Proposal to Acquire and Restore the "Connecticut 1401"

Robert Garner, rev2, 2/2007

1 Introduction

The raison d'être behind the Museum's project to restore an IBM 1401 is to recreate an operational vintage computer data processing center that can be relied on for public demos and hands-on classes for many years. This memo lays out the benefits that acquisition of an available second complete system would bring to the 1401 restoration endeavor.

A team of about a dozen retired IBM customer and product engineers has been painstakingly restoring our "German 1401," procured from Hamm, Germany in 2004. The system's main units (1401 CPU, 1402 card reader/punch, 1403 printer) are up and running, but some effort remains to get its tape drives operational.

2 Background to the Connecticut 1401

On Aug 23rd, 2007 I was contacted by Scott Bellefleur, the son of Solime "Buzz" Bellefleur, inquiring whether the Museum might have an interest in acquiring their IBM 1401. (He had found my email on our 1401 web site, 1401RestorationProject.) Scott and his father are offering the Museum a first right to purchase their system.

Remarkably, Buzz had operated a billing service business until 1995 out of his home in Darien, Connecticut, primarily for Westchester County country clubs.

After perusing our in-depth 1401 restoration web site, Scott became enamored of the team's passion for our project, their articulated craftsmanship and enthusiasm for demonstrating the running system to Museum visitors. Scott answered inquiries and provided excellent pictures (two below and more at SelectCT1401Pics).

I visited Scott, Buzz and their 1401 on Oct 26nd and found it to be in remarkably excellent shape: nary a scratch and essentially no corrosion—undoubtedly because it was operated for 23 years with an air conditioner and dehumidifier in the basement. The absence of dust on the 1401 SMS cards was striking. (A DVD is available and was shown to the Museum Restoration Committee on Nov 14th.) About half the time Buzz's system was under an IBM maintenance contract and, after that became too expensive, IBM friends helped Buzz keep it running. By 1995 Buzz retired from his business as his clients had (finally) converted over to PC or web-based billing services.

The Connecticut 1401 has a nearly identical configuration to our German 1401:

- 1401 CPU, 1402 card reader/punch, 1403 printer
- 1406 12K extended memory, and four 729 tape drives (model II)

Spare items include:

- one spare 1403, two spare 729s (model II), spare 1406 memory unit
- many spare SMS cards, several spare print trains

Additional included unit record equipment includes:

- 083 Sorter, 088 Collator, 129 Card Keypunch.


Figure 1a. Scott Belle and Buzz Belle with system in basement

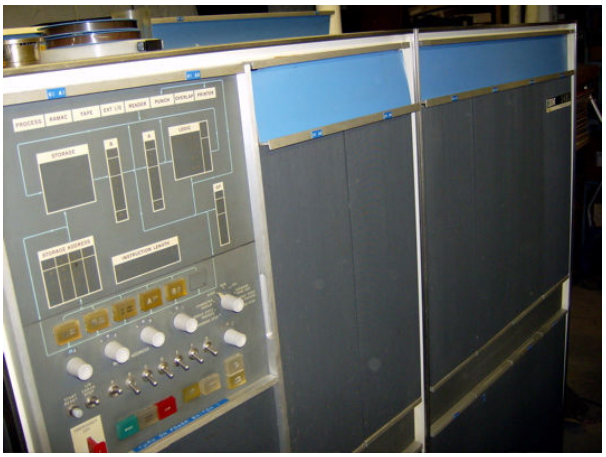


Figure 1b. 1401 CPU and 1402 Card Reader

3 Rationale for acquiring the Connecticut 1401

The reasons for acquiring the complete Connecticut IBM 1401 focus around strengthening the plan for demonstrating an operational, classic data processing "mainframe" for Museum guests and also provide the opportunity for educational classes in operating and programming such a vintage machine. From the perspective of the volunteers and docents operating and demo'ing the machine, an important prerogative is that the machine will be sufficiently reliable so that there will be minimal down time and maintenance for many years.

What follows are eight arguments to acquire and restore the Connecticut IBM 1401. For these reasons, our expectation is that it will likely replace the current German 1401 as the public demo machine.

1) Connecticut 1401 is in better overall shape than the German 1401.

Although the Connecticut and German 1401s are nearly identical in their early history, configuration, and usage, they are in radically different shape primarily because the German 1401 was stored in a non-environment controlled garage for 27 years, whereas the Connecticut 1401 was still operated for 18 of those same years in an air conditioned and humidity controlled environment.

