

**A System Dynamics Analysis
of the
New England Ocean Cluster House**

Martin Schelasin
Haleigh O'Donnell
John Voyer, Ph.D.
voyer@maine.edu

School of Business
University Of Southern Maine

Abstract

Business incubators have received little attention from system dynamicists. The only system dynamics study of incubators focused less on how to run an incubator and more on how to use them as part of a national innovation system. The present paper fills part of this gap with a focused system dynamics analysis of one freestanding business incubator—the New England Ocean Cluster (NEOC). NEOC's long-term goals include evolving New England ocean resource industries into an environment more hospitable to entrepreneurs, and more conducive of innovation, by relying heavily on collaboration among incubator clients. A system dynamics analysis of the NEOC revealed significant financial challenges with its business model. It also showed the fundamental importance to the business model of intense collaboration among clients.

Introduction: Business Incubators

Business incubators come in many varieties (Barbero, et al. 2012; Barbero, et al. 2014). The first distinction among types of incubators is between not-for-profit and for-profit incubators (Hansen et al., 2000). Non-profit incubators foster a social purpose; for-profit incubators try to offer their owners financial returns. For-profit incubators generally seek returns from fees charged to their entrepreneur tenants for services provided and from investing in medium- to long-term equity stakes in tenants' ventures (Becker and Gassmann, 2006). Becker and Gassmann (2006), in their examination of corporate-based incubators, provide a typology adaptable for freestanding incubators:

- **Fast-profit incubator:** Commercializes noncore technology with the goal of exiting from its ventures through spin-off and profit making.
- **Leveraging incubator:** Increases the utilization of internally developed technology by leveraging it to the market, hoping to exit by integrating the technology back into the core business to support the corporation's future growth.
- **In-sourcing incubator:** Uses technological knowledge to screen external markets for promising ideas and high-potential start-ups that it might later "spin in" to expand the corporation's core competencies. It exits from the ventures by integrating them into the corporation, through either an existing or new business unit.
- **Market incubator:** Tries to develop a market for a complementary non-core technology to increase demand for its own technology and products. It supports the development of complementary technologies without having a specific potential acquisition in mind.

Business incubators have received little attention from system dynamicists. The only system dynamics study of incubators (Tepov, 2013) focused less on how to run an incubator and more on how to use them as part of a national innovation system. The present paper fills part of this gap with a focused system dynamics analysis of one freestanding business incubator—the New England Ocean Cluster (NEOC). In the Becker and Gassmann typology, the NEOC would be a hybrid of the fast-profit and market incubator types.

The New England Ocean Cluster

The model for the New England Ocean Cluster is the immensely successful Icelandic Ocean Cluster (IOC). The IOC has gained popularity amongst Nordic ocean resource utilizers and made its mark in the cod industry by creating a collaborative environment that fostered developments that increased cod utilization to previously unimaginable levels. The NEOC is an example of what Grimaldi and Grandia (2005) call an Independent Private Incubator:

IPIs are incubators set up by single individuals or by groups of individuals (companies too may be among their founding partners), who intend to help rising entrepreneurs to create and grow their business.... They invest their own money in the new companies and hold an equity stake. (Grimaldi and Grandia, 2005)

The New England Ocean Cluster House (NEOHC), based in Portland, ME, is an office building that hosts a variety of businesses in the ocean resource field. NEOHC houses a number of offices for firms, with shared collaborative space, and an incubator offering desk rentals for start-ups within the industry. Further, NEOC offers the option of participating through non-in-house membership. This cluster aims to promote creative collaboration that is a result of bringing together NEOC members.

NEOC's long-term goals include evolving the New England ocean resource industries into an environment more hospitable to entrepreneurs, and more conducive of innovation. Maine, because of

its flourishing seafood industry and its largely unique access to Lobster as a resource, made it a very good locale for the North American adaptation of IOC. Patrick Arnold, Owner of SoliDG (a port logistics and management firm) and head of NEOCH development, posits in his strategic outlines that Maine harvests \$450 million in seafood every year, which is linked to 1.5 million jobs in saltwater fisheries (Arnold, 2015) Given the overwhelming regional prominence of NEOC’s targeted industries, the NEOCH would appear bound for success. The present paper will outline the strategic composition of NEOC, present a model representative of NEOC’s revenue generation, and perform sensitivity simulations to draw actionable conclusions on the soundness of NEOC’s current operational premise.

