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# Three Mile Island

## Life-changing Lessons -- 30+ Years Later

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# March 28, 1979

- A day I will **never forget**
- A turning point for commercial nuclear power, in the US and around the world
- A learning experience of incalculable value to those involved in nuclear (and other) large scale industrial enterprises

# Premises

1. Most of the TMI accident – what happened, why it happened, and how it could have been avoided – has less to do with nuclear technology than with the broad realities of complex, technically demanding applications
2. The lessons to be derived from that event are as important today as ever, and with broad applicability to all aspects of our business.
3. Some of these lessons are particularly germane to the Fukushima events, others to the cleanup – and all are applicable to continued use of nuclear power in Japan and elsewhere.

# The Japan Connection

- Japanese nuclear utilities were heavily engaged in the TMI-2 Recovery project
  - Research, manpower, funding
- Japanese participation at TMI was driven by
  - Recognition of shared interests and the importance of international collaboration
  - Opportunity to learn
- Fukushima Daiichi
  - Today's compelling case for continued collaboration, worldwide

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# TMI Accident, in brief

- The Plant:
  - TMI Unit 2, a large nuclear power plant near Harrisburg Pennsylvania. The plant had been in commercial service for only one year
- The Climate:
  - Anti-nuclear sentiment in the U.S. was growing: *The China Syndrome*, a movie about a nuclear plant accident, was a #1 box office hit and was prompting much public interest and debate.
- Initiating events:
  - At 0400, automatic plant shutdown due a minor equipment failure in the **non-nuclear** part of the plant caused the reactor to shut down automatically.
  - In the subsequent transient, the pilot-operated relief valve (PORV) opened properly, but then failed to shut. Worse, it's position indicator showed it to be shut, greatly confusing the matter.

# TMI Accident (continued)

- Progressive Loss of Cooling (small break LOCA):
  - Cooling water, vital for core protection, drained from the reactor through the stuck-open valve.
  - Automatic backup systems came on to replace the leaking coolant; but the plant operators, still unaware of the ongoing leakage, turned off the backup systems.
  - At 6:27am, the operators stopped the leak by shutting a downstream valve – but even then did not grasp the cause or consequences of the extended loss of cooling water.
- Overheated nuclear fuel:
  - Fuel cladding fails; zirconium-water reaction releases hydrogen
  - major release of radioactivity into cooling water, high radiation in the containment, airborne activity in surrounding structures

# TMI Accident (continued)

- Chaos and confusion, in the plant
  - For the next two days, operators worked to stabilize the plant and some measure of control. Damage to reactor system equipment and the unprecedented and still-misunderstood plant condition impeded progress at every turn.

- and outside…
  - Internal and external communications were abysmal, and public and political involvement rapidly intensified. TMI-2 was on the world stage.

# TMI Accident (continued)

- The down spiral continues:
  - On Friday, **two days after the event,** misinterpretation of in-plant data prompted the NRC to recommend – and the Governor of Pennsylvania to direct – a “precautionary” partial evacuation
  - The ensuing evacuation was widespread and traumatic, and it caused immeasurable loss in public confidence.
- Years of recovery:
  - Regaining full control and stability of the plant took several months. The full extent of core damage was not known for about two years. Restart of the undamaged reactor (TMI-1) took six years. TMI-2 cleanup and deactivation cost ~$1billion and took 14 years.
- No new U.S. reactors have been built since then.

# Consequences

- The **Good**:
  - No one, on site or off site, was harmed
  - The environment was not harmed
  - Rugged containment and defense-in-depth saved the day
- The **Bad**:
  - We destroyed a brand new, billion dollar power plant
  - We nearly bankrupted a great company
- And the **Very Bad:**
  - We terrified our neighbors near TMI area, and many others
  - We derailed a booming nuclear industry
  - We were lucky. It could have been worse

