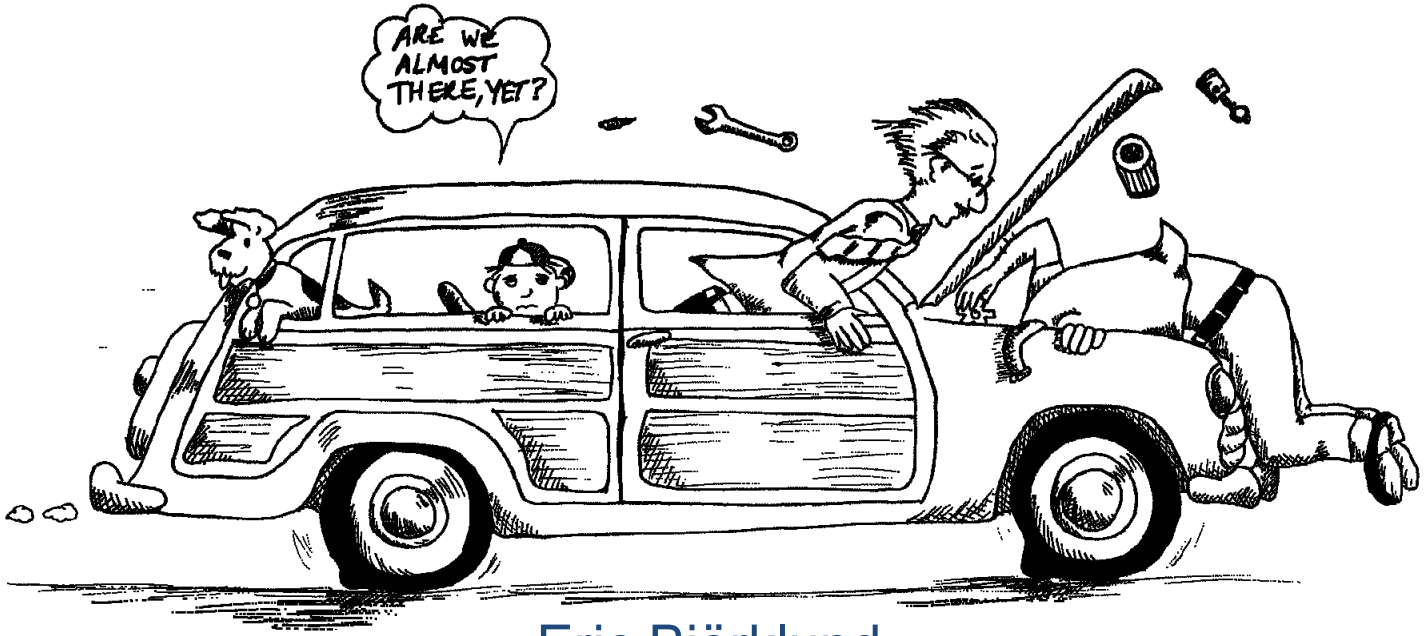
Replacing the Engine In Your Car While You Are Still Driving It

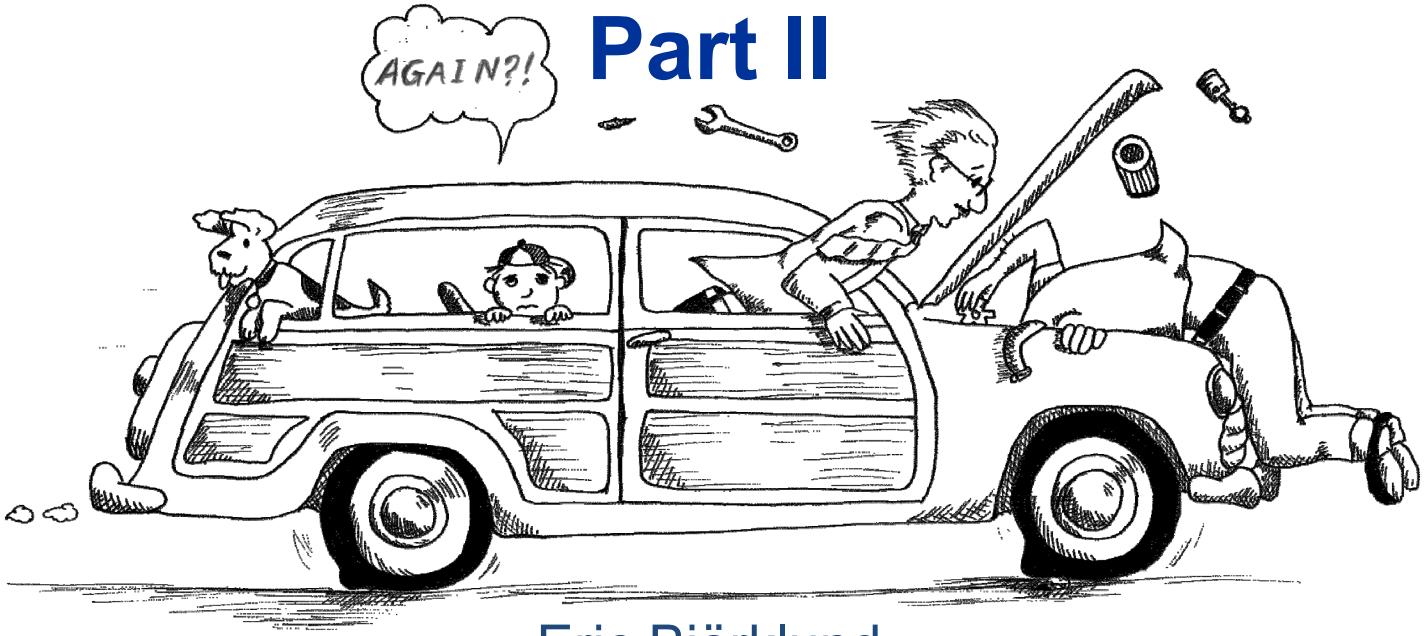


Eric Björklund
Los Alamos National Laboratory

LA-UR-17-27661

Replacing the Engine In Your Car While You Are Still Driving It

Part II



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Lessons Learned From A Very Ambitious Upgrade Program

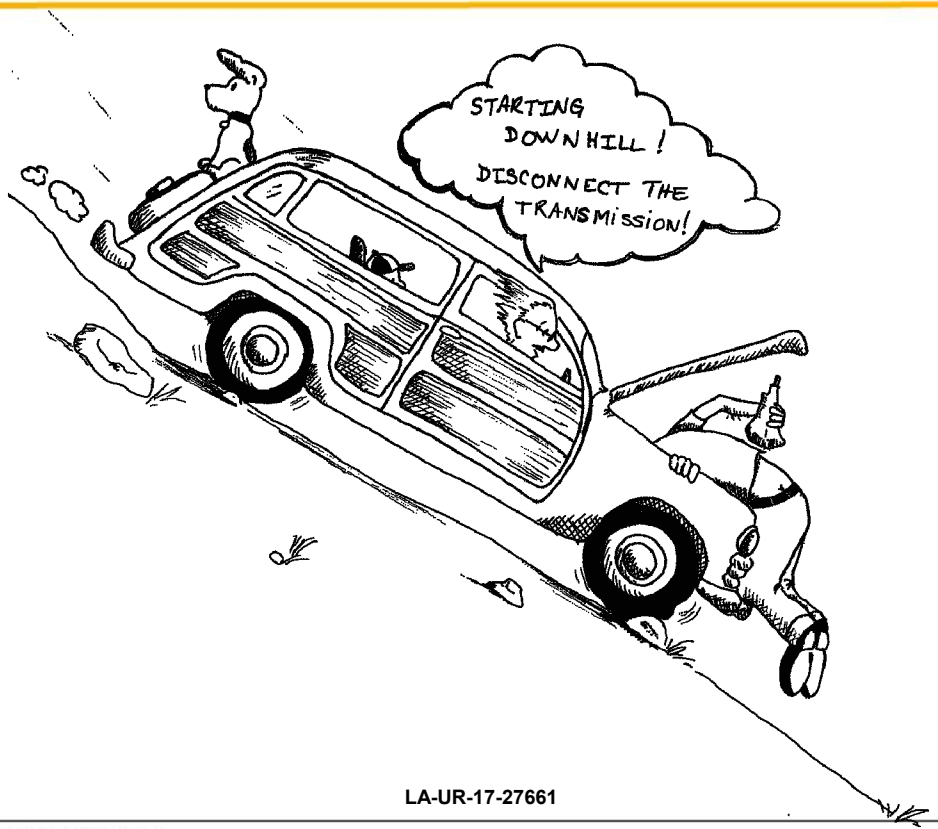
Complete With:

3 (Recycled) Observations &
1 (New) Recommendation

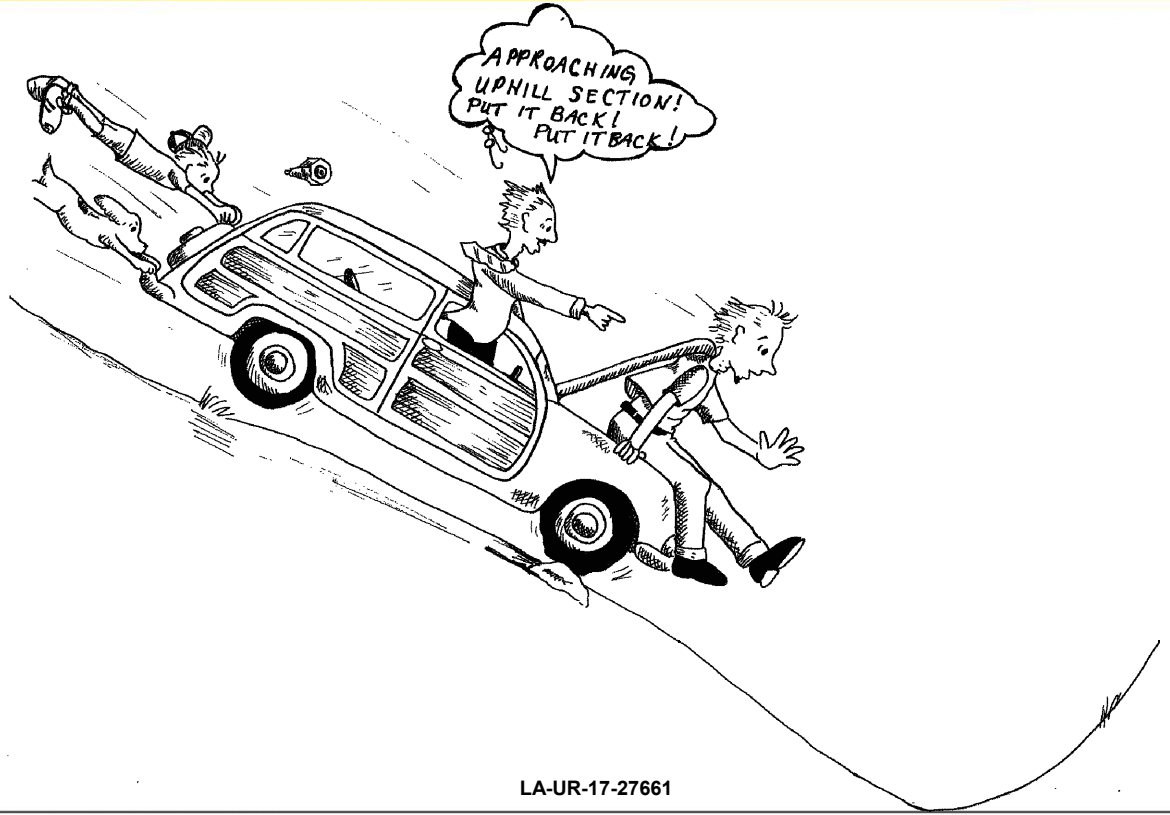
For Anyone Contemplating A Similarly Ambitious Upgrade

Recap:
Negotiating the upgrade schedule is like driving in mountainous terrain.

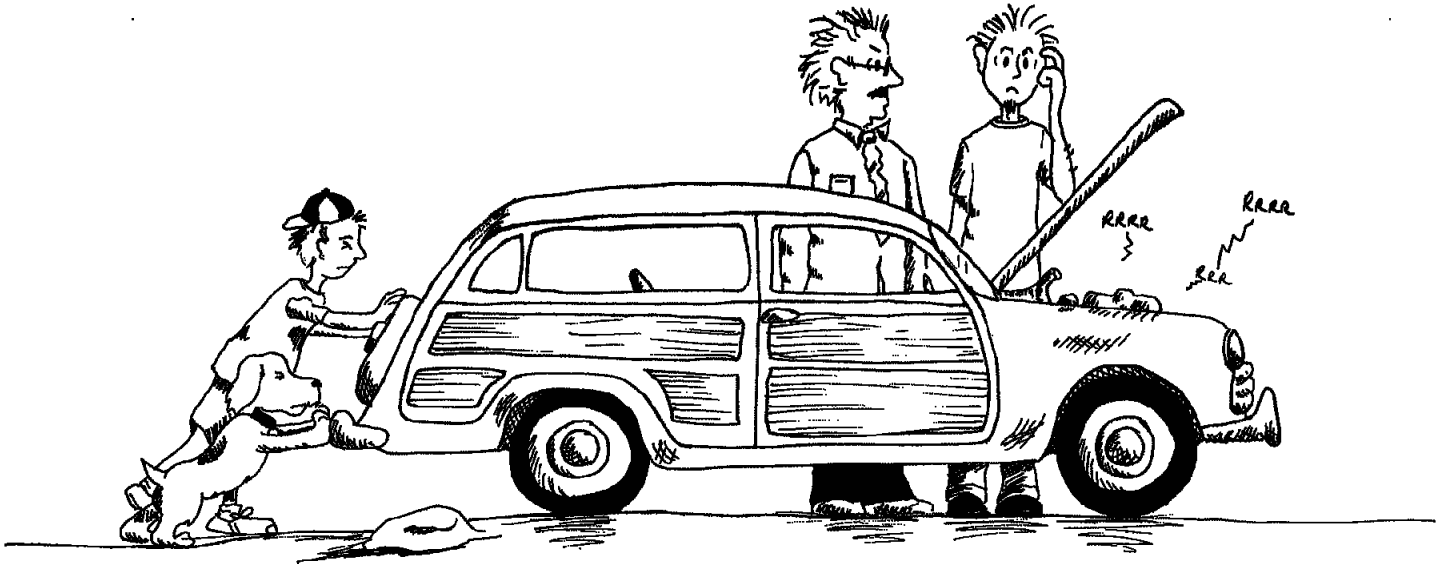
Recap:
Down Hill: The Maintenance Periods



Recap:
Up Hill: The Operational Periods



Recap:
Level: The Startup Periods



Recap:
Observations and recommendations

Observations

- You can't replace the whole system at once.
- Some compatibility must be maintained between the old and new systems.
- You will be surprised.

Recommendations

- Always have a way to fall back.
- Have sympathy for the operations staff.

Recap:
The scope of the project

- ✓ Install New Network Backbone
- ✓ Replace 201 MHz RF Tubes
- ✓ Replace Low-Level RF System
- ✓ Replace Timing System
- ✓ Replace Industrial I/O System
- ✓ Replace Beam Synchronous Data Acquisition System
- ✓ Replace Fast Protect Reporting System
- ✓ New Wire Scanner Hardware
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Recap Finished:
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The scope of the project

- At LANSCE, these three functions were originally all performed by one system.
- "**R**emote **I**nformation and **C**ontrol **E**quipment"

AKA

RICE

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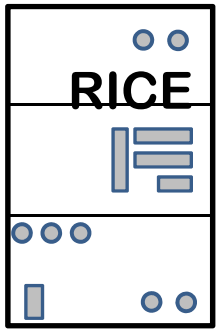

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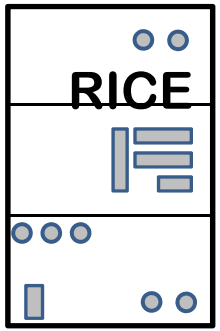

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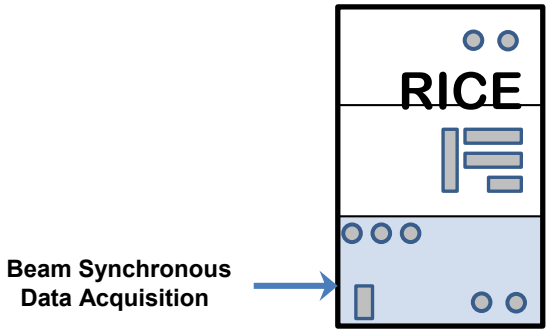

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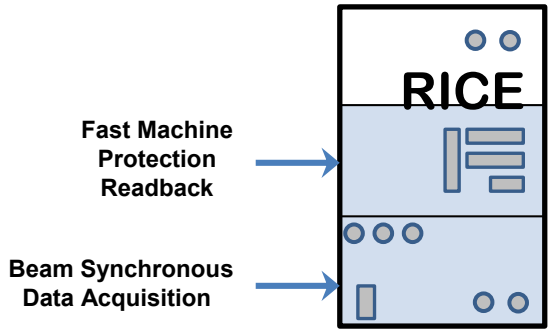