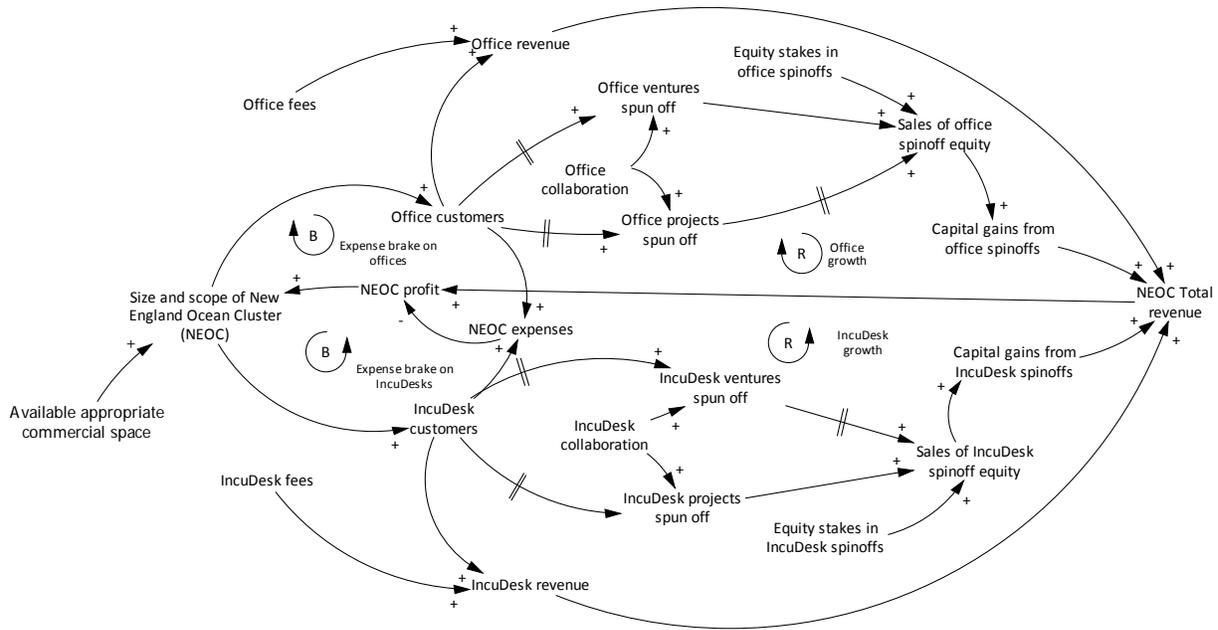


Figure 1. Causal Loop Diagram for the New England Ocean Cluster.

Dynamic Hypothesis

Figure 1’s causal loop diagram captures, at its highest level, the NEOC’s dynamic hypothesis for achieving financial sustainability. It recruits companies that use its larger office spaces and it recruits companies that use smaller “IncuDesk” spaces. Both types of companies pay fees that are its primary short-term source of revenue. By encouraging collaboration, the NEOC promotes spin-offs of both types of companies, taking an equity stake when they happen, making this a form of equity spin off or equity carve out (Powell, 2010). Later, the NEOC will sell off its equity, which enters the revenue stream as well. The major limits on the NEOC’s size are the availability of appropriate commercial space, the size of the expenses incurred in running the NEOCH, and the degree to which it succeeds at encouraging collaboration and, thereby, spinoffs.

Preliminary Analysis

In terms of strategy dynamics (Warren, 2008), the NEOC has a distinctly complex multi-faceted structure. Notably, the organization has three, in some ways four, primary revenue generators. These categories are in-house office rental, in-house incubator desk rental (IncuDesk), out-of-house NEOC membership, and the most abstract final revenue stream—capital gains from NEOCH-produced venture or project investment. In terms of a resource-based view, each revenue stream is associated with a

distinct stock and flow structure (which we did not exhaustively include in the model because of lack of complete information and over-complication).

Table 1 summarizes this stock and flow structure.

INFLOW	STOCK	OUTFLOW
New Office Companies	Office Customers	Office Companies Lost
<p>Determined by:</p> <p>Total Potential NEOCH Office Companies (Not modelled because of lack of market research and presumed expansion of this pool during the years of operation as the ocean resource and fisheries industries expand)</p> <p>Sensitivity to Collaboration (Approximated in model because of lack of market research. This function is in turn dictated by the exhibited amount of collaboration in the NEOCH)</p> <p>NEOCH Office Collaboration</p> <p>Sensitivity to Price (Approximated in model because of lack of market research. This function is in turn dictated by the current cost for office rental charged by the NEOCH)</p> <p>NEOCH Office Rental Cost</p> <p>Potential Customer Growth (Effects of word-of-mouth, advertising, etc. Not modelled because of inevitable over complication of the model.)</p> <p>Underlying Historical IOC Rate for Baseline</p>	<p>Determines:</p> <p>Variable Office-Allocated Operating Expenses</p> <p>Operating Revenue from Offices</p> <p>Ventures Produced by Offices</p> <p>Projects Produced by Offices</p> <p>Collaboration in Offices (Network Effects: Not modelled because of inability to adequately approximate necessary functions; would account for the rate of collaboration’s sensitivity to more or less offices in-house, I.E. at 0 offices, there can’t be any collaboration.)</p>	<p>Determined by:</p> <p>Sensitivity to Collaboration (Approximated in model because of lack of market research. This function is in turn dictated by the exhibited amount of collaboration in the NEOCH)</p> <p>NEOCH Office Collaboration</p> <p>Sensitivity to Price (Approximated in model because of lack of market research. This function is in turn dictated by the current cost for office rental charged by the NEOCH)</p> <p>NEOCH Office Rental Cost</p> <p>Underlying Historical IOC Rate for Baseline</p>

