Scenario Analysis using a Simple Econometric Model of Alcor Finances

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1. Introduction

Sound finances can boost Alcor's security and credibility as an organization. But recent articles by Charles Platt [1] and Ralph Merkle [2] have highlighted the financial challenges faced by Alcor – in particular, the current mismatch between cryopreservation funding minimums and actual costs when cryopreservation services are actually rendered, often decades later, combined with Alcor's heavy reliance on bequests and on the continuing generosity of living donors to support core functions. There have been heroic efforts in past decades to begin to address these issues by properly analyzing the actual costs of cryopreservation and long-term storage at Alcor, most notably by Bridge and Darwin in 1982 [3, 4], Darwin in 1990 [5], Perry in 1990 [6], Whelan in 1993 [7], and Platt in 1998 [8] and 2002 [9]. But apparently no basic top-down econometric model [10] of Alcor's finances has ever been published.

To remedy this lack, I used publicly available data to create a simple econometric model for current Alcor total expenses and all major revenue sources in a 246-column Excel spreadsheet format. The model is "simple" because it attempts to capture only the most financially important relations while ignoring many nuances and specific details of Alcor's finances. This data-driven model was used to estimate future Alcor expenses and revenue items assuming average membership growth rates of 0%-8% per year and historical inflation rates, projected 30 years forward in time. By altering a few key parameters in the model, a number of interesting remedial scenarios can be numerically tested – such as the effects of adding cost-of-living adjustments (COLAs) or of altering current cryopreservation minimums, dues, standby fees, set-aside ratios, "grandfathering" policy, membership growth rates, and so forth. My objective here is not to produce precise forecasts of future Alcor income and expenses, but rather to explore the sensitivity of net revenues to various alterations in Alcor's income streams that might be implemented by the Board. This more limited goal is intended to provide useful quantitative information on the utility of various approaches to Board members as they deliberate possible changes aimed at improving the financial stability of the organization.

2. Total Expenses Model

Data on Alcor total expenses [11] were taken from Financial Statements (e.g., Consolidated Statement, "Total Expenses") prepared by various accounting firms during 1990-2005 and 2007, and from Forms 990 (e.g., Part I, "Total expenses") that were filed with IRS during 2004-2008, that were publicly available as of July 2010. Expenses include cryopreservation, maintenance, program, and other expenses for all Alcor operations. For the three years in which Financial Statements and Forms 990 overlapped, the higher reported expense figure was assumed to be correct (the Statement figure was higher in two years and the Form 990 figure was higher in one year). This provides a time series of actual Alcor total expenses (TE) in nominal dollars during 1990-2008.

Inflation is taken as the Consumer Price Index for urban consumers (CPI-U) as of mid-year (June) of each year on the 1982-84=100 basis [12], shifted to a 2010=1.0000 basis by dividing all Index data by the June 2010 figure. Dividing total expenses by this shifted CPI index converts nominal total expenses into "real" total expenses, expressed in constant 2010 dollars ($TE_{\$2010}$).

Which independent variables most strongly influence Real Total Expenses, or $TE_{\$2010}$? In keeping with the broad-brush nature of this analysis, there are three main functions performed by Alcor that generate real expenses:

(1) "keeping existing cryopatients frozen," the cost of which is predicted by the total number of Alcor cryopatients N_{cryo} residing in dewars in any given year (incorporating the relevant neuro/WB mix);

(2) "freezing new cryopatients," the cost of which is proportional to the number of cryopreservations n_{cryo} performed by Alcor during any given year (incorporating the relevant neuro/WB mix); and

(3) "servicing cryopreservation members who may someday become cryopatients," a cost that is predicted by the total number of Alcor members N_{memb} on the membership roster in any given year. These expenses include research, administrative, legal, publishing, marketing, training, inventory, and other general costs of running the organization. (At this writing, the spreadsheet assumes $N_{memb} = 950$ by year-end 2010.)

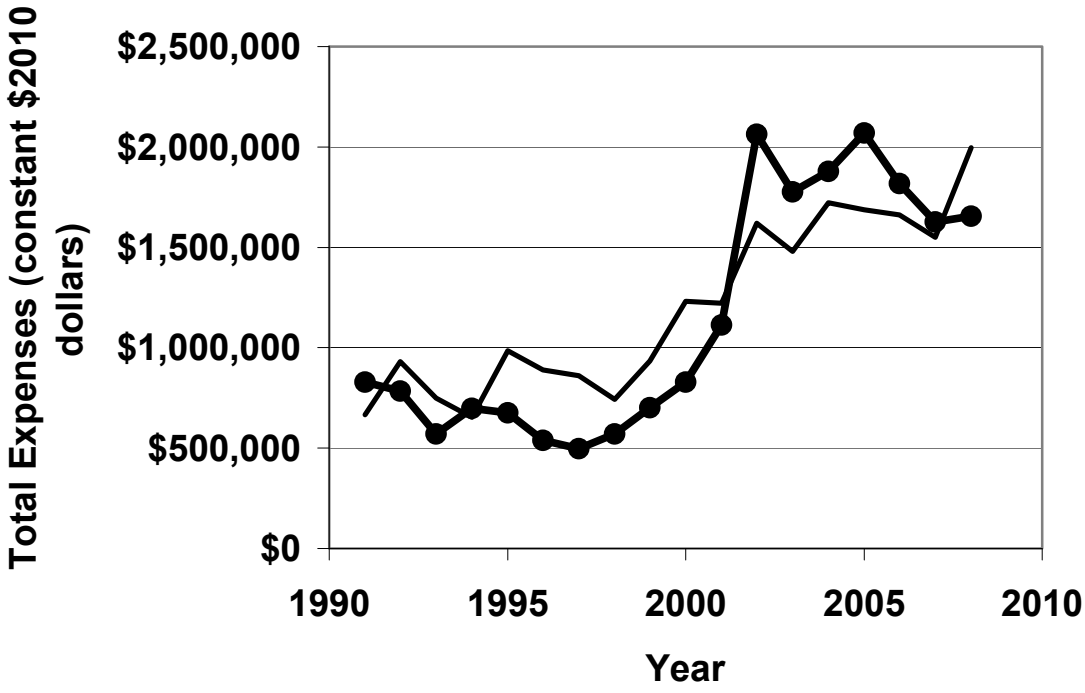
Historical data for all three independent variables (N_{cryo}, n_{cryo}, N_{memb}) is available online [13].

Looking first at the impact of N_{cryo}, Ralph Whelan performed the most recent detailed analysis [7] of cryopatient storage costs in 1993. Including liquid nitrogen supplies, the rental of floor space for the dewars, custodial labor, equipment amortization, utilities, administration and other overhead, Whelan calculated the maintenance cost as c_{neuro} = $689.40/patient-yr for neuro patients and c_{WB} = $2,465.35/patient-yr for whole-body (WB) patients in 1993 dollars, which translates to c_{neuro} = **$1,042.65**/patient-yr and c_{WB} = **$3,728.60**/patient-yr in constant 2010 dollars using our shifted CPI index. Earlier estimates by Darwin in 1990 [5], to which Whelan [7] took exception, yielded c_{neuro} = **$111.10**/patient-yr (Bigfoot) or **$253.46**/patient-yr (XLC-1520) and c_{WB} = **$1,436.42**/patient-yr (Bigfoot) or **$2,836.47**/patient-yr (A-9000M), again after conversion to 2010 dollars. It must be noted that by 2010, new neuro storage units had replaced the smaller ones used in the early 1990s when Darwin and Whelan did their analyses. Today, 10 neuros can be placed in the same dewar storage volume as 1 whole-body patient. Unfortunately, no updated survey comparable to Whelan's has been published since 1993. Most recently in 2010, Wowk [14] made a quick estimate of c_{neuro} = **$115**/patient-yr and c_{WB} = **$1,149**/patient-yr, but this calculation may be incomplete as it only takes account of "...the marginal cost of liquid nitrogen and dewar space" and omits custodial labor and several other costs. For concreteness and for purposes of illustration, the present article will assume that total cryopatient storage costs in 2010 dollars may be approximated as c_{neuro} = **$150**/patient-yr and c_{WB} = **$1,500**/patient-yr. Assuming a constant neuro/WB mix of 65%/35% in the present and future [15] cryopatient population (see below), the total cost of maintaining the average cryopatient at Alcor is estimated as $c_{cryo\$2010} = [(0.65)c_{neuro} + (0.35)c_{WB}]$ = $622.50/patient-yr in 2010 dollars. The total real cost per year to maintain all cryopatients in cryostasis is therefore: $\mathbf{CC_{\$2010} = (\$622.5)N_{cryo}}$.

A reasonable approach that minimizes statistical overspecification errors is to model the quantity ($TE_{\$2010} - CC_{\$2010}$) as a simultaneous function of n_{cryo} and N_{memb} using a trivariate regression, imposing the constraint that this function should go to $0 at $n_{cryo} = N_{memb} = 0$. We then recover $TE_{\$2010}$ by adding $CC_{\$2010}$ to both sides. This procedure yields: $\mathbf{TE_{\$2010} = (\$76{,}520)n_{cryo} + (\$1{,}614)N_{memb} + (\$622.5)N_{cryo}}$ with the square of the correlation coefficient (i.e., the coefficient of determination) $R^2 = 0.77$. In this formulation, each member costs Alcor $1,614/yr in base expenses [16] and each new (average) cryopreservation costs Alcor about $76,520, with both figures measured in constant 2010 dollars. The latter figure seems a bit high but is very roughly consistent with estimates made by Darwin in 1990 [5] of the total cost of a neuro ($48,010) or WB ($62,526) cryopreservation in constant 2010 dollars, especially considering that much less-expensive cryoprotectants were used in 1990 than the much pricier ones (e.g., M22) that are employed in 2010. (Whelan's 1993 estimates [7] of $42,320 (neuro) and $53,325 (WB), as converted to 2010 dollars, are slightly lower than Darwin's.) Our model prediction also compares well to

actual real expenses, as shown in **Figure 1** which was prepared by substituting historical time series data for $n_{cryo}(t)$, $N_{memb}(t)$, and $N_{cryo}(t)$ in calendar years t = 1991-2008. (1990 was an anomalous year for the expense data and thus was ignored when building this part of the model.)

Figure 1. Model prediction (thin line) and actual (black dots on thick line) annual real total expenses in constant 2010 dollars, or $TE_{\$2010}$.



3. Forecasting Membership, Cryopatients and Total Expenses

The cryopreservation membership growth rate of Alcor since inception is shown in **Figure 2**. Although highly volatile in the early years when there were few members, growth averaged +7.5%/yr during 1995-2005 but only +3.8%/yr during 2006-2009. The data for t = 1990-2009 can be represented by the regression formula $\mathbf{N_{memb}(t) = (36.237)t - 71909}$ with $R^2 = 0.97$, a curve which predicts long-term trend growth slowing from about +4%/yr today to about +2.5%/yr by 2040. A well-funded marketing effort aimed at signup prospects outside the usual precincts might improve the growth rate. But for this modeling exercise we assume historical trends continue intact and that growth rates will remain largely within the recent +2%/yr to +8%/yr range (**Figure 3**). Alternatively, for a constant percentage membership growth rate of g_{memb} (= +2%/yr, +4%/yr, +6%/yr, +8%/yr) as in Figure 3, $\mathbf{N_{memb}(t) = N_{memb}(t - 1) (1 + g_{memb}/100)}$ for $t \geq 2010$. Since any changes to the existing Alcor fee schedules or policies that might be implemented by the Board are likely to at least temporarily discourage some membership growth, we conservatively assume a +2%/yr membership growth rate for many of the scenarios presented later in this article.

Figure 2. Alcor cryopreservation membership growth rate, in %/yr, during 1973-2009.

