



# 成大拖航水槽的國際化與 臺灣培育造船工程師的挑戰 **The Internationalization of NCKU Towing Tank & The Challenge of Taiwan's Cultivation of Naval Architects**

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成大拖航水槽  
**NCKU TOWING TANK**

# PAST: HISTORIC MILESTONES

## 成大拖航水槽發展沿革及特色

- **Dept. of Naval Architecture was established in 1970.**
- **NCKU's 1<sup>st</sup> towing tank was established around 1982 at 成杏校區物治系館**
- **Relocated to the current position (the 2<sup>nd</sup> TT ) with the dept. in 1994.**



Railway Station

Towing Tank

# 成功大學拖航水槽基本資料

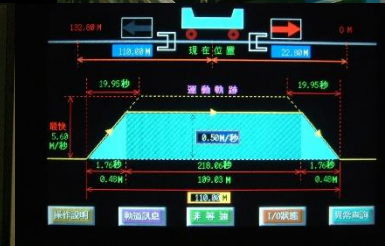
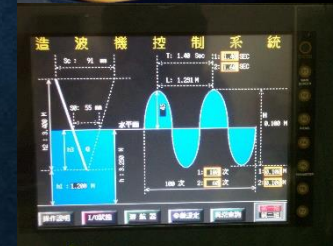
## INTRODUCTION TO NCKU TT

### • LAB:

- Length 175m L,
- North-South direction,
- Altitude: 30m

### • Towing Tank:

- 165m L x 8m W x 4m D
- Max. sped of carriage: 5.5m/s
- Wave maker: regular and irregular waves
  - Wave length 波高 < 0.6m
  - Period 週期 0.8~3.8s
  - Wave length 波長 0.23~25m
- Cranes x 3



# **AVAILABLE TESTS 實驗項目**

- 船模阻力實驗 **Resistance test**
- 自推實驗 **Self-propulsion test**
- 單獨螺槳實驗 **Open water test**
- 艤跡流測量 **Wake Survey**
- 流場測量、油墨實驗

**Flow field measurement, ink paint test**

- 船舶耐海性及操縱實驗 **Seakeeping & maneuvering test**
- 波浪發電實驗 **Wave generator experiment**
- 深海壓力測試櫃 **Deep sea (high) pressure test tank**
- 海洋結構物動態分析 **Ocean structure analysis**
- 水下運動潛體通訊機電控制研發

**Submerged vehicle mechatronics & communication**

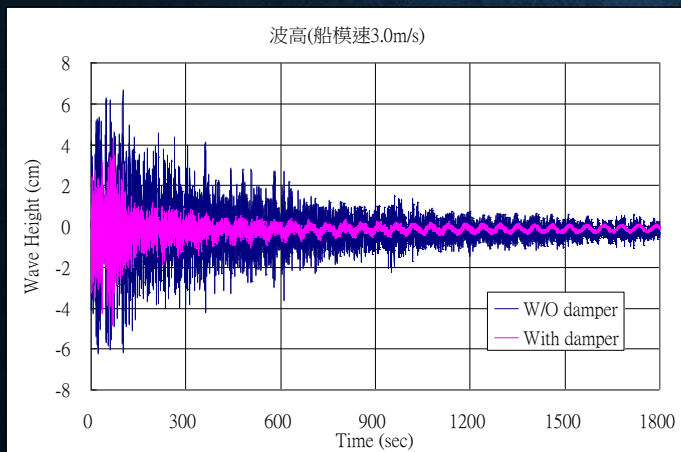
# **NOW: RECENT EXP. TECH IMPROVEMENT**

## **成大拖航水槽近年實驗技術精進**

- **Cooperated with CSBC, SOIC (former USDDC), and other shipyards in Taiwan**
- **Facility renovation & expansion**
- **New tests and techniques**
- **Personnel training**
- **Procedure standardized**
- **Efficiency improved**
- **ITTC Guideline matched**
- **Keep improving**



- **Rails**
- **Cranes, cradle**
- **Model storage**
- **Wave damping**



- 定期進行儀器校驗 **Routine Calibration**
- 全可追溯至國家或國際標準  
**National / International Standard**



量測科技股份有限公司  
104 (94)200002  
A (94)200002  
量測儀器  
品質管理



量測科技股份有限公司  
Measurement Technology Co., Ltd.  
CALIBRATION REPORT  
儀器校正報告書



1734

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NO. K05-10-317-93  
Issue Date  
發行之日期 2016/10/4

