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Final Project: *Hutspiel*

Introduction

Hutspiel is a theater-level war game designed by the Johns Hopkins Operations Research Office (ORO) in 1955 to study the effects of tactical atomic weapons and conventional air support in a hypothetical conflict between NATO and USSR forces. The game was designed to run on the Goodyear Electronic Differential Analyzer (GEDA), an analog computer produced by the Goodyear Aerospace Corporation. *Hutspiel*is notable for its role in the histories of war gaming and commercial video games, post-WWII operations research in the United States, and analog computing. Some contemporary sources credit the game as the first theater-level war game designed for computers[1].

Due to the circumstances of its development, information about *Hutspiel*is scarce. The mathematical model which underlies *Hutspiel'*sgameplay incorporates Army statistics regarding NATO forces and contemporary estimates as USSR forces. ORO's documentation of the *Hutspiel*project pointedly does not include descriptions of play, which would allow the game to be described in greater detail in subsequent histories. Perhaps consequently, the game, as well as other ORO projects developed on the GEDA, are often neglected in official histories ofUS operations research (OR). This may also be due to ORO's rocky relationship with the Army. The Army pulled funding for ORO in 1961, following a falling out with ORO Director Dr. Ellis

[1]Mark J. P. Wolf, *The Video Game Explosion: A History from PONG to Playstation and Beyond* (Westport, Conn.: Greenwood Press, 2008), 32.
This claim should be taken with a grain of salt. Wolf erroneously attributes development of *Hutspiel*to the Research Analysis Corporation (RAC), ORO's effective successor as an Army-sponsored operations research center. Other sources similarly misattribute ORO projects to RAC, such as Thomas B. Allen's *War Games*.

Johnson[2]. The Army would then form the Research Analysis Corporation (RAC), which would absorb staff, projects and assets from ORO. While an exact rationale has not been disclosed from official sources for ORO's dissolution, official histories concur that the Army and ORO had severe disagreements regarding the scope of ORO's research projects and its internal culture. Some RAC publications reference *Hutpsiel*, but the drama surrounding ORO's rise and fall seems to have largely overshadowed the game. The RAC would be purchased in 1972 by the for-profit General Research Corporation[3].

As such, this paper aims to situate *Hutspiel*in the contexts of the history of wargaming and post-WWII US operations research. Various aspects of *Hutspiel*can be discussed in isolation, making it difficult to describe as a specific media or process. However, contextualizing *Hutspiel*with regard to one topic provides an incomplete picture of the game. Framing *Hutspiel*as an early video game fails to account for its development following ORO's sponsorship by the US Army. Likewise, framing *Hutspiel*solely as a war game neglects the fact that it was designed for analog computers, despite the availability and proliferation of digital computers before and after its development. Context on these topics will be provided as necessary to demonstrate both their influence on *Hutspiel'*spurpose and design.

Gameplay of *Hutspiel*

Descriptions of *Hutspiel*in secondary sources tend to come from two sources: a section in a 1964 RAC technical paper by Joseph O. Harrison, Jr., *Computer-Aided Information Systems*

[2]United States, *A History of the Department of Defense Federally Funded Research and Development Centers*, Background Paper (Washington, DC: Office of Technology Assessment, Congress of the U.S. : For sale by the U.S. G.P.O., Supt. of Docs, 1995). 21.
[3]Charles A. H. Thompson, *The Research Analysis Corporation: A History of a Federal Contract Research Center* (McLean, VA: Research Analysis Corporation, 1975), iii.

for Gaming, and ORO's 1958 project report for the game, which was recently uploaded to the Internet Archive in 2022. Most secondary sources cite Harrison's paper, which may account for *Hutspiel*'s frequent misattributions to the RAC, rather than ORO. These two sources provide the fullest description of how *Hutspiel*played, so this section will quote from them extensively.

As mentioned before, *Hutspiel*is a theater-level wargame designed for an analog computer. The game stages a hypothetical military conflict between NATO (BLUE) and USSR forces along the Rhine river in summer 1955, a near-future scenario at the time of development[4]. Both blue and red players had access to the same five kinds of elements: ground forces, atomic weapons, aircraft, supply depots and rail transport. Supplies and troops could be transported between sectors. Input values for these elements reflected military information and estimates available to ORO at the time. Players input values into *Hutspiel*using potentiometer dials on a special display board to represent attacks on opposing forces and non-combat elements[5]. Planes could attack all targets, including supply depots and rail transport; ground troops could attack each other, and atomic weapons could attack all targets except for planes in flight. Damage to supply depots and rail transport from enemy attacks would slow the rate of transport for supplies and troop movement, although these could be repaired over time.As *Hutspiel*was designed to run on the analog computer, the dials functioned as radial potentiometers, reducing a circuit's output voltage by increasing exposure to a resistive material[6]. Output information would be displayed to players on a series of galvanometers. *Hutspiel*was played mainly by Army personnel, but it was also played by some ORO analysts as well. Play was initially conducted in real-time, such that

[4]Dorothy K. Clark et al., *HUTSPIEL: A Theater War Game*, ORO-SP-53 (Chevy Chase, MD: Operations Research Office, 1958), https://archive.org/details/hutspiel-a-theater-war-game. 3.
[5]Joseph O. Harrison, Jr, *Computer-Aided Information Systems for Gaming*, Advanced Research Division, RAC-TP-133 (McLean, VA: Research Analysis Corporation, 1964). 20.
[6]"Electronics Basics - How a Potentiometer Works | Random Nerd Tutorials," August 11, 2016, https://randomnerdtutorials.com/electronics-basics-how-a-potentiometer-works/.

the state of the game, the amalgam of variables which the game's model tracked, would advance by one in-simulation day for every real-life second without direct player intervention; players could press a button to pause computation to enter their input values, and then resume play. The game was later modified to use an epochal progression - the game would first wait for both players to input values and unpause the game with a button press; the game would then advance the game state by one day, then pause again.