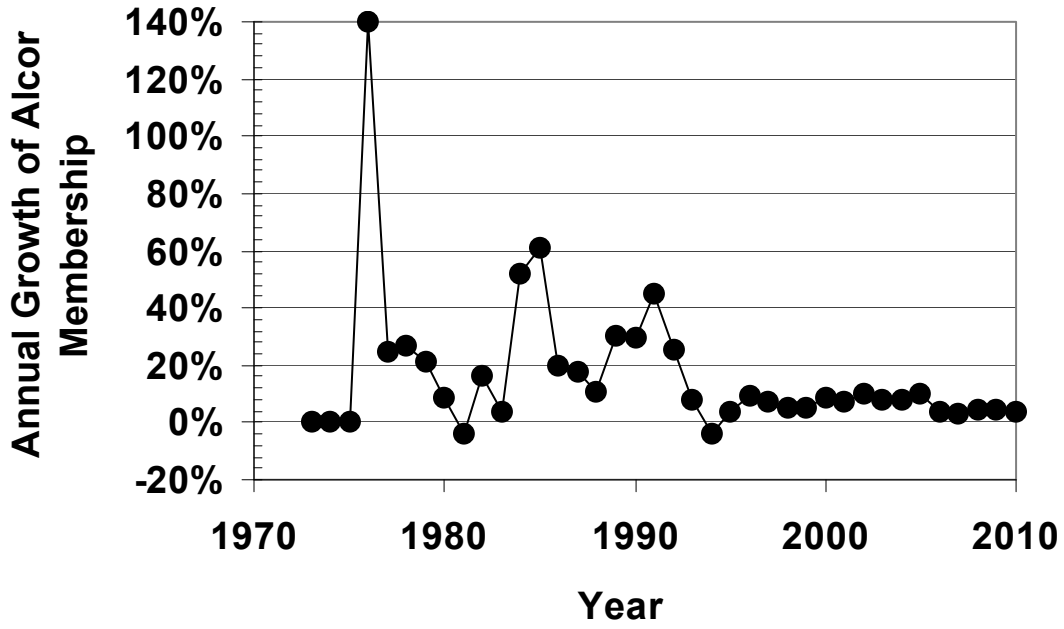
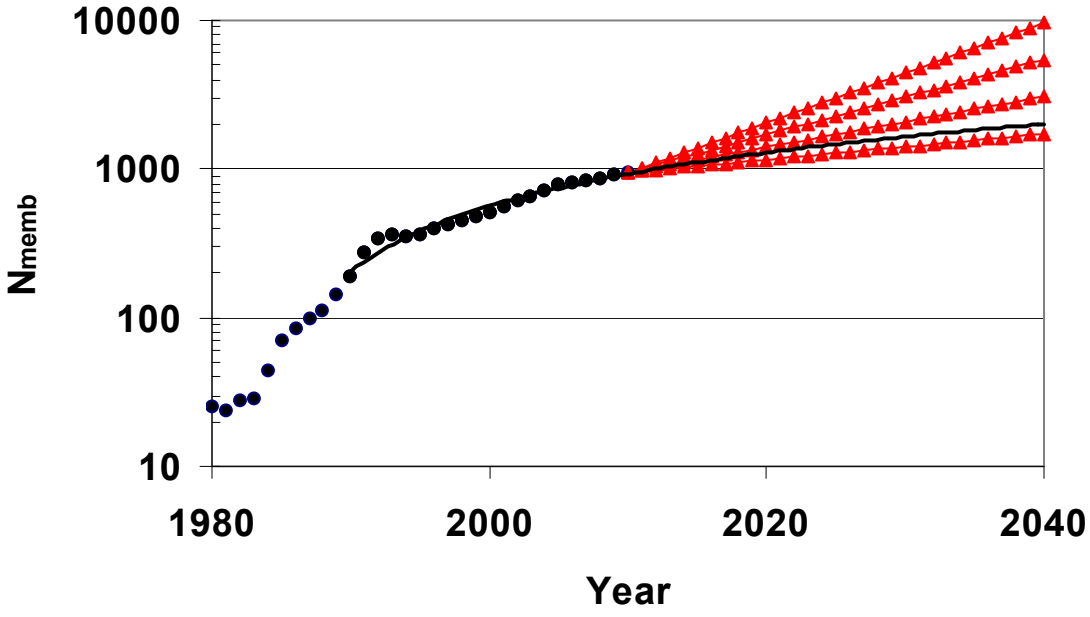


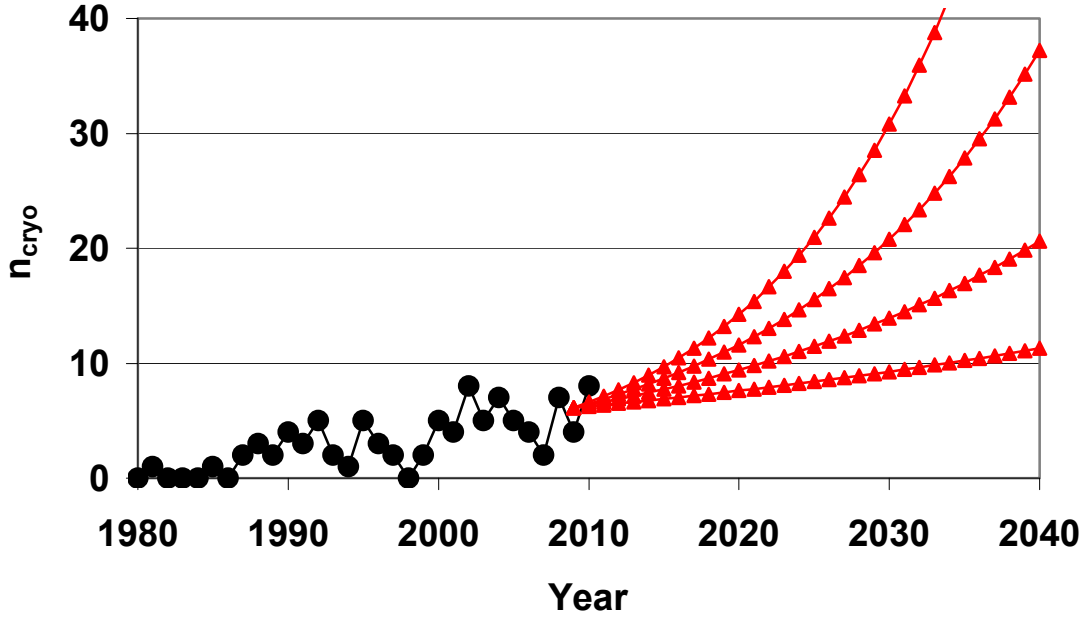
Figure 3. Alcor cryopreservation membership (N_{memb}): actual data, 1980-2009 (black dots); regression formula prediction, 1990-2040 (black curve); N_{memb} prediction for 2010-2040 (red triangles), assuming constant +2%/yr (bottom), +4%/yr, +6%/yr, or +8%/yr (top) growth rates.



The number of cryopreservations in a given year is conveniently modeled using a straight bivariate regression of N_{memb} on n_{cryo} while requiring that $n_{cryo} = 0$ when $N_{memb} = 0$, yielding the formula: $\mathbf{n_{cryo}} =$

(0.0067)N_{memb} with $R^2 = 0.55$ (**Figure 4**). One interpretation of this formula is that adding ~149 (= 1 / 0.0067) new members on average adds 1 additional cryopreservation per year to Alcor's likely workload.

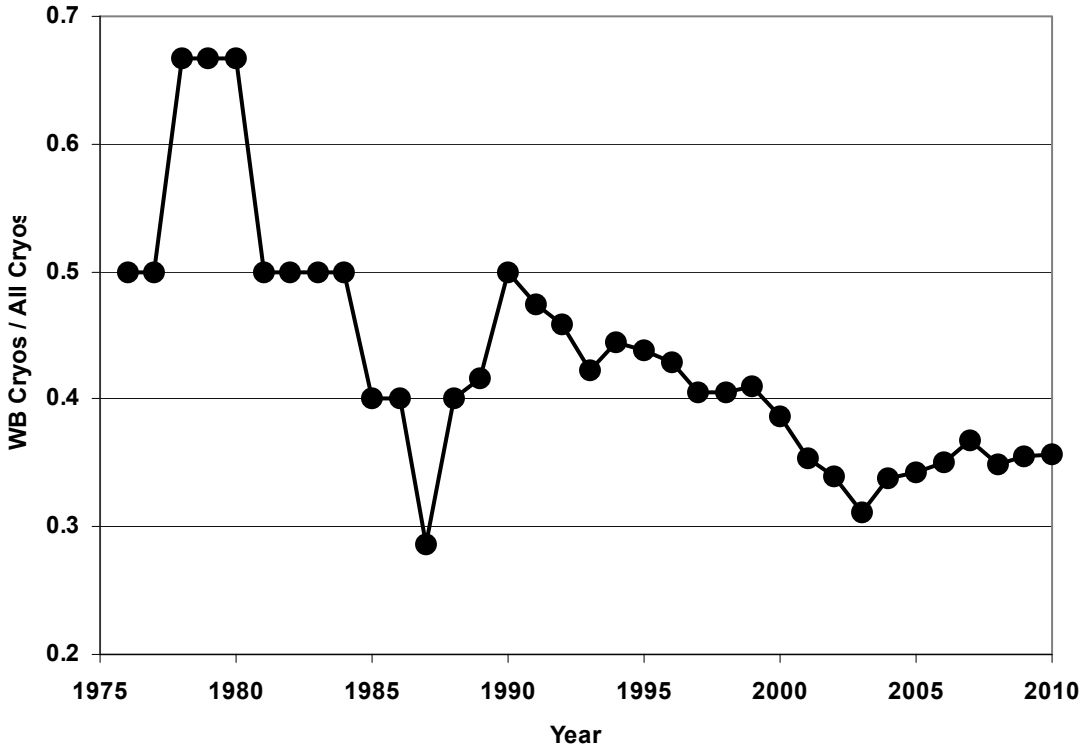
Figure 4. Alcor cryopreservations per year (n_{cryo}): actual data, 1980-2010 (black dots); n_{cryo} prediction for 2010-2040 (red triangles), assuming constant +2%/yr (bottom), +4%/yr, +6%/yr, or +8%/yr (top) growth rates.



Another more interesting interpretation of the above formula is that the average annual death rate for Alcor cryopreservation members is predicted to be 6.7 per 1000 members. In 2002, Platt [9] cited internal membership birthdate data that showed the average age of Alcor members had increased from about 40 years old to about 50 years old, from 1998 to 2002, with half of the increase attributed to over-40-year-old CryoCare returnees. Platt predicted 9 cryopreservations per year for 2002 at $N_{memb} = 611$ members, which implies ~14 per year by 2010 if $N_{memb}(2010) \sim 950$. But Alcor has averaged only 5.3 per year during 2003-2010. The discrepancy occurred because Platt erroneously applied the doubly-high 1998 death rates for black males [18], not the death rates for all Americans as claimed in the article, in his analysis. Using the correct 1998 death rates for white males [18] (who dominate Alcor's membership), the projected rate of cryopreservations should have increased only from 3.6/yr in 1998 to 5.5/yr in 2002, not from 6.1/yr (1998) to 9.1/yr (2002) as claimed by Platt. Since the observed cryopreservation rate should average only 6.7/yr today according to our model, the "rapid aging" of Alcor's membership may have come to rest near a mean age of about 53 years. That's the approximate age at which U.S. white males have a death rate of 6.7 per 1000 [19].

It's also useful to forecast the fraction of n_{cryo} that will become neuro or WB cryopreservations. **Figure 5** shows that the cumulative fraction of whole-body cryopreservations at Alcor steadily declined during the 1970s, 1980s and 1990s, but in the 2000s appears to have leveled off at around $f_{WB} = 35\%$ of the total. For the present model, we assume that the neuro/WB cryopreservation ratio stays constant at the current level of 65%/35%, or about 2:1, during 2010-2040.

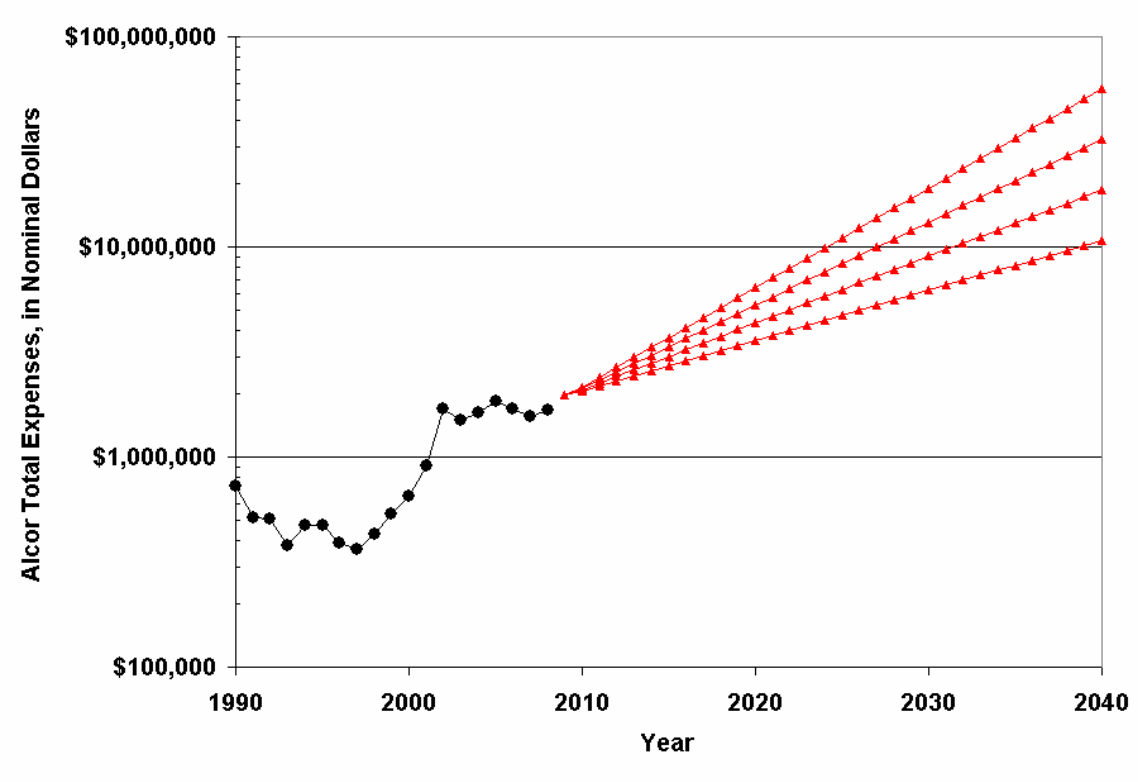
Figure 5. Cumulative fraction of all cryopreservations at Alcor that are whole-body (f_{WB}).



