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www.scaae.org

From the Editor

David Lin and Diane Li

I would like to take the opportunity to thank and congratulate all SCAAE members for all your personal and professional accomplishments in the past 25 years and your great contribution and participation in our very own SCAAE organization. To make this journal possible, we have many members who donated their personal times to help in many different ways, many thanks to those individuals. We sincerely thank those who placed commercial advertisement in our journal. Thanks are also extended to many of our friends and family members for your continuous support. In this 2014 edition of journal, we would present you our variety activities happened in the past year, share with you our ideas, thoughts, joys and knowledge that reflect our dedication to the organization and professional life. With your participation, SCAAE tradition and spirit cultivated from date one by Chinese American Engineers will continue.

And welcome to visit SCAAE website at http://www.scaae.org

All views and opinions presented in this journal are represented by each individual contributor and do not reflect the position of SCAAE.

Finally I wish you enjoy this 2014 journal and another wonderful and flourish year ahead.

About SCAAE

The Society of Chinese American Aerospace Engineers (SCAAE) is a professional organization. It was established in 1989 at Pasadena, California. After years of growth, it now has more than 300 members. SCAAE consists of three local chapters and a national chapter, i.e., the West Chapter in Los Angeles, the Northwest Chapter in Seattle, and the South Chapter in Dallas. The three local chapters then form the National Chapter to represent the entire organization to the outside world. The purpose of SCAAE is to support members' professional growth and career development, promoting cooperation among aerospace industries in USA, China and Taiwan. We also want to increase Chinese American Aerospace Engineers' influence and maintain members' benefits in the aerospace industry.

From SCAAE-West President and Chairman

We are proud to celebrate 25 years of SCAAE's existence in 2014. For over a quarter of a century, SCAAE has kept its momentum going strong in serving our members and the aerospace industry. SCAAE has great traditions that our founding members have established and all members have carried out. As a professional organization, SCAAE has been multifaceted in terms of its activities, connections and promotions. Not only can each member participate and learn, but they help and impact other people and communities that would not be possible without SCAAE. For the time being, SCAAE, resembling the entire aerospace industry, is experiencing generation shifting that is profoundly affecting the industry. SCAAE is actively riding through the challenges with new sets of vision and objectives to position itself and better serve our members and communities in a long run. Once again, our thanks extend to all SCAAE sponsors for supporting us and all members, their families and friends for being with us over the years.

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SCAAE 2014 ORGANIZATION CHART
美華航太工程師協會 2014 年組織及會務人員

全美総會 (SCAAE-National Chapter)

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孫嘉康 (Chuck Sun), 王嵩壽(George Wong), 陽道華 （Eric Yang）,

袁保麟(Pao-lin Yuan), 曾山英 (Shanying Zeng)

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歐陽小平 (Philip Oyoung), 潘建光 (Tony Pan), 孫嘉康 (Chuck Sun),

仝冰 (Bing Tong), 袁保麟 (Pao-lin Yuan), 翁达聪 (Dacong Weng), 王蓉 (Amy Wang),

王嵩壽 (George Wong), 鄭大光 (Daguang Zheng)

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<u>美南分會 (SCAAE-South)</u>

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<u>顧問(Advisors):</u>

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駐台北代表: 戎凱

SCAAE NATIONAL CHAPTER HONOR ROLL
美華航太協會全美總會歷屆會長和理事長

Year	President （會長）	Chairman （理事長）
2014	曾山英 (Shanying Zeng)	陽道華 (Eric Yang)
2013	陽道華 (Eric Yang)	曾山英 (Shanying Zeng)
2012	李湘渝(Shiang-Yu Lee)	馬在莊(Nelson Mar)
2011	馬在莊(Nelson Mar)	李湘渝(Shiang-Yu Lee)
2010	戴羿(Jason Dai)	黃啟鵬(Louis Huang)
2009	田長焯(CC Tien)	戴羿(Jason Dai)
2008	黃啟鵬(Louis Huang)	田長焯(CC Tien)
2007	黃啟鵬(Louis Huang)	田長焯(CC Tien)
2006	李全伶(Charles Lee)	田長焯(CC Tien)
2005	田長焯(CC Tien)	李全伶(Charles Lee)
2004	李全伶(Charles Lee)	田長焯(CC Tien)
2003	田長焯(CC Tien)	歐陽小平(Philip Oyoung)
2002	田長焯(CC Tien)	歐陽小平(Philip Oyoung)
2001	歐陽小平(Philip Oyoung)	田長焯(CC Tien)
2000	歐陽小平(Philip Oyoung)	田長焯(CC Tien)

SCAAE WEST CHAPTER HONOR ROLL
美華航太協會美西分會歷屆會長和理事長

Year	President （會長）	Chairman （理事長）
2014	潘建光 (Tony Pan)	王嵩壽 (George Wong)
2013	王嵩壽 (George Wong)	鄭大光 (Daguang Zheng)
2012	鄭大光 (Daguang Zheng)	孫嘉康 (Chuck Sun)
2011	孫嘉康 (Chuck Sun)	袁保麟(Pao-lin Yuan)
2010	袁保麟(Pao-lin Yuan)	林峰(Frank Lin)
2009	袁保麟(Pao-lin Yuan)	林峰(Frank Lin)
2008	林峰(Frank Lin)	陳西書(His-Shu Chen)
2007	陳西書(His-Shu Chen)	佟儀(Tony Torng)
2006	佟儀(Tony Torng)	（陳立德）（Victor Chen）
2005	（陳立德）（Victor Chen）	滕穎(Ying Teng)
2004	滕穎(Ying Teng)	陳 淳(Bill Chen)
2003	陳 淳(Bill Chen)	陽道華(Eric Yang)
2002	陽道華(Eric Yang)	賴英政（John Lai）
2001	賴英政（John Lai）	沈方楠 (Fred Shen)
2000	沈方楠 (Fred Shen)	黃啟鵬(Louis Huang)
1999	(趙秀軍)(Richard Chao)	黃啟鵬(Louis Huang)
1998	黃啟鵬(Louis Huang)	許志凡(Jeffrey Shu)
1997	黃益三(Yatsum Huang)	馬在莊(Nelson Mar)
1996	許志凡(Jeffrey Shu)	李龍富(Tom Lee)
1995	馬在莊(Nelson Mar)	李全伶(Charles Lee)
1994	李龍富(Tom Lee)	劉政平(Stephen Liu)
1993	李全伶(Charles Lee)	楊孫均(Michael Yang)
1992	楊孫均(Michael Yang)	歐陽小平(Philip Oyoung),
1991	劉政平(Stephen Liu)	歐陽小平(Philip Oyoung),
1990	歐陽小平(Philip Oyoung)	
1989	歐陽小平(Philip Oyoung)	

SCAAE NORTHWEST CHAPTER HONOR ROLL
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Year	President （會長）	Chairman （理事長）
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2013	Jack Jianxia Liu (柳建夏)	Kangmin Niu (牛康民)
2012	Jack Jianxia Liu (柳建夏)	Shanying Zeng （曾山英）
2011	Shanying Zeng （曾山英）	Shawn Li （李湘宏）
2010	Shawn Li （李湘宏）	Key Donn（唐克）
2009	Shawn Li （李湘宏）	Ed Miao （繆志毅）
2008	Ed Miao （繆志毅）	Jason Dai （戴羿）
2007	Jason Dai （戴羿）	Oliver Hsu （徐一宸）
2006	Oliver Hsu （徐一宸）	Key Donn （唐克）
2005	Key Donn （唐克）	Jason Dai （戴羿）
2004	Key Donn （唐克）	Jason Dai （戴羿）
2003	Key Donn （唐克）	Jason Dai （戴羿）
2002	Jason Dai （戴羿）	Kuen Y. Lin （林坤源）
2001	Kuen Y. Lin （林坤源）	CC Tien（田長焯）
2000	Kuen Y. Lin （林坤源）	CC Tien（田長焯）
1999	CC Tien（田長焯）	
1998	CC Tien（田長焯）	
1997	CC Tien（田長焯）	

謝謝捐款讚助

Thank you for donation

李全伶	(Charles Lee)	$500
歐陽小平	(Philip Oyoung)	$200
劉政平	(Stephen Liu)	$100

Highlight of SCAAE (West) Activities in 2013

George Wong, President of SCAAE - WEST

With the support, participation of the members and friends, also the hard working board members, officers to endure the few after hours working meetings, SCAAE is able to provide services, activities and networking for members.

We want to solute Charles Lee to allow SCAAE using his office and stay late to support board meetings as always.

On March 2nd, the 24th annual SCAAE 2013 convention and seminar were held in Cerritos, California. 50 members showed up at the day-time seminar sessions, and 200 guests gathered in the evening convention events. We appreciated everybody's support and will work hard to make sure our future success of these events.

2013 SCAAE Evening Convention

SCAAE March 2nd 2013 Convention Day Time Technical Seminar

March 30th, 2013, we attended The Chinese-American Engineers and Scientists Association of Southern California 51st Convention.

On April 20th, China Commercial Aircraft Co. (COMAC) delegation of 7 people visited Southern California. 50 SCAAE members joined the dinner with the delegation. COMAC shared the C919 project status, the company growth; it is encouraging to know that China Commercial Aviation is attracting many high caliber engineers and management to help building the growing industry.

August 17, 2013, we were invited to celebrate The Overseas Chinese Civil and Structural Engineer Association (OCCSEA) Founding Ceremony in Orange County.

SCAAE held 2013 BBQ picnic party in Cerritos Park East on Oct. 8th. We had a good time with old and new friends to catch up with work and daily life.

2013 has been a memorable year of SCAAE. Tony Pan will take over to become new president of SCAAE – West into 2014.Our membership kept growing. We nominated couple of new board members to replace the retired members, let's welcome our two new members; Diane Li and Amy Wang.

SCAAE NORTHWEST 2013 HIGHLIGHTS AND RETROSPECT

Jack Jianxia Liu (柳建夏) Ph.D., 2013 SCAAE NW President

2013 is a historical unforgettable year for SCAAE North West chapter. This is because SCAAE NW chapter was officially incorporated in Washington State as a non-profit organization/ corporation and also filed application with Department of the Treasury Internal Revenue Service for the Recognition of Exemption Under Section 501(c)(3) of the Internal Revenue Code. This laid a solid foundation for SCAAE NW chapter to grow healthily in the future. With the effort made by members, officers, board directors, and supporters, SCAAE NW chapter held the events that would leave very beautiful memories as highlighted in the followings.

On February 9, 2013 SCAAE NW hosted Chinese New Year Eve celebration at Community Center in Mercer Island, WA. SCAAE NW greatly appreciated sponsors for the thousands of dollar prizes ranging from cash, housewares, event tickets, international round trip airplane tickets, and over $1000 one day wedding photograph certification. SCAAE NW would like to especially thank to professional photographer, Mr. Michael Chandler for offering the certificate and a free portfolio photos sitting for all participants.





On March 2, 2013 CC Tien, Shiang-Yu Lee, Shanying Zeng, Helen Jiang, and Jack Liu from SCAAE NW Chapter attended 2013 SCAAE seminar and annual convention held at Artesia and Cerritos, CA.

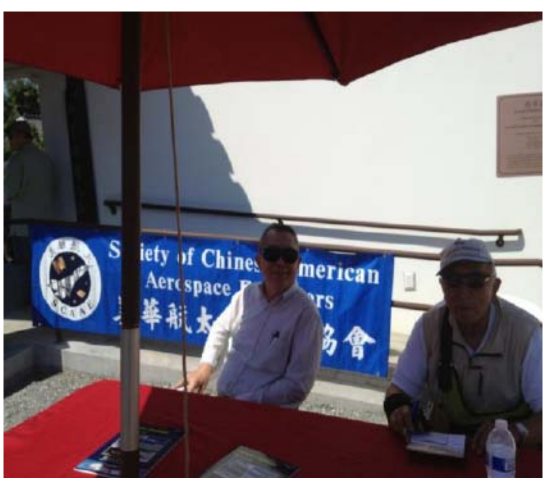
On April 12, 2013, SCAAE NW hosted Introduction of Civic Aviation Administration of China (SAACC) at Everett Lucky Buffet Restaurant. SAACC 中国民用航空局,适航局局长和主任 gave the introduction of SAACC and over 60 members attended this event.

On April 18, 2013 SCAAE NW and CIE co-hosted Spring Dinner Gathering with COMAC guests at Chengdu Garden (蓉园) Restaurant, Bellevue, WA. Guest speakers gave a brief introduction to Chinese Commercial Aircraft Development Progress and Future as well as the C-919 commercial aircraft design. Over 60 SCAAE members attended this event.

On June 15, 2013, SCAAE NW hosted 2013 June Technical Seminar at Kirkland Library, Kirkland. Dr. Katie Zhong, Westinghouse Distinguished Professor of Washington State University presented a "Nano-Nectar" (Liquid Nano-Reinforcement) Technology Leading Epoxy to High Performance and Low Viscosity. Dr. Weidong Song, a structure lead engineer at the Boeing (IRC) in Everett, WA presented Ultrasonically Aided Electrospraying (UAE) technology.

On July 17, 2013, SCAAE NW participated in the joint summer picnic event with several Seattle Chinese-American associations at Newcastle Beach Park, Bellevue.

On August 10, 2013, SCAAE NW sponsored Seattle Chinese Garden Kite Festival 风筝节.



On September 1, 2013, SCAAE NW hosted Triton Aerospace Tour, target shooting and BBQ Dinner. SCAAE NW greatly appreciated SCAAE life time member, Mr. Tom Guohang Xue hospitality for opened up his facilities and resources to members for this event. Over 50 members attended this event by car and Ed Miao attended this event by flying a smaller airplane.




On September 21, 2013, as the invited guests SCAAE NW chapter board directors: Helen Jiang, Kangmin Niu, and Jack Liu attended CIE 2013 Annual Convention held at The Westin Bellevue, Bellevue. SCAAE NW board directors: Jack Peng, Shiang-Yu Lee, and Ed Miao who are on CIE board are present at the convention and Ed Miao is President of CIE Seattle chapter this year.

On October 26, 2013, SCAAE NW hosted 深秋化妆舞会 at Mercer Island Community Center, Mercer Island, WA. On Nov 10, 2013, SCAAE NW sponsored China in Water Ink - a gala performance《水墨中华》at Meydenbauer Convention Center, Bellevue, WA.