Despite using separate display boards for each player, *Hutspiel*was designed as an analytical tool to investigate the effects of various uses of nuclear weapons and conventional air support in a Soviet attack on established NATO fortifications. As such, the blue and red players would discuss their possible next actions with each other, so as to investigate potential strategies for the blue player to last the longest against the red player's attacks[7].

Hutspiel's role in the history of war games

While it may or may not be the first theater-level war game designed for computers, *Hutspiel*is arguably one of the earliest computerizations of wargaming concepts at that scale. The designation of 'theater-level' is used in both professional military and commercial wargame communities to denote the scale of a given game. Tactics or operational-level games will focus on an individual conflict within a larger theater. By contrast, a theater-level wargame can encompass several simultaneous tactics-level conflicts within a designated geographic zone. The jump from isolated tactics-level conflicts to theater-level wargames introduces several layers of complexity, such as simulation of terrain, weather and supply transport lines. On occasion, this complexity has necessitated experimentation with integrating smaller tactical games into larger

[7]Clark et al., *HUTSPIEL: A Theater War Game*. 16.

"systems of games," where output results from one game would be used as inputs into another game,[8]. In theory, this would allow for smaller facets of warfare to be simulated without sacrificing accuracy.

Still, *Hutspiel*did not introduce the concept of theater-level wargaming; the game owes much to its predecessors.Histories of military wargaming generally cite *chaturanga*, *go*, and chess as early examples[9]. These examples were structured as competitions between two players to maneuver their pieces to outflank their opponent[10]. Gameboards were not intended to reflect real-world geographic terrain, butto provide an abstract space for gameplay; successful play requiresanticipating opponent's potential moves and maintaining control over the space of play.

Nineteenth century wargames would embody reactions to the changing state of warfare by placing a greater emphasis on accuracy and detail. Baron George Leopold von Reiswitz's 1811*Kriegsspiel* typifies such changes in wargame design. By necessity, war games must simplify and abstract aspects of warfare to be able to function as coherent systems of rules with which players engage. Von Reiswitz's*Kriegsspiel*attempts to reduce this impasse between abstract strategy and the reality of warfare by incorporating details of his service in the Prussian Army into his game's mechanics. For example, player moves must be executable within two

[8]Harrison, *Computer-Aided Information Systems for Gaming*,21.
"There is sometimes a requirement for a game to treat both the broad strategic aspects of an operation and smaller tactical details….ORO has experimented with such systems in games for both air defense and for ground warfare. In air defense the results of a detailed surface-to-air missile computer simulation were used as inputs to a theater-level air defense game with human commanders."
[9]Thomas B Allen, *War Games: The Secret World of the Creators, Players, and Policy Makers Rehearsing World War III Today* (New York: McGraw-Hill, 1987), 115.
"The envisioning of battle through games-as in chess, the Hindu *chaturanga,* and the oriental *go*-is an idea so old and universal that its origins are lost to time.
[10]Charles R. Shrader, *History of Operations Research in the United States Army*, vol. 1942–1962, 3 vols., CMH Pub 70-102–1, <70-110-1> (Washington, D.C: Office of the Deputy Under Secretary of the Army for Operations Research, U.S. Army, 2006),113.
"The game of chess is believed to be the oldest form of wargame, although the Chinese sage Sun Tu is said to have created a wargame called "Wei Hei" around 1,000 BCE."

minutes; this temporal limit derives from the time necessary to load and fire a cannon[11].While Reiswitz initially developed his game to play in any setting, he would later commission the construction of a chest of drawers to serve as the game board and house its piece[12]. The gameboard was assembled from interchangeable tiles bearing terrain features, such as rivers, forests and roads, allowing gameplay to simulate unit traversal over real-life geographical terrain, albeit to a limited extent[13]. Where early wargames relied upon a conception of geography relative to one's opponent's pieces, von Reiswitz's*Kriegsspiel*instead attempts to emulate geography as terrain. The pedagogical role of wargames would come to be supplanted by their use for planning and simulation. Von Reiswitz's son would later push *Kriegsspiel*further in this direction, substituting his father's tile sets for a "map-like chart with a scale of 1:8,000"[14].

