



Improving Quality and Reliability through

Effective Failure Analysis

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Content

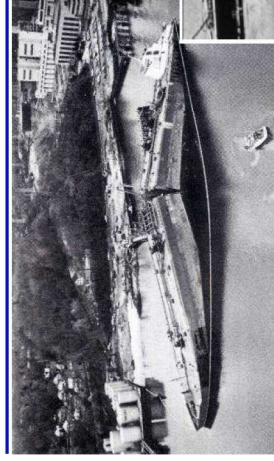


- Introduction
- Effective Failure Analysis
- Selecting Analysts
- UTC's clients and recognitions
- UTC's Competencies
- Investigated High Profile Cases
- Summary

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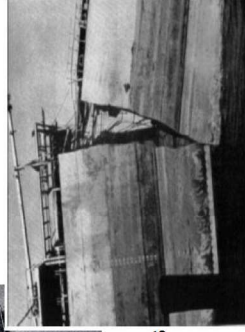
Introduction



During WWII (1941-1945)
500 T2 tankers & 2700 liberty ships
30% tankers and ships suffered
from catastrophic fracture into
halves !

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Examples of failures



Introduction

Examples of failures

4 Nov, 2010, Qantas Flight
32, one of the Airbus
A380's four Rolls-Royce
engines failed minutes after
it had left Singapore for
Sydney, resulting in engine
fire and danger of 440
passengers and 29 crew on
board.



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Introduction



London Grenfell Tower fire

- 1:00 on 14 June 2017, fire broke out in the kitchen of a fourth floor flat at the 23 storey.
- Within minutes, the fire had raced up the exterior of the building and then spread to all four sides.
- Seventy-two people died.



Introduction



On 15 Dec 2011
4 trains stalled
Disruption - 4 hrs 53 min.
Affected >123,000 passengers
7 Dec 2011

On 17 Dec, 2011
5 train stalled
Disruption - 7 hrs 9 min
Affected > 94,000 passengers

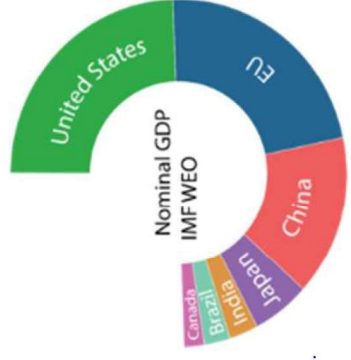
PM called to set up Committee of Inquiry (COI) and public hearing

Introduction



Economic loss caused by failures and accidents

- ~ 4% GDP
- GDP in USA was worth 20.54 trillions US dollars in 2018 (World Bank)
- Economic loss - US\$822 billions
- Global GDP - 80 trillion U.S. dollars.
- Economic loss ~ US\$ 3.2 trillions



Introduction



- **What caused?**
 - Manufacturing,
 - management,
 - operation,
- **Who shall be responsible for?**
 - Manufacturer,
 - contractor,
 - user,
- **How to prevent recurrence?**
 - Counter measures

Failure Analysis

Introduction



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Objectives

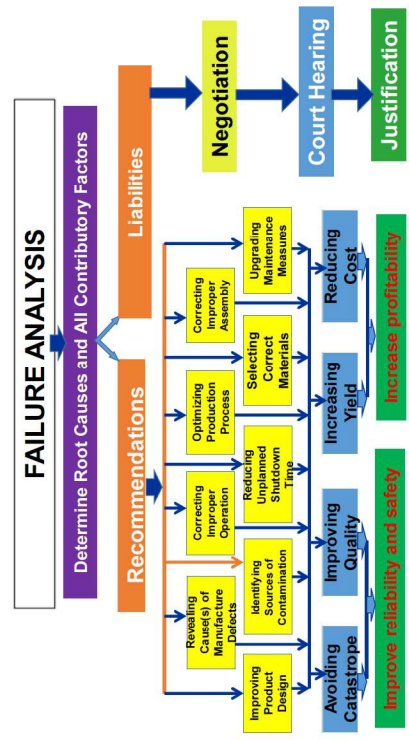


Failure Analysis

- Determine the root cause(s), contributory factors of the failure, failure mode(s), and mechanism(s);
- Recommend proper remedy and/or preventive measures(s) in aspects of design, manufacturing, installation, operation and maintenance for prevention of future failure;
- Provide expert opinion with evidence for adjudication of legal disputes.

