EE15N
The Art & Science of Engineering Design
Winter Quarter 2019

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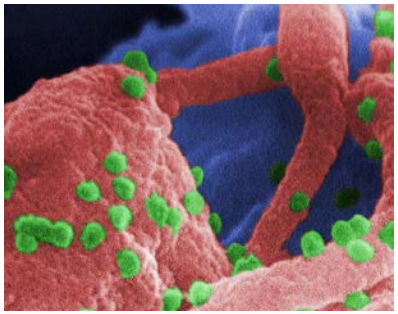
FEBUARY 20,2019



OUTLINE

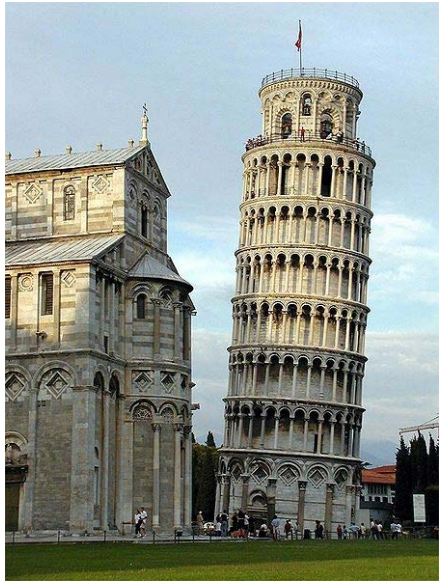
- Administrative Details:
  - Due Midnight Tonight: Morphological Chart, Gallery Method Sketches of Design Alternatives, Weekly Project Meeting Notes.
  - Due Next Week: Weekly Project Meeting Notes, Writing Assignment 2.
  - Tesla trip: Pick up 1:30pm February 27 on Panama Street at Via Ortega. Bus will leave at 1:40pm sharp.
    - Let us know ASAP if you are not attending the field trip.
- Lecture
  - Why Things Fail
- Speaker
  - Steve Rummage, Davis Wright Tremaine LLP

WRITING ASSIGNMENT 2

- Due Wednesday February 27 at Midnight.
- Report on how society shapes technology or vice versa.
  - Examples: stem cell research, cell phones, nuclear power, the Internet, Twitter. Please pick a specific technology for discussion.
- A case study of a complex engineering project.
  - Examples: the IPOD/iPhone, Facebook, the space shuttle, the power grid, MRIs, electric cars.
- Describe in more detail an engineering project executed by one of our guest speakers.
- Pick your own topic related to engineering design.
- Pick a topic different from your topic in Assignment 1.

LECTURE

WHY THINGS FAIL



DEFINITION OF FAILURE

According to Random House Dictionary, Failure is defined as:

- Nonperformance of something due or expected.
- Insufficiency.
- Deterioration or decay.
- Person or thing that proves unsuccessful.

ENGINEERING DEFINITION OF FAILURE

- Definition Of Failure:
  - Inability of a component, structure, or facility to perform its intended function.
- Types of Failures:
  - Safety Failure: involves death, injury, or placing people at risk.
  - Function Failure: involves compromise of intended usage of structure or facility.
  - Ancillary Failure: includes factors that perversely affect schedules, cost, or intended use.

Source: David W. Fowler, The University of Texas at Austin, Forensic Engineering: Detective Engineering

WHY ENGINEERING PRODUCTS FAIL

- Inadequate articulation of requirements
- Poor planning
- Lack of teamwork
- Poor communication/coordination about design, its construction, or how it should be used
- Inadequate technical skills and continuity
- Human error
- “Cutting corners” via materials, construction, safety, …
- Insufficient monitoring of progress
- Inferior corporate support
- Material and/or component failure
- Manufacturing failure
- Misuse/Lack of Maintenance

CAUSES OF FAILURES
(*Structural Designs*)

From a study conducted by Swiss Federal Institute of Technology in Zurich that analyzed:

- 800 cases of structural failures.
- 504 deaths, 592 injuries, and millions of dollar of damage.