Finally, we also need N_{cryo} if we want to forecast $TE_{\$2010}$. N_{cryo} is the total number of Alcor cryopatients residing in dewars in any given year. Neglecting the few rare instances of forced cryo-thawings and assuming no revivals before 2040, this number is given by the simple summation formula: $\mathbf{N_{cryo}(t) = \Sigma\, n_{cryo}(i)}$, i = 1974 to t.

With these formulas in hand, we can now forecast $TE_{\$2010}$ – Alcor's total expenses in constant 2010 dollars – for the period 2010-2040. CPI-U inflation [12] over the last 30 years (1980-2010) averaged +3.3%/yr, conveniently roughly paralleling hikes in the required cryopreservation funding minimums during 1980-2010 (i.e., neuros +4.0%/yr, WBs +3.1%/yr). Conservatively applying the same average CPI-U inflation rate as occurred during 1980-2010 to our forecasted $TE_{\$2010}$ for 2010-2040 gives a prediction for Alcor total expenses (TE) in nominal dollars during 2010-2040 (**Figure 6**) of: $\mathbf{TE(t) = TE_{\$2010}(t)\,[CPI(t)/CPI(2010)]}$.

Figure 6. Alcor annual total expenses (TE) in nominal dollars; actual data, 1990-2008 (black dots); predicted expenses for 2009-2040 (red triangles), assuming constant +2%/yr (bottom), +4%/yr, +6%/yr, +8%/yr (top) growth rates.



4. Forecasting Alcor Revenues

Alcor has five principal revenue sources: (1) dues, (2) standby fees, (3) proceeds from cryopreservations, (4) Patient Care Trust (PCT) earnings, and (5) grants, donations and bequests. Alcor and PCT costs and revenues are consolidated to keep the model as simple as possible. Math-averse readers can ignore the small-type paragraphs and will still be able to follow what the revenue model is doing.

Dues are currently typically assessed as a fixed quarterly fee per cryopreservation member. The formal rate structure was $100/Qtr during 2001-2009 and $120/Qtr in 2010. But there are reduced rates for certain family members, students, a few "lifetime members" who have paid one lump sum to avoid periodic dues and dues increases, and there are perhaps a few hardship cases who are paying dues at other special rates. As a result, the actual dues received is always somewhat less than the theoretical (dues) x (members) product would indicate. Comparing theoretical dues to actual revenue figures from Alcor's filed Forms 990 [11], we find that the "dues yield" ranged from 63%-100% during 2001-2008 but the median (and a good representative value) for the dues yield is y_{dues} = 85%. Dues can then be modeled as a function of the number of cryopreservation members, the current dues billing rate, and the dues yield.

Taking $r_{dues}(t)$ as the annual dues rate for cryopreservation members (i.e., $r_{dues}(2010)$ = $480/yr), the total dues revenue for Alcor in nominal dollars may be modeled as: $\mathbf{R_{dues}(t) = ½[N_{memb}(t) + N_{memb}(t-1)]\ r_{dues}(t)\ y_{dues}}$, which is adjusted to reflect dues being paid by the average number of members in a given year, and not by the slightly higher number (N_{memb}) present at the end of each

year. Dues are currently being held constant for many years. If dues were continuously adjusted for inflation in 2011 and beyond, then we would have: $r_{dues}(t) = r_{dues}(t - 1)\ [CPI(t)/CPI(t - 1)]$.

Standby fees are also assessed as a fixed quarterly fee per cryopreservation member, starting at $30/Qtr in 2005 and still at that level in 2010. Standby is paid by lifetime members, which is why the "standby yield," again based on Form 990 figures, is slightly higher than for dues, at $y_{standby} = 87\%$. Standby fees can be modeled as a function of the number of cryopreservation members, the current standby billing rate, and the standby yield.

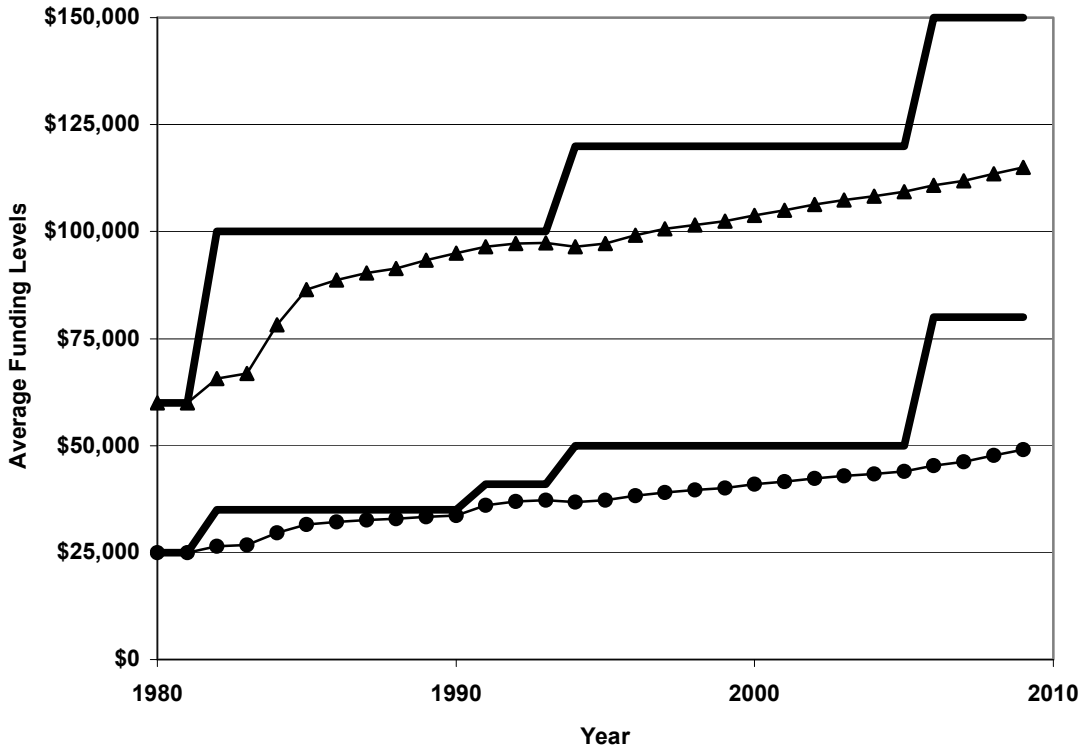
Taking $r_{standby}(t)$ as the annual standby fee for cryopreservation members (i.e., $r_{standby}(2010) = \$120/yr$), the total standby revenue for Alcor in nominal dollars may be modeled as: $\mathbf{R_{standby}(t) = ½[N_{memb}(t) + N_{memb}(t - 1)]\ r_{standby}(t)\ y_{standby}}$, with a similar adjustment to midyear N_{memb} as with dues. Also as with dues, continuously adjusting standby fees for inflation after 2010 would yield: $r_{standby}(t) = r_{standby}(t - 1)\ [CPI(t)/CPI(t - 1)]$.

Cryopreservation revenue is generated when a member suffers legal death and enters cryostasis, and (most commonly) his life insurance proceeds are paid to Alcor. We assume that members who deanimate are selected randomly from the pool of existing cryopreservation members – either without regard to the length of time they've been signed up or after a statistically typical or average period of signup. In any given year, the existing pool of members has some average insurance policy amount in force. This average amount can be estimated by multiplying the number of members added in each year by the cryopreservation funding minimums prevailing in that year, then adding that product to the cumulative total of all similar annual products since Alcor's inception and dividing by the number of members in the cumulative pool. As new members arrive in later years and are forced to take out larger funding minimums, the average funding level of the pool slowly rises but always lags the current funding minimum by some variable amount (**Figure 7**). (The pool average is a minimum because some members have arranged more funding than the minimum [20], but this excess cannot be predicted without access to confidential membership records. Also, an insurance policy or other investment vehicle might be worth significantly more or less at the time of cryopreservation than it is today, beyond guaranteed death benefits.) The model assumes that the amount of cryopreservation revenue generated by each patient is the current pool average.

Note also that there are actually two separate pools because funding minimums (r_{neuro} and r_{WB}) are different for neuros and WBs, giving pool averages of: $\mathbf{p_{neuro}(t) = [1 / N_{memb}(t)]\ \Sigma\{[N_{memb}(i) - N_{memb}(i - 1)]\ r_{neuro}(i)\}}$ and $\mathbf{p_{WB}(t) = [1 / N_{memb}(t)]\ \Sigma\{[N_{memb}(i) - N_{memb}(i - 1)]\ r_{WB}(i)\}}$, i = 1974 to t. (This gives slightly erroneous results in the rare years that N_{memb} declines, when the current pool average should be subtracted for each departing member, not the current funding minimum, but the error produces negligible effects and a more conservative revenue number.) In 2009 the funding minimums were $r_{neuro}(2009) = \$80{,}000$ and $r_{WB}(2009) = \$150{,}000$ and the pool averages were $p_{neuro}(2009) = \$49{,}037$ and $p_{WB}(2009) = \$115{,}038$ for neuro and whole-body, respectively. Continuously indexing funding minimums for inflation after 2010 can be described by: $r_{neuro}(t) = r_{neuro}(t - 1)\ [CPI(t)/CPI(t - 1)]$ for neuros and $r_{WB}(t) = r_{WB}(t - 1)\ [CPI(t)/CPI(t - 1)]$ for WBs.

Cryopreservation revenue R_{cryo} can now be predicted for each posited membership growth rate track (from +2%/yr to +8%/yr) using our previous estimates for n_{cryo} (Figure 4), distributed 65%/35% to neuro/WB, using: $\mathbf{R_{cryo}(t) = (0.65)n_{cryo}(t)\ p_{neuro}(t) + (0.35)n_{cryo}(t)\ p_{WB}(t) - r_{PCT}(t)}$. This formula assumes that all members are "grandfathered", meaning that their earlier lower-value policies are deemed as payment in full for cryopreservation services performed later in time when funding minimums may be higher. Grandfathering has heretofore been an unofficial Alcor policy. In a no-grandfathering scenario, members would have to pay the full current minimum rate in effect at the time when the cryopreservation services are rendered, as described by: $\mathbf{R_{cryo}(t) = (0.65)n_{cryo}(t)\ r_{neuro}(t) + (0.35)n_{cryo}(t)\ r_{WB}(t) - r_{PCT}(t)}$.

Figure 7. Cryopreservation funding for neuro (bottom pair) and WB (top pair) patients at Alcor: required funding minimums (bold lines), neuro pool average (dots), WB pool average (triangles).



Whenever a member is cryopreserved, a significant fraction of the insurance policy proceeds are not spent on the cryopreservation but are immediately diverted to the Patient Care Trust (PCT). This growing capital acts something like a permanent endowment fund whose annual earnings are intended to pay most or all of the actual maintenance expenses for all current cryopatients at Alcor. Diversions of capital into the PCT in a given year are modeled as a function of the number of cryopatients in that year times the current dollar amount of diversion allowance per patient. PCT income is modeled as a 2% real return on all income-producing assets.

The additional factor $\mathbf{r_{PCT}(t)}$ in the above formulas for $\mathbf{R_{cryo}(t)}$ represents the portion of the insurance proceeds that are diverted to the PCT. In 1982, these diversions were set at $15,000 for neuros and $80,000 for WBs. Currently, $r_{PCT:neuro}(2010) = \$25{,}000$ for each neuro and $r_{PCT:WB}(2010) = \$65{,}000$ for each WB, with ~31% of cryopreservation revenue going to the PCT and ~69% to operations, for neuros, and ~43% of cryopreservation revenue going to the PCT and ~57% to operations, for WBs. Hence $\mathbf{r_{PCT}(t) = (0.65)n_{cryo}(t)\, r_{PCT:neuro}(t) + (0.35)n_{cryo}(t)\, r_{PCT:WB}(t)}$. (We'll look at the effects of changing the neuro/WB mix of diverted proceeds later.)

