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ABSTRACT: The digital slot machine entered the gambling floor in the mid-1970s and, within a decade, it became gamblers' favorite and the main contributor to casinos' gross revenue. This paper traces the main developments of this transition, particularly the role of the inventors, entrepreneurs, and the business context that made it possible. Decisively shaped by the culture of the casino floor and advancements in computer technology, the emergence of the microprocessor slot machine involved the gradual replacement of mechanical parts with digital components and created new opportunities for casino managers.

Keywords: Slot technology, techno-politics, virtualization, casino gaming, Las Vegas

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A symbol of the modern casino, the slot machine owes its huge popularity of today to the substantial transformations it underwent during the 1960s and 1970s. Prior to that time, a blend of technological and economic considerations relegated the device to a marginal position on the gambling floor. Much like its late-19th century predecessor, the slot machine of the 1950s consisted of a nickel-plated box, whose side-handle set in motion the reels through an intricate clock mechanism with hundreds of moving parts. This crude mechanical arrangement was the machine's soft spot, which caused its vulnerability to cheating, frequent malfunction, cumbersome auditing, and significant overhead costs.

In their search for a technological fix to these challenges, engineers and casino operators gradually replaced the deficient mechanical parts with digital components, in a process that shaped a device better equipped to satisfy the security needs of casinos. The massive adoption of digital slot machines in casinos and their subsequent integration within computerized information and control systems provided managers with the effective means to streamline the activity on the casino floor and, later, to broaden the casino customer base.

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Si Redd & the Modern Slot

The emergence of the modern slot is associated with Bally Manufacturing, one of the early major producers of coin-operated devices. Many observers attributed Bally's rise as the leading manufacturer of slot machines to the business acumen of William S. Redd, later nicknamed "The King of Slots." Redd spent many years working as a jukebox and game distributor for Bally, mostly in the southern United States. Las Vegas casinos of the early-1960s, with their obsolete inventory of "fifty to seventy-five years old machines," struck Redd as the perfect ground for reform and innovation.[1] Redd began searching for the causes that impeded the popularity of the slot machine. He questioned its basic design, functioning principles, and perceived flaws, attempting to re-imagine the device and offering new standards of performance and profitability. Beginning in 1967, at the helm of Bally Distributing Company, the company's newly established branch in Reno, Redd was poised to tap into the Nevadan market.

Redd and his team of engineers introduced several pivotal changes in the mechanics and philosophy of the electro-mechanical slot machine. An early assignment led to a feature that gave the gambler the option of simultaneously playing multiple coins on the same machine. Up to that point, the standard of the casino floor was the "single-coin machine," whereby a coin would buy a single pull of the handle. The new version enticed the players with its enhanced rewards because the more coins bet, the higher the odds of winning larger payouts. Bally also pioneered winning formulas based on the vertical, diagonal, or left-to-right reading of the symbols on the reels, in contrast with the standard left-to-right alignment on the display.

In years to come, Redd continued to push improvement in the speed of games, establishing a technical standard and measure of productivity for the slot machine. A focus on speed brilliantly linked the possibilities to boost the profitability of the machine while enticing players with larger payouts. "The player came to win," said Redd, "he didn't come to lose, [so] speed it [the game] up, give him more, be more liberal. Let him win more, but then [you make money] still with the speeding up, because it was extra liberal."[2] This bold combination of higher payouts and faster games challenged pervasive assumptions about the slot machine and sowed seeds for further advancement. Although "everybody in that business reasoned that the larger the denomination was the tighter the machine would get," Redd was of a different mind. "[3] It should be just the opposite," opined him, "a dollar slot machine… must be tremendously more liberal than a penny machine or a nickel machine."[4] He proposed a device that worked with dollar coins and paid out more than any penny or nickel counterpart. Adjusted to pay back 90–95 percent of the coins played, Bally's dollar machine became one of the most popular games in Nevada from the 1970s onward, demonstrating that the slot machine might have an important place in the future of casino gambling.

