Demo-cracy in America

Claude Rosental

Occasional Paper 49
Paris, Institut Marcel Mauss – CEMS
2018

Demo-cracy in America

Claude Rosental

Abstract

This paper examines how NASA developed a sophisticated software program for the preparation of space missions during the 1990s. I show that computer demos were one of the main sources shaping the activity and relationships of the researchers working on the project. More generally, I study the demos' conditions of possibility and the constraints on their practice and uses in Silicon Valley. The analysis highlights capitalist procedures in the production of demonstrations. It further reveals the establishment of a demo-cratic regime establishing the power of the demos and their talented users.

Keywords: Demo, NASA, Space Mission, Silicon Valley, Scientific Capitalism, Artificial Intelligence.

Demo-cracy in America

Claude Rosental

This paper examines how artificial intelligence researchers used computer "demos" as they developed a sophisticated software program for the preparation of space missions during the 1990s.[1] One of my main goals is to describe the practices this term alludes to, pointing out that demos are a prime subject for sociological analysis.

"Demo" is a term researchers in artificial intelligence and computer logic commonly use to refer to a situation in which a demonstrator comments on the running of a device (a computer software or a robot for instance) in order to illustrate the value and/or validity of a specific formalism, method, or approach. Researchers may use this particular form of demonstration to obtain funding for a research project from an industrialist as well as to contribute to scientific exchanges.

To shed light on the ins and outs of the use of demos, I will analyze some results of a research program aimed at promoting a historical sociology of the forms of demonstration[2]. In particular, I will draw on a study on the conditions in which a "revolutionary" software called Orion has been developed at NASA over the last decade of the 20th century[3]. Orion is a program designed to prepare space missions, more specifically to define the trajectories of "space conquest" probes. This unprecedented software was used in particular to prepare the Cassini mission, the latest of a series of great explorations of the outer planets of our solar system. Decided in 1989, this mission planned to launch a satellite in 1997 to study Saturn and its environment for at least four years, starting from July 2004.

My analysis will be based on interviews, field observations, as well as electronic exchanges and records collected between 1993 and 2001. I will outline the key features of the project and its conditions of development. Afterwards, I will analyze more specifically the nature and stakes of the demonstrative work carried out by the actors. I will then show the

[1] Author's address: CEMS-IMM, CNRS-EHESS, 54, bd Raspail 75006 Paris, France. Email: claude.rosental@ehess.fr. A preliminary version of this paper was translated by Nathalie Plouchard-Engel (nplouchard@gmail.com) and the members of the *Atelier de traduction des sciences sociales* (Denise Celentano, Elsa Forner-Ordioni, and Yolinliztli Pérez) at the Centre d'Etude des Mouvements Sociaux – Ecole des Hautes Etudes en Sciences Sociales in Paris, France.
[2] For additional empirical analyses and theoretical developments on this topic, see in particular C. Rosental, "Toward a Sociology of Public Demonstrations", *Sociological Theory*, 31(4), 2013, pp. 343-365.
[3] Apart from NASA, the names of the research groups, institutions and projects involved here have been changed for confidentiality reasons.

various uses of demos, as well as the constraints and conditions of possibility peculiar to this task. Finally, I will study the capitalist dynamics characteristic of this activity and the kind of demo-cratic regime it leads to. This will help document how the field of AI and computer logic research operates in Silicon Valley, bringing together researchers, scholars, entrepreneurs, and representatives of various military institutions. In particular, I will show that demos are one of the main means by which these actors structure their activities and relations.

The Orion project

The Orion software has been developed to plan and analyze spacecrafts' trajectories by gathering information and basic programs from a database of the US space agency on the solar system and its dynamics, the SPACE library. This computer program could perform calculations useful for determining the respective positions of the celestial bodies and a spacecraft at a given time. Its advanced versions allowed users to visualize simulated trajectories as video animations and to formulate, with diagrams, problems relating to the optimization of a probe's position in space.

Astronomers and astrophysicists defining and organizing space missions were among the first users Orion's developers had in mind. These scientists had indeed to reconcile their goals and their constraints of observation of various phenomena in order to define a flight plan. Prior to Orion's development, calculations and single-use *ad hoc* programs used to be designed for each space mission. Among other things, Orion thus limited the budget and the amount of time invested in the writing of computing software.

