Implementing strategic insights to transform operations performance in large organizations

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Abstract: *There are very few stories of 'wildly successful initiatives' where step change breakthroughs were sustained. In this paper, we examine 20 years of experience leading to such transformations in industrial settings. In the transformation efforts that succeeded, system dynamics model based insights and the five disciplines of a learning organization were applied, enabling the organization to self-generate an entirely new future for themselves, worth billions of dollars. Performance and organizational results of the transformations are presented. The generic policies and interventions needed to create this kind of change in every individual person and collectively in the organization are discussed in this paper. Sufficient repeat experiences of cross functional actions embedded good practices, built alignment across functions, created new habits, improved operating discipline, and led to culture change that sustained.*

Key words: business transformation, system dynamics, culture change, learning organization, leadership, management, continuous improvement, defect elimination, experiential learning, simulators, asset management, operations, reliability, maintenance

1. Introduction

Change and transformation efforts are common and needed, yet few seem to achieve sustainable changes in breakthrough performance. There are a number of frameworks that describe the steps for making this kind of transformational change, including Kurt Lewin's unfreezing, transition and freezing concept (1947), seven steps proposed by John Kotter (2007), the concept of the Hero Journey (1949), or Robert Schaffer's Breakthrough Strategy (1990). There is a large amount of literature describing 'how to do it' in detail, including business process re-engineering, process improvement techniques, quality movements (Crosby's 14 steps (1979), Deming's 14 points (1986), Toyota Production System (TPS), GE Workout, Reliability Centered Maintenance (RCM), Lean, TPM, Six Sigma. The System Dynamics community goes even deeper to focus on 'structures' of

systems that are fundamental to the problems that constrain transformation efforts (policy resistance), e.g. work on the 'capability trap' (Repenning and Sterman 2001).

Yet, regardless of all available knowledge, Jane Linder in her search for "wildly successful initiatives" (2008), or Jim Collins investigating "good to great" (2001) were able to identify only a few organizations which not only went through transformation and achieved significant business performance, but also managed to sustain the results.

One of the "wildly successful initiatives" was transformation of Lima refinery from 4th quartile to 1st quartile on industry benchmarks within 3 years, enabling employees to save it from closure (see the Results section) (Kuenzli et al 1998, Petzinger 1998, Petzinger 1998, Griffith et al 1999, Houshower et al 1999, Sterman 2000, Repenning et al 2001, Ledet 2005, Heinsohn 2007, Linder 2008).

The transformational change of Lima refinery (led by one of the authors of this paper and investigated by the other author) reveals a number of key policies that appear to have been instrumental, in this success. This paper builds on this experience and insights of 20 years following to describe key learnings that other organizations may use to replicate this kind of success.

The paper also points to policies and practices that contributed to unusual ability to sustain step change performance improvements over time. A key element of these policies is that they are designed to enable people in the change program to change personally, and then change as a collective. Long standing mental models and habits of working are evolved by enactment of these policies, resulting in changes in personal identity, goals, and capability.

These policies (discussed later in more detail) were:

- Focus attention on noble goals
- Provoke and support innovative actions as 'one team' across functional boundaries to escape the capability trap and reactive mode of operations
- Create a true learning organization, by systematically putting together organizational silos and cultures, to foster opportunities for collaboration
- Build collective understanding and executive support sufficient for middle management to tolerate the 'scale' (measured in thousands of actions) and pace necessary to overcome the embedded defects
- Move towards self-management to evolve employees identity and capability to behave as 'empowered citizens' rather than being limited by job role or title
- Engage the senior management to expand the scope of transformation actions beyond functional/local programs to focus on bigger system issues

The policies are brought to life through purposefully designed interventions that not only redesign and set in motion new system structure, but also affect the thinking and behaving across the entire organization and even beyond. This allows performance to improve and organizational tribes to come together. These particular interventions work outside the formal organizational structure to lower the threat of the change until the organization actually changes, when new habits and behaviors take over.

2. Leveraging the success of transformation

One of the fundamental concepts of System Dynamics methodology is that by looking at events over time, one can observe trends and behaviors, driven by system structure. System structure in turn is created by people, driven by their mental models, attention, goals, vision, and collaborative skills.

In the industrial settings natural response to an event is reaction, and the time available to think deeper is not typically available. If a pump fails, causing $100,000 production loss per day, such an event becomes a priority, and breaks the carefully optimized work schedule. It then forces mobilization of all necessary resources on short notice, including a rush to expedite parts, so that the pump can be put back online as soon as possible. Once the job is done the 'overtime heroes' are rewarded. Then, everyone rushes to extinguish the next 'fire'. These dynamics are well illustrated by Repenning and Sterman (2001), who drew on the experience of the authors of this paper, and from DuPont and Lima refinery.

These dynamics are common across all industrial sectors. The experience of the capability trap has been a driver for development of improvement methodologies and techniques across the world. This includes Kaizen, Toyota Production System (TPS), Workout and Six-Sigma, TPM and Lean. These approaches, from the system structure perspective, aim at escaping the "work harder" loop to evolve such that the organization "works smarter", using simpler and more efficient business process to create improved business performance and/or survival over the longer time horizon.

Since the structure of the capability trap is known, the solution is straight forward. It takes allocating time to improvements, which over time results in improved capability and then performance. The premise is that going through a "worse before better" period to achieve the desired end state is worth it. To buy this premise, deeply held and long standing mental models must be challenged, to trust that the organization 'can' work smarter, build the missing capability.

In one of the endeavors undertaken by the authors, we used the capability trap model structure to develop a simulator that would reflect the situation in the client's organization. A workshop with senior management was conducted, world class subject matter experts were invited to advise the client. The fundamental problem with work harder / work smarter was presented as well as necessary actions to shorten 'worse before better' period.

Despite the reputation of System Dynamics, and world class experts giving advice, the client was not motivated and would not utilize the insights from the model i.e. focus on building capability and be patient. The client's response was immediate – they cannot do what the model suggested – they don't have the luxury to experience *'any'* worse before better impact an*d 'there was no money to invest in the capability building'*. A possible explanation for why the client was unwilling is that their whole life experience up to that point did not match what the model suggested needed to be done.

This presents some questions that challenge our perception about the scope of System Dynamics application:

- Is System Dynamics about building models and their presentation only?
- What does it take to apply System Dynamics model based insights to transform a large organization?
- How to increase leverage, facilitate reflection and learning processes, tap into mental models, and then adjust real world 'system structure'?

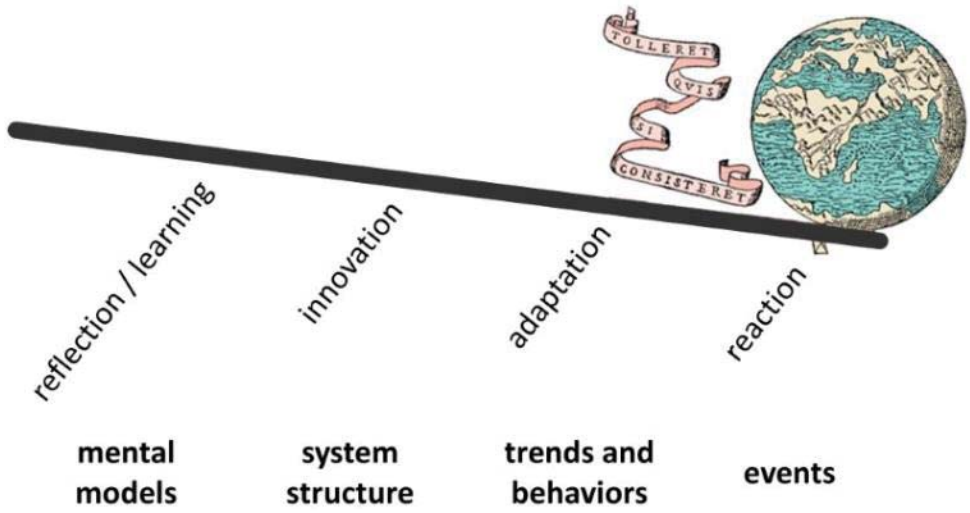


Figure 1 Archimedes: 'Give me the place to stand, and I shall move the earth'

There is a 'knowing / doing' paradox – where people 'know what to do' but then fail to do this, or are unable to create the conditions in the organization for it to occur. As a result, what tends to happen is that people never evolve beyond reacting to events.

In our experience many transformation efforts run short in two dimensions – scope and level of involvement.

In our other article on "Sustainable Organizational Change - Can you make the change happen with Large Teams alone?" (Rydzak at al 2009) we present an argument against the SixSigma approach. Blackbelts typically impact the technical domain and while they can be relied upon to deliver a performance result, the social aspect of transformation does not occur. This seems to occur because 1) the number of people involved in the improvement process is too small, 2) the level of ownership for the changes is low (i.e. the main driver for sustaining the change is missing), and 3) work habits are not adjusted, so 'self-managing' will not increase (operating discipline impact is low).

Before GE 'went big' on SixSigma, Jack Welch used Work-out. This was the means to engage significant portions of people in the organization and to stress the focus on action rather than the analysis (Ulrich et al 2002).

This insight is often missed in how various continuous improvement (CI) approaches are brought into organizations. As an illustration, a typical SixSigma or Lean approach starts by naming a new director for CI or business performance improvement. He or she then hires and directs greenbelts and/or blackbelts to start addressing particular events or performance shortfalls. In oil and gas industry this may be loss of primary containment where hydrocarbons are leaked or lost due to failure of process piping or tubing,

deviations from operating procedures, inefficient optimization of rig movements, etc. If for instance, there are 5 blackbelts hired, each of them will typically be involved in 4 projects a year and engaged with 5 people for each project. In that way the scope of involvement across the organization might reach 100 people per year. The average value of "hard" financial savings per Six Sigma Black Belt project is $200,000. So in this example of 5 blackbelts the annual savings might account for $4 million per year. Looking only at the financial value it seems to be a reasonable return on investment.

