Algorithms & Power Systems Architecture:

Using Historical Analysis to Envision a Sustainable Future

Oral History Project

Interviewee: Jean Mahseredjian

Interview Date: July 19, 2023

Place: Hyatt Regency Orlando, Orlando, Florida

Interviewer(s): Julie Cohn, Sairaj Dhople, Daniel Molzahn, Rahul Gupta

Transcription: Temi.

Keywords: Jean Mahseredjian, Hermann Dommel, Bill Tinney, Electromagnetic Transients Program (EMTP), Hydro-Québec, L'Institut de recherche d'Hydro-Québec (IREQ), Réseau de transport d'électricité de France (RTE), Électricité de France (EDF), transient stability analysis, electromagnetic transients, computer hardware, computer software, power system simulation, Windows computers Bonneville Power Administration (BPA), Transient network analyzer (TNA), graphic user interface (GUI), Vladimir Brandwajn, Fernando Alvarado.

***Abstract*:**

Jean Mahseredjian begins by describing his educational training at Polytechnique Montréal, and his early career in the research group (IREQ) at Hydro-Québec. He discusses developing and commercializing the Electromagnetic Transients Program (EMTP) software for simulating and analyzing power systems. He explains some of the features of the software, now used by utilities around the world. He discusses the early challenge he took up to rewrite software originally developed for an older generation of mainframe computers, in order to do transient analysis on the newer computers becoming available in the late 1990s. He notes that there is an array of problems that can now be solved very accurately for systems that include wind turbines and solar arrays, including contingency analysis and voltage collapse. He mentions that senior engineers were skeptical of his efforts. He describes developing ways to solve complex problems and develop new generation software (electromagnetic transients program – EMTP – software) using advanced numerical methods and programming

techniques. He built on earlier modeling schemes that were limited by older hardware that was slower and had less memory. He explains that his work on software developed in parallel with the evolution of hardware in the computer industry. He discusses sources of financial support, his relative isolation as one of very few engineers working on the simulation of electromagnetic transients at the time, and he mentions others with whom he collaborated, especially at Hydro-Québec. He explains that Transient Network Analyzers (TNAs), while useful, were problematic because they were easily disturbed by, for example, a lab cleaning crew that unplugged cables. He discusses marketing his software to industry, focusing on its superiority to other tools and replacing phasor domain methods. He mentioned that his company provides the EMTP to universities for free. He further explains that his software is useful for modeling grids that are 100% renewable, and that he anticipates seeing multiple types of analysis – protection, socioeconomic, load-flow, etc, combined into a single tool with a single graphic user interface (GUI). He closes by encouraging young engineers to get involved in power systems and to work very hard.

Note regarding Transcript and Timestamps:

Timestamps appear in the transcript but may not align with the recording. Pauses and interruptions may have been removed and the overall length of the recording may be reduced.

[REMOVED FROM TRANSCRIPT: casual conversation]

Julie Cohn (00:01:52):

This is Julie Cohn. I'm conducting an interview with Jean Mahseredjian on Wednesday, July 19th, 2023, at the Hyatt Regency Orlando in Orlando, Florida. With me are Daniel Molzahn, Rachel Harris, Sairaj Dhople, and Rahul Gupta, all of whom may ask questions during the interview. During today's interview, we're especially interested in your early work on electromagnetic transients and how you see this evolving with the future grid as related to stability and control. But we'll begin with some introductory questions and general background information about you. So, if you please, would you describe your educational background and your professional positions in the field of electrical engineering?

Jean Mahseredjian (00:02:40):

Well, I had studied at the University of Montreal—the Polytechnique Montréal is the Engineering School of the University of Montreal—and I did my bachelor's degree there, and I did my master's degree there, and I did my PhD there. So, then I finished my PhD, and I went to work for Hydro-Québec, the research center. That is called IREQ and there I stayed; I worked there 17 years. And then, in 2004, I left Hydro-Québec to become professor at my university again, and I have been there since then.

Julie Cohn (00:03:17):

So, do you see yourself more as an academic, as somebody—as an industrial person, as somebody who bridges multiple worlds?

Jean Mahseredjian (00:03:25):

Well, my love is academic. But recently because of what I did—developed a software that became commercial—I decided to join the organization that is in charge of the commercialization. And I became the CEO of the local company that is in charge of that, because, before, I was just receiving development contracts. And with this approach now, I'm managing also everything in the company. So, I started liking it because you realize that there is some aspect there that is really—business is something. And also, when I was at IREQ, it was an industrial organization. I mean, we were doing research, but it was really something that they needed, so it was applied. So, we had access to practical data, practical problems. So, I always like practical problems.

Julie Cohn (00:04:10):

So, you really are a hybrid? <laugh>

Jean Mahseredjian (00:04:12):

Yeah, in a way, yeah.

Julie Cohn (00:04:14)):

Yeah, yeah.

Sairaj Dhople (00:04:14):

Can you say a little bit more about your company and what you all do?

Jean Mahseredjian (00:04:17):

The EMTP company is basically—well, you can check the story if you type wiki, EMTP. You'll see the story. Basically, that company is in charge of developing and commercializing the software. So, the company has people that do marketing. It has also people that are in charge of web and people that are in charge of accounting. And we have a legal—we pay contracts for legal people, which is my daughter. She works in a company—, she's a lawyer. And then we have people that are developing the software. And me, I'm the CEO. But the thing that I like the most in my life is to develop software and write code, so if you take that away from me, I'm not very happy. <laugh>

(00:05:00): So, I still work a lot. I code a lot of lines of codes every day, and I'm in charge of the official version of the software. Everything that gets released goes through me. It's crazy amount of work, but I don't see myself—for the moment at least—abandoning that part of my life.

Sairaj Dhople (00:05:18):

And can you tell us a little bit about what this software does?

Jean Mahseredjian (00:05:21):

EMTP is a software that basically simulates power systems. Like, you want to simulate if you had an oscilloscope. So, it gives the full signal. It is unbalanced. It is a circuit-based software. So, with that, you can do very accurate things, and it's becoming more and more popular because the demand of that kind of accuracy—especially with the inverter-based resources—it's very high right now. So, the software starts from a load flow solution.