More precisely, Orion's working principle was that the software made it possible to translate a question formulated as a graph into a logic problem. For instance, the question could be: where on Jupiter does the moon Io cast its shadow as observed by the spacecraft Voyager 2 at time t (given that the various bodies are moving and that the speed of light is known)? An automated theorem-proving software incorporated in Orion, called STAR, offered a logical treatment of the problem, which was later translated into a computer program. Once activated, this program answered the initial question by using SPACE data and subroutines. The latter was managed by a group of NASA engineers, the CANDID group.

For its designers, STAR was Orion's engine. The data and subroutines provided by the CANDID group were processed by STAR. This block diagram corresponded to an institutional reality in the development of the project. The latter had been launched by a group of AI researchers and engineers from one of NASA's major research centers. From 1993, this small group based in Silicon Valley, later called BETA, had started collaborating with a team of software engineers from another Silicon Valley research institution, named FLI. This team had already developed a version of the automated theorem-proving software STAR. Its adaptation within what would become the Orion project had formed the basis of a collaboration with the BETA group. While the cooperation between the FLI team and NASA's team was central to this initiative in 1994, it would no longer be the case later on, as the project evolved and branched out. Many other groups had been contacted and had been more or less strongly involved. There is no need here for further clarification since the analysis will mainly focus on the work carried out by these two teams from 1993 to 1994.

Destination ~~Saturn~~ demo

Research work in logic is often viewed essentially as a solitary, deduction-based mental activity. Started in fall 1993, the collaboration between the FLI group and the NASA group was completely different. After a series of preliminary tests deemed promising by the teams, the aim was to adapt the STAR software to NASA researchers' specific problems and goals. Among other things, this approach entailed writing and re-writing computer programs, organizing work meetings, and exchanging emails, sometimes on a daily basis, since the two research centers were located a few miles apart. The emails dealt in particular with the progress of the research and conveyed a wide range of information requests and transmissions.

Initially, this project mainly involved two researchers in logic at FLI, together with a computer engineer and a researcher in AI at NASA. The latter was the main project leader. Many engineers and researchers subsequently participated in the project to varying degrees. The research therefore had a significant collective dimension. However, it was also characterized by an extensive experimental and observational work[4].

In the early months of the collaboration, FLI researchers made adjustments to STAR so that it could solve astronomical problems usually formulated in preparation for space

[4] As Jean Largeault states in *La Logique*, Paris, Presses Universitaires de France, 1993, p. 117: "The fact that there are logics destroys the apriority of classical logic, just like non-Euclidean geometry destroys the *a priori* rational nature of Euclidean geometry. […] Pluralism is surprising because we are used to associate formal with *a priori*, and because the *a priori* is necessarily unique […]. This plurality is less unsettling if logic is viewed as an observational science. It all depends on what one decides to focus on and what observation reveals."

missions (for instance: Where does celestial body A cast its shadow on planet B as observed by the spacecraft at time t?). The experiments focused in particular on the choices of heuristic strategies adapted to the "application" domain for the theorem-proving software and on the formulations of axioms able to produce "satisfactory" results. The researchers studied the behavior of successive versions of the software in specific cases – especially its difficulty finding solutions based on problem formulations – and the nature of the solutions STAR possibly suggested.

This work soon entailed searching for some "good" examples. To be deemed "good," an example had to tackle issues commonly encountered while preparing space missions. But these issues also had to be addressed and resolved by the software prototype, and this more quickly than with the material and human resources used until then. A list of some fifteen "convincing" examples has thus gradually been drawn up.

In other words, the actors' work and the very nature of the prototype were straightaway strongly structured by the prospect of having to make "convincing" demos in a relatively short period of time. These demos were meant to justify the research activity both within the institutions involved and without – we will come back to this. With fifteen examples or so, the protagonists were *a priori* able to show the "operational" as well as "promising" nature of their research in a few minutes.

Is a demo a public experiment?

One of the first demos could, for instance, take place as follows. To exhibit the running of their prototype, one or more participants in the project would visit its potential users – scientists in charge of the definition of probe trajectories or computer engineers from large high-tech companies possibly interested in adapting the software to other purposes. The representative/demonstrator (when alone) would present the operation of the software in a series of previously selected cases, from a computer workstation and in front of a small audience. He could for instance show how to calculate the position of the moon Io's shadow on Jupiter as observed by the spacecraft Voyager 2 at time t. With the right graph, he would present how one should formulate this question, before emphasizing how quickly the software processed the data to provide a response on the screen (a few seconds, for example), which he would then print out.