Insufficient knowledge	36%
Underestimation of knowledge	16%
Ignorance, carelessness, negligence	14%
Forgetfulness, error	13%
Relying upon others without sufficient control	9%
Objectively unknown situation	7%
Imprecise definition of responsibilities	1%
Choice of bad quality	1%
Other	3%

Source: Department of Materials Science and Engineering, State University of New York at Stony Brook, Engineering Disasters and Learning from Failure

DEALING WITH FAILURES

- Acknowledge failures:
  - Failures happen.
  - Acknowledge, Analyze, & Advance.
- Correct failures
  - Understanding what failed is the first step to fixing it.
  - Often harder to correct a failure than design correctly from the start.
- Learn from failures:
  - Learning how failure occurred can help prevent future failures.
  - Learning helps build team camaraderie instead of finger pointing.

"There is the greatest practical benefit
in making a few failures early in life."

Thomas H. Huxley, On Medical Education – 1870, Technology Review, Feb/Mar 1997

ENGINEERING FAILURE CASE STUDIES

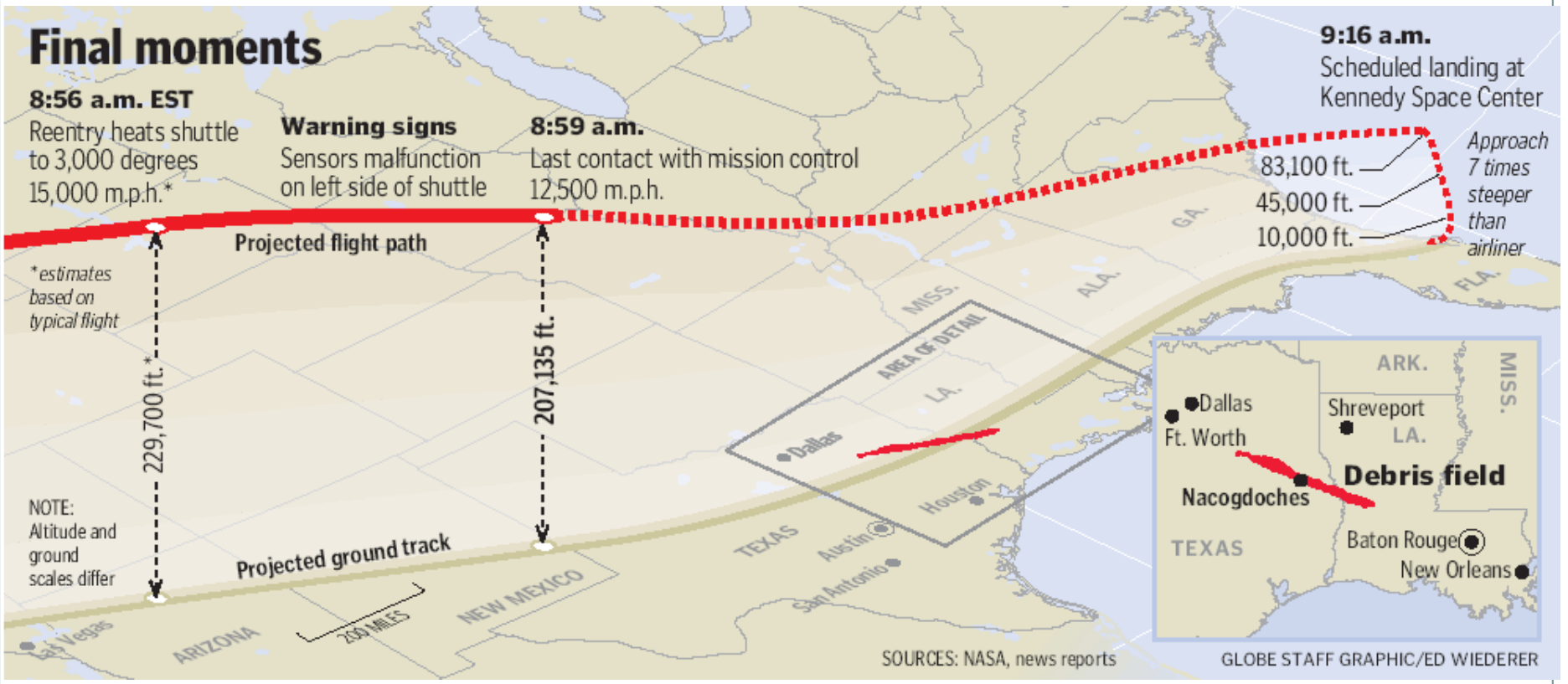
- Columbia Shuttle Disaster
- Samsung Galaxy Note 7