校對單 國立成功大學

校址 台南市東區大學路1號

製造廠商 聯準儀器

儀器名稱 標準法碼

校正程序 MTC-C95-017

Condition of calibration 校準前之儀器條件

Model No. 型號 1 kg ~ 15 kg / pcs

Serial No. 序號 K051011703

Received Date 接收日期 2016/10/7

Calibration Date 校準日期 2016/10/13

Temp. 溫度 20 °C ~ 21 °C

Relative Humidity 相對濕度 55 % ~ 85 %

Page 1 of 2

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Equipment 儀器名稱  
ELECTRONIC BALANCE  
電子天平  
STANDARD WEIGHT SET

Manufacturer 製造廠商  
METTLER  
METTLER  
METTLER

Model 型號  
XP2004S  
P1603MC  
T3308-70

Serial Number 序號  
B339817332  
P160379

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| Traceability<br>追溯機構 | Report No.<br>報告號碼 | Calibration Date<br>校準日期 | Due Date<br>有效日期 |
|----------------------|--------------------|--------------------------|------------------|
| MTC(1734)            | M04-10-165-02      | 2016/10/14               | 2017/1/31        |
| MTC(1734)            | M04-10-168-04      | 2017/10/30               | 2016/10/29       |
| MTC(1734)            | M06-01-001-02      | 2016/1/14                | 2017/1/13        |

MTC hereby declares that the equipment noted herein has been compared with the above listed standards. The standards used to perform this calibration are traceable to the national measurement laboratory (NML) of ROC. The MTC laboratories are in compliance with ISO/IEC 17025.

國家標準局認可實驗室。本公司所屬實驗室均符合國際標準局認可之 ISO/IEC 17025 之要求。



中國合格評定  
報告專用章

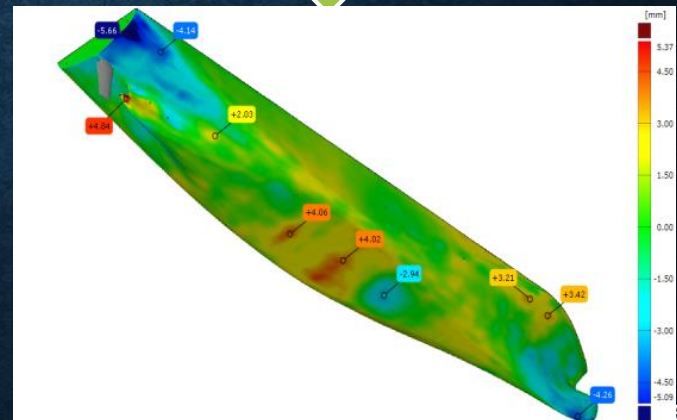
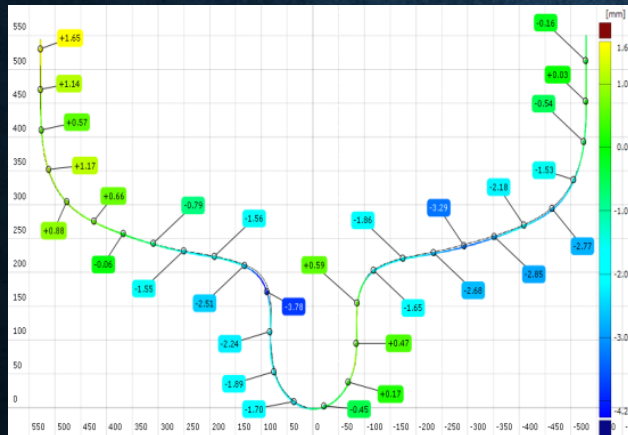
Appointed Signatory  
報告簽字人



Lab. Head  
實驗室主管



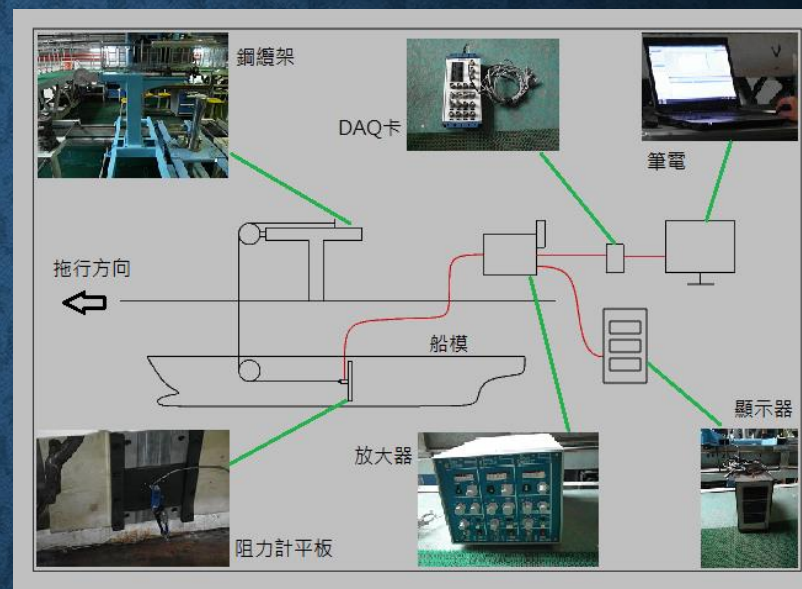
- **3D Scanning for Model Precision Check**