Following this series of displays, the demonstrator could invite the members of the audience to try out the software. In his presence, the viewers would practice formulating problems more or less predefined by the representative/stage director. The latter could suggest reformulations of a problem to the users if the software didn't provide any solution. Like the preliminary presentations, these exercises would often be punctuated by intense exchanges, partly determined by the scenario and questions concocted by the demonstrator.

Describing demos as public experiments, in keeping with many works stemming from the social history of science[5], might lead to misunderstandings about the nature of the phenomena involved. The use of demos is quite different from the trial and error process laboratory work is based on. The aim isn't to experiment in the presence of an audience with the running of a device. Rather, it is to enact a long-prepared scenario. The aim is to present a show or, more precisely, a demonstration. I use this term to refer to an activity at the crossroads of a proving process (aimed at proving that a software and an approach to computer logic "work" well) and an ostentatious practice (displaying a product with unexpected, even unprecedented results, and emphasizing how valuable they are)[6]. In this sense, demos have properties characteristic of more traditional logical and mathematical demonstrations, in written form[7].

Like the latter, demos enact the demonstrator's disappearance at certain times to insist on the objective nature of the statements, while they enact his/her reappearance at other times to showcase the demonstrator by transferring the credit of the results to their author. Demos also entail a long preparatory work. Moreover, they have a fully scriptural dimension. Even if demos don't consist of written productions, they do rely on a script. While paper-based demonstrations have to lead the readers, step by step, from the beginning of the text to its end, demos tend to guide the viewers in an even stricter fashion. The readers of written demonstrations can easily skim one or more steps of the demonstration, dwell on them, or skip them altogether, whereas demos force their viewers to follow elaborated displays and questions, which unfold within an inescapable timeframe. In this sense, demos bring to light a fundamental dimension of a formalist project for logical demonstrations, showing everything

[5] These works mainly focus on the experimental sciences. See, for instance, D. Gooding, T. Pinch, and S. Schaffer (eds), *The Uses of Experiment*, Cambridge, Cambridge University Press, 1989.

[6] A systematic sociological analysis of ostentatious practices is essential. See, for instance, E. Claverie, "Voir Apparaître, Regarder Voir", *Raisons Pratiques*, Vol. 2, 1991, pp. 1-19; L. Daston, "Marvelous Facts and Miraculous Evidence in Early Modern Europe", *Critical Inquiry*, 18, 1991, pp. 93-24.

[7] See C. Rosental, "Certifying Knowledge: The Sociology of a Logical Theorem in Artificial Intelligence", *American Sociological Review*, Vol. 68, 2003, pp. 623-644.

so as to allow everyone to see the legitimacy of each step of the demonstration. Demos even offer additional means for undertaking this project, more rigorously than written demonstrations.

However, more often and more visibly than in the past, demos lead logicians to set up spectacular forms of demonstrations, akin to those used in the seventeenth-century French and British experimental sciences, which served as a basis for the exchanges between the learned world, entrepreneurs, and political or religious authorities[8]. While managing to prove an important theorem – after a long demonstration as ingenious as unexpected – may be considered spectacular by logicians, demos generally aim to highlight the exceptional performance of a device and its underlying approach.

Demos on and off stage

Given all its characteristics, the use of demos strongly structures researchers' workspace. In particular, it institutes a specific divide between the laboratory space and the "outside," giving a particular meaning to the closed world of research centers. Since preparing demos involves a considerable investment in time and energy, given how important demos are in sustaining research activity, as I will show, the laboratory space is ultimately left off stage, while the "outside" takes center stage since it is often where demonstrations are performed [9]. To run "convincing" demos, participants in the Orion project had for instance to tactfully address some uncertainties on the potential results of their research. Marked by doubts about the positive outcome of the experiments, their interpretation, and the success of a set of heuristic strategies, laboratory work contrasted with the confident attitudes suitable for running demos.

Likewise, comparisons between the time the Orion software required to solve problems and the time a programmer needed to accomplish the same tasks were statistically analyzed by the research teams. The selection of the problems considered, the nature of the problem formulations on Orion, the power of the computers used, or the experience of the programmers making the comparisons were all decisive factors in the production of statistics favorable to the new software[10]. The mere fact that the time it takes to print out the results

[8] See in particular C. Licoppe, *La Formation de la Pratique Scientifique. Le Discours de l'Expérience en France et en Angleterre (1630-1820)*, Paris, La Découverte, 1996.
[9] In other words, actors tend to be in fact immersed in dramaturgical action rather than in communicative action. About these categories, see J. Habermas, *The Theory of Communicative Action*, Boston (MA), Beacon Press, 2 Vols, 1984 and 1987; E. Goffman, *The Presentation of Self in Everyday Life*, London, Penguin Books, 1990.
[10] Some AI researchers are well aware of the importance of the opacity of the criteria for comparing the performances of devices and the non-systematic nature of comparative approaches in the financing of research.

wasn't taken into account in the time comparisons and that demonstrators didn't insist on this data during demos was important in reinforcing the spectacular nature of demonstrations. This work added to the intense efforts, made day after day by FLI researchers, to reduce the problem-solving time thanks to clever axiomatic formulations and heuristic strategies.