頒贈 2013 年榮譽獎報告

歐陽小平 博士

美華航太工程師協會自 2010 年起頒發兩項榮譽獎給過去對本會有重大貢獻的人士，以彰顯他們的成就及表達我們的感謝。首項獎項是〝航太協會終身成就獎 (SCAAE Lifetime Achievement Award) 〞，得獎人的資格為超過 62 歲並加入本會十年以上的資深會員、且非地方分會的現任理事、在過去多年內曾持續對航太協會有重大貢獻者；至於對曾大力支持幫助過我們的外界朋友們，我們每年擇一頒贈〝航太協會之友獎 (Friend of SCAAE Award) 〞。

去年經過理事會慎重的舉荐與討論後，決議第四屆航太協會終身成就獎得獎人為黃啓鵬博士，而航太協會之友獎的得獎人從缺。理事會在 2013年的年會中頒獎給黃博士，實質榮歸，甚獲佳評。現特將得獎人的簡介刊登如下以供讀者參閱，航太協會並在此再向他致賀與致上最大的謝意。

2013 SCAAE Life Time Achievement Award
2013 年航太協會終身成就獎
得獎人: 黃啟鵬博士 (Dr. Louis Huang)

黃啟鵬前理事長畢業於國立台灣大學機械工程系，來美進修於普渡大學航空工程系得碩士學位，後於俄亥俄州立大學航空及太空工程系獲博士學位。他是太空系統安全的專家，於1969年進入Radiation Inc. 工作，他日後服務於 Computer Science Corp, Rockwell International, Naval Civil Engineering Lab等公司及單位担任科學家或企劃工程師，曾參與太空梭研發等大型計畫。他於1985 年進入美國空軍洛杉磯空軍基地 (LAAFB) 的太空及飛彈系統中心 (SMC) 工作至 2009 退休，直接為美國政府效力長達24年之久，在華人中是少見的。在這期間，他曾擔任 Branch Chief, Manager, Deputy Director, Acting Chief 及 Acting Director 等職務，在職位上曾領導團隊參與多項美國大型航太計劃及飛彈計劃，在軍方文職人員中有極傑出的表現，深受同仁尊敬，更為華裔爭光。

黃啟鵬博士對航太協會一向有著深厚的感情，故他在繁忙的政府工作外，還盡量抽出時間為本會服務，不遺餘力。他曾於1998年擔任會長，於1999 及2000年擔任理事長。他又於2007及2008兩年擔任全美總會會長，於2010年擔任總會理事長。他於過去的24年間持續大力支持航太協會，未曾間斷，對本會今日的成果貢獻良多。故理事會決議頒贈他”2013年航太協會終身成就獎”，以表彰他對航太協會重大的貢獻及在航太工程界的地位。

Reliability Modeling and Failure Forecast for Some Aerospace Engineering Systems

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Abstract — **Repairable system reliability modeling and failure forecast plays an important role in aerospace engineering. When performed properly, it can help to: 1) ensure and improve aircraft system reliability, flight safety and airline schedule reliability, 2) reduce airline repair and maintenance cost and 3) optimize budget planning and spare parts inventory control. This paper introduces some important stochastic models that can be implemented by reliability professionals in aerospace industry. A Monte Carlo simulation procedure is proposed to solve this complicated problem.**

Keywords - reliability, failure forecast, repairable systems, virtual age, repair effectiveness.

I. INTRODUCTION

Most aerospace systems and components, such as aircraft engines, are repairable. Repairable system reliability modeling and failure forecast is not an easy task, especially for the aerospace systems. This is mainly due to complexity of the system itself and the effect of repair. Lots of research studies have been conducted in this area and various reliability modeling approaches have been developed. However, it is difficult to find a readily available approach to practically solve the real world problems. There are several factors that are crucial to the success of a viable approach: 1) effective data collection, 2) through understanding of the system's functions, structures, components, repair and maintenance practices, 3) useful tool sets for reliability analysis and modeling at various levels (system, subsystem and component, etc.) and 4) clear understanding of modeling capabilities and limitations.

This paper aims to introduce a systematic approach which can be used to predict the quantity of repairable system failures for a fleet of aerospace systems, for instance, a fleet of aircraft engines. Some commonly used stochastic models that are applicable to repairable systems will be introduced. An example on small gas turbine engines will be presented to illustrate the newly developed approach.

II. REPAIRABLE SYSTEM RELIABILITY MODELS

A system is considered reparable if upon failure it can be restored to operating condition by any procedure other than complete replacement. Compared to non-repairable systems, repairable systems reliability modeling is more complicated [1, 2], mainly because of the repair effect on reliability. For instance, upon failure, a gas turbine engine will typically be sent to a repair shop and for condition based repair. It will be disassembled, repaired, and tested after repair. The degree of repair depends on the failure mode, severity of the failure effect, and conditions of the engine. It can be: 1) minimum repair, such as no fault found, 2) minor repair, such as carbon seal replacement, 3) partial repair, such as replacement of several parts, or 4) major repair (overhaul), such as replacement of more than half of the key components. The expected time to next failure is correlated to the degree of repair. Therefore, reliability modeling of aircraft gas turbine engines needs to consider repair effectiveness.

The times between failures of a repairable system are random variables. Therefore, the life cycle of a repairable system can be depicted by a stochastic process. The time to first failure of a new system can be modeled by a life time distribution. When the times to first failures data from multiple and identical systems can be collected, a life time distribution analysis (e.g., Weibull analysis) can be conducted to estimate the model parameters. However, this model is only applicable to the time to first failure analysis, unless each repair can restore the system back to as good as new condition. In reality, due to cost and other reasons, a system may not be restored back to as good as new condition. If this is true, then the times between two consecutive failures may not be independently and identically distributed. Currently, three categories of modeling approaches have been developed for analyzing repairable systems: 1) RP (Renewal Process), 2) NHPP (non-homogeneous Poisson process), and 3) GRP (General Renewal Process). All of these models are stochastic point processes. There is also a key assumption: compared with the system operating times, the repair times are typically negligible.

A. *Renewal process*

Renewal process can be applied if after failure a system can be restored to as good as new condition. For a renewal process, the times between failures are independent and identically distributed. For the aircraft engines, if all repairs are at the overhaul level, which means after each repair, an engine will be restored to as good as new condition, then the failure process can be modeled by a renewal process. The homogeneous Poisson process (HPP) is a special case of RP. The times between failures of a HPP follow an Exponential distribution.

B. *Nonhomogeneous Poisson process*

Nonhomogeneous Poisson process (NHPP) can be used to model a repairable system if all of the repairs are minimum, which means a repair or maintenance action will only restore the system back to as bad as old condition. For instance, an oil change will not change an automobile's condition as long as no parts have been replaced or repaired during maintenance. Therefore, oil change is the only repair or maintenance action conducted and after the oil change the system's reliability property will not change. From system stand point, a NHPP can be properly used to model the as bad as old system.

C. General renewal process

In reality, the two assumptions mentioned above: 1) as good as new, and 2) as bad as old, are rarely applicable in practical applications, especially in the field of aircraft system repair and maintenance. A more realistic model, general renewal process, can be applied [3]. In aerospace industry, many repair activities may not necessarily restore a system back to as good as new condition, or to as bad as old condition. Instead, it is more likely that the condition after repair is somewhere in between: better than old but worse than new. Recently, many reliability models based on general renewal theory have been proposed. However, too much attention has been paid on the modeling side. Some practical considerations, such as applicability of the modeling assumptions, easiness of parameter estimations, and availability of the data required, have been ignored.

The main purpose of this research study is to develop a new and practical approach that can be used to predict the number of system failures and prioritize failure risks in order to better arrange repair activities. More specifically, the focus is on small gas turbine engine failure forecast and risk prioritization. The risk of small gas turbine engine failures can be monitored for an aircraft fleet and not just for a single aircraft system. The analytical result can be used by both reliability professionals and management people in their fleet management activities.

III. GAS TURBINE ENGINE FAILURE FORECAST - A CHALLEGING REALWORLD PROBLEM

Reliability modeling and failure forecast is important for small gas turbine engines because it influences the aircraft's system reliability and flight safety. If done correctively, it helps a repair shop to better manage its repair operations and control the budget plans. Before a successful approach can be developed, the following problems need to be considered:

- What is the system structure and decomposition
- What are the life critical components and failure modes
- Different repair levels and repair effectiveness
- Common practices in small gas turbine engine repair
- The "virtual age" concept

An extended general repair model is proposed to model the effect of repair. Failure forecast and risk ranking are realized by Monte Carlo simulation and conditional failure probability calculation, respectively.

The analysis method consists of three major steps: first, field operation data (engine operating fours) and historical repair data are collected and comprehensive statistical life data analyses (Weibull analyses) are conducted; second, a Monte Carlo simulation program is developed to predict the total number of failures over specified time period. Based on the analysis, appropriate actions can be recommended to manage the repair activities.

A. System structure and decomposition

Understanding a system's structure and main functions is crucial for correct modeling of its reliability. Figure 1 shows a typical small gas turbine engine for commercial transport aircraft. It is used for auxiliary power generation and comprises three main modules: power section, compressor section, and gearbox (Figure 2). Each module may have many components. However, for the purpose of mathematic tractability, it is recommended that the engine system be decomposed only to the module level and not to the more detailed component level. Otherwise, the system reliability model will be too complicated and data collection can be extremely difficult.

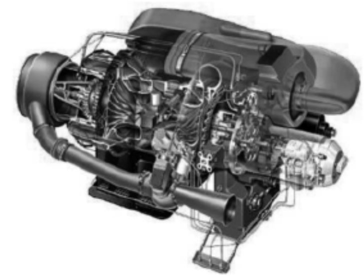

Figure 1. An Example Small Gas Turbine Engine

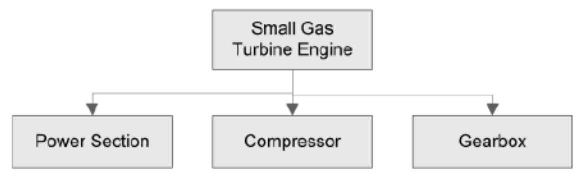

Figure 2. System and Main Modules

B. Life critical components and failure modes

It is important to identify the life critical components and failure modes of a repairable system. For small gas turbine engines, the life critical components include but not limited to the following: turbine wheels, compressors, combustor, shaft, bearings, carbon seals, etc. Identification of life critical components can be realized by collecting system failure events and detailed repair data, and then creating shop findings Pareto chart. Weibull analysis can be conducted on the critical components/failure modes and also for the major modules/subassemblies.

C. Modeling of system failure and repair processes

For repairable systems, such as small gas turbine engines, APUs, etc., the failure process is typically considered as a stochastic process [2]. However, statistical modeling and prediction of repairable system failures can be complicated and difficult when the following factors are considered:

1) Dynamic fleet size and different component life times

Due to limitation on production capacity of aircraft OEMs, new airplanes are typically delivered to the airlines in a staged way. Therefore, an airline operator may not receive its ordered airplanes simultaneously. Its fleet size can grow significantly over its service life. Also, after repair, a system may have different component life times.

2) Corrective action plans and corresponding effects

Corrective actions, such as reliability improvements, redesign, retrofit, and other risk mitigation actions can change the system reliability. Failure forecasting needs to consider availability and limitations of the improvements. For instance, based on a preliminary risk analysis, a decision is made to improve the reliability of a safety-critical component. One option is to redesign the component. However, due to limited resources, it is unrealistic to expect that the newly designed component is readily available for 100% of the fleet being replaced by the redesigned component immediately.

3) Competing failures

Complex systems, such as gas turbine engines, can fail in many different failure modes. For instance, if a system contains different component A, B, and C and each component has several different failure modes, then these failure modes are considered as competing failure modes. To model the system times to failure properly, the competing failures must be considered.

D. Virtual age

A system or a module has its real age. But after repair, the real age may not necessarily be associated with its reliability. Virtual age can be used instead. The virtual age concept stems from the rationale that after repair, a system's risk of failure will be reduced to certain extent. For instance, replacement of a turbine wheel reduces the failure probability of the power section. Overhaul on the compressor module improves its reliability. Normally, after repair a system's virtual age will be less than its virtual age right before the repair. Exceptions are, engagement of human errors, defective parts being used during repair, etc. The value of virtual age depends on the degree of repair.

E. General renewal process and Kijima models

Kijima [4, 5] proposes two models for repairable systems. Kijima model I [4] is developed based on the assumption that repair activities can only fix the damage and wear occurred in the last period of operation; Kijima model II [5] is based on the assumption that repairs can fix all of the damage and wear accumulated historically. Kijima model II is more applicable to the gas turbine APU application. However, it is assumed that the degree of repair parameter, q, is a constant single value. In reality, the degree of repair can be different for each failure. Therefore, the degree of repair parameter can have different values which depend of the degree of repair. The Kijima model II has been extended to accommodate the more complicated problem.

Kijima model II considers a repairable system has observed failure times, starting from time t_0=0, and successively denoted by t_1, t_2, …, and the inter-arrival failure times denoted by x_1, x_2,…, where

$x_i=t_i-t_{i-1}$, for i=1,2,…

Also, denote the virtual age after n^{th} repair by v_n, then we have: $v_0=0$, $v_1=qx_1$, $v_2=q(v_1+x_2)$, …, $v_n=q(v_{n-1}+x_n)$. The n^{th} inter-arrival failure time x_n is distributed according to the cumulative density function

$$F(X \mid V_{n-1}=y)=\frac{F(X+y)-F(y)}{1-F(y)}$$

Mettas and Zhao [6] developed likelihood function for data observed from multiple and identical systems:

$$L\{data \mid \lambda,\beta,q\}=\prod_{i=1}^{k} f(t_{i,1})f(t_{i,2} \mid t_{i,1})\cdots f(t_{i,n_i}) \mid f(t_{i,n_i-1})\cdot\left[R(T_i \mid t_{n_i})\right]^{\delta}$$

where $\delta=\begin{cases}0, & \text{if failure truncated}\\ 1, & \text{if time truncated}\end{cases}$

For a Weibull process with model parameters λ, β, and q, Mettas and Zhao [6] derived a log-likelihood function as

$$LnL=\sum_{l=1}^{k} n_l(\ln\lambda+\ln\beta)-\lambda\delta\sum_{l=1}^{k}[(T_l-t_{l,n_l}+v_{n_l})^{\beta}-v_{n_l}^{\beta}]$$
$$-\lambda\sum_{l=1}^{k}\sum_{i=1}^{n_l}[(x_{l,i}+v_{l,i-1})^{\beta}-v_{l,i-1}^{\beta}]+(\beta-1)\sum_{l=1}^{k}\sum_{i=1}^{n_l}\ln[(x_{l,i}+v_{l,i-1})$$

F. Extended Kijima model II with mutiple q values

Kijima model II assumes a single value for q. In reality, q may have multiple values each corresponding to a repair level, such as minimum, minor, partial, full repairs etc.

The problem has become so complicated such that it cannot be solved virtually by any of today's commercially available tools. Monte Carlo simulation seems to be the only feasible approach to this problem. The Monte Carlo simulation procedure can be realized in Microsoft Excel with macros written in Visual Basic codes. At the end of a simulation run, the total expected system failures can be calculated so that the risk factor can be estimated. Prediction intervals can be established for the number of failures accordingly.

The following is a step-by-step simulation procedure (see Figure 4 for an example flow chart) to predict the total number of APU failures over the next 12-month for the fleet. It can be realized in MS Excel.

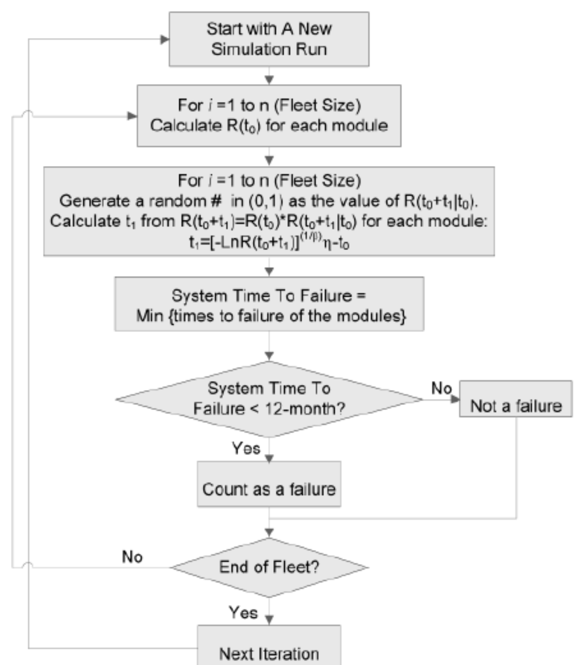

Figure 4. Simulation Flow Chart

- Step 1. Set up the initial condition for the simulation. The following input data is often required: model parameters of the failure time distribution for each module, virtual age for each module, time on wing since install for each module.
- Step 2. For each APU, calculate initial reliability of each module for a given virtual operating time (age) t_0. Next, generate a uniform random number between 0 and 1, which will be used as the conditional probability (or reliability) of survival in the next operating time t_1, given that the system has not failed through t_0. Then calculate $R(t_0+t_1)$ which is the product of previous two measures. t_1 can then be reciprocally calculated from

$$t_1=\eta\cdot(-\ln R(t_0+t_1))^{\frac{1}{\beta}}-t_0 \qquad (2)$$

where β and η are the Weibull shape and scale parameters of the module. Equation (2) is derived from the reliability function of a 2-parameter Weibull time to failure distribution.