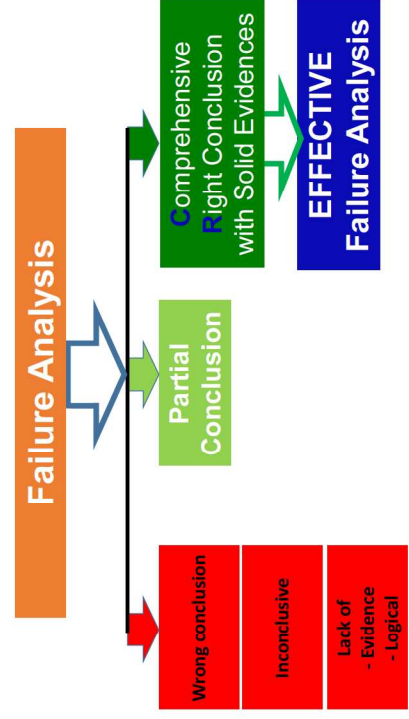
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Benefits



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Effective Failure Analysis

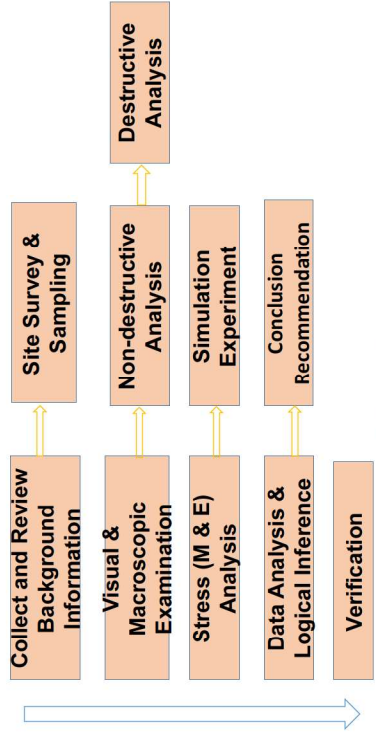


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Effective Failure Analysis



General Procedures



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Effective Failure Analysis



Verification

- ✓ Explain all phenomena and data
- ✓ Feedback from the clients
- ✓ Peer review
- ✓ Effectiveness after FA and implementation
- ✓ Court acceptance

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Effective Failure Analysis



Key Elements

- Qualified analysts
- Good track records
- Proven analysis procedure and approach
- Multi-discipline and cooperative team
- Adequate analysis tools – instruments
- Impartial, objective and trust

CORE - Analysts

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Selecting Analysts



Price vs. Quality

- According to a study by IBM, > 72% consumers are more concerned with quality of medicine and food they buy rather than price.
- **Why? Medicine Quality i.e. its effectiveness is more crucial / important for curing diseases**
- **Similarly, for investigation effectiveness**
Ineffective investigation resulting in wrong conclusions – no value or even negative value due to waste precise time and misleading

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Selecting Analysts

Lower Price ≠ Saving

- *Ineffective investigation - no value or even negative value, no matter how cheap.*
- *Price comparison must be based on the same level of experience and track records of investigators.*
- *Only lean organizations with much experience and better traceable track records are competitive in quality and saving.*

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Selecting Analysts

Cost-effective Investigation

- *High quality.*
- *Price or cost competitive.*
- *Open market proven.*
- *Traceable track records.*

GeBIZ is a platform for government agencies to procure technical services (tenders & contracts). Gebiz awards are very good indicators for cost-effective investigation.

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UTC's Profile

- Key staff had accumulated more than 35 years industrial experience in various areas.
- As Principal Investigators, had successfully completed thousands significant projects.
- Served various industrial sectors and government agencies, such as aerospace, marine, defense, petrochemical, electronics/ microelectronics, transportation, construction, power, amusement.
- UTC and key staff had served MOM, MOT, DSTA, RSAF, Navy, PUB, LTA, Enterprise Singapore (ex-SPRING), Senoko power, Rajah & Tann, SMRT, RWS, SBS transit, Shell, Exxon Mobil, ST Aerospace, Eagle Services Asia, SIA Engineering, HP, Dell, Infineon, ST Marine, Takenaka, Hyundai E & C, Sembawang Shipyard, MSIG, China Taiping Insurance etc.