COLUMBIA DISASTER

TIMELINE OF FAILURE: 2003

- Jan. 16: Columbia is launched into space for a 16 day mission of science experiments.
  - 81 seconds after launch pieces of foam break off and hit the tiles of the wings.
  - Tiles protect from 3000 degree re-entry heat.
- Jan. 17: NASA asks Boeing engineers to analyze the impact of the foam hitting the wings.
  - Engineers use software simulations for their analysis.
  - Determine that the foam impact would not cause a serious risk (simulations are conservative).
- Jan. 23: Boeing reports to NASA that tile would survive foam impact, not a flight safety risk.
  - Recommend modest changes for future flights.

FEB 1: BREAKS UP ON RE-ENTRY



Would better action after the fact have helped?

- NASA did not try to observe the damaged area with ground telescopes or satellites.
  - They did not believe the pictures would be useful.
- Even if they did find damage, there was nothing the crew could have done to fix it.
  - There was no way they could carry out work in space, hence the Shuttle was doomed from launch.
- They could not fly to the International Space Station (ISS) because they would have been in the wrong orbit.
  - They would have been stuck in space.

FALLOUT

- NASA's third fatal spaceflight tragedy and the second shuttle accident in the space plan program's history.
- NASA suspended space shuttle flights for more than 2 years as it investigated.
- Disaster directly led to NASA's retirement of the space shuttle fleet.
  - Transitioned to a new space exploration plan that includes use of private spacecraft and a focus on deep-space exploration.

