do tradeoff and iterations duly, which decreases workload, improves design efficiency, reduces the development cost and speeds up the development cycle. Then larger economic and social benefits would be achieved.

2 Application of RMS engineering and CAD in domestic and abroad

During the Eighth and Ninth Five Year Plans, Chinese has accumulated plenty of experience on equipment reliability, safety, maintainability, testability and supportability design and analysis theoretic. A set of perfect operational methods in engineering was formed preliminarily which has solid practice in engineering. Moreover, a normative and practical "Five Characters" design and analysis flow has been epurated and many basic data of "Five Characters" have been accumulated.

With the extensive application of RMS design and analysis technique and the development of computer, massive "Five Characters" CAD software have appeared at abroad since 1980s, which were mainly from America and Europe and were extensively applied to products design. They not only improved work efficiency, but also achieved economic benefits to some extent. Recent years, some software like RELEX, ITEM, ISOGRAPH and RELISOFT have entered into China market. As follows:

- Supporting traditional reliability, maintainability and supportability design and analysis software;
- The application of EDA-based software in reliability;
- Supportability simulation and analysis software.

Similarly, Chinese have done plenty of studies on the development of reliability, maintainability and supportability CAD software. For example, ARMS2.5, which supported all of the traditional reliability, maintainability and supportability design and analysis. It was developed by Reliability Engineering Technology Center of Beihang University and put into market after secondary development like engineering and commercialization, which was extensively applied in Chinese enterprises.

3 Application of RMS-CAD technique

3.1 Application Framework of RMS-CAD based on Digital Platform

Fig. 1 depicts the application framework of reliability, maintainability and supportability CAD based on digital platform.