While commercial wargames would be developed throughout the earliest twentieth century, 'professional' wargames would continue to expand upon *Kriegsspiel's*design philosophy and use for military planning[15]. Most of this work would be taken up by the burgeoning field of operations research, which traces its origins to the British war effort in WWII[16].The United States military would incorporate OR into its own war effort following the British model, treating military operations as problems for scientific experimentation and

[11]Philipp von Hilgers, *War Games: A History of War on Paper* (Cambridge, Mass.: MIT Press, 2012), http://proxy.library.nyu.edu/login?url=https://muse.jhu.edu/book/19774, 49.
[12]Ibid, 43-51.
[13]Ibid, 50-51.
"Subsequent to the war, Reiswitz developed a system for the printing of maps….he designed a system comparable to lead printing with which different printed characters were designated for distinct capitals, fortresses, and other structures as well as main and side streets, forestes, bodies of water, and other geographical features."
[14]Shrader, *History of Operations Research in the United States Army, 113*.
[15]Allen, *War Games,* 117-118.
[16]Ibid, 130.
"The term *operational research* traces back to 1937 when some workers at the Air Ministry Research Station were given the task of figuring out how to put a promising new radio-echo detection system that later would be dubbed radar. The word *operational* was inserted into the group's research title to set off what they were doing from traditional research and development activities".

inquiry. Research groups would be staffed by civilian scientists. As the US military would later scale down in the post-war era, the Department of Defense would fund research and development centers as a way to retain the civilian scientific research community which it had built up during the war[17]. These federal research centers, later named federally-funded research and development centers (FFRDCs), would occupy a middle ground between for-profit contractors and in-house government work. FFRDCs were subject to several restrictions in their activities due to this status: FFRDCs had to operate as a non-profit and refrain from competing with for-profit industry; they were expected to only retain their sponsoring branch of the US Military as their sole client. ORO would be sponsored by the US Army in 1948.

ORO's documentation for the *Hutspiel*project demonstrates the game's influence by prior professional wargames. The game's structure as a competition between two sides, designated with blue and red, follows a longstanding convention[18].Equations involving ground troops reference multiple sectors, although the layout of the game map is not described[19]. Prior ORO wargaming projects, such as Maximum Computer Complexity Battle (MCCB), are described as using a hexagonal grid for unit movement[20]. In professional wargames, units are typically able to move between adjacent squares, including diagonally; hexagonal grids are used to resolve

[17]United States, *A History of the Department of Defense Federally Funded Research and Development Centers,* 8. "The rapid epochal changes in technology, the advent of new disciplines like operations research, and the developing threat from the Soviet Union created a desire on the part of the military…to retain a number of these scientists for national needs"
[18]Allen, *War Games,* 120-121.
[19]Clark et al., *HUTSPIEL: A Theater War Game*, ORO-SP-53 (Chevy Chase, MD: Operations Research Office, 1958), https://archive.org/details/hutspiel-a-theater-war-game, 18.
[20]Allen, *War Games,* 133.

ambiguities with diagonal movement[21]. Given that MCCB uses a hexagonal grid, it would be reasonable to assume that *Hutspiel*would as well.

*Hutspiel's*and MCCB's main advancements their predecessors are in their representation of combat interactions through a mathematical model. Prior war games designed for hand would use written tables to detail the results of combat, which players would consult. Entries in CRTs contain the outputs of a series of mathematical functions, based on input variables representing relevant circumstances to the combat encounter. Users do not perform computational work themselves to derive combat results, but instead locate the corresponding entry on the CRT. Wargames designed for computer, such as *Hutspiel*, inherit this abstraction, substituting the computer's hardware for the CRT.Rather than consult a table, *Hutspiel*players set input values on the GEDA's hardware; the GEDA processes these inputs and updates the state of the game following a predefined system of equations; the GEDA then relays the results of combat to players on a special display board. The use of a computer to derive combat results, rather than a printed CRT, allowed for *Hutspiel's* underlying mathematical model to grow more complex and to incorporate more granular inputs from players. Combat results could also be derived much more quickly. *Hutspiel*was able to process the results of one in-game day of combat in one second; the game was initially designed to run automatically as a result, allowing the combat model to advance without pausing for player input[22].

[21]Henry Lowood, "War Engines: Wargames as Systems from the Tabletop to the Computer," in *Zones of Control: Perspectives on Wargaming*, ed. Matthew G Kirschenbaum editor and Pat Harrigan, Game Histories (Cambridge, Massachusetts: The MIT Press, 2016), 83–105, https://ebookcentral.proquest.com/lib/nyulibrary-ebooks/detail.action?docID=4509808, 86.
The hexagonal grid was used in Avalon Hill's commercial wargames starting with 1961's *D-Day, Chancellorsville* and *Civil War*, replacing an earlier square-based grid. The invention of 'hex-based' movement entails conflicting accounts of influence between professional wargaming projects from the RAND Corporation and commercial titles designed by Avalon Hill founder, Charles S. Roberts.
[22]Harrison, *Computer-Aided Information Systems for Gaming,* 20.

*Hutspiel*and analog computing

ORO's decision to design *Hutspiel*for the analog GEDA computer was purposeful, not borne out of technical or logistical constraints. Information on ORO's analog computers is limited, but most official resources mention that ORO leased a digital computer in 1955, the ERA 1103[23]. Before that, ORO would rent time on digital computers operated by governmental agencies, such as the Bureau of the Census[24].Thus, ORO had access to digital computers prior to 1955. One of the major aims of the *Hutspiel*project was to develop a theater-level wargame for analog hardware. *Hutspiel'*sproject documentation lists as one of its main conclusions that the project "demonstrated convincingly that the GEDA can be used successfully for deterministic war games in which player decisions are a major element"[25]. ORO's decision to develop *Hutspiel*for the GEDA would greatly impact its design.