# ACCREDITED EXPERIMENTS

## • Resistance Test

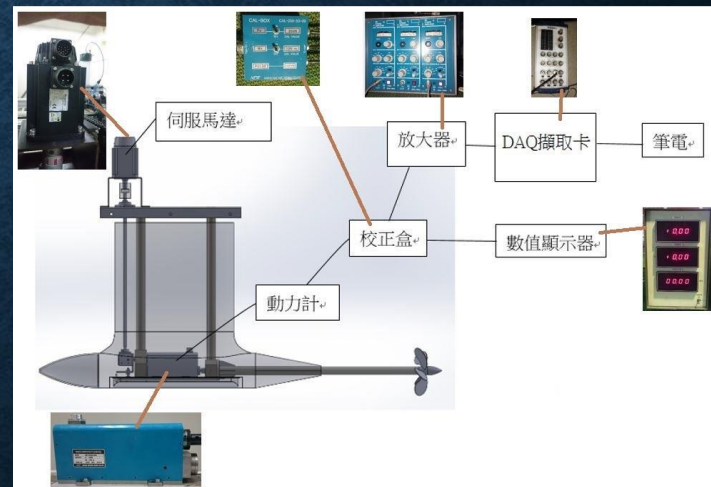
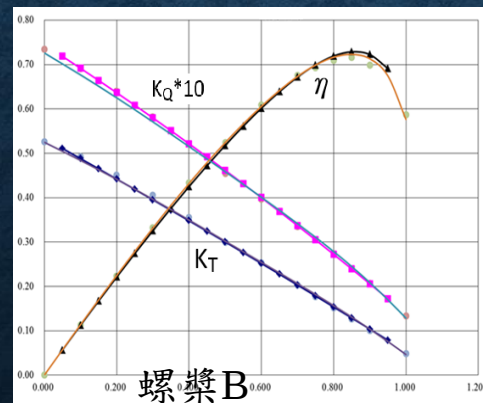
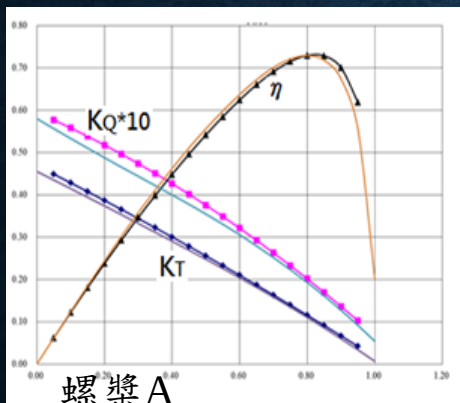
- Towing Rod method
- Towing Wire method added
- Blockage effect correction
- Consistency
- 同一船模在不同日期、相同條件下進行四次阻力試驗，除了其中一次的誤差為1.11%之外，其餘均保持在 $\pm 1\%$ 以內，顯示良好的再現性。



| 試驗日期    | 2015/12/9 | 2015/12/29  | 2016/1/7    | 2016/1/25   | 平均          |
|---------|-----------|-------------|-------------|-------------|-------------|
| 水溫      | 25.3      | 24          | 23.5        | 22.2        |             |
| 船模試驗總阻力 |           |             |             |             |             |
| Vm=1.87 | 5.845412  | 5.902811157 | 5.821305376 | 5.843175906 | 5.853176032 |
| Vm=1.99 | 7.047138  | 7.109840689 | 7.037895829 | 7.058543973 | 7.063354588 |
| Vm=2.15 | 8.605817  | 8.640625828 | 8.530126374 | 8.52630078  | 8.575717568 |
| 誤差百分比   |           |             |             |             |             |
| Vm=1.87 | -0.13%    | 0.85%       | -0.54%      | -0.17%      |             |
| Vm=1.99 | -0.28%    | 0.79%       | -0.43%      | -0.08%      |             |
| Vm=2.15 | 0.51%     | 1.11%       | -0.78%      | -0.84%      |             |