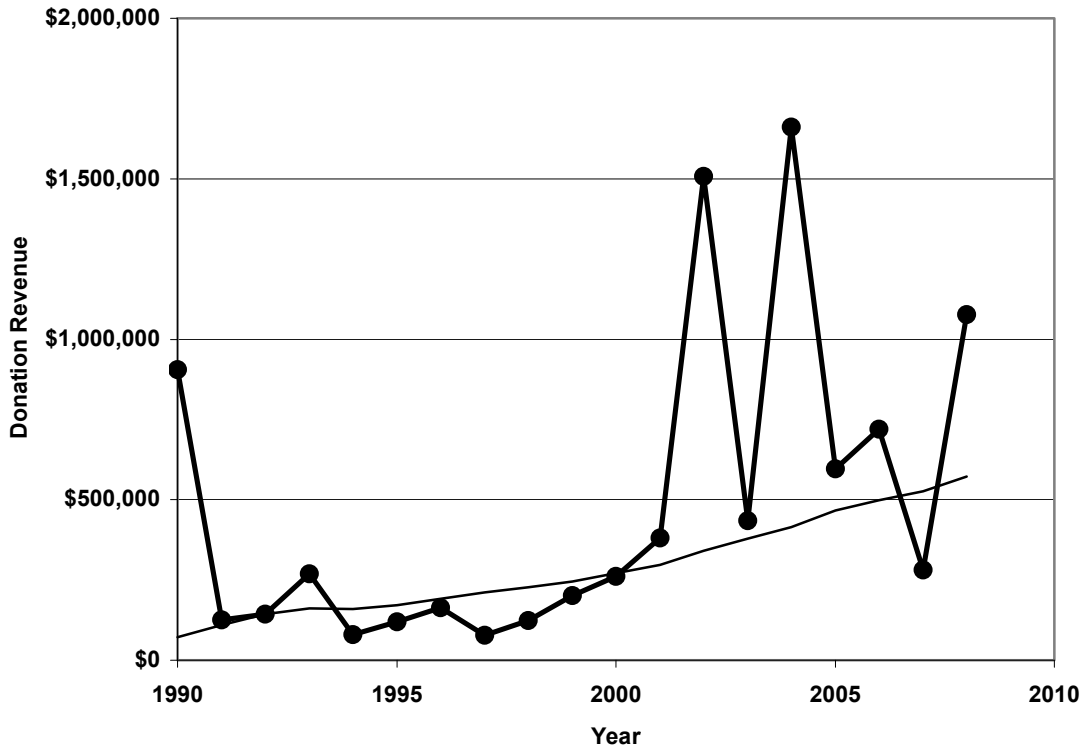
The income-producing portion of the Patient Care Trust assets is conservatively assumed to yield a spendable real return of $I_{PCT} = 2\%/yr$. For example, if inflation is running at $\Delta CPI(t) = +3.3\%/yr$, PCT assets are presumed to produce a nominal +5.3% total return, with 3.3%/yr of this return permanently retained in the Trust to enable income-producing capital to grow at the rate of inflation and 2.0%/yr of the return withdrawn as spendable income to cover cryopatient expenses. The PCT receives additional capital inflows from cryopreservation insurance proceeds in the amount of $r_{PCT}(t)$ as described above. Alcor records [21] indicate that as of 30 June 2010 the PCT consisted of non-income-producing assets (cash and equipment) valued at $974,000 and income-producing assets (investments and real estate) valued at $C_{PCT}(2010) = \$2{,}473{,}468$, up +12.1% from $2,206,577 in January 2009. We model PCT income-producing capital at the end of each year as: $\mathbf{C_{PCT}(t) = [C_{PCT}(t\text{-}1) + r_{PCT}(t\text{-}1)]\,[CPI(t)/CPI(t\text{-}1)]}$. Assuming capital accumulates at a constant pace through the year, spendable PCT revenue can be modeled as: $\mathbf{R_{PCT}(t) = I_{PCT}(t)\,[C_{PCT}(t) + C_{PCT}(t\text{-}1)]/2}$. Alcor Statements [11] from 1998-2005 listed additional "rental income" (presumably from unused spaces in the Alcor building) averaging $104,991/yr but these figures showed a slowly declining trend, with the last statement in 2007 mentioning rental income of only $17,390/yr. (Cryonics Property LLC owns the building and receives rental income, but the PCT owns 75% of Cryonics Property LLC.) For purposes of the present analysis, we assume that any current rental income

in the consolidated system is already captured in our model by including the real estate portion of the PCT in the income-producing assets listed above – but please note that rental income is only a very modest component of the total.

The last revenue item is donations, including grants and bequests. Historical data from published Statements [11] included the sum of restricted and unrestricted donations in 1990, the sum of public support and endowment fund donations plus research in 1991, "public donations and bequests" in 1992-97, and "contributions" plus "other" in 1998-2005 and 2007. For 2006 and 2008 where no Statement was available, dues were subtracted from Form 990 data on "gifts, grants, contributions and membership fees" to obtain net donations. **Figure 8** shows that actual inflows are inherently volatile and difficult to predict. In the past 20 years there have been 5 major bequests during a time when 82 new patients were cryopreserved, so on average we're seeing one large bequest per every ~16 cryopatients. Since the model predicts the number of cryopatients as a function of the number of members, the model can rationally predict donations as a function of (A) the total number of cryopreservation members and (B) the general rate of inflation.

To create a conservative model, we throw out four anomalously high-donation years (1990, 2002, 2004 and 2008) and perform a bivariate regression of inflation-adjusted "real" donations as a function of N_{memb} using the remaining 15 years of "normal" data, on the reasonable assumptions that (1) the number of likely future donors will remain a roughly constant fraction of the future population of cryopreservation members, and (2) the size of the average donation will generally scale with the prevailing cost of living. Imposing the additional condition that donations must go to zero at $N_{memb} = 0$ yields a formula with a modest correlation of $R^2 = 0.56$. Multiplying by the modified CPI index produces the following conservative model forecast (see Figure 8) of nominal-dollar donations revenue: $\mathbf{R_{donations}(t) = (\$705)\ N_{memb}(t)\ [CPI(t)/CPI(2010)]}$. One interpretation of this result is that in "normal" years or "on average," about $705 (in constant 2010 dollars) of donations are received by Alcor for every member.

Figure 8. Reported data for annual donations, grants and bequests received by Alcor during 1990-2008 (heavy line with dots) and the conservative model forecast for these data (thin line).



Alcor's total revenues can now be estimated as: $\mathbf{TR(t) = R_{dues}(t) + R_{standby}(t) + R_{cryo}(t) + R_{PCT}(t) + R_{donations}(t)}$, and Alcor's net revenues can be forecast as: $\mathbf{NR(t) = TR(t) - TE(t)}$. When NR(t) < 0, either expenses must be cut or revenues must be increased in order to bring the budget into balance. In broad overview, keeping 2010 status-quo dues, fees and minimums in place, this model predicts that in "normal circumstances" about 32% of Alcor revenue for 2010 would come from dues/fees (25.6% dues + 6.6% standby fees), 20% from cryopreservations, 3% from PCT investment income, and 45% from donations.

It should be noted that while Alcor finances fluctuate significantly from year to year, the PCT has been deliberately designed to produce a relatively stable revenue stream. These stable revenues are sequestered and earmarked solely for cryopatient care expenses, providing a strong foundation for patient security and giving the PCT a special importance to Alcor that transcends its impact on total Alcor revenues. It is possible that in the future the PCT might be split off from Alcor as a separate legal entity to further ensure long-term cryopatient safety. The model presented here focuses only on the macro or aggregate level of analysis and ignores these nuances. In future work, and if sufficient historical data can be marshaled, the model presented here could be expanded to include separate modules for Alcor and for the PCT in order to further clarify the separate functions of the two entities.

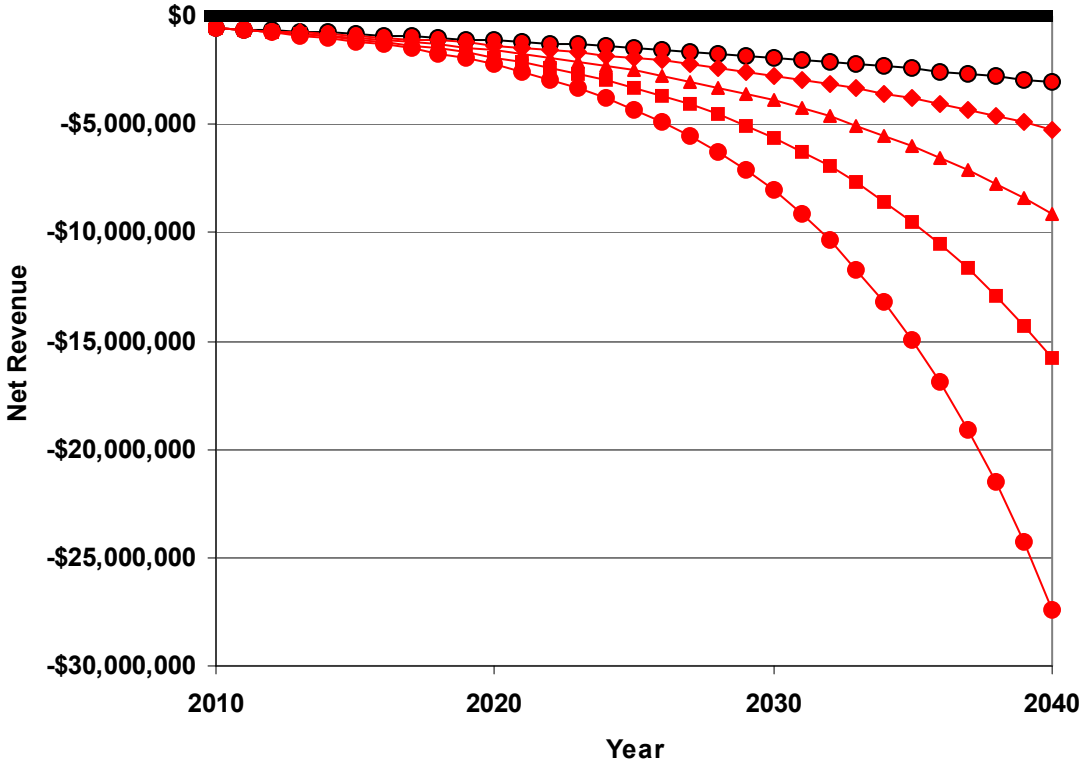
So, how serious is Alcor's current financial situation?

Figure 9 shows the projected net revenue for Alcor under 2010 status quo assumptions – dues/fees and required funding minimums are fixed at today's levels, there are no adjustments made for inflation, the informal "grandfathering" policy remains in place, and future inflation over the next 30 years averages the same as it has over the past 30 years – for several reasonable levels of cryopreservation membership growth. The situation is not encouraging. If nothing is done, Alcor faces massive and growing budget deficits in future decades unless changes are made or donors with unprecedented generosity can be found.

Paradoxically, with the current fee structure in place, Alcor is apparently losing money on every new member. The magnitude of this loss can be estimated by comparing the model prediction for $N_{memb}(2010) = 950$ members to the prediction for $N_{memb}(2010) = 949$ members – i.e., the loss of one member. Assuming current dues/fees and minimums, a +0%/yr growth track, no COLAs and retaining grandfathering, Alcor's net revenue is predicted to be $727/yr higher in 2010 and $2045/yr higher by 2040 if it sheds one member in 2010.

Do we really lose money each time we add a new member, or is it our marginal cost of operation that is the problem? Surely, one might think, we could add 50 more members without hiring new staff to service them? The added paperwork expense might seem minimal [22] and the added income from membership and standby fees would seem to be a benefit. However, according to the Total Expenses model created in Section 2, each cryopreservation member apparently costs Alcor an average of $1,614/yr in base expenses. But each cryopreservation member pays only $600/yr in dues and standby fees, leaving an ongoing deficit of $1,014/yr per member that must be made up with revenues from elsewhere in the consolidated system. This result is consistent with our estimate of a $727/yr deficit per member in the previous paragraph. Still worse, to the extent that new members are underfunded for cryopreservation then these new cryopreservations create losses. More members means more potentially underfunded cryopreservations with the expectation at some point of adding expensive equipment and more skilled staff, even if no technical improvements are made. Each new member potentially represents an incompletely funded liability if grandfathering continues.