The Connecticut 1401, built in 1961, was operated 24/7 by an insurance company until 1972, then used by Buzz for billing services in his small home business until 1995. Maintenance records show normal expected repair actions. There is no significant observable corrosion (except on two external surfaces. Being only 12 years since it was last operated, we expect on the order of 15 – 20 defective SMS cards in the system.)

The German 1401, built in 1964, was operated 24/7 by an insurance company until 1972, then used by Arnold Schweinberg for billing services in his small home business until 1977. Although inspected before its purchase, 27 years of storage (1977 – 2004) in a non-humidity-controlled detached auto garage in damp Germanic climate took its toll. The resulting corrosion severely affected its surfaces (which the team would like to refurbish to original, high-quality appearances), and unbeknownst to us until well into the restoration, affected the machine's moisture-sensitive Germanium transistors and diodes themselves.

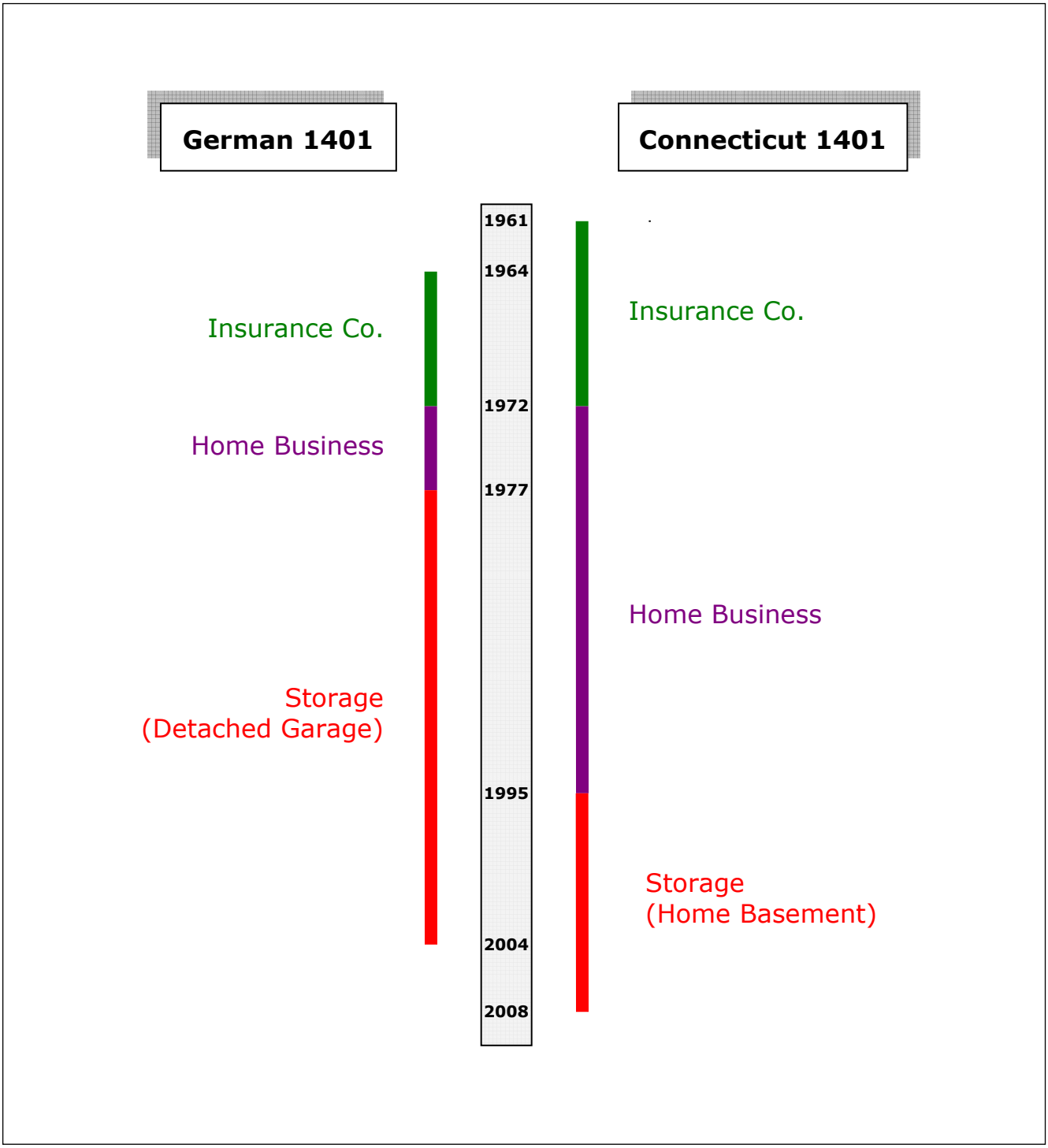

Figure 2. Chronology of German 1401 vs. Connecticut 1401

One adverse diagnosis the restoration team has made over the past several years is that the semiconductors in the system were, to varying degrees, damaged by moisture-induced corrosion and infiltration. In summary, we've learned that the Germanium, alloy-junction transistor TO-5 metallic cans and point-contact diode leads are ferrous (iron) and thus are susceptible to corrosion and rusting.