However, this kind of the approach typically misses the engagement of 75% to 95 % of the organization, which do not have the will ("it is not my job") or capability (we refer to it as 'being') to participate in performance improvement. Their attitude is that improving is work for the blackbelts to do. As a consequence a large part of the organization presses on unperturbed, generating defects. From a System Dynamics perspective of stocks and flows, the rate at which problems are removed from the organization through small number of Six Sigma projects does not match the rate at which the problems are introduced into the organization. A small number of highly successful blackbelt led projects cannot compete with a larger amount of new problems generated every day by lack of organizational discipline to follow standards and good practices. To balance defect / problem inflow with outflow such that the 'level' of problems in the stock reduces over time, the majority of people need to change long standing habits.

In 1960, a safety study (Heinrich 1959) found a relationship between major injuries and other less severe incidents to near misses and minor injuries. Heinrich pointed out that behind each major safety incident there are 300 incidents with no visible injury or damage (near accidents, close calls, HIPO's, unsafe acts or behaviors). Similarly, in the area of equipment maintenance, each corrective work order is an indication of a problem. Usually 3 to 14 defects are associated with each work order. So in an organization with 5,000 work orders a week, the number of defects that led to these work orders would be 15,000, to be on the conservative side. The only way to address all these defects is broad participation of all employees.

The scope of engagement needs to be extended beyond a few individuals, such as blackbelts, to include and influence the entire organization and … beyond. The authors' experience is that transformation requires looking beyond the boundaries of any element of organization to include the whole system. It might require engaging other organizations in the value chain, vendors or suppliers of materials and services, or even society, e.g. family members, local community members, teachers from a local school, etc.

The second dimension where transformation efforts run short is the level at which people become involved, i.e. function, being and/or will (Bennett 1956). Function is about what an individual does in an organization. Being relates to togetherness in an organization. Will is the driver behind action.

As an example, the moment a maintenance technician hears strange noises on equipment, they would like to address this issue as soon as possible. However, for an operator, to take equipment down for maintenance means production loss, thus would prefer to keep the equipment running. Function has a deep impact on understanding each other. Schein (1996) describes three predominant professions with their own cultures, in most

organizations: 1) operational, 2) engineering and 3) executive culture. Each of these cultural tribes has their own attitudes about people, work, money, time, technology, and authority. Transformation efforts need to include building bridges and common understanding across them (create 'being').

The authors' experience is that the most difficult element to address is 'will." Dealing with the will requires attention to noble goals, morale, building shared vision, addressing authority issues, organizational and functional identities and sense of purpose. The will to take action comes from a conviction that the action is necessary and proper, that it is the right thing to do.

As illustrated in Figure 2, the five disciplines defined by Senge (1990) – personal mastery, team learning, shared vision, mental models and system thinking – address what is needed to encompass the scope and three levels of people's involvement for transformative changes. The disciplines of a learning organization offer 'territories for interventions', but are not the interventions themselves. Picking the right interventions and sequencing how they are introduced and used are the key challenges for transformation leaders.

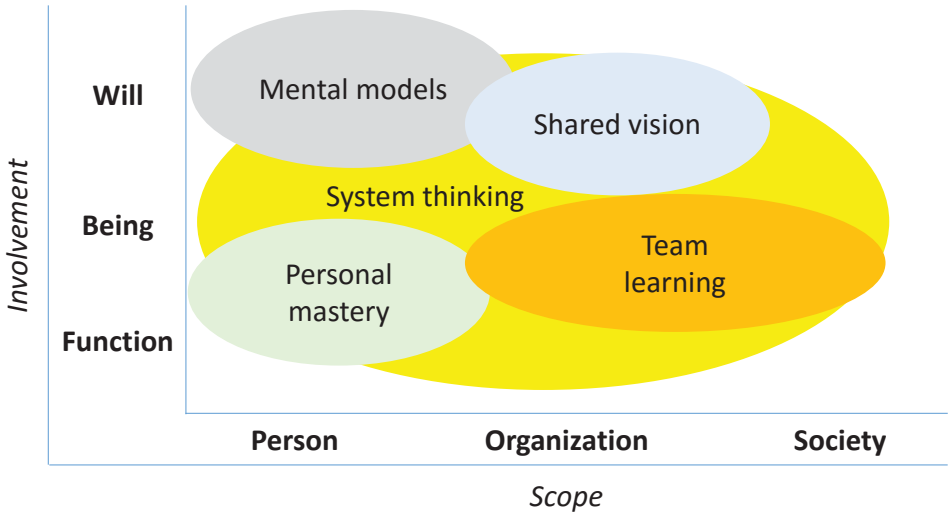


Figure 2 Extend of interventions for transforming organization

3. Closing the loop

Studying the literature dedicated to change in organizations gives an impression that transformation can be designed as a linear process or executed as a project with a clearly defined beginning, milestones and an end, that will achieve the desired business results.

As an example, John Kotter (2007) defined eight steps to transform an organization:

1. Establishing a Sense of Urgency
2. Forming a Powerful Guiding Coalition
3. Creating Vision
4. Communicate the Vision
5. Empowering Others to Act on the Vision
6. Planning for and Creating Short-Term Wins

7. Consolidating Improvements and Producing Still More Change
8. Institutionalizing New Approaches

Step 3 and 4 are similar to one of Senge's disciplines, i.e. building shared vision. A lesser view of Kotter's steps 3 and 4 would ask the CEO to define what the vision for the organization is, after which a communication manager would rollout or cascade the vision down to every person in the organization using supervisors and managers to explain and engage the organization.

A more evolved interpretation of these Kotter steps, closer to our experience of what is required for transformation, is that a shared vision is developed through multiple interactions, open dialogue, listening to each other and exchange of ideas. This more evolved interpretation views the steps as a feedback loop rather than a linear process, and one that requires involving the majority of the organization, vs. just the 'top.'

Similarly, step 5, 6 and 7, in our experience works as a loop where "consolidation of improvements and producing still more change" causes or needs to cause "empowerment for others to act".

Our second concern is related to various descriptions of transformation where the implied assumption is that managers can control the change. Referring to another work by Kotter (1990), good management controls complexity, whereas leadership produces useful change. Change is driven by acts of leadership not acts of management. Furthermore, leadership is not an act of a single person as there is no leader without a follower (Ledet 2012). The follower(s) make the leader, not the other way round. A good illustration of leadership can be found in Derek Sivers' (2010) TED Conference talk on 'How to start a movement'.

In our experience, a person initiates a transformation by calling for other's attention. To evolve and transform, this 'call' to some vision or change must be listened to, or 'paid attention to' – this is an attribute of will in followers.

People have limited attention, and have to give up paying attention on something else in order to focus on the 'call'. They may say that it "sounds good, but what about all the crisis driven work that is constantly coming my way every day – how do I deal with that and the drain on my attention from it just to survive until tomorrow"?

The call should be clear, simple, emotionally powerful, and aligned to a larger noble goal for the organization and asset. In Lima refinery the call was to save the refinery from closure, set to occur in 1998. People of the refinery responded to this call and shifted their attention from focus on short term cost minimization and daily production numbers to pay attention to defects and defects elimination. They enacted a new identity as 'defect eliminators' to apply 'don't just fix it, improve it' as the overarching simple decision rule for action.

The attention from the primary aims of the transformation that the person intends to remain focused on can easily be interrupted by other demands for attention, such as

equipment breakdown event or executive intervention or usual daily activities. The structure and typical dynamics of attention is illustrated in Figure 3.

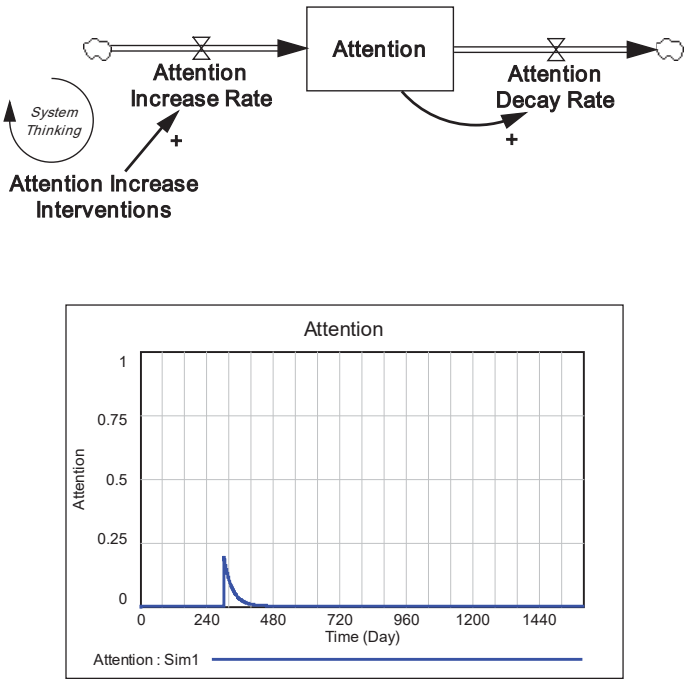


Figure 3 Increase and decay of attention

Since attention is easily distracted, the call for the attention needs to be designed to have a lasting effect. There is opportunity for system thinking based tools to serve this purpose, as they are grounded at the system structure level and have a potential to challenge our mental models. However, such tools or interventions should not stop at the 'thinking' level. As somebody said, knowing but not doing is not knowing at all. Even if a number of impactful interventions are applied multiple times to boost the attention, it may not result in action. The attention will fade away once the interventions cease, if actions do not reinforce the attention density (Rock and Schwartz 2006) through experience. These dynamics are illustrated in Figure 4.

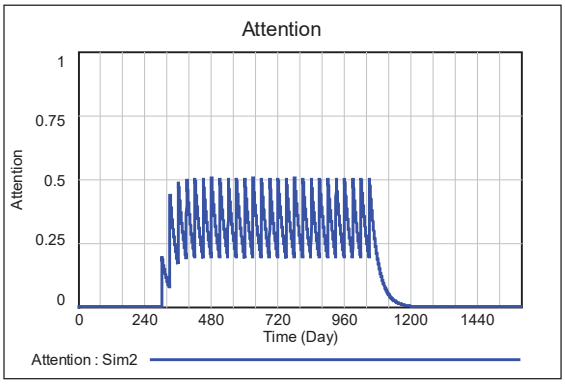


Figure 4 Increase and decay of attention

There is a need for experiential learning, to engage head, heart, and body of each person so that ‘attention’ to the call becomes ‘intention’ to take action to enact the goals of transformation.