New IncuDesk Companies	IncuDesk Customers	IncuDesk Companies Lost
<p>Determined by:</p> <p>Total Potential NEOCH IncuDesk Companies (Not modelled because of lack of market research and presumed expansion of this pool during the years of operation as the ocean resource and fisheries industries expand)</p> <p>Sensitivity to Collaboration (Approximated in model because of lack of market research. This function is in turn dictated by the exhibited amount of collaboration in the NEOCH Incubator)</p> <p>NEOCH Incubator Collaboration</p> <p>Sensitivity to Price (Approximated in model because of lack of market research. This function is in turn dictated by the current cost for IncuDesk rental charged by the NEOCH)</p> <p>NEOCH IncuDesk Rental Cost</p> <p>Potential Customer Growth (Effects of word-of-mouth, advertising, etc. Not modelled because of inevitable over complication of the model.)</p> <p>Underlying Historical IOC Rate for Baseline</p>	<p>Determines:</p> <p>Variable IncuDesk-Allocated Operating Expenses</p> <p>Operating Revenue from IncuDesks</p> <p>Projects Produced by IncuDesks</p> <p>Collaboration in Incubator (Network Effects: Not modelled because of inability to adequately approximate necessary functions; would account for the rate of collaboration's sensitivity to more or less IncuDesks being in the incubator, i.e. at 0 IncuDesks, there cannot be any collaboration.)</p>	<p>Determined by:</p> <p>Sensitivity to Collaboration (Approximated in model because of lack of market research. This function is in turn dictated by the exhibited amount of collaboration in the NEOCH)</p> <p>NEOCH Incubator Collaboration</p> <p>Sensitivity to Price (Approximated in model because of lack of market research. This function is in turn dictated by the current cost for IncuDesk rental charged by the NEOCH)</p> <p>NEOCH IncuDesk Rental Cost</p> <p>Underlying Historical IOC Rate for Baseline</p>

New Out-of-House Members	Out-of-House NEOC Members (OoH Members)	Out-of-House Members Lost
<p>Determined by:</p> <p>Total Potential NEOC Members (Not modelled because of lack of market research and presumed expansion of this pool during the years of operation as the ocean resource and fisheries industries expand)</p> <p>Sensitivity to Collaboration (Approximated in model because of lack of market research. This function is in turn dictated by the exhibited amount of collaboration in the NEOC)</p> <p>Collaboration in NEOC</p> <p>Sensitivity to Price (Approximated in model because of lack of market research. This function is in turn dictated by the current cost for membership charged by the NEOC)</p> <p>NEOC Membership Cost</p> <p>Potential Customer Growth (Effects of word-of-mouth, advertising, etc. Not modelled because of inevitable over complication of the model. Benchmarked on IOC inflow rates per existing historical data)</p> <p>Underlying Historical IOC Rate for Baseline</p>	<p>Determines:</p> <p>Variable OoH-Member-Allocated Operating Expenses</p> <p>Operating Revenue from OoH Members</p>	<p>Determined by:</p> <p>Sensitivity to Collaboration (Approximated in model because of lack of market research. This function is in turn dictated by the exhibited amount of collaboration in the NEOC)</p> <p>NEOCH Incubator Collaboration</p> <p>Sensitivity to Price (Approximated in model because of lack of market research. This function is in turn dictated by the current cost for Membership charged by the NEOC)</p> <p>NEOC Membership Cost</p> <p>Underlying Historical IOC Rate for Baseline</p>

New Pending Capital Gains from or Project Investment	Pending or Project Capital Gains	Realized Capital Gains
<p>Determined by:</p> <ul style="list-style-type: none"> Average Stake in Ventures Purchased Monthly Average Value of Ventures Average Projected Return of Ventures Average Stake in Projects Purchased Monthly Average Value of Projects Average Projected Return of Projects 	<p>Determines:</p> <p>Cumulative Retained Earnings (In contribution with Net Operating Income)</p>	<p>Determined by:</p> <p>User/Company Decision</p>