The decision to develop *Hutspiel*for analog was likely in response to the limitations of digital computers in the early 1950s. Where digital computers could process much more information than their analog counterparts, their size and the amount of cooling required for their operation was difficult to manage. ORO's ERA computers were so large that they needed to be installed in its own dedicated building, formerly a plumbing supply warehouse, separate from both ORO's main campus in Chevy Chase, MD and its expanded facilities leased in conventional

[23]Alexander Smith, "Shall We Play a (War) Game?," in *They Create Worlds: The Story of the People and Companies That Shaped the Video Game Industry*, vol. 1: 1971-1982, 1 vols. (Boca Raton, FL: CRC Press/Taylor & Francis Group, 2020), 17–29 http://proxy.library.nyu.edu/login?url=https://www.taylorfrancis.com/books/9780429423642, 24.
[24]Shrader, *History of Operations Research in the United States Army, 114*.
MCCB was likely developed when ORO was renting time on digital computers. This would explain MCCB's protracted development compared to *Hutspiel,* which was developed in-house on hardware that ORO either purchased or leased from Goodyear.
[25]Clark et al., *HUTSPIEL: A Theater War Game. 16*.

office buildings[26]. Air conditioning was unable to offset heat generated from the ERA's vacuum tubes to maintain sufficient cooling, so the ERA was not used during the muggy summer months. By contrast, photographs of ORO's GEDA show that both the console and player input & display boards comfortably fit inside of one room[27].

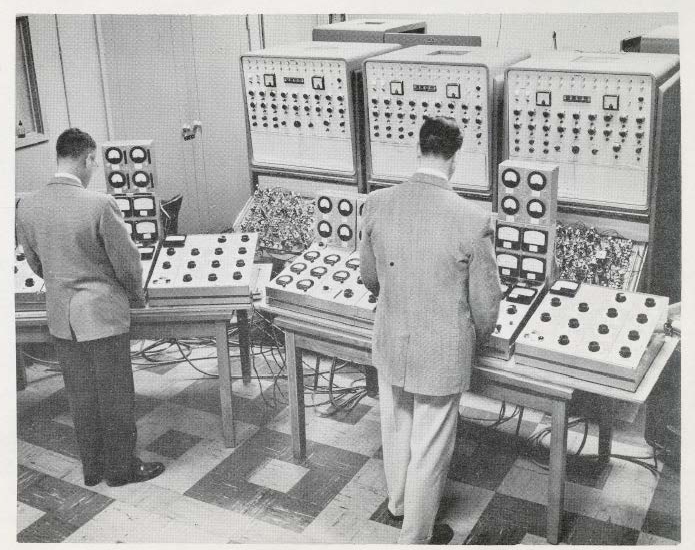
HUTSPIEL Players at GEDA Control Panels

Figure 1: Hutspiel GEDA unit at Johns Hopkins ORO (1955)

Moreover, analog computers permitted faster iteration upon *Hutspiel*'s gameplay loop. Digital computers at the time used various physical input and output formats, such as punch cards and magnetic tape to ingest and encode information into a machine-readable format. This is suitable for simulations which proceed without user input, but less so for wargames like *Hutspiel* which are structured around frequent player decisions. It would be possible to use digital output media as input data for the same game but this would require significant physical intervention, greatly slowing proceedings[28]. By contrast, analog computers do not act as transducers; inputs and output values are represented with the same physical medium. Analog computers simulate mathematical equations, such as addition, multiplication and sign-changing by manipulating voltage via specially designed circuitry, typically incorporating direct current (DC) amplifiers with other circuit components, such as

[26]Eugene P. Visco, "The Operations Research Office," *Army History*, no. 38 (1996): 28.
[27]Clark et al., *HUTSPIEL: A Theater War Game, 15*.
[28]Harrison, *Computer-Aided Information Systems for Gaming.* 21.
ORO experimented with this as well. Per Harrison's description of ORO's later work on incorporating simpler games into a larger system, it seems that the main method of integrating these games together was by ingesting one game's physical output media into a separate computer running another game.

resistors and capacitors[29]. Electronic differential analyzers, a subset of analog computers designed to solve differential equations, employ additional circuits to act as feedback mechanisms for operations which can be handled iteratively, like multiplication and arbitrary function generation[30]. Inputs can be entered via potentiometer dials and outputs can be displayed on galvanometers far more quickly as a result. The decision to design *Hutspiel*for the analog GEDA can thus be framed as a tradeoff between early digital computing's greater data capacity and its drawbacks in necessitating extensive physical operation to facilitate player decision-making anditssevere demands for physical space and adequate cooling.

ORO's prioritization of speed over complexity likely influenced the initial decision for *Hutspiel* to run in real-time, such that the state of combat would advance without direct user involvement such that one in-game day would progress in one second[31].This would certainly not have been possible with their ERA 1103 or even with the 1103A which ORO would lease in 1957. Like other digital computers at the time, the 1103A used punch cards and magnetic tape; a

[29]Ibid, 21.