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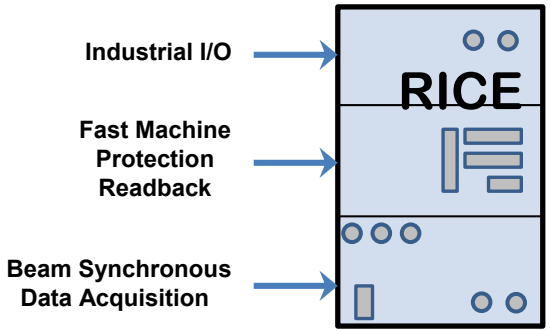
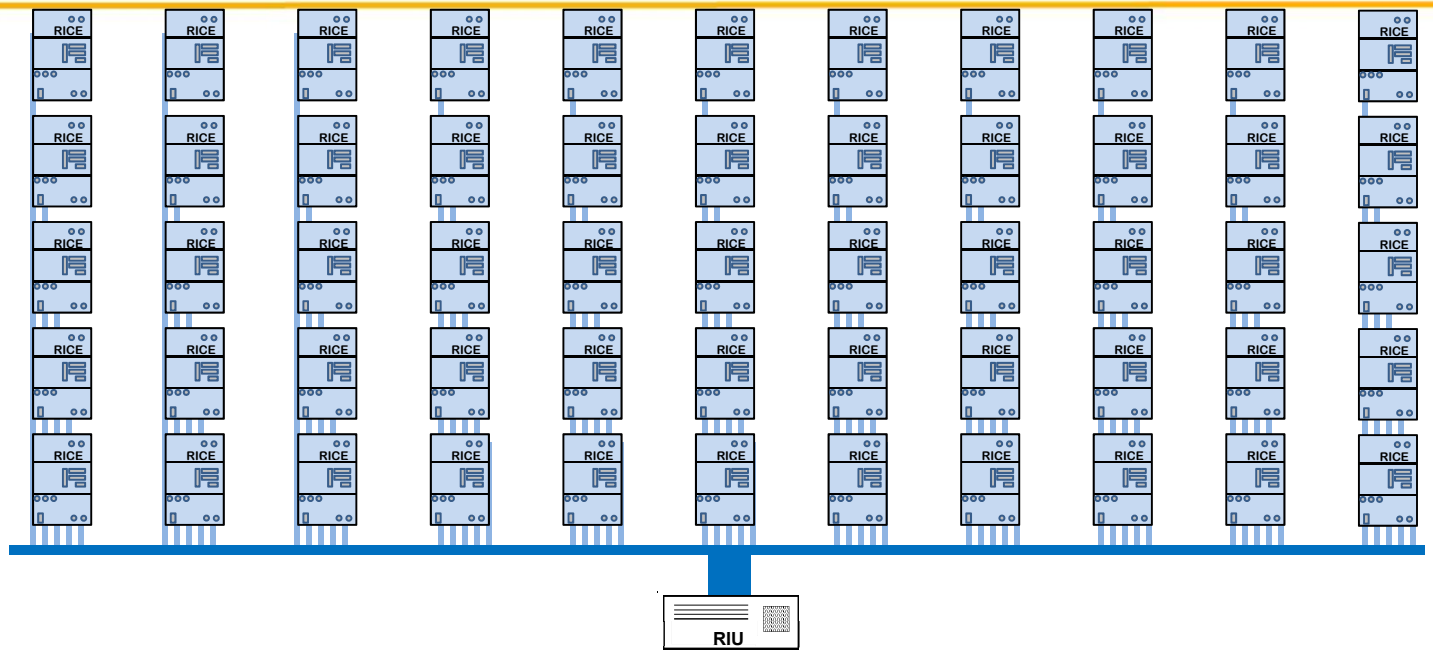
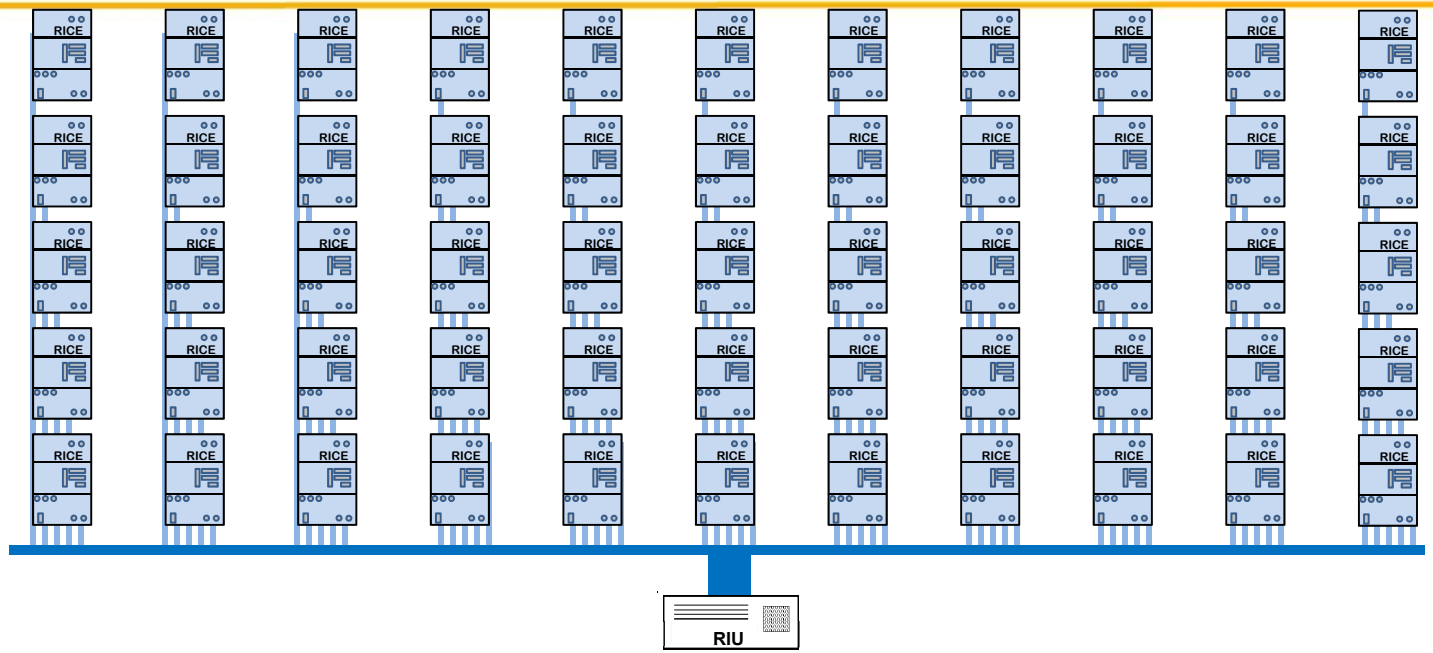


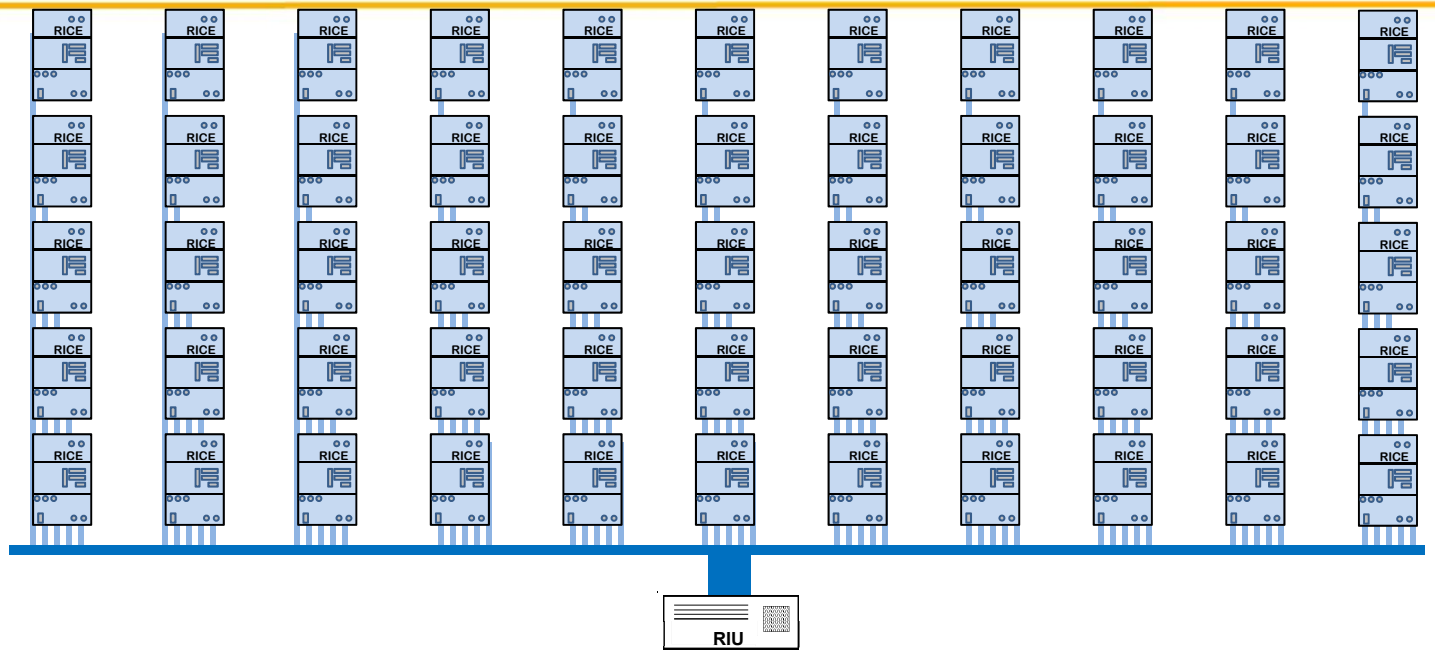
Up to 128 RICE stations interface through serial links to one “RICE Interface Unit” (RIU)