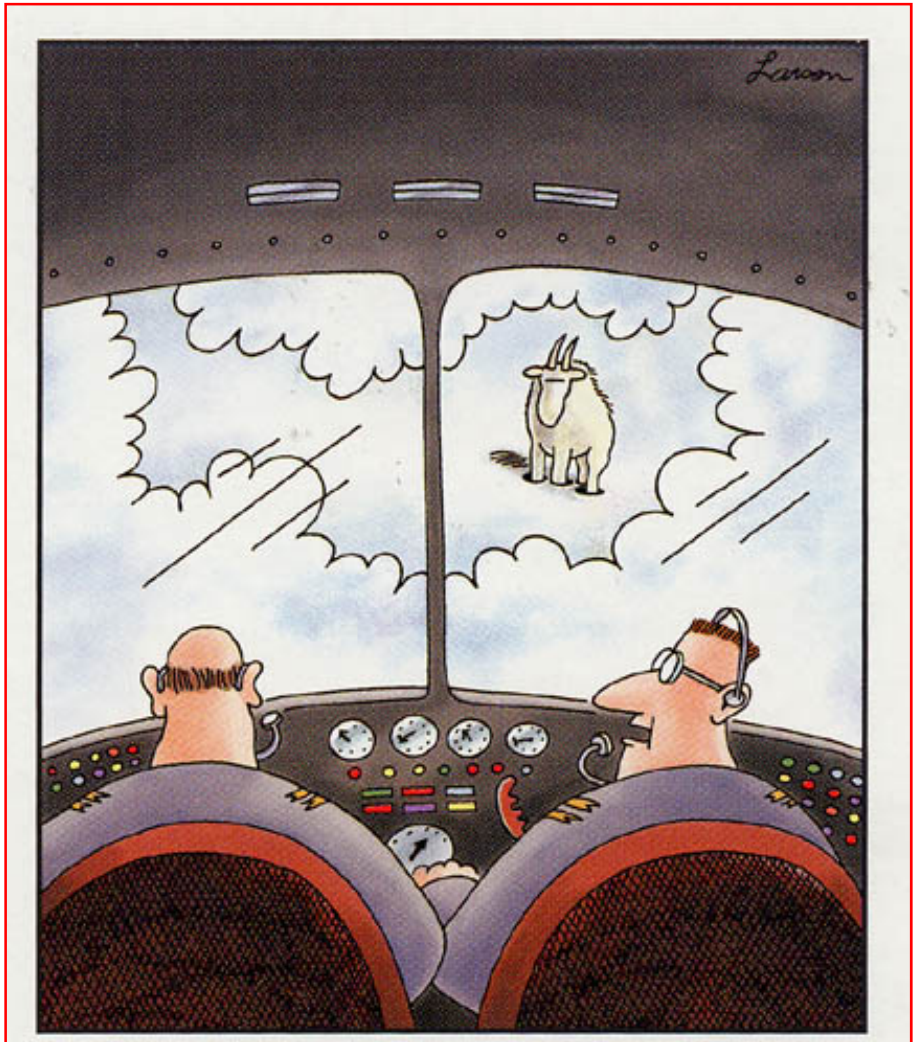
# Causes / Contributors

1. Designed-in Operational Challenges
   - Excessive complexity, driven by economics or regulatory requirements
   - Man-machine interface that did not support operators' needs under upset conditions
2. Inadequate preparedness, on all fronts
   - Superficial or misguided training
   - Minimal pre-staged, rehearsed emergency response capability
   - No foundation of public trust (against a backdrop of highly charged, polarized sentiment about nuclear power)
3. Myopia
   - Inordinate confidence in regulatory compliance, as a surrogate for real safety
   - Blindness to precursors, both stark and subtle
   - Complacency, driven by pervasive mindset

# MINDSET

- Just what is **Mindset**?
  - Unjustified confidence that all is well, life is good (FDH)
  - Selective grasping for data that support one's expectations - and willing rejection of those that do not
  - Unintended intellectual arrogance
  - Insidious, debilitating
- **Mindset** – organizational and individual – is the antithesis of a healthy **safety culture**

# MINDSET




"Say … what's a mountain goat doing way up here in a cloud bank?"

# TMI Lesson 1

- Perspective on **Safety Regulation**:
  - Safety is **NOT** primarily a matter of regulatory compliance
  - Full compliance with safety regulation provides no guarantee of event-free operation

- Corollaries to Lesson 1:
  - Nuclear Safety – or other high consequence accident - is **NOT** an abstract or hypothetical concept.
  - Disproportionate attention to regulatory issues (e.g., recordable injuries) dilutes attention to other, important safety matters.