[30]A.B. MacNee, "An Electronic Differential Analyzer," *Proceedings of the IRE* 37, no. 11 (November 1949): 1315–24, https://doi.org/10.1109/JRPROC.1949.229676.; W. A. Wildhack, "New Instruments," *Review of Scientific Instruments* 23, no. 11 (November 1952): 651–58, https://doi.org/10.1063/1.1746131.

Pages 1317-1319 of MacNee's paper offer a detailed description of the electrical components that would be necessary for electronic differential analyzers to work, complete with circuit diagrams. These include designs for a DC clamping circuit, used to "fix the output of each computing element" prior to operation.

While these descriptions are theoretical, it would seem that the GEDA incorporates these, or similar circuitry.A 1952 description of the L3 GEDA in the *Review of Scientific Instruments* states the GEDA uses "automatically stabilized" DC amplifiers, likely for the same purpose as MacNee's theoretical DC clamping circuit. While the L3 GEDA may not useMacNee'sexact circuit designs, MacNee's paper is nevertheless instructive in outlining how some of the core components of analog computers may work.

[31]Harrison, *Computer-Aided Information Systems for Gaming, 21, iii*; Dorothy K. Clark et al., *HUTSPIEL: A Theater War Game,* 1.

Harrison's claim that *Hutspiel*was designed to run in real-timeis not directly corroborated by ORO's project documentation for the *Hutspiel*project. The documentation instead states that "Between each computation, time was allowed for the players to study and record the interactions shown on the control board and to register thereon their next decisions," which would be consistent with either real-time or epochal operation. The project documentation also does not reference a change in how player turns were handled. However, Nicholas M. Smith provides the foreword to Harrison's paper; Smith was one of the five authors of *Hutspiel's*project report and may have been able to provide additional information on the game not included in the report.

*Hutspiel*designed for the 1103A would also play much more slowly, due to the need to produce and ingest punch cards encoding the current game state and player inputs[32]. Curiously, the game would be redesigned so that play would instead proceed epochally. Both players would enter input values for each in-game day, and press a button to confirm their inputs. The GEDA would update the game state and display updated output values to players; computation would pause until both players confirm their inputs[33]. The project report does not directly acknowledge this change. Epochal play is mentioned, as players are permitted to "take time between computation periods to deliberate," but not the initial real-time play.The deliberation periods, more in line with the game's use as an analytical tool, also clash with *Hutspiel's* initial design as a competition between two players.

[32]"Univac_Scientific_1103A_Reference_Manual_1956.Pdf," 2, accessed November 29, 2022, http://www.bitsavers.org/pdf/univac/1103/Univac_Scientific_1103A_Reference_Manual_1956.pdf.
[33]Clark et al., *HUTSPIEL: A Theater War Game. 5*.

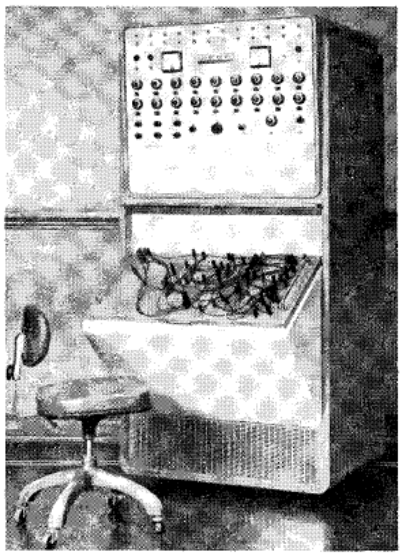

Figure 2: L3 GEDA unit (1952)

ORO was already in possession of a GEDA prior to *Hutspiel's*development. Harrison's description of *Hutspiel*mentions that the game was the "outgrowth of a series of simpler man-machine games developed at ORO for GEDA"[34]. These games were much smaller in scope than *Hutspiel*, concerning more limited conflicts, like a two-sided missile exchange. The decision to use the GEDA was thus made prior to the initial design of *Hutspiel's*mathematical model; *Hutspiel*served more as a proof-of-concept for theater-level wargaming on the GEDA than as a general advancement of computerized wargaming, analog or digital. Consequently, *Hutspiel*'smathematical model was designed to leverage the GEDA's strengths and in recognition of its limitations. As a differential analyzer, the GEDA is designed to solve linear differential equations. Consequently, the *Hutspiel*model mostly consists of this form of equation[35]. Differential equations denote the relation between a given operation and its rate of change over time. This allows *Hutspiel*'s model to track the changes in variables over time while also responding to player actions.

Still, analog development would impose its own exigencies; the decision to use linear differential equations was likely born out of logistical issues. Analog equipment is considerably lower in computational power than digital computers, necessitating the use of additional equipment; increases in model complexity thus introduce their own exigencies on space. Project documentation states that *Hutspiel*links damage per unit attack to a target's remaining inventory,

[34]Harrison, *Computer-Aided Information Systems for Gaming, 20*.
[35]Clark et al., *HUTSPIEL: A Theater War Game.* 11.

which results in a linear differential equation. Otherwise, other definitions for damage to targets would a set of non-linear differential equations, which would "considerably increase the amount of computing equipment needed"[36]. A similar rationale is provided for *Hutspiel*'s lack of stochastic elements; incorporating some degree of variation would have "more than doubled" the amount of analog equipment required[37].