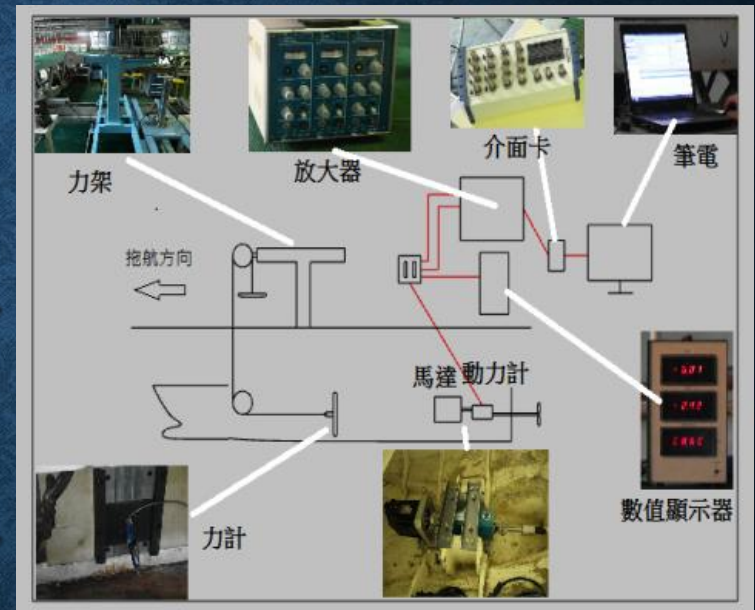
## • Propeller open water test

- Forward & backward
- Accuracy
  - 編號A與B的兩個螺槳模型，分別在成大拖航水槽與國際著名水槽進行螺槳單獨試驗。圖中的符號點是成大的試驗數據，而曲線是國際著名水槽的結果，兩者相當接近。



## • Self-propulsion Test

- Equal Loading method
- Equal Speed method
- 再現性 Consistency
  - 同一船模與螺槳在相同條件下，不同日期分別進行三次自推試驗。三次推力的誤差在 $\pm 1.3\%$ 之內；扭矩的誤差除一次為 $1.5\%$ 之外，其餘均在 $\pm 1\%$ 以內，顯示再現性相當良好。

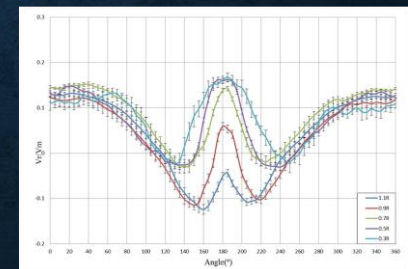
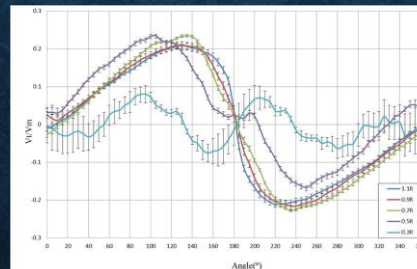
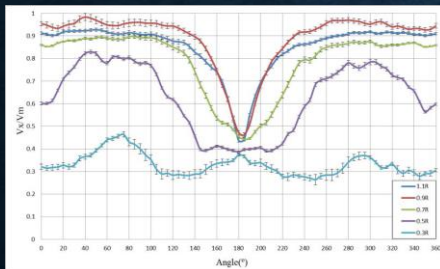
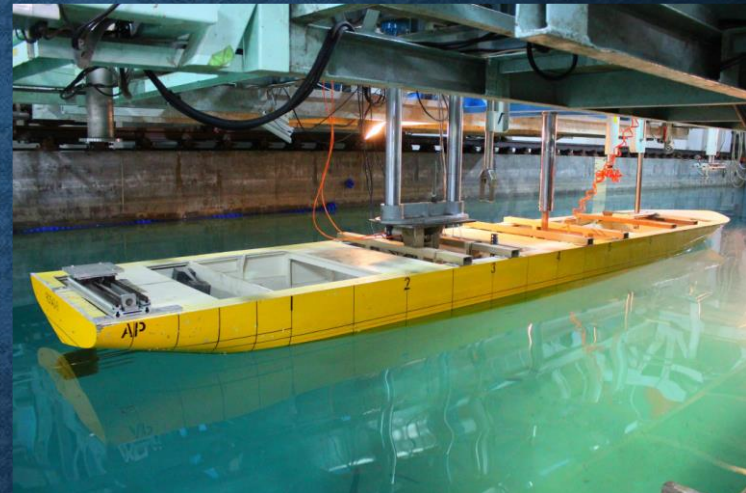