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UTC's Profile

Your benefits with our strength

- *Reliable results and solutions* - UTC's team consists of experts in multiple-disciplines with more than 35 years relevant experience and track records.
- *Cost saving* – UTC staff directly work with clients, which significantly reduces the costs incurred by heavy overheads and administration, especially in those large organization.
- *Short turnaround time* - UTC's staff have abundant relevant experience and solve issues fast, technical experts and decision maker, no unnecessary administrative interruptions.
- *UTC's reports are reliable & well recognized, can stand up in any occasions including technical litigation in courts.*

UTC provides reliable results and solutions in more efficient and cost effective approach, solves the issues effectively.

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UTC's Profiles

Cost-effective Analysis and Investigation

Examples of GeBIZ awards to UTC

- MOM, Investigation on fatal gate toppling at construction site.
- SCDF, Period contract of failure analysis & investigation (2015-2018)
- SCDF, Period contract of failure analysis & investigation (2019-2020)
- LTA, Conduct training course "Vehicle Fire Investigation" (3 runs)
- SPRING, Investigation on explosion of storage water heater
- Enterprise SG, Investigation on liquid dispenser fire
- RSAF, Failure analysis on unmanned aerial vehicle structure fracture
- RSAF, Failure analysis on aircraft brake bolt failure
- RSAF, 3 days training course "Failure Investigation and Analysis
- SCDF, Investigation on taxi fire and explosion near Buona Vista MRT
- SCDF, Forensic investigation on CNG vehicle fire @ Maymount Road
- PUB – 1 year contract for failure analysis on facility damages
- ...

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UTC's Profiles

Typical projects (mechanical and structures)

- Damages of amusement rides (track, roller coaster vehicle)
- Train accident (3rd rail, track)
- Accidents of cranes (toppled, collapsed, injuries)
- Aerospace engine damage, landing gear system failure
- Automotive steering system failure
- Hovercraft accident (gear box damages, propeller fan failure)
- Failures in gas and steam turbines
- Failures in jack-up rigs (piping, windows, jack up gear)
- Heat exchanger burst, structure collapse, piping leakage in petrochemical plants
- Large ship-lifting system cracking, propeller corrosion
- Failures in building and structures
- Hovercraft gearbox and propeller damage.

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UTC's Profiles

Typical projects (electrical and electronics)

- Failure analysis on circuit breaker outage (NE MRT line).
- Failure analysis on circle line power cable damage.
- Investigation on power interruption- porcelain insulator (NE MRT line).
- Forensic investigation on HV connector explosion (MRT vehicle).
- Failure analysis on CCTV camera cable damage in MRT stations.
- Failure analysis on insulator flashover (NE MRT line).
- Failure analysis on notebook computer burning, printer damages.
- Investigation on extra-hydrogen release in huge battery of Submarine (>300 Kg).
- Failure analysis on transformer fire.
- Investigation on electrical switchgear fire (ship).
- Failure analysis on electrical distribution station explosion.
- Investigation on busbar explosion in shopping centre.
- Forensic investigation on major MRT disruptions with power supply
- Investigation on LED burning @ Marina Square Shopping Mall
- Failures of PCB, PCBA, LCD, IC, MLC, microprocessor malfunction.

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UTC's Clients



And many more

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Client's Recognitions



Project: "Investigation and Expert Witness on Fatal Fire of aluminium cladding panels @ Toh Guan Road "-. UTC was engaged by a lawyer firm

Comments from Mr Jeshua-Lawyer of NETTO & MAGIN LLC

"Your report is excellent, exceed our expectations".

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Client's Recognitions



Project: " Investigation on ship propeller corrosion "

The client's comments: "Dr YU, I thank you for the most excellent report".

in E-mail from Mr Tony Fielding, Project Director, Teekay Shipping (Australia) Pty Ltd and Sembawang Shipyard Pre Ltd.

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Client's Recognitions



Projects: " Failure analysis investigation" – Singapore Civil Defence Force (SCDF)

- A. Period Contracts – Year 2015 -2018 and 2019-2020
- B. Investigating two CNG taxi fires and explosion jointly engaged by SCDF and LTA

SCDF and LTA highly appreciated UTC's investigation works and competencies. They further requested UTC to conduct three runs of training course "Vehicle Fire Investigation" in 2018. LTA's management and technical staff as well as four team leaders of SCDF fire investigation units attended the course.

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Client's Recognitions



Projects: " Failure analysis on aircraft structures and component damages - RSAF"

"SAF has cooperated with UTC several times previously and UTC has proven to be capable of fulfilling our requirements. We are very satisfied with UTC's performance."