However, despite these fresh approaches by manufacturers, most of the slot machines in use until the early 1970s were still "old-timers," needing steady maintenance and generating overhead costs. Most of the Las Vegas casinos dated from the 1950s. They featured aging infrastructure as well as obsolete gambling equipment, which had survived

the passage of time with little or no alteration. In fact, many "old school" slot managers preferred the technology and manufacturers that they had become accustomed to. In their cautious logic, the purchasing of new, unknown, and presumably less reliable products made no business sense, provided that in-house mechanics could fix and revamp the existing machines. For instance, throughout the 1960s, Harrah's in Reno and Lake Tahoe remained faithful to the mechanical Pace machine—a popular pre-WWII model that was discontinued in 1953.[5] The maintenance of the Pace inventory was an around-the-clock job as, at any moment, any of the hundreds of parts of a typical three-reel device could break due to abusive use or normal wear and tear. Spare components were made in-house. "Every part that broke on those machines, we had no parts to replace it. You repaired it. You welded it or you made a new one," recalled a head mechanic.[6] At Harrah's, maintenance meant more mending of the "cripples" (machines that broke on the floor and came to the shop for emergency repair) than periodical checkup. With no new equipment, old components were reused in reassembled devices to replace the broken inventory or to expand the casino floor.

Development of the Modern Slot

The 1970s was a decade of accelerated and decisive alterations in the design, capabilities, and functions of the slot machine. In the timeline of the history of electronics, this decade coincides with a period of significant gains in the efficiency, processing power, and cost of integrated circuits and the consequent wave of breakthrough practical applications. A cadre of engineers with training in high-tech and gaming industries pioneered the use of electronic components in gambling devices, thus shaping a new horizon of possibilities for manufacturers and casinos alike.

Economic historians who studied the evolution of the gaming devices industry in the U.S. have noticed the spectacular rise to prominence of Bally Manufacturing, shortly after its takeover by a new management team in the early 1960s.[7] By 1967, Bally claimed 94 percent of all the machines sold in Nevada and, just three years later, the position of the world's largest manufacturer of spinning-reel gambling devices. A few contextual factors created a favorable climate for Bally. First, the international growth of legalized casino gambling, particularly in Europe, determined many countries to look for competitive gaming machines and choose Bally for the convenient financial solutions it developed for new customers. Secondly, on the home front, Bally encountered limited competition because the international manufacturers, to enter the market of Nevada, had to follow tight licensing procedures. More importantly, judging from the diversification of Bally products, the company showed faith in the business philosophy of its Nevada distributor, William S. Redd, "[the product] had to change – constantly change – in order to be successful."

Bally's core of creative energy stemmed from its research lab established in Reno, the heartland of the casino industry, in 1974.[8] The department started under the management of Inge Telnaes, a Norwegian electronics engineer, trained in Germany, and formed in his native country's defense industry and matured in the United States computer industry.[9] Telnaes' initial agenda included the improvement of a computer system for monitoring slot machines that Bally, in its

strategy to crop the most promising ideas in the market, had recently purchased from Electro Module Inc., a small California-based business. Installed at Harvey's Wagon Wheel Casino in Lake Tahoe, Nevada in the early 1970s, this system consisted of electronic boards that were mounted on each of the 1,000 mechanical machines on the gambling floor. [10] These boards collected information about the functioning of each device and sent it electronically for processing to the two IBM system/7 machines in the computer center of the casino.[11] Although functional, this pioneering slot system suffered from frequent breakdowns whose fixing exceeded the resources of the parent company. At that moment, Bally took over the project and, over the next several years, Telnaes' team improved it as per the patent for "Monitoring system for use with amusement game devices" issued in 1978. [12]