- Step 3. Repeat step 2 for each module. The time to next system failure is the minimum of the failure times generated for each module.
- Compare the minimum system time to failure against the expected operating time during the 12-month. If it is less than the later one, then system failure would occur during the 12-month. Otherwise, the system will survive beyond the 12-month.
- Step 4. Repeat steps 2-3 until all APU units have been covered. The total number of failures can be counted for current iteration.

The steps described above constitute only a single simulation run. Therefore, it shall be repeated for a large number of iterations (simulation runs), e.g., 1,000 ~10,000 times.

IV. NUMERICAL EXAMPLE

As a numerical example, a real case study is presented here to illustrate the new approach.

A. Failure history and data collection

When conducting a reliability analysis, the first and most important step is data collection. The data being collected in this case is the hours to failure or hours to suspension for each module, which is part of a small gas turbine system. If the system fails it will be removed from the airplane and sent to a repair shop, and the total accumulated operating time will be recorded. For those gas turbines still on-wing, it is difficult to get the actual operating hours, but we can estimate them by counting the number of days-on-wing and multiply it by average fleet daily utilization rate (hours/day). The data can be used in Weibull analysis and failure prediction.

B. Weibull analysis

Based on Weibull analysis, Weibull parameters (the shape parameter β and the scale parameter (characteristic life) η) are estimated for each module and some critical components/failure modes, if needed. The estimated Weibull parameters are used as input parameters in the Monte Carlo simulation program.

C. Repair effectiveness and virtual age estimates

The repair effectiveness parameter q is determined subjectively by engineering judgment and experts' opinion as the following: 1.0 for no repair; 0.8 for minor repair; 0.4 for partial repair; 0.2 for major repair/overhaul. For each module, the updated virtual age t can be calculated by

virtual age (after repair) = virtual age (before repair) * q

Table 1 shows an example of repair degree and virtual age data. As can be seen, the virtual age for a specific module would change after repair. For example, the virtual age is 2071 hours for the first engine's all three modules. But due to the different degrees of the repair on these three modules (full repair for power section and gearbox, and partial repair for the load compressor), the virtual ages are different after the repair. (414 hours for power section and gearbox, and 828 hours for compressor).

Table 1. Example Repair and Virtual Age Data

Virtual Age (before repair)			Degree of Repair			Virtual Age (after repair)		
PS	LC	GB	PS	LC	GB	PS	LC	GB
2071	2071	2071	Full	Partial	Full	414	828	414
2913	2913	2913	Full	Partial	Full	583	1165	583
2093	2093	2093	Full	Full	Partial	419	419	837
2953	2953	2953	Minor	Minor	Full	2362	2362	591
2946	2946	2946	Full	Full	Full	589	589	589
4407	4407	4407	Full	Full	Full	881	881	881
4978	3538	4498	Full	Full	Minor	996	708	3598

D. Simulation template

Based on the flow chart shown in Figure 4, an Excel Macro is developed to run the simulation. The simulation result is used to predict the number of system failures within certain time, and the risk of failure for the whole engine fleet can be ranked based on the conditional probability of failure by using the updated virtual age and the Weibull parameters for each module. Due to the limited space, only a portion of the simulation template is illustrated in Figure 5.

LC Module					PS Module				
Eta	20,000				Eta	12000			
Beta	3.00				Beta	4.00			
t_0	$R(t_0)$	Rand for $R(t_0+t_1 \mid t_0)$	$R(t_0+t_1)$	t_1	t_0	$R(t_0)$	Rand for $R(t_0+t_1 \mid t_0)$	$R(t_0+t_1)$	t_1
1010	1.00	0.67	0.67	8765	1027	1.00	0.33	0.33	5846
3439	0.96	0.72	0.69	5917	3439	0.91	0.97	0.88	318
4874	0.91	0.22	0.20	13991	4874	0.73	0.97	0.71	105
4846	0.91	0.49	0.44	8734	5083	0.69	0.27	0.19	2644
1211	1.00	0.95	0.95	2589	1211	1.00	0.17	0.17	6651
2265	0.98	0.87	0.86	3933	2265	0.98	0.62	0.60	3261
6492	0.84	0.61	0.52	5799	6348	0.44	0.40	0.18	1451

Figure 5. Simulation Template

V. CONCLUSION

A systematic reliability modeling and failure forecast approach has been developed for some repairable aerospace systems. A Monte Carlo simulation procedure was proposed to solve the complicated problem. Both the modeling approach and simulation procedure are flexible and can be adapted to different application scenarios, such as different aircraft systems, components, failure modes, etc. This approach is practical and can be applied to solve real world problems that are commonly seen in daily airline operations, aircraft maintenance, and repair activities.

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Aerospace Integrity Program

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Nomenclatures:
Typical value: average value, 50% survival rate on life
Minimum value: -3σ value, near 99.9% survival rate on life (exact percentage depends on σ value)
DSL – Design Service Life
DTL – Damage Tolerance Life

INTRODUCTION ON AEROSPACE (STRUCTURAL) INTEGRITY PROGRAM (IP)

***What* ?-** IP was first introduced on Space Station by NASA, then on F-22 and F-35 airplanes by DOD. Now it is a mandatory requirement in specifications. Contractors must comply the requirements. So structural, design, project engineers and program managers in an aerospace company all need to understand it.

***Why* ? -** Structural problems and failures on flight vehicles are costly to fix and may jeopardize the functions of a machine and/or a system. Even worse, it may result in a catastrophic failure and leads to loss of vehicles and/or loss of lives, thus generates a huge liability to a company.

Background ? - There are numerous contractors in the US aerospace industry. They have different ways on designing and manufacturing flight hardware. In order to ensure structural integrity, it is necessary to have all contractors adopt the same proven approach.

***How* ? -** Require contractors to execute Integrity Program in an organized and structured way on aerospace products to achieve structural integrity and high reliability. A company needs to designate an *Integrity Manager* on a large program to take charge of IP. He acts as the focal point to coordinate all engineering functions on integrity issues on that program.

GOALS

An integrity program intends to ensure the following things to a flight hardware:

- Product integrity (structural)
- Safety
- Reliability
- Mission effectiveness
- Affordable cost of ownership.

Integrity program plan describes and defines a process that provide programmatic and technical guidance for the

- Design
- Development
- Manufacturing
- Qualification (test & analysis)
- Life management (in service)

STRUCTURAL INTEGRITY TECHNOLOGIES

- Formularized Stress Analysis
- Finite Element Modeling Analysis

- Solid Modeling (e.g., Pro/E, Catia)
- Fatigue Analysis (on durability critical parts)
- Fracture Mechanics Analysis (on safety critical parts)
- Rotor Dynamics (high speed rotating machines)
- Vibration, Shock and Acceleration Analyses
- Strength Tests (on all materials and critical components)
- Impact Dynamics
- Accelerated Life Testing (ALT)
- Non-destructive Test (NDT)

Concept: Integrity Program integrates the above technologies into a process to ensure success of design, development, qualification, production, and service of a flight hardware.

SUPPORTING ANALYSES AND DATA

- Material design data:
  - Ultimate strength
  - Yield strength
  - Fatigue strength and S-N curves (stress vs. life)
  - Fracture toughness and da/dN vs. ΔK curve (crack growth rate)
- Reliability Analysis includes:
  - Historical data in field reliability and component failure modes of similar hardware
  - FMECA (Failure Mode Effects and Criticality Assessment)
- Thermal Analysis => Thermal Maps => Thermal Gradient => Thermal Stress
- R&M (Repairability & Maintainability), Testability

INTEGRITY TASKS

Integrity Program consists of the five tasks below:

- Task I – Plans and Design Information.
- Task II – Design Analysis and Development Testing.
- Task III - Qualification Testing.
- Task IV - System Ground and Flight Testing.
- Task V - Service Life Tracking and Manufacturing Quality Assurance.

Time period for conducting an IP program:

- For aircrafts - 10 years typical
- For machines - 5 years typical

FAILURE MODE ANALYSIS

Prior to performing any structural integrity analysis, a Failure Mode Analysis should be performed by a reliability engineer in the way below:

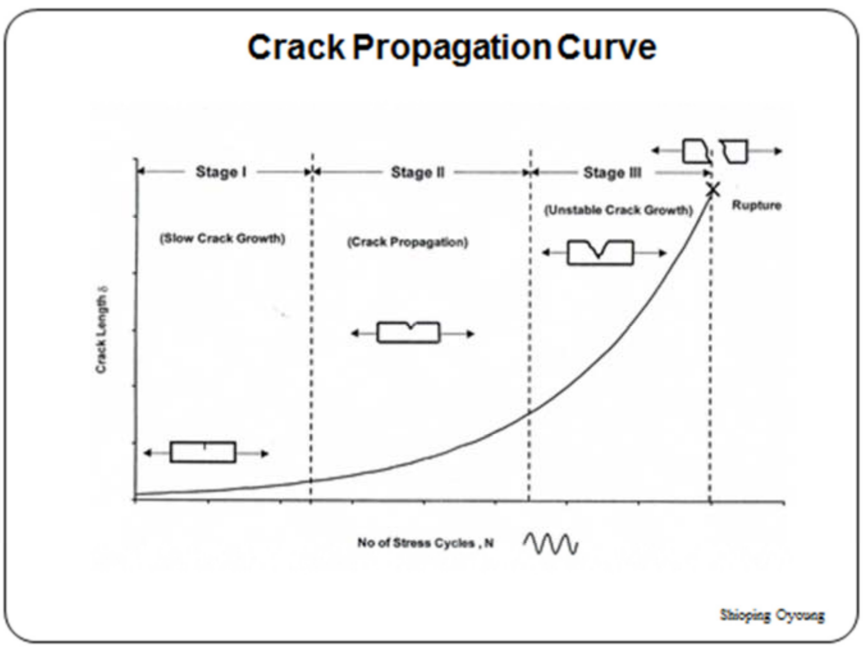
- All potential failures of a part shall be considered. Their severity levels and impacts shall be estimated.
- Collect historical data in repair and overhaul of similar hardware. Those data should be categorized by possible failure modes and they should be statistically analyzed.
- The above results should be summarized and tabulated for easy to check purposes .

CRITICALITY ASSESSMENT ANALYSIS

- Use the results of a Failure Mode Analysis to categorize the criticality of an entity according to the severity of its failure imposed to a flight vehicle.
- Four (4) Categories of Criticality:
  1. Non-Critical
  2. Durability Critical
  3. Mission Critical
  4. Safety Critical
- The task ought to be co-performed by a team of integrity manager (Team Lead), stress integrity engineers, project engineer, design engineer and reliability engineer.

DEFINITION OF CRITICALITIES

1. ***Non-Critical*** - A failure will not result in a significant impact on mission capability, safety and cost.
2. ***Durability Critical*** - A failure will not result in a significant impact on mission capability and safety, but it will be costly and/or time consuming to repair.
3. ***Mission Critical*** - A failure will result in an abortion of a mission but it will not result in a significant impact on safety,
4. ***Safety Critical*** - A failure will result in the loss of flight vehicle and/or personnel injury or the loss of life.



LIFE ANALYSIS METHODS

Two (2) Methods to calculate life, often caused confusion:

- *Fatigue Analysis*
- *Fracture Mechanics*

Both methods calculate operating life under fatigue loads. Can you answer 4 questions below?

Q1. Will the two methods lead to the same predictions in life?

Q2. Are the two life values means the same type of life?

Q3. When should one use Fatigue Analysis to calculate life?
When should one use Fracture Mechanics Analysis to calculate life?

Q4. What are the roles of the above two life values to hardware?

NON-DESTRUCTIVE TEST (NDT)

NDT is inspection methods that will detect small cracks or flaws in a component. They will not impose damage to the item after inspection. Commonly used methods in industry are:

- *Magnetic particle inspection* (MPI) – on magnetic steels
- *Fluorescent penetrate inspection* (FPI) – on aluminum and non-magnetic steels (e.g., most stainless steels)
- *Eddy Current*
- *Ultrasonic*
- *Radiographic*

Eddy Current, Ultrasonic and Radiographic inspections can detect very small crack, they are used on various raw materials or on research parts. MPI and FPI are used on inspecting finished parts and on failed parts.

FATIGUE ANALYSIS CONCEPT & METHODOLOGY

- *Assumption*:

  There are no "initial cracks" of notable size exist in the material. Note that the effects of unavoidable imperfection in material and test specimens are already included in an S-N curve by statistical means when compiling the test data.

- *Failure Criteria*:

  It is considered that a fatigue failure occurs as soon as a "detectable crack(s)" is noted by an inspector on a part thru MPI or FPI inspection.

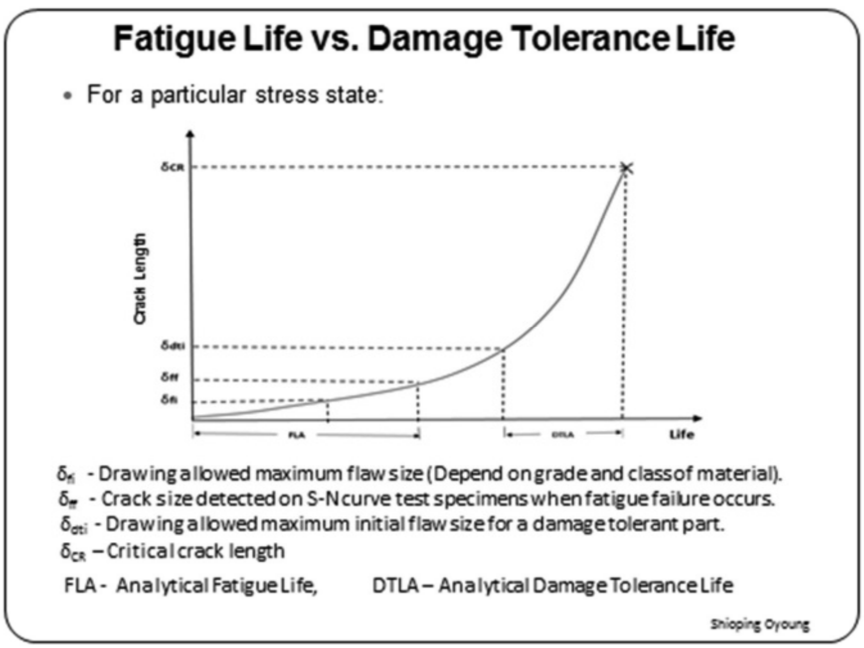
- *Design Analysis Data* - S-N Curve of material or similar finished parts
- *Test Specimens* - Tensile test bar specimen or circular rod rotating beam specimens
- *Method of Analysis*:
  Based on S-N Curves and cumulative damage theory, e.g., Miner's Rule.

FRACTURE MECHANICS ANALYSIS CONCEPT & METHODOLOGY

- *Assumption*: Initial flaws pre-exist at the most critical area on a part.
- *Source of flaws*:
  1. Unavoidable material imperfection and defects, e.g., inclusions, chemicals
  2. Rouge flaws (due to machining, handling,…etc)
- *Why the need exists*?