Figure 9. Projected annual Alcor net revenue assuming 2010 status quo rates for dues/fees and cryopreservation funding minimums, assuming historical inflation rates with grandfathering and no COLAs, for cryopreservation membership growth rates of 0%/yr (top red curve), +2%/yr, +4%/yr, +6%/yr, and +8%/yr (bottom red curve with dots).



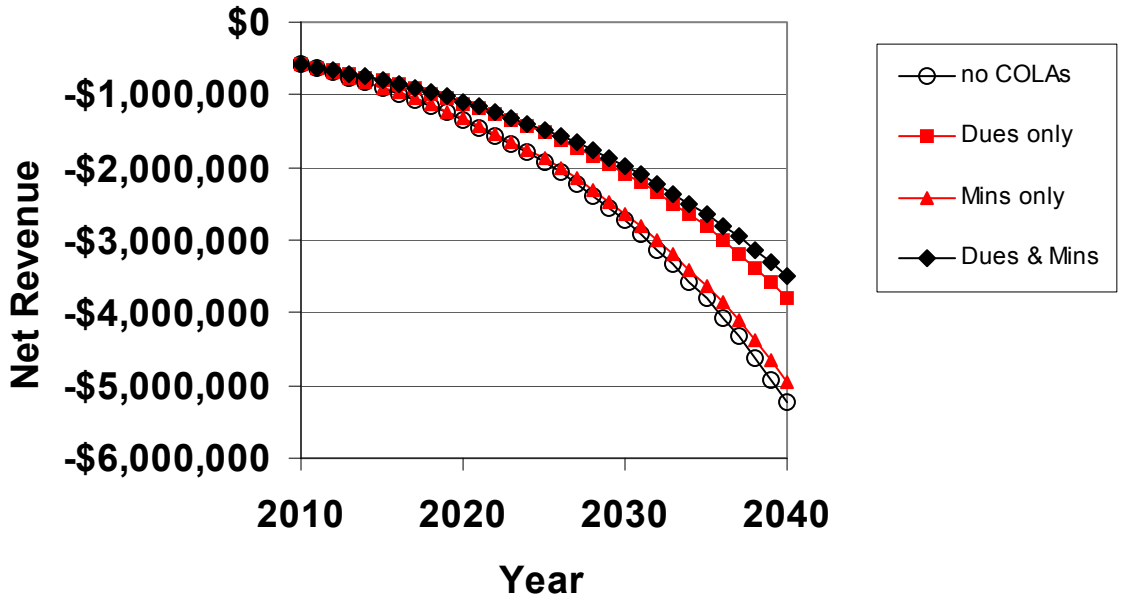
5. Budget Impact of COLAs

We can now use the model to examine the sensitivity of Alcor's finances to various classes of changes that might be considered by the Board. Let's start with the budgetary impact of adding cost-of-living adjustments (COLAs) to Alcor's revenue sources. **Figure 10** reveals the effects of implementing COLAs on funding minimums only, on dues/fees only, and on both minimums and dues/fees, assuming a +2%/yr membership growth rate and leaving grandfathering in place. The chart shows that implementing COLAs across the board starting in 2011 reduces the negative net revenue in 2040 from -$5.2M to -$3.5M, eliminating one-third of the budget shortfall. Adding COLAs appears to be the simplest, most painless, psychologically acceptable, and most efficient means for rapidly plugging a significant portion of the budget deficit hole.

Accordingly, we assume the application of COLAs to dues/fees and funding minimums in all of the hypothetical scenarios presented in the rest of this article.

As a side issue, it is important that the COLA should be calculated using a relatively objective standard such as the CPI-U or perhaps a relevant generic medical cost index if a suitable one can be found. Using a homebrew in-house index of Alcor's "actual costs" to generate the COLA as has been proposed [1] would be inherently less trustworthy to members, and might give rise to justifiable suspicions of self-dealing or at least an appearance of the "fox guarding the henhouse."

Figure 10. Effects on annual net revenue of adding COLAs to the 2010 status quo rates for dues/fees and cryopreservation funding minimums, assuming a +2%/yr membership growth rate with grandfathering.



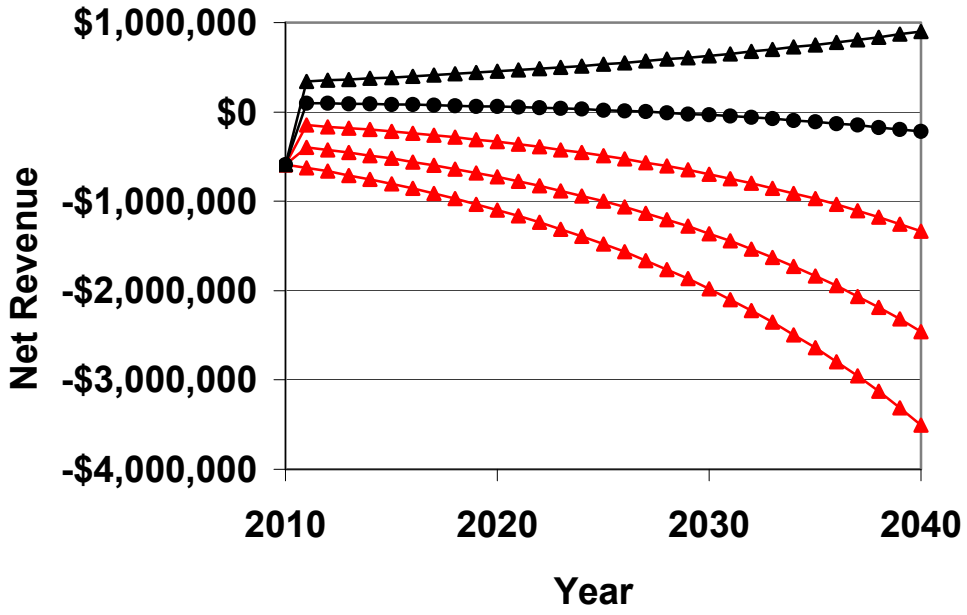
6. Budget Impact of Dues/Fees and Funding Minimums

Figure 11 shows the effects of various percentage increases in dues and standby fees if implemented in 2011, with no change in current cryopreservation funding minimums but initiating COLAs on both dues/fees and minimums starting in 2011, assuming a +2%/yr membership growth rate and no change in the donation rate. The grandfathering policy is assumed to remain in effect. Net revenues go nearly flat if dues/fees are hiked just once, by about **+150%** in 2011, thereafter having no further increases other than the small annual COLAs. In other words, the model predicts that a sharp one-time increase in dues/fees alone, combined with COLAs starting in 2011, largely eliminates Alcor's budget shortfall through 2040.

A sudden +150% hike in dues/fees, even in such a good cause, is a rather large pill to swallow. What can be done? Charging younger members less and older members more could be difficult. Steve Bridge has pointed out [1] that a formal age-indexing policy might precipitate various legal, regulatory, and tax problems that have yet to be fully explored, but a further review of this option (especially as regards Arizona law) seems advisable before making any final policy commitments.

To help soften the blow, the "one-time" dues/fees hike can be phased in over a small number of years, a procedure that may be called "ramping". How might this work?

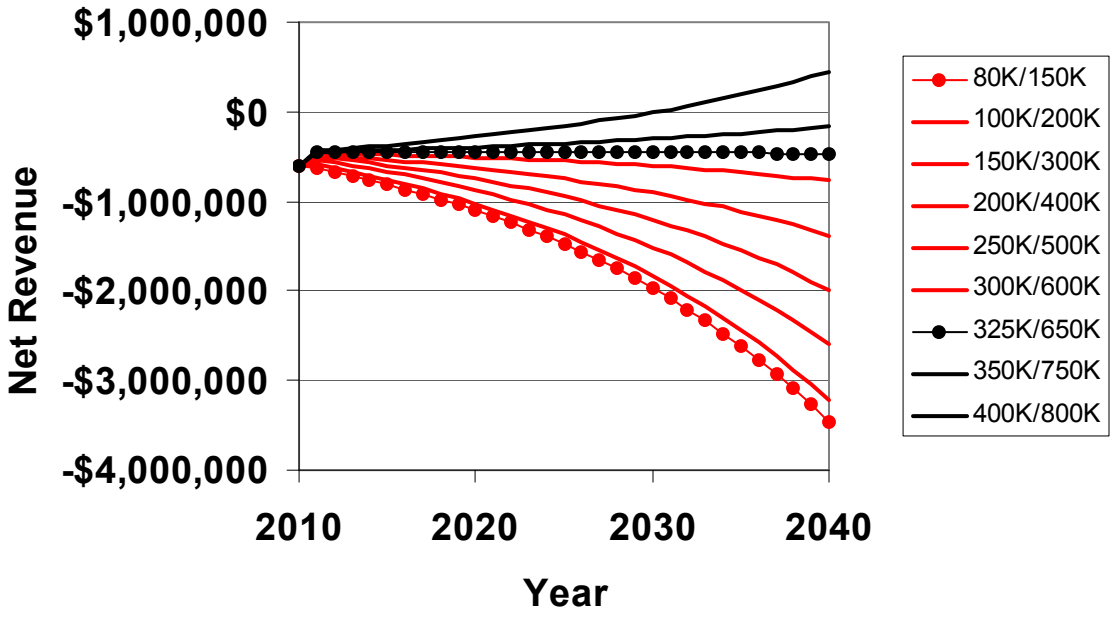
Figure 11. Effect on annual net revenue of a one-time percentage hike in dues/fees in 2011 while keeping status quo funding minimums, at +2%/yr membership growth with COLAs starting in 2011, no decrease in donations, and with grandfathering in effect: 0%, +50%, +100% (red triangles), +150% (black dots), and +200% (black triangles).



Let's assume the Board decides to plot a course to long-term financial stability over a period of T years, assuming +2%/yr membership growth, minimums at the current $80K/$150K for new members while retaining grandfathering, and COLAs on dues/fees and minimums after 2011. A sudden hike in one year (T = 1 yr) that increases dues/fees by +150% causes these charges to jump from the current **$50/mo in 2010** to **$125/mo in 2011**, then rise slowly thereafter due to the COLAs. But introducing the hike using a more gentle 5-year ramp (T = 5 yrs) would be easier on members' wallets. Assuming average inflation levels and allowing the COLAs to operate, the model predicts that dues/fees must reach a $142.33/mo target level by 2015 in order to achieve sustainable long-term financial stability by that year. A simple 5-yr ramp with dues/fees rising +23.3%/yr for 5 years, then dropping back to pure COLA increases (+3.3%/yr) thereafter, yields the following dues/fees schedule during the ramping period: **$50/mo (2010)**, **$61.64/mo (2011)**, $75.98/mo (2012), $93.66/mo (2013), $115.46/mo (2014) and $142.33/mo (2015); then $147.03/mo (2016) in the first post-ramp COLA-only year.

Figure 12 shows the effects of various dollar increases in neuro/WB cryopreservation funding minimums implemented in 2011, with no change in current dues or standby fees but putting in COLAs on both dues/fees and minimums starting in 2011, assuming a +2%/yr membership growth rate and assuming the grandfathering policy is still in effect. Net revenues go flat (though still slightly negative) if minimums are hiked by about +320% in 2011 but with no further increases thereafter except for the annual COLAs. This is so large (i.e., from $80K to $325K for neuro and from $150K to $650K for WB) that ramping seems unlikely to help much.

Figure 12. Effect on annual net revenue of a one-time hike in neuro/WB funding minimums in 2011 while keeping status quo dues/fees, at +2%/yr membership growth with COLAs starting in 2011, and with grandfathering in effect.



The model predicts that it will take more than twice the percentage hike in funding minimums alone, compared to a hike in dues/fees alone, to entirely eliminate the long-term budget shortfall (with the assistance of COLAs in either case). One reason for this difference is Alcor's current informal policy of grandfathering. Under this policy, immediate changes in funding minimums only slowly affect the average funding levels in the neuro or WB pools because most pool members are not subject to the new minimums, as previously illustrated in Figure 7. If grandfathering was eliminated, then any changes in funding minimums would be felt at once. With grandfathering in place, hikes in dues/fees are a much bigger budgetary lever because they are paid immediately by everyone.

To reiterate the message of these last two charts, Alcor apparently can achieve long-term budget stability (even at only +2%/yr membership growth and while keeping grandfathering) either:

(1) by putting in a one-time hike only on dues/fees, for all members, from the current $50/mo going up to $125/mo by the end of a 5-year ramp-up, and implementing COLAs on dues/fees (for all) and minimums (for new members only), starting in 2011; *or*

(2) by putting in a one-time hike only on funding minimums, just for new members, from the current $80K/$150K going up to $325K/$650K, then implementing COLAs on dues/fees (for all) and minimums (for new members only), starting in 2011.