The description of the Bally Slot Data System (SDS) spelled out the issues of cash security and staff dishonesty as the main concerns and driving forces for innovation, particularly in "commercial establishments [where] there are often several hundred or more of such devices and the amounts of money that are handled by the devices as a whole are quite large." Although SDS used the same hardware as its predecessor (a central computer connected to individual machines via electronic coupler units), it addressed broader aspects of security. First, the system tracked and recorded the coin in, coin out, and jackpots, thus keeping an accurate report of all the discrete money transactions related to a specific machine, a group of devices or the entire floor. A special software program saved the information into a database that was accessible on the terminals in the computer center. Secondly, the system has clear surveillance features as it intended to establish a tighter control over the interaction of the staff with the machines. Each attendant carried a personalized electronic unit, to be attached to any machine when a jackpot occurred and initialized the report of the transaction to the main computer. Knowing the name of the staff member who made the payment as well as the value of the payoff reduced "the likelihood that an attendant can make double payoffs or other transactions in an attempt to steal without being detected" and helped with keeping the "bank" (money amount) that a change/jackpot person managed during a shift. Also, "the opening of the access door to the change box … [could] be detected and transmitted to the computer" when a staff person used their ID card on the machine. The system did not control or affect the operation of the slots but merely monitored their performance and the staff members' access to them. [13]

Las Vegas Hilton was Bally's first SDS customer. During the first year of operation, the computer-monitored slots generated a $400,000–$500,000 increase in revenues, or the equivalent of 1 percent of the entire casino's total profit.[14] As Inge Telnaes recalled, this growth resulted partly from a decline in the leakage of money due to negligence or theft by casino employees, particularly some of the slot mechanics' customary practice of rounding up their salary by collecting loose coins from the inside of the machine. Ironically, while the SDS system simplified the red tape by eliminating some manually filled forms, it also presented the staff with unforeseen challenges and routines. In one instance, on New Year's Eve 1977, after inspecting a winning machine and finding no

physical evidence of tampering, Hilton employees paid a large jackpot to a player who later proved to belong to a criminal ring.[15] Had the staff checked the computer printouts before making the payment, they would have learned that the slot machine door had been fraudulently opened and the reels set on the winning position. In the light of this incident, checking the computer reports became a loop in the procedures for jackpot validation.

The same circumstances revealed that, despite the SDS advanced monitoring capacities, the vulnerability of the machine's reels remained a salient technical problem. Their crude mechanical nature involved significant wear and tear, which could (and commonly did) alter the payouts. Also the simple manual manipulation of the reels by shaking and tilting could disturb their spinning and stopping, with crucial consequences to the game's outcome. The optimal performance of the reels required steady maintenance as well as considerable expenses for replacing and fixing the worn-out parts. Aware of these deficiencies, slot machine designers increasingly focused on finding ways to protect the randomness of the process that determined when the reels stopped and the alignment of the symbols in the display window. While, initially, engineers opted for mechanical adjustments or contraptions attached to the reels, later efforts turned to electronics and solid-state components.

Mircoprocessor Slot Machines

One invention in particular dominated others in the transition of the slot machine to the modern digital one. The 1975 patent by James C. Saxton et al. for the "amusement apparatus and method" commanded the attention of casino executives and manufacturers because of its revolutionary tamper-proof features.[16] The description of the patent highlighted the use of electronics as the most notable advancement for reducing fraud and misuse. Saxton proposed the use of "random code generators to produce independent random stopping positions for each wheel…, with a varying score previously determined by a predetermined logic system." [17] In other words, the combination of symbols aligned in the machine's display after the reels stopped lost its traditional function of dictating the outcome of the game. The old mechanically generated "randomness" gave way to a more effective electronic alternative. The digital brain of Saxton's machine consisted of two interconnected parts: the random number generator (RNG), which replaced the winding time mechanism and arbitrarily stopped the reels in predetermined positions, and a memory chip (EPROM) that stored information about the winning combinations and the payoff schedule.[18]

Bally's R&D department took the Saxton patent a step farther with one of the first mass-produced microprocessor-controlled slot machines. The E-1000 and the subsequent (and more successful) E-2000 series became "the workhorse of the industry," being found in most major casinos by the mid-1980s.

Trumpeted by Bally as a sample of engineering excellence, the microprocessor-controlled E -Series machines shared the casino floor with a new breed of electronic gambling devices. In his innovative spur and having the backing of the strong R & D department at Bally, William S. Redd became interested in the applications of solid state electronics to amusement devices and orchestrated the acquisition of Raven Electronics Corporation in Reno in 1971.