| 日期                     | 2016/7/22 | 2016/8/16 | 2016/10/6 | 平均       |
|------------------------|-----------|-----------|-----------|----------|
| 水溫(°C)                 | 27.0      | 27.0      | 26.9      |          |
| 船模試驗推力(thrust)原始值(N)   |           |           |           |          |
| $V_{m=1.87}$ (m/s)     | 34.97793  | 35.7865   | 35.32368  | 35.36270 |
| $V_{m=1.99}$ (m/s)     | 44.15517  | 45.27884  | 44.78983  | 44.74128 |
| $V_{m=2.15}$ (m/s)     | 56.28133  | 56.62416  | 56.54288  | 56.48279 |
| 偏差百分比                  |           |           |           |          |
| $V_{m=1.87}$ (m/s)     | -1.08%    | 1.20%     | -0.11%    |          |
| $V_{m=1.99}$ (m/s)     | -1.31%    | 1.20%     | 0.11%     |          |
| $V_{m=2.15}$ (m/s)     | -0.36%    | 0.25%     | 0.11%     |          |
| 船模試驗扭矩(torque)原始值(N-m) |           |           |           |          |
| $V_{m=1.87}$ (m/s)     | 1.208741  | 1.216062  | 1.22226   | 1.215687 |
| $V_{m=1.99}$ (m/s)     | 1.494877  | 1.528853  | 1.52922   | 1.51765  |
| $V_{m=2.15}$ (m/s)     | 1.90103   | 1.904113  | 1.90567   | 1.902604 |
| 偏差百分比                  |           |           |           |          |
| $V_{m=1.87}$ (m/s)     | -0.57%    | 0.03%     | 0.54%     |          |
| $V_{m=1.99}$ (m/s)     | -1.50%    | 0.74%     | 0.76%     |          |
| $V_{m=2.15}$ (m/s)     | -0.14%    | 0.03%     | 0.11%     |          |



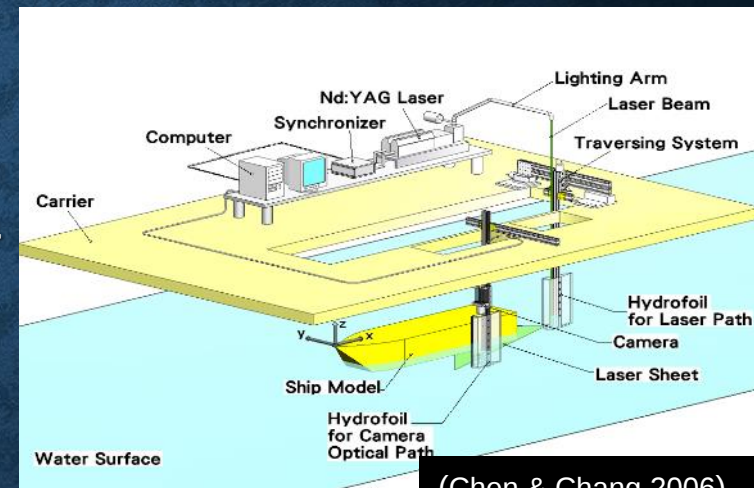
# OTHER EXPERIMENTS

- Wake survey: 5-hole Pitot Tube Array

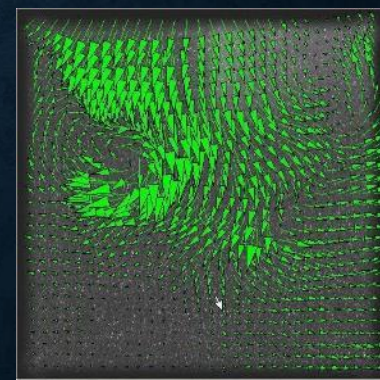
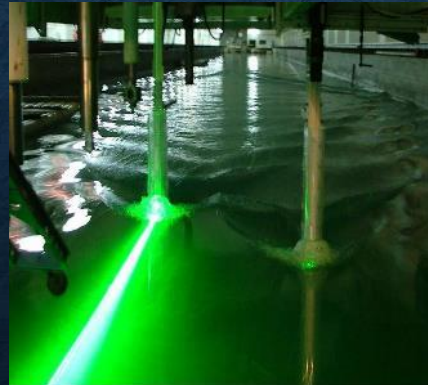
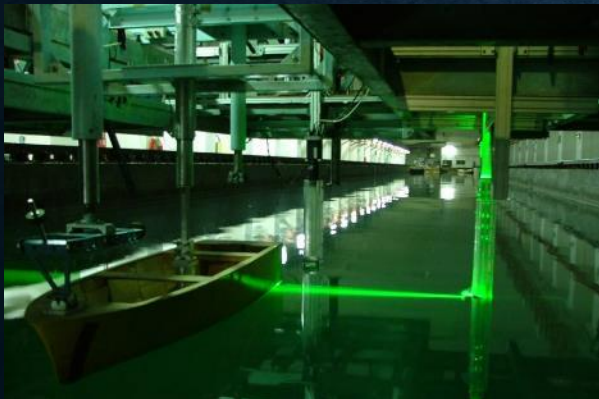


## • Flow Field Measurement: PIV since 2005

- Home made, 2D2C
- paper published (Chen & Chang, 2006)
- To be **upgraded** to 2D3C PIV soon
- & mini LDV