Analog computing's exigencies on space also had a knock-on effect on the variables which *Hutspiel's*model tracked, reducing the scope of what the game modeled. ORO's GEDA consisted of 5 GEDA consoles total, three linear and two non-linear, likely the L3 model[38]. The L3 is described in the *Review of Scientific Instruments* as being capable of solving "twelfth-order differential equations involving 10 initial conditions"[39]. *Hutspiel's*limitation to linear (first-order) differential equations is likely due to the number of variables used. Introducing more variables imposes a greater demand for additional computing equipment than the complexity of the mathematical equations used. *Hutspiel's*use of 80 variables, stored in 80 DC amplifiers across the GEDA's three linear consoles, thus placed a severe limitation on the complexity of its mathematical mode[40]. Much of the project report details factors which had to either be simplified or excised from the model completely.For example, various models of aircraft were aggregated into a single type of unit; rail transport was modeled, but not transport via truck or highways;

[36]Ibid, 11-12.
[37] Ibid, 4.
[38] Ibid, 5; W. A. Wildhack, "New Instruments," *Review of Scientific Instruments* 23, no. 11 (November 1952): 651–52, https://doi.org/10.1063/1.1746131.
The L3 GEDA was released in 1952 and contained 24 DC amplifiers, matching the description of the consoles used for *Hutpsiel.* ORO's acquisition of an L3 GEDA prior between 1952 and 1955 would also be consistent with Harrison's accounts of prior projects for GEDA, and the *Hutspiel* project report's own references to the ORO GEDA predating the project.
[39]Wildhack, 651.
[40]Clark et al., *HUTSPIEL: A Theater War Game, 5*.

effects from weather, terrain, intelligence, troop mobility and damage to airway runways were omitted entirely[41].

Even though ORO took many steps towards reducing the amount of necessary computing equipment the complexity to play *Hutspiel*by simplifying its mathematical model, additional equipment was still required. In addition to the 5 GEDA consoles, ORO also used a Mid-Century Instrumatics electronic arbitrary function generator, to model effects of damage on transport lines, and two panels with potentiometers and galvanometers, allowing players to input and read out information in secrecy from each other. This would befit an initial design of *Hutspiel*as a competitive game, and contrasts with the documented open collaboration between players[42]. Like the decision for epochal play,this discrepancy between*Hutspiel's*initial design, suggested by the game's hardware, and information about play records demonstrates that gameplay had diverged significantly from its initial design. If players openly collaborated, there would be no need for panels to be separated from each other.

Player collaboration may have emerged in response to the game's deterministic nature. Due to the lack of stochastic elements in *Hutspiel's*model, the same sequence of player actions would always produce the same results. *Hutspiel's*game states could thus be represented as a decision tree. Discovery and repeated use of a dominant strategy would consistently steer the game towards one branch of the tree, neglecting the game's roots as an analytical tool used to studythe effects of various employments of atomic weapons and conventional air support[43]. Collaboration would allow players to effectively steer the game towards novel situations, befitting the project's analytical approach. Thus, the GEDA's relatively low computing power

[41] Ibid, 11;Harrison, *Computer-Aided Information Systems for Gaming. 20.*
[42]Clark et al., *HUTSPIEL: A Theater War Game, 14*.
[43] Ibid, 15.

indirectly influenced how *Hutspiel*was played. Collaboration would arguably not be necessary if *Hutspiel'*smodel contained stochastic elements; these would introduce a degree of variation, so repeating a given action would not necessarily yield the same results. This would prevent dominant strategies from fully optimizing play.

Hutspiel and Post-WWII US Operations Research

As mentioned before, the FFRDC which developed *Hutspiel*, ORO, had a rocky relationship to the Army which led to their dissolution in 1961 and effective replacement by RAC. Official sources do not provide a specific reason for ORO's dissolution, but point to a more general disagreements between ORO and the US Army, exemplified in the Army's relation with ORO's director, Dr. Ellis Johnson. ORO was affiliated with Johns Hopkins University; the university affiliation was to make ORO more attractive for civilian scientists than a new government agency would be[44].Dr. Johnson reportedly modeled ORO's institutional culture after academic institutions, likely treating ORO's connection to higher education as a mandate. Johnson took a multidisciplinary approach to staffing, hiring professionals with backgrounds in engineering, biology, chemistry, geography, history and anthropology. Moreover, he worked to clear all ORO analysts for access to all ongoing research[45]. ORO would also have a large presence in the early history of the Operations Research Society of America; ORO employee Thornton Page would be the first editor of the Society's journal; Page and Johnson would both serve on the Society's Formation Committee, as well.

[44]Thompson, *The Research Analysis Corporation: A History of a Federal Contract Research Center*,8-9.
[45]Visco, "The Operations Research Office." 28.