Not only were some transistor/diode leads so rusted that they break off at the package lead entrance, but in many cases the corrosion further compromises their hermetic seals, which admits water vapor, which contaminates the semiconductor junctions, which subtly causes device instability or failure. Erratically, they will work at some temperatures, voltages, or logic circuit states, but not others. Figure 2 shows an example of a moisture-damaged, "loopy" alloy-junction transistor I-V curve besides a more typical, but aged, I-V curve:

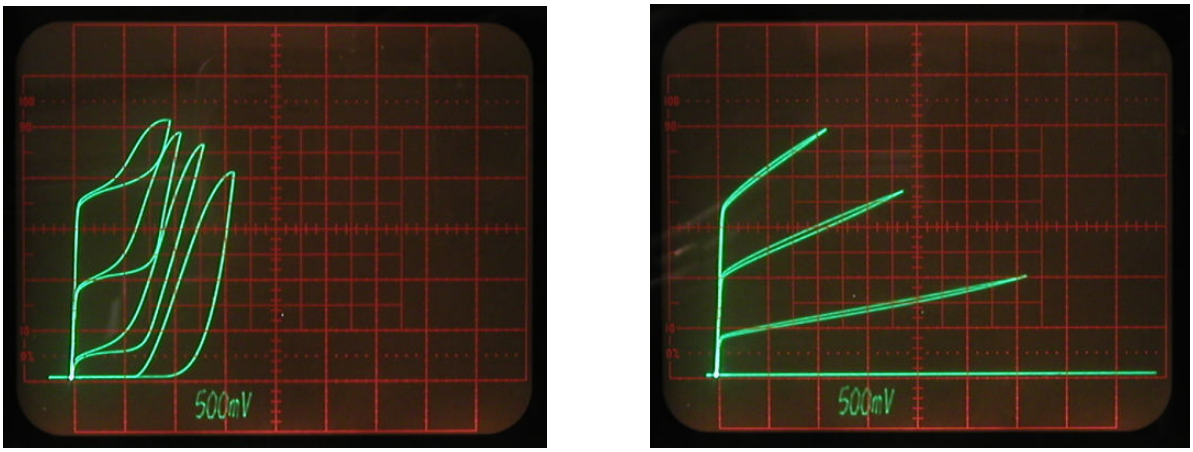

Figure 2: "Loopy" IV curve on left due to corrosion-induced moisture infiltration and more typical aged IV curve on right.

After 3 years restoring the German 1401, the team uncovered and repaired 112 SMS cards (out of ~3,000 in the system). Sometimes there were multiple transistor or diode failures per card. Most of these failures were due to corroded transistor and diode packages. The SMS boards are covered with dust and grime, especially near the fans, which encourages the accumulation of moisture.

The issue going forward is that there are likely more compromised transistors and diodes in the German system that may, at an inopportune time, cross a contamination threshold and begin to cause flakey system behavior, taking the system down until the offending device is located—a painful and slow bug shooting process that requires well-honed knowledge of the logic design and inter-workings of the system.

2) Connecticut 1401 is an endemic 60 Hz system.

Being from Europe, the German 1401 requires 50 Hz power.[1] The issues with 50 Hz power going forward are: reliability, serviceability, potential converter replacement cost, noise, and power inefficiency.

Our current 1970's era 50 Hz power converter is a tenuous, single point of failure. Although still manufactured by Pacific Power (390-GR Spec), it is not under a service contact/warranty: We must repair it ourselves and depend on the good will of senior engineers at Pacific Power. Replacing it could be very expensive as used or comparable units, typically switchers, sell for about $30k. (Our power converter smoked and was damaged once due to incorrect, unintentional wiring that created an unintentional ground loop through an undersized internal connector.)