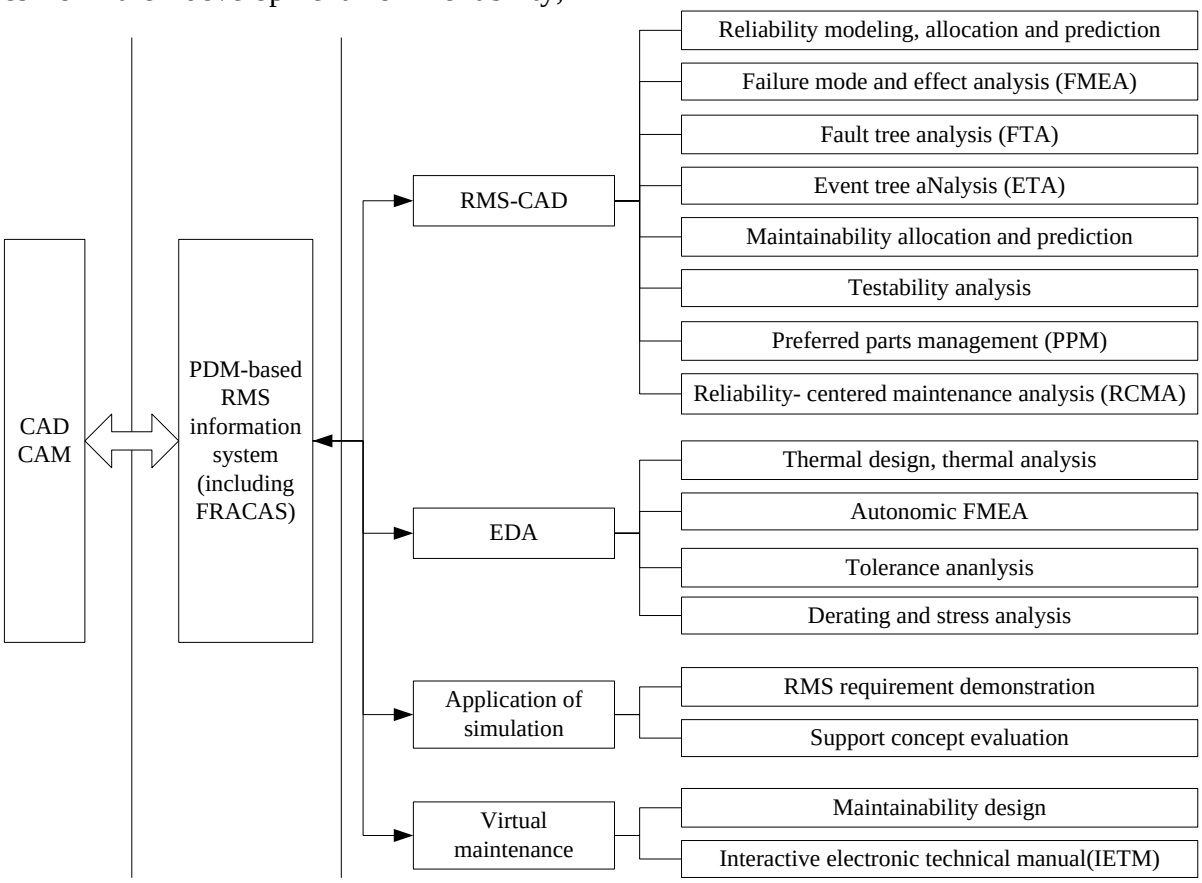

Fig. 1 The application framework of RMS–CAD based on digital platform

The contents it contains are as follows:

- Traditional RMS design and analysis techniques
- The application of EDA-based performance and reliability integration

- The simulation-based RMS technology (demonstration and evaluation)
- The application of virtual reality technique in equipment maintainability

3.2 Traditional reliability, maintainability and supportability CAD(RMS-CAD)

The conventional and traditional reliability, maintainability and supportability design and analysis techniques are as follows:

- Reliability and applicability model;
- Reliability allocation and prediction;
- Failure modes, effect and criticality analysis(FMECA);
- Fault tree analysis(FTA);
- Event tree analysis(ETA);
- Maintainability allocation and prediction;
- Testability analysis;
- Reliability-centered maintenance analysis(RCMA);

Failure report, analysis and corrective action system(FRACAS).

3.3 Application of EDA-based performance and reliability integration[1]

Traditional reliability design that not actually applied into equipment development was disjunctive with performance design on which the results of "five characters" design and analysis have no effect. As follows:

- Because of lax management and ineffective supervision, reliability design was always behind performance design in development phases. They are always asynchrony. Therefore; reliability can't play a role in finding defects.
- The lagging of knowledge training about reliability brought that many performance designers lack of reliability knowledge and ignore its importance. Therefore; they had wrong concept about reliability or neglected it during the design.
- Except from subjective and management factors above, lacking autonomic reliability analysis tools synchronizing with performance design was the objective factors. Owing to extensive contents of reliability in technique including standards, criterions and methods, designers should spend much time on complete FMEA, prediction, tolerance analysis and so on. If designers combine "five characters" design with performance design, the combination between thermal design and tolerance analysis is a better choice because of their related hardware and EDA software.

Followings are contents(shown in Fig. 2) it contains.