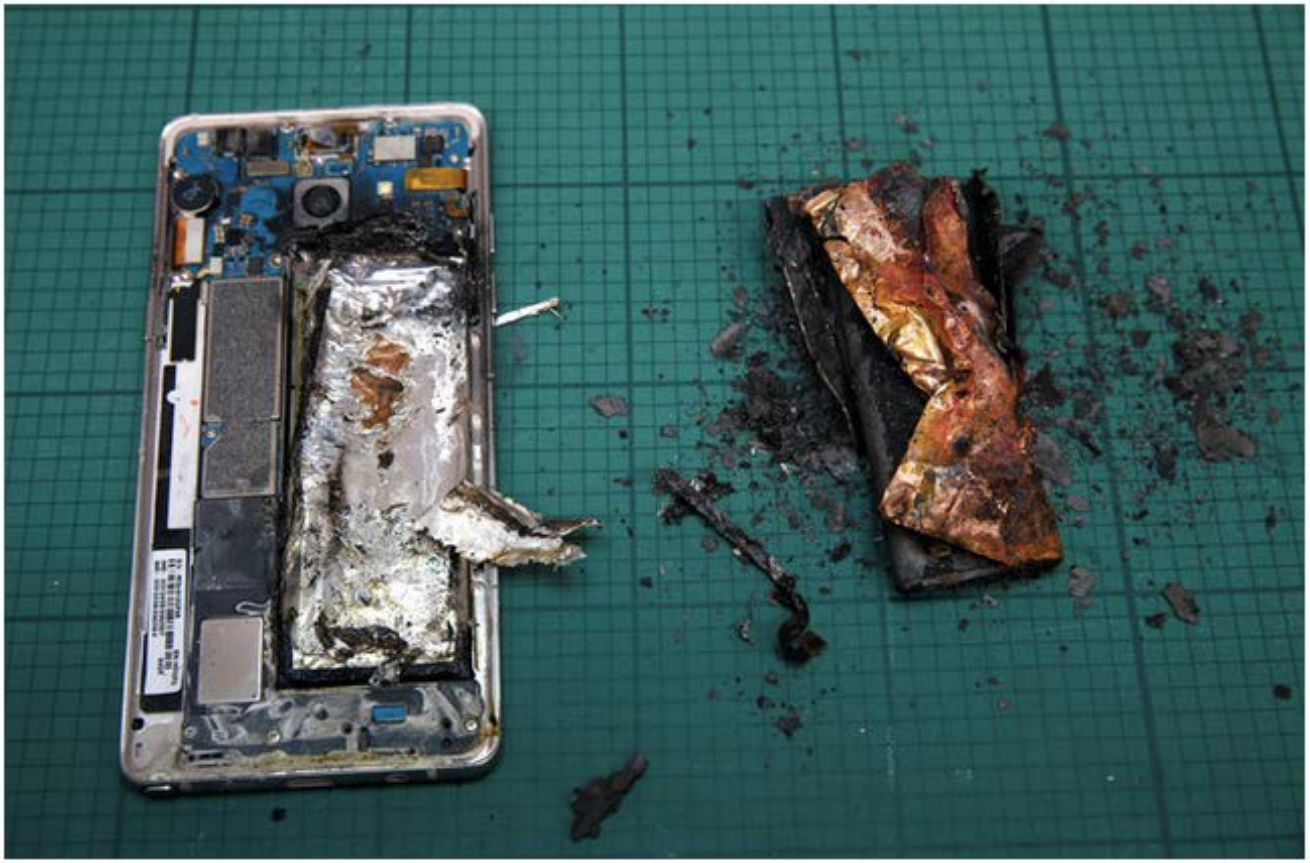
LESSONS LEARNED

- Investigation board determined the problem with foam had been known for years.
- Systemic problems unveiled during investigation included:
  - Complacency about dangers of human-manned spaceflight.
  - Warning signs about smaller engineering failures were not heeded.
  - Lack of predictable funding and political support led to impossible deadlines and goals.
  - Investigative board primarily blamed the culture at NASA for the accident.

LESSONS LEARNED (cont)

“Cultural traits and organizational practices detrimental to safety were allowed to develop," "reliance on past success as a substitute for sound engineering practices" and "organizational barriers that prevented effective communication of critical safety information" were among problems found

SAMSUNG GALAXY NOTE 7



A Note 7 handset next to its charred battery after it caught fire during a test at the Applied Energy Hub battery laboratory in Singapore in October. Edgar Su/Reuters

TIMELINE OF FAILURE: 2016

- **2 August:** Model unveiled in New York.
  - It's seen as Samsung's big rival to the upcoming iPhone 7.
- **19 August**: Sales start in 10 markets, including South Korea and the United States.
  - European markets are scheduled for October.
- **24 August:** The first report of a Note 7 device "exploding" appear in the news.

Source: http://www.bbc.com/news/technology-37615496

TIMELINE OF FAILURE: FIRST RECALL

- **2 September:** Samsung announces a voluntary global recall of some 2.5 million Note 7 phones, citing faulty batteries.
  - The company offers to either refund or replace the device.
- **8 September:** US federal aviation administration and numerous airlines worldwide tell passengers not to turn on or charge the Note 7 while on a plane.
- **9 September**: The US Consumer Product Safety Commission urges people to stop using the phone. On 15 September, issues a formal recall.
  - Meanwhile, Samsung announced it will resume selling the Note 7 on 28 September in South Korea.
- **19 September:** Reports appear of phones in China catching fire as well.
  - Samsung said the batteries for the devices sold in China were from a different supplier and not affected by the recall.
- **1 October:** Samsung resumes sales of the Note 7 in South Korea.
  - In the US, the replacement of phone is in full swing.