Table 1. NEOC Stocks and Flows Chart

Model

Translating the above into a model required the dissecting of NEOC into four substructures, one for each of its revenue streams. The reader will find a shared Sysdea version of the model at

<https://app.sysdea.com/shared/y6ZN78Oz5Fu9ICvGkPqzIQ>

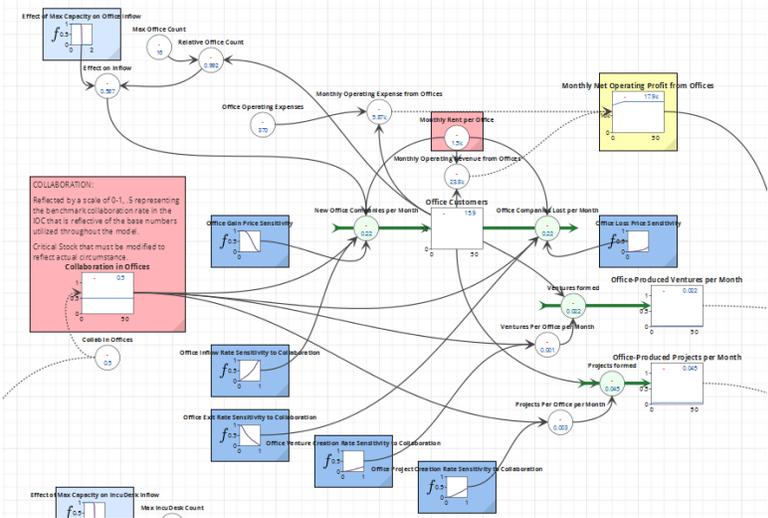


Figure 2. Office Substructure

For the three rental/membership revenue sources (offices, IncuDesks and Out of House members), the structure was relatively straightforward. (See Figures 2 to 4.) The first element represents the inflow of new customers, modified by price sensitivity, collaboration sensitivity, and capped at the maximum capacity when applicable with a first-order control. This inflow drives the stock, which then acts as a multiplier base for incremental variables, such as revenue per offices or desk or member, projects

or ventures per month per office or desk, and costs per office or desk or member. Meanwhile, much like the inflow, price sensitivity and collaboration sensitivity drive the outflow. Importantly, there are additional holding stocks that represent the resource of *produced ventures*. These stocks drain into the fourth, non-rental or membership substructure that calculates pending capital gains, and their respective contribution to revenue inflow.