In our work across various organizations, we have been using The Manufacturing Game which provides experiential learning based on a system dynamics model. Participants take roles of operators (produce product), maintainers (inspect equipment, schedule and execute repair), and business services (procure spare parts, manage inventory in the storeroom, sell product and manage money). In two days workshop participants experience 35 weeks of simulated production under real world constraints. It feels like running a real plant in which all three functions need to work together.

The experience of interaction in the game goes across all three levels of involvement – will, being and function, and the mental models about operations, maintenance and business services functions are challenged. The participants experience the dynamics of a bigger system, compared to the silo they are in on a daily basis. Instead of blaming the other functions, people realize their personal accountability to drive defect elimination and manage risk. See some pictures of participants in one of these sessions in Figure 5.

Figure 5 The Manufacturing Game workshop

The game is followed by debrief on what was learned. Sharing individual insights from the games and bridging them to the daily operations reinforces attention towards the call and gives courage to apply learnings from the game to the real world.

After the debrief a representative of management delivers a talk on current reality and defect elimination, to encourage participants to take action to eliminate defects, within safety boundaries, and in alignment with the emerging shared vision for the asset. This reinforces the ‘call’, through which attention might become intention.

An integral element of the workshop is launching Action Teams, where 3 to 4 people representing various functions start attacking a small problem that affects all of them. In that way, attention is channeled towards action. As Argyris (2004) stated, effective action is the fundamental objective of human and organizational performance. Because the game has just concluded, the participants are in a new mental space, receptive to hear the

message in a new way. They have just accomplished a step change of performance in a simulated production facility, so the call to do this in 'real life' isn't a strange concept. It feels a natural follow on to what they had just been experiencing in the game world.

At the very end of the workshop people are given a token - a "no-bug" poker chip ('bugs' in the game refer to defects affecting the organization). Participants can keep the token in their pocket as a reminder of the learning – which is yet another intervention to keep or increase peoples' attention. The token can also be used to remind other people – be it a co-worker or a manager – especially in a situation when they are about to act against the organizational vision, work in a silo vs as one team. One of the authors returned to a site that had used the Manufacturing Game workshop a year prior, and asked a participant how it was going now. The reply was 'we are still killing the bugs' – and the person pulled a well-worn 'no bugs' poker chip from her coveralls to show that the idea was still alive and in use.

We have found it essential to have the majority (everyone, or at least 80%+) of the organization to participate in the workshop over the first year of the transformation. In that way everyone has a similar experience and common language. It is not enough to have only the workers or leaders participate in the experiential learning. Some of the best action teams were catalyzed by non-typical leaders like secretaries or truck drivers.

After the Manufacturing Game workshop the team members continue doing their 'normal' jobs while at the same time work together to eliminate the common problem. So the problem and the scope of the action need to be small enough to be actionable and within their authority. The action teams launched during the workshop have up to 90 days to conclude the action, but many finish in 2 weeks. We have observed that teams completing actions quicker, while the attention density is still high, are more successful.

This is a very different approach than traditional transformation or engineering led programs where six sigma blackbelts are working, and the vast majority of people in the organization are not involved. Success with this action team approach depends on engaging the entire workforce in defect elimination, to achieve business success. An essential change in identity is feeling accountable and committed to personally contributing to defect elimination and the success of the business, vs. sitting back and waiting for the blackbelts or engineering projects to deliver the improvements.

Typically 50% of action teams succeed (quite high percentage of failure compared to a six sigma approach). However, performance improvement is not the only measure of success to be applied here. Even if the action team did not deliver any tangible results, the experience of working as a cross-functional team by itself creates benefits for the organization, in that new connections are made across functional boundaries and awareness of the defects and obstacles is increased, enabling a future effort to become successful. So even if one particular action team fails to deliver an improvement in performance or save costs, it is a good thing to practice. And the failure itself might be a good learning experience and give ideas for other improvements. This increases the organizational capability and will.

Our belief is that for transformation, on average each person in the organization should participate in four action teams a year. Participation in fewer action teams risks backsliding to old ways.

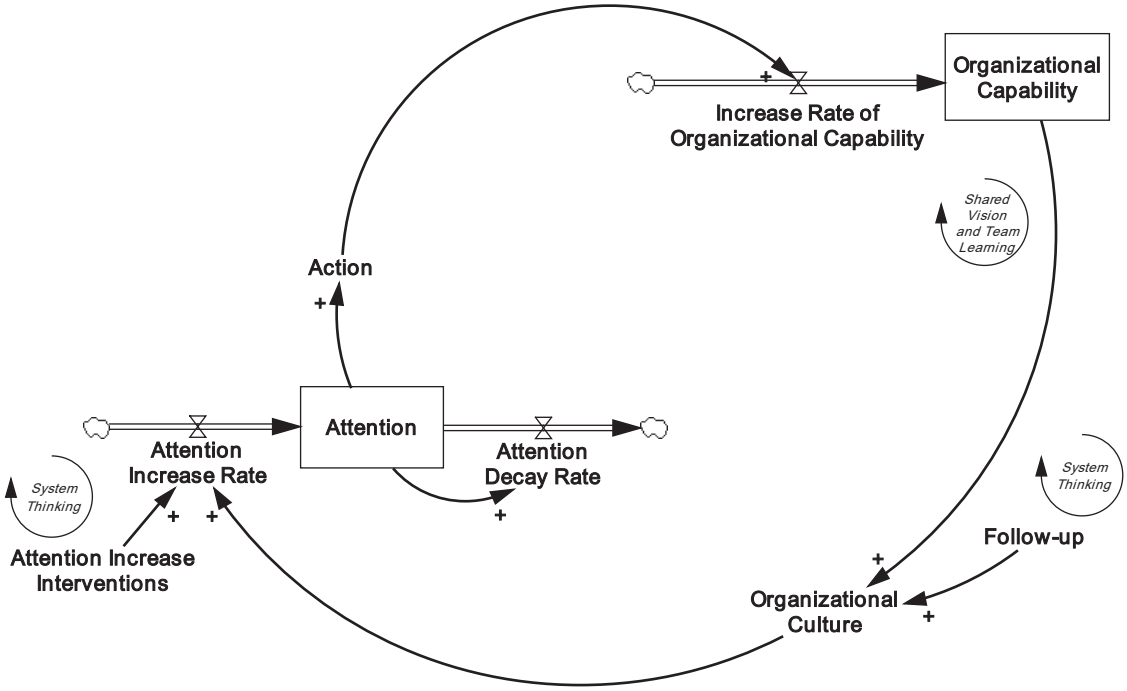


Figure 6 Shared Vision and Team Learning

Action tackles problems, triggers innovations and builds capability muscles within organizations. We found it instrumental to close the loop to maintain the attention and create the momentum of the transformation. Otherwise the transformation stagnates not achieving its full potential.

We simply call such interventions 'follow-up'. Fundamentally, the follow-up facilitates sharing the vision and team learning. It needs to be stressed that the follow-up is not one time event. It takes repetitive effort to keep the loop closed (Figure 6). It might take a few years before this loop is self-maintained.

A gathering that we called Leadership Forum or Continuous Improvement Forum is one intervention that has been utilized for the purpose of the follow-up. It is attended by positional leaders and a self-appointed collection of front line workers who share an interest in a long term future of the business. The CI forum had a number of purposes, including:

- reflecting on action to learn and improve,
- celebrating success, when an action team harvests an improvement opportunity,
- inquiring into constraints and barriers within the site or organization, such that managers become aware and can address these constraints,
- to build a common understanding of current reality and future desired state (vision),
- to co-create the path forward - brings everyone together

Looking back, we belief that without the CI Forum intention would not have been maintained sufficiently to drive the change program to sustainability. The key idea of the CI Forum is to have the 'whole system' in the room. In some sites, the CI Forum met monthly or twice per month, in groups as large as 100 persons (approximately 10% of the headcount). As a result of dialogue and sharing of learning from actions many people changed their views. Hearing stories and perspectives from outside one's own work environment broadened the individual and exposed misalignment of goals between functions. Reducing misalignment reinforced taking further actions.

The CI Forum was a venue to build shared vision, the process of which happened via dialogue. Reflecting on the stories of successful action teams helped people realize what is possible and show greater intentionality of purpose.

In case of Lima refinery the vision extended beyond the refinery to include the supply chain, pipelines and logistics infrastructure, marketing outlets and terminals, the non branded stores and commercial channels of trade, and even the community. Various clients found it helpful to make the vision visible on work wear, caps, shirts and coats to remind people and keep renewing their attention.