Jean Mahseredjian (00:05:50):

There are some unique features in my EMTP. So, it starts from an unbalanced load flow solution that is used for initializing everything. So, we initialize the synchronous machines. From that we initialize the controls of the synchronous machines. We also initialize the wind turbines, the PVs, and we start with wind turbine power electronics—initialization is complicated. It takes more time, but we are achieving below 200 milliseconds of initialization right now, approximately. Then we go into steady state, and we can apply faults, and can see the exact waveforms. So, it's very powerful because basically the next step is to go into detailed magnetic circuit simulations, which are not needed because you are not designing apparatus. So, it's very, very accurate. And you can also do transient stability very accurately. You can do load flow. You can do contingency analysis. You can do voltage collapse if you want.

Julie Cohn (00:06:40):

And is it used primarily for simulation, or are there applications on actual power systems?

Jean Mahseredjian (00:06:47):

Yeah. For example, this software, you will see it in utilities around the world—we are talking about thousands of thousands of clients—and what they do is they simulate the power system. Like in Hydro-Québec, or in France, or RTE, EDF, they will simulate their power system. They will put a lot of details.

They will do faults, transformer energization, transient stability analysis, integration of wind turbines. We also do other things like scan in frequency domain to find the unstable conditions. We now also are moving into the development of eigenvalue analysis into the package. So, I got also lucky because in my university job, I got a chair with Hydro-Québec, RTE, EDF, and OPAL RT—it's a company in Montreal. And also, the Canadian government NSERC—basically the equivalent here of NSF—I teamed. So that chair has been lasting for a while; it'll finish the 10th year, 2024. So, like every year I have—now I'm starting to reduce because I'm getting old—but basically, I always had like 20 students: 12 to15 PhD research associates. So, it's a big team.

Julie Cohn (00:08:04):

So, looking back, what would you say was the most difficult or interesting technical problem you'd tackled early in your profession; early in your career?

Jean Mahseredjian (00:08:16):

Well, when I was young, I started working at IREQ. In those days, computers were nothing. You guys, you don't know, you're so lucky today. So, we had cards, for example, or we had that kind of stuff, or tapes. And it was very, very limited. But me, I always thought that this will be the future. And usually, so far, I have been lucky. I'm able to very well predict what will happen. So, then I started—I always wanted to do this thing: transients—and then I joined a group that was already working on that in the old days; this is the old EMTP. And so, then I told them, "I want to rewrite this thing because it's very old, it's old technology, old computing systems." And it took a lot of time to convince them to allow me to do it because I was young, and I didn't have a lot of credibility.

(00:09:02): But then I gave them prototypes. And so, eventually, I convinced them to do it. Then the funny thing is that you start doing something like that. In many organizations—but sometimes it's also cultural—is that they start telling you, You cannot do it, it's too complicated, you will never finish, it'll take—so, they discourage you. But me, because of my background in Armenia, when we say, We do something; we do something. It's not a joke. <laugh> But the more they told me that, the more I started working harder and harder. So, I must admit that it was too much. It was crazy. I don't know how I'm still married—35 years now. <laugh> Especially at the beginning, the babies—two girls—were born, and I was always working all the time. Sometimes I was feeding them, but basically. <laugh> So, my wife took care of many things. So, yeah, it was really challenging to cope with all that. Also, all the people that tell you, You cannot do it, you cannot do it. And eventually, when it succeeded, they were really surprised.

Sairaj Dhople (00:10:00):

So, what aspect did you rewrite, or what aspect did you read?

Jean Mahseredjian (00:10:04):

Well, the old software had many problems. For example, if you simulate a power system like that, you need to have a fully nonlinear solver; it could do pieces in nonlinear, not the rest. It was not object-oriented; it was the control system solver. Because we solve control load diagrams with our product—if you're familiar with that—they have to put delays in the loops to break the loops manually, or that kind of stuff. So, I came up with techniques to avoid all that: computation performance, the quality of machine models, transmission line models; I mean, name it and it continues. We all continuously improve. So, it was quite challenging to do it because everybody also said that, Don't do object-oriented, it's not good. You know how it is. It's like, because I was surrounded by older people, they didn't want to.

Daniel Molzahn (00:10:55):

So, what timeframe was this?

Jean Mahseredjian (00:10:57):

I took like almost two years to get all the funding to convince them and to give me the money, because there were many people there. There was the Japanese organizations, there was several American organizations, there was EDF in France, then RTE, there was also even at some point some Brazilian organization. And so, it took like a couple of years before I convinced them to give me the money. Meanwhile, we were maintaining the old EMTP on Windows—I don't know if you know Windows 11 or Windows 98, or maybe you were not born in that time—but basically that—

Daniel Molzahn (00:11:28):

<laugh> <inaudible> not that young.

Jean Mahseredjian (00:11:30):

Well, them maybe. And her maybe. We don't know. <laugh>

Julie Cohn (00:11:34):

I was born first. <laugh>

Jean Mahseredjian (00:11:40):

So basically, it was taking too much time to convince, because they have to give you the funding. But Hydro-Québec was very good in backing me up and telling me, Yes, we need it. Because there's the research center, and then there's the people downtown, and the people downtown trusted me fully. They said, We need it, we need it, do it. So, then I got the funding. I started developing coding in 1998. Initially, I was all alone because it's difficult to find people, , so for about two and a half years, I was kind of alone. Then it finished in 2003. So overall about five years.

Julie Cohn (00:12:13):

So, for the non-engineer in the room.

Jean Mahseredjian:

Yeah.

Julie Cohn (00:12:19):

<laugh> Were you rewriting the software because the hardware was working differently, or were you changing the underlying sort of algorithmic logic at the same time?

