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Caution light: The Anik E2 solar disruption and its effect on Telesat Canada

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ABSTRACT

Telesat Canada is a satellite communications firm, founded in 1969, that provides global broadcast and broadband services. Its fleet of satellites includes the geostationary Anik line. On January 20, 1994, a major solar storm knocked out communications on two Anik satellites. Anik E1 was recovered through a backup system within hours. However, Anik E2 was non-operational until June 1994, when engineers used an innovative ground fix to regain control.

1. Introduction

Telesat, a Canadian satellite company, provides broadcast services to corporate and government customers across most of the world. On January 20, 1994, high-energy particles streaming from the sun disabled two of its satellites, Aniks E1 and E2. Anik E1 was brought back online within hours. When Anik E2 couldn't be recovered immediately, the crisis reportedly pushed Telesat — about to celebrate its 25th year of operations — to the brink of bankruptcy. A dedicated team worked to implement a fix for Anik E2 that not only worked, but kept the satellite functioning well for another nine years. It took until June for the crisis to be fully resolved, but their dedication saved the satellite and the company.

Telesat had a dual challenge when the Anik E2 satellite was damaged. The first was to rescue the satellite, and the second was to rescue the company since the failure of the satellite put Telesat itself in danger. Although the company had changed ownership change prior to the Anik E2 event, the authors were unable to find evidence that the new ownership affected Telesat's response to the crisis.

2. Formation of Telesat

Canada's communications infrastructure in the 1960s posed an expensive challenge for the country because of the country's large physical size, and sparse population [1]. The Canadian government appointed a task force to identify the major entities who were doing work in space. That effort resulted in a report, Upper Atmosphere and Space Programs in Canada: Special Study No. 1, 1967, which recommended satellite communications to bind the country together [2].

Based in part on the report's findings, in early 1969, the Pierre Trudeau government proposed the Telesat Act to form a Crown corporation. This entity would include a financial stake from the government and would launch Canada's first domestic communications satellite. According to Minister of Industry Eric Kierans, a Liberal party member noted for his economic nationalism, the government rejected the notion of fully privatizing Telesat or, by contrast, making it fully public. Private ownership would leave

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Telesat out of government hands except in the case of legislating certain activities. Public ownership would be unnecessarily costly to the taxpayer because the common carriers "have acquired an outstanding expertise in the economic development of telecommunications" [3]. The act was assented to on June 26, 1969 and became effective on Sept. 1, 1969 [4]. Parliament's control of Telesat would last for about 30 years.

Telesat was initially owned by both the federal government and Canadian carriers. This changed slightly when in 1975, the Trans-Canada Telephone Systems (TCTS) became a member. Telesat is still a member of TCTS today, although the consortium has undergone structural changes and is now known as Stentor [5]. Prior to Anik E2's launch, the government announced it would sell its 53% interest in Telesat as part of an ongoing move to privatize Canadian Crown corporations [6]. In 1992, Telesat's sale was approved for $154.8 million to buyer Alouette Telecommunications Inc. This was a consortium of several companies, including Bell Canada Enterprises (BCE) and Spar Aerospace Ltd. [7]. BCE then bought out its partners in 1998. The current owners are Loral Space & Communications and Canada's Public Sector Pension Board, which bought Telesat from BCE.

3. Anik E2 launch and solar storm

The $300 million Anik E2 lifted off from French Guiana (the site commonly used for France's Ariane rocket launches) on April 3, 1991. Anik E2 and its twin satellite, Anik E1, were intended to replace the older satellites in the successful Anik line – most critically Anik D1, which was nearing the end of its fuel life and could not maintain its orbit to reliably transmit signals to fixed ground station antennas [8].