This company, under the management of electronics engineer Richard Raven (who would soon move to a satellite and communications business) experimented with electronic blackjack machines featuring video displays and pushbuttons.[19] Just four years later, after breaking away from Bally and taking the exclusive rights over the video side of the business, Redd also purchased Nutting Associates, Inc. of Mountain View, California, where a then anonymous engineer named Nolan Bushnell had developed Computer Space, the first coin-operated arcade game. Because the game hit home with the community of engineers but not with the "videogames virgins of the general public," who could not make sense of the intimidating console with TV monitor and complicated instructions, Bushnell left Nutting Associates to found his own company Atari, the "cradle" of Pong, the first commercially successful video game.[20] Redd continued his march towards acquiring the most promising innovation on the video game market with Fortune Coin Company in 1978. Electronics engineers at Fortune had designed a machine that displayed, for the first time, colored fruit symbols in the typical arrangements of mechanical slot machines. All mechanical parts were replaced by interchangeable modules and, with the exception of the screen, the appearance of the machine remained unchanged. In next decade, drawing from all these early innovations, William S. Redd and his company, renamed Sircoma and later IGT (International Game Technology), continued to invest heavily in research and development and launched increasingly successful lines of products.

Available in formats such as poker, bingo, keno and racing, these so-called "specialty games" addressed a niche market initially. As a commercial flyer explained, they had a rather gimmicky role— to "enhance the casino floor with a spirit of excitement that draws more players to the other slot machines."[21] To whet the casinos' appetite for the new technology, Redd proposed a distribution strategy that he had used as a salesman of arcade games and offered the devices on a participation basis, with renters paying a percent from the profits generated by the machine, and asked for space outside the gambling floor, particularly in bars.[22] In just a few years, video draw poker became the front-running IGT machine and a serious challenger to the popularity of slots. Observers tied the accomplishment to its novelty feature. Unlike the slots, which presented the player with a single combination of symbols for each pull of the handle, video games introduced the element of personal choice to the play. "The player gets to make his own decisions and the game is not too fast for him or too tiresome ... And most of all, some way or another, the player gets an extra thrill knowing he did something to help himself win."[23] Nonetheless, the video machines' success with the public benefited from the increased competition among manufacturers and the subsequent decline in the product's price.[24]

IGT's leap to the top position in the gambling devices industry also gained momentum from the strategic acquisition of Saxton's and Telnaes' patents on which the modern slot machine still rests today. Telnaes' idea stood in marked contrast with prior inventions in that it changed nothing else but the "players' attitude and acceptance of the device," by the means of increased payoffs [25] Previously, the value of the jackpot depended on the size of the machine: the more and bigger the reels,

the more symbols on them and, according to the probability theory, the more the payback combinations, and the higher the winning odds. However, this interdependence psychologically undermined the player, who perceived the bulky machines as "being less good."[26] Telnaes creatively used software instead of hardware to increase the number of symbols in play as well as the payoffs, while keeping the size of the reels unchanged. His design associated the usual mechanical reels with some counterparts that carried more symbols and existed only in the machine's memory, hence their name "virtual reels." This system, which also included a random-number generator that selected the combination of virtual symbols and their real correspondents on the pay line, projected the wining probability into a broader and adjustable interval and payoff schedule. The virtual-reel machine became a smash hit. The first 108 devices installed at Four Queens Casino in Las Vegas in 1984 doubled the profit from an equal number of "real reel" machines over the same period of time.[27]

CONCLUSION

By 1980, the old mechanical slot machine was irreversibly marching to obsolescence. The floor belonged to a generation of devices, whose digital brain supported new and improved functional and aesthetic features. Driven by the casino operators' efforts to limit cheating and theft, a succession of innovations had made great strides in protecting the game outcome and controlling the access to the cash in the machine. The economic value of these developments reached its peak when the device became the primary element of the casino data highway, an information system that provided casino managers with the means to control and streamline the activity of all the equipment and related staff. Further on, the focus on player appeal and the invention of the virtual reel machine opened a constellation of technical possibilities that solidified even more the slot machine's position as a leading gambling technology during the 1990s and onward.