Quality Control may escape once a while during the entire life span of a plane (generally 25 year service life), i.e., an inspector missed catching flaws larger than drawing allowables and thus does not reject the part. A defective component is then slipped through the system and be installed on airplane. It can lead to a premature failure. An approach to avoid this type of failure to occur is to conservatively design a machine for this adverse condition in addition to the normal conditions.

- *Design Analysis Data* - Crack growth rate vs. fracture toughness curve (i.e., da/dN vs. ΔK Curve)
- *Test Specimen*s - Fracture toughness and crack growth rate test by using V-shaped pre-cracked specimens.
- *Method of Analysis* – Consider there is an "initial flaw "exists at the most critical location on a part, calculate crack growth after each cycle of operating loads based on da/dN vs. ΔK curve.
- *Failure Criteria* - When a crack grows to the length of critical crack length, the structure is consider failed because the remaining structure will become unstable and rupture will occur right away.



SUMMARY OF LIFE ANALYSIS METHODS

- *Fatigue Analysis* covers the crack length region from material's initial micro cracks on fatigue test specimens to the minimum NDT detectable crack length by naked eyes without using a magnifying glass/microscope.

- *Fracture Mechanics Analysis* covers the crack length region from a specified initial flaw size to the critical crack length. Note that different from Fatigue Analysis, the initial flaw size here is determined by an inspector's NDT capability rather than by material's quality.

- "*Fatigue Life*" and "*Fracture Mechanics Life*" are two different types of life. Since both of them are called by the same term (i.e.,"Life"), it is easy to be confused.

Note: A metal part exhibits small cracks after durability test is not considered a failed part if they cannot be visually noted by a regular MPI/FPI inspector in the company even though they can be noted under other powerful instruments. Understanding of this rule can avoid the unnecessary admittance of test failure and the subsequently required redesign efforts (=> Save a lot of money and time for a contractor).

TYPE 1 LIFE REQUIREMENT IN IP - DURABILLITY LIF

- *Definition* - Resistance to:
  - Fatigue damage (cracking)
  - Wear and Deterioration
  - Thermal Degradation
  - Corrosion

- *Requirement*:

A component shall be *durable* and *economically maintainabl*e throughout 2 x Design Service Life (DSL) under the requirement environment.

- *Analyses to perform*:
  - Fatigue analysis
  - Wear Analysis

TYPE 2 LIFE REQUIREMENT IN IP - DAMAGE TOLERANCE LIFE

- *Definition* - Ability of a part to resist failure for a specified period of usage when flaws, cracks, or other type of defects exist at the most critical location since beginning of usage. At the end of period of usage, the hardware shall be able to sustain the limit load one time without rupture (i.e., Residual Strength Capability).
- *Durability requirement* still apply (Durability Analysis)
- *Damage Tolerance Analysis to perform*:
  - Fracture Mechanics Life Analysis
  - Residual Strength Analysis

Q. How do we determine which life requirement should be met by a part?
Ans. Based on "*Criticality*" of the part.

CRITICALITY VS. LIFE REQUIREMENTS

In Integrity Program, the criticality category of a component determines the life requirement that the component needs to meet. They are listed below:

- *Non-Critical* – Fatigue Analysis
- *Durability Critical* - Durability Requirement applies (Fatigue Analysis + Wear Analysis).
- *Mission Critical* - Damage Tolerance Requirement applies (Damage Tolerance Analysis). However, if a customer allows, a contractor may adopt Durability Requirement only.
- *Safety Critical* – Damage Tolerance Requirement mandatory.

DESIGN LIFE REQUIREMENTS AND APPROACHES

A. *Durability Critical Parts*:

- Analytical Fatigue Life > 4 DSL's (based on worst geometry, typical S-N curve)
  Or > 1 DSL (based on worst geometry, minimum S-N curve)
- Tested Fatigue Life > 2 DSL's (concept: a test part is likely with typical geometry and typical fatigue strength)

B. *Damage Tolerant Critical Parts*:

Task 1. Meet all requirements of Durability Critical Parts.

Task 2. Perform Fracture Mechanics Life Analysis

- Analytical Damage Tolerance Life > 2 DSL's (based on minimum geometry, typical crack growth rate curve)
- Tested Damage Tolerance Life > 2 DSL's (concept: a test part is likely with typical geometry and typical crack growth rate data; when conducting a test, a crack equals to the size of drawing allowed maximum initial crack needs be machined at the most critical area on the part prior to the test)

<u>HOW TO HANDLE DAMAGE TOLERANT CRITICAL PART?</u>

Step 1. Consider if the part is sized by Damage Tolerance Analysis?
If yes, continue to Step 2; if no, go to Step 4.

Step 2. Is DTOP > 2 DSL's? If yes, go to Step 5; if no, continue to Step 3.

Step 3. The part is considered a ***Limited Life Part***. A plan must be developed on conducting periodic maintenance/inspection. The part needs to be replaced when a crack grows to a certain length prior to reach the critical crack length. Go to Step 5.

Step 4. Perform a fatigue analysis (considering change in geometry due to a large initial flaw) to demonstrate:

Fatigue Life >> 2 DSL's, Margin of Safety is HIGH

Then the part needs to be approved by Buyer and the government agency in charge.

Concept: This is the only way not to perform damage tolerance analysis on a damage tolerant critical part. A contractor can take advantage of this rule to save cost.

Step 5. Implement material and process traceability, manufacturing controls, serialization, and life tracking during service.

<u>Conclusion</u>

- Integrity Program has been implemented by several modern aerospace programs with success. It also has been implicitly adopted by major commercial aircraft programs.
- Integrity Program is now a standard approach for US government agencies and aerospace companies to ensure structural integrity of flight vehicles and space systems. It integrates various structural integrity technologies into a single systematic design, analysis and verification process for all contractors to follow.

Gummy Electrolyte for Safe and Flexible Energy Storage Devices

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Developing advanced electrolyte materials has been critical for the advancement of the next generation of energy storage devices as lithium ion batteries (LIBs) with flexibility[1] and safety are increasingly demanded by various industry sectors including electronics, electric vehicles, aircraft and bio-medical electronics.[2] As a central component placed between the two electrodes (anode and cathode), an advanced electrolyte has to possess good properties in different aspects: electrochemical properties, ionic conductivity, mechanical properties, and interfacial properties as well as safety, which create many challenges for electrolyte materials.[2-5]

To achieve the desired properties as described above, our lab specially designed a gummy electrolyte with multi-network structures (see **Fig. 1**).[6] The multi-network structures include: (a) a double percolation network structure, i.e., a percolation network of a liquid electrolyte supported by a packing network of solid particles and (b) a strong entanglement network of polymer electrolyte (ultra-high molecular weight poly(ethylene oxide), PEO, with lithium salt $LiClO_4$). The liquid percolation network can provide an "express pathway" for the ion transportation. To construct this percolation network, a new type of core-shell particles with the liquid electrolyte ($LiClO_4$ in propylene carbonate (PC), 1 mol/L) as the shell was obtained by emulsion technique, which means the liquid adheres to the particle surface. At the same time, to improve the safety of the hybrid electrolyte, we chose thermally sensitive particles as the core (wax particles in this case).

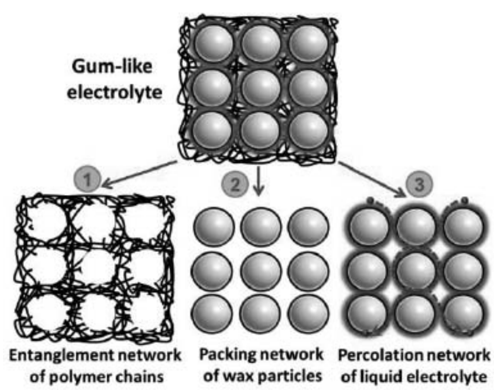

Figure 1. Schematics of the multi-network structures of the gum-like electrolyte

Ionic conductivity and damage-tolerant capability

Fig. 2(a) shows that the gummy electrolyte has a liquid-like high ionic conductivity (frequency-independent behavior).[7] This behavior indicates a liquid-based conductive pathway for the ion transport, that is, the percolation of the liquid shell as designed. The conductivity level is close to that of commercial liquid electrolyte (~ 10^{-3} S/cm at room temperature).

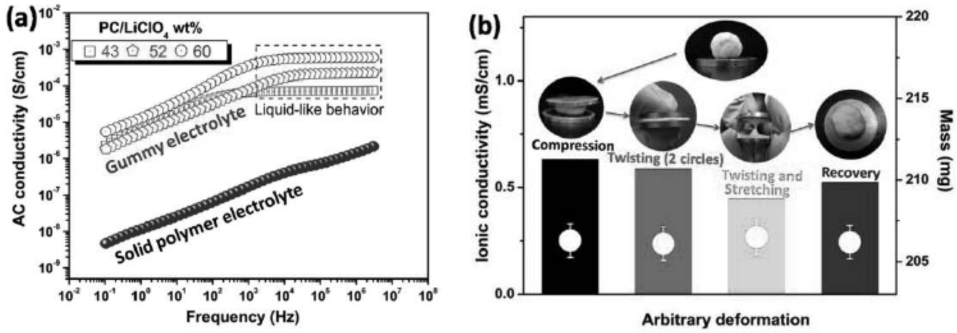

Figure 2. a) AC conductivity of the gummy electrolytes at room temperature (all experiments below were performed at room temperature unless otherwise noted). b) Performance stability of the gummy electrolyte against arbitrary deformation (columns represent the ionic conductivity, white circles are the weight of the gummy electrolyte recorded after each different deformation, photos are the snapshots for the deformations as described).

At the same time, the gummy electrolyte shows excellent performance in structural integrity under arbitrary deformations (damage-tolerant capability). **Fig. 2**(b) demonstrates how the gummy electrolytes respond to arbitrary deformations. We found that arbitrary compression, twisting and stretching barely affected the ionic conductivity, indicating good structure integrity or a fast structure recovery against different deformations. Moreover, the mass of the gummy electrolytes can remain constant after each kind of deformation (also see **Fig. 2** (b)), indicating that the retention of the liquid phase in the gummy electrolyte is very stable.

Mechanical and adhesion properties

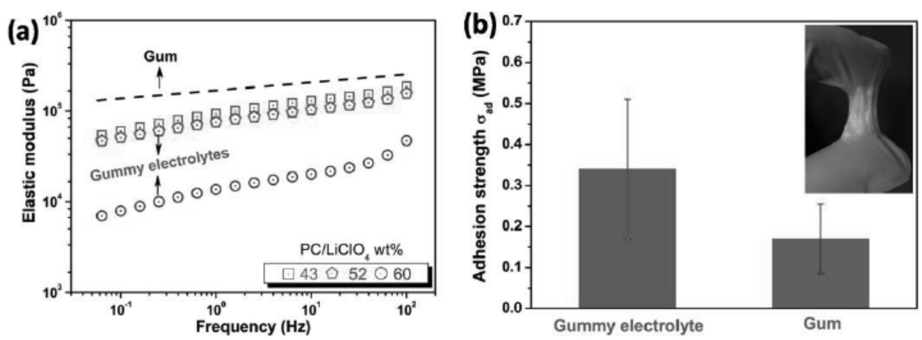

Figure 3. a) Dynamic mechanical properties and b) adhesion strength of the gummy electrolytes as compared with a gum. The insert in b) demonstrates the adhesion property of the gummy electrolyte with plastic gloves.

In addition to a high ionic conductivity, mechanical properties, such as modulus, flexibility or extensibility, of an electrolyte are critical for high-performance energy storage devices. The gummy electrolytes can show gum-like mechanical properties as displayed in **Fig. 3** (a). Overall, the gummy electrolyte with liquid electrolyte content of ca. 50 wt% shows a balance between high ion conductivity (ca. 3×10^{-4} S/cm at room temperature) and good mechanical properties (ca. 0.1 MPa). In addition to transporting ions, the electrolyte also serves to form contacts with the electrodes and to separate them from each other; therefore, we should also take the adhesion/contact of the electrolyte with the electrode materials into account, especially when battery flexibility is of interest. As shown in **Fig. 3** (b), the gummy electrolyte demonstrates excellent adhesion properties (sticking to almost any substrate). The average adhesion strength (defined as F_{max}/A, where F_{max} is the maximum force that the gummy electrolyte can hold, and A is the contact area for the adhesion test) was found to be 0.34 MPa, which is about two times of that of a gum.

The above properties of the gummy electrolyte, including the liquid-like ionic conductivity, the gum-like mechanical properties, the structural integrity against various deformations, and the good adhesion/contact with the electrodes, are very critical for the electrolyte applied to flexible/stretchable batteries or working with an electrode having complex surface morphology structures, such as 3D electrodes. These integrated properties can provide batteries with an effective and stable contact at the electrolyte/electrode interface especially against various deformations or even punching.

Thermal-protection capability

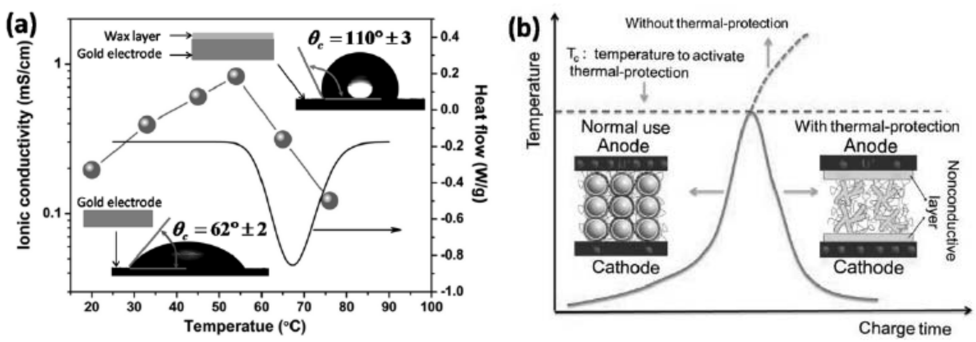

Figure 4. Thermal-protection capability of the gummy electrolyte. a) Temperature dependent behavior the ionic conductivity of the gummy electrolyte. The curve shows the melting behavior of the wax particles. The inserted photos are the contact angle testing of the electrode surface before (the one with much lower contact angle) and after the high temperature testing. b) The mechanism of the thermal-protection capability to improve the safety of lithium ion batteries.

More significantly, the gummy electrolyte possesses thermal-protection capability for safe design of LIBs. Although the gummy electrolyte is expected to be much safer than liquid electrolytes, the presence of liquid electrolytes will always introduce safety risks. Similar to the safety mechanism of the porous polyolefin film employed for liquid electrolytes today,[8] we introduced a type of high loading of thermally sensitive wax particles into the gummy electrolyte to obtain the thermal-protection capability. Significantly, we found that the ionic conductivity of the gummy electrolyte begins to decrease, instead of increasing as frequently reported, at a high temperature around the melting point of the wax particles as shown in **Fig. 4** (a). This result indicates that the wax particles can form a non-conductive layer (wax layer) between the electrolyte and electrodes as designed. The ability of the gummy electrolytes to form a wax layer on the surface of the electrode can be proven by the contact angle testing of the electrode surface as shown by the inserts in **Fig. 4** (a). A hydrophobic surface with a high contact angle (110

°) for the electrode after high temperature testing indicates the existence of the wax layer.