Note that option (2) imposes a **$454/mo** increase [23] in out-of-pocket expenses for a 50-year-old healthy male Alcor WB member (or an extra **$161/mo** for a similar 25-year-old [1, 23]) due to higher insurance premiums ($223/mo and $79/mo higher for neuros), whereas option (1) is far cheaper, imposing only a **$75/mo** increase in out-of-pocket expenses (or **$15/mo**, if ramped over 5 yrs) for each cryopreservation member of Alcor. Raising the dues/fees is a powerful financial lever. If the existing Alcor membership is willing to accept a one-time hike in dues/fees (followed by COLAs) of +150% in exchange for making the unofficial grandfathering policy permanent thereafter, then even at a conservative +2%/yr

membership growth rate the funding minimums for new members could be kept unchanged at the current $80K/$150K level. Of course, these figures assume that the pace of donations remains unchanged.

Some combination of a smaller one-time hike in dues/fees combined with a smaller one-time hike in funding minimums can also work. Furthermore, Figures 11 & 12 assume a +2%/yr growth rate of the cryopreservation membership of Alcor. If membership can somehow be induced to grow faster (e.g., via marketing?), then average funding levels in the neuro and WB pools will increase more rapidly because more people are being added at the higher required minimums and are diluting out the lower minimums held by existing pool members who are being grandfathered. The top half of **Table 1** shows the tradeoffs between a one-time hike in dues/fees and a one-time hike in minimums (both followed by modest annual COLAs in perpetuity) that are required to produce flat net revenues through 2040 (i.e., no worsening budget shortfall), assuming several different membership growth rates and assuming that Alcor's current informal grandfathering policy is formalized and made permanent.

Table 1. Pre-COLA neuro/WB cryopreservation funding minimums in constant 2010 dollars that are required to produce long-term budget stability, for various membership growth rates and one-time hikes in pre-COLA annual dues and standby fees. The funding minimums for 2010 were $80K/$150K.

Pre-COLA Annual Dues/Fees (% hike)	**Cryopreservation Membership Growth Rate**				
	0%/yr	**+2%/yr**	**+4%/yr**	**+6%/yr**	**+8%/yr**
Grandfathering policy is in effect					
$480/$120 **(0%)**	n/a*	$325K/$650K	$230K/$460K	$200K/$400K	$180K/$360K
$720/$180 **(+50%)**	n/a*	$260K/$520K	$180K/$360K	$160K/$320K	$145K/$290K
$960/$240 **(+100%)** $1140/$285 (+138%) $1160/$290 (+142%)	n/a*	$185K/$370K	$130K/$260K	$115K/$230K ***$80K/$150K***	$105K/$210K ***$80K/$150K***
$1200/$300 **(+150%)** $1280/$320 (+167%)	n/a*	$105K/$210K ***$80K/$150K***	***$80K/$150K***		
$1440/$360 **(+200%)** $1480/$370 (+208%)	n/a* ***$80K/$150K***				
No grandfathering					
$480/$120 **(0%)**	$130K/$260K	$135K/$270K	$135K/$270K	$135K/$270K	$135K/$270K
$720/$180 **(+50%)**	$105K/$210K	$105K/$210K	$105K/$210K	$110K/$220K	$110K/$220K
$960/$240 **(+100%)** $980/$245 (+104%) $1000/$250 (+108%) $1000/$250 (+108%) $1020/$255 (+113%)	***$80K/$150K***	$80K/$160K ***$80K/$150K***	$80K/$160K ***$80K/$150K***	$85K/$170K ***$80K/$150K***	$85K/$170K ***$80K/$150K***

* Not affected by choice of funding minimum: Our simple model assumes that no new members enter the pool at a "0%/yr" membership growth rate, even though in reality there is a small influx as dying members are replaced by an equal number (about 0.67%/yr) of new members. This factor will usually have negligible budgetary impact.

For example, if the maximum tolerable one-time hike in dues/fees is +100% (i.e., both dues and standby fees are doubled), then to achieve long-term budget stability the neuro/WB funding minimums must be raised just once, from today's $80K/$150K to $115K/$230K at +6%/yr membership growth, or to

$130K/$260K at +4% growth, or to $185K/$370K at +2%/yr growth, in all cases with COLAs in place, starting in 2011. Any of these changes can be ramped. Note that the higher minimums are imposed only on new members. All existing members would be allowed to keep their current funding arrangements without any change because they would be "grandfathered in". Of course, both new and existing members would equally have to pay the one-time +100% hike in dues/fees along with the subsequent annual increases in dues/fees as those charges are slowly adjusted upward by the COLAs. Later-arriving new members would also face slowly rising funding minimums due to the action of the COLA.

The main problem with this approach is that if the growth rate of new memberships falls below the current +4%/yr, then the burden on new members rises significantly. For example, at only +2%/yr membership growth rate with a +100% hike in dues/fees, followed by COLAs, starting in 2011, the required funding minimums must rise from the current $80K/$150K to $185K/$370K to achieve long-term budget stability. Life insurance premiums for a healthy new 50-year-old male WB member might rise from $136/mo for a $150K policy to $336/mo for a $370K policy [23], a **$200/mo** jump in out-of-pocket expenses (or an extra **$71/mo** for a similar 25-year-old [1, 23]). New members would also have to pay **$50/mo** extra in dues/fees. Existing members who were grandfathered would get a better deal, paying only the extra $50/mo in dues/fees but no increase in policy premiums.

7. Budget Impact of Grandfathering

So far we've assumed that Alcor's traditional but informal policy of honoring the prior financial arrangements of existing members, called "grandfathering," is kept in place. What happens if we eliminate grandfathering?

The bottom half of Table 1 shows the results of eliminating grandfathering from 2011 onward. Assuming membership growth rates are unaffected by this policy change and remain near +2%/yr, then doubling the current dues and standby fees in 2011 and then implementing COLAs on both dues/fees and minimums in 2011 should achieve long-term budget stability with a tiny one-time hike in funding minimums from the current $80K/$150K level to only $80K/$160K. This would produce a negligible increase in the insurance premiums that might be tolerable for all Alcor cryopreservation members. As another example, if dues/fees are not changed at all, then to achieve long-term budget stability at +2%/yr growth the funding minimums would have to be hiked once to $135K/$270K **($109/mo** higher premiums for 50-year-old WBs, **$50/mo** higher for neuros [23]) – only about half as high as the $325K/$650K minimums (**$454/mo** higher for WBs, **$223/mo** higher for neuros [23]) that would be required if grandfathering was kept in place.

But there are several problems with this approach. First, eliminating grandfathering might only modestly affect the rate of acquisition of new members but it could hit many existing members hard, some of whom have had their policies in place for many years and can't easily get replacement insurance at dramatically higher policy amounts – either because they're now older, or in poorer health, or both. Some members may be un-reinsurable at almost any price. Aside from its cryopatients to whom it owes the highest duty, Alcor owes its next highest duty to its existing members who, over the past years and in many cases decades, have faithfully supported the organization and its growth with dues, donations, and volunteer work, and whose presence alone has added the strength of numbers and has helped forge Alcor into the leading cryonics provider in the world. Eliminating grandfathering is likely to force a departure of some existing Alcor members, a preponderance of whom might have been with Alcor the longest (having the oldest and hence lowest-value policies in place). Overall membership growth would likely be at least temporarily depressed, perhaps even into negative rates, for some period of time.

Second, Charles Platt believes that the existence of grandfathering has long been a disincentive against members leaving Alcor. That's because as long as members stay with Alcor, they get a bargain – and one that slowly increases in value over time. If members leave Alcor for another organization and then later try to return, they'll have to pay the then-current funding minimum which will most likely be higher than when they left. Phasing out grandfathering for existing members removes the disincentive against them quitting from Alcor, making them much more likely to go elsewhere. The continuation of grandfathering for existing members may be a necessary sacrifice if Alcor wants to continue receiving dues from as many members as possible.

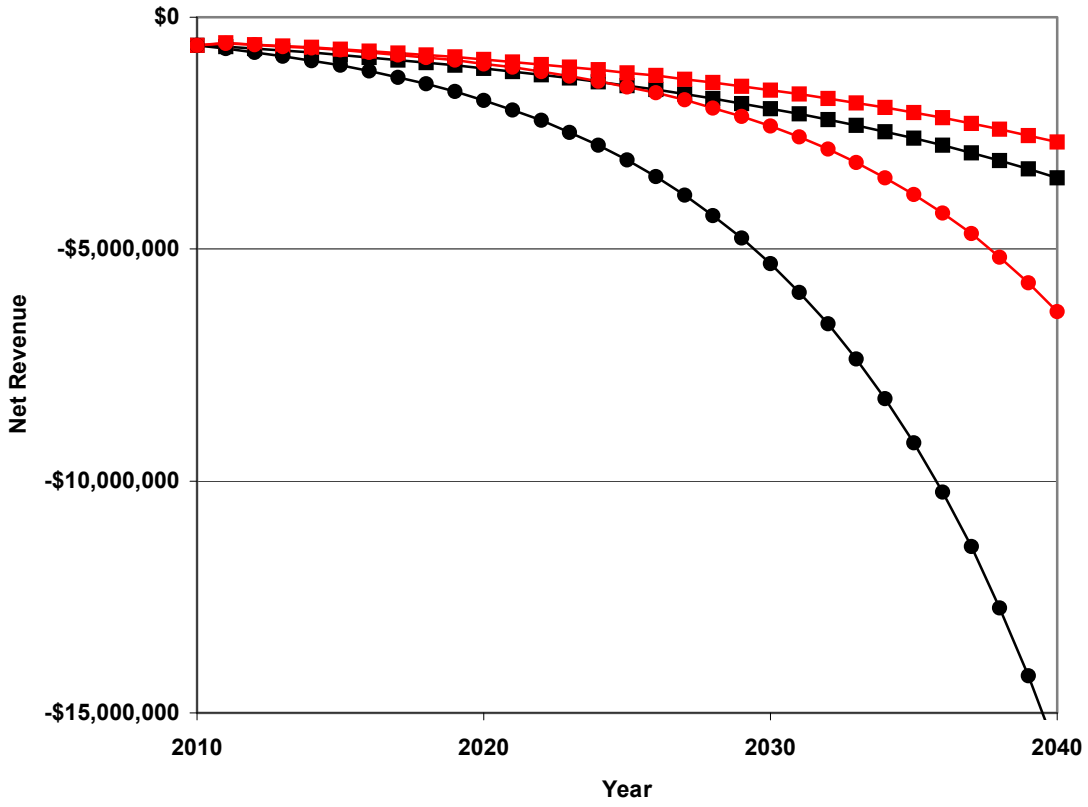
Third, in any workable scenario the funding minimums will have to continue being raised over time, as inflation and improved technologies gradually increase the expense of future cryopreservations. These raises can be accomplished either in low annual doses using COLAs or in sudden large jumps about once a decade (as has been past practice). With a grandfathering policy in place, raises in funding minimums can be ignored by existing members and are easily accommodated by new members, who simply apply for a life insurance policy at the new somewhat higher level. But if grandfathering is eliminated, then both existing and new members have three options: (1) take out a policy today for the amount that matches the required minimum that will be in effect on the unknown future date of their legal death (perhaps using actuarial life expectancy tables), (2) take out a new/revised policy once a year (COLAs) or once a decade (jumps) in order to match the slowly- but ever-rising minimums, or (3) purchase an inflation-adjusted whole life or "Index Universal Life" [23] insurance policy and hope that future increases in funding minimums fall in line with the death benefit buildup or inflation index used in the policy. Apparently inflation-indexed life insurance is very rare or almost non-existent; a review of the actual availability of such policies, before eliminating grandfathering, would be prudent. And all three options appear to require either an ability to accurately forecast the future or an ability to reinsure at increasing levels indefinitely into the future, both of which seem problematic.

Note that it is at depressed growth rates where the financial advantage of eliminating the grandfathering policy is strongest – but not overwhelmingly so. For example, assume that we wish to achieve long-term financial stability while holding funding minimums constant at $80K/$150K. At a 0%/yr membership growth rate, total dues/fees must rise to $1850/yr if we retain grandfathering but only to $1200/yr if we relinquish grandfathering, a savings to each non-departing cryopreservation member of $650/yr. At a membership growth rate of +8%/yr, the savings falls to just $150/yr. Thus the urgency to eliminate grandfathering should be weakest at the highest growth rates.