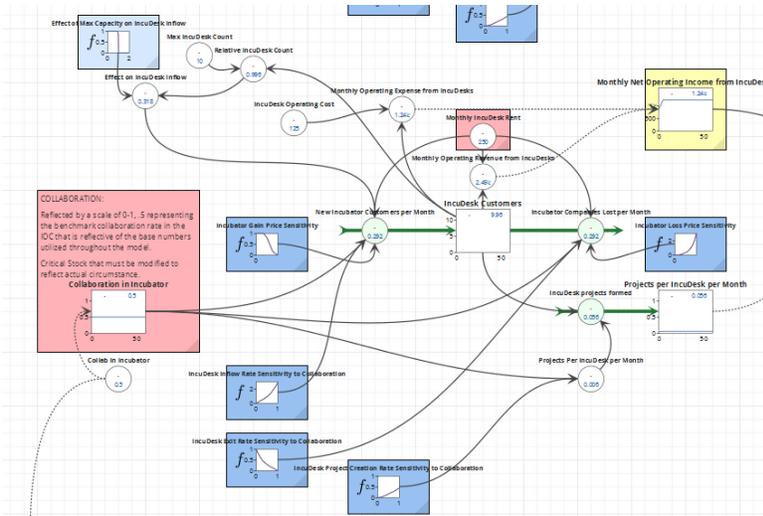


Figure 3. Incubator Substructure

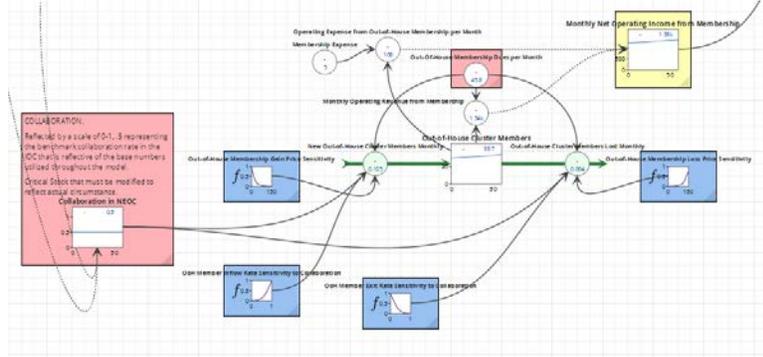


Figure 4. Out-of-House Membership Substructure

Pertaining to the final of the four major substructures, the investment or spin off substructure, the holding stocks from the office ventures/projects and incubator projects flow through equations that modify the degree to which NEOC holds equity investments in them. Specifically, the projected yield of the investment influences the amount invested; the model converts the yield to a dollar amount using an average of project value. The converted dollar value of capital gains then collects in a cumulative pool of pending capital gains that can be “realized” via an outflow dictated by a user or company decision. (See Figure 5)

All of the revenues from these substructures run into a cumulative revenue pool, which nets through sunk expenditures and non-allocated recurring expenses. This allows for the final calculation of net equity to date.

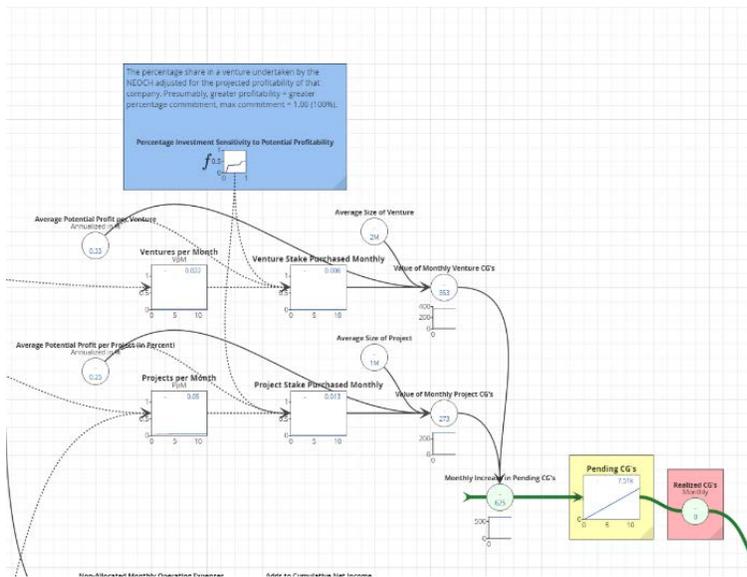


Figure 5. Investment Substructure

Simulation Runs

The simulation runs reported here aimed to analyze one primary facet of NEOC: the effect of collaboration on the revenue of the organization. This is one element of what Bergek and Norrman (2008) call “strong business support,” and is the primary objective of what the NEOC wants to provide its tenants and members (Arnold, 2015). Collaboration is an extremely dynamic and hard to simulate element of the NEOC’s strategic considerations because of the absence of absolute measures for the collaboration itself, as well as an absence of market research to adequately gauge the target demographic’s sensitivity to collaboration when making rental or membership decisions.

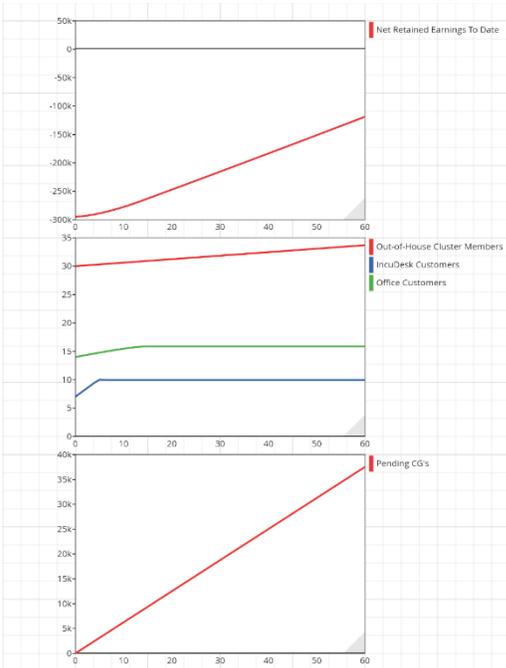


Figure 6. Simulation 1 Results

Simulation 1: Base Case

To analyze the effect of collaboration on the revenue stream of the NEOC successfully, we first ran through a simulation using the best base-projections possible: the historical numbers reflective of the IOC. To represent a standard/average amount of collaboration we used a value of .5, when applied to the underlying functions for sensitivity to collaboration; it produces the IOC-derived base numbers. Because of the intended isolation of Collaboration as the experimental variable, we left static all other decisions concerning price, at the rates disclosed by NEOC managers.