The above phenomenon is significant for the safety of a battery with the electrolyte. It is well-known that the root of the safety issues, for liquid electrolytes or electrolytes with a liquid component, is the electrochemical reactions between electrodes and electrolytes at high temperatures.[9-11] Therefore, one effective way to solving this problem is to separate the electrolytes and electrodes at high temperatures. As demonstrated in **Fig. 4**(b), as long as we choose particles with the melting point around the electrochemical reaction temperature, T_c, the electrochemical reaction will be stopped by the melt layer of the thermally sensitive particles and the temperature of the battery system can remain in a safe range. It is noted that the temperature to activate the thermal protection can be easily adjusted as we can select particles with desired melting points. Regarding the application of this type of gummy electrolytes in LIBs, the study is ongoing in our lab and the results will be reported in the near future.

In summary, the gummy electrolyte provides a very good solution for high-performance electrolytes for energy storage devices, such as LIBs. The structural integrity under arbitrary deformation, coupled with a strong adhesion and thermal-protection capability in addition to the high ionic conductivity, will promote the realization of the advanced batteries with high performance in safety, flexibility or even extensibility.

Acknowledgement

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Tri-Polar Aviation Industry in the 21st Century

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田長焯

ABSTRACT

Globalization is the driving force behind the aviation renaissance on the horizon. Growth in new markets is altering today's world of commercial aviation. Shifts in air traffic demand and the geographies demand a change in the industry model that has existed for decades.

Asia Pacific is expected to lead in air traffic growth and in the rapid development of their air transport infrastructure to accommodate the expected increase in demand. One major company forecast shows China will acquire more than 5,000 aircraft by Year 2029, of which 75% will be the single-aisle type like Airbus A320/Boeing 737.

The emerging aircraft manufacturers such as those in China, Canada, Brazil, Russia and Japan are all planning to capitalize on these shifts

Duo-Polar Airbus/Boeing- or the A/B duopoly-- each with more than 50 years of experience in modern aviation, is dominant in the commercial jet market. With tremendous investment of past decades, Airbus and Boeing are reluctant to give up the basics of their design and manufacturing. Without drastic changes in the dynamics of global aviation industry, duopoly will stifle air travel development for a long time.

China is definitely the leading new player and the mission of COMAC is absolutely correct.

The ARJ21 and C919 delays illustrate that the path of commercial airplane is full of pitfalls and headaches, owing to scant civil airplanes experience and few experienced designers.

The recent announced COMAC/Bombardier cooperation (the C-group) could provide a timely and crucial opportunity to engage them synergistically and to create the third group to compete with the established duopoly. An A/B/C tri-polar aviation industry is desirable and feasible in the near future.

The C-group should not satisfy with following in the footsteps of aviation culture of the A/B groups, but should set a path to compete with them in near-term and also a long-term, deliberate plan to be ahead of them with innovations.

Near-term objectives are: to continue the C919-Bombardier commonality program in China; and a COMAC-Bombardier team to study the re-design and re-engine of C-Series 100/130 which can compete with Airbus A320 NEO and Boeing 737 MAX on the world market. The work should be undertaken in Canada. A pool of experienced engineers in the North America can easily be recruited to work onsite in task force teams.

Long-term plan is: replacement of A320 and B737 single-aisle aircraft with emphasis on operational economics, passenger comfort and environmental issues. It is important that behavior economics should be considered with traditional economic issues such as fuel burn for the future aviation. In addition to new technology, cabin air, quiet operation, board-deplane time, etc need more attention.

* Robert Brown is a co-author and contributor to this paper. Mr. Brown was the Vice-President and Chief Engineer of Boeing 757 Project. He was known for solving a serious pitch problem with the prototype B-47 by adding vortex generators

中国的高速铁路

洪 源

中国的高速铁路始建于 2004 年，简称中国高铁或高铁。但高铁的前期研究则始于上一世纪九十年代中期，其中最为著名的事件是上海磁悬浮列车的建立。这对后来高铁建设时究竟采用轮轨还是磁悬浮技术产生了很大的影响，也带动了全国广泛的讨论。哪个技术更成熟？哪个技术中国可以得到？哪个技术在中国可以得到保障？哪种技术更适合中国的现状？以及从哪个国家得到技术所涉及的国际政治关系更为有利？等等， 都引起了广泛的讨论。当然中国的高铁最后还是采用了轮轨技术。车厢从日本进口少部分， 多数还是国产的。高铁由中国政府决定兴建， 工程在全国范围内展开。与美国兴建高铁的工程不同，很多美国地方政府因为债务问题反对兴建高速铁路，而中国的地方政府则是积极响应，甚至是大家在抢这个项目。这样就可以得到中国政府的拨款，因此可以拉动地方经济，提高地方政府的政绩。

在开始兴建的四年后， 中国的高铁于 2008 年开始投入运行， 同时兴建也在同步进行，在过去的五年时间里投入运行的里程数和车次都在不断地增加。中国现在基本形成了八横四纵的高速铁路网。高铁的建成，使得中国的交通效率大为提高。由过去横贯全国三天三夜的铁路交通，变成一天内到达全国的任何地方。例如，笔者小时候乘火车从西安到北京，全程 1200 公里， 火车要走 23 个小时。 到上世纪 80 年代中， 火车提高运行速度，特快列车减少停站次数， 从北京到西安也还要运行 16 小时。现在高铁只要六个小时就可以到达。如果是直达高铁列车，则不到五个小时就可以到达。当然普通速度的铁路仍在运行，普通铁路与高铁相比速度不到一半，但票价要低很多，约为高铁票价的三分之一。这对于相当一部分低收入民众来说仍是可接受的交通方式。目前高铁的平均运行速度约为 200 公里/小时，最高运行速度是 300 公里/小时。

高铁的运行速度快，就要求铁轨很直而且平，铁轨的接头少，铁轨的温差变形小。这与普通铁路的要求完全不同。中国的高铁与普通铁路是两个完全不同的铁路系统。两种列车在完全不同的铁轨上运行， 车站也是不同的。 有时两种车站相互距离很远，两种车站之间开车要走二十分钟也很常见， 这使得在两种列车系统之间转车非常不方便。高铁运行速度快，停站少，用于大城市或省会城市之间的交通是很方便的。但是如果始终点站不是大城市，那么不同运输系统之间的换乘就是不可避免的了。因为高铁系统新，特别是刚开通的新高铁站，辅助运输系统常常还不完善。

2013 年 4 月笔者乘坐由北京到西安的 295 次高速铁路列车，总体感觉非常之好。全程停了十个车站，运行了六小时， 最高运行时速 299 公里/小时， 多数车站的停车时间只有二分钟。与同年 8 月笔者在美国乘坐的 Amtrak Starlight 相比，列车的平稳程度和速度都要好很多。高铁很多细节的地方都采用了非常人性化

的设计。例如上下车时，高铁的乘客走出车厢，车内的地面与月台的地面在同一水平面上。而列车与月台之间的间隙也与电梯与楼层之间的间隙差不多，这对于行动不便的旅客是非常重要的。中国的旧式火车，列车车内地面比月台地面要高出两级楼梯。到站时列车员要打开列车内地面的盖板，让乘客通过盖板下的列车附带的楼梯下车。美国的月台设计非常奇怪，每站的月台高度是不一样的。有的月台在列车到站时，列车员必须把车上带的黄凳子放在月台上，让乘客踩着凳子上下车。再一项设计是技术性的了。在每个月台上，对着车门的方向划有两条白线与车门同宽。白线在安全线之外，旅客站在两条白线之间排队等车，列车停稳后，车门两边正对着两条白线。高铁列车都是全密封气密车厢，车厢是滑动式自动车门。由于车厢的生产厂家不同，有的车门是在车厢外滑动，有的车门是在车厢内滑动。

与普通火车座位不同，高铁的座位不是两排旅客相对而坐，而是与飞机一样，都是面向前进方向。每排五个座位，用左三右二的方式排列。车厢的前方壁板上和中间的顶上设有数台电视，有趣的是，虽然没有人面向后方坐着，但是车厢中部的电视是双面的，从前方和后方都可以看到电视。唯一美中不足的是，坐在第一排的乘客没有办法看清电视。因为电视的安装高度远高于第一排乘客的眼睛高度，第一排乘客看到的是黑白画面。

高铁的票价是比较贵的，北京到西安的高铁票价约 500 元人民币，约合 80 美元。对于下岗工人或农民工来说，这个票价是太高了。 对于白领职工来说，这个票价还是可以接受的。笔者所乘坐的高铁列车，一节车厢可乘 80 到 90 人，因为车厢布置稍有不同， 所以乘员人数也稍有变化。整趟列车的上座率超过 80%。因为票价贵，并采用实名制，车票还是很好买的。以前普通车票没有实行实名制，所以车票黄牛很多，这让普通乘客叫苦连天。

说到中国高铁，不能不说一下温州动车追尾事故。事故发生前，中国铁道部认为，中国高铁不会发生追尾事故，但事故还是发生了。笔者认为高铁事故存在着硬件，软件和管理三方面的原因。第一硬件方面，各个系统的独立性不足，一次雷击就造成列车动力系统，信号系统，和铁路通信系统全面失效。这说明高铁设计上，抵抗共同因素失效的能力不够强。第二软件方面，在非正常情况下，软件系统未能发出强制后方列车停车命令。当列车失去动力，又没有发出

信号时，软件系统应当带有记忆功能，记忆此次列车的所在位置。只有当无信号列车出现在下一区间时，本区间的记忆才能消除。软件系统显然没有做到这一点，而让两趟列车同时出现在同一区间。 第三管理失误，列车调度应当具有绝对的权力命令后方列车停车，而不是与后方列车商量让后方列车减速。希望这次事故能提高中国高铁的可靠性。

高铁对航空运输的影响是不言而喻的，虽然国际上两大飞机制造商对中国飞机需求量进行预估时都避免谈及高铁的影响，但这种影响无疑是巨大的。首先高铁和航空运输的服务对象是基本重叠的。与高铁相比，飞机更快，但是优势并不明显。原因是机场距市中心的距离比高铁车站距市中心的距离更远。例如北京市，首都机场距市中心 45 公里，而高铁站距市中心仅 5 公里。西安市咸阳机场距西安市中心约 60 公里，高铁站距西安市中心只有十公里。飞行快速节省下来的时间被辅助交通的时间消耗掉了。北京到西安飞行时间约二小时，高铁是五到六小时，辅助交通时间高铁约一小时，而乘飞机要两小时以上，再加上安检与取行李的时间，乘飞机也就能节省不到一小时。但是更多的人愿意乘高铁，因为高铁的运行时间受其它因素的影响较少，而飞机晚点是经常发生的事情。

中国的航空业都认为，航空运输对于有直线高铁联接的城市间交通较具优势。但是高铁的载客量大，一趟列车约是一架飞机载客量的 5-20 倍，高铁虽不能完全取代飞机运输，但它会使飞机的上座率下降，这一点对于航空公司还说是致命的。为了增加上座率，航空公司不得不经常降价以招徕顾客，因此航空公司的赢利能力大幅下降。中国的航空公司将必须采用低运营成本的飞机如 787，737-Max 和 A350。 因为跨洋航线的存在，航空运输是不可能被取代的。

SCAAE 全美總會會章

宗　　旨

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會　　章

1. 本會總會訂名「美華航太工程師協會」名稱，目前設以下三個分會：
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     (Society of Chinese American Aerospace Engineers/West)
   - 美南美華航太工程師協會
     (Society of Chinese American Aerospace Engineers/South)
   - 美西北美華航太工程師協會
     (Society of Chinese American Aerospace Engineers/Northwest)
2. 各分會獨立自主，分會會章以不得抵觸總會會章為準則。
3. 總會理事由分會推薦產生：
   分會會員一百人以下設訂四人基準，每增加一百人添加理事一位。
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6. 總會理事會以每年至少召開一次為原則，總會會址以當年總會長所在地為準，理事會可經由理事長、會長或 1/3 理事聯署召開，除會章另規定外，任何提案經由過半數理事出席及出席理事過半數贊成而通過。
7. 分會每年按照推薦理事名額繳交總會理事會費，金額由總會理事會每年初決定。
8. 修定總會會章及罷免理事至少需要 2/3 全體理事參加理事會，並經 2/3 出席理事通過。
9. 理事長及會長職權：
   理事長：召開理事會，主持選舉，推動會務及發展計劃。
   會長：執行會務，舉辦活動及財務管理等（經過理事會通過及理事長附署）。對外活動，會長為第一代表，理事長為第二代表。

SCAAE 美華航太工程師協會
永久會員

張家聲	張銘琛	趙和治	陳淳
陳西書	陳烈偉	陳中	何偉強
蔣維新	朱名譽	周俊民	周光武
丁傲然	范哲源	洪源	胡樂耕
黃啟鵬	黃益三	柯金象	桂正岡
賴英政	李全伶	李龍富	廖越峰
林清芳	林峰	劉政平	馬在莊
牛春勻	歐陽小平	沈方楠	沈正中
沈自元	許志凡	湯小屏	滕穎
佟儀	陈興邦	蔡奮鬥	蔣正華
段心得	董致陽	王道基	翁敬忠
鄔錦文	陽道華	楊孫均	戎凱
余嘉	余崇孝	繆大成	劉亮
錢感曾	陈南瑾	崔洪波	蔡伯勲
吴洵	袁保麟	鄭大光	李鷗
張海明	陳琛	柳建夏	牛康民
胡晓籲	洪國興	李小光	李湘渝
繆志毅	唐克	李湘宏	彭之光
阮鋼	楊少寧	曾山英	盧璐
倪祖麟	姜紅	沈伟	王嵩壽
潘建光	李偉	戴羿	劉劭群
田長焯	薛国航	張崇鈺	宋偉東

會員通訊錄

Last Name	First Name	Chinese Name	Company Name / Home or Mailing Address	City	State	Zip	Phone		E-mail