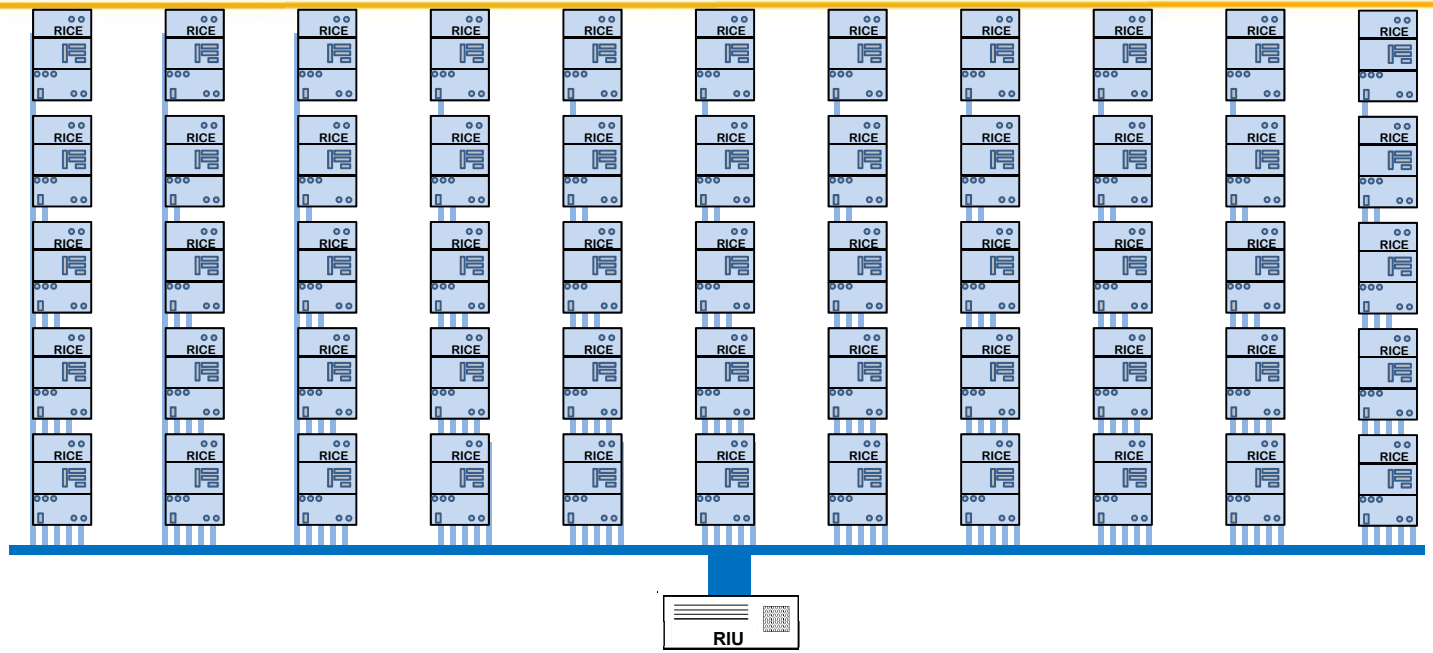
One “RIU Read” operation will return up to 128 data words (one from each station)



All 128 data words are read at the same time (plus or minus cable delays)

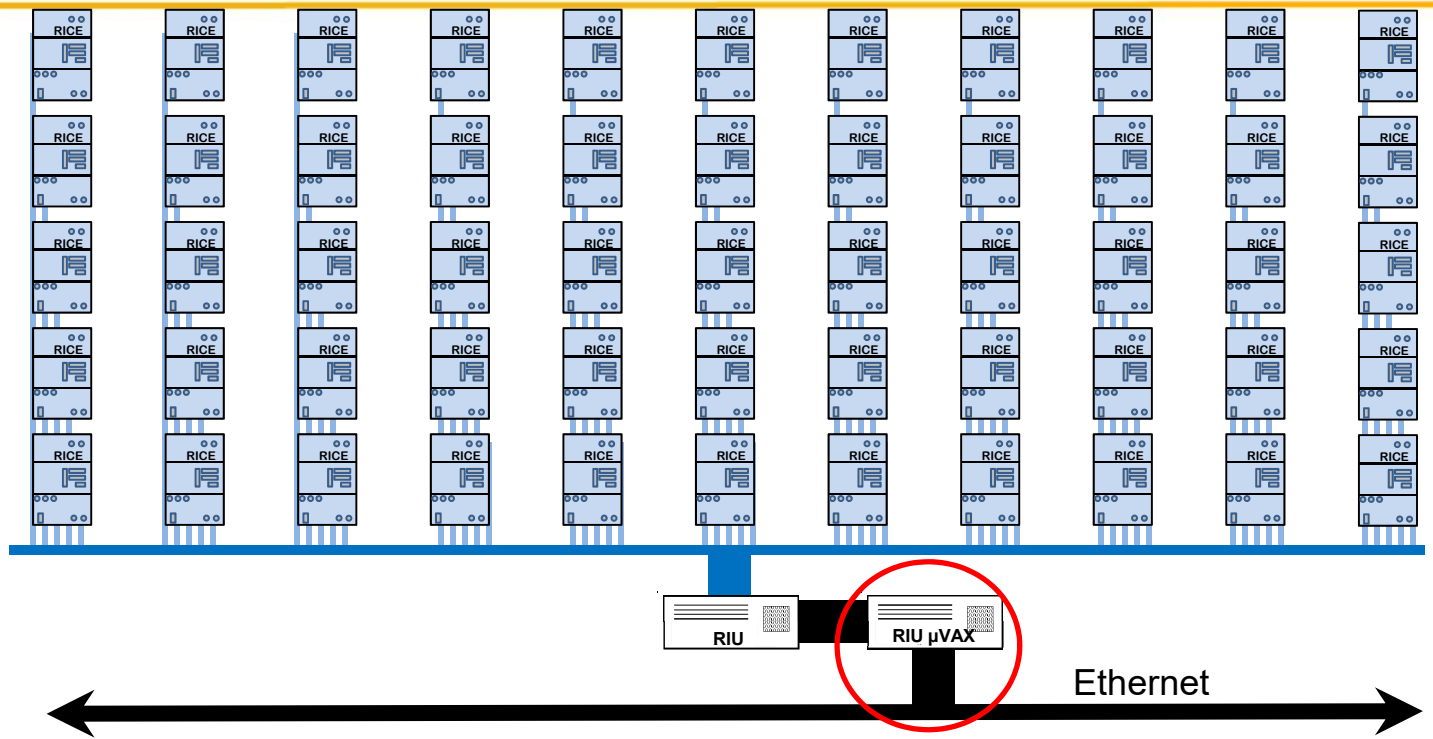


This is how RICE does beam synchronous and fast machine protection data acquisition.



RIU interfaces to a microVAX, which serves the data to the network.

System worked well, but as time progressed, it also became our biggest bottleneck.



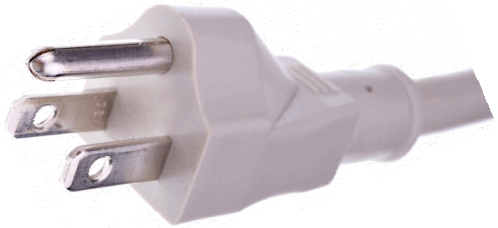
Observation 1:
You can't replace the whole system at once.

- We divided the RICE replacement project into three sub-projects.
  - Industrial I/O: Use National Instruments cRIO crates running EPICS
  - Fast Protect Reporting: Use compact PCI crates with timing modules and binary input cards.
  - Beam Synchronous I/O: Use VPX crates with timing modules and wave-form inputs.

Observation 1b:
Sometimes you can't even replace a whole sub-system at once.

- None of the sub-projects could be completed during a single maintenance period either.

Observation 2: Some compatibility must be maintained between the old and new systems.

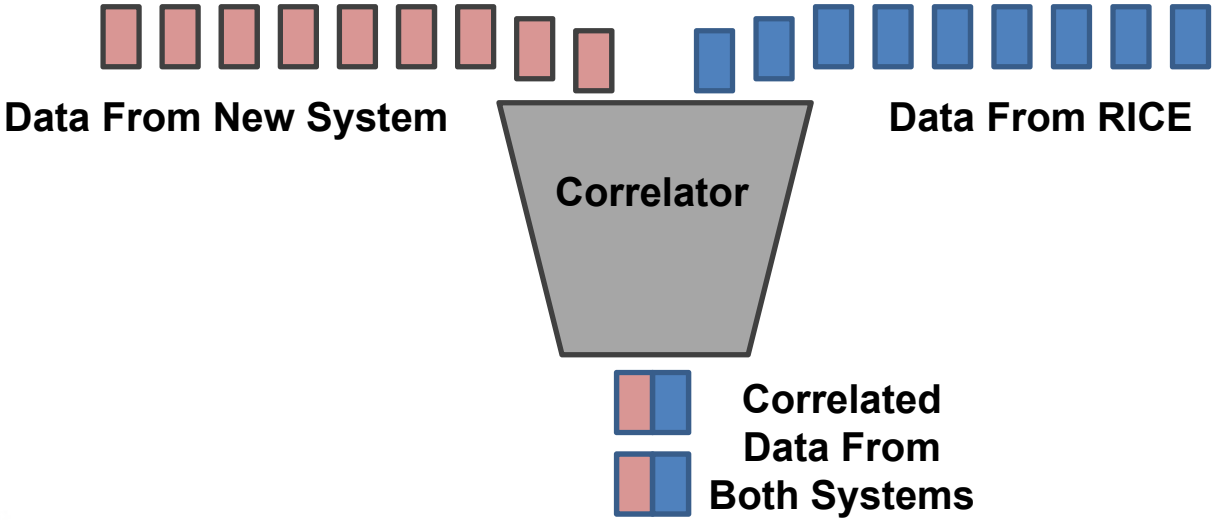


Observation 2: Some compatibility must be maintained between the old and new systems.

- Until we can get the entire sub-system converted, the control system will have to deal with data from both sources.
- Not a problem for industrial I/O since the data sources are independent from each other.
- Is a problem for beam synchronous and fast protect readbacks because the data returned must be simultaneously sampled by both systems.

Observation 2: Some compatibility must be maintained between the old and new systems.

- Like many other facilities, we use a ”correlator” program to to combine the data from both the old and new systems.