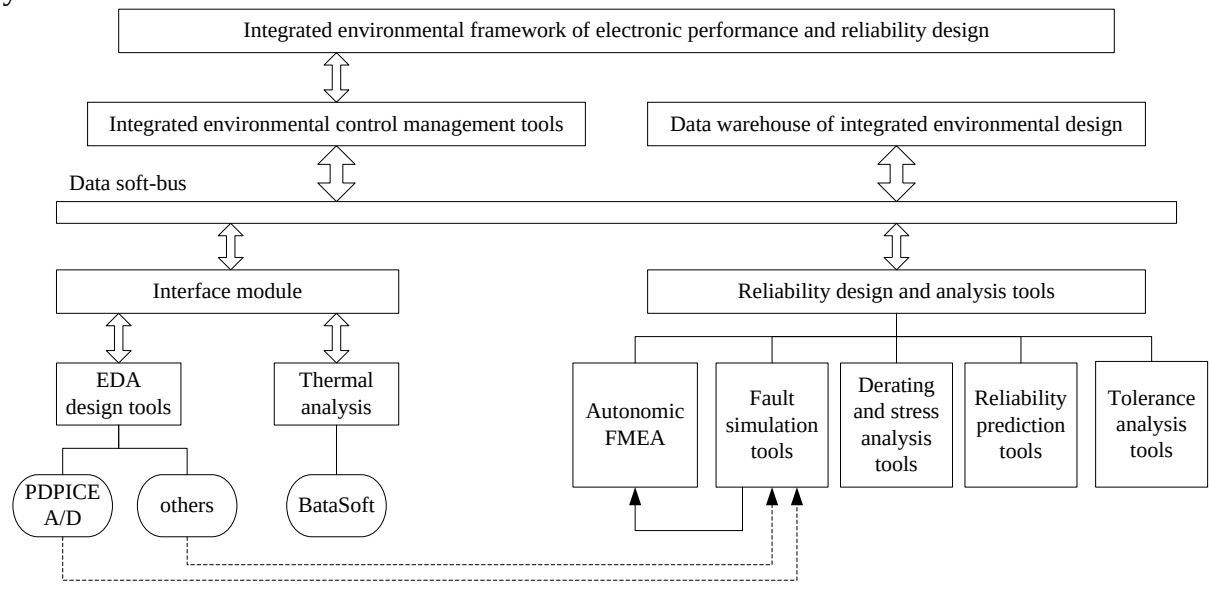

Fig. 2 The application of EDA-based performance and reliability integration

- General technology of electronic performance and reliability integration

It includes general technology concept, integrated environmental framework design of performance and reliability, model of parts failure modes, interface design principles of typical EDA tools, fault injection technique, fault identification technique and so on.

- Construct integrated environmental platform of electronic performance and reliability design(prototype)

It should develop or integrate performance with reliability design and analysis tools exist like EDA tools, thermal analysis tools, reliability prediction tools, fault simulation tools, autonomic FMEA tools and stress derating analysis tools.

3.4 "Five characters" items based on simulation

3.4.1 Demonstration of weapon materiel RMS requirement based on simulation

In the demonstration of equipment tactical and technical index, reliability, maintainability and supportability indexes are required on the general requirement of research, but their demonstration is very difficult for operational departments and development departments. The causes are as followed.

- Understanding of the indexes;
- Implementation of indexes' verification methods;
- Lack of perfect demonstration and analysis tools;
- Lack of basic data.

Simulation refers to models to test instead of systems, while computer simulation prefers to using models to test in computer instead of actual system. Demonstration of arms' RMS indexes based on combat simulation is to use attack-defense confrontation simulation to achieve operational effectiveness index according to arms' RMS indexes and operational effectiveness index to some extent, and to decide that the index is good or bad by its value. The followings are general processes.

- Depict operational environment and mission;
- Construct evaluation indexes;
- Establish simulation concept and models;
- Simulation tests and evaluation.

The paper considers that using simulation to RMS requirement demonstration is feasible after implementing it to several main materials, and there are supporting tools.

3.4.2 Research on support concept evaluation based on simulation[2]

There are ten elements in materials' support. Support facilities, support equipment, personnel, supply support, technical data, computer resource support, training support and packaging, handling, storage and transportation are included.

However, there are lack of systematic techniques and software tools to evaluate support capability of support system matching to materiel. For example, analyzers calculated spare requirement through empirical formula, its failure rate and support probabilities. They didn't consider products' future operational mission comprehensively.

Based on relevant research, we achieved several models and software of support resource evaluation and analysis based on simulation. Fig. 3 depicts the framework of support concept evaluation system based on simulation.