The Pacific Power converter generates more fan noise than the rest of the entire 1401 (n/c the print hammers and card mechanisms). Also, its noise will need to increase, since in order to power the entire 1401 system with a full complement of four 729 tape drives (for ~13 kW total draw), we'll need to add a second rack of Pacific Power inverters, beyond the rack we've deployed so far (~9kW per rack, 18kW total capacity)—doubling its fan noise and lowering reliability. Docents and the team have already complained about the high noise levels from the converter.

The Pacific Power converter is also an energy hog at only ~65% efficiency, consuming 1.6 kilowatts for every kilowatt delivered. (Nevertheless, its linear design makes it suitable for powering inductive loads, such as the units ferroresonant AC supplies.)

3) The Connecticut 1401 doubles our inventory of spare/swappable parts.

The ideal paradigm for restoring such a complex vintage computer is to have *three* of the machines: The first for hands-on restoration, the second in accessible storage for swapping components with faulty ones, and the third only for display and preservation (hands off!). Note that the 1401 system has upwards of 200,000 discrete components, thus a source of spare/swappable parts is crucial for its long-term maintenance and viability.

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[11] It is impractical to directly run the German 1401 on 60 Hz because there are many 50 Hz, unalterable ferroresonant power supplies located throughout it, including one in each 50 Hz geared 729 tape drive. Instead, we convert 3-phase 60 Hz / 280 VAC to 50 Hz / 380 VAC via a 18 kVA "Pacific Power 390-GR" power converter that was purchased surplus from IBM San Jose after several decades of service in their EMC lab. For each of the three AC phases, it converts the incoming 60 Hz to DC that then powers 50 Hz linear, Class B, ganged power amplifiers/inverters.

Although our German 1401 came with some spare SMS cards and a potpourri of mechanical parts (and we have acquired some via eBay or from folks stumbling upon our restoration site), our inventory of spare SMS cards and mechanical parts is far from complete for the entire system.

The spare SMS cards in particular are lacking and ill-matched to the actual distribution of ~3,000 SMS cards in the machine. Although we have 114 spares out of the 223 different possible SMS types for the 1401 CPU, they're not in the same proportion as those present in the CPU. For most spare card types in inventory we only have 1 or 2 examples, and for some critical types we have none, such as the tape controller (TAU) cards, print hammer driver cards, and critical CPU register (STAR) cards. Also, we have no spare SMS cards for the ~200 used in each 729 tape drive.

The Visible Storage 1401 has been our only source of some swappable spares to date. But since it's an incomplete system (with only a single tape drive), incompatible design/serial number[2], and sliced cables, we've been restoring the German 1401 *without* the benefit of a full complement of commensurate spare/swappable components. Nevertheless, we've had to swap several dozen components with the Visible Storage units (1401 and 729 SMS cards and mechanical parts from the 1402 & 1403)—always a staff-intensive, problematic and ultimately self-defeating procedure.

The Museum also recently acquired a 1401 CPU (only) as part of last year's SAP donation. (The acquired 1402 was for the IBM 360 system, so is incompatible.) However its condition, having been stored in an open-to-the-outdoors warehouse in Germany, is very poor. Although it may be a potential source of spare/swappable SMS cards for the CPU, like our current situation wrt to the VS 1401, it doesn't have any potential spare parts for the peripherals: 729 tape, 1402 card, 1403 printer, or 1406 memory units.

4) Connecticut 1401 does *not* include intricate "overlap feature."

In about 1963 (between manufacture of the 1961 Connecticut and 1964 German 1401s), IBM introduced a major 1401 feature enhancement called "process overlap" (Van's Overlap Story) that allowed for concurrent CPU and card I/O operations (i.e., programs can read, calculate, punch and print concurrently).

Although the process overlap feature has no practical value for demonstrations, when there are faults in the overlap circuits, the bugs are much harder to shoot as

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[2] There was a major 1401 design engineering upgrade/change at serial #25,000. The Visible Storage 1401 (#20,811) predates this change, whereas the 1961 Connecticut 1401 (#25,478) and the 1964 German 1401 (#28,421) postdate the design change and thus are fundamentally compatible.

the overlap control signals permeate "everywhere" and impact much of the logics. (Ron Williams spent nearly half a year debugging overlap circuit related problems even though we don't use the "feature.") That the Connecticut 1401 does *not* include the overlap feature is an auspicious debugging and maintenance advantage.

We've also discovered over the years that the German 1401 contains certain home-brew, bootleg, undocumented modifications that have caused several bug shooting headaches. Since the Connecticut 1401 was under IBM maintenance for much of its life and Buzz did not tinker with its hardware, we're fairly certain there are no hardware surprises.