Extract from E-mail of WONG Shi Min | Procurement Manager | Defence Science and Technology Agency on 2/2/2018.

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UTC's Competencies

Qualification and accreditation

- ✓ Fellow of [Institution of Engineers, Singapore \(IES\)](#)
- ✓ Chartered Engineer in [Materials Science and Engineering, Engineering Council \(UK\)](#)
- ✓ Member, National Association of Fire Investigators (USA)
- ✓ Professional member of [Institute of Materials, Minerals, and mining \(UK\)](#)
- ✓ Chartered Engineer in [Civil and Structures, Engineering Council \(UK\)](#)
- ✓ Certified Pressure vessel inspector API 510 ([American Petroleum Institute](#))
- ✓ Professional member of [Institution of Structural Engineers \(UK\)](#)
- ✓ Chartered Engineer in [Aerospace Engineering \(Singapore\)](#)
- ✓ Expert/Technical Assessor of [Singapore Accreditation Council \(SAC\)](#)
- ✓ Executive committee member of [The Institute of Materials \(East Asia\)](#)

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UTC's Competencies

Relevant investigations & experience

- ✓ Failure analysis on wire rope fracture of lift – **HDB**
- ✓ Forensic investigation on tower crane collapse with wire rope breakage @National Art Gallery – **Takenaka (Japan), Arbitration Court**
- ✓ Forensic investigation on wire rope damages of mobile crane – **China Taiping Insurance, High Court**
- ✓ Investigation on wire rope breaking of 4 winch lifting system- **Hyundai**
- ✓ Investigation on wire rope fractures in MRT- **SBS Transit**
- ✓ Investigation on wire rope breakage of tower crane - **Hyundai**

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Our Competencies

Relevant investigations & experience

- ✓ Forensic investigation on corrosion @ Esplanade Theatres – **Pentagon, Japan**
- ✓ Forensic investigation on wire rope damages of mobile crane (corrosion fatigue) – **China Taiping Insurance, High Court**
- ✓ Investigation on aircraft aluminium foil corrosion – **ST Aerospace**
- ✓ Investigation on hovercraft propeller failure (aluminium bolts corrosion and fatigue)– **ST Marine/Navy**
- ✓ Forensic analysis on cast iron pipeline cracking (corrosion) – **NTUC Health**
- ✓ Investigation on ship propeller corrosion - **Sembawang Shipyard**
- ✓ Investigation on manhole corrosion and breakage - **PUB**
- ✓ Investigation on stainless steel U-bolt fracture in MRT (stress corrosion cracking) - **SBS Transit**
- ✓ Forensic investigation on 29" pipeline leakage – **Universal Terminal**
- ✓

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UTC's Competencies

Court Statements

Suit No: 409/2010X, "Investigation on damages of MC50 Printer"

The judge's statement: "in the analysis report, Dr YU made following findings: The analysis report was not challenged. It was clearly at the odds"

Extracted from High Court Judgement in "Singapore Law watch" (2011).

It appears in [Singaporelaw.sg \(MovingU Pte Ltd vs. Trans-cab Service Pte Ltd\) \(Clause 27\)](#).



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UTC's Competencies

Publications

Published many technical papers and presentations
In International Journals and Conferences

Int. J. Forensic Engineering, Vol. 3, No. 4, 2017

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Forensic investigation on crane accidents

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Abstract: Crane accidents often result in the significant loss of assets and human lives. Forensic investigation on crane accidents is necessary to identify the causes of the accidents, to determine the factors involved, and to recommend effective measures to prevent recurrence of similar accidents. Forensic investigation should meet the requirements of high professional standards in providing technical support to all kinds of litigations. This article reviews common forensic methods and root causes of crane accidents, and introduces a forensic investigation method. Some forensic cases (e.g., mobile crane toppling, hoist wire rope breakage and boom/jib collapse of tower crane) are studied and discussed to demonstrate the investigation practice.

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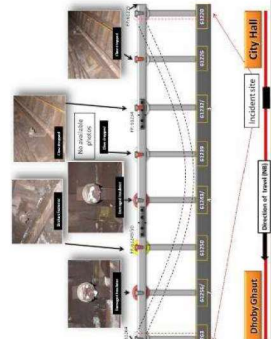
UTC's Competencies

Government documents

Committee Of Inquiry (COI) Report – Ministry of Transportation

On MRT Disruptions in 2011

PDF, 133 CHAPTER 8 EXPERT VIEWS ON ... - Ministry of Transport
<https://www.mta.gov.sg/news/COI%20reports%20-%20Chapter%20-%208%20-%202012.pdf>
Dr Yu Yonghe (YH2), Principal Consultant and Principal Investigator of Failure Analysis and Inspection Services.