Jean Mahseredjian (00:12:31):

Well in these years—in the nineties, like, when we had Windows computers and that kind of stuff—the computing changed a lot. Because initially, we had only mainframes—for example, VAX computer, that kind of stuff—so that change of personal computers became a big thing. And the codes that we had were not designed to work on that kind of computers. Moreover, there were terrible codes, because most of these codes were done by pure engineers that will code it like a calculator. They will say, D1 equals something, D2 plus D1 equals—. So, it's not the way you develop software. And it was almost not maintainable anymore—except for some people like me that knew it—but it's a big code. And with the computer architecture changing, you have more memory, more capabilities, so you realize that you can do much better.

(00:13:14): And also, the numerical techniques, I worked a lot on improving them. So now I started coding with new techniques.

Sairaj Dhople (00:13:31):

Did you have a computer science background?

Jean Mahseredjian (00:13:33):

Not really. But I am an electrical engineer; that's the thing I like the most: numerical methods, mathematics. And I spend—now I'm really getting obsolete, I'm getting old—but I spend a lot of time learning. I know almost every language, so I learned, I like learning computing by myself. So, I learned a lot in those days because I wanted to have a professional code, not a joke. So, I learned over time the programming. I did all by myself. So, it has to—otherwise you cannot do it. It'll not become industrial grade; it will eventually fail. But, it's succeeded; I'm so happy. My company has about—now we're getting close to 18 employees.

Julie Cohn (00:14:09):

That's great. So, was there an underlying logic though that you did seek to carry over from the older way of doing things, or did you also upend that?

Jean Mahseredjian (00:14:21):

In a way without—I don't want to downgrade what was done before; they did many excellent stuff. And a lot of the research that was done before on many things, like models, contributes to what I did. Of course, I didn't develop the same way, I didn't code the same way, but it contributed. But honestly, there was no reason to keep what we had because it was too old, and it was so limited in a way, it has so many problems: memory allocation. In those days, they were allocating memory by coding this—they would put in an array hard coded—that kind of stuff, computing—so all the typical stuff that you need to do in a software development process was not there. But all the technology, for example, if you look at the transmission line model—I mean—we don’t invent the wheel, but we had new models that became much better. So yeah, you learn from this of course.

Julie Cohn (00:15:16):

So, were you like leading the industry into the new computer hardware, or was the industry adopting the computer hardware, then finding they couldn't use it?

Jean Mahseredjian (00:15:25):

Well, the hardware was evolving, so everybody was getting the idea that now there are many more possibilities. At the beginning, everybody was skeptical.

Julie Cohn (00:15:33):

Yeah.

Jean Mahseredjian (00:15:34):

Like, when I was starting this thing, they told me, Come on, Windows will never work, forget about it.

Julie Cohn (00:15:39):

Yeah.

Jean Mahseredjian (00:15:39):

I don't remember. IBM OS/2—you were probably not born—but this was an excellent operating system, but it died because IBM was not good in commerce, I guess. So, I developed also on that, and everybody said, No, no, it won't work, it is not good, it's gonna be slow. But it was obvious that for me, it was so obvious.

Julie Cohn (00:15:57):

Yeah.

Jean Mahseredjian (00:15:57):

So, the people that had computers, they eventually—everybody started moving to Windows. Unix started going away. Now, most engineers use Windows, or maybe Apple, but mostly Windows. So, it was evident that they will go there, and it was important to have a solution when they go there, so me, I started doing it. But it's like a tunnel. You enter into that tunnel and don't even realize you go, go, go, and eventually, you wake up, and you—I got lucky, very lucky also.

Julie Cohn:

Yeah.

Daniel Molzahn (00:16:31):

So, you're saying it was obvious that this was the path forward.

Jean Mahseredjian (00:16:35):

Yeah.

Daniel Molzahn (00:16:36):

Was industry thinking it's obvious, or was something—

Jean Mahseredjian (00:16:37):

Well, they gave me the support to do it.

Daniel Molzahn:

Yeah, yeah. Of course.

Jean Mahseredjian (00:16:42):

The many members were agreeing, but there were other people that were saying, It's an impossible job; because the previous one took maybe 20 years, I don't know. But in those days, they had limited resources. I don't know what to say, but many people were thinking that it will never finish. In the committee, for example, in that committee there was a Japanese member—and you know how Japanese are—if you say, "You're gonna do something"; you're gonna do something, —and, at the end, he says, "I do not understand why you are all afraid that it won't work, because he said it'll work, and I believe him." <laugh> So, he was very nice. He invited me to Japan. <laugh>

Julie Cohn (00:17:20):

That's great. Well, you mentioned that as you started this work, you were working alone, but then later you had collaborators, or—

Jean Mahseredjian (00:17:28):

Well, what happens in a research organization is not so easy, because you need to have resources, people to work with you. And sometimes people just kind of waiting to see, will this guy eventually quit or go crazy, <laugh> because honestly, the task was too much. It was effectively a bit crazy. So, then they saw that it makes sense, then I started having people. And then I needed a graphical user interface, because you can develop software, but if you develop software and you don't have a GUI, nobody will use it; forget about it. And me, I thought that developing a graphical user interface—it's gonna be easy. It's the worst thing you can ever imagine. Forget about complex mathematics. It's nothing. Nothing. So, it's a very hard job. But again, I got lucky.

Jean Mahseredjian (00:18:15):

I found a partner that was in Vancouver—actually doing things that were related to the way I want to do it—and then we hired him and he started developing with me. But the way it was done, it had open architecture, so I was able to change anything I wanted without calling him and evolved like that. So, I got lucky with the graphical user interface. And then I had—of course—a couple of more, but we were never more than four people overall in those days.

Julie Cohn (00:18:44):

Mm-Hmm. <affirmative> And they were all within your research group?

Jean Mahseredjian (00:18:46):

Yeah, yeah, in IREQ. Except this guy was in Vancouver.

Julie Cohn (00:18:49):

Yeah. In Vancouver.

Jean Mahseredjian (00:18:49):

Yeah. And I had also students because in those days I was—In Quebec, we say, Associate Professor, it means professor associate here; it's like an external professor. I don't know how you call it in US. You are adjunct teaching at the university, but you are not paid by the university, only for courses they paid.

Julie Cohn (00:19:05):

Right.

Jean Mahseredjian (00:19:05):

But you can have PhD students.