Moreover, while for several reasons it might seem interesting for STAR's creators to present Orion as an extraordinary "application" of their approach to automated theorem proving, this description covered a complex reality, difficult to grasp for whoever wasn't familiar with daily laboratory work. STAR had indeed been adapted according to the specificity of the computational domain and in particular to the kind of formulated questions and assertions. A great deal of work had been carried out to express at best the axioms at play. This contrasted with the fact that, in a demonstrative situation, STAR's independence of the "application" domain was highlighted or suggested.

Likewise, the automated nature of STAR's running could be supported during a demo all the more easily that the selected modes of problem formulation had been tested beforehand in daily laboratory life. Orion's solving of some selected problems could be fast and spectacular in a demonstrative situation since unsuccessful graphical translations had been performed and identified as such during preparatory work. Demos could thus largely eclipse the need to acquire a know-how essential to the proper running of the software. Through the graphical formulation of their questions, Orion's users in fact fully contributed to the solving of the problems they submitted. When the demonstrator "supervised" the viewers trying out the software during a demo, as later when they would be "supervised" by a user manual of the computer program, the semi-automated nature of Orion's running could appear unclear. While the existence of a graphical interface in the Orion software could be considered inessential during a demo, compared to STAR's role, its importance and the reasons for NASA researchers' considerable investment in its development are on the contrary more obvious.

Lastly, let me point out that the spectacular nature of a software demo could also be due to the seemingly unique dimension of the developers' approach. Indeed, demonstrators didn't always have to refer to comparable approaches to automated theorem proving or the reuse of preexisting software in order, for instance, to stress the reduced risks of investing in their project. Not always highlighting the substantial monitoring work carried out in their

See in particular H. Levesque, "If AI is an Experimental Science, Where are the Experiments?", Department of Computer Science, University of Toronto.

research field, especially by participating in various seminars and conferences or by reading relevant articles on a daily basis, could help give the image of an approach not only unique but also truly “revolutionary.”

The exploratory uses of demos

The use of demos marked both the structure of the researchers’ workspace and the management of their relations. Running demos was first of all a mode of presentation of self. Under certain circumstances, researchers in AI and computer logic could straightaway introduce themselves as follows: “Hello, nice to meet you. I’ll run a demo if you’d like.” The first meeting between the FLI team and the NASA group started this way. Following an email question asked by a NASA researcher about the approach implemented in STAR, FLI researchers immediately suggested that they met around a demo. The collaboration between the two teams was partly based on the performance of a demonstration.

The same holds true for the academic and industrial partnerships that had developed around their project thanks to civilian and military funding. For researchers, demos thus were a tool for meeting other actors, with a view to establishing exchange relations. Moreover, they were fully-fledged transactions: in return for a meeting granted, demonstrators rewarded their hosts with a device exhibition. For demonstrators, these forms of demonstrations represented not only an outcome of, or a milestone in, their theoretical and technological research, but also a form of door-to-door selling and a means for discovering institutions likely to offer new resources.

In fact, demos provided Orion’s developers with a Trojan horse in their struggle to ensure the success of their project. They could allow them to gain admittance to groups of potential users and then to convert them to a certain extent. When they analyzed the reactions to their demos, demonstrators could indeed collect data on their viewers’ possible expectations, on the ways they might appropriate the device, and on the adjustments to be made to the prototype to facilitate its adoption. This approach was essential to turn viewers into future users, letting them participate in the development of the project later on[11].

The involvement of the target audiences, through various forms of partnerships, was actually a valuable resource for adapting the device to future users as well as for helping users

[11] On this point, see also S. Woolgar, “Configuring the User: The Case of Usability Trials”, J. Law (ed.), *A Sociology of Monsters: Essays on Power Technology and Domination*, London, Routledge, pp. 57-99.

adjust to the tool – a practice commonly referred to as "supervision" or "training." A market was thus constituted, the prototype becoming a finely "targeted" product.