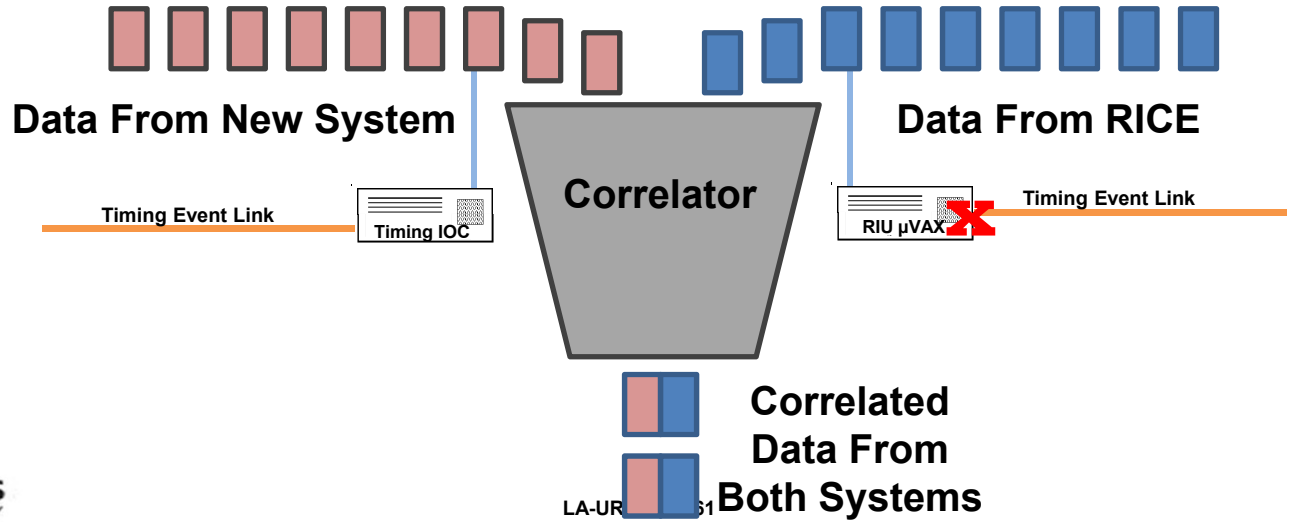


Observation 2: Some compatibility must be maintained between the old and new systems.

- Data is correlated by timestamp.
- To make life easier/possible for the correlator, a single timestamp is assigned to each beam pulse.
  - Correlation is achieved by exact timestamp match.

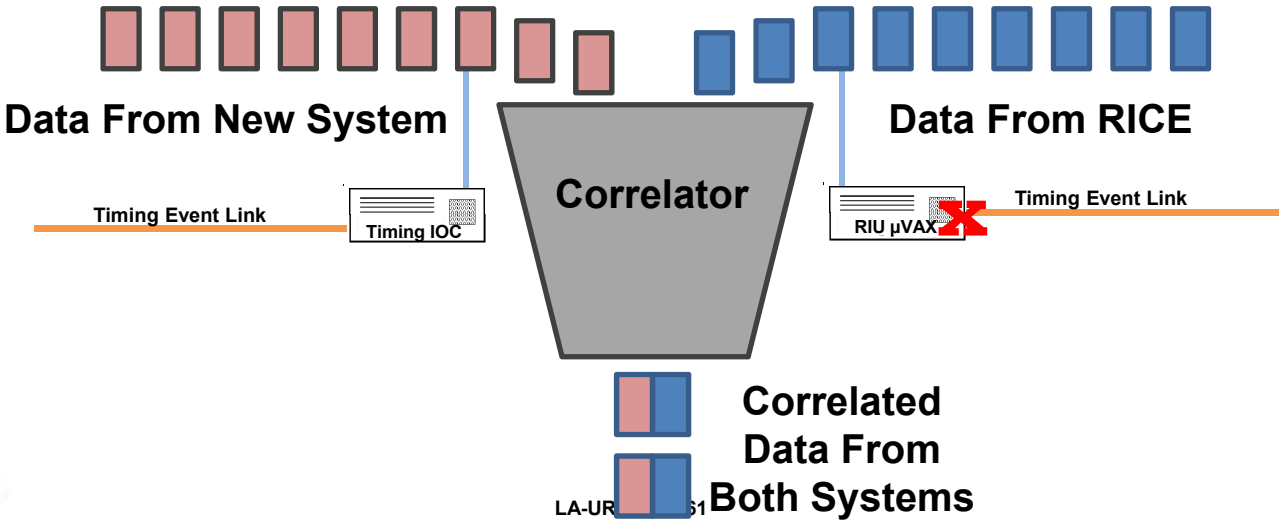
Observation 2: Some compatibility must be maintained between the old and new systems.

- On new system, timestamp comes from the timing event link.



Observation 2: Some compatibility must be maintained between the old and new systems.

- On new system, timestamp comes from the timing event link.
- But… A microVAX can't interface to the timing event link!



We aren't actually using all 128 stations that the RICE system is capable of.

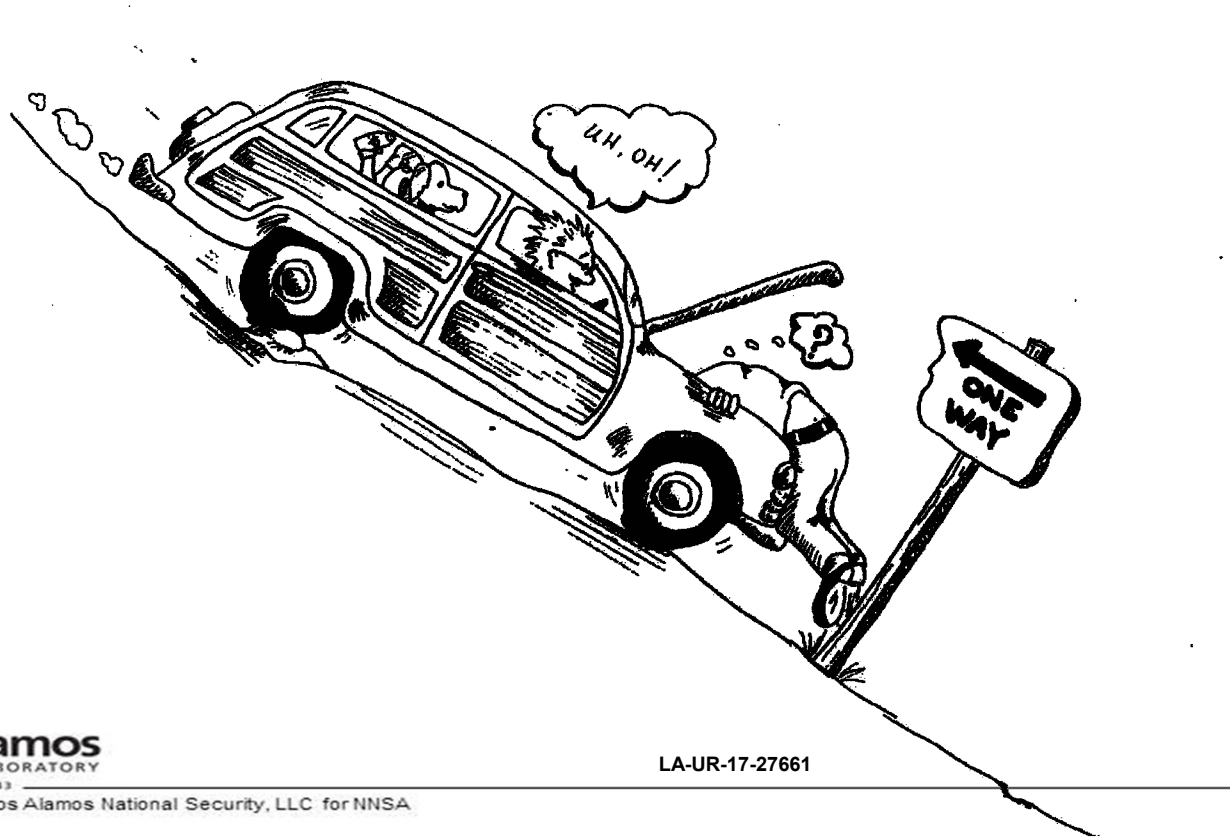
So find three “Station-Slots” that aren’t being used and remove them from the RIU bus.

Get an IOC with an event link and three 12-bit binary output modules.

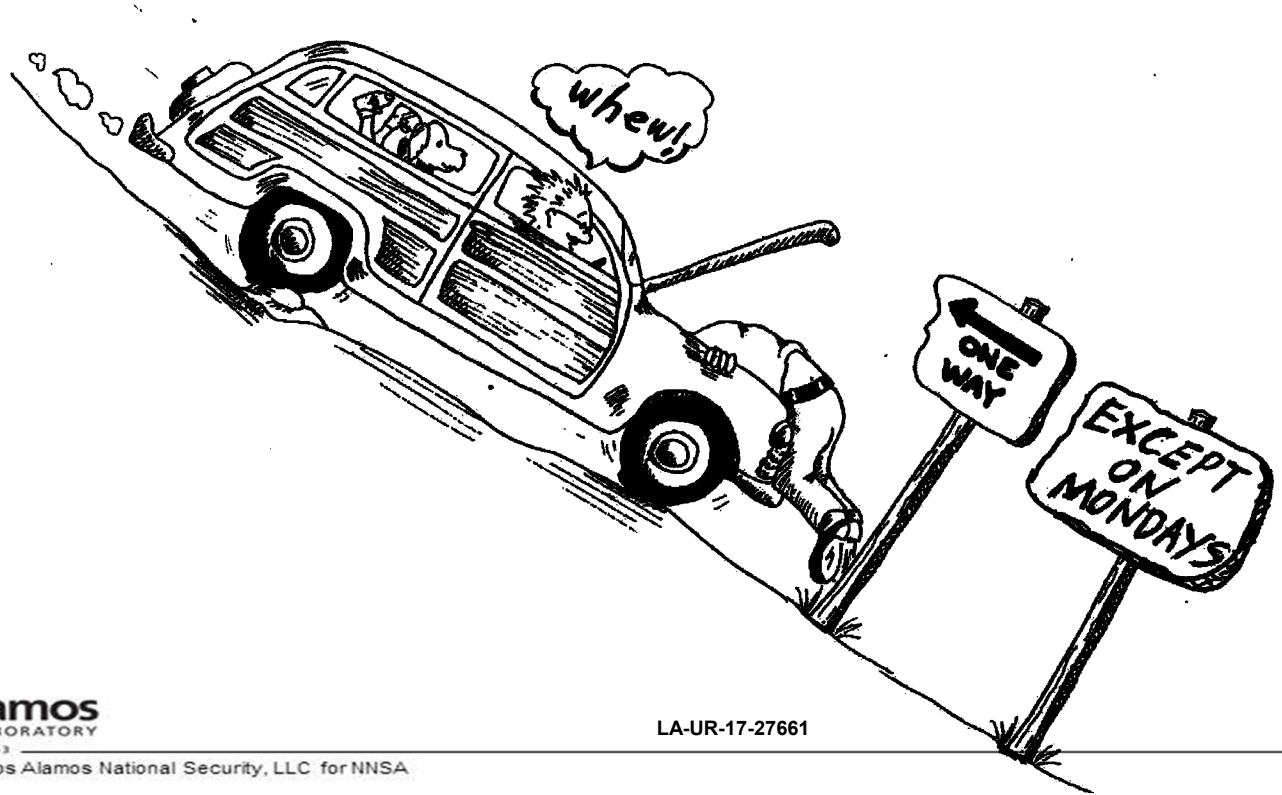
Write the middle 36-bits of the timestamp into those vacant slots on the RIU bus.