The satellite reached geosynchronous transfer orbit easily and also performed well in a series of apogee burns to put it in the right orbit. Anik E2 initially had trouble deploying its C-band and Ku-band antennas, but spin maneuvers resolved the problem [9]. Carrying most of Canada's broadcast signals, Anik E1 and E2 subsequently did their work virtually flawlessly for more than two years, until the afternoon of Jan. 20, 1994. The NOAA Space Environment Center tracked high-speed solar wind from "coronal holes," areas where the sun's plasma is less dense than usual and moves out at higher speeds. Then NASA's SAMPEX satellite began to pick up high-energy electrons in geosynchronous orbit, where the Aniks orbited [10]. In general terms, when plasma hits a satellite, it can artificially create a negative electrical charge. In transistors and semiconductors, this can lead to single-event upsets (SEUs), or temporary "blips" in the way the spacecraft functions. At worst, the charge can create a single-event burnout that damages the way the spacecraft functions. At geosynchronous orbit, where the Aniks were orbiting, surface charging happens during magnetospheric substorms [11].

For users of Anik, the first sign of trouble came at 12:34 p.m. that Thursday. Don Wintzel, the national sales and marketing manager of Novanet Communications, was using Anik E1 to send news from outlets that included the Canadian Press, Reuters and Broadcast News. The disruption stopped the news from flowing and kept it that way until 7:56 p.m., he recalled in a newspaper interview. "It was the largest story in the telecommunications industry in the country and we had no way to transmit it," he said [12]. Further, the Canadian Press could not deliver all of its news to the 100 newspapers and 450 radio stations who were members of the co-operative at the time [8]. (Officials from the Canadian Press and Novanet who recalled the incident declined interviews for this analysis.)

Natural Resources Canada also saw indications of unusual solar activity. One of the responsibilities of this government department is to provide space weather forecasting; David Boteler was a research scientist there at the time. In an interview for this analysis, he said that as with other users, the department was simply reacting to what it saw. However, the advantage was they had instruments showing solar activity and could pass that information along to Telesat.

> We were seeing elevated levels of energetic electrons at the geostationary orbit. There's [*sic*] instruments on the GOES satellite operated by NOAA that was measuring our [*sic*] energetic electrons, specifically the electrons with energies greater than 2 MeV. We could see elevated levels of the greater than 2 MeV electrons … It was significant in terms of the energetic electrons. In terms of the magnetic activity, it was not so significant. There was ongoing magnetic activity, and that is one of the contributing things that causes the energization of the electrons. But it wasn't [the] dramatic storm that was needed to affect systems on the ground [13].

When the storm hit Anik E1, engineers saw it had knocked out the electronics for the satellite's momentum wheel control electronics apparatus. The 0.39-inch thick gyroscope served as a counterbalance to stop the satellite from spinning and to maintain a constant attitude – and accordingly, stability for signals. Once the wheel stopped spinning, Anik E1 itself began to spin and mispoint. Fortunately for the engineers, Anik E1's backup momentum wheel was still working properly and engineers could communicate with the satellite through its omni-directional antenna. It took 7 h to come up with a fix, but when that was achieved, the satellite came back online without a hiccup [12].

Barry Turner, who was an engineer and vice-president of sales and marketing at Telesat at the time, credits that success to the ability of the emergency committee to convene, evaluate the problem and fix it quickly. The committee included a cross-section of people from different departments of Telesat, ranging from senior management to satellite engineers.

> As it happened on that particular day, most of the executive [senior management] was away so there was only myself, and the chief financial officer in town. Eventually we were able to reach everybody and get them all back in but it was relatively short-staffed at the senior management level [14].

Only an hour after Anik E1 recovered, Anik E2 reportedly failed at 9:15 p.m. [15]. (Memories of participants in the interviews were not accurate enough to verify the exact time.) Although the impact on users was about the same, the long-term situation was more serious with the latter satellite; both control wheels were malfunctioning. The satellite began rotating once every 2 min – "sitting quietly", in the words of Len Stass, Telesat's vice president of space systems – and remaining uncommunicative with Earth [15]. Members of the emergency team that had so quickly convened to solve Anik E1 were going home at that point, recalled Turner. When Anik E2 failed, he attempted to contact the team, but there was a problem. Not only were cell phones uncommon at the time, but the pagers the team used – unbeknownst to anyone then – "looped through the satellite," he recalled. "So the pagers were out too." Turner and others had to use land lines to reach the emergency team members [14].

> So eventually we were getting the team back. We only had one satellite operating, but now it's full panic station. I'm getting calls from the president of the CBC, the minister of communications, generals in the military, because the north warning system is out and … I mean it's really, really serious. Now we