A central dimension of this work of demonstrative conquest lied in the numerous performances. Demonstrators acted as representatives, and even more often as business representatives, since "selling" their project was generally a priority. They went on the road, running demos in companies, in institutions, or at conferences. They visited various firms, tried to get funding from defense agencies, and showed the operation of their device in various NASA centers or at academic seminars and symposia. These were thus real demonstrative campaigns. The exploratory work was carried out in a systematic way. It involved covering a certain number of spaces to create a mass effect in terms of circulation of information about the project. It wasn't indeed uncommon for investment decisions to be made on the basis of indirect representations of the working of a device. Demo audience members acted as witnesses likely to share their views on the project within extended circles, beyond the exhibition sites.

As part of such door-to-door selling, demos were usually supported by other actions and forms of demonstration. Such was the case of more traditional talks, resulting in hybrid presentations, halfway between demos and standard lectures. Such was also the case of a few sentences exchanged with managers in offices or corridors. These sentences were aggregated in short, carefully prepared blurbs, which formed part of demonstrators' repertoires. Abstracts outlining the project were also distributed and sometimes featured on websites. Besides these research clips, intended to generate interest among busy "decision-makers," longer reports were written and circulated within the organizations.

It should be noted that these demonstrative campaigns weren't led by isolated individuals. On the contrary, they resulted from orchestrated action and involved the coordination of a group of demonstrators. The latter generally ran their demos in complementary spaces, in a concerted fashion. However, they also sometimes gathered to present complementary aspects of their project. This allowed them to enhance the spectacular dimension of the demo. Quantity added to quality. The speakers' experience could help impress the audience. The explorations of institutions then proceeded from demonstrations of strength[12].

[12] For an analysis of other uses of demonstrations of strength in a different context, see C. Mukerji, *Territorial Ambitions and the Gardens of Versailles*, Cambridge, Cambridge University Press, 1997.

In other words, while the demonstrative activity is usually perceived as an individual activity, demos were far from isolated demonstrative *coups*. They were performed in waves so as to cover a large number of spaces. This practice of demonstration wasn't peculiar to the participants in the Orion project. The latter came across their counterparts in the institutions they visited. Other demonstrators engaged in similar actions. Thus, representatives/demonstrators sometimes traded slides with one another to develop their demonstrations. Correlatively, universities, research institutes, and various civilian and defense organizations were the scene of demonstrative festivals. This seemingly unique phenomenon actually corresponded to a set of constraints and possibilities specific to the world of demonstrators. Let us look into the field of AI and computer logic research in Silicon Valley to clarify this.

Possibility conditions for the use of demos

The rise of computer science doesn't suffice to explain the development of the use of demos, compared to other, more traditional forms of demonstration. Technical determinism alone doesn't account for this phenomenon.

First of all, it should be noted that research institutes like FLI enter into civilian and military industrial contracts, often in collaboration with academics. Many research institutions in the United States, and in particular in Silicon Valley, also resort to internal contracting. The research conducted at NASA is no exception. For instance, the Orion project manager at NASA worked in the early 1990s as a consultant.

Demos prove to be a well-suited form of demonstration in this context. During internal and external evaluations, they enable researchers and engineers to show results more "tangible" than those featured in highly specialized articles, and this in a matter of minutes. These results can be grasped by busy and unspecialized managers. Demos also allow the latter to follow the progress of a project, often less perceptible in successive theoretical refinements, and thus to maintain their confidence in a middle-run research program. Moreover, they are suited to a project-oriented activity (and, as a result, to project-oriented evaluations), unlike a periodical analysis of a set of academic papers. They also complete the presentations of results in the traditional form of lengthy reports or in the form of abstracts presupposing that research managers are fond of reading, which is not so often the case.

In other words, the fact that some top researchers wear the sales representative hat in Silicon Valley is due to the low level of autonomy of the AI and computer logic research field, as well as to the importance attached to the research evaluation conducted by sponsors as much as, or even more than, that conducted by peers. The prevalence of the recourse to demos is closely linked to the kind of relations formed between learned practices and entrepreneurial approaches.

Furthermore, the identities of the actors in this research field aren't clear-cut. Many researchers are simultaneously consultants, academics, high-tech firm managers or executives, and defense advisors. Such is the case, for instance, of research institute members who are consulting professors at Stanford University or of philosophy professors at Stanford who are also consultants or CEOs. Managers have often had long careers in research and industry. Demos are thus a highly effective form of communication in this environment. They can indeed be employed in a "universal" way and can be capitalized, insofar as they can be used and *reused* in all facets of the actors' professional lives: to present theoretical results, technological accomplishments, or future high-tech products. This contrasts with academic papers, for instance, as the latter are mainly reserved for academic exchange.