Julie Cohn (00:19:07):

Oh, okay. Yeah

Jean Mahseredjian (00:19:07):

So, I had master's and PhD that will come, and it was good because they were learning with me and coding so.

Julie Cohn (00:19:13):

Were there people in the industry who actually would sit down with you in the process, or were they sitting back and waiting for you to present the finished—

Jean Mahseredjian (00:19:20):

No, there was mainly Hydro-Québec that was checking very closely. Hydro-Québec has excellent level of expertise in everything; they are number one company. And several guys there that were really experts in magnetic transient simulations—used to use the old packages and things like that—were following me and checking the way I do things, but we were never too many. But I don't think it needs too many people because if you have too many, then you have difficulties managing, and then it takes exactly nine months to have a baby.

Julie Cohn (00:19:51):

<laugh> Yeah.

Sairaj Dhople (00:19:52):

Jean, why is Canada synonymous with EMTP?

Jean Mahseredjian (00:19:55):

Yeah, that's a very good story. I don't know. Very good question. I don't know. It's a bit funny because, in Canada, we have EMTP; we have PSCAD, which is another excellent software; we have RTDS, excellent software; HYPERSIM, which is a real-time version, excellent software; then we have—I don't know if there is more, but there are many. For some reason in Canada—it must be something in the water, I don't know. <laugh> I don't know; honestly, it's funny. But it is also a bit funny because initially a lot of work started in BPA. And then people left BPA and it kind of shifted towards Canada. In fact, one of the initial guys—professors—that left came to Canada, and then many things shifted to Canada, kind of. But it could have stayed in BPA in the US.

Julie Cohn (00:20:45):

Who is that?

Jean Mahseredjian (00:20:46):

And there is a guy that still develops the old version that we abandoned that is in BPA; he retired now. His name is Scott Meyer, I think. Yeah.

Julie Cohn (00:20:54):

Was he the one who came to Canada, or that was somebody else?

Jean Mahseredjian (00:20:57):

No, it was professor Dommel that basically—

Julie Cohn (00:21:00):

Oh.

Jean Mahseredjian (00:21:01):

He did a PhD thesis in this field and then came to BPA. If you go to Wikipedia—wiki, EMTP—the story is there. And then he left BPA to become professor at UBC.

Julie Cohn (00:21:11):

He's the one who co-published with Tinney, right?

Jean Mahseredjian (00:21:14):

Yeah. In fact, one of the most cited papers in his career—I think—is that paper on load flow.

Julie Cohn (00:21:19):

Yeah.

Jean Mahseredjian (00:21:19):

But Tinney did amazing things. I think it is because of him we have the sparse matrices and all that stuff. And unfortunately, he passed away now.

Julie Cohn (00:21:27):

Yeah.

Jean Mahseredjian (00:21:27):

But he would tell me things; he was amazing.

Daniel Molzahn (00:21:31):

So, I always had in the back of my head that a large part of the reason that all the software came out of Canada was that you had such long lines; there were instability problems.

Jean Mahseredjian (00:21:39):

Yeah. That's a good point. Yeah, that's a good point.

Daniel Molzahn (00:21:41):

Is that part of it, or am I inferring?

Jean Mahseredjian (00:21:44):

No, no, it's a good point. Hydro-Québec was a pioneering company in many things. And then the first thing they did is, they effectively realized that to build those long transmission lines, without transmission lines that are more than 1000 kilometers. In those days, we didn't have series compensation. And they first built something that is called Transient Network Analyzer—you probably know, you haven't seen those—but basically, these are blocks that you assemble at the low voltage level that imitate the system. To do transmission lines they would basically put pi sections in series—which is not very accurate, but it's not bad. And machines have lower—, scaled-down machines. And that TNA was very nice because it was allowing them to analyze many problems, but they wanted to have—in those days, they did not really believe that we could do it on a computer because—but yeah, they wanted to have something more flexible.

Sairaj Dhople (00:22:41):

Can you tell us which years this was, the TNA, and what your personal opinion about them—did you ever mess around with these transient network analyzers?

Jean Mahseredjian (00:22:50):

TNA? Yeah, I don't know. I don't know what to say because it is recording. It's politically—I have to be politically correct. It was not a good idea, honestly. First of all, the— I can tell you many stories because they—I don't know; you have seen TNA?

Sairaj Dhople (00:23:05):

No, I have not.

Jean Mahseredjian (00:23:05):

It's full of wires—like, you have a red, blue—but as engineers, we have to work; we don't have time necessarily to maintain all the coding. And sometimes, the cleaning person or somebody would accidentally take out the wires and nobody will even notice. So, it was hard to maintain. It's not flexible. But it's possible today there are some companies that are delivering that kind of stuff to do something much more sophisticated and much easier to maintain with computers. And it gives you some reality of things. You can have consoles, but with a software like EMTP—with the graphical user interface—you have so much flexibility. If you make a fault, the machine will not explode, and you can see what happens within the lab.

(00:23:46): I mean, I find personally that it has a lot of limitations. It's nice to see, but at the end if you really want to learn—you can do many things today with software. You can even study space harmonics if you want. You can show what is a rotating field. Can you show it in a real machine?

No, you can't see it. So, software is the best thing. Now we are talking about digital twin. It is exactly what I said I want. I think you won't believe me, but 20, 30 years ago, I said that,"We have to develop,"—I called it electronic copy, but now we call it digital twin—"Yes, we have to do that."

Sairaj Dhople (00:24:22):

And when about did transient network analyzers give away to more—

Jean Mahseredjian (00:24:27:

It's not so long that they abandoned completely. I don't want to make a mistake. Maybe already five, seven years that they dismantled everything; maybe 10 years. They gave it to scrap metal. But some places, I'm not sure, but I think in Japan, they still have one. Some people still maintain it. You can also buy it now, someday, for teaching, but it's much more sophisticated. But honestly, I am subjective; like, software is the best.

Julie Cohn (00:24:57):

So, what were some of the milestones or dead ends in this process from getting the money to having a company selling this all over the place?