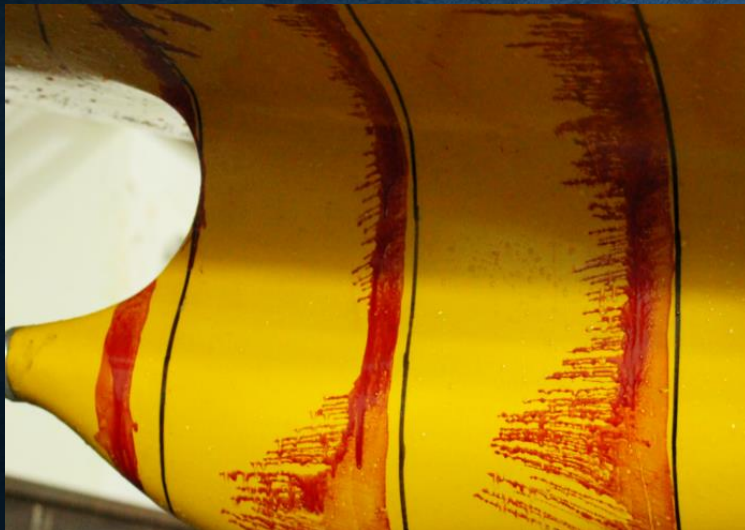


(Chen & Chang, 2006)



- **Flow Visualization**

- Single color (black, red, blue, green)
- Multiple colors



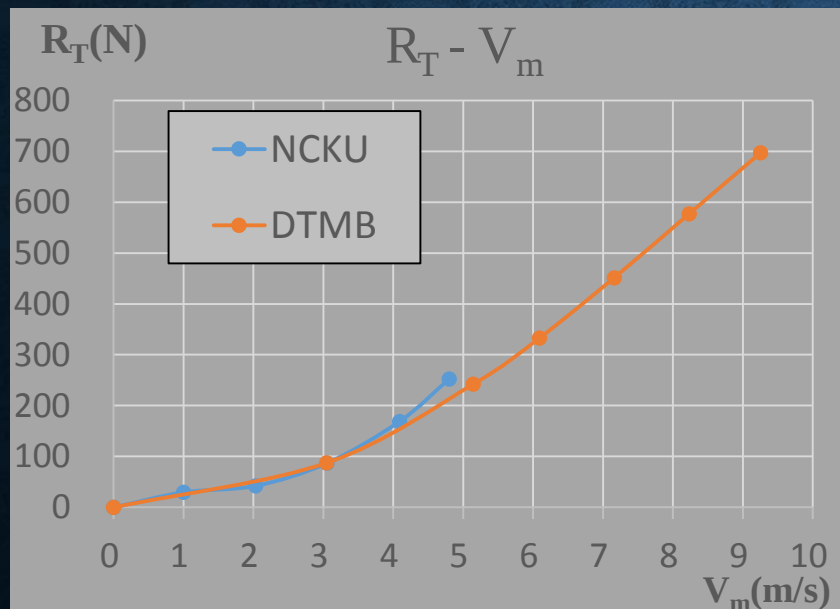
# SUBMERSIBLE BODY

- **Rear supporting system**
- **Side supporting system**



## • SUBOFF Resistance Test:

- Exp. Date: 2016-08-12 (Preliminary Testing Run)
- Model: **NCKU Suboff 5470-01** (No appendage)
- Depth: 1.8m
- Towing speed: 1.00~4.80 m/s;
- Error<1% @ 3.05m/s