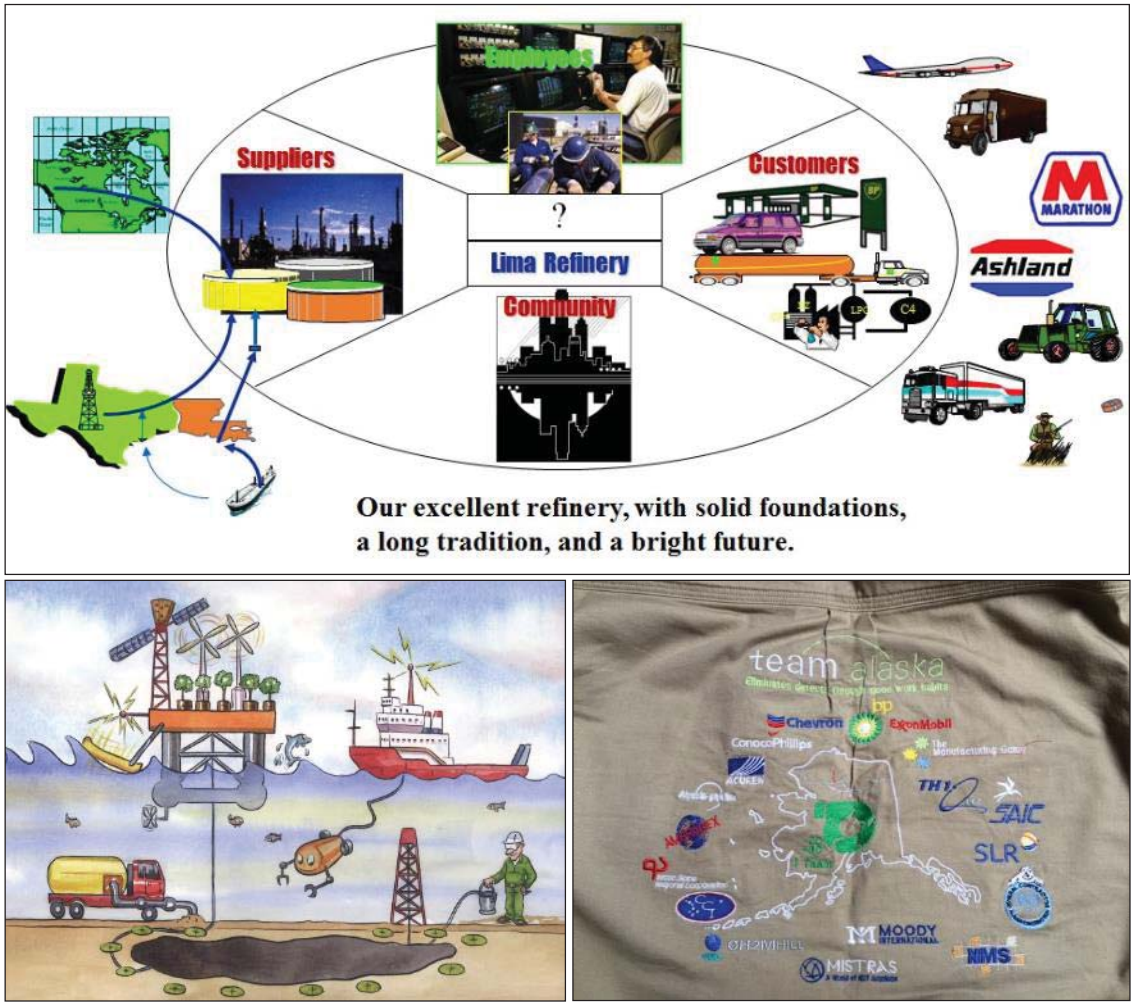


Figure 7 Examples of organizational visions

A different intervention was the use of CI Celebration events. These occurred quarterly and served to provide recognition for successful action teams. It also provided a venue for practical sharing of learnings, networking and enjoying each other. People could see the innovations or try new tools. These celebrations occurred much like a trade show, where for a couple of hours everyone could enjoy good food in a nice atmosphere and be together.

Figure 8 CI Celebration – presentations of innovations

Figure 9 CI Celebration – recognitions

The monthly CI Forums and quarterly CI Celebrations were interventions that kept the "Shared vision and Team Learning" loop closed (see Figure 6) and boosted peoples' attention towards the objectives of the transformation. In addition to these, even more interventions were used to also boost attention, including:

- steak fry nights with families invited
- VP having 'lunch and learn' with groups of 7 frontline employees daily
- billboards in the community, celebrating improvements and performance gains
- employee book club
- cross business visits
- training people on the practice of dialogue and action science principles
- publishing articles for internal magazines and external conferences

- sponsoring System Dynamics student projects to engage engineering and executive leaders in system thinking
- developing and applying new learning environments (System Dynamics based games)
- engaging workers in activities with community (in schools, government agencies, municipality)
- employee prayer group (to pray for senior management)
- The Manufacturing Game facilitators following the action teams
- Comic book, newsletters, short home-made videos showing the innovations in the field
- CI website for sharing the learning.

By this point one should have already recognized that the transformation happens in a group. But for the transformation to be sustained the change needs to happen in individuals, in their habits and routines. The transformational leader needs to impact and facilitate the development of the personal capability through closing the 'Personal Mastery' loop (Figure 10).

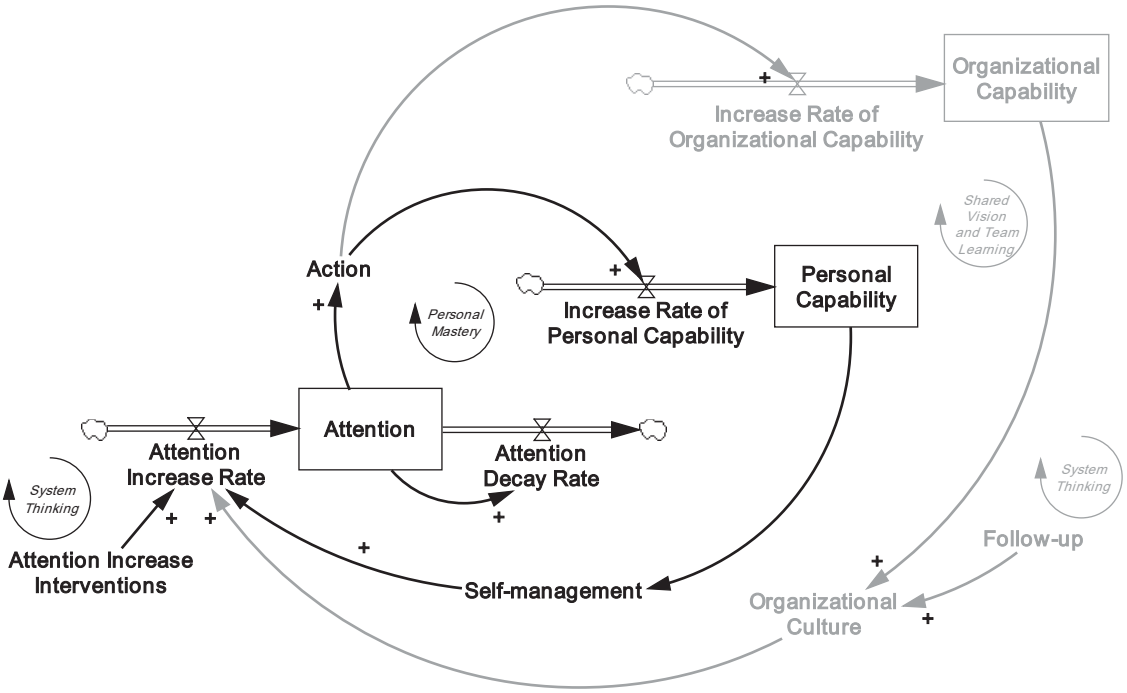


Figure 10 Personal Mastery

On one hand this loop is about doing a 'good job' – be it operations, workmanship or any other aspect of work in an organization – which might take some additional learning and training (e.g. calibrations, alignment, condition monitoring, the use of tools, etc.). However, this loop is also about personal choices and identity. One might have knowledge and skill but choose not to use them.

As an example, when a mechanic makes a repair usually she feels pressure to give equipment back to operations as soon as possible – equipment down means production loss. She needs to make a decision to trade seed of the repair vs. quality of the workmanship to ensure defects are not introduced. Her decisions might align with the vision promoted through transformation or work against it.

In order to help an individual to make the good decision on the spot, we found it appropriate to establish simple decision rules – simple statements that help making the 'right choice' to move towards the shared vision. This supports self-management and offers the reinforcing link between capability and attention. Over the transformation the simple decision rules might evolve to fit better the current reality.

Here are some examples of simple decision rules that have been used:

- Don't just fix it, improve it!
- Address the defect as quickly as possible
- Always do the preventive maintenance
- Don't let the bug bite
- Do it right
- Don't hammer on equipment
- No harm to people or environment
- Focus on value, not cost
- Maintain reputation and the privilege to operate
- Follow the rules, Finish what we start, Follow-up

Some of these rules were made visible on posters, t-shirts, etc. to be a constant reminder to people and reinforce the attention and shared vision.

Figure 11 Visualization of simple decision rules

Figure 12 illustrates the dynamics of two loops ('Shared Vision and Team Learning' and 'Personal Mastery' illustrated in Figure 10) with interventions aimed at boosting attention. People become mobilized, take some actions resulting in a number of personal and organizational improvements but the transformation does not take off due to lack of support from managers.

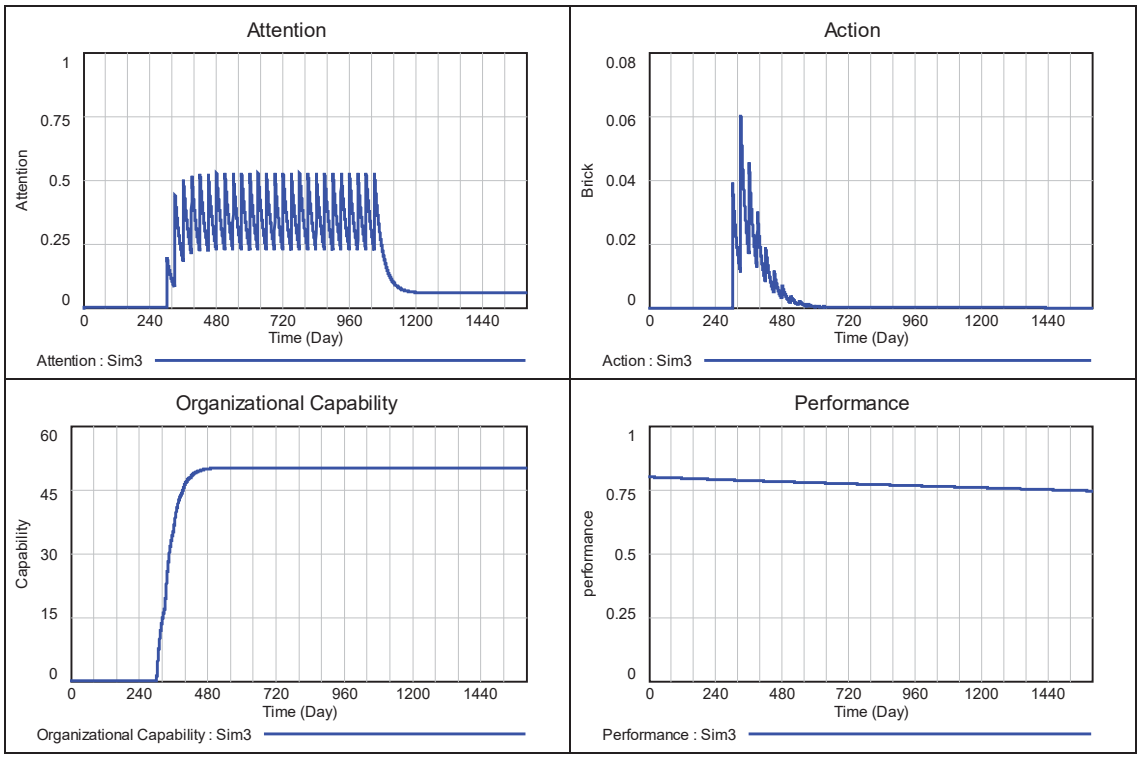


Figure 12 Two loops at work

Over years, we have observed many such initiatives that were not able to pass this threshold. Initial mobilization, training, first improvements occur but then the attention and performance gains backslide to the original start position. Since backsliding dynamics are commonplace, people react to any new program no matter how skillfully crafted or executed with skepticism. People privately wonder 'are we serious about it this time', or 'I have heard this before', or 'This looks like another fine program, but we won't stick with it', etc. The reason to this is the lack of support from management.