SCAAE -West Chapter Members

Last Name	First Name	Chinese Name	Company Name / Home or Mailing Address	City	State	Zip	Phone		E-mail
CHAING	**WEI-SHING***	**蔣維新**	HONEYWELL				310-512-2606	(O)	
			21415 CHIRPING SPARROW	DIAMOND BAR	CA	91760	909-396-9066	(H)	
CHAN	LEO	陈建鹏						(O)	
			19204 IVORY WAY	ROWLAND HEIGHTS	CA	91748		(H)	
CHANG	**DANIEL**	**张海明**	AEM, INC				858-481-0210X1250	(O)	
			11525 SORRENTO VALLEY RD.	SAN DIEGO	CA	92121		(H)	
CHANG	DAVID	張秩	TRW					(O)	
			5317 ARVADA ST	TORRANCE	CA	90503		(H)	
CHANG	JAMES	張振邦	AEROSPACE CORP.				310-336-5625	(O)	
			1708 N. MOUNTAIN VIEW PL.	FULLERTON	CA	92831	714-870-9187	(H)	
CHANG	KAUNG JAIN	章廣建	ROCKETDYNE					(O)	
			5859 LARBOARD LANE	AGOURA	CA	91301		(H)	
CHANG	MING	張明	BOEING				562-593-8121	(O)	MING.CHANG@BOEING.COM
			2985 PRIMROSE AVE.	BREA	CA	92671	714-996-2225	(H)	
CHANG	**JULIAN***	**張家聲**	APPLIED INDUSTRIAL TECHNOLOGY					(O)	
			13363 RUSTY FIG CIR	CERRITOS	CA	90703		(H)	
CHANG	SHIH HOW	張世厚						(O)	
			3404 ORANGEWOOD	IRVINE	CA	92618		(H)	
CHAO	**CHARLES***	**趙和治**	SOLAR TURBINE INC.				310-225-4118	(O)	chchao@aol.com
			5317 WILMA ST	TORRANCE	CA	90503	310-542-5351	(H)	
CHAO	WILLIAM F.	趙烽	Callenge Global Investment & Trading Inc.				818-895-7707	(O)	
			3001 LAZY MEADOW DR	TORRANCE	CA	90505	310-325-2421	(H)	
CHAU	STEVEN	周樹雄	BOEING				562-593-5365	(O)	chinese_hoho@yahoo.com
			824 S. STONEMAN AVE. #14	ALHAMBRA	CA	91801	626-576-1788	(H)	626-374-7730 (C)
CHEN	**BILL***	**陳淳**	GE POWER SYSTEMS				310-493-7947	(O)	chenbtcj@msn.com
			5537 LITTLEBOW ROAD	RPV	CA	90275		(H)	
CHEN	**CHEN ***	**陈琛**						(O)	chenchen@China heartbmd.com
			Suite 313, bld A2, 218 Xinhua Street, Suzhou Industrial Park, Suzhou 214125, China					(H)	
CHEN	**HSI-SHU***	**陳西書**	SCIENCE & TECH. CORP				949-837-5618	(O)	HsiChen8@aol.com
			24951 HON AVE	LAGUNA HILLS	CA	92653	949-837-1067	(H)	
CHEN	JOHN	陳治宏	NORTHROP					(O)	chenbtcj@msn.com,
			BOX 2182	RHE	CA	90274		(H)	
CHEN	**JOSEPH C.***	**陳中**	AJILON					(O)	joseph_cchen@yahoo.com,
			19472 CORALWOOD DR.	HUNTINGTON BEACH	CA	92646		(H)	
CHEN	KELLY J.	陳瑞宏						(O)	
			1173 MAERTZWEILER DR	PLACENTIA	CA	92870		(H)	
CHEN	MARK A.	陳逸材	HONEYWELL					(O)	
			21714 TALISMAN ST	TORRANCE	CA	90503	310-316-1481	(H)	
CHEN	MING CHENG	陳名正	AEROSPACE CORP				310-336-8916	(O)	mingchen33@yahoo.com,
			3630 OLEANDER ST	SEAL BEACH	CA	90740		(H)	
CHEN	NAN JIM	**陳南瑾**	BOEING				562-593-5370	(O)	Nan.Chen@boeing.com
			13729 CAPRISTRANO RD.	LAMIRADA	CA	90638	562-694-3728	(H)	
CHEN	PHILIP C.	陳黔海	APEX COMPUTER SYSTEMS INC				562-926-6820	(O)	pchen@acsi2000.com
			8142 VILLAVERDE DR.	WHITTER	CA	90605	562-789-9888	(H)	
CHEN	ROBERT P.	陳澎	HONEYWELL				310-512-3568	(O)	
			22820 VAN DEENE AVE.	TORRANCE	CA	90502	310-830-1684	(H)	
CHEN	SAMMY		BOEING					(O)	

會員通訊錄

Last Name	First Name	Chinese Name	Company Name / Home or Mailing Address	City	State	Zip	Phone		E-mail
			10062 VALLEY FORGE DR	HUNTINGTON BEACH	CA	92646		(H)	
CHEN	SEAN	陳長恒	INFORMATIN SYSTEMS MANAGEMENT SOLUTION				626-715-8234	(O)	SCHEN@IS-MS.COM
			1506 HALLGREEN DR.,	WALNUT	CA	91789	909-595-7886	(H)	
CHEN	SHIH H.	陳世雄	BOEING ROCKETDYNE				310-336-8916	(O)	
			3970 CALLE DEL SOL	THOUSAND OAKS	CA	91360		(H)	
CHEN	SHIN	陳思行	AEROSPACE CORP					(O)	
			12763 ALCARE ST	CERRITOS	CA	90703		(H)	
CHEN	SUSAN	洪淑貞	BOEING ROCKWELL				562-593-9121	(O)	SUSAN.H.CHEN@BOEING.COM
			PO BOX 10084	FULLERTON	CA	92838	714-879-4498	(H)	
CHEN	WEI L.	陳偉賚	UNIV. OF CENTRAL FLORIDA				407-275-2245	(O)	
			3672 JOHN ANDERSON DR	ORMOND BEACH	FL	32176	904-673-8888	(H)	
CHEN	**WILLIE***	**陳烈偉**	HUGHES					(O)	
			5623 MISTRIDGE DR	RPV	CA	90274	310-541-5538	(H)	
CHENG	DENNIS	鄭 江	BOEING					(O)	
				LONG BEACH	CA	90801		(H)	
CHENG	PAUL C.	鄭傅海	MARTIN MARIETTA					(O)	CHENGER49@YAHOO.COM
			3787 E. PHILLIPS CIR.	LITTLETON	CO	80122	303-770-0330	(H)	
CHEUNG	CHRISTOPHER K.	張國忠	BOEING				425-717-8185	(O)	christopher.k.cheung@boeing.com
			1912 MARIPOSA LANE	FULLERTON	CA	92833	714-879-4936	(H)	
CHIANG	GEORGE S.	姜西華	BOEING				562-496-5793	(O)	geochiang@yahoo.com
			1089 EL CAMPO DR.	PASADENA	CA	91107	626-396-9213	(H)	
CHIANG	KEN	蔣光燦	BOEING				805-371-7164	(O)	
			5408 JON DODSON DR	AGOURA HILLS	CA	91301	818-991-1921	(H)	
CHIANG	TED T.	江德賢	FORD AEROSPACE				301-805-0446	(O)	
			22 HOLLYBERRY CT	ROCKVILLE	MD	20852	301-881-0874	(H)	
CHIANG	TIEN-HON	蔣天鴻	CAST INTERNATIONAL					(O)	
			3 ANDALUCIA	IRVINE	CA	92714		(H)	
CHIEN	**PATRIC***	**錢感曾**	BIRCHWOOD INTERNATIONAL					(O)	
			12325 KERRAN ST STE.B	POWAY	CA	92064	858-689-9886	(H)	
CHIEN	JOHN C.	簡崇仁						(O)	
			9341 LARKSPUR DR	WESTMINSTER	CA	92683		(H)	
CHIEN	RAYMOND	簡光和	RKC METALLURGICAL INC				317-230-6737	(O)	
			P.O.BOX 420, SC-R12	INDIANAPOLIS	IN	46206-042(	317-230-2872	(H)	
CHIN	PHILIP C.	金駿禔	PARKER HANNIFIN					(O)	
			8752 DOLPHIN DR	HUNTINGTON BEACH	CA	92646	714-968-2352	(H)	
CHOU	VICTOR	周勝年	BOEING					(O)	
			3 HOPKINS ST	IRVINE	CA	92715	714-786-0187	(H)	
CHOW	BENJAMIN	周 斌	BOEING					(O)	
			7871 BARBI LN	LA PALMA	CA	90623		(H)	
CHOW	**EDMOND***	**周光武**						(O)	
			P.O. BOX 389	SAN GABRIEL	CA	91778		(H)	
CHU	CARY	朱啓杰	BOEING				562-982-7625	(O)	
			13007 WARREN AV	L.A.	CA	90066	310-390-4865	(H)	
CHU	**MING-YUH***	**朱名譽**	NORTHROP				310-371-7134	(O)	mingyuh@hotmail.com
			19135 FIRMONA AVE	TORRANCE	CA	90503	310-542-5638	(H)	
CHU	PAUL	朱德玉	LITTON				818-715-4977	(O)	
			12730 MONTANA AVE.	LA	CA	90049	310-829-5147	(H)	
CHU	TSANN HSIN	朱燦忻	BOEING ROCKWELL					(O)	
			20214 AVENIDA PAMPLONA	CERRITOS	CA	90703	562-860-5453	(H)	

會員通訊錄

Last Name	First Name	Chinese Name	Company Name / Home or Mailing Address	City	State	Zip	Phone		E-mail
CHUNG	Y.T.	鍾永政	BOEING				714-896-3311	(O)	
			12375 ANDY ST.	CERRITOS	CA	90703	562-860-2482	(H)	
CHWA	RICHARD	蔡松	BOEING					(O)	
			4236 ARICA AVE	ROSEMEAD	CA	91770		(H)	
CUI	EDWARD	崔洪波	HONEYWELL				310-512-2002	(O)	edguizhi@yahoo.com
			1128 S. ELMOLINO ST.	ALHAMBRA	CA		626)457-8264	(H)	
CUI	PETER Y.	崔亚飞	DEUTSCH METAL COMPONENTS				310-323-6200	(O)	
			537 N. COLGATE ST	ANAHEIM	CA	92801	714-229-9459	(H)	
DING	GANG	丁刚					626-290-2622	(O)	gding668@yahoo.com
			30 RIDGE VALLEY	IRVINE	CA	92618	949-932-0386	(H)	
DUNN	MIKE	鄧德邁	BOEING ROCKETDYNE					(O)	mitym@aol.com
			1707 HERRIN ST.	REDONDO BEACH	CA	90278	310-318-6362	(H)	
FAN	**JASON***	**范哲源**	AMERITCH AEROSPACE					(O)	
			119 E SANT JOSEPH ST, #A	ARCADIA	CA	91006		(H)	
FANG	JAMES J.	方日進	BOEING ROCKETDYNE					(O)	
			21300 GERMAIN ST	CHATSWORTH	CA	91311	818-998-1671	(H)	
FUNG	JOHN W.	馮強長	BOEING					(O)	
			212 WEST LINDA VISTA #C	ALHAMBRA	CA	91801		(H)	
GUO	BRIAN	郭英培	PARKER HANNIFIN CORPORATION					(O)	BGUO1@JUNO.COM
			14300 ALTON PARKWAY	IRVINE	CA	92618	619-8389518	(H)	
HO	SEAN	何鴻志	BOEING				562-922-5859	(O)	sean.h.ho@boeing.com
			12824 HERITAGE PL.	CERRITOS	CA	90703	562-924-2866	(H)	
HO	MARK	何子平	BOEING					(O)	
			8370 GALLATIN RD	DOWNEY	CA	90240	562-861-4610	(H)	
HONG	SU-DON	洪賜當	SIDA CORP.					(O)	
			10551 E. DANBURY ST.	TEMPLE CITY	CA	91780		(H)	
HONG	**YUAN***	**洪远**	BOEING				562-982-2759	(O)	Yuan.Hong@boeing.com
			9367 CHRISTOPHER STR.	CYPRESS	CA	90630	714-220-2766	(H)	
HU	JUN	胡軍	BOEING				562-593-0157	(O)	
			9521 ROSE ST.	BELLFLOWER	CA	90706	562-866-8008	(H)	jun.hu@boeing.com
HSEU	BILL	許世賢	EATON CORP.				310-643-9938	(O)	
			27 MALLORCA	LAGUNA NIGUEL	CA	92677	714-495-7138	(H)	
HSIA	YEU-CHUAN	夏雨川	BOEING					(O)	
			11765 MONTE LEON WAY	NORTHRIDGE	CA	91326	818-368-4554	(H)	
HSIEH	ALBERT R.	謝若松	eCONNECTIONS, INC.					(O)	
			13332 PRESIDIO PLACE	TUSTIN	CA	92782	714-505-3795	(H)	
HSU	TOM	許同光					310-512-5733	(O)	
			9212 MOLT RIVER CIR	FOUNTAIN VALLEY	CA	92708		(H)	
HU	PAUL	胡名浦	BOEING				562-593-5298	(O)	
			18404 MANSEL AV	REDONDO BEACH	CA	90278	310-371-4737	(H)	
HU	CHARLENE	胡晓兰	HAMILTON SUNDSTRAND				858-627-6544	(O)	
			12985 SEABSEEZE FARMS DR.	SAN DIEGO	CA	92130	858-663-2620	(H)	xiaolanh@hotmail.com
HUANG	FRANK	黃重照					714-559-8143	(O)	
			11 SARATOGA	IRVINE	CA	92715		(H)	
HUANG	IKE	黃福照	HONEYWELL				310-512-1620	(O)	
			2535 E. VISTA PORINT DR.	ORANGE	CA	92667	714-921-4775	(H)	
HUANG	**LOUIS***	**黃啓鵬**	SPACE & MISSILE SYSTEM CENTER				310-363-6436	(O)	
			30115 AVENIDA TRANQUILA	RPV	CA	90275	310-377-9162	(H)	
HUANG	TAI	黃台	BOEING				562-982-5718	(O)	tai.huang@boeing.com

會員通訊錄

Last Name	First Name	Chinese Name	Company Name or Mailing Address	Home City	State	Zip	Phone		E-mail
			28195 MEADOW LAND DR	YORBA LINDA	CA	92687	714-692-2361	(H)	
HUANG	YULI	黃 毓 驪	BOEING				562-593-5383	(O)	yulhua@yahoo.com
			1829 PROSPECT AVE	HERMOSA BEACH	CA	90254	310-279-3356	(H)	
HWANG	**YATSUN***	**黃 益 三**	TRW				310-814-5734	(O)	yatsun_hwang@yahoo.com,
			5962 PRIEST DR.	LA PALMA	CA	90623	714-828-5412	(H)	
JAI	RAYMOND B.	翟 本 鈺	HONEYWELL				310-512-5457	(O)	
			7011 WILLOWTREE DR	RPV	CA	90274	310-541-1004	(H)	
JEN	YUAN	任 元	BOEING NORTH AMERICA					(O)	
			6391 ACACIA HILL DR.	YORBA LINDA	CA	92886		(H)	
JIA	TONY							(O)	TONYJIA_99@YAHOO.COM
			7842 DAISY CIRCLE	HUNTINGTON BEACH	CA	92648	714-333-8767	(H)	
JOU	RICHARD	周 慶 隆	FORTUNE CNC INC					(O)	
			7803 E. BRIARWOOD	ORANGE	CA	92669		(H)	
KAN	HAN-PING	甘 漢 鏞	NORTHROP GRUMMAN				562-332-5285	(O)	
			12733 LUCAS ST.	CERRITOS	CA	90703	562-926-4528	(H)	
KAO	ALMON S.	高 學 武	BOEING				562-982-9641	(O)	almon.s.kao@boeing.com
			2260 ROANOKE RD	SAN MARINO	CA	91108	818-308-0080	(H)	
KAO	MIKE P.	高 本 木					310-512-4078	(O)	
			17543 MONDIND DR.	ROWLAND HTS	CA	91748		(H)	
KHO	CHIAN H.	許 箭 發	EDS				909-736-1930	(O)	
			1973 STARFIRE AVE	CORONA	CA	91719	909-229-8353	(H)	
KING	WILLIAM	金 榮 耀	BOEING				310-816-1394	(O)	william.a.king5@boeing.com
			740 TERRACE DR	LONG BEACH	CA	90807	310-423-5088	(H)	
KLEIN	JACLYN	劉 效 其	BOEING				562-593-5234	(O)	jaclyn.h.klein@boeing.com
			2738 DEERFORD ST.	LAKEWOOD	CA	90712		(H)	
KO	**SHANNON***	**柯 金 象**	CHEN-TECH INDUSTRIES, INC.				949-855-6716	(O)	
			25622 RAPID FALLS	LAGUNA HILLS	CA	92653	949-362-6549	(H)	
KUAN	KAIN H.	關 健 興	BOEING					(O)	
			1806 KELLEHER PL	PLACENTIA	CA	92670		(H)	
KUEI	**STEVE C.***	**桂 正 岡**					310-512-2701	(O)	
			12909 CHAPARRAL RIDGE	S.D.	CA	92130	858-481-9612	(H)	
KUNG	RU-LI	龔 汝 立	ALLIED-SIGNAL					(O)	
			21210 CORRAL CT	WALNUT	CA	91789		(H)	
KUO	KENNETH	郭 維 新	BOEING					(O)	
			20515 LAKE CANYON DR.	WALNUT	CA	91789		(H)	
KUO	SU-YU	郭 書 毓	STUDENT (UC IRVINE)					(O)	
			19 LOREN ZO	IRVINE	CA	92614		(H)	
LAI	**JOHN***	**賴 英 政**	HONEYWELL				310-512-1312	(O)	
			5411 MANITOWAC DR.	RANCHO PALOS VERDES	CA	90275	310-542-8274	(H)	laijohn1@gmail.com
LAI	DANIEL							(O)	
			7633 CARMENITA LN.	WEST HILLS	CA	91304	818-888-1276	(H)	
LAM	WINSON	林 文 偉	TRW				310-613-3149	(O)	
			19031 S. SABRINA AVE	CERRITOS	CA	90703	562-402-5029	(H)	
LAN	MING-SHONG	藍 敏 雄					805-373-4429	(O)	
			2841 CONEFLOWER ST	THOUSAND OAKS	CA	91360	805-493-4019	(H)	
LANG	K.W.	郎 果 偉					818-710-6227	(O)	
			8043 CLEMENS AVE	W. HILLS	CA	91304	818-704-6025	(H)	
LAU	**JOSEPH***	**劉 亮**	HONEYWELL				310-512-3255	(O)	joelau41@aol.com
			1332 VIA ROMERO	PVE	CA	90274	310-541-9275	(H)	