3.5 Application of virtual reality technique on equipment maintainability

Some problems exist in traditional maintenance tasks, which induce these tasks need designers to simulate on prototypes. Therefore; the development lags behind. The same problem happened on the development of maintenance regulations establishment and maintenance training. In this case it should wait until production finalization phase or operation phase preliminarily. This "serial" design mode can't settle the problems in products as soon as possible. And some problems relevant to maintenance didn't appear until the products were put into use. However, it's difficult to improve the products because of the end of design work.

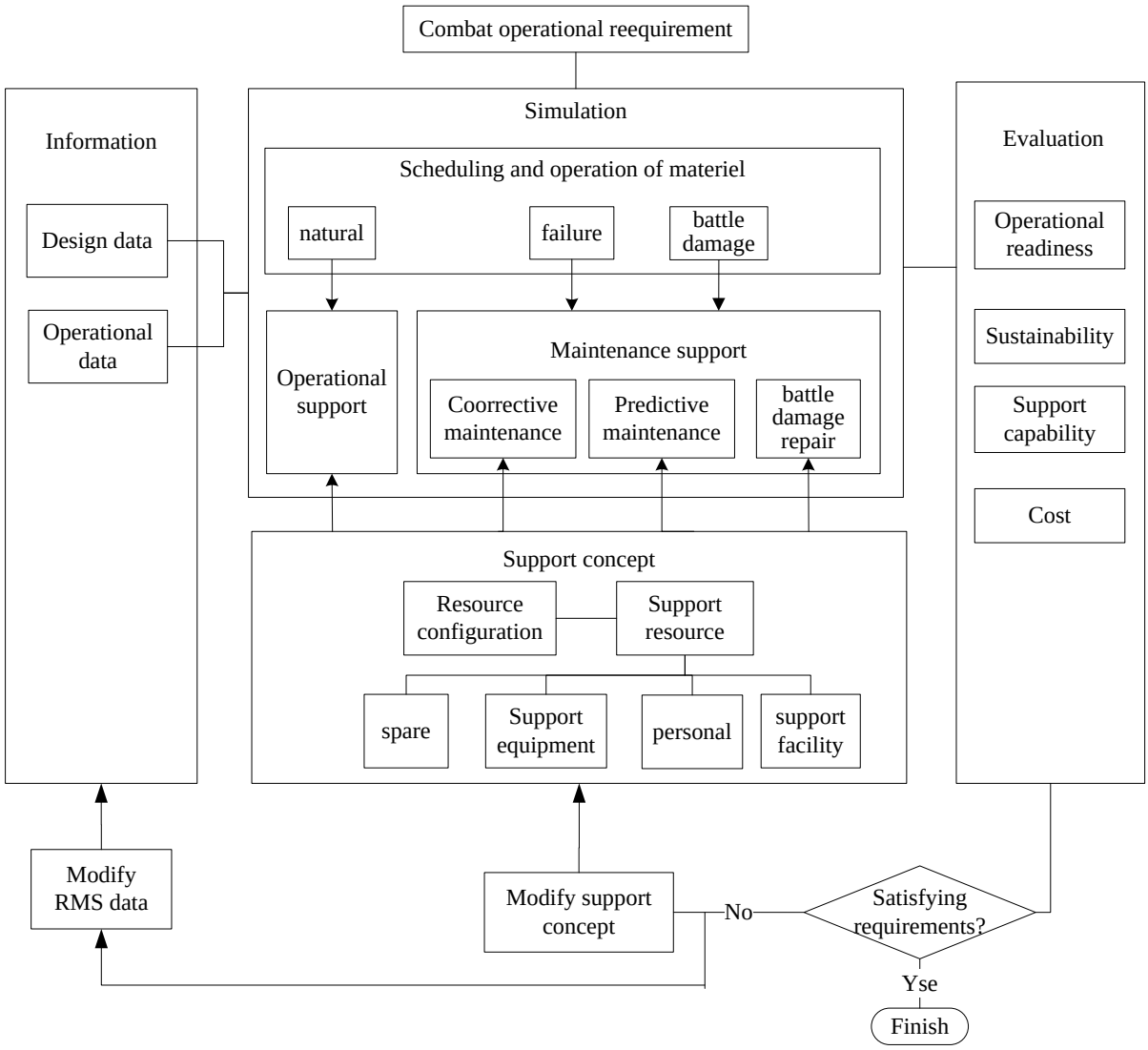

Fig. 3 Support concept evaluation system based on simulation

In order to perfectly design and evaluate products' maintainability in early life cycle, it is necessary to introduce new methods. Recently, digital type technique has achieved success in industry like Boeing 777, whose design and produce are no paper, which improve its production efficiency and diminish its development cycle greatly. On the other hand, because of quick development of 3D mannequins, body 3D model in Delmia and Jack systems are extensively implemented in industries like cars, aeronautics and astronautics. Moreover, it was also introduced into CATIA of CAD/CAM, and Boeing's BHMS system has all body models needed in human factors analysis. Therefore; it's possible to study on products' maintenance problems under virtual environment.

Digital type technique allows designers to design products' appearance and structure character earlier than physical prototype phase, which is convenient for designers to know products' maintainability. And it can achieve a maintenance simulation of "virtual one repair virtual products" by integrating digital type to 3D mannequins, which will be provided as additional tools for maintainability and maintenance tasks.

The writer belongs to national defense science and industry committee, who has done plenty of studies about it and has gotten greater accomplishments. For example, virtual maintenance process depiction tools, maintenance tasks evaluation and analysis technique based on virtual maintenance.

Developing digital and virtual maintenance implement system based on combination of 3D mannequins, digital type and virtual technique, is convenient for designers and maintainers to qualitatively or quantitatively evaluate products' maintainability in early design phase and provide suggestions to improve maintainability design. Then, the maintenance effectiveness will be improved and the lagging of maintainability and supportability tasks will be meliorated greatly. Moreover, the virtual maintenance system can be aid to configure maintenance support resource, establish maintenance regulations and provide maintenance training. Implementation scheme of virtual maintenance system is shown in Fig. *4*.