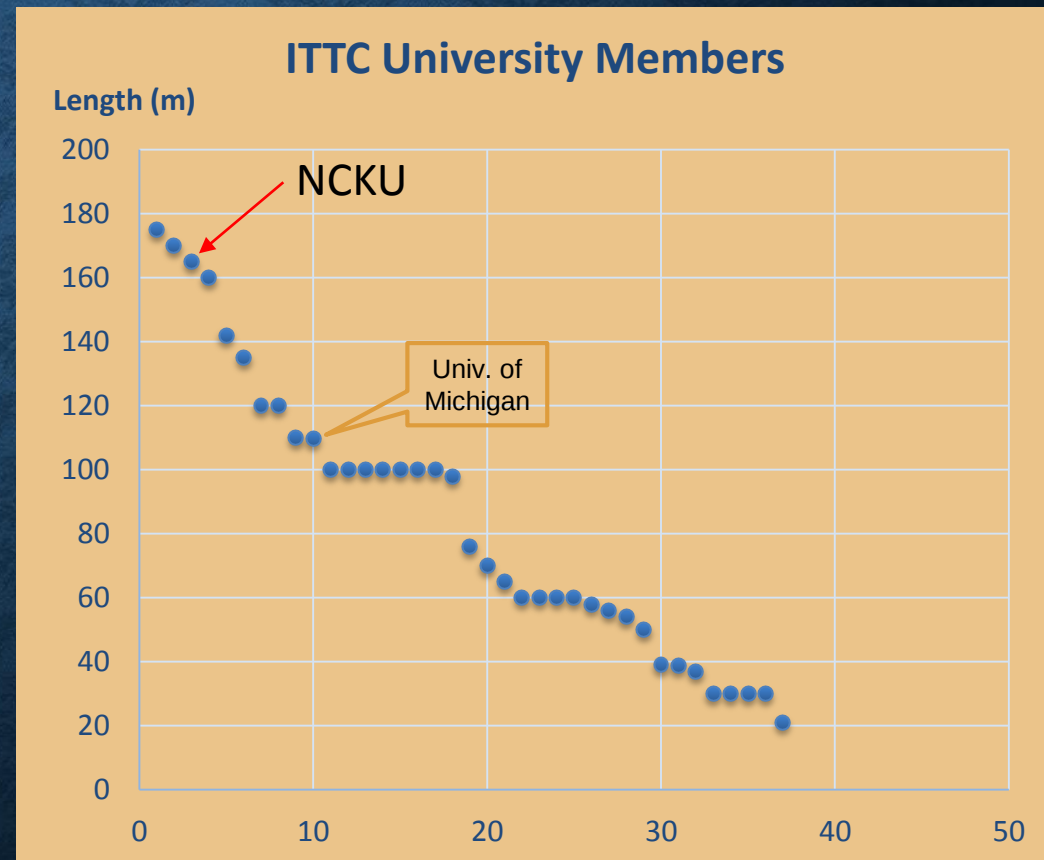


# COMPARISON WITH ITTC'S UNIVERSITY MEMBERS 與ITTC大學會員水槽之比較

- 37 university members of ITTC

- The longest 2 members

- 華中科技大學  
Huazhong, China (175m)
- 大連理工大學  
Dalian, China (170m)
- 成大 NCKU (165m)



# SIGNIFICANT INFLUENCE OF INDUSTRY COOPERATION

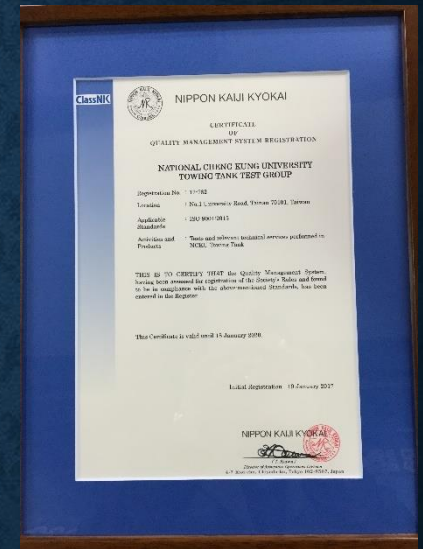
## 近年與業界合作的重大影響

- 實驗精度提高，更為實用  
**Better precision:**
  - 軌道平行度、真直度 rails
  - 台車減震與速度平穩 Less vibration
  - 測速、測溫、測力 force & speed
  - 可靠度、再現性提升 Reliability
- 實驗效率提升 **Higher Efficiency**
  - 起重設備 cranes added
  - 消波裝置改善 wave damping ropes
- **More tests available**
  - Wake survey,
  - Self-propulsion,
  - Propeller open water test



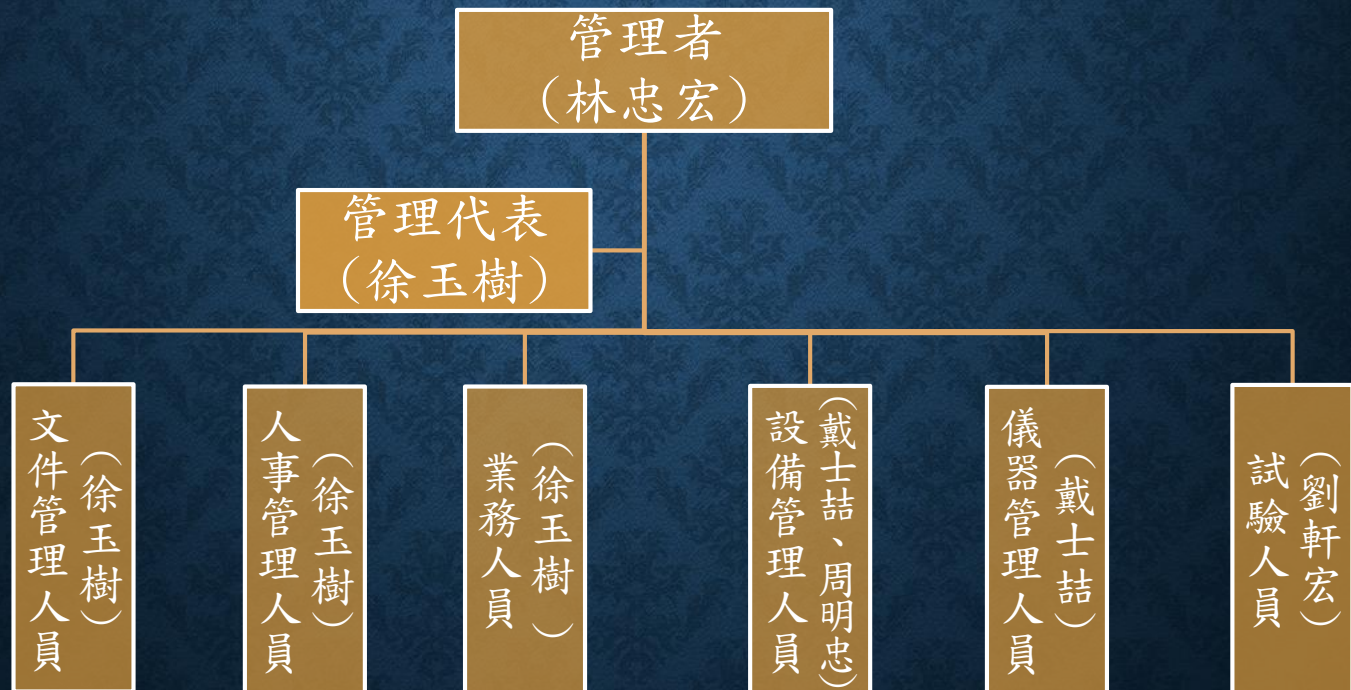
# ACCREDITATION AND INTERNATIONALIZATION 認證與國際化