Source: http://www.bbc.com/news/technology-37615496

TIMELINE OF FAILURE: SECOND RECALL

- **6 October**: There's the first report of a replacement Note 7 still showing the same problems.
  - A phone on board a Southwest Airlines flight in the US starts emitting smoke and the plane get evacuated.
- **9 October:** US carriers AT&T and T-Mobile say they will stop issuing new Note 7 replacement and stop selling the phone.
- **11 October:** Samsung announces it is stopping all sales of the phone while it investigates the problems.
  - The company also tells people to power down their phones and stop using them.

Source: http://www.bbc.com/news/technology-37615496

FALLOUT

Cost of Battery Unit: $40

Cost of Removing the Problem:
$5.1B

CAUSES OF FAILURE

- Samsung held conference on January 22, 2017.
- Causes of failure:
  - First Recall: design failure. Unusually thin lining between the electrodes of the battery.
  - Second Recall: manufacturing failure. Issues with welding, as well as a crucial part left out of some handsets.

OTHER CAUSES OF FAILURE?

- “The management pushed their engineers to make the battery separator really thin,” said Qichao Hu, founder of the battery start-up SolidEnergy Systems. He added that doing so could increase the likelihood of fires or explosions in batteries.
- “The rather poor way they handled the first recall suggests that they have trouble accepting problems until they become quite big and they have no choice but to face them,” said Willy C. Shih, a professor at the Harvard Business School. “This time, it will really call into question how they communicate problems, whether management is open to hearing things from the front line.”

Source: https://www.nytimes.com/2017/01/22/business/samsung-galaxy-note-7-battery-fires-report.html?_r=0

BENEFITTING FROM FAILURES

Historians have uncovered new evidence of Edison's enormous talent for appropriating techniques that failed in one instance and using them to great effect in another.

Seth Sullivan, Unlocking the Legacies of the Edison Archives, Technology Review, Feb/Mar 1997

- Failures can be successes in disguise
- Failures in a design or design team are great learning experiences
- If your design fails, thinking outside-the-box might indicate how a failed design might be useful
  - Might be useful for a different product
  - Undesired side effects may be desirable in other settings

BENEFITTING FROM FAILURE: 3M'S POST-IT NOTES

Reuters/Damir Sagolj

BENEFITTING FROM FAILURE: 3M'S POST-IT NOTES

- In 1968, Spencer Silver tried to develop a strong adhesive for tape.
  - Didn't succeed. Only create a weak adhesive called microspheres.
- In 1974, Arthur Frye thought of using adhesive to create a new type of bookmarks after hearing one of Silver's talks.
  - One that would not damaged the marked page.
- From bookmark idea, new type of notes was created – in 1980.
- Silver's failed adhesive is the key ingredient of 3M's best-selling product.

3M'S POST-IT NOTES: STICKY NOTES MARKET

- Post-It Notes went on the market in 1980.
  - Sale reached $2M in first year.
- Post-it Notes Market today:
  - Available in 27 sizes, 57 colors, and 20 fragrances.
  - $2.190 billion in 2017.
  - 3M is the world leading manufacturer.

Sources: http://www.worldwatch.org/node/6387 & https://www.marketwatch.com/press-release/post-it-sticky-notes-industry-sales-supply-and-consumption-2018-analysis-and-forecasts-to-2025-2018-10-03

GROUP ACTIVITY

You are building a complex engineering system, for example:

- A station to live on Mars
- A robotic device to do heart surgery
- An automated highway system
- The new World Trade Center in New York City
- Chose your own

For your choice of system, what is most likely to fail and how would you design the system to avoid such failures.

TODAY'S SPEAKER

STEVE RUMMAGE

DAVIS WRIGHT TREMAINE LLP