Figure 6 shows the results of simulating the first five years of operation. For a concise outline of relevant metrics, see Table 2, where we can see that *the simulation assesses that NEOC will be unable to reach a break-even point even after five full years of operation.* Originally, a two-year break-even had been predicted, prior to the final leasing of a location for the NEOCH

considerably smaller than the average possible size evaluated beforehand (final location 16 office and 10 desk capacity, original projection of 30 offices 12 desks). This break-even, however, may not include all possible credits and or additional revenue streams. NEOC management alluded to a large revenue

Metric	Value at end of Simulation
Net Retained Earnings to Date (Cumulative Net Income less Sunk Expenditures)	-\$118,724.96 USD
Pending Capital Gains (Standing Unrealized Value from Investments, not accounted for in Net Retained Earnings to Date)	\$37,529.03 USD
Office Members	Effectively Maximized at ~16 Maximum reached after 13 months
IncuDesk Members	Effectively Maximized at ~10 Maximum reached after 5 months
Out of House Members	33.7

Table 2. Simulation 1 Core Metrics

stream that helped cover incubator costs; this may roll over to cover other expenses and shift the breakeven forward dramatically.

Other important points of interest from the base case simulation include the amount of Pending Capital Gains (effectively unrealized revenue not accounted for in net revenue), the number of out of house members, as well as the number of months it took to reach capacity in both the offices (13 months) and the incubator (five months).

Regarding the pending capital gains, the base case simulation projects that, after five years of operation, the NEOC will hold \$36,529.03 worth of equity in projects and ventures from the house and incubator, assuming it realizes none during this time. This metric is of critical importance in maintaining a comprehensive view of NEOC's all-inclusive value and income.

The number of Out-of-House members represents the only incremental revenue stream for the NEOC that physical capacity does not affect. As such, its variation because of shifts in collaboration represent, arguably, the most important factor NEOC's management can manipulate to expedite their break-even process. During the base simulation, the number of out-of-house members reached 33.7.

Addressing the rates at which the NEOC reaches capacity maximums, this is important as it is simply an indirect representation of gained or lost revenue. In the base simulation, the NEOC reached capacity in the offices after 13 months, and in the incubator, in only 5 months. If we assume each month represents lost incomes in the offices and incubator of approximately 1.5k * (empty offices) and 250 * (empty desks) respectively, the considerable impact on revenue becomes dramatically apparent.

Simulation 2: High Collaboration

Progressing from the base case, we ran the second simulation with a hypothetical collaboration rate of .8, approximately 160% the collaboration of the base case. (See Figure 7) The aim of this simulation was to deduce whether it would be effective, and financially viable, for the NEOC to encourage even higher volumes of collaboration.

After simulating the first five years of operation (60 months), we show the charts for the produced outputs in Figure 7. For a concise outline of relevant metrics, see Table 3, which shows that, even with a considerably higher rate of collaboration, it is readily apparent that NEOC fails to break-even within a 5-year window (absent any extenuating unknown factors as previously mentioned). However, the amount of underlying debt from sunken expenditures is considerably lower, and is nearly counterbalanced in full by a doubled amount of pending capital gains in contrast to the base case; it increased by \$37,738.47. (See Figure 8)

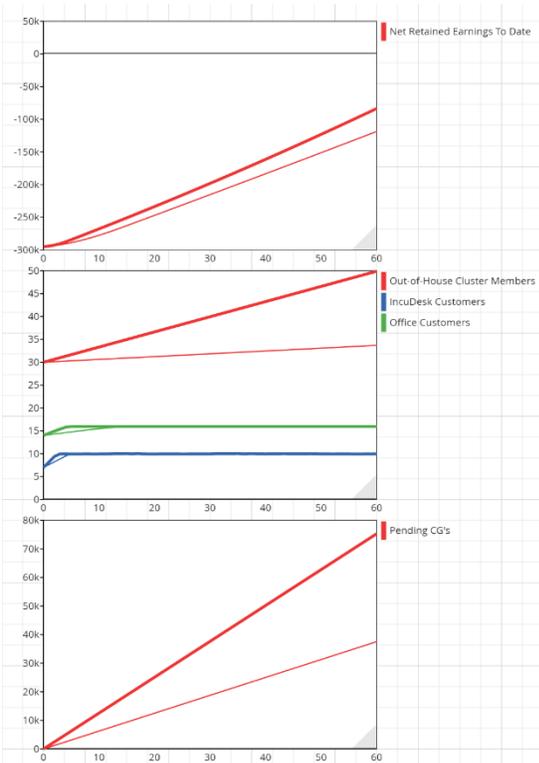


Figure 7. Simulation 2 Results: Increased Collaboration
(Base case represented by non-bold lines)

While the increase was somewhat negligible in the incubator, in the case of offices the move forward represents multiple thousands of dollars in gained revenue.