The RICE data set now contains enough of the timestamp to “deduce” an exact match.

Observation 3:
You will be surprised.

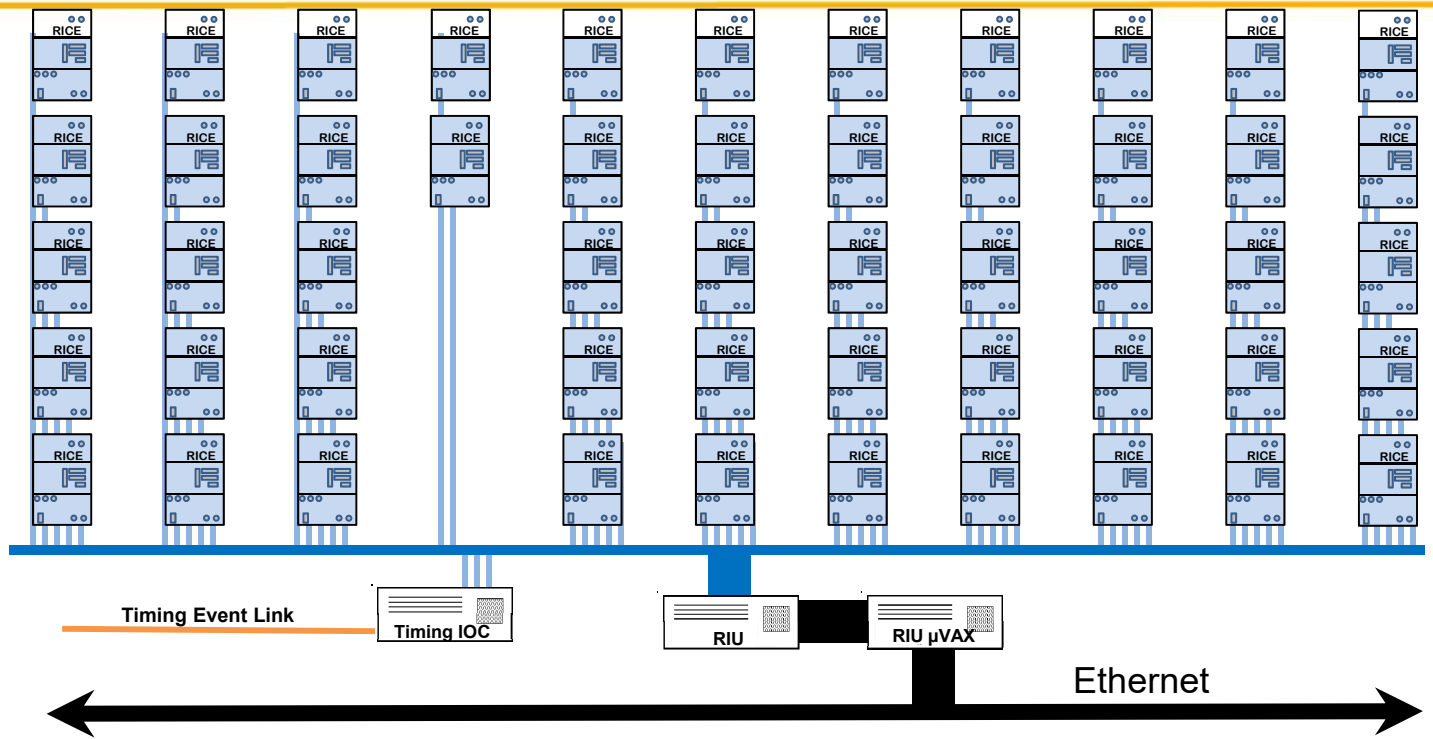


Observation 3a:
But sometimes the surprise will be pleasant!



In 2015, we replaced the industrial I/O function in 4 RICE stations

In 2016, we replaced the industrial I/O function in 7 RICE stations



In 2017, we replaced the industrial I/O function in 33 RICE stations!

How did that happen?

- More people
- Relatively homogenous RICE stations
- Change of tactics

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- Relatively homogenous RICE stations
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Recommendation 1: Do as much as you can before the maintenance period starts.

- Most of the productivity gain in 2017 was due to planning.
  - Inventory the existing wiring
  - Cross-check for unused wires
  - Remove all unused wires
  - Remove all trunk cables that only contain unused wires
  - Label the remaining wires
  - Install terminal blocks for new systems
  - Pre-build the new cRIOs.

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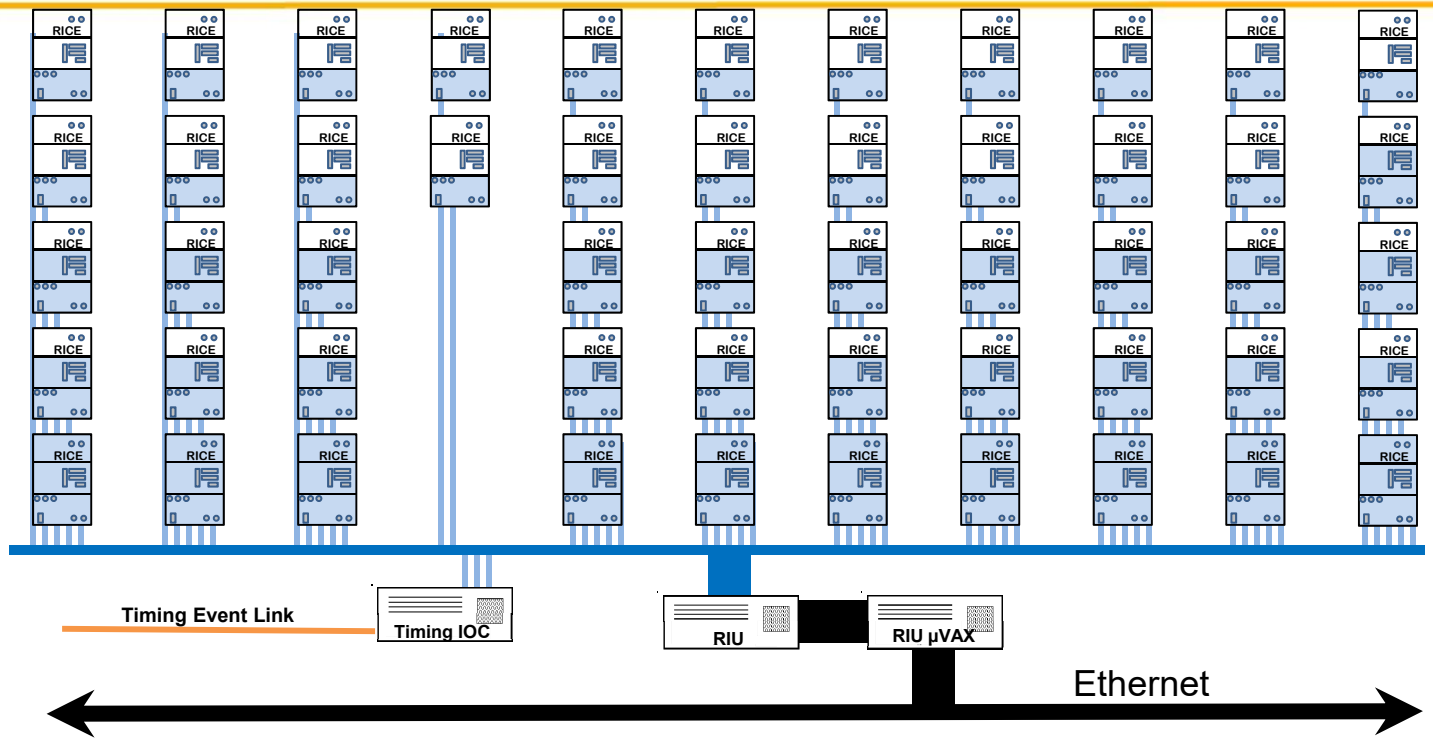
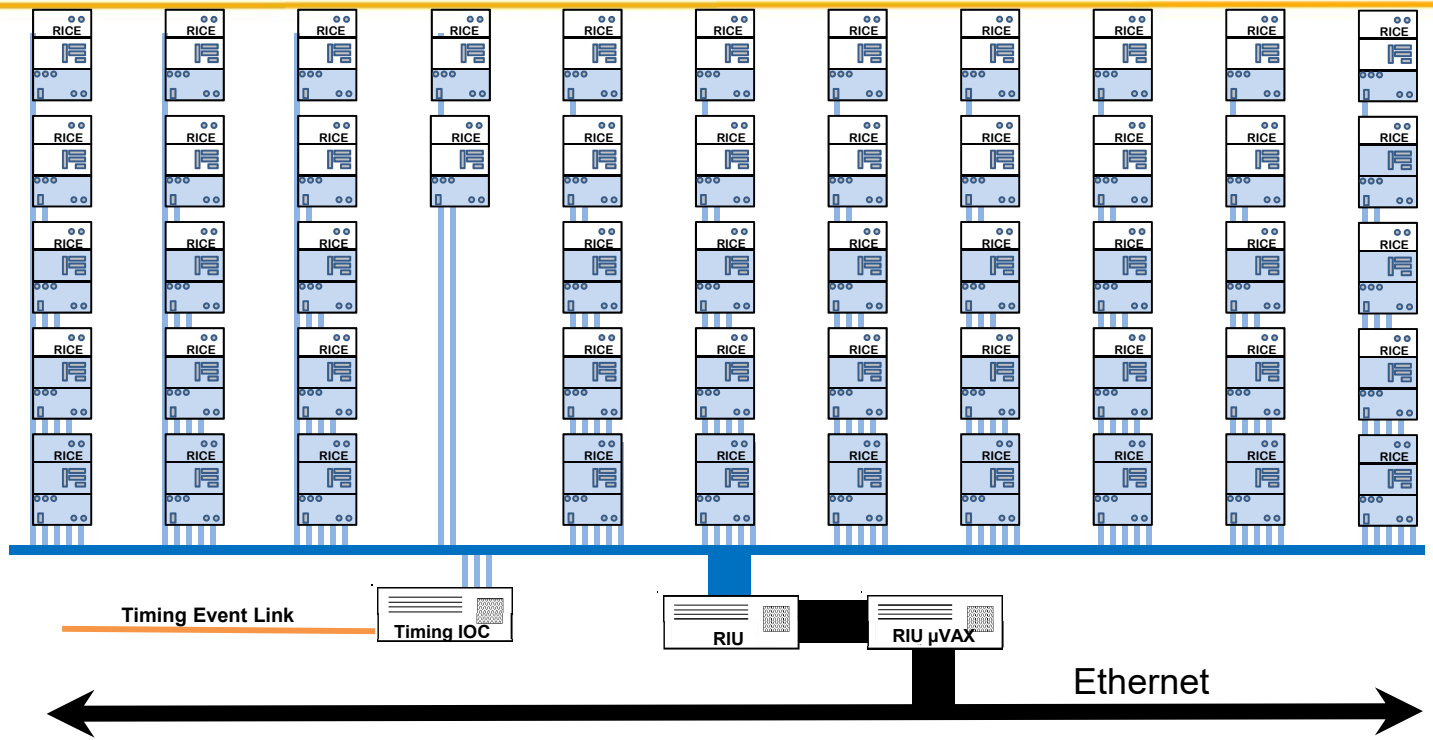
  - Pre-build the new cRIOs.
- Most of the maintenance period work consisted of just moving wires from one place to another.