Jean Mahseredjian (00:25:06):

Well, that's another story. So, in 2003, I left. And I wanted—in that day, we were really number one, because there was almost no competition, but unfortunately, in an organization like mine, it is quite scientific, they didn't really put a lot of effort to commercialize. So, in fact, I purchased the web "EMTP.com." <laugh> But I got it, and then I gave it to them. So, they started commercializing slowly, and it took some time, but it needed really an organization that will be very, very solid. Eventually, they went out for request for proposal. And they had their first organization that started doing a good job. The name was Powersys. And then we were just developing. In that time, I had just a development team in university, so I was receiving development contracts.

(00:25:55): And then eventually the owners—that are three right now: RTE, EDF, and Hydro-Québec—said, It's better to have him and his team integrated into one monolithic organization. And then I accepted to—I think I'm the best to control the destiny of my stuff—become the CEO of that company. But it's not an easy job because you do things that you may not necessarily like. Like you have to read the accounting, you have to—I don't know—take care of many administrative problems that you don't want to do as a scientist, or, you prefer—my fun goes away when I do those things. My fun is to sit down and code and so—

Julie Cohn (00:26:42):

So, what about on the academic side? Were you presenting papers about this at conferences or publishing about it over the course of those years, or—

Jean Mahseredjian (00:26:51):

Well, it's all tied up.

Julie Cohn:

Yeah.

Jean Mahseredjian:

So initially, already when I was developing, I started publishing papers about the new methods, et cetera. And then I went to university, so now I have a chair. So, we use the software for testing ideas by students, that kind of stuff.

Julie Cohn (00:27:06):

Oh.

Jean Mahseredjian (00:27:06):

So, it allows us to do research. We publish a lot and, whatever we publish anybody can take it and they can put it in on their own software.

Julie Cohn (00:27:15):

Yeah.

Jean Mahseredjian (00:27:15):

But typically, the students cannot deliver industrial-grade stuff. So, sometimes after some time, we may decide that we put it in the official one, but it's really rare because it's more concepts. But inside the company, I have my people that do R and D, so then they develop something that's industrial grade, we put in the software. But yes, we publish all in papers. In fact, the company also publishes, because that is—This software, and a lot of software in power system is actually scientific software. Basically, it's not something off the shelf.

Julie Cohn (00:27:46):

Yeah.

Jean Mahseredjian (00:27:46):

And it'll continue evolving even more; much more now than before.

Julie Cohn (00:27:51):

Yeah. So, do you have a sense of— So, in 1998-ish, or a little before then, the old timers were saying, Don't bother, or, It's not gonna work; or something. When did people start saying, This looks good, I think this is really gonna work?

Jean Mahseredijian (00:28:00):

Yeah.

(00:28:09):

Well, the way it is: you always have some people that are negative. But overall, they supported me. But they were worried that this is too complicated—this guy is crazy—because I have the capability of convincing people, <Daniel laugh>. But at the point where they saw that we are able to do a synchronous machine, a transmission line, and they saw the flexibility of the graphical user interface, and how much we work, they started saying, This is becoming a [software]—and then everybody that was more skeptical, they said, Okay, it seems to be working.

Julie Cohn (00:28:44):

And were you the only person in the world trying to modernize this or were there competitors out there?

Jean Mahseredjian (00:28:49):

No. Well, yes and no. Because as you know, there are other packages in Canada, for example, PSCAD, but then they started from scratch later than the DCG afterwards. So, mine is much—I mean—I think inside the code has been done after. But I don't know anybody that was really acting like me, like a soldier that starts doing something on its own. I don't know, personally.

Julie Cohn (00:29:23):

Yeah, yeah. And it sounds like your software package is becoming—is in in standard use now?

Jean Mahseredjian (00:29:30):

Yeah, everybody's using it. Yeah. It's commercially available for universities; it's free, so every university can get the free version without any limit.

Julie Cohn (00:29:39):

So, do you have a sense of, like, what percent of the industry uses your package versus somebody else's?

Jean Mahseredjian (00:29:44):

I cannot give you that information.

Julie Cohn (00:29:45):

Okay. That's proprietary. Yeah.

Jean Mahseredjian (00:29:47):

But a lot.

Julie Cohn (00:29:48):

A lot.

Jean Mahseredjian (00:29:49):

And what makes me really, really proud—every time I talk about it, I feel emotional—is when I started coding; the first day I put the first lines of code. If you told me one day that I will travel several times to Australia to teach about it, and people in Australia are using it, I would've said, “You are crazy." <laugh>

Julie Cohn (00:30:06):

I'm glad that it turned out you were crazy. <laugh>

Jean Mahseredjian:

Yeah. Yeah.

Daniel Molzahn (00:30:12):

So, was there actually a lot of those lines? It's used all over.

Jean Mahseredjian (00:30:17):

Yeah, yeah.

Daniel Molzahn (00:30:18):

How much, when you were doing outreach, were people coming to you and saying, We want to use this tool; or—

Jean Mahseredjian (00:30:22):

Well, the universities is easy. They learn from scientific papers, et cetera, so they get it for free. The industry—well, it is marketing, right? So, there's always new opportunities. For example, right now we are pushing; we are dreaming getting into the control centers, so ISOs, et cetera. We're pushing that. But yeah, the marketing—they buy, learn they have a need, and the company in Greece wants to simulate cables—so, they find that this is what they want. So of course, it's a competitive market, and honestly, most packages are very good, but we try to compete.

Daniel Molzahn (00:31:00):

But was it selling the software—like this particular software—or was it—would you have to spend time selling the idea of doing—

Jean Mahseredjian (00:31:07):

No, No. The software is available. It's a commercial package, so it's software. You download the install.

Daniel Molzahn (00:31:15):

But I guess I'm asking: did you have to convince people about the value of electromagnetic transient analysis period, or was that sort of—

Jean Mahseredjian (00:31:24):

Well, okay. That's a good question; not a simple answer. But basically, there are people that already know that, so they will seek to find the software for doing their job as we try to sell our version. But now what is happening is that many, many people are realizing that if you use a phasor domain package—for example, transient stability analysis—you may have phenomena that you will not see. You may have, for example, resonance, <inaudible> oscillations, and battery storage systems, and the performance that it will give will not be the same. So now we try to convince them to move away and to use more—I mean not to necessarily move away, phasor domain will always be useful—but to start seriously using this approach because it is able to show all that and is able to detect much more and much more accurate.