8. Budget Impact of WB/Neuro Charge Ratio and Set-Aside Ratio

There is some debate as to whether the relative costs of cryopreservation and long-term storage for whole-body vs. neuro cases are best represented by the current minimum funding WB/neuro charge ratio of ~2:1 (r_{WB} = $150K, r_{neuro} = $80K), the ~4:1 ratio estimated by Whelan [7] in 1993, or by some still higher ratio. We can use our model to predict the effects on Alcor net revenue of varying the WB/neuro charge ratio of required minimum funding levels in high- or low-growth scenarios. **Figure 13** shows that changing the WB/neuro charge ratio from 2:1 (black curves) to 5:1 (red curves) has little impact on net revenues at a +2%/yr membership growth rate (squares), but at a +8%/yr growth rate (dots) a 5:1 ratio cuts the net revenue shortfall -60% by 2040, assuming grandfathering, no dues hikes, and COLAs in all scenarios. If Alcor anticipates high growth in the future, then increasing the WB/neuro charge ratio could materially help balance the budget. But at low membership growth rates the budget impact of a ratio increase is likely to be fairly modest.

Figure 13. Effects on Alcor annual net revenue of setting funding minimums at a r_{WB}/r_{neuro} charge ratio of 2:1 ($160K/$80K, black curves) or 5:1 ($400K/$80K, red curves) when membership growth rates are +2%/yr (squares) or +8%/yr (dots).



Now let's look at WB/neuro set-aside ratios. Recall that a significant fraction of patients' life insurance policy proceeds are diverted to the Patient Care Trust (PCT) for the purpose of providing the PCT with assets yielding enough earnings to pay for the storage costs of the cryopatient indefinitely. It is possible to use the model to calculate objective estimates of the "proper" amount that should be set aside from each cryopreservation to adequately sustain the costs of long-term patient care. The model can also provide a rational basis for setting "proper" funding minimums. But to obtain reliable results we need more up-to-date estimates of the actual cost of cryopreservation and the actual cost of secure long-term storage. The most recent detailed estimates [5, 7] are now almost two decades old!

For concreteness and for purposes of illustration, the present article assumes that total cryopatient storage costs in 2010 dollars may be approximated as c_{neuro} = **$150**/patient-yr and c_{WB} = **$1,500**/patient-yr (Section 2). If these sums must be entirely provided by a spendable real return on PCT assets of I_{PCT} = 2%/yr, then the assets that must be set aside from each cryopreservation are $\mathbf{d_{WB} = c_{WB} / I_{PCT}}$ = $75,000/patient for WBs and $\mathbf{d_{neuro} = c_{neuro} / I_{PCT}}$ = $7,500/patient for neuros in constant 2010 dollars. This is slightly higher than the $r_{PCT:WB}(2010)$ = $65K/patient currently being set aside for the PCT to care for each WB cryopatient and much lower than the $r_{PCT:neuro}(2010)$ = $25K/patient currently being set aside for each neuro.

Besides providing for long-term cryostasis care (paid for by using earnings from d_{WB} or d_{neuro} of set-aside funds), the insurance benefits must also pay the immediate costs of initially placing patients into cryostasis (K_{neuro} and K_{WB}). This amount is currently set at $\mathbf{K_{WB} = r_{WB} - r_{PCT:WB}}$ = $150K - $65K = $85K/patient for WBs and $\mathbf{K_{neuro} = r_{neuro} - r_{PCT:neuro}}$ = $80K - $25K = $55K/patient for neuros. Thus to provide the full amounts necessary both for being put into cryostasis and for being kept there indefinitely would require a new funding minimum of $\mathbf{M_{WB} = d_{WB} + K_{WB}}$ = $160,000 for WBs, a small increase from the current

funding minimum of $r_{WB}(2010)$ = $150K, and $\mathbf{M_{neuro} = d_{neuro} + K_{neuro}}$ = $62,500 for neuros, a moderate decrease from the current $r_{neuro}(2010)$ = $80K funding minimum.

The budget is moderately sensitive to the two variables c_{neuro} and c_{WB} so it appears worthwhile to invest the resources required to obtain reliable estimates for them – and to resist the temptation to be unduly optimistic about them. In addition, an updated bottom-up analysis of the actual cost of initially placing patients into cryostasis (K_{WB} and K_{neuro}) should also be undertaken. After that, once we have more accurate 2010 numbers for c_{WB}, c_{neuro}, K_{WB} and K_{neuro} in hand, the above formulas can be used to more reliably estimate the required 2010 values of d_{WB}, d_{neuro}, M_{WB} and M_{neuro} that are required to achieve long-term financial stability for Alcor. The proper amount of the insurance proceeds to be diverted to the PCT can then be recalculated as $\mathbf{r_{PCT:WB} = M_{WB} - K_{WB}}$ for WBs and $\mathbf{r_{PCT:neuro} = M_{neuro} - K_{neuro}}$ for neuros, consistent with the twin objectives of: (1) an independent PCT covering all long-term cryostasis costs, while (2) leaving sufficient funds to place the patient into cryostasis in the first place. All the numbers calculated above should be regarded as constant-dollar ($2010) figures, and we assume that COLAs are applied in all years after 2010 to protect the future set-asides from the degradative effects of inflation yet to come. (The spreadsheet includes a "PCT Set-Aside Calculator" to simplify these computations.) With M_{WB} and M_{neuro} rationally in hand, the dues/fees hike needed to balance the budget could be estimated, then implemented using a member-friendly 5-year ramp.

The above procedures should rationalize future patient needs but would not address any pre-existing shortages in current PCT assets relative to the current cryopatient population. How big is the pre-existing shortage in PCT assets? It depends, very sensitively, upon the actual costs of long-term storage, but the current PCT shortfall apparently ranges somewhere between $0.5M-$2M. Additional funds of unknown magnitude might also be added to the PCT to help defray the future cost of revivals.

Using $d_{neuro}(2010)$ = $7,500/patient and $d_{WB}(2010)$ = $75,000/patient as computed above, the average PCT capital needed per current cryopatient is $d_{65/35} = 0.65\ d_{neuro} + 0.35\ d_{WB}$ = $31,125/patient. There were $N_{cryo}(2010)$ = 98 cryopatients as of July 2010, so the model predicts the PCT would need $D_{existing} = d_{65/35}\ N_{cryo}(2010)$ = $3,050,250 of income-producing capital to support the pre-existing cryopatient population indefinitely. The PCT currently has $C_{PCT}(2010)$ = $2,473,468 of such assets, leaving a pre-existing PCT capital shortfall of $X_{existing} = D_{existing} - C_{PCT}(2010)$ = **$576,782**. Repeating this analysis using slightly higher values for storage costs, e.g., c_{neuro} = $200/patient-yr and c_{WB} = $2,000/patient-yr, yielding $d_{neuro}(2010)$ = $10K/patient and $d_{WB}(2010)$ = $100K/patient, gives us $d_{65/35}$ = $41,500, $D_{existing}$ = $4,067,000, and a pre-existing PCT capital shortfall of $X_{existing}$ = **$1,593,532**. Our estimate of the PCT capital shortfall thus appears fairly sensitive to the cryopatient maintenance cost variables c_{WB} and c_{neuro}.

9. Budget Impact of PCT Real Return

Because PCT revenue is only a small fraction of consolidated total Alcor revenue, attempting to boost its real return doesn't help much and may serve only to increase risk to capital. For example, assuming status quo dues/fees and minimums with COLAs starting in 2011 and a +2%/yr membership growth rate, with a +2%/yr real return the PCT component slowly climbs from 3% of annual total revenues in 2010 to less than 6% of total revenues in 2040. Keep in mind that the pre-tax real total return (= income yield plus capital appreciation, less inflation) on U.S. government Treasury bills, Treasury bonds, and corporate bonds from 1920-1995 averaged just +0.5%/yr, +1%/yr and +2%/yr, respectively, so a real return of +2%/yr is a conservative target that should be achievable by the PCT without substantial risk of significant drawdowns over long periods of time.

Over the same historical time period, stocks returned about +7%/yr real total return, but these returns were quite volatile. From 1965-1982, a 17-year period marked by high inflation, the real return on stocks was effectively zero. Let's say that we split the difference between corporate bonds and stocks and assume the PCT can achieve a long-term real total return of +4%/yr with acceptable risk. In this case, the PCT contribution adds an incremental 3% to total revenues in 2010 and an extra 6% to total revenues in 2040. Given that the budget deficit for status quo scenarios with COLAs ranges from 40%-60% of revenues depending on year and membership growth rate, the additional return only defrays one-tenth of the predicted budget deficit. That doesn't seem like much reward in exchange for the extra risk to capital.

The model predicts that income-producing PCT capital will rise to $7M-$12M by 2025 and to $16M by 2040 at a 0%/yr membership growth rate, or up to $60M by 2040 at a +8%/yr growth rate, assuming a

status quo scenario but with COLAs and grandfathering. If PCT income-producing capital could somehow be doubled or tripled above its current growth track, presumably via large exogenous donations or bequests into the PCT or a related income-producing permanent endowment fund, then the earnings from this source could make a more significant contribution to Alcor revenues.

10. Budget Impact of Bequests as a Funding Mechanism

Another possibility is that existing members could have their funding minimums grandfathered while agreeing to pay some intermediate level of higher dues/fees and COLAs, with the resulting budget shortfall recouped via a contractual donation of income-producing assets to be placed in trust for the benefit of Alcor until the member's legal death [24], after which the assets would pass to Alcor and be added to the PCT or a related income-producing permanent endowment fund. There are countless permutations of this scheme so we'll consider just one example for concreteness.

Let's assume that an existing cryopreservation member is willing to pay a one-time +100% dues/fees increase in 2011 with subsequent COLAs on dues/fees but wants to keep the funding minimum fixed, with permanent grandfathering. The model predicts that in a +2%/yr membership growth environment, this arrangement (if practiced by all members) would produce a $158,954/yr budget deficit ($164.04/yr per member) in 2011, increasing to a $1,293,272/yr budget deficit ($751.47/yr per member) by 2040.

If actuarial tables predict that the member is likely to experience legal death in 2011, then placing assets equal to ($164.04 / 2% =) $8,202 into the trust would allow the trust to generate the single-member budget shortfall amount of $164.04/yr in the year of the member's legal death, assuming a 2%/yr income payout from the assets. If the actuaries say the member is likely to live until 2040, then the trust assets must grow from $8,202 in 2011 to ($751.47 / 2% =) $37,574 by 2040, in order to cover the anticipated single-member budget shortfall in 2040. To attain this necessary growth the assets must appreciate at an average rate of +5.39%/yr in addition to the 2%/yr payout annually to Alcor during the member's life, or a total return averaging +7.39%/yr during 2011-2040. Stocks have averaged about +11%/yr total return since 1920 so this scenario appears feasible but hardly conservative. The Board must be willing to shoulder the risks: (1) of stock market volatility and subpar returns that can last a decade or longer, (2) that the member might revoke the trust at the last minute without telling Alcor, or (3) that a member's greedy relatives might launch a legal challenge to redirect the trust assets away from Alcor near the time when the member needs cryopreservation.

As a practical matter, funds placed in such a trust might most simply be configured as a mix of asset classes designed to generate a long-term +7.39%/yr total return with minimum volatility, and with a flat 2% of assets automatically withdrawn each year (regardless of asset performance in any particular year) to defray the ongoing Alcor budget shortfall that is indirectly attributable to that member. Automatic withdrawals of fixed dollar or percentage amounts is a common arrangement for retired people who seek a reliable stream of fixed income from, say, their mutual fund investments.

11. Budget Impact of Donations

Donations – an inherently unsteady form of income – loom large in Alcor's current core budget and threaten to loom still larger in future core budgets if nothing is done. For example, assuming status quo dues/fees and minimums and a +2%/yr membership growth rate, the model predicts that donations will rise from 45% of annual total revenues in 2010 to 63% of total revenues in 2040. This is an extremely dangerous state of affairs that places Alcor's core finances on a "foundation of quicksand." It is unreasonable to expect wealthy donors to continue subsidizing Alcor's ever-increasing budget deficits for essential operations indefinitely into the future. At least by adding COLAs to all dues/fees and funding minimums starting in 2011, but still retaining grandfathering, the model predicts that donations only rise from 45% in 2010 to 47% of annual total revenues by 2040, or stay constant at 45% if a membership growth rate of +8%/yr can somehow be engineered.

The above should not be misconstrued as a call to eliminate the need for donations. Donations are both necessary and welcome, and we must increase both our ability to get donations and our ability to cover our costs more efficiently. More specifically, Alcor is a 501(c)(3) tax-exempt non-profit that is required to demonstrate public support through donations, not just through membership fees. If all of Alcor's income was through membership fees, the existing tax-exempt status might be lost. If Alcor's income came mostly from a foundation or endowment fund, the organization might be forced to shift to a different kind of non-profit with only partial tax-exemption. Donations are absolutely *required* to maintain Alcor's current status. A good case can be made for increasing both fees *and* donations, possibly by finding ways for the general public to begin supporting cryonics research the way they support other charitable medical research.