5) Connecticut tape drives are all the same type.

The Connecticut 1401 has four model II 729 tape drives and two spare model II units. Having all tape units of the same model should be easier to debug and maintain as components are easily swapped and expertise is shared.

Our German 1401 system has a cortege of two model V's, one model IV, and two model II's. Restoration focus has been on one of the model V's, which is not yet reliably running. Although the other four German 729s have had extensive mechanical overhauls, that their refurbished clutches and bearings could likely be used in the Connecticut 729's if necessary.

Our hope is that the four main Connecticut 729s could become operational without needing full mechanical overhauls, as they were running only 12 years ago. That notwithstanding, as model II's, there is significant relay control logic not in model V's and we have no experience with these circuits yet (as we haven't brought up a German model II yet).

6) Software release tapes for FORTRAN, COBOL, Autocoder, and Sort7.

Until this time, we have been unable to find Autocoder, FORTRAN or COBOL compiler binaries for the 1401. (We did pick up a Sort7 from eBay, but haven't run it yet as it requires four tape drives.) This software is a significant find in itself!

7) Connecticut 1401's original owner is not far away.

Buzz Belle is helpful and resourceful, as he ran a data processing business from his home (with several card punches, printers, and accounting machines) and learned to maintain the 1401. He and Scott also restore old cars, so they appreciate the value of "old things" and have respected the integrity of the system. Buzz also attached and programmed a classic Atari micro as a system console. They're very excited about the prospect of their 1401 being restored at the Museum by the current team.

4 Restoration proposal for the Connecticut 1401

While the Connecticut 1401 is being acquired (contract, transportation, etc) and during its bring-up, we would keep the German 1401 running—available for demos, docent training, restoration of its 729 tape drives, completion of the TAU/729 Analyzer/Simulator, and continuation of its ongoing reliability assessment.

The proposal for the Connecticut 1401 restoration is:

1) Inventory and copy all documentation and software.

2) As shown in Figure 3, free up and create an auxiliary restoration area in the 1401 room by removing the unneeded, redundant 30-ton Liebert System/3 Computer Room Air Conditioner (CRAC) and the now defunct EPC UPS system with lead-acid batteries. Current expectation is to sell or donate these large units. (Thanks to Stan Paddock for working on the arrangements.)

3) Install the Connecticut 1401 CPU, 1402 card reader/punch, 1406 extended memory, and a single 729 tape drive in the auxiliary restoration area (and relocate 50 Hz converter).

4) Temporarily store the other Connecticut units including the two 1403 printers, spare 1406, and five 729 tape drives in the Museum's Milpitas warehouse.

5) Reform and verify the 1401 and 1402 power supplies. Power up and begin bring-up of just the 1401 CPU, 1402 card, and 1406 memory units. (It's expected that this could be a propitious training opportunity for the "younger" team members or new recruits.)

6) While the core of the 1401 system is being restored, assess and attempt to bring up the single 729 tape drive in standalone.

7) Make a decision as to whether to replace the German 1401 with the Connecticut 1401. If "yes," then move the German 1401 into the Milpitas warehouse as a source of spare/swappable components. (A closer location would be more ideal, but the Museum is slated to be under construction.) If "no," the Connecticut 1401 becomes the source of spare/swappable components.