Daniel Molzahn:

Mm-Hmm, <affirmative>.

Jean Mahseredjian (00:32:16):

But it's not easy because power system engineers are typically conservative. They start doing something and they don't want to change, so you have to convince them. There's also the data issue because if somebody has already data in a given environment, they don't want to spend too much time, but the need will make us win. Because people are realizing that with the integration of wind turbines, power electronics is a key aspect for us because it's not easy to model power electronics otherwise.

Daniel Molzahn (00:32:45):

And maybe one other question along these lines: how do you do validation of it? So, you have very high-fidelity simulations.

Jean Mahseredjian (00:32:52):

Yeah.

Daniel Molzahn (00:32:52):

Are you comparing against faults that occur in the system, or what's the validation process?

Jean Mahseredjian (00:32:58):

Yeah, it's a very long history. So, we do many, many things. For example, there was a group of BPA that were giving us switching transients on the line. And we can match it so well that you think that I'm using my finger to draw this <gestures with hand>. <laugh> So, then we had a lot of events, for example, <inaudible> events in Hydro-Québec. Of course, initially, you may have to perturbate a little bit, but you—we had the cases of cables in France; we even went ourselves to make measurements there. We are happy with RTE that had the most advanced MMC: 401 levels. So, then they basically did many, many tests on that. They even had actual controllers for the 100, 400 modules—the Siemens controllers—and it gives you a lot of accuracy to see how it performs.

Daniel Molzahn (00:33:58):

Sure.

Jean Mahseredjian (00:33:58):

But it continuously, continuously, continuously—everything we do—these companies that are surrounding us, they give us tests. Sometimes companies, like for example, Hellenic Cable in Greece, are happy. They do energizations and things like that, and they tell us, Oh, okay. So, we validate it continuously; yes, you have to.

Daniel Molzahn (00:34:16):

Do you have any stories? I suspect you might have stories about really challenging cases where there was something really subtle about how to get it to validate.

Jean Mahseredjian (00:34:24):

Well, the measurements are not easy to do, because there's always problems, like when you energize cables, the ground, whatever. I want to say something funny, but my theory is that if we are not able to reproduce, maybe you made a mistake in the experiment. <laugh> Sorry, <laugh> it should be able to reproduce. Sometimes it's really tough, but it's always feasible. Because now also we have these tools that are parametric, so we can run like 1000 simulations on the cloud to check sensitivity.

Daniel Molzahn (00:34:58):

Okay.

Jean Mahseredjian (00:34:59):

And the way it's going to go, eventually we'll have interval computing. You will see in 10 years. So, you will say to the guy, "Okay, your answer is between these two bounds, because sensitivities of parameters."

Daniel Molzahn (00:35:11):

Sure.

Jean Mahseredjian (00:35:11):

Normally, you have to; you can always validate. If needed, you can go down to detailed magnetic circuit modeling. We are also doing that now.

Daniel Molzahn (00:35:21):

Yeah.

Jean Mahseredjian (00:35:22):

We are kind of trying to do FEM-type simulation inside the EMTP.

Daniel Molzahn (00:35:27):

And I'm just curious from a technical point of view. Is there work going on that feeds back into the phasor models to—is there some middle ground where you can say, "I'm trying to inform maybe by proxy constrains or something else"?

Jean Mahseredjian (00:35:44):

Well, generically speaking, what I see in some utilities, they see that there are things that are important, and then they go back to the phasor domain tool, and they try to tweak it, and to kind of reproduce the problem. I'll give you an example: typically, phasor event packages don't model PLL, but now they are trying to come up with PLL models and things like that because it's very important; because of the PLL, you may have subsynchronous oscillations and that. So yes, there is, but again, I think the phasor domain tools are excellent and we always need them, but you cannot compete with circuit-based representation. Now you can start saying other things. You can say, "Ah, the manufacturers, they don't give you." But now they are new standards. We are forcing the manufacturers to give us the codes of the controllers in DLL format.

(00:36:35):

That is supposed to be exactly the same thing as in the field; it's a contract. So, we have also generic, but then they have [validation]—so, you are getting very, very close. How you compete with that is difficult, the circuit-based systems. And I'm telling you, the EMTP now will start also doing voltage collapse with the load flow.

Daniel Molzahn:

Sure.

Jean Mahseredjian (37:02):

And it's nice because when you do voltage collapse and you go into time domain, and you can reproduce the problem. Of course, if you are realistic, you have to put the protection relays. What we are not doing now is adding all the protections. We are gonna do that soon because with all the cores that you have you can basically have a copy of the system with all the protection systems, and you can see how the lines they trip or not; there's no limit in a way.

Daniel Molzahn:

Sure.

Jean Mahseredjian:

And I think in the next years, there will be much more activity. Sorry, I'm talking too much.

Julie Cohn (00:37:27):

No, no, you're talking plenty and we would like more. <laugh> I was going to see if there were more follow-on technical questions on this topic. I wanted to go back; you mentioned the name Dommel.

Jean Mahseredjian (00:37:40):

Yes.

Julie Cohn (00:37:41):

Am I pronouncing it correctly?

Jean Mahseredjian (00:37:42):

Hermann Dommel. Yes.

Julie Cohn (00:37:42):

Hermann. We haven't heard his name come up among other people we've interviewed, except in one instance, and you said you worked with him?

Jean Mahseredjian (00:37:51):

Yeah, because—like I said—he initiated this whole idea of simulating with the software. So, yes, I worked with him, and other people that did a lot of work in coding. For example, there was a person called Vladimir Brandwajn that went to work in California. I have lost him now; I don't know. So yeah, I worked with many people like that. I learned many things from them. I was very young, so it was good.

Julie Cohn (00:38:16):

Do you have any stories about—is it Professor Dommel or was he in the civilian world. <laugh>

Jean Mahseredjian (00:38:24):

He was a professor, yes.