Lastly, the collaboration increases effect on the number of out-of-house members was stupendous. It increased the amount at simulation end to nearly 150% (148.07%). Because of the miniscule fees required for membership this ultimately led to small shifts in revenue and a largely unnoticeable effect on breakeven. The implications of this however, are immense should NEOC use this information as a propeller to assess potential changes in OoH membership fees.

In direct reflection of the increased collaboration rate, the points at which office and incubator spaces reached their caps moved forward.

Metric	Value at end of Simulation
Net Retained Earnings to Date (Cumulative Net Income less Sunk Expenditures)	-\$83,609.78 USD
Pending Capital Gains (Standing Unrealized Value from Investments, not accounted for in Net Retained Earnings to Date)	\$75,267.50 USD
Office Members	Effectively Maximized at ~16 Maximum reached after 4 months
IncuDesk Members	Effectively Maximized at ~10 Maximum reached after 3 months
Out of House Members	49.9

Table 3. Simulation 2 Core Metrics

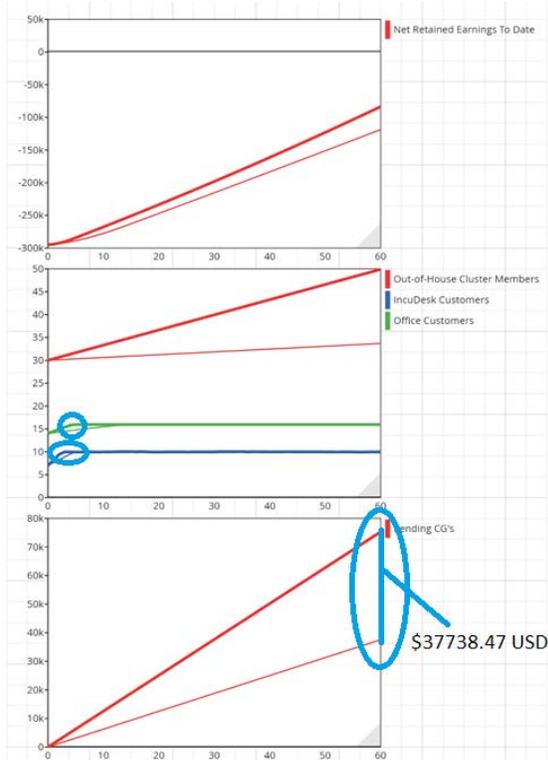


Figure 8. Simulation Comparison: Base versus Increased Collaboration
(Base case represented by non-bold lines)

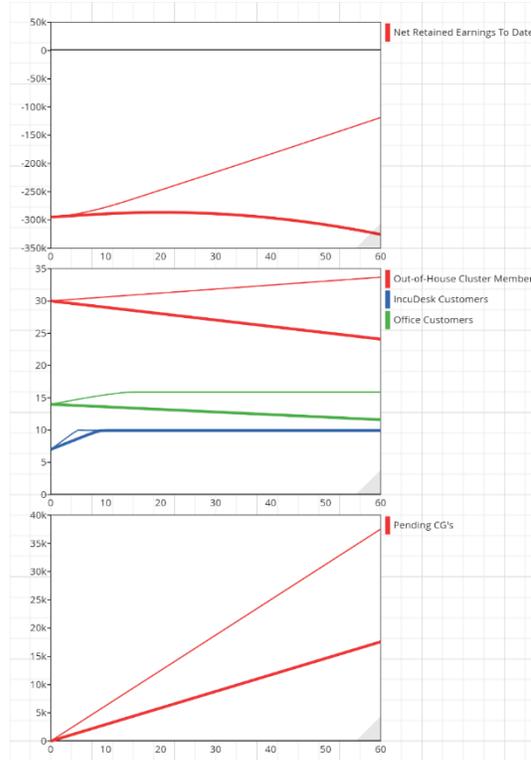


Figure 9. Simulation 3 Results: Reduced Collaboration
(Base case represented by non-bold lines)

Simulation 3: Low Collaboration

To affirm the conjectures supported by the high collaboration simulation, a proof-of-concept test lowering collaboration is of equal or greater value because of its inherent creation or disproval of the observed pattern. This investigates the primary contrasting position of that in Simulation 2; NEOC loses such negligible revenue in a low collaboration environment that initiatives to increase collaboration are not only not profitable, but a noteworthy misuse of resources. To simulate this scenario, we used a collaboration rate of .3. We show the output for simulating the first five years of operation in Figure 9. For a concise outline of relevant metrics, see Table 4.