In order to enable the full potential of transformation, there is a need for the third loop, which has its roots in organization capability and mental models.

It seems that managers' perception about probability for successful transformation by engaging everyone in the organization to build good work habits and focusing on cross-functional cooperation and defect elimination is generally very low. This mental model is a factor that drives executives to select Six Sigma and engineering project led approaches - something they perceive can be 'managed', in their control and thus 'will succeed'.

This is despite forerunners who have demonstrated very large financial benefits, in the billions, from succeeding with this kind of approach if skillfully led. A calculation for one client indicated potential savings of over $7billion in the course of 3 years. Such a large value increase was beyond the experience of these managers and therefore they could not imagine the potential gain from this kind of transformation.

However, Lima refinery stands as a clear example of this kind of hidden potential. Over the course of 3 years 37.5% of total maintenance work was reduced via action teams eliminating defects. In the next 3 years elimination of total maintenance work reached 70% of the original level (see Results section).

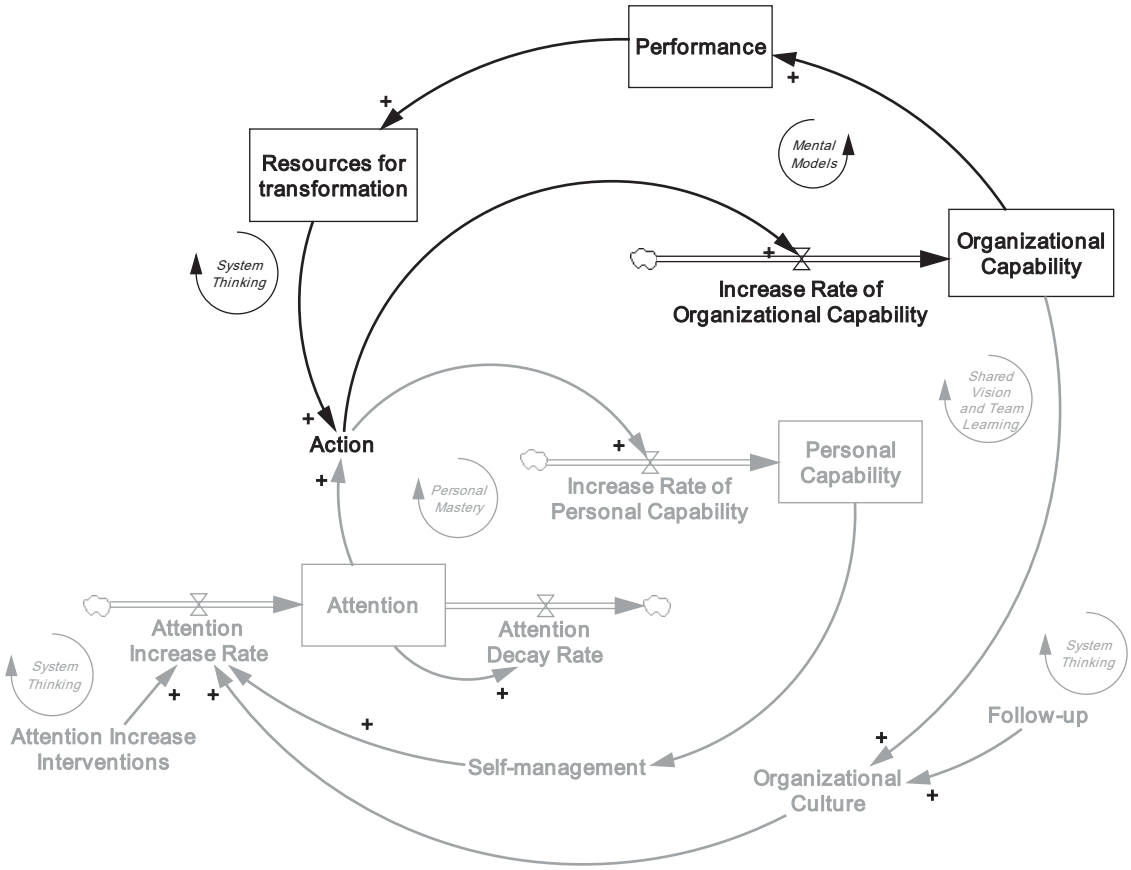


Figure 13 Mental Models – cooperation of management and leadership

The 'Mental Model' loop (Figure 13) has to do with what is expected from the transformation; these expectations influence the level of support for the effort. This is the area where leaders cooperate with managers to shape the emerging shared vision for the transformation effort. This supports removing barriers and obstacles that are hindering people from taking actions.

Negotiating the right boundaries and providing resources for transformation are aspects where managers should cooperate with leaders. Examples are:

- granting $5000 per each Action Team so that it can spend it on improvement without proving justification,
- limiting time to be dedicated for work in Action Teams down to 2 hours,
- expecting teams to complete actions within a period of time.

Leaders facilitating the transformation set up a venue for considering these things adjusting mental models, setting boundaries, and overcoming the obstacles so that resources and pace are appropriate.

Additional interventions may be needed to further address mental blocks and disbelief about the value of transformation. An example intervention was a workshops for managers during which the benchmark results were presented and evaluated using a system dynamics model. The model had been calibrated to the client's organization and compared against the historical results of previous transformations is similar organizations. Another example was a policy exercise workshop. The managers tested six policies and their impact on the dynamics of transformation across various sites and actors using a simulator based on an agent-based model (Figure 14).

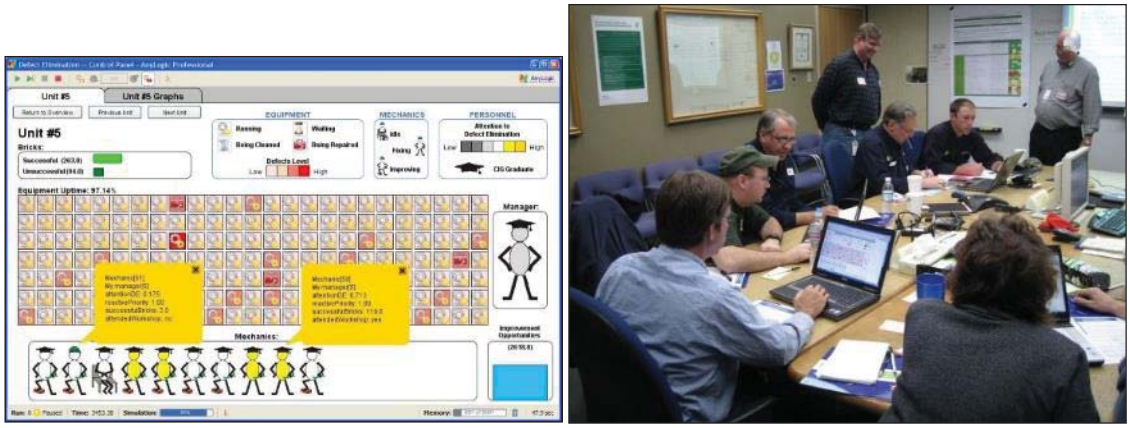


Figure 14 Site managers and leaders – simulator at work

Yet another intervention was a skit to tell a system dynamics based story about improvements. Having hard-edged corporate commanders dressed up in costumes to perform amateur theater in front of disgruntled union workers was unusual protocol. It provided a realization and set a pattern - if managers can step up to do such a thing, everyone in the organization could and should go beyond their familiar behaviors and rigid routines. To produce this skit the managers had to face their fear of looking 'stupid' in front of their subordinates. However, they chose to do this 13 times with different groups as a kick-off to a day long workshop designed to address mental models and work on obstacles. Every person in the organization participated in this workshop within a month. After the skit, dialogue about what was possible and what was blocking success began, using system archetypes including fixes that fail, shifting the burden, eroding goals and accidental adversaries.

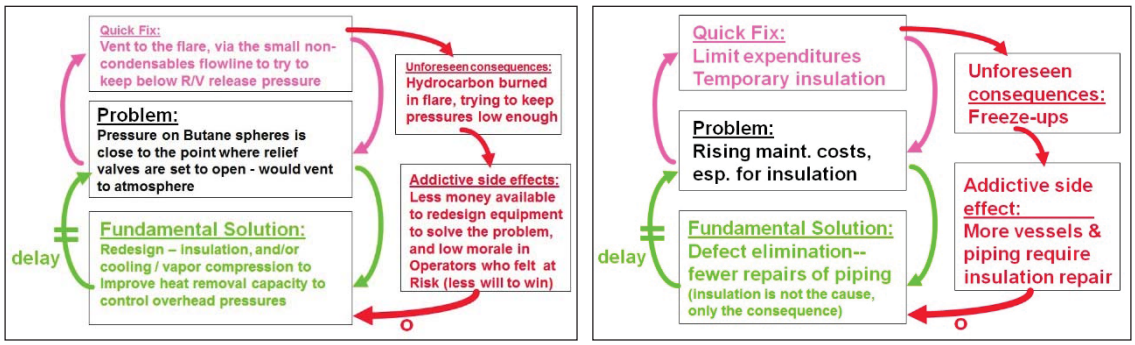


Figure 15 System archetype template filled in by the workshop participants

The outcome of this day long workshop was that workers and managers came to better understand the thinking of each other, laying the foundation for better cooperation. Interventions like the skit made many people believe that there was much more that could be done. From the managers perspective it was granting people the license to act upon the shared vision. From the worker perspective it was a significant empowerment.

Figure 16 shows dynamics and results from setting all three loops in motion (Sim 3). Attention is self-sustained at a higher level than was seen in the earlier case. Even after all interventions to boost attention are stopped, the attention plateaus at a high level. Once the habit of paying attention to defects and defect inflow are deeply engrained, people just keep working on defect elimination as a normal aspect of their daily work.