Demos are so widespread that not using this form of demonstration has ultimately become improbable. They are thus one of the preferred operators for the management of social relations between the actors. They even greatly help maintaining the very specific links between research, industry, and federal administration in Silicon Valley, which have been developing for several decades[13].

Admittedly, demos have other properties. First of all, they enable executives and managers to assess projects not only based on the opinions of third parties, called in as "experts" for the occasion, but also based on technological achievements they can judge for themselves. The limited time needed to attend a spectacular demo – all the more spectacular that the performance is well calibrated in time – offers evaluators a unique opportunity to apprehend (or to think that they apprehend) submitted projects, independently of guarantors. This is essential in a world where certain models of science prove to be particularly unrealistic.

[13] The essential role played by demos of course isn't in contradiction with the existence of a set of other factors determining the hybridization of the field. Such is the case for instance of many calls for proposals, which favor the financing of partnerships between universities, research institutes, and companies.

Indeed, knowledge and techniques aren't always assessed and certified in ideal conditions of infinite attention. On the contrary, evaluation often takes place within a very imperfect economy of time[14]. Besides, representatives of defense institutions seem predisposed to demos. The latter are in line with the traditions of spectacular demonstrations and demonstrations of strength underlying military events. However, unlike parades, they leave certain aspects of the projects in the dark, thereby protecting "secrets" about the working principles of the devices. Demos also perfectly embody the logic of showcase building characteristic of consultants' success stories, since they are based on so-called "exemplary" cases, presented as tremendous successes. This form of demonstration is most useful in a world where subcontracting (another term sometimes used to refer to outsourcing or to the recourse to consultants) has become widespread, including in research, and where the actors have to account for their activity.

Demos thus constitute an ideal medium between, on the one hand, the world of laboratories and the uncertainties of the research process and, on the other hand, the world of "decision-makers" seeking the most certain scenarios. The self-assurance demonstrators generally need to meet these expectations, when they comment on their demos, largely helps bridge the gap between the two worlds[15]. Through these repeated opportunities and experiences, demos ultimately tend to convey unrealistic representations of science. As the doubts punctuating the research process have to be laid aside, facts are hardened, assertions are turned into statements without history, and progress becomes inexorable.

Learning how to demonstrate

This phenomenon is primarily due to the fact that the art of demos is something one has to learn. Demonstrators' assertiveness is part of the attitudes acquired through a long learning process. This learning is partly self-taught. The corresponding know-how isn't taught at universities. Demonstrators acquire their skills partly by themselves while running demos. What takes place is thus a lifelong learning, fueled by experience.

Mimicry is another dimension of this learning. A corporatist transmission of know-how is a vehicle for this process, although it can't be reduced to this aspect. Whereas the

[14] See in particular C. Rosental, "Social Studies of Evaluation", *Social Studies of Science*, 40(3), 2010, pp. 481-484.

[15] This explains why the demos developed in the United States often yield different results when they are run in France: faced with more mistrustful, even defeatist, approaches, demonstrators' attitudes may be viewed as suspicious and presumptuous, to the point of being counterproductive. See in particular C. Rosental, *Weaving Self-Evidence: A Sociology of Logic*, Princeton, NJ, Princeton University Press, 2008.

generations who experienced the "beginnings" of computer science in their early careers could count only on themselves, the same can't be said about the following generations. For the latter, the art of demos can be passed on in the form of advice as well as that of hierarchical incentives. Both project leaders and research managers, who are often also chief demonstrators, take care of the supervision. They are usually the first to encourage researchers to present their projects as success stories.

This effort is already evident in the recruitment criteria of Silicon Valley. The know-how required to run demos is part of the abilities needed to get hired. Young recruits can generally develop their skills under the guidance of chief demonstrators. Often good scientists, good managers, good project leaders, and good representatives, with a large number of contacts, chief demonstrators are able to determine whether the possible demonstrative scenarios are more or less appropriate for the target audiences. They can also identify the finest adjustments to be made in each case. Even though demos have a polysemous nature, so much so that one demo may be apprehended very differently from one viewer to the other, the fact remains that their adaptation to various audiences is an important aspect of demonstrators' work to make sure that demos are efficient.