About the Author

Cristina Turdean is assistant professor of museum studies and material culture at the University of Mary Washington in Fredericksburg, VA. Cristina completed her PhD at the University of Delaware with the dissertation titled "Betting on Computers: Digital Technologies and the Rise of the Casino Industry (1950-1995)."

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[1] Orley B. Caudill, "An Oral History with Mr. William "Si" Redd," (The Mississippi Oral History Program of the University of Southern Mississippi, 1983), vol.257, 26, UNLV Special Collections.
[2] Ibid.11
[3] Ibid.11, 27.
[4] Ibid.
[5] Ibid. 8, 212.
[6] Mondo Rueda, oral history interview by David Schwartz, 2003, 42–43, UNLV Special Collections.

[7] Mirko Ernkvist, *Creating Player Appeal. Management of Technological Information and Changing Pattern of Industrial Leadership in the U.S. Gaming Machine Manufacturing Industry. 1965-2005* (Goteborg: Goteborg Studies in Economic History, 2005), 109-125.
[8] In parallel, Bally continued to run its already existing R & D department at its headquarters in Chicago. Financing two similar departments had the goal to accelerate the design of new and successful products.
[9] Inge Telnaes, interviewed by the author, March 4, 2009.
[10] Theodore R. Sabin, Michael Dahl, and Paul R. Brugger, "The Slot Machine Data System, an Accounting Method, a Security Technique, and a Marketing Tool," *Gambling Research: Proceedings of the 7th International Conference on Gambling and Risk Taking,"* (University of Nevada, College of Business Administration, 1988), 347–58.
[11] Ron Gallaway, (untitled presentation, World Gaming Conference and Expo, Atlantic City, November 1988), tape code 341B_04, UNLV Special Collections.
[12]Bally Manufacturing Corporation, "Monitoring system for use with amusement game devices," U.S. Patent 4072930, filed August 20, 1976, and issued February 7, 1978.
[13] Ibid.35.
[14] Ibid.32.
[15] Ibid.
[16] James C. Saxton, Bruce H. Osterberg, Joseph C.Kawan, "Amusement apparatus and method," U.S.Patent 4095795, filed June 9, 1975and issued June 20, 1978.
[17]Ibid. 39.
[18]This is how the Saxton machine works. Every fraction of a second, the RNG generates random numbers from zero to several billion. The pull of the handle assigns the most recent number to the game being played. The microprocessor then checks the EPROM for the reel- stopping positions corresponding to that number, spins the reels, and stops them at those positions. The result of the game is determined when the random number is selected and depends solely on the time of the pull. The payout percentage (the percentage that the machine will return to the player in the long run) does not depend on the random number that determines the spinning and stopping of the reels but on the payout combinations of symbols on the reels (i.e., one coin vs. two coins back for a combination of one diamond and two spades) or the number of winning symbols on each reel. Each state regulates the minimum payout percentage.
[19] Bueschel, *Lemons, Cherries*, 258-259.
[20] Steven Poole, *Trigger Happy. Video Games and the Entertainment Revolution* (New York: Arcade Publishing, 2004), 19-21.
[21] Advertisement for specialty machines in Bueschel, *Lemons, Cherries,* 281.
[22] Ibid.11,38–39.
[23] Si Redd quoted in Ernkvist, *Creating Player Appeal,* 146.
[24] An IGT machine sold for $12,000 in 1980 and $7,500 in 1982 (Ernkvist, *Creating Player Appeal,*155.
[25] Inge S. Telnaes, "Electronic gaming device utilizing a random number generator for selecting the reel stop positions," U.S. Patent 4448419, filed February 24, 1982, and issued May 15, 1984.
[26] Ibid. 48.
[27] "A 'virtual' success," *Gaming and Wagering Business*, October 1984, 18.