Performance continues on an upward trend due to increase of organizational capability, and is sustained by good work habits that drive adherence to standards with rigor and operating discipline. Because the capability is being used, the Action is measured in thousands.

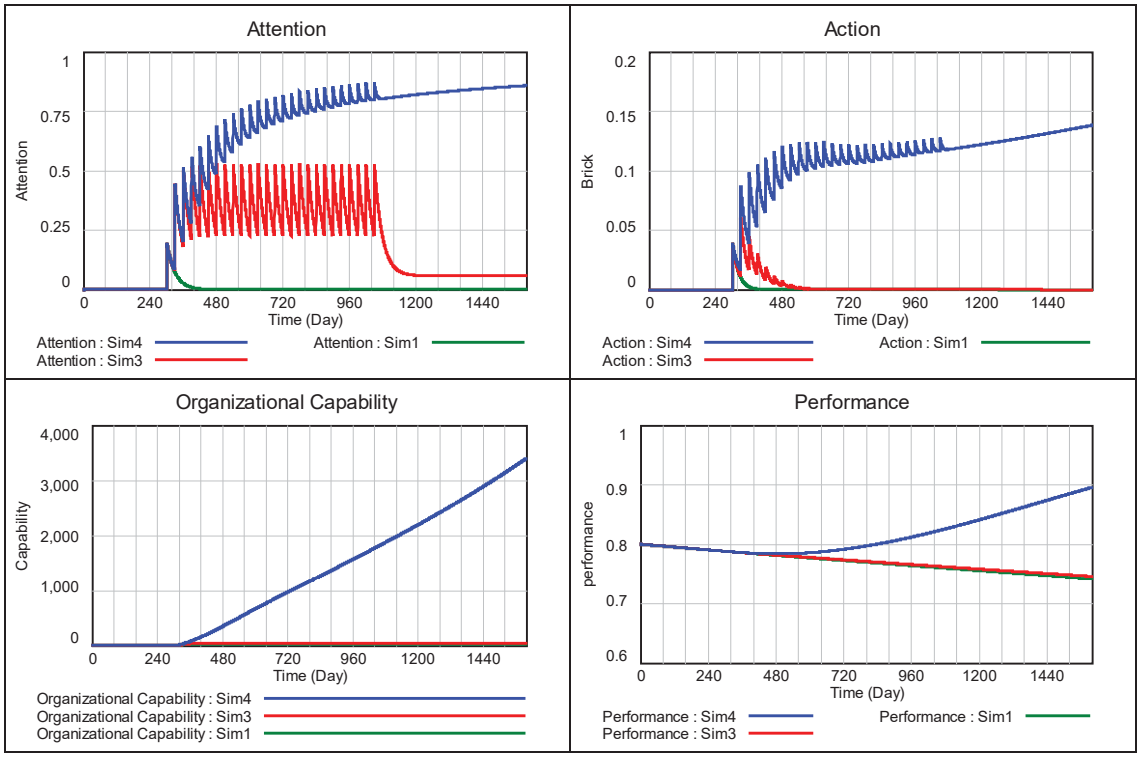


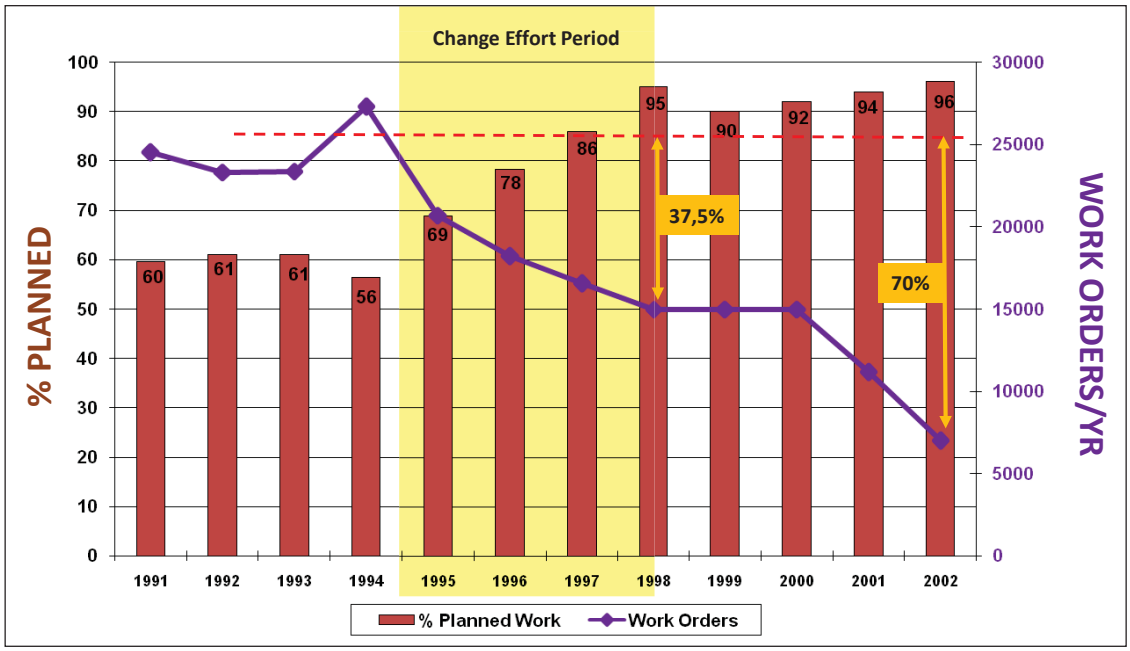
Figure 16 Three loops at work

4. Results

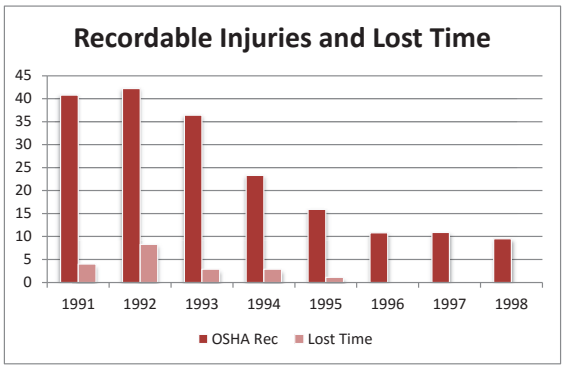
In this section we present a few representative results from transformations in various organizations. They include not only tangible performance figures, which are important, but also we try to show the dynamics of peoples' interactions which we believe was also important. It required behavior change to put in place new policies and system structure. These were the basis for sustaining the results of transformation.

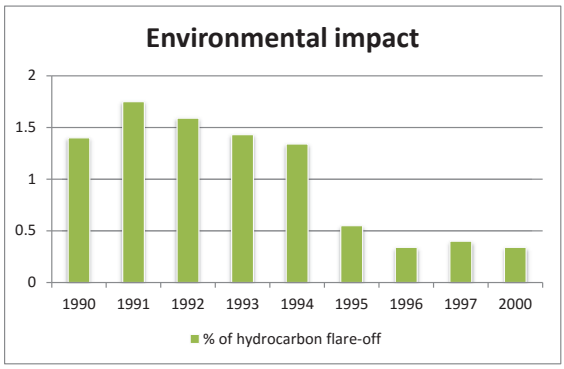
Lima refinery

The graphs below show the scale of change. It is worth repeating that over 7 years 70% of work was eliminated. Basically it means that the equipment fails 70% less frequently.



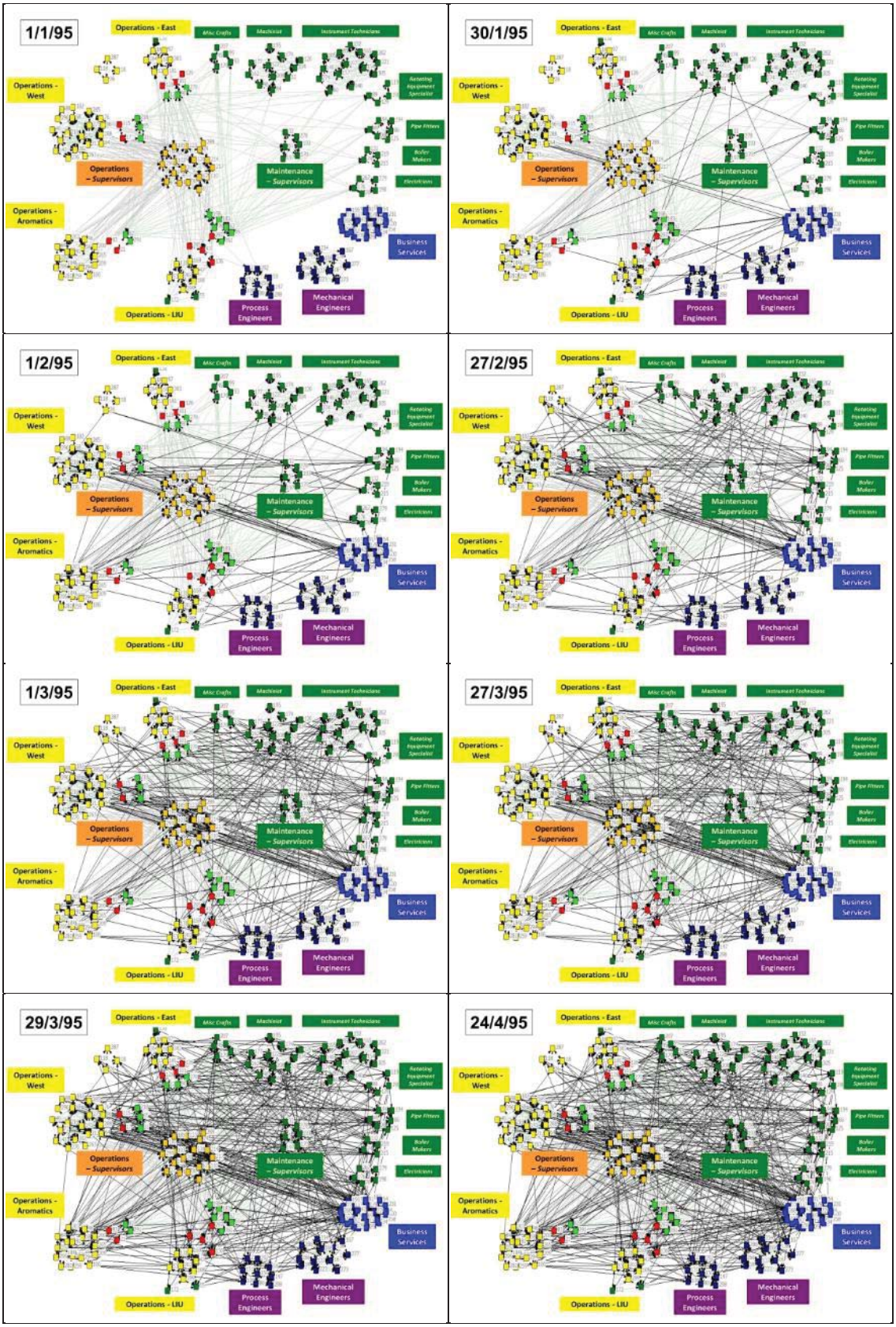
The transformation was also reflected in safety and environmental performance.