In dramatic contrast to the prior simulations, a decrease in collaboration of even 40% results in catastrophic breakdown of the NEOC's revenue structure unless remedied aggressively. After 20 months of clinging to profitability, the lack-of-collaboration's effect on member/office/IncuDesk outflow overwhelms the point of inflection for profitability, and the standing debt of the NEOC increases steadily from there on. This supports the operating theories introduced by Simulation 2. NEOC would not only benefit immensely from spurring additional collaboration, but *it faces inevitable failure in the event it does not maintain collaboration in the immediate range of the initial IOC benchmark rates.*

Metric	Value at end of Simulation
Net Retained Earnings to Date (Cumulative Net Income less Sunk Expenditures)	-\$325,719.67 USD
Pending Capital Gains (Standing Unrealized Value from Investments, not accounted for in Net Retained Earnings to Date)	\$17,576.87 USD
Office Members	Fails to Reach Maximum Ending Value of 11.6
IncuDesk Members	Effectively Maximized at ~10 Maximum reached after 9 months
Out of House Members	24.1

Table 4. Simulation 3 Core Metrics

Known Oversights & Model Caveats

Table 5 summarizes unaccounted-for variables pertinent to the model.

Consideration	Explanation & Elaboration
Adoption Rates & Finite Potential Customer Pool	This model does not currently account for a finite pool of potential customers for any of the operating areas. This may or may not be a valid assumption going forward depending on growth rates within concerned ocean resource industries. Additionally, it does not model “adoption rates” such as the effect of word-of-mouth on the inflow and outflow rates within the NEOC.
Factors Affecting and/or Calculation Process for Collaboration	Collaboration is represented as a user/company defined quantified variable. This is may be considered a brash assumption and may be better suited to having a sub-model which can better approximate a value. (The substructure would likely be based on project or venture output, but would then be subject to risk of a circular reference interfering with proper calculation)
Pre-Tax Revenue Output	The model does not currently adjust for taxes and as such is an approximation.
Percentage Investment Sensitivity to Project or Venture Size	This model currently does not alter the amount invested in projects/ventures based on their size. A variable for available liquid capital would likely be needed to disallow investing more money than the NEOC had on hand, and limit its investment percentage in extremely high size projects. (I.E. if through some means a \$100m+ project was produced, it is highly unlikely NEOC

	would approach it with the same investment mentality as a \$1m project)
Compounding CG's	Does not account for the compounding of capital gains after their purchase over multiple years of holding. Presumably, modelers could fix this with multiple substructures for each project in which there is an investment, and with an accumulating stock that tracked the compounding amounts.

Table 5. Model Oversights & Caveats

Summary & Closing

The simulations presented in the present paper show both an intricate elaboration on the NEOC's revenue structure and a functional hypothesis that collaboration stands as one of, if not the most, critical element to the NEOC's longevity and profitability.

The base case in Simulation 1 presented a scenario in which the NEOC reached Icelandic Ocean Cluster levels of collaboration, venture production, project production, and inflow and outflow in offices and the incubator. This case offered a solid case for NEOC being a profitable venture in the long-term, even without strategic shifts in the current operational layout.

In Simulation 2, evidence arose of a critical link between NEOC's approach to break-even and collaboration in the incubator and office environments. Not only did the revenue in the NEOCH increase, but also the number of out-of-house members of the NEOC increased dramatically. This led to the conclusion that increases in collaboration, coupled with an increase in the cost for out-of-house membership, would better NEOC's ability to achieve break-even at an attention-demanding magnitude.

Simulation 3 confirmed the pattern suggested in Simulation 2 and precipitated a pressing change in implication. The hypothesis shifted from support for the value of increase in collaboration, to include the strict inadvisability of allowing collaboration to drop in any considerable capacity.

Lastly, we can recommend a number of operational methods to the NEOC. These recommendations are likely generalizable to many Independent Private Incubators (Grimaldi and Grandia, 2005) that seek to use collaboration as their primary contribution to the enterprises they host:

- Promote collaboration in any, and all, ways possible within reasonable cost bounds.
- Develop a proprietary formulaic approach to calculating the rate of collaboration in the house, and the cluster as a whole.
- Actively track and maintain running reports on the rate collaboration in the house (as calculated using the new formula); performing routine analytics to identify warning signs in this data is of critical importance.
- Create a scalar model to dictate increases in membership price as collaboration increases or decreases (this is theoretically accomplishable by modification of the model supplied in the present paper).

The NEOC will likely find success in its current format. However, should it approach its first years of operation with the above-mentioned tactics enacted, it will reach break-even at a significantly faster rate, and will avoid undue risk to its continued operations.

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