Johnson's vision for ORO would contrast with that of the Army. Johnson and ORO researchers would advocate for leeway to tackle complex issues without guarantee or obligation to produce actionable results.By contrast, the Army would emphasize "short-run, concrete, clearly feasible studies that would produce visible short-run improvements"[46]. The Army's emphasis on the short term likely stemmed from inter-service rivalry with the Navy and Air Force. These military branches would contract their own FFRDCs between 1945 and 1946[47]. By contrast, the Army relied on other services' OR groups during WWII, and would sponsor ORO a few yearslater in 1948. The Army thus seems to have wanted to use ORO to catch up to the Navy and Air Force to remain relevant in the United States' nuclear-age national defense strategy[48]. ORO's broad, multidisciplinary scope of research and reluctance to promise concrete results chafed against this attitude.

The *Hutspiel*project is very much a product of ORO's institutional culture, as ORO's project report and Harrison's description of the game demonstrate.The project report's five listed authors each specialize in a different field under the banner of OR, in line with Dr. Johnson's multidisciplinary approach to research: Paul Iribe was an expert in computer science and electrical engineering and likely programmed the game; Nicholas Smith specialized in "calculations related to atomic bomb fallout"; Lloyd Yates likely "provided expertise related to the air combat portion of the simulation"; Dorothy Clark provided expertise on ground combat.

[46]Thompson, *The Research Analysis Corporation: A History of a Federal Contract Research Center,* 11,12.
[47]United States, *A History of the Department of Defense Federally Funded Research and Development Centers,* 14,15.
MIT would sponsor the Operations Evaluation Group (OEG) on November 1, 1945, renamed from the wartime Naval Operations Research Group; OEG would remain under contract with the Navy. The Air Force would sponsor the RAND Corporation in 1946.
[48]Thompson, *The Research Analysis Corporation: A History of a Federal Contract Research Center, 12*.
"The situation for Army morale was not eased much by the Eisenhower Administration's patent preference for seeking security through massive retaliation, in which the Air Force would play a major role."

The year prior, Clark published a paper "modeling the effect of troop losses on combat effectiveness"[49]. ORO's project report references "[data] from WWII and the Korean conflict" on casualties from conventional air support on ground troops, possibly referencing Clark's paper[50].

While the *Hutspiel*project'sstated goals of analyzing the use of conventional air support and atomic weapons reflect the Army's immediate concerns during the nascent Cold War, Clark & co.'s report views the game as more iterative than conclusive. *Hutspiel*thus reflects ORO's long-term research priorities, which were more concerned with identifying future areas of inquiry[51]. Harrison describes *Hutspiel*as the "outgrowth" of several simpler games developed for ORO's GEDA[52]. The project report also exclusively states its conclusions in terms of *Hutspiel'*svalue for "models of future theater war games," neglecting any conclusions related to employments of conventional air support or nuclear weapons[53]. Not only is *Hutspiel*the outgrowth of prior wargaming projects, but it was developed with the intention to contribute to future wargame design as well.*Hutspiel'*siterative design goals are also reflected in the report's lack of records of play. The report contains a brief description of play, but lacks transcripts or analysis of specific games played by ORO analysts and/or Army personnel. Instead, it rationalizes that inclusion of such material would not be necessary, as gameplay results would

[49]Aaron A. Reed, "HUTSPIEL and Dr. Dorothy K. Clark," Substack newsletter, *50 Years of Text Games* (blog), January 26, 2022, https://if50.substack.com/p/hutspiel-and-dr-dorothy-k-clark; "Dinesh Manocha Joins UMD as the Paul Chrisman Iribe Professor of Computer Science," May 9, 2018, https://www.cs.umd.edu/article/2018/05/dinesh-manocha-joins-umd-paul-chrisman-iribe-professor-computer-science.
Elizabeth Iribe, Paul's wife, established a professorship endowment at the University of Maryland for computer science. UMD also maintains a close relationship with Iribe's family; their center for computer science building is named for Elizabeth's son, Brendan, co-founder of Oculus (now Reality Labs, a division of Meta).
[50]Clark et al., *HUTSPIEL: A Theater War Game, 8*.
[51]Thompson, *The Research Analysis Corporation: A.History of a Federal Contract Research Center,* 11.
"At the outset the researchers strove to outline problem areas…as a means of outlining important future problems."
[52]Harrison, *Computer-Aided Information Systems for Gaming, 20*.
[53]Clark et al., *HUTSPIEL: A Theater War Game, 3*.

only be meaningful to the extent that the "model itself [acts as] a fair approximation of reality"[54]. The game was designed around military intelligence current in 1955, which would have been outmoded at the time of the report's 1958 publication. While records of play could be used by preservation or reimplementation projects to evaluate the game's behavior, these were clearly not a priority of Clark & co. Instead, *Hutspiel*was developed as a stepping stone in computerized theater-level wargaming. This attitude would also explain the decisions to change from real-time to epochal progression, and for players to openly collaborate rather than compete; both choices were likely made to make the game easier to analyze.Unlike Reiswitz's*Kriegspiel*, *Hutspiel*was never intended to be used as a tool for military operations planning, but instead as an object to be analyzed to advance future development of computerized theater-level wargames.

After *Hutspiel*

Befitting the iterative goals of the *Hutspiel*project, both ORO and RAC would develop later wargames for digital computers. ORO would develop the first *Carmonette*simulation in 1956, which would incorporate stochastic elements via Monte Carlo techniques to represent probabilities[55]. High continuity of staff and assets would allow RAC to continue work on *Carmonette* throughout the 1960s; RAC would extend *Carmonette*to represent battalion-level operations, eclipsing the scale of *Hutspiel'*smodel[56].