會員通訊錄

Last Name	First Name	Chinese Name	Company Name / Home or Mailing Address	City	State	Zip	Phone		E-mail
LEE	**AU ***	李　鷗	BOEING				562-593-5371	(O)	Au.Lee@Boeing.Com
								(H)	
LEE	**CHARLES L.***	**李全伶**						(O)	charleslee40@hotmail.com
			12730 PALM ST.	CERRITOS	CA	90703	562-926-9860	(H)	
LEE	FRED	李世嘉	TAIWAN AEROSPACE					(O)	
			2732 S. RIO LEMPA DR	HACIENDA HEIGHTS	CA	91745	818-961-8713	(H)	
LEE	HUI-AN	李會安	BOEING				562-593-8006	(O)	
			17303 BABER AVE	ARTESIA	CA	90701	310-924-4375	(H)	
LEE	LANSON	李蘭蓀						(O)	
			HOME ADDRESS N/A			92705		(H)	
LEE	NANCY	張海韻	BOEING				562-982-6747	(O)	
			16351 WILDFIRE CIRCLE	HUNTINGTON BEACH	CA	92639		(H)	
LEE	SAMUEL	黎妙榮	BOEING				714-762-3182	(O)	
			28103 BRAIDWOOD DR.	RPV	CA	90275	310-544-7250	(H)	
LEE	TEH HWEI	李德恢	SUPERIOR DESIGN COMPANY					(O)	
			5541 IROQUOIS AVE.	LAKEWOOD	CA	90713	562-804-1068	(H)	
LEE	**TOM L.***	**李龍富**	HONEYWELL (RETIRED)					(O)	
			11 CHESTER	IRVINE	CA	92612	949-854-2290	(H)	t2_lee@yahoo.com
LEUNG	**KENNETH**	梁國基	BOEING				562-593-7098	(O)	kennethleung@engineering.ucla.edu
			909B W HELLMAN AVE	ALHAMBRA	CA	91803	626-758-8334	(H)	
LEVINE	**BARRY**		BARRY LEVINE FINANCIAL & INSURANCE					(O)	
			949 SOUTH COAST DRIVE SUITE 280	COSTA MESA	CA	92626		(H)	
LI	DIANE	李国青	PARKER HANNIFIN CORPORATION				949-465-4180	(O)	diane.li@parker.com
			14300 ALTON PARKWAY	IRVINE		92618	949-291-1273	(H)	gli8895@gmail.com
LI	MIN-CHUNG	林敏俊	KAISER COMPOSITEK		CA		714-990-6300	(O)	
			8 BRISA	IRVINE	CA	92620	714-505-1938	(H)	
LI	RICHARD	李欣生	RLM ASSOCIATE				714-962-3191	(O)	
			4 HARCOURT	NEWOORT COAST	CA	92657		(H)	
LIAO	**HENRY**						562-598-1383	(O)	liaojames@yahoo.com
			P.O. BOX 595	LOS ALAMITOS	CA	90720	562-500-7888	(H)	
LIEN	JOSHUA	练建亨	EATON LLC				818-409-0386	(O)	JOSHUA.H.LIEN@GMAIL.COM
			818 W NAOMI AVE #6	ARCADIA	CA		626-294-9261	(H)	
LIM	WAI K.	林衛國	BOEING				562-593-8589	(O)	waiklim@yahoo.com
			25624 AMBER LEAF RD	TORRANCE	CA	90505	310-325-6458	(H)	
LIN	ALBERT Y.	林友鶴	BAE SYSTEMS				310-915-8227	(O)	astromba@att.net
			6215 PAT AVE.	WEST HILLS	CA	91307	818-347-2593	(H)	
LIN	CHING-FANG	林清芳	AMERICAN GNC				805--582-0582	(O)	cflin@americangnc.com
			888 EASY STREET	SIMI VALLEY	CA	93.065		(H)	
LIN	CHUN-HONG	林俊宏	ALLIED IND. & ENG. CORP				818-285-9559	(O)	
			2570 MELVILLE DRIVE	SAN MARINO	CA	91108	818-285-0550	(H)	
LIN	DAVID	林　为	PARKER HANNIFIN CORPORATION				949-465-4177	(O)	
			8738 YOUUNGDALE ST.	SAN GABRIEL	CA	91775	626-673-7086	(H)	texram@hotmail.com
LIN	FRANK	林雨壽	HYDRO-ELECTRIC				818-843-6211	(O)	
			907 BALBOA DR	ARCADIA	CA	91007	818-309-5393	(H)	
LIN	**FRANK ***	**林　峰**	HONEYWELL				310-512-4208	(O)	frank.lin1@verizon.net
			4134 PACIFIC COAST HWY, #114	TORRANCE	CA	90505	310-791-2099	(H)	frank.lin2@honeywell.com
LIN	JOHN	林裕民	NEW YORK LIFE				714-572-2100	(O)	
(ASSOCIATE MEMBER)			108 N 2ND ST APT D	ALHAMBRA	CA	91801	626-821-8706	(H)	
LIN	HONG ZONG	林宏容	BOEING NORTH AMERICA				562-922-5768	(O)	

會員通訊錄

Last Name	First Name	Chinese Name	Company Name / Home or Mailing Address	City	State	Zip	Phone		E-mail
			14 BROADLEAF	IRVINE	CA	92612		(H)	
LIN	Nncy	林予华	MTI, LAB				562-881-5477	(O)	
			17821 MARTHA PLACE	CERRITOS	CA	90703		(H)	nancylinbox@hotmail.com
LIN	PEI	林 培	BOEING ROCKETDYNE				805-371-7564	(O)	
			6392 FENWORTH CT	AGOURA HILLS	CA	91301	818-706-2576	(H)	
LIN	RICHARD	林渝寰	ITRI				035-917600	(O)	
			BLDG 11,195 CHUNG HSING	CHUTUNG, HSINCHU	TWN	31015	035-711217	(H)	
LIN	WEIYAN	林維彦	C&D ZODIAC				714-523-9977	(O)	weiyanlin@hotmail.com
			2346 BATSON AVENUE				626-825-7787	(H)	
LIU	ANTHONY	劉 昱					562-922-1016	(O)	
			2101 VIRAZON DR	LA HABRA	CA	90631	310-697-4493	(H)	
LIU	CHI J.	劉啓疆	BOEING					(O)	
			9892 CARRAR CIRCLE	CYPRESS	CA	90630	714-527-7307	(H)	
LIU	DANKAI	劉登凱	JPL				818-393-0712	(O)	
			2222 FOOTHILL BLVD, E-172	LA CANADA	CA	91011	818-352-7832	(H)	
LIU	FRANK H.M.	劉興民	MM-WAVE TECHNOLOGY					(O)	
			21328 MONTECITO ST	WALNUT	CA	91789		(H)	
LIU	SARAH	刘蓓敏	HONEYWELL				909-680-5742	(O)	
			11 CORRIENTE	IRVINE	CA	92614	959-302-2881	(H)	pan_home@hotmail.com
LIU	**STEPHEN C.***	**劉政平**	PACIFIC CENTURY CUSTOMS SERVICE				310-670-1891	(O)	stephen@pccschb.com
			3 CHUCKWAGON RD	ROLLING HILLS	CA	90274	310-265-1901	(H)	
LIU	XIANMINHG	刘先明	SPACE ENVIRPNEER TECHNOWGISE				626-616-1479	(O)	XLIU@SPACENIRONMENT.NET
			19928 MANSEL AVE	TORRANCE	CA		310-317-5352	(H)	
LIU	YUN-CHIEN	劉運傑	JENNISH INTERNATIONAL				714-528-0871	(O)	
			520 GARDENIA AVE.	PLACENTIA	CA	92670	714-528-0871	(H)	
LO	ROGER	羅南平	UCLA PhD PROGRAM					(O)	
			3620 TULLER AVE.	L.A.	CA	90034	310-391-6217	(H)	
LO	WENSO	羅文碩	BOEING				562-593-6556	(O)	wenso_lo@msn.com
			9080 MCBRIDE RIVER	FOUNTAIN VALLEY	CA	92708	714-968-3534	(H)	
LU	MICHELLE	陆晓程	USC					(O)	Michellexlu@gmail.com
			4717 LOWELL AVE	LA CRESCENTRA	CA	91214		(H)	
LU	YAW-MIN	陸耀明	RAYTHEON					(O)	
			4814 DARIEN ST.	TORRANCE	CA	90503	310-860-5924	(H)	
LUI	MITCHELL	呂文聰	C & D ZODIAC				714-891-1906 *244	(O)	
			2000 CHOCTAW DR	WEST COVINA	CA	91791	310-922-3239	(H)	
MAH	WALLACE J.	馬永康	BOEING					(O)	
			1901 S. POINT VIEW ST	L.A.	CA	90034	213-933-6490	(H)	
MAR	**NELSON***	**馬在莊**	AEROSPACE CORP (PART TIME)				310-336-2493	(O)	Marfather1@cox.com
			30 ANDIAMO	NEWPORT COAST	CA	92657	949-497-1234	(H)	nelsontmar@yahoo.com,
MENG	LIQUN	孟力群	BOEING				562-593-0389	(O)	liqun.meng@boeing.com
			1642 BEECHWOOD	COSTA MESA	CA	92626	714-424-0139	(H)	
MIAO	**DAVID CHENG***	**繆大成**	JSC/NASA					(O)	
			P.O. BOX 67	ALHAMBRA	CA	90241	310-863-9489	(H)	
MIN	GWO BAO	閔國寶	MINS CONSULTING ASSOCIATES				415-838-1200	(O)	
			394 PRINCETON LN	DANVILLE	CA	94526	415-837-5903	(H)	
MOH	STEVEN	莫辭中	LORAL				714-770-3262	(O)	
			22545 FACINAS	MISSION VIEJO	CA	94526		(H)	
NG	BEN	吳來章	BENTERY				310-541-7828	(O)	
			30512 C. PORVINER	RPV	CA	90274		(H)	

會員通訊錄

Last Name	First Name	Chinese Name	Company Name or Mailing Address	Home City	State	Zip	Phone		E-mail
NG	BING	黃昭明	A. G. EDWARDS				800-876-0353	(O)	
			1221 FLAMINIAN WAY	SANTA ANA	CA	92705	714-832-8311	(H)	
NIU	**MICHAEL***	**牛春匀**	AD AIRFRAME CONSULTING				818-993-1169	(O)	Mniu@att.net
			18516 MAYALL STREET ,#H	NORTHRIDGE	CA	91324	818-993-1169	(H)	
OYOUNG	**S. PHILIP***	**歐陽小平**	HONEYWELL (RETIRED)					(O)	
			1860 SOMERSET LN	FULLERTON	CA	92833	714-871-2610	(H)	oyoungsp@yahoo.com
PAI	JASON	白瑜						(O)	yupai7@yahoo.com
			12321 REVA ST	CERRITOS	CA	90703	562-809-0022	(H)	
PAN	TONY	潘建光	GE AVIATION				626-249-0695	(O)	pan_home@hotmail.com
			11 CORIENTE	IRVINE	CA	92614	949-302-2881	(H)	
PENG	WILLIAM W.	彭文昌	CAL STATE UNIV./FRESNO				209-294-2014	(O)	
			678 W. MAGILL AVE	FRESNO	CA	93704	209-436-0357	(H)	
PHO	TINA	傅楚貞	TRW				310-814-8005	(O)	
			15412 CERISE AVE	GARDENA	CA	90249	310-644-4131	(H)	
SHEN	FRANK C.	沈晴輝	BOEING				562-797-1225	(O)	frank.c.shen@boeing.com
			19366 E. LEGACY PL.	ROWLAND HEIGHTS	CA	91748	714-595-3630	(H)	
SHEN	**FREDERICK F.***	**沈方楠**						(O)	
			13112 MOZART WAY	CERRITOS	CA	90703	562-483-5283	(H)	fredshen00@yahoo.com
SHEN	**MIKE T.***	**沈自元**	BOEING				562-982-6139	(O)	shennet02@yahoo.com
			12251 SILVA PLACE	CERRITOS	CA	90703	562-865-9384	(H)	
SHEN	RICK	沈毅					310-974-3313	(O)	taichi50us@gmail.com
			11437 HART ST	ARTESIA	CA	90701	562-809-9181	(H)	
SHENG	SHIH YUNG	沈世榮						(O)	sunwahsheng@aol.com
			10726 EQUESTRIAN DR	SANTA ANA	CA	92705	714-731-1224	(H)	
SHIAO	FU K.	蕭福國	BOEING ROCKWELL				714-762-8196	(O)	
			4525 VIA DEL BUEY	YORBA LINDA	CA	92686	714-777-8197	(H)	
SHIAO	SUN MING	蕭慎明	HONEYWELL				562-512-3608	(O)	sam.shiao@honeywell.com
			12519 E. SANDYCREEK LN	CERRITOS	CA	90703	562-926-3834	(H)	
SHIH	CHIH-YUAN	施志遠	BOEING				562-496-6540	(O)	
			4 TEAL	IRVINE	CA	92714	714-551-9479	(H)	
SHIH	DAVID WEI	施維德	BF GOODRICH				310-944-6244	(O)	wei.shih@allcomp.net
			20420 VIA CADIZ	YORBA LINDA	CA	92686	714-970-5553	(H)	
SHU	**JEFFREY C.***	**許志凡**	HUGHES SPACE AND COMM				310-662-6040	(O)	
			13103 MOZART WAY	CERRITOS	CA	90703	562-926-4968	(H)	
SMITH	WICKHAM	史偉克	WICKHAM SMITH & ASSOCIATES				949-753-3505	(O)	
			3922 ASH	IRVINE	CA	92714	949-552-3591	(H)	
SONG	EDDY	桑大禮	SINO-SWEARINGEN AIRCRAFT				562-496-9543	(O)	
			1675 WEST DRIVE	SAN MARINO	CA	91108	818-576-2990	(H)	
SONG	SARA	宋穎红	PARKER HANNIFIN CORPORATION				949-465-4358	(O)	sara.song@parker.com
			14300 ATON PARKWAY	IRVINE	CA	92618	623-455-0831	(H)	
SU	PAUL J.	粟鎮宇	BOEING SPACE, HB				714-896-2147	(O)	
			18828 TETON CIRCLE	FOUNTAIN VALLEY	CA	92618	714-968-2292	(H)	
SU	RICHARD	蘇昌禮	BOEING				562-593-5217	(O)	richesu@yahoo.com
			1807 CHARLEMONT AVE	HACIENDA HEIGHTS	CA		714-699-3219	(H)	
SU	WILLIAM		NORTROP				310-813-0150	(O)	
								(H)	
SUN	CHUCK	孫嘉康	BOEING				562-593-5257	(O)	C343435@YAHOO.COM
			535 MAGNOLIA AVE, #115	LONG BEACH	CA	90802	626-320-2781	(H)	
SUN	DAVID T.	孫定武	BOEING				562-593-5861	(O)	