Current Status:
Over halfway finished replacing industrial I/O

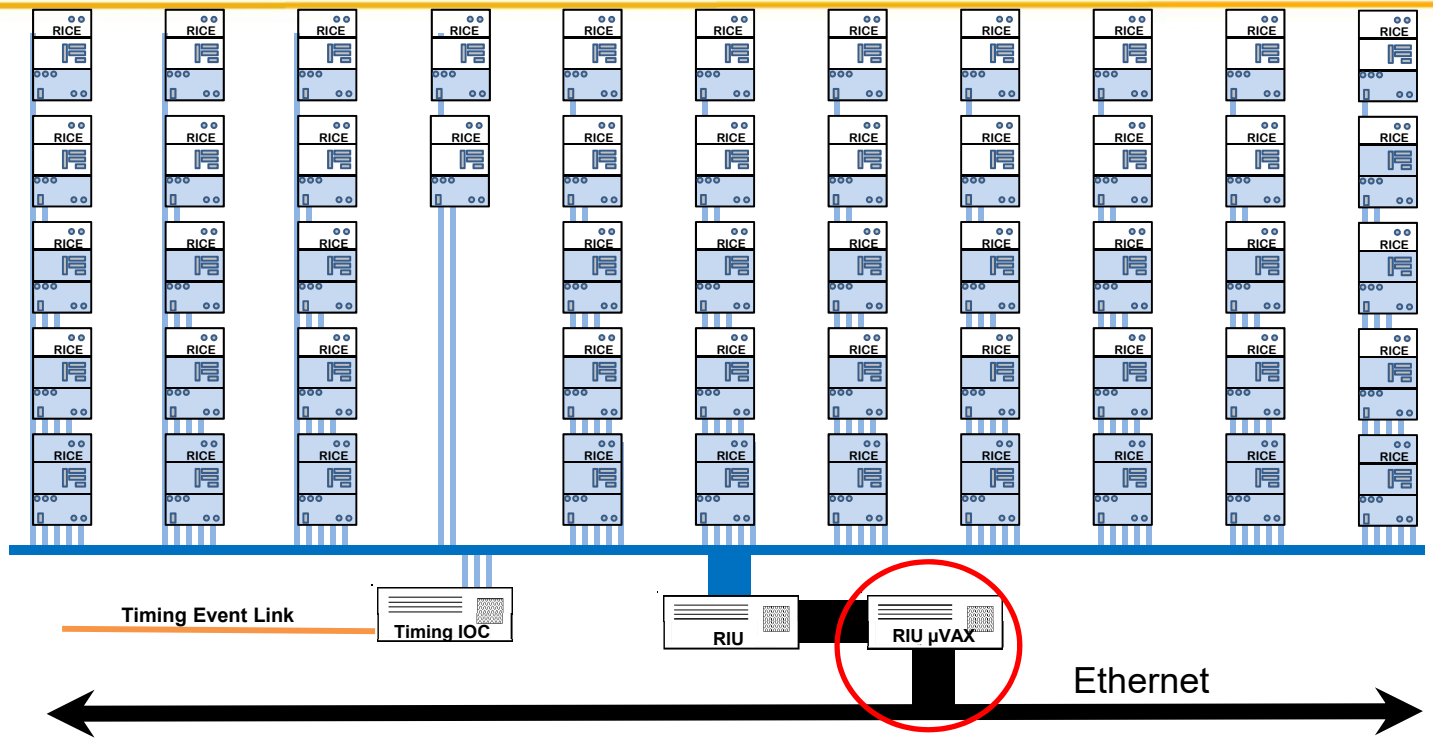
Current Status:
Over halfway finished replacing fast protect readback



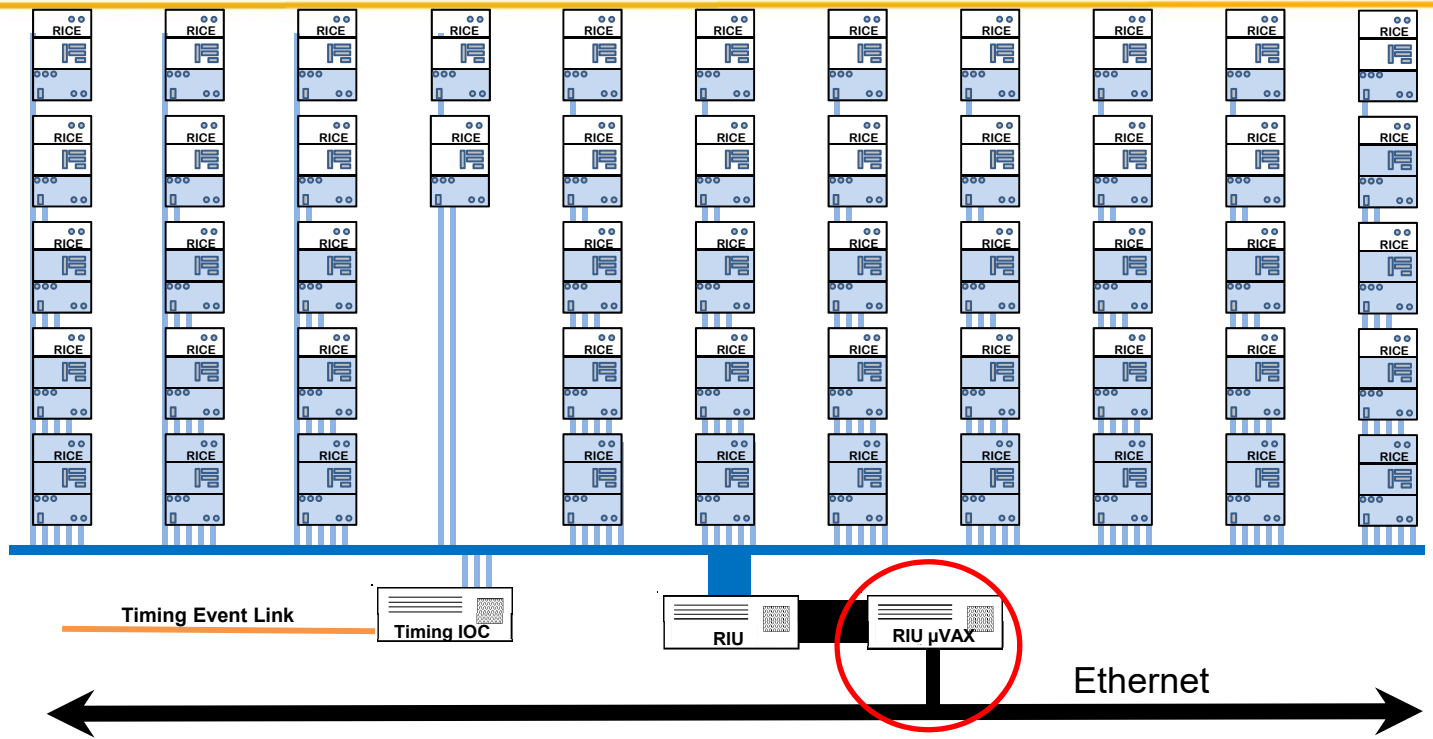
Current Status:
Beam Synchronous I/O just getting started