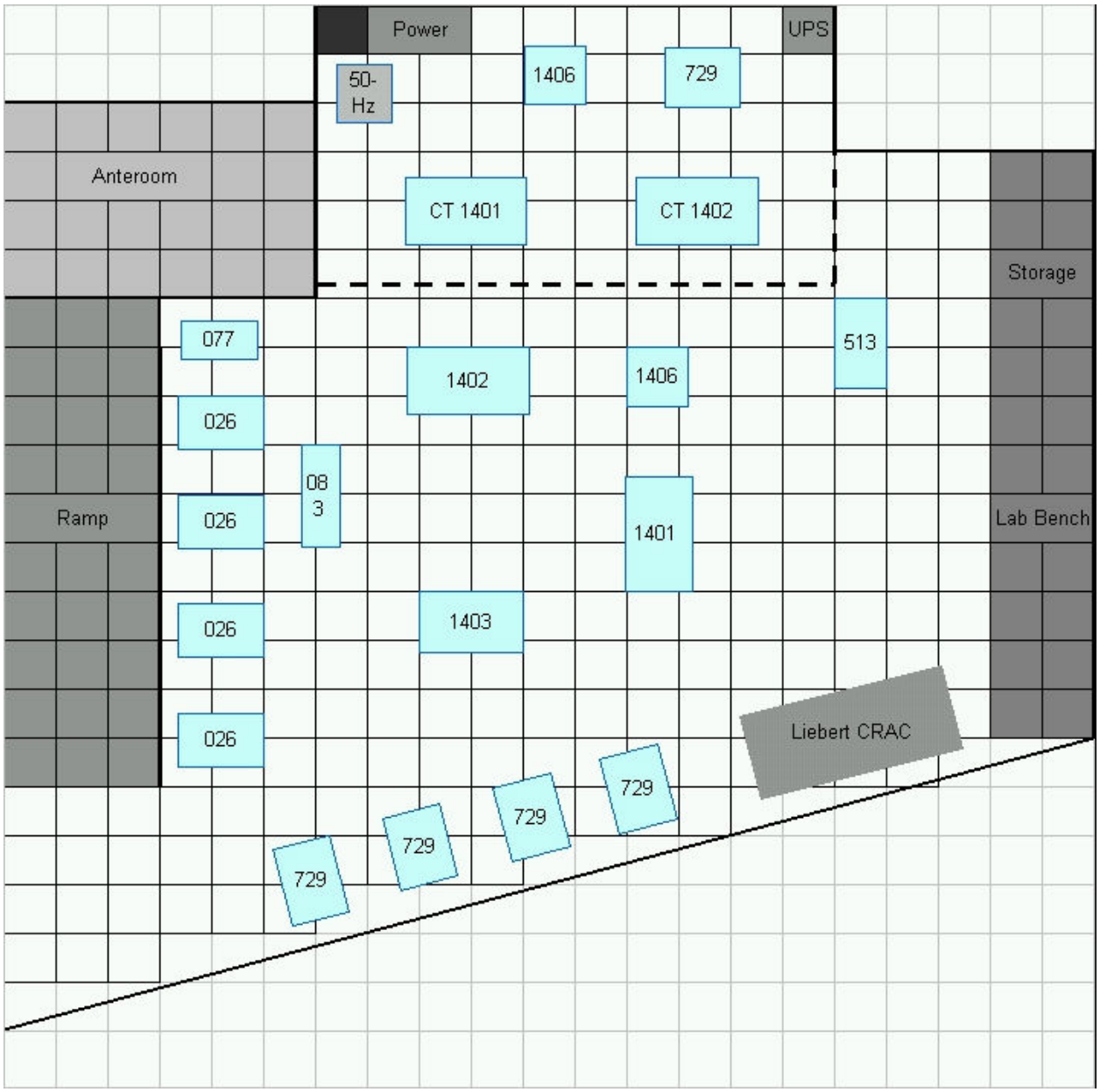

Figure 3: Proposed 1401 new restoration room floor plan: Accommodates all existing German units, main Connecticut units, and existing unit record equipment.

5 Anticipated acquisition costs for the Connecticut 1401

Scott Belle and his father are asking $ XX,000 for the complete 1401 system, spare units, spare SMS components, software, and documents. As a comparison, the German 1401 was priced at € YY,000 ($ ZZ,000 in late 2003).

Packing and land shipment from Darien, CT to Mountain View will, at a discounted cost to the Museum, about $ 6K.[3]

If the Museum decides not to pursue this acquisition, Scott has indicated he will look for a higher offer from private collectors. (He already has already spoken with Sellam Ismail on how such a process might work.)

My expectation is that the Museum's acquisition of the Connecticut 1401 will help to guarantee a solid, first-class vintage data processing system for years of live, trouble-free operation and demonstrations.[4]

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[3] As a comparison, packing and shipping via land and sea in 2004 from near Dortmund, German to Mountain View cost €8,580 ($10,000) —packaging and surface charge was €4,760 ($5,555) and €3,820 ($4,460) for sea and surface from Oakland port to Mountain View. This packaging and shipping bill was graciously paid for by IBM Research San Jose.

[4] The 1401 had a reputation for very high field reliability, rarely needing service:
"The 1401 was a great machine to use. And it kept running under the most adverse conditions. I recall one time when there is a voltage drop and the 360 and its equipment shut down. We had no lights in the computer room. In the darkness with the lights off and the 360 down, the 1401 kept merrily running, its lights and its 729s being the only illumination in the room. The 1401 was an IBM version of the Energizer bunny - it just kept running and running..." — Sam Druck, John Felix Assoc service bureau, Connecticut.