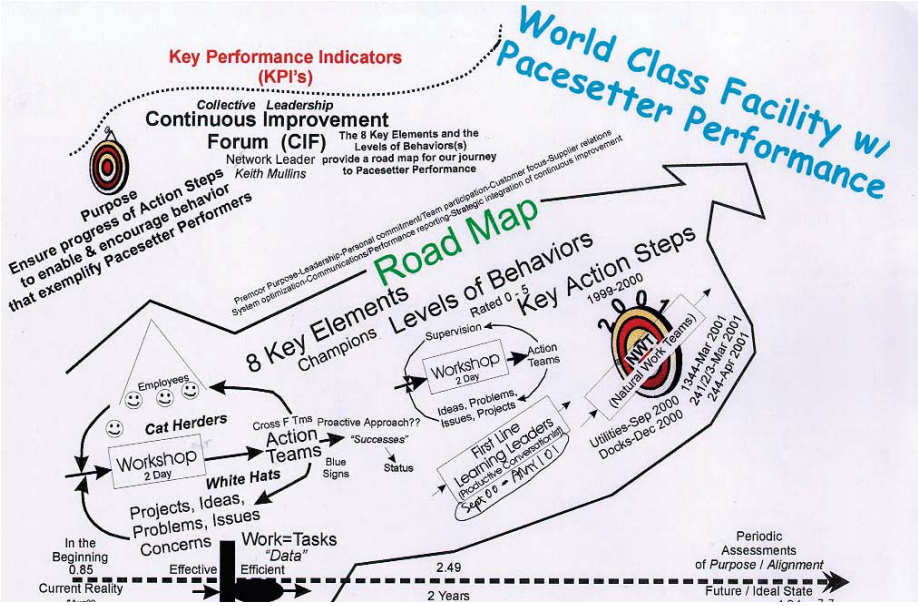
The story of the Lima Refinery has been well documented (Kuenzli et al 1998, Sterman 2000, Repenning et al 2001, Ledet 2005, Linder 2008). This paper provides additional focus on the structure of the social dynamics in Lima's transformation.

The following graphs present people in the organization. Each node on the diagrams represents a single employee. Different colors are used to indicate four main functions in the plant – yellow is used for operations, green for maintenance, light blue for business services and dark blue for engineering. The lines between the nodes represent new cross-functional relations induced into the organization through the action teams launched in the Manufacturing Game workshop. These cross-functional actions can be perceived as "priming" the 'Shared Vision and Team Learning' loop illustrated in Figure 6.

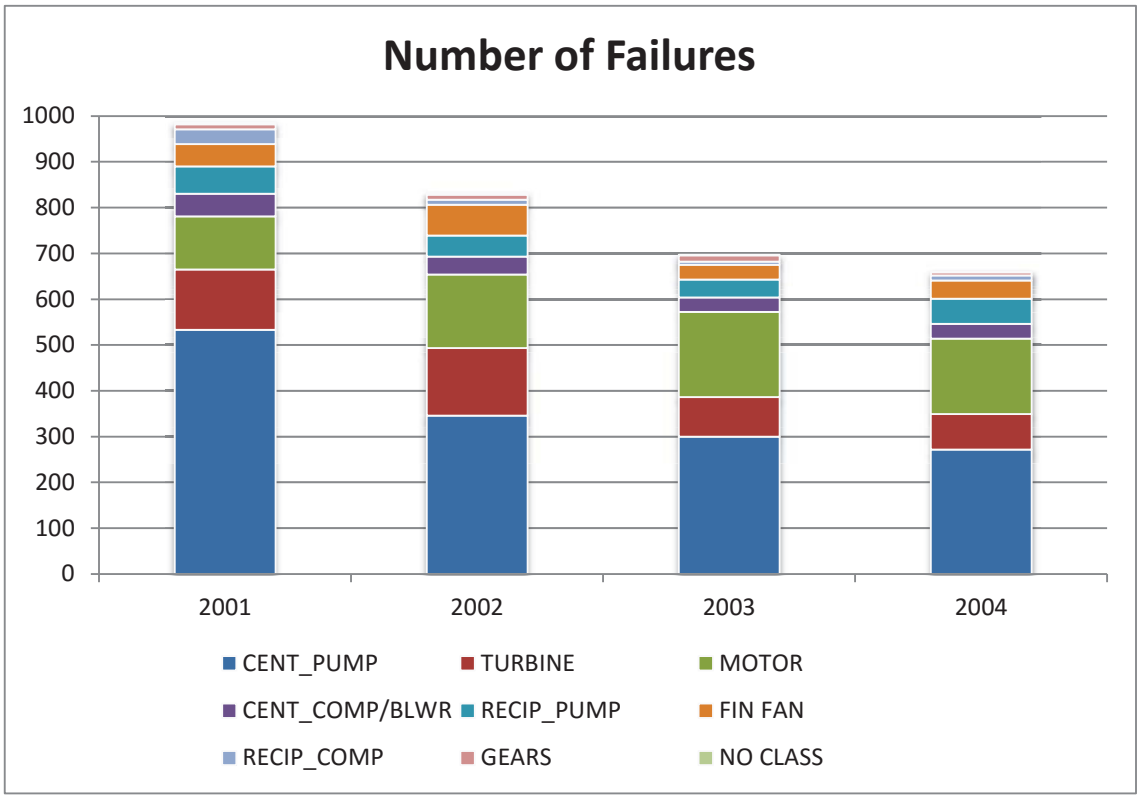

1/1/95
30/1/95
1/2/95
27/2/95
1/3/95
27/3/95
29/3/95
24/4/95
Operations - East
Misc Crafts
Machinist
Instrument Technicians
Rotating Equipment Specialist
Pipe Fitters
Boiler Makers
Electricians
Operations - West
Operations – Supervisors
Maintenance – Supervisors
Operations - Aromatics
Business Services
Operations - LIU
Process Engineers
Mechanical Engineers

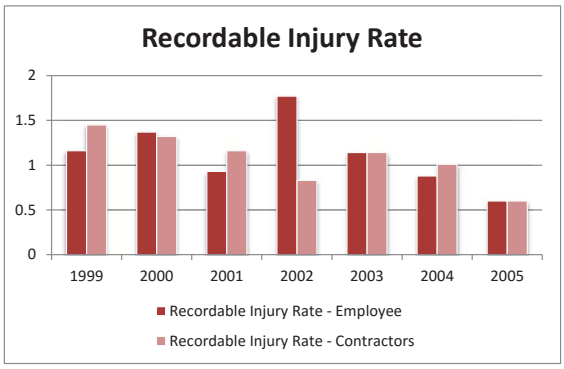
Case 2

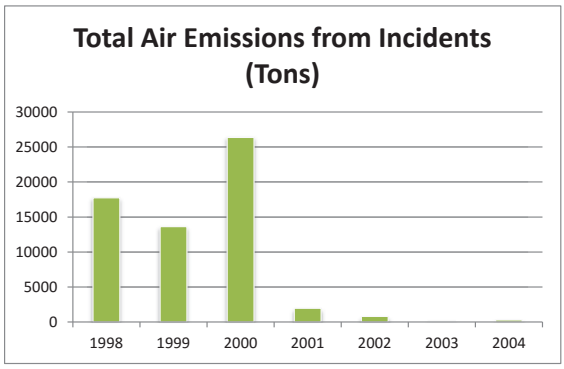
The Lima refinery success was replicated in another place where similar interventions were used in order to set up the same fundamental policies. In the Road Map one can recognize some of the interventions listed earlier, like "Workshop 2 Day" (The Manufacturing Game) or Continuous Improvement Forum.



The performance was again visible not only in terms of reliability but also safety and environmental results.