Chief demonstrators' in-depth knowledge about institutions, the identities of the preferred intermediaries, the context, diplomatic bias, clan oppositions, procedures for preparing the "field," or the appealing theses and displeasing remarks is a valuable resource for ensuring successful demonstrative events. This is why chief demonstrators can teach demo lessons and orchestrate the demonstrative effort. This is also one of the reasons why the demonstrative repertoires seldom have a singular dimension, despite what the register of the spectacular may suggest. Quite on the contrary, the similarities between various demo commentaries are noticeable and originate in the collective dynamics governing their development.

Demos under constraint

If demonstrators invest so much in demos, it is also because the prototypes built on this occasion are often end products. It generally isn't easy to distinguish between a demo tool and an end product, insofar as the fast development of computer science plunges the actors into a system of permanent transition. The stakes of demos are so high that demonstrators are often keen to master the software before displaying it in public. It usually seems more efficient to show a device with previously identified bugs than a tool improved a few days earlier, whose behavior may be more uncertain. Given the time needed to be familiar with the running of a device, the tools used in demo campaigns are frequently "frozen" into software versions.

The Orion project's demo campaigns were thus carried out around deliberately "frozen" versions of the software. Stabilizing the device in successive versions, with ever more interesting features, allowed demonstrators to give credence to the idea that their research could yield "concrete" results within a "reasonable" period of time. Far from representing a mere medium for public experiments, demo tools could therefore lead to commercial transactions, be legally protected, and capitalized as products.

However, the Orion project's demonstrators couldn't disregard the legal risks overly triumphant claims involved. Preparing demonstrative repertoires thus meant considering a potential endangerment of persons and goods. For instance, participants in the project had to know whether the calculation of spacecraft trajectories by the software might lead to human or financial losses due to the failure of space missions, and whether the occurrence of such disasters might be attributed to the software developers. The important role played by lawyers in large high-tech companies and their frequent intervention in the formalization of partnerships offered demonstrators a strong incentive to be cautious, which tempered their pursuit of the spectacular.

Running demos was also sometimes constrained by the logic of software licenses. The first Orion demos thus necessitated equipment transportations or remote connections, in order to be able to use a little-distributed and expensive software required by Orion. Faced with this constraint, demonstrators were forced to circumvent obstacles and to adjust their software and their demo. The content of demos was also dependent on situational phenomena. For instance, the development of the first Orion demos was closely linked to the difficulties NASA encountered in the early 1990s. Following a series of incidents that caused human losses and problems in large-scale space explorations, demonstrators had to highlight various advantages offered by their device, such as a better reliability, better safety conditions, and a reduced cost of mission preparation. The scenarios of demos therefore emphasized the automated nature of computational software production, which limited human intervention and "consequently" error risks and skilled labor costs[16].

[16] On a similar dynamic, see D. MacKenzie, *Inventing Accuracy: A Historical Sociology of Nuclear Missile Guidance*, Cambridge (MA), MIT Press, 1990.

The content of demos was also determined in part by the dynamics of recognition of everyone's contribution. In the case of the Orion project, the balance of power and the alliances were such that engineers/researchers weren't in a position of weakness compared to theoretical researchers[17]. This is why Orion was most often presented as a both technological and theoretical event. Therefore, the paternity and nature of the project generally weren't associated as a priority, by this reductionism as blazing as it was usual, with the group's logicians and the power of mathematical logic, although the varying audiences sometimes led demonstrators to influence the distribution of credit granted to each person.

Likewise, the commentaries provided during or around demos handled carefully the potential or actual partners of the project, such as the CANDID group programmers. Great attention was paid to the description and the highlighting of the progress associated with the development of the Orion software. Indeed, owing to the distribution of, and capitalization on, the credit demos implied, the actors were fully aware that demos could maintain, strengthen, or damage the relations and exchanges between the individuals or teams[18].

The formation of demo-cracy

The supporters of various theories of, and approaches to, computer logic and AI commonly use demos to compete with one another. Indeed, demos enable them to highlight the value of a learned position commensurate with its technological achievements[19]. However, demos can also be useful to an institution like NASA to justify its spending to the public and federal authorities. In the 1990s, this phenomenon was all the more noteworthy that NASA had to tackle a series of tragic accidents and incidents, as mentioned earlier. In this context, an adaptation of demos to novice audiences was an asset for the space agency.