But donations, being a highly volatile source of income, should most logically be reserved for discretionary expenses, not for essential core expenses, to the greatest degree possible. The Board would be wise to consider additional ways to reduce the fraction of core revenues represented by donations as low as possible. For example, the model predicts that a one-time hike of +150% in dues/fees while keeping funding minimums unchanged, adding COLAs and retaining grandfathering causes donations to fall from 45% of annual total revenues in 2010 to 32% (at a +2%/yr growth rate) or 31% (at a +8%/yr growth rate) by 2040. Note that these percentages are very insensitive to membership growth rate. By 2040 in the aforementioned scenario, dues/fees have grown to 55%/53% of all revenues, to 9%/14% for cryopreservation income, and to 4%/2% for PCT income, assuming +2%/+8% per year membership growth rates, respectively.

A few final cautions: If costs to members (e.g., dues, minimums, etc.) are significantly hiked, it is possible that some members might feel less motivated to donate at previous levels of giving, causing donations to fall below even the model's conservative prediction and thus exacerbating the revenue shortfall. Higher costs may also temporarily depress membership growth or even cause some members to quit in favor of competing cryonics organizations, although this may be offset by the prospect of long-term organizational financial stability and the promise of guaranteed grandfathering at the current minimums which could motivate accelerated signups. The provision of multiple tiers of membership also remains an option, with cheaper memberships offering, e.g., no standby service or a slightly reduced level of protection from ice damage, but this strategy could lead to brand confusion with competing organizations. These sorts of secondary effects are difficult to forecast and are beyond the scope of the present analysis, but must be taken into account by the Board during its deliberations.

12. Conclusions

A simple model of current Alcor revenues and expenses was used to estimate future Alcor revenues and expenses, and the sensitivity of Alcor's finances to the imposition of cost-of-living increases and changes in cryopreservation minimums, dues and standby fees was explored as a function of membership growth rates and grandfathering policy. Several possible pathways to long-term financial stability were identified by this analysis. For example, one method that achieves both long-term financial stability for Alcor and the smallest incremental out-of-pocket personal expenditure **($75/mo** extra at the end of a 5-yr ramp) for *both* new and existing Alcor members alike is a ramped one-time +150% hike in dues and standby fees, followed by COLAs on all dues/fees and funding minimums thereafter, with grandfathering then retained as a formalized Alcor policy.

While possibly increasing bookkeeping complexity, members could alternatively be offered a cafeteria-style selection among several choices all of which are believed to produce long-term budget stability at

Alcor. For example, members might be asked to choose one of several Board-approved options, for example (illustrative only): (1) a +150% dues/fees increase with COLAs and grandfathering, (2) a +100% dues/fees increase with COLAs but without grandfathering, (3) a voluntary increase in policy death benefit by some significant amount that is permanently grandfathered, thereafter paying dues/fees with a COLA in place, (4) a 0% dues/fees increase with a significant contractual donation held in trust for Alcor until legal death, and so forth. Perhaps the membership could be polled for its preferences among Board-approved choices prior to their implementation. It is my personal opinion that members should always have available to them at least one viable option that includes the permanent grandfathering of their account.

The Excel spreadsheet model created for this article is available on the Alcor website. The model's initial settings use status quo rates and minimums with COLAs and grandfathering in place, but these assumptions are easily modified by simple changes in the relevant columns. While the latest version of Excel allows 10,000 columns, I chose to keep this model small enough to fit within the 256-column limit using Excel 2003 which is a software package that should be more widely available to everyone.

The analysis presented here suggests four specific recommendations for Board consideration:

(1) Immediately perform a bottom-up study of the annual cost of long-term storage (c_{neuro} and c_{WB}), updating to 2010 the earlier estimates from 1982 [4], 1990 [5] and 1993 [7]. This update is long overdue. The revised storage cost figures should include the neuro or WB cryopatient's pro rata share of the cost of LN2, custodial costs, electric/gas/water utilities, equipment depreciation including dewars having a 10-15 year useful life [25] or the cost of dewar "revac", real estate costs (the dewar's share of rent, property taxes, and building depreciation), and perhaps some allowance for legal defense costs and relevant administrative, research, or related costs. Without reliable numbers for c_{neuro} and c_{WB}, it is impossible to know whether or not current assets and income of the PCT are sufficient to care for its patients indefinitely, or to rationally estimate the current PCT capital shortfall.

(2) Immediately perform a bottom-up analysis of the actual cost of initially placing patients into cryostasis (K_{neuro} and K_{WB}), updating to 2010 the earlier estimates from 1982 [3, 4], 1990 [5] and 1993 [7]. This update is also long overdue. The average cost of the 8 cryopreservations performed so far in 2010 might be representative. With better numbers in hand, a more objective basis for setting specific funding minimums (M_{neuro} and M_{WB}) and set-asides ($r_{PCT:neuro}$ and $r_{PCT:WB}$) can be established, e.g., using the formulas described in Section 8. **With M_{WB} and M_{neuro} rationally in hand, a dues/fees hike that is sufficient to balance the budget could be estimated, then implemented using a member-friendly 5-year ramp.**

(3) Use the econometric model developed here (or other tools) to test and implement changes in Alcor's revenue streams, policies, and capital pools that will place the organization on a path to a sound financial structure, thus ensuring the security of both pre-existing and future cryopatients. The Board has some difficult choices to make. First, increasing fees too much (especially "too much, too soon") could cut our existing membership significantly and put a nearly complete halt to new memberships. This problem can perhaps be ameliorated by using a ramped introduction of higher dues/fees as described above. Second, some people might not be able to afford to join at the higher rates and many others who could afford to join might not join, if it appeared to them that Alcor was either an uncontrolled money pit or, worse, a fraud raking in "huge profits" from unsuspecting persons. This second problem can be addressed by describing the fundamental financial rationale for a new rate structure clearly, openly, accurately, concisely, and convincingly, and then, when new funds arrive, by managing those funds – and the organization – extremely conservatively.

(4) Reduce reliance on donations as the single largest source of funds for core operations, putting the organization on a path leading toward minimizing this source in support of crucial or essential functions as quickly as practicable. Ideally, the bulk of Alcor's basic core expenses should be supported by membership revenues with irregular donations preferentially employed for "making progress". In other words, we should try to reserve donations, grants and bequests for long-term investments such as augmenting the patient care trust fund, creating a permanent endowment fund, upgrading physical facilities and equipment, marketing efforts for building membership, and most importantly research aimed at making genuine medical progress such as improving cryopreservation techniques, biological and physical research, brain studies, and ultimately supporting and developing key strategies for revival.

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8. Charles Platt, "Growth and its Consequences," ***Cryonics*** 19(1998 Qtr III):16-20; http://www.alcor.org/cryonics/cryonics1998-3.pdf

9. Charles Platt, "The Standby Dilemma: Disturbing Consequences of an Aging Cryonics Population," ***Cryonics*** 23(2002 Qtr IV):12-15; http://www.alcor.org/cryonics/cryonics2002-4.pdf

10. Econometrics is the application of statistical methods to financial or economic data. An econometric model is a set of interlocking mathematical equations that describes the behavior of specific dependent

variables when other independent variables fluctuate within their allowed ranges. A "top-down" or "macro" model, as used here, is simplest and can be constructed by starting with top-level aggregated data (e.g., total expenses) and modeling the behavior of that data as a function of several lower-level causative variables (e.g., total number of customers). A "bottom-up" or "micro" model is more complicated (but often more accurate), and may be constructed by starting with low-level unaggregated data (e.g., time series representing actual expenditures on each of 1000 items that the organization must buy in order to provide its services) and then constructing separate sub-models for each of these items, then summing the results of all the sub-models to forecast the top-level aggregated variable(s) of interest. Acquiring the huge amount of data necessary to drive a good bottom-up model can be very expensive and time-consuming. See, for example: Michael K. Chapko et al., "Equivalence of two healthcare costing methods: bottom-up and top-down," ***Health Economics*** 18(October 2009):1188-1201; and Hang Ryu, "Economic assumptions and choice of functional forms: comparison of top down and bottom up approaches," ***Journal of Productivity Analysis*** 32(August 2009):55-62.

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13. "Alcor Membership Statistics," 30 June 2010; http://www.alcor.org/AboutAlcor/membershipstats.html

14. Email to Alcor Board, Alcor Advisors and PCTB on 8 July 2010 from Alcor Board member Brian Wowk.

15. Alcor must expand the current storage area into adjoining units of the building once the existing patient bay is filled with dewars. A New York Times interview with Joe Waynick in 2005 (http://www.nytimes.com/2005/02/13/business/yourmoney/13freeze.html?pagewanted=3) claimed that current capacity is 300 WBs or 900 neuros. With a time-of-writing cryopatient population of 35 WBs and 60 neuros, the earliest the bay could fill would be if the next ~200 patients were WBs (extremely unlikely) which would fill the bay, at the earliest, by 2021 (at +8%/yr growth) or 2027 (at 0%/yr growth). When this event occurs, remodeling costs will impose a one-time expense and there will be loss of rental income from the unit(s) that can no longer be rented out – but rental income is a small and declining percentage of total consolidated revenues (Section 4).

16. The real base servicing cost per member might increase in future years if more personnel must be hired to address the increasing risk of near-simultaneous cases as membership grows [8, 17], though some reduction in these costs might occur if caseload increases sufficiently to justify regional response groups or single specialized providers such as SA.

17. R. Michael Perry, "Tracking Caseload Trends," ***Cryonics*** 27(Spring 2006):13-14; http://www.alcor.org/cryonics/cryonics0602.pdf

18. "No. 100. Death Rates by Age, Sex, and Race: 1970 to 1998," ***Statistical Abstract of the United States: 2001***, U.S. Census Bureau, Washington, DC, p. 75; http://www.census.gov/prod/2002pubs/01statab/vitstat.pdf

19. "No. 98. Expectation of Life and Expected Deaths by Race, Sex, and Age: 1998," ***Statistical Abstract of the United States: 2001***, U.S. Census Bureau, Washington, DC, p. 74; http://www.census.gov/prod/2002pubs/01statab/vitstat.pdf

20. According to Rudi Hoffman, about 80% of the neuro signups for which he negotiated insurance funding during 1995-2005 were at a face amount of $100K or greater. This is due to price breaks and in some cases requirements of face amounts of $100K or more. Thus these neuros were overfunded because the prevailing minimum was $50K at the time. (Whole body signups were much less likely to be overfunded.) Taking full account of this would certainly increase the predicted pool averages, but what is the impact on revenues? During 1995-2005 Alcor added 419 new members, presumptively 65% or 272 of them neuros. Overfunding 80% of these by $50K would yield $10.9M of overfunding or ~16% of Alcor's total predicted funding commitment of $69.7M in 2010. Applying this overfunding to the predicted $0.29M of cryopreservation income generated in 2010 adds just 3% to the predicted $1.481M of total consolidated revenues for Alcor, a negligible increase. Similarly, the extra $35K PCT set-aside would add just 1.1% to PCT assets, also negligible. Future hikes in dues, minimums or COLAs would further diminish these percentage impacts.

21. "The Alcor Patient Care Trust," 30 June 2010; http://alcor.org/AboutAlcor/patientcaretrustfund.html

22. The process of guiding a new member through the signup process is very labor intensive (perhaps 10-20 hours, according to several people), comparable to the process of a realtor guiding a client through paperwork associated with buying or selling a house, and is usually preceded by months or even years of phone calls and emails, asking questions.

23. Information from Rudi Hoffman CFP, currently writing about 83% of cryonics funding policies worldwide, who provided the following rates for a whole life type policy with a cryonics friendly A-rated carrier: For a 50-year-old preferred nonsmoker, a $150,000 policy costs about $136 a month ($1,632 a year). For a $570,000 policy, the rate is about $518 a month, or $6,216 a year. Other rates are estimated by interpolation.

24. However, funding via trust can incur extra legal expenses for the member because estate attorneys must be educated in the special requirements of cryonics, and is labor intensive for the organization because Alcor must verify that the trust is acceptable. Funding via bequest is an invitation to litigation from hostile relatives and can easily cost the organization more money in legal fees than it generates.

25. "The average working life of a cryogenic dewar is about 10 to 15 years." From: Mike Darwin, "Intelligent Use of Resources," ***Cryonics*** 8(April 1987):30; http://www.alcor.org/cryonics/cryonics8704.txt. See also: Michael Darwin, Hugh Hixon, "Life Expectancy and Performance of Superinsulated Dewars," ***Cryonics*** 5(May 1984):27-28; http://www.alcor.org/cryonics/cryonics8405.txt