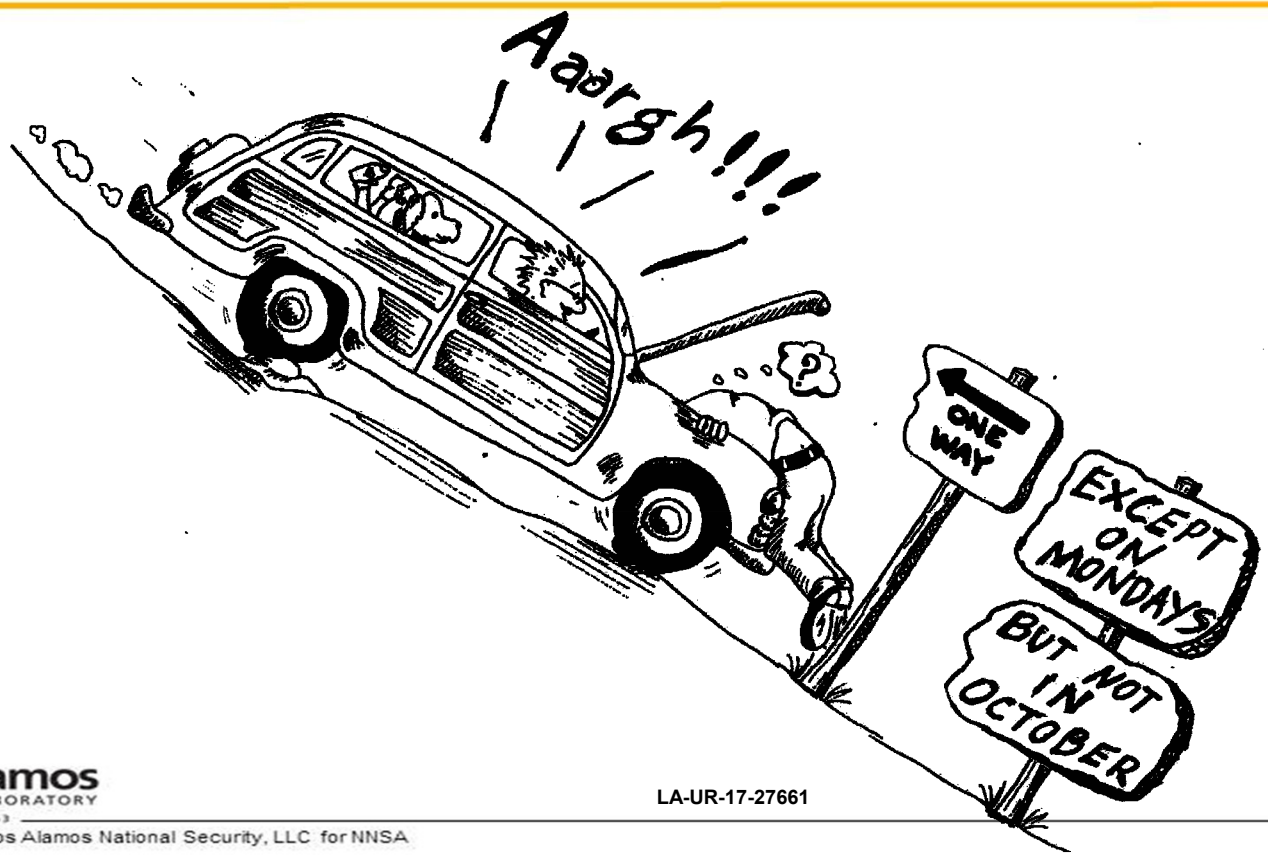
Current Status:
Significant load reduction on the RICE system



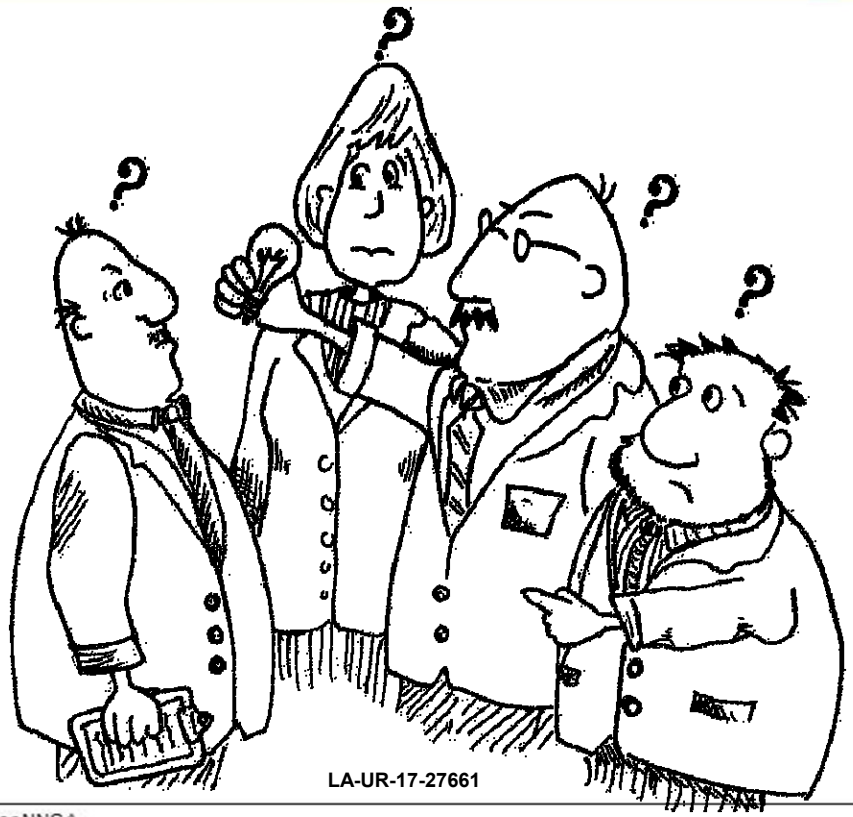
Current Status:
Bottleneck got worse…



Observation 3b:
..and sometimes the surprise will not be pleasant.



Question: What Happened?



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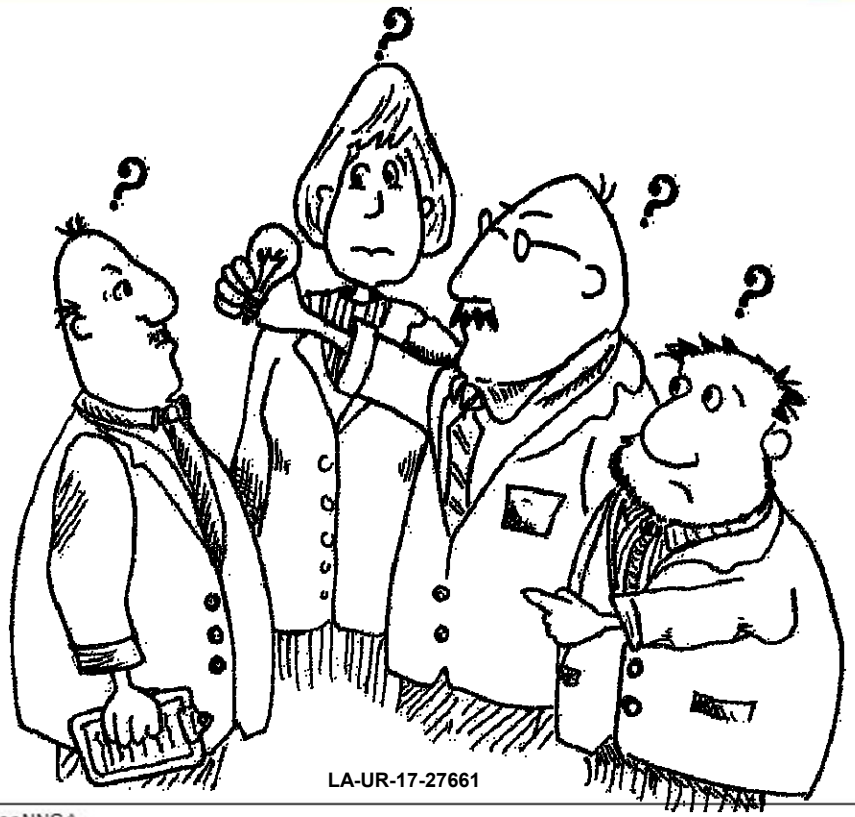
Question: What Happened?
Answer: We Don't Know ….Yet.



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to be continued…..

Thanks…

Special Thanks To Kristi Carr

(the Carr-Toonist)

Thanks…

And Thank You For Your Attention!