# TMI Lesson 2

- Very bad accidents may (and in fact are likely to) unfold as **insidious**, seemingly manageable combinations of events:
  - Catastrophic, design basis events (such as seismic) are not the only, or the biggest, worries.
  - Murphy is alive and well.
  - Complacency is in play (i.e., “we know how to handle this”) inhibits immediate, decisive response -- that **mindset**, again

One key to success can be to nip initiating events in the bud – stop the accident when it’s still stoppable

# TMI Lesson 3

- In a bad accident, **chaos, confusion and miscommunication** rule the day
  - This was the case at TMI-2, and by all reports is the common denominator of emergency response to catastrophic events of all kinds.

It is not possible to work too hard at developing, refining and practicing emergency communications

# TMI Lesson 4

- Every time something goes wrong, there is someone who **knew** it was going to happen.
  - Find and engage that person in your organization, NOW!!
  - The key observation often comes from the least expected source
  - Encourage, empower and celebrate open communications, at all levels

**Questioning Attitude and Intolerance of Mediocrity, are central to a healthy and effective Safety Culture**

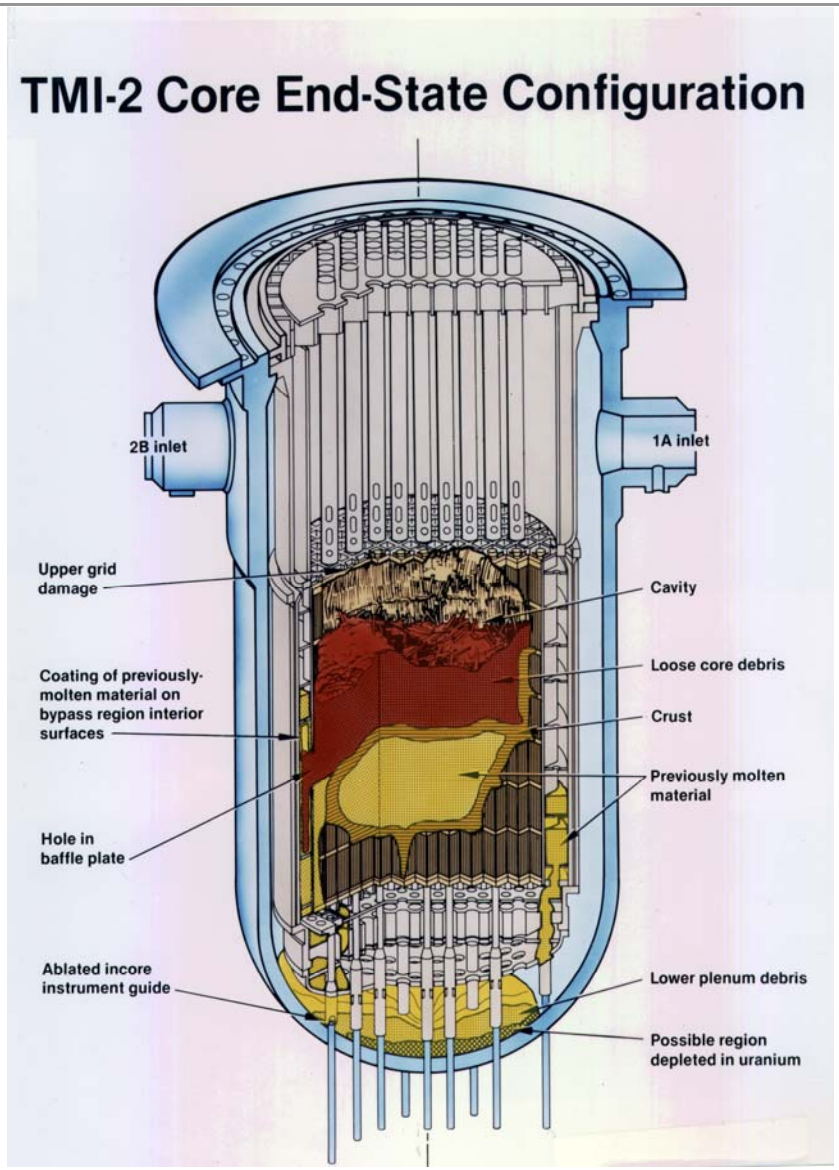
# TMI Lesson 5

- Decisions are based on information; **bad information** invariably prompts **bad decisions**
  - In evaluating data, always consider the source.
  - Nothing beats **hard evidence**
  - Groupthink is a very poor substitute for data
  - At TMI, this was the compelling lesson of the PORV indication (teeing up the accident) and of the Quick Look (which completely changed our understanding of the core condition).