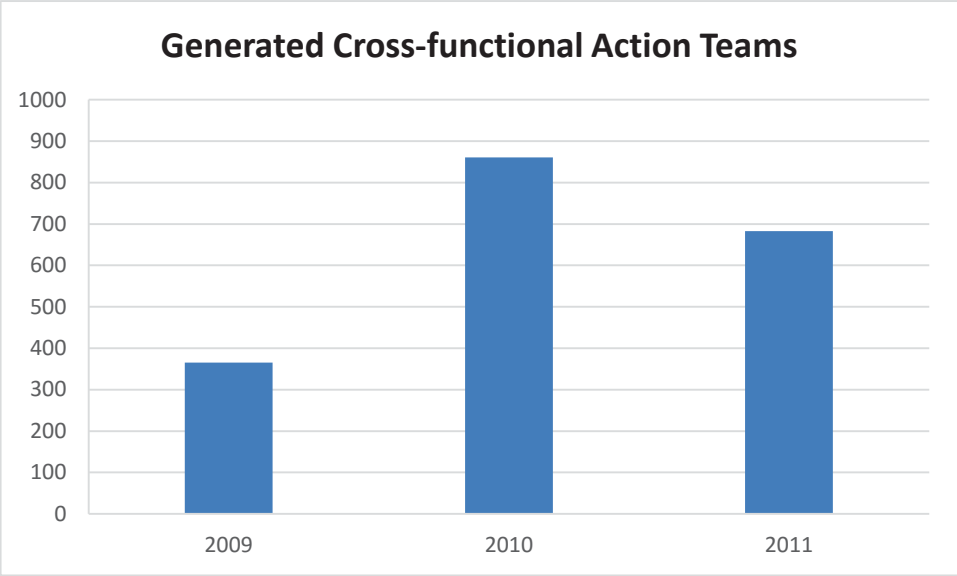


Case 3

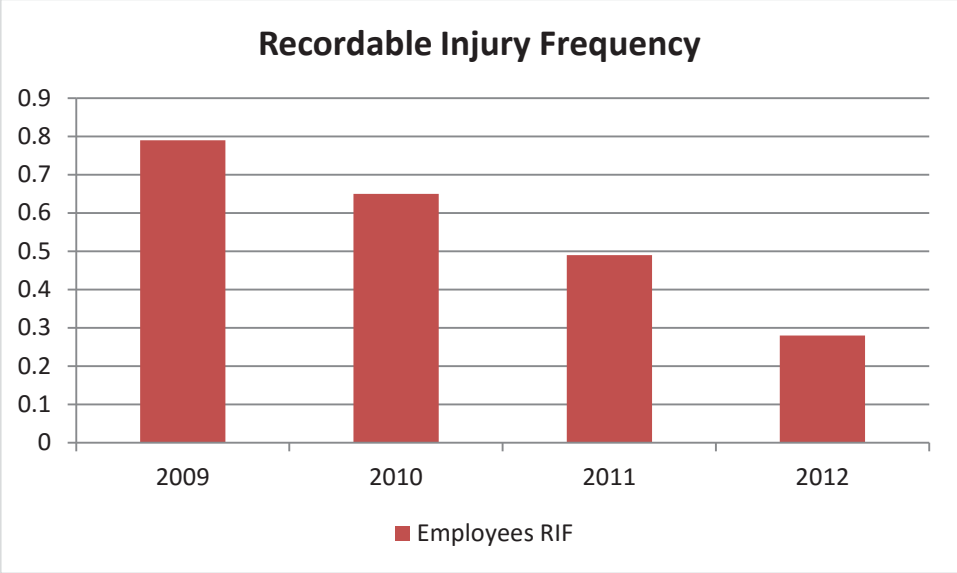
In this case it is worth noticing the scale of the engagement and improvements with more than 800 actions initiate in a single year. This graph itself challenges the mental models of managers who typically cannot imagine this scale of engagement and action.

In 2010 alone the improvements resulted in $13,472,141 of verified cost savings.

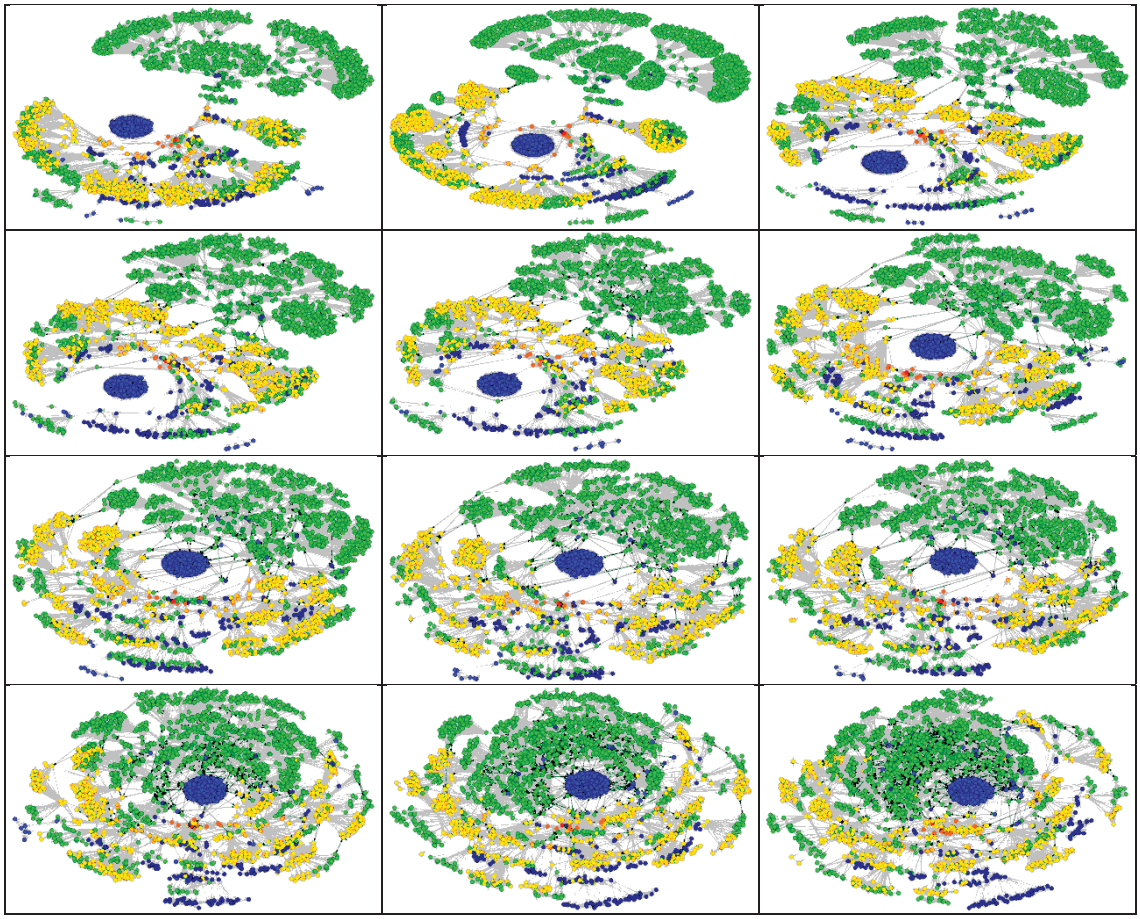
The results below account only for officially tracked improvements; they do not include so called “self-generated” action teams.



The safety results also improved as a consequence of employees becoming engaged in defect elimination (see figure below).



Network diagrams below illustrate the dynamics of the transformation from the perspective of people interactions and togetherness. Each diagram represents snapshot of peoples' working relations at a discrete time over the course of transformation.



There are 2942 nodes on each diagram representing every single employee. The first diagram contains 258,662 edges (connections) representing functional connections in the

organizational hierarchy. These connections are the outcome of interventions to directly connect workers who would normally have to connect with each other through their line supervisors. In social network analysis the cross-functional connections between workers make the supervisor lose power of control. However, trusting the workers and allowing self-management as described in this paper provides managers with outstanding business performance.

One other advantage of this network analysis is identification of brokers / connectors. These are highly 'connected' individuals who have the potential to spread the guiding ideas to many other people across vast areas of the organization.

We like to think about the network diagrams as the analog of the 'big brain' of the organizations. Like in the individual person, the ability to behave in new ways is thought to require new neural network pathways in a physical human brain, similarly the transformation effort needs to result in establishing connections between members of the organization. In that way individuals become teams, learn as teams and build collective intelligence. These new 'pathways' connect people with each other, enable performance improvement, and steer the organization towards the shared vision.

5. Conclusion

In a number of places where we have been involved in successful transformation efforts, a few fundamental things have occurred:

The entire organization was engaged
The transformation started with front line workers. It was not a top down approach. They are the closest to the equipment and know what the main reasons for low reliability are. Purposefully designed interventions were used to alter system structure, personal mental models, and levels of thinking and acting to draw peoples' attention towards the noble goals of the transformation.

Engagement was channeled towards action
Having a 'case for change', smart people, strong interest, high passion are all good to have, but these are not sufficient unless people take action. Attention gained through engagement needs to become intention, such that people become willing to cooperate across functional boundaries to take actions aligned with priorities. Over time repetitive actions eventually become good work habits such that the whole system works as an integrated value chain, and also satisfies societal needs.

Follow-up
In order to enable a sufficient number of repetitions of taking action, attention needs to be boosted purposefully to compensate for the decay of attention as new events demand attention away from defect elimination or noble goals. Attention must be boosted over and over, until the new work habits become stable and actions from these are self-generated. Good work habits are the basis for sustaining the organization in the new performance regime, enabling a "better world".

Visiting Lima refinery more than 15 years after the transformation, one of the authors of this paper asked if they had kept on doing "defect elimination" - the answer was

"no". But after a while, the person reflected that whenever there is a problem a cross-functional team is automatically created and the problem is addressed. This is the usual way of working, which had become a habit, so it was difficult to observe by the members of the organization.

Leadership and management were balanced
Engagement, action, and follow-up create and sustain the reinforcing loops presented in this paper. Enacting these loops tend to generate fear of chaos and loss of control over the organization in managers. To enable these loops to run, leaders need to engage the managers, build trust, and align on scope and boundaries so that chaos coming from the change is balanced with enough order. The change affects frontline supervisors, who must 'let go of control to trust their people' and then evolve their ability to become leaders with competent followers who self-manage. The interaction between leaders and followers is critically important.

The feedback loops described in this paper are not easy to enact within industrial settings. There is a difference between being a modeler versus application of model insights in the real world. To introduce a new casual relation or to close a loop quite often takes a significant effort and time, and skill.

Furthermore, it is not enough to stay in the domain of system thinking only. We focus on using all of the five disciplines of a learning organization: mental models, building shared vision, team learning, personal mastery, and systems thinking. This seems to be the only way to enable a true and lasting transformation. We design new system structure and orchestrate interventions to create quick wins, build capability and motivation, and to shift personal identity.

Still, it is not a deterministic process. The change to the system structure emerges. Lima Refinery defied the odds of failure that block most change efforts, escaped the capability trap, and has sustained a wildly successful initiative for over 18 years, leading to new investment that enables a long and bright future. Subsequent efforts to replicate Lima's success have been ongoing in a number of other places.

Our work within industrial settings has highlighted the need for System Thinkers and System Dynamists to expand their focus to include the application of model insights such that they become change leaders and facilitate transformation. We observe how often people in organizations get stuck and lose the bigger picture in the "complexity of details". They also get caught dealing with today's events and are unable to recognize patterns and trends, much less the deeper structure of the system. And even if the system structure is recognized there is still a need to address how people are thinking and behaving.

We see the need for System Thinkers and System Dynamicists to walk in two worlds – operations and research – while keeping the system view and its dynamics in mind, to help people deal with day-to-day operations so the organizations can transform how it pursues noble goals.

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