Dr YU was engaged by MOT and AGC, and testified in COI, which is documented in COI report of MOT and can be found in website of MOT.

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UTC's Competencies

Publications

Published many technical papers and presentations
In International Journals and Conferences

Int. J. Forensic Engineering, Vol. 3, No. 4, 2017

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UTC's Competencies

Straits Times – Top of News 30 July 2015 (A4)

On massive MRT breakdown



Salt deposits from leak caused MRT breakdown, Transport News ...
www.straitstimes.com/singapore/transport/news/1348-deposits-from-leak-caused-mrt-breakdown
Jul 30, 2015 - Salt deposits from leak caused MRT breakdown ... They coincide with a hypothesis put forth by Dr George Yu, a chartered engineer specialising in industrial ... LTA SMART identify cause of massive rail disruption on July 7...

In this news reported that Dr YU correctly determined the root causes of the massive MRT breakdown/disruptions and provided effective recommendations.

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UTC's Competencies

Peer Views

Criminal trial @ State Courts
On Construction fatal accident
Suit No: DSC — 900613 — 2015

Mr Ho, ex-President of Singapore Steel Structural Society, Professional engineer, >30 years experience. He was the expert witness engaged by the another party.

During his testifying in court, Mr Ho said that “Dr YU, you are right.”

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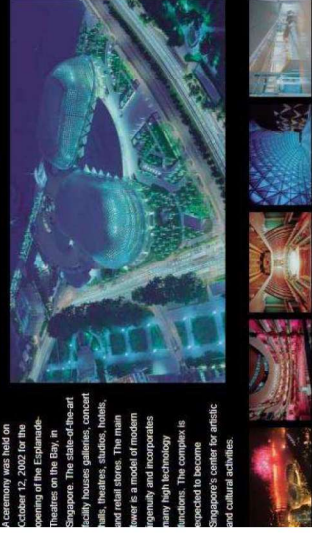
Investigated High Profile Cases



Corrosion @ Esplanade Theatres

Esplanade- Theatres on the Bay

© Perini-Osaka Construction Co., Ltd.



A ceremony was held on October 12, 2002 for the opening of the Esplanade- Theatres on the Bay, in Singapore. The state-of-the-art facility houses galleries, concert halls, theatres, studios, bookshops and retail stores. The main tower is a model of modernity and incorporates many high technology functions. The complex is expected to become Singapore's center for artistic and cultural activities.

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Investigated High Profile Cases



Crane collapse @ National Art Gallery

<https://www.straitstimes.com/singapore/crane-collapse-at-least-2-dead-and-3-seriously-injured-at-national-art-gallery-site>



- At least 2 dead and 3 seriously injured, major building damages.
- UTC was engaged in investigation by Takenaka (Japan) and as expert witness in Arbitration Court.
- Compensation ~ ten million SG Dollars.
- Litigation was settled in favor of our client shortly after UTC releasing the report and even before Court Hearing.

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Investigated High Profile Cases



A fatal accident involved a gate toppling at Tai Seng Facility

© 2018. Contractor fined \$220,000 after water connected to steam by rapped gas at Bentley Road - Chatterbox Residences



- UTC was engaged by Ministry of Manpower to investigate the causes of accident.
- Dr YU, as expert witness, testifying in Criminal Court.
- UTC's conclusions and opinions were accepted by The Court.

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Investigated High Profile Cases



Explosion of electric water heater reported by Straits Times

🕒 PUBLISHED OCT 4, 2017, 5:00 AM SGT

Melody Zacharias Close call for condo tenant as water heater explodes, Singapore News & Top Stories - The Straits Times <http://www.straitstimes.com/singapore/close-call-for-condo-tenant-as-water-heater-explodes>



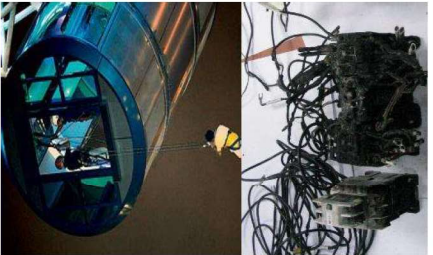
- Heater in bathroom exploded, ripping bathroom door off its hinges, blowing out windows. The force sent door flying across bathroom, moved the bed, and smashed windows and glass doors to balcony.
- UTC was engaged by Enterprise Singapore (ex-SPRING) to investigate accident causes.