Julie Cohn (00:38:25):

Professor Dommel. Yeah.

Jean Mahseredjian (00:38:26):

Which is civilian also.

Julie Cohn (00:38:27):

Oh, I know. But with respect to academia. <laugh> Yeah. Professor Dommel's—working with him and how he'd approached problems—any reflections he offered about the people who had worked on things before him?

Jean Mahseredjian (00:38:43):

Not exactly. I had a friendly relation with him. We used to have beers, and think, and chat. But the people that I had more relation regarding the software, the code, was that guy—Vladimir Brandwajn.

Julie Cohn (00:38:56):

Oh, okay.

Jean Mahseredjian (00:38:57):

And the story of these things in our life is we are privileged. Look, here: we are here in Orlando; we have a good life. So, we go out, have drinks, and since day one I started working with them. Because this was an organization, they had the meetings all over the world. And for example, once we go to France to visit the lab of research in France in Renardière, and then there is a château, the Fontainebleau, the castle. But everybody wanted to go to the château. Nobody wanted to have a meeting. <laugh> So, I convinced the driver to stop to the château because I was the only one in the group that knew French, and we were in a small bus, and we went to the château for a couple of hours.

(00:39:35): And unfortunately, some of these people passed away. There was another guy, Bill Long, that passed away. And about people that inspired me a lot, I met Fernando Alvarado.

Unidentified Voice:

Yeah.

Jean Mahseredjian:

So, he always—everything I had, he would tell me, "Yes, it will work, but you should also do this and do that." And he was very close to me and he inspired me a lot. He was extremely open-minded about everything. He was exactly what I needed, because some people were saying, Oh, it's too difficult. But he went, "No, no, no, it'll work." So, <laughter> he retired, and Bill Long passed away, unfortunately. You met Bill Long, probably. Yeah, he was in University of Wisconsin. He was taking care recently of the extension courses.

Daniel Molzahn:

Ah, I see.

Jean Mahseredjian:

So then other people passed away; other many people passed away. I had another colleague that came from Japan that stayed with me for five years—recently—to work on new techniques for lines and cables, Aki Ametani; that inspired me a lot. He passed away also recently, but they are all there; they are reaching me. I'm 64, so they are reaching 80, so it is normal that they pass away. So, I have many fun stories with all these people. Many bars that we visited, many cities, many parties we did. This is the beauty in fact of the job, so—

Daniel Molzahn (00:41:03):

And these were all mostly computational people or software algorithmic people?

Jean Mahseredjian (00:41:08):

Not necessarily. Fernando was kind of like me. He was mathematics, power system engineering, numerics. But some people were more specialized in particular topics, and they were not necessarily into developing software, but they were coming up with formulas with mathematics or—

Daniel Molzahn (00:41:28):

So, were there folks that were doing high voltage engineering? Actually, going out and testing devices at high voltage levels that you used to do the validation, or—

Jean Mahseredjian (00:41:36):

Yeah. Yeah. In IREQ—when I was young—they had many things. They had a corona cage—it's still there by the way, and they gave me measurements from that—that's the reason, we needed it to be a corona model. And we had validation. There were people in France, like Claude Gary, that had energization, and we had the validation.

Daniel Molzahn (00:41:52):

So, was it important to have those—

Jean Mahseredjian:

Sure.

Daniel Molzahn:

Would you have been able to do this without those?

Jean Mahseredjian:

Oh, no.

Daniel Molzahn:

I'm trying to think of what the ecosystem you had in Canada to make this.

Jean Mahseredjian (00:42:00):

Yeah. I was really lucky to have access to all that tests in IREQ. It's amazing. We had also tests for breakers: SF6. So, we modeled all that. We have tests for many, many things; otherwise, you cannot do it because—but the thing is, we publish continuously. So, people can take it, and then they can also —if they want—develop. But fortunately for the moment, there's not too much competition. But it's okay. Fernando used to say that if they copy us, we'll come up with something new. <laugh>

Julie Cohn (00:42:40):

That's great. Well, you've reflected a little bit on how what you've done to date might change or influence what happens next: what do you see as the value of the current solutions that you've developed for the future power system? Do you see another major shift in how to apply?

Jean Mahseredjian (00:43:05):

It is happening right now. Basically, many organizations—for example, the recent experience we have is for the Chilean grid, they want to become a hundred percent renewables by 2030, something like that. And basically, they are building the entire grid. They're simulating, they are putting battery, they’re putting wind turbines there. And you need this kind of tool to be able to do that. Otherwise, you will not have enough confidence on what's going to happen. And also, you need that to tell the manufacturers what kind of performance you need in the system that you have. It is going to become more and more popular. And you already see in my company—also in research—that we are being bombarded continuously by people that want to join us, want to work with us, want to do things; many, many big organizations that are realizing the importance of this field.

(00:43:56): And I am really happy to say that I predicted that 20, 30 years ago, and it's really happening. But there's coming more, and more, and more. I also believe that the power system engineer should not have one tool for protection, one tool for short circuit analysis, one tool for load flow. He should have only one tool, one graphic user interface that should be the equivalent copy of the system, and he should do all these studies there with all the engineering tools. And I think that's what we need to develop more and more, because right now there are still people using separate packages, and there's no communication between packages. So, me, I'm trying to have a kind of standardization of data, at least through the CIM format that you might know, so—

Julie Cohn (00:44:34):

Mm-Hmm. <Affirmative>,

Daniel Molzahn (00:44:36):

One other kind of technical question, looking forward.

Jean Mahseredjian:

Yeah.

Daniel Molzahn:

One of the things that we often exploit in power systems analysis is timescale separation.

Jean Mahseredjian:

Yeah.

Daniel Molzahn:

And so, you're—have very accurate models at very high timescales, fast timescales.

Jean Mahseredjian:

Yeah.