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Last Name	First Name	Chinese Name	Company Name / Home or Mailing Address	City	State	Zip	Phone		E-mail
			13861 PROCTOR AVE	LA PUENTE	CA	91746	818-333-7927	(H)	
SUN	FRANK	沈懷俠	MDC (RETIRED)					(O)	
			21221 SAN MIGOEL	MISSION VIEJO	CA	92692	714-846-5327	(H)	
SUN	JOHN	孫 強	NORTHROP				310-332-3565	(O)	
			750 LYNNMERE DR	THOUSAND OAKS	CA	91360	805-492-5982	(H)	
SUN	TOM	孫祖洪						(O)	
			22909 WADE AVE	TORRANCE	CA	90502	310-530-3346	(H)	
SUNG	CHING-HSIA	宋景霞						(O)	
			1322 ARBORWOOD CIRCLE	CORONA	CA	91720	909-279-7718	(H)	
SY	JAYME	施建國	BOEING				562-496-8893	(O)	JAYME.T.SY@BOEING.COM
			10228 LIVEOAK AVE	ARCADIA	CA	91007	310-593-8740	(H)	
SZETO	FRANK	司徒傑	BOEING				562-209-6649	(O)	FZETO1881@YAHOO.COM
			1881 S. FLOGD CT	LA HABRA	CA	90631	562-697-9832	(H)	
TAI	DAVID W.	戴維茗	BOEING				425-266-3252	(O)	david_ty@yahoo.com
			27 RHODE ISLAND	IRVINE	CA	92606	949-733-0888	(H)	
TANG	LI-KEN	湯力耕	BOEING				310-416-0628	(O)	LI-KEN.TANG@BOEING.COM
			115 S. CORDOVA	ALHAMBRA	CA	91807	626-576-7795	(H)	
TANG	**PHILIP H.***	**湯小屏**	BOEING				562-496-6547	(O)	philip.h.tang@boeing.com
			532 W. WINNIE WAY	ARCADIA	CA	91007	626-574-7207	(H)	
TENG	CALVIN	鄧中恆	NORTHROP				310-332-9452	(O)	
			957 BARTON CT	ANAHEIM HILLS	CA	92808	714-281-9155	(H)	
TENG	**ROCK YING***	**滕 穎**	BOEING				562-593-0275	(O)	YINGTENG@aol.com
			30542 Rhone Dr.,	Rancho Palos Verdes	CA	90275	310-543-5298	(H)	Ying.Teng@boeing.com
TIEU	NAM TOAN	趙家強	U.A.S. ENGR CO.				818-913-1648	(O)	
			18020 E. WILLOW COURT	ROWLAND HEIGHTS	CA	91748	818-709-8600	(H)	
TONG	BING	仝 冰	PARKER HANNIFIN CORPORATION				949-465-4473	(O)	bing.tong@parker.com
			12985 SEABREEZE FRAMS DR.	SAN DIEGO	CA	92130	858-663-1883	(H)	
TORNG	**TONY***	**佟 儀**	BOEING/RSS				714-421-2166	(O)	TonyTorng@Yahoo.com
			20985 JADE CT.	DIAMOND BAR	CA	91765	909-598-7855	(H)	
TRAN	**HUNG BAN***	陈兴**邦**	BOEING				562-799-4933	(O)	
			2734 N. MEREDITH STREET	ORANGE	CA	92867	714-974-6579	(H)	
TSAY	ROBERT B.	蔡伯勳	BOEING				714-372-2542	(O)	
			20008 PASEO LORENZO	YORBA LINDA	CA	92686	714-779-5046	(H)	
TSIANG	**T.H.***	**蔣正華**	SINO-SWEARINGEN AIRCRAFT				210-258-3921	(O)	
			14207 DAYLIGHT RIDGE	SAN ANTONIO	TX	78230	210-561-9899	(H)	
TU	JEFFREY	杜震宇	BOEING				562-982-9851	(O)	
			12515 WILLOW CREEK LN	CERRITOS	CA	90703	562-802-8905	(H)	
TUAN	**SHIN-TEH***	段心得					310-512-3589	(O)	
			19701 VINTAGE ST	CHATSWORTH	CA	91311	818-993-8262	(H)	
TUNG	**LOUIS C.***	**董致陽**	BOEING				562-593-8603	(O)	
			19428 AMHURST CT	CERRITOS	CA	90703	562-924-8730	(H)	
TZONG	GEORGE	宗才致	BOEING				562-797-2759	(O)	tsair-jyh.tzong@boeing.com
			5291 PEMBURY DR	LA PALMA	CA	90623	714-994-3879	(H)	
WAI	S.K.	衛錫光	ASI INDUSTRIES				408-262-8883	(O)	
			44459 VIEW POINT CIRCLE	FREEMONT	CA	94539	511-226-166	(H)	
WAN	JACK	萬建新	PRUDENTIAL SECURITY				626-810-0905	(O)	
			18359 E CAMINO BETLO, #C	ROWLAND HEIGHTS	CA	91708	626-810-2992	(H)	
WAN	JUN	万 军	EDS				714-952-5354	(O)	
(ASSOCIATE MEMBER)			12937 ARABELLA PLACE	CERRITOS	CA	90703	562-809-3636	(H)	

會員通訊錄

Last Name	First Name	Chinese Name	Company Name / Home or Mailing Address	City	State	Zip	Phone		E-mail
WANG	AMY	王 蓉	HONEYWELL AEROSPACE		CA		626-589-3633	(O)	
								(H)	amywang70@yahoo.com
WANG	EDWIN C.C.	王建中	BOEING				562-593-6648	(O)	
			12728 E. CHARLWOOD ST	CERRITOS	CA	90703	562-860-0862	(H)	
WANG	JANE	汪 健						(O)	
			5751 SIERRA CIELO RD	IRVINE	CA	92612	949-725-3168	(H)	
WANG	**RICHARD***	**王道基**						(O)	richard.t.wang@GMAIL.com
			1907 W. 238 ST	TORRANCE	CA	90501	310-530-9638	(H)	
WANG	TENNYSON	王滇聲						(O)	
			5724 SPINNAKER BAY DR	LONG BEACH	CA	90803	310-598-8514	(H)	
WEI	K. H.	衛高華						(O)	
			16465 FALLEN OAK RD.	HACIENDA HEIGHTS	CA	91745	626-330-1526	(H)	
WEN	KEVIN	温克文					310-812-7268	(O)	kwwen@hotmail.com
			3482 LOTUS STREET	IRVINE	CA	92606	949-249-1417	(H)	
WENG	**CHING C.***	**翁敬忠**	HONEYWELL				310-512-3610	(O)	
			16402 HOBART LANE	HUNTINGTON BEACH	CA	92647	310-848-4094	(H)	
WENG	**DACONG**	翁 达聪					310-512-4778	(O)	dacong.weng@honeywell.com
								(H)	
WONG	GEORGE	王 嵩 壽	BOEING				714-372-1917	(O)	
			19405 S. SHERYL CIRCLE	CERRITOS	CA	90703	562-924-3861	(H)	
WONG	HENRY	王 蘅 壽						(O)	tthwong51@hotmail.com
			419 DOWNEY LN	PLACENTIA	CA	92870	714-996-5665	(H)	
WONG	KENNETH	黃國鴻	PARKER HANNIFIN				714-833-3000	(O)	
			3655 PROVINCETOWN	IRVINE	CA	92715	714-651-8425	(H)	
WONG	NORMAN	黃文輝	ARVAN, INC.					(O)	
			28928 CRESTRIDGE RD	RPV	CA	90274		(H)	
WONG	PAUL P.	王炳坤	TELEDYNE				818-717-6835	(O)	
			20352 EVERGLADES LN	HUNTINGTON BEACH	CA	92646	310-377-7968	(H)	
WONG	TA-HSIUNG	王遠雄	ALLISON ENGINE COMPANY				317-230-2325	(O)	
			9211 SELKIRK COURT	INDIANAPOLIS	IN	46260	317-844-5701	(H)	
WOO	ROBERT	吳恩錫	BOEING				562-496-9421	(O)	
			2649 W.RUSSELL AV	ANAHEIM	CA	92801	714-995-7470	(H)	
WU	**BENJAMIN***	**鄔錦文**						(O)	BENCWU@HOTMAIL.COM
			5262 BRYANT CIRCLE	WESTMINSTER	CA	92683	714-895-3820	(H)	
WU	ERH-RONG	吳爾融	MEGA RESEARCH, INC.				310-541-5287	(O)	
			29711 WHITLEY CALLINS DR	RPV	CA	90274	310-541-5287	(H)	
WU	HSI-YUNG	吳熙雍	BOEING				562-496-7415	(O)	
			6176 JEFFREY MARK ST.	CYPRESS	CA	90630	714-952-2615	(H)	
WU	JOAN	吴光群	BOEING				206-310-9052	(O)	
				SEATTLE	WA			(H)	
WU	**PETER E.**		PARKER HANNIFIN CORPORATION					(O)	peter.wu@parker.com
			16666 VON KARMAN AVE	IRVINE	CA	92606	949-648-8856	(H)	
WU	**PETER H.**	吳 洵	BOEING MILITARY AIRPLANE				316-526-2351	(O)	
			1445 CEDAR PARK CIRCLE	WICHITA	KS	67235	316-721-4348	(H)	
WU	SHU-LIANG BOB	吳叔粱	ALL STAR ENGINEERING				818-288-3809	(O)	
			5344 PONDOSA AVE	SAN GABRIEL	CA	91778	818-795-3518	(H)	
XIE	KANG	謝 康						(O)	
			144 ARDMORE DR.	SAN GABRIEL	CA	91775	626-299-1273	(H)	
XU	VERA FU							(O)	

會員通訊錄

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			6919 MAYCROFT DR	RANCHO PALOS VERDES	CA	90275		(H)	
YAM	ALIVIN	任兆麟	WESTMOUNT ACCET MGMT				626-463-7366	(O)	AYAM@WESTMOUNT.COM
ASSOCIATE MEMBER			70 SOUTH LAKE AVE, STE 1000	PASADENA	CA	91101		(H)	
YANG	**ERIC***	**陽道華**	BOEING				562-593-8008	(O)	eric.d.yang@boeing.com
			18 HILLTOP CIRCLE	RANCHO PALOS VERDES	CA	90275	310-378-6232	(H)	ericyang4@cox.net
YANG	JESSERSON YS	楊源生	ASIAN PACIFIC FELL CELL TECH.				714-630-9669	(O)	
			7217 DAPPLE CIR	ORANGE	CA	92669	714-639-3597	(H)	
YANG	**MICHAEL S.***	**楊孫均**	HONEYWELL (RETIRED)					(C)	Mike.yang7@verizon.net
			3815 VIA PALOMINO	PALOS VERDES ESTATES	CA	90274	310-378-2510	(H)	mikeyang36@gmail.com
YANG	STEVEN	杨少宁	BOEING				425-266-7914	(O)	
				SEATTLE	WA			(H)	
YANG	T.T.	楊添才	ROCKETDYNE				818-586-3154	(O)	
			728 S. BRISTOL AVE.	LA	CA	90049	310-829-7471	(H)	
YEH	DAVID T.	葉定葳	BOEING				714-896-1261	(O)	
			12534 INGLENOOK LANE	CERRITOS	CA	90703	310-865-3208	(H)	
YEH	HARRY C.	葉洪江					310-541-9476	(O)	
			7024 HEDGEWOOD DR	RPV	CA	90274	310-377-1988	(H)	
YEH	TE FUNG	葉德風	ALLIED-SIGNAL (RETIRED)					(O)	
			3811 FUCHSIA CIRCLE	SEAL BEACH	CA	90746	310-598-1100	(H)	
YEN	ANNA	嚴安娜	NORTHROP				310-942-5392	(O)	
			1521 23RD ST.	MANHATTAN BEACH	CA	90266	310-545-7603	(H)	
YING	BENEDICT	應愛義	HONEYWELL				310-512-4084	(O)	
			1017 PARK CIRCLE DR	TORRANCE	CA	90502	310-534-3615	(H)	
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YONG	**KAY***	**戎凱**						(O)	
			26 DECENTE	IRVINE	CA	92714	714-975-1236	(H)	
YOUNG	KENNY C.	楊欽凱	UNITED AIRLINE					(O)	
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ASSOCIATE MEMBER			1016 W. STADIUM AVE	W. LAFAYETTE	IN	47906	626-329-3289	(H)	
YU	**JIA***	**余嘉**	GOODRICH				619-691-4087	(O)	
			GOODRICH CO. 850 LAGOON DR MZ107P	CHULA VISTA	CA	91910	858-259-6758	(H)	
YU	**SEAN***	**余崇孝**	MORGAN STANLEY				626-446-6656	(H)	
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會員通訊錄

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					WA		818-471-3859	(H)	lovelulu83@hotmail.com
LU	ROBERTO	魯 異	BOEING					(O)	
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McCelland	JIM		BOEING					(O)	
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			4037 S 160th St	SEATAC	WA	98188	206-965-0328	(H)	zmsun688@yahoo.com
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WANG	CHEN-AN	王鎭安	MENASCO				817-267-3551	(O)	
			1016 CLEMSON DRIVE	ARLINGTON	TX	76012	817-795-1789	(H)	
WANG	JOHN C.	王慶頤	BELL HELICOPTER				817-280-5070	(O)	
			2004 LAKE COUNTRY DRIVE	ARLINGTON	TX	76012	817-274-7904	(H)	
WANG	PHONE-NAN	王芳男	COMPUTER SCIENCES CORP.				817-762-8762	(O)	
			3801 DANBRY	ARLINGTON	TX	76016	817-496-0953	(H)	
WEI	PAUL	魏英佶	LOCKHEED MARTIN				817-762-0231	(O)	
			7956 MORNING LANE	FORT WORTH	TX	76123	817-294-9955	(H)	
WU	JAMES	吳雲華	LTV, MISSILE DIVISION				214-266-1180	(O)	
			2204 COPPER RIDGE RD.	ARLINGTON	TX	76006	817-640-8912	(H)	
WU	PEILI	虞培麗	LOCKHEED MARTIN				817-935-1117	(O)	
			3108 REGAL DRIVE	ARLINGTON	TX	76016	817-496-3107	(H)	
YUAN	JAMES J.	袁拯民	ASSOCIATED AIR CENTER				214-350-4111	(O)	
			3536 MEADOWSIDE DRIVE	BEDFORD	TX	76021	817-354-4777	(H)	

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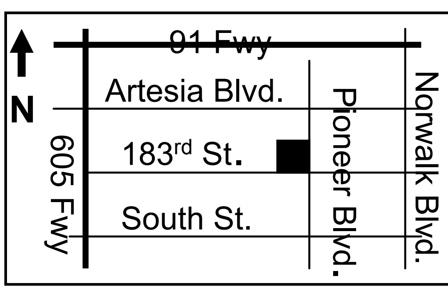

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