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Investigated High Profile Cases



23/12/2008, >170 petrified passengers got trapped on the world's tallest observation wheel after a fire broke out. six hours for the power to return before walking off the 165-metre Singapore Flyer



<https://www.mirror.co.uk/news/uk-news/passengers-trapped-on-worlds-tallest-observation-367522>
<https://www.traveller.com.au/singapores-giant-wheel-reopens-after-fire-7qcy>

Dr YU was engaged by Singapore Flyer to joint investigation on cause(s) of fire.

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Investigated High Profile Cases



SINGAPORE
SINGAPORE POLITICS ASIA WORLD IDEAS MULTIMEDIA LIFESTYLE FOOD FORUM OPINION BUSINESS SPORT TECH

4 men injured after taxi explodes on Commonwealth Avenue

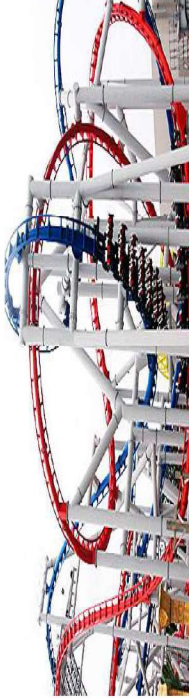


SINGAPORE - Four men, including a Singapore Civil Defence Force (SCDF) officer, were injured after a Tata Nano Cab taxi exploded on Commonwealth Avenue opposite Buona Vista MRT station on Sunday (April 30) afternoon.

UTC was engaged to investigate the case by SCDF and LTA, and successfully determined the root causes of the fire.

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Investigated High Profile Cases



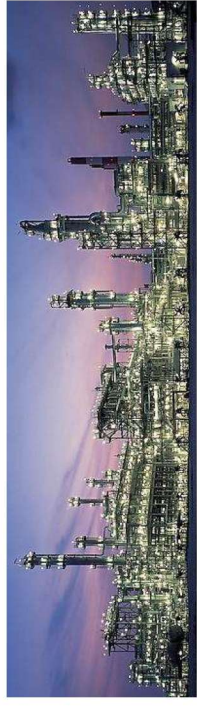
Dislodge of Seats of one most advanced roller coaster, resulting in shutdown for about one year



Dr YU, as principal investigation, conducted investigation on the causes of incident, provided recommendations in design and manufacturing. Such incident never happened again for > 8 years

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Investigated High Profile Cases



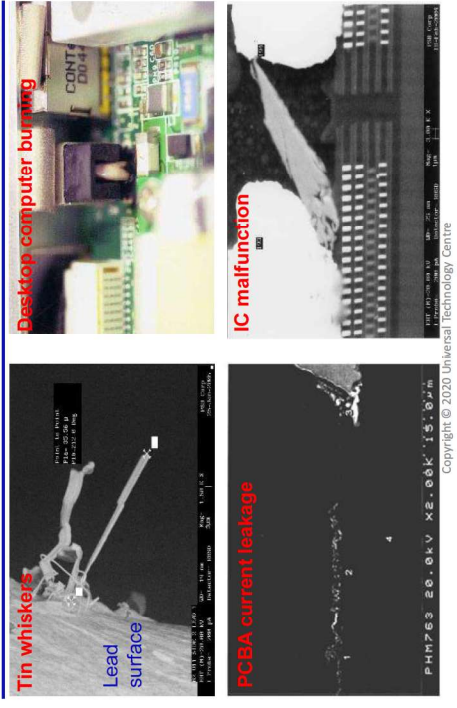
Explosion of heat exchanger in one leading oil refinery plant



Dr YU, as principal investigator, conducted investigation on the causes of explosion.

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Investigated Cases



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Summary



- ✓ Failure analysis plays a key role in improving quality and reliability.
- ✓ Only effective failure analysis can really contribute to improving quality and reliability.
- ✓ Assurance of effective failure analysis is rightly selection of investigator(s).
- ✓ Qualification, experience and traceable track records of investigator(s) are key selection criteria.

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Thank you

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