Daniel Molzahn:

How do you see that translating into longer time scales? Where you're—

Jean Mahseredjian (00:44:51):

Well, it's just an issue of computing speed. So, if we can do at 50-microsecond or 10-microsecond time steps extremely fast, we don't have an issue. But we are not bad. For example, the Chilean grid are able to achieve excellent speeds on the simple laptops. And it's becoming better and better with parallel computing mainly. Meanwhile, I don't really believe that in myself, but many people do that. And I think most of it is related to just publishing a paper. But many people say, Okay, meanwhile, I'm gonna put a phasor solver here. But how do we know where to cut, or people use other techniques, like dynamic phasors? I'm not sure, honestly; maybe I'm old. Now I'm becoming old myself. I'm criticizing. <laugh> So, I think that the pure stuff of computing like an oscilloscope, you cannot—I mean, it is—so, you just push start. You should not do: I'm gonna cut here, maybe not here; I'm going to publish a paper all how to move from phasor domain, now there are 101,000 papers on that. But eventually, I'm not sure. And I'm an old guy, so I don't think it—it'll not work. <laugh>

Julie Cohn (00:46:14):

So, any other—did you have a question?

Rahul Gupta (00:46:17):

Yeah, maybe related to validation.

Jean Mahseredjian:

Yeah.

Rahul Gupta:

Like, different components coming from different manufacturers have different characteristics, right?

Jean Mahseredjian:

Yeah.

Rahul Gupta:

When you do validation, how do you reconcile with like all these different components?

Jean Mahseredjian (00:46:31):

Well, that is a very good question because one of the things that I see very often when they talk about digital twin, et cetera we have difficulties getting simple data for transformers. Except you are a big company that—for example, Hydro-Québec has facility of testing the transformers. But often, we have difficulties getting basic stuff, and they tell me about digital twins. So, now when they say, We are going to use artificial intelligence from the test, we will—okay, maybe okay; but that's a problem, so the manufacturers should participate more into—already the DLL is very good because there is a standard also, so that's already very good. But there is—yes, we need much more, much more. For synchronous machines it's kind of very well established; controllers are established. In Hydro-Québec, there are people—one of them was my ex-PhD student—they go and test the machine standstill frequency response, and we can derive all the parameters; we can look at aging stuff.

(00:47:30): But wind turbines; we don't have a lot of experience. So, we need maybe to have more information on the physical electrical circuit because right now they just give us mainly the controls. Some can. Sometimes you can request more, but transformers—it's not an easy topic, especially if you want to deal with complicated problems like GMD.

Unidentified Voice:

Mm-hmm, <affirmative>.

Jean Mahseredjian:

Transmission lines is not really complicated. But yes, they should give more and more. Batteries is an issue. Converters, generically speaking, should provide much more information. It should be kind of a standard. They should be obliged to give it to you because it's also good for them too. But I guess they're afraid of competition; I don't know.

Rahul Gupta (00:48:11):

Yeah. I mean, especially they are in data sheet format.

Jean Mahseredjian (00:48:14):

Yeah, yeah, yeah.

Rahul Gupta (00:48:16):So, if there is some translation you can do from data sheet to—

Jean Mahseredjian (00:48:19):

Yeah, you can also check if it makes sense. Because often the problem is bad data. But there is an effort there because, for phasor domain, it is not as complicated. You don't need so much information; it's much more simple. In fact, everything is in per unit often; you don't even know what is the length of the line. But as we need of that, the manufacturers—I think it's starting. We are pushing that in many communities. And I think NERC is pushing; there are many nice things going on. You guys are—I mean, you two are still very young; are lucky, <laugh>. This is the day that the power systems are reaching—it is amazing; it is apotheosis, so there is so much activity. In my days, there was nothing going on: nothing, nothing, nothing. We couldn't hire any students. When I did my PhD, there was zero funding. I mean, I just had to teach courses to survive.

Rahul Gupta (00:49:13):

It's also overwhelming, <laugh>.

Jean Mahseredjian (00:49:14):

It is overwhelming; yes. I don't know what to do sometimes. Sometimes I wake up in the morning, I say, “What are we gonna do?” And I'm afraid that the young people I have will become discouraged. But you are really lucky; it's amazing. Everything is going on in power systems right now, and it's the future because the engineers will save the planet, I guarantee to you <laugh>.

Julie Cohn (00:49:34):

Are there any other questions? Because I think we're reaching a great closing.

Sairaj Dhople (00:49:38):

Yeah. So, on that note, if you had a few words of advice for the next generation of power engineers, what would that be?

Jean Mahseredjian (00:49:45):

Well, it's difficult to say. I don't know. You know when you get old, you start complaining, so we have to be careful. I find that the students are more lazy than before. <laugh> For example, my postdoc last week, he says to me, “I'm going to take one, two weeks of vacation.” Normally, he has the right to do it, but me, when I was young—vacation, what is that? <laugh> In my days, if a guy in my team was taking a paternity leave, we would think that he is not very good. But today, is the standard, which is good. But I think I have the impression that some young generations are not working as hard. So, I think if you want to succeed, you have to work hard, and you have to work harder than anybody else, because you might be very clever, but at the end, if you want to finish something, you need to work. You need to sit down and work. So, work very, very hard. Don't make assumptions, don't fall into traps—like this is like that. And question continuously—question, question continuously. In fact, that is our profession.

(00:50:54):

Because sometimes people say, It's like that. Why is it like that? And then you realize that by questioning, you really discover something that everybody forgot. And then you have to stay humble, but you say, "Why they didn't notice that?" So, I will tell you fundamental stories; for example, the calculation of per unit length parameters with Carson and Pollaczek formulas. I had a PhD student and I told him, "We have to rewrite all this thing." It's crazy, and I was right. It's all—big people were making these assumptions, and nobody cared. So, you have to work hard. Number one advice: work hard. Number two advice: work hard. Number three: <laugh> because once you graduate and finish, then you can relax a little bit—although I'm not sure—but you can relax a little bit. But now it's not time to take vacation <laugh>

Julie Cohn (00:51:44):

Okay, well great. Well thank you so much for giving us this hour of your time.

Jean Mahseredjian (00:51:49):

Thank you.

Julie Cohn (00:51:50):

And we appreciate your coming.

Jean Mahseredjian (00:51:52):

Okay. Thank you very much. Thank you.

[End of Interview]