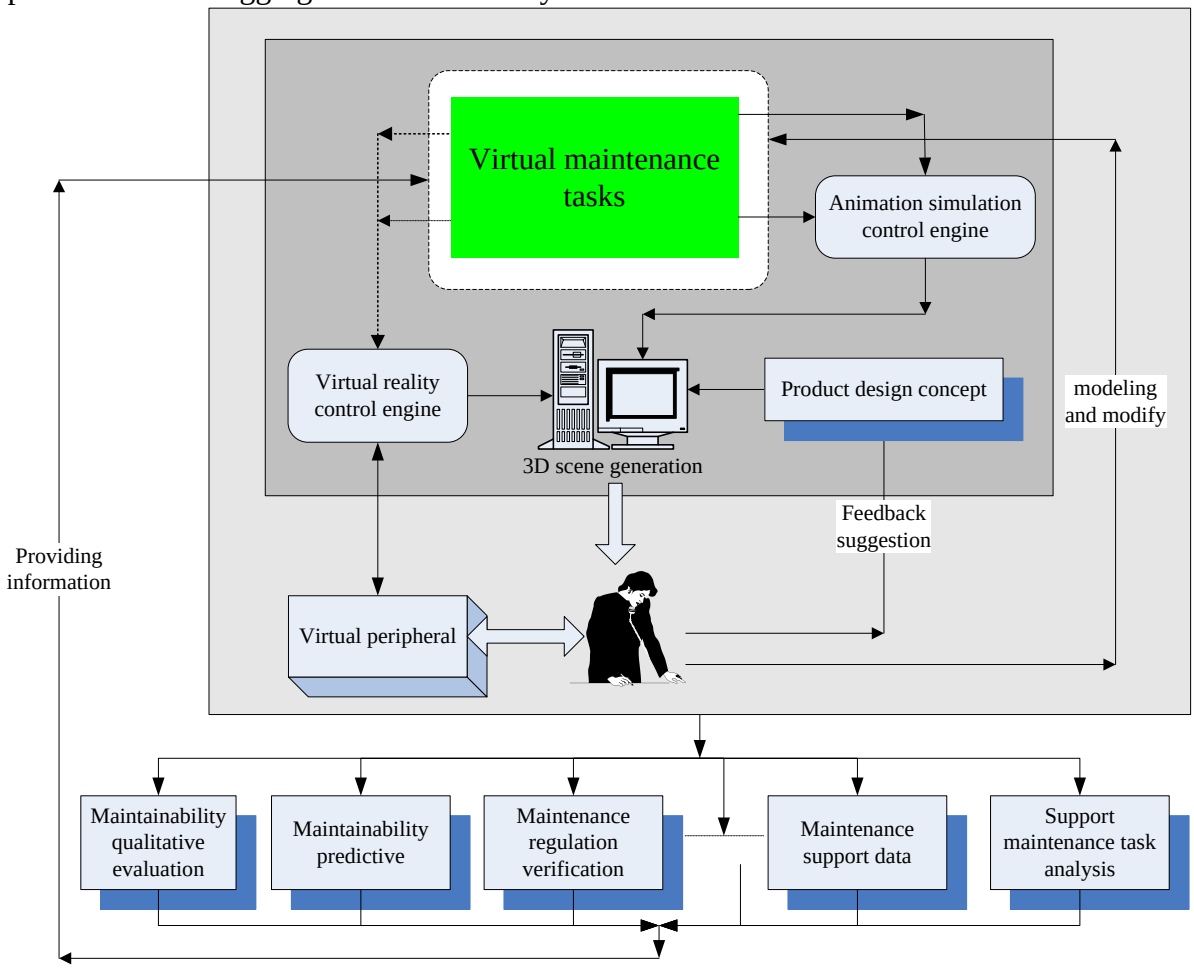

Fig. 4 Implementation scheme of virtual maintenance system

In aspect of developing virtual maintenance simulation, our laboratory has complete and advanced virtual maintenance hardware, seasoned researchers and developers and abundant implementation experience, which can provide concept for virtual maintenance implementation on materiel development.

3.6 RMS information system based on PDM[3]

There are massive reliability, maintainability and supportability information produced in concept demonstration phase, design and development phase, production phase and operation phase. Following is the mainly contents.

- Reliability, maintainability and supportability thresholds, predicted value, analyzed value, test evaluated value and operation evaluated value produced in materiel demonstration, development and operation;
- Quality assurance program, reliability, maintainability and supportability program plan and their review reports;

- Reliability, maintainability and supportability analysis reports;
- Major failure analysis and corrective actions in development and operation;
- Results and analysis reports of performance test, environment test, durability test, reliability test, maintainability demonstration, test run flight test, et al;
- Severe and general abnormal quality and reliability problem, analysis, handling and effects;
- Reject analysis and handling information in production;
- Products acceptance and qualified rate of routine test in production;
- Information about products' operation, failure and defect;
- Information about products' storage reliability;
- Information about products' useful life;
- Information about products' maintenance way, cycle, man hour and cost;
- Stat of maintenance error and results;
- Category and list of common and peculiar support equipment;
- Supplies of support equipment and its exist problems;
- Information about operation and maintenance technical data list, supplies and suitability;
- Static of operation and maintenance personnel level;
- Other basic data(similar product, military standards, manual and instruction, training data, et al).

4 Summary

The paper analyzed reliability, maintainability and supportability data produced in materiel life cycle systematic and scientific. Based on ERP and PDM exist and WAN technology of guarantee data security, it promised general framework of distributed database in each materiel development phase, achieved new generational information system which can collect, analyze and release information about materiel reliability, maintainability and supportability, and carried out information communication between development departments and operation departments based on this system.

Contact Author Email Address

Wenjin Zhang: zwjok@buaa.edu.cn
Dezhen Yang: muyidz@126.com

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