**Garbage in, Garbage Out**

# "Quick Look" Inspection

Core Condition as found during 1981 Quick Look



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# TMI Lesson 6

- **Rugged Design** and **Defense-in-Depth** really work
  - At TMI they saved the day.
  - They worked in ways never explicitly anticipated by the designers, regulators, or operators.

Defense in depth doesn't stop at design

Safety barriers, work practices, safety procedures, protective equipment, emergency preparedness measures all are enhanced by **margin**

# TMI Lesson 7

- **Well-intended but unnecessary complexity will sneak up and bite you, when least expected:**
  - For the TMI accident, design complexity was an initiating factor, it made diagnosis more difficult, and it compounded corrective action.
  - In operations, maintenance and construction complexity is similarly problematic
  - Poster child: **Operating and Safety Procedures** that are made ever more complex in a misguided attempt to capture every detail.

Adhere to the US Navy Nuclear KISS principle:
(Keep it simple, stupid)

# TMI Lesson 8

- Engage the other side (i.e., the folks we don't get along with)
  - Their insights and perspectives can be instructive
  - Polarization blocks communication, response, action
  - We're not always as far apart as we seem

# TMI Lesson 9

- When your world is turning brown, it is a very bad time to **begin** to build public trust

and…

- **Once lost**, public trust is nearly impossible to regain

Earning **stakeholder trust** is an essential, proactive and never-ending process

# TMI Lesson 10

- The power of **true leadership** is boundless:
  - On a grand scale, success (or failure) is often dictated by the action (or inaction) of one person.
  - That person – the leader – is not always the person in charge.
  - It might be you

Never Forget the *Shadow of the Leader*
It **always** works

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# A Safety Culture Framework

| Elements | | Principles | Good Practices |
|---|---|---|---|
| I | Leadership | • Shadow of the Leader<br>• Unambiguous Expectations | • Model teamwork and safety behavior, all the time<br>• Attack Mindset, relentlessly |
| | Teamwork | • One Team, fully aligned | • Balanced, shared incentives<br>• Effective, proactive communications and transparency, at all levels and in all directions |
| II | Standards | • Clear, real safety standards | • Set only meaningful safety requirements and enforce them rigorously.<br>• Zero tolerance for feel-good standards |
| III | Awareness | • Eyes open, all the time<br>• Learning, continuous improvement | • Time Out process<br>• Major focus on Near Miss events<br>• Effective Root Cause / Extent of Condition Assessment |
| IV | Preparedness | • Defense in depth<br>• Readiness for the expected – and the unexpected | • Effective training / pre-job briefs<br>• Emergency response capability – drill, drill, drill |

# Nuclear Since '79, in Summary

- Maturing technology, and steady improvement in nuclear operations worldwide:
  - Modifications to existing plants, reflecting operating experience
  - Fundamental changes in operational training, practices, procedures, emergency planning
  - Greatly improved regulatory processes, standards and practices
  - Accountability and self policing via INPO and WANO
  - **Every** US nuclear operational performance metric has improved, remarkably so, since 1979
  - Much better, more realistic understanding of pant accident sequences and attendant emergency response
- Growing public understanding and acceptance of nuclear energy
  - **But** Fukushima was a major setback
- Excellent designs for next generation plants
  - **But** implementation stalled with economic and political obstacles

# But Challenges Remain

- An aging nuclear fleet
  - License renewal / life extension make possible strong economic environmental and energy supply reliability benefits, BUT they introduce new issues and concerns
- Safety Culture
  - Attacking mindset is a never ending challenge
- Are the TMI lessons being forgotten – or perhaps never learned?
  - A new generation of owners and operators are running the plants
  - Amid generally strong performance, alarming safety lapses persist (e.g, Davis Besse RPV head)

# Fukushima Daiichi

- An event of **transcendent** importance to the future of nuclear energy, world wide:
  - Plant and environmental cleanup on an unprecedented scale
  - A new volley of design, operations, regulatory, human performance and socio-political issues to be addressed
  - Public confidence shattered, now must be rebuilt
- Concerted, collaborative efforts will be required, on all sides

# *Questions???*