- 經過9個月準備、建置，2016年9月申請，3個月的內外部稽核
- 2017年1月19日獲日本海事協會通過**ISO 9001**認證  
**ISO 9001** accreditation by NK on Jan. 19, 2017
- 成為驗船協會能源效率設計指標(**Energy Efficiency Design Index, EEDI**)認證執行機構  
**EEDI** accreditation possible
- 產學小聯盟  
**The Academia-Industry Little League**
- 預備國際化商業水槽的規劃  
**Preparation for international commercial towing tank**



# 低排廢氣船舶設計、測試與驗證 產學技術發展聯盟

- 組織架構



# EXTENSION POTENTIAL

## 未來擴充發展的可能性

- **Land (underground space) available**
  - Length: possible to be extended up to 400m
  - Area: possible to be extended to 180m x 180 m for maneuvering basin
  - Maybe the only option, but expensive? Or relatively cheap?



# THE CHALLENGE OF HUMAN RESOURCES IN NAVAL ARCHITECTURE

## 造船人才培育的挑戰



# THE PROBLEM

## 臺灣造船工程人才培育的問題

- 各相關科系的船舶領域教學發展近況
  - 系的數量太多，maybe 2+1
  - 招生數太多， maybe 80+80?
  - 每個系的船舶領域師資萎縮且太少， maybe >14~21/系
  - →難以形成健康的學術社群
- 業界人才招募情形與水槽實驗經驗
  - 薪水：有些提高了，但.....
  - 工作環境：衛生、設備、美學、及其他
  - 職涯發展：長期發展的決心與信心
- 培育下一代造船工程師的各種挑戰
  - 與誰/什麼競爭?
  - 競爭什麼?

# GENERATION GAP

## 世代斷層

- 師資斷層
  - 嬰兒潮世代教授退休
  - 中生代工程師、教師斷層：人數少、部分外流
- 招募
  - Where?
    - 國內：學術研究導向與水準、人數
    - 留學：<5，滯外工作
    - 外籍：機敏計畫問題、條件問題
  - 競爭對象與條件：機械新領域、能源.....
- 需求
  - 領域：熱流、結構、機電應用
    - 領域的問題很麻煩
  - 身分：各年齡層、女性

# THE DESIGN OF PROFESSIONAL EDUCATION 養成教育設計

- 課程設計需要變革
  - 大一工程概論、導論科目：**情意**、內容、體驗、知識
  - **美學**素養的強調與貫穿
  - 大四總結式課程：設計+實作
  - 專業課程
    - 必修科目減少、選修科目增加
    - 核心科目強化：加深加廣、品質要求
    - 學程化：開發多種學程、吸引跨域修課 (工設、機械、航太?)
    - **跨域選修**及整合的教學設計
  - 境教陶冶、專業文化

# SUPPORTING SYSTEM 支援體系

- 研發人力
  - 博士級研究員及經理
  - 碩士級研究助理?
  - 學士級研究助理
  - 技術人員
- 小型工作間
- 船模製造?
  - 五軸加工：附屬或外包?



# SUGGESTIONS 建議

- 公費留學
- 國內獎學金
  - 實務人才
  - 研發人才
  - 學術人才
- 校際競賽
- 其他



# THANK YOU