A few years after the Orion project was initiated, demos were thus modified to become accessible to the general public and were introduced on websites. These adaptations were designed for science enthusiasts, amateur astronomers, elementary and high school students and science teachers, as well as all those who, while browsing the Internet, might stumble across NASA websites. These websites included images and animations presenting the past,

---

[17] This phenomenon is rare in the history of computer science, where theorists generally seem dominant within theoricians-engineers pairs, before their frequent divorce. See P. Lévy, "L'Invention de l'Ordinateur", in M. Serres (ed.), *Eléments d'Histoire des Sciences*, Paris, Larousse-Bordas, 1997, pp. 761-794.

[18] The same applies to other "clips" of research, such as abstracts featured on websites.

[19] For comparison, see how counting frames and calculating machines have been vehicles for the development of mathematical analysis in nineteenth-century England in A. Warwick, "The Laboratory of Theory or What's Exact about the Exact Sciences?", in M. N. Wise (ed.), *The Values of Precision*, Princeton, New Jersey, Princeton University Press, 1995, pp. 311-351.

present, and future views of the planets from space probes or the dynamics of the celestial bodies. These images and video clips were realistic simulations generated by recent versions of the Orion software, calculated thanks to NASA's data on our solar system. The first demonstrative scenarios were reworked. In particular, earlier commentaries and oral instructions were partly modified and transcribed into brief accompanying texts. Some presentations were also repurposed and featured on the websites.

What was initially a demo instrument, before becoming a work tool for the preparation of space mission, was thus again turned into a demo tool for the general public and, as I will explain, into a work tool for schools and high schools. Just as the line between demo tool and end product is easily blurred, so too is that between an exhibition tool and a work tool[20].

NASA researchers capitalized on their demonstrative effort while developing educational software. NASA has long targeted the educational world when leading its promotional campaigns and looking for supporters. Demos and their adaption on the Internet lend themselves quite well to scientific vulgarization and pedagogical situations. In the case of the Orion project, demonstrators turned their demo scenarios into introductions to astronomy for elementary and high school students. By logging onto NASA websites, teachers could thus have access to "exciting" audiovisual material to explain solar-system dynamics to students sitting in front of computer screens. Demonstrators developed educational scenarios based partly on "space conquest" news, fed by series of questions and answers, with data inputs and videos, calling for exchanges between teachers and students.

Scientists-turned-educational-software-designers asked high school teachers to share their feedback on the pedagogical scripts by email, so that they could produce improved versions. Demonstrators thus continued to look for ways to collect data on future partners' practices, to develop both their software and the educational practices, as well as to build a network and "market" around their "product."

This work was actually beneficial to the institution in several ways. As mentioned earlier, adapting demos helped promote the institution. Tangible results of its expenditure were thus displayed. Alongside demonstrative scenarios, FAQs[21] emphasized the benefits of space missions, their drastically reduced costs, and the attention NASA paid to public money. The message was delivered to an ever-increasing public, interested in "space adventure" news

[20] Not that the help menu of the most common software often use demos to guide users.
[21] Frequently Asked Questions.

and animations, as evidenced by the growing traffic overload of the websites. Besides, the increasing demand for the quick display of pictures taken during space missions and the high number of questions on the uses of NASA's budget illustrated that the "general public" was prompt to request accountability as soon as the opportunity arose.

Scientists' relation to the public has been evolving. Researchers are often almost on the frontline when it comes to managing the public representations of their activity. Extending their demonstrative activity involves, among other things, the right to scrutinize the production of the laboratories and, consequently, a democratization of science, which can't be reduced to an access to its sole concepts, in an ordinary vulgarization approach. However, adapting demos offers additional benefits to NASA and its partners. Alongside animations, webpages are dedicated to selling space mission-related merchandise, such as postcards or spacecraft models. The promotion work demos do for the institution thus also supports lucrative activities, in a fashion similar to the practices that characterize the exploitation of Hollywood movies.

NASA is a capitalist scientific enterprise, at least because it capitalizes on the demonstrative effort made within it. The capitalization on demonstrations takes place over a longer timeframe and is more protean than it may seem at first. Researchers/entrepreneurs aren't the only ones capitalizing on their demonstrations, in particular by developing products or by accumulating various forms of credit. An institution like NASA also benefits from this, just like its leaders, who have to account for its budget. Altogether, a demo-cratic regime, very specific by comparison with Tocqueville's democracy model, seems to have emerged in the United States[22]. It sanctions not so much the general public's power and right to scrutinize the closed world of laboratories, as that of demos and their preferred users, the new capitalists of science.

[22] See A. de Tocqueville, *Democracy in America*, Chicago, University of Chicago Press, 2000.