*Hutspiel*was developed for the analog GEDA in response to severe exigencies on space and cooling imposed by the ERA 1101 and 1103, and the lack of a clear method to facilitate a core gameplay loop. Later digital computers, such as the ERA 1103A, which ORO leased in

[54] Ibid, 15.
[55]Thompson, *The Research Analysis Corporation: A History of a Federal Contract Research Center, 37-38*.
[56]Shrader, *History of Operations Research in the United States Army, 115*.

1957, would improve upon these exigencies immensely. Eventually, wargaming models would grow in complexity, out of a need to provide more accurate simulations. Ironically, analog computing's own limitations on data capacity would eclipse its speed and comparatively low space and cooling requirements. Harrison's comparison of *Hutspiel*and *Theaterspiel'*srespective data capacities is instructive[57].Assuming that each variable can be represented by 5 bits, Harrison estimates that *Hutspiel's*40 variables per side can be presented with 300 bits of digital information; RAC's *Theaterspiel*(1962) uses 150-200 bits per unit, for a maximum size of 100,000 bits with 275 units per side; later iterations on *Carmonette*use 90,000 bits.Digital computing allows for orders of magnitude more information to be stored, facilitating the incorporation of stochastic elements and other features into a given wargame's mathematical model. RAC's *Carmonette*series(1958-1972) and *Theaterspiel*(1962) are theater-level wargames which incorporate "[various] kinds of terrain and weather conditions"[58]. In this context, the simplifications to *Hutspiel's*model, imposed by analog computing's much lower information density, no longer seem as necessary.

Conclusion: Preservation of Analog Computing

While the L3 GEDA and *Hutspiel*have both been obsoleted in their respective fields, *Hutspiel*is nevertheless significant for Clark & co.'s efforts in developing an early theater-level wargame. In conception and development, *Hutspiel*serves as a document of a transition.The game's development for an analog computer demonstrates ORO's early ingenuity and evidences both a highwater mark of complexity in analog computing and an early period in digital

[57]Harrison, *Computer-Aided Information Systems for Gaming, 24*.
[58]Allen, *War Games, 304*.

computing's history, where the severity of digital computers' material demands outstripped its utility.

Still, *Hutspiel*poses several issues for preservation. Several hobbyists have undertaken projects to restore analog computers. However, RAC technical papers largely neglect *Hutspiel*and do not mention any subsequent work for GEDA or other analog computers. It is likely, then, that the GEDA and electronic function generator used for *Hutspiel* were discarded during the transition from ORO to RAC or RAC's acquisition by GRC. It could be possible to reimplement *Hutspiel*on a surviving GEDA, although ORO's project report neglects records of play and input values used to define the starting numbers and exchange strengths of NATO and USSR forces. While the basic mechanics of the game could be reimplemented, more work would be necessary to approximate the game's general behavior.

Emulation may present another means of preserving the game. Analog computing lacks digital computing's clear distinction between hardware and software; data manipulation is directly reliant upon circuit design and patching signals between components. This lack of abstraction means that analog computers are designed to function without the use of key structural elements in computer systems, such as operating systems, and assembly & machine languages. Still, GEDA hardware, or at least particular circuit designs commonly used in analog computing, could be simulated via digital applications such as PyAnalog, an open-source Python package used to interface with the Analog Paradigm Model-1 analog computer[59]. Other programs, such as LTSPICE, can digitally simulate circuits; circuits can be chained together to

[59]Santos, Rui, "PyAnalog: A Pythonic Analog Computer Demonstrator Interface," Mathematica (2020; repr., Anabrid GmbH, November 5, 2022), https://github.com/anabrid/pyanalog.

build more complex allow users to set up more complex models, approximating the functionality of a 'virtual analog computer' (VAC)[60].

[60]Glazar, Arthur, "A Virtual Analog Computer for Your Desktop," *EDN* (blog), June 29, 2012, https://www.edn.com/a-virtual-analog-computer-for-your-desktop/.

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Allen, Thomas B..*War Games: The Secret World of the Creators, Players, and Policy Makers Rehearsing World War III Today*. New York: McGraw-Hill, 1987.

This book details topics in the United States military's use of computerized war simulations and player-driven wargames for planning, mainly focusing on wargames developed and played in the 1970s and 1980s. It contains some discussion of US operations research in the 1950s, which is relevant to this project, as well as an interview with James Dunnigan, founder of commercial wargame publisher Strategic Publications, Inc.

Clark, Dorothy K., Archie N. Colby, Paul Iribe, Nicholas M. Smith, and Lloyd D. Yates. *HUTSPIEL: A Theater War Game*. ORO-SP-53. Chevy Chase, MD: Operations Research Office, 1958. https://archive.org/details/hutspiel-a-theater-war-game.

Primary source report on the *Hutspiel*project by project staff; this represents the most complete description of *Hutspiel*. Report covers the game's scenario, rules of play, rationale for development of mathematical model. However, specific technical documentation (e.g. definitions and default values for input variables, wiring diagrams, transcripts of games played) are not included.

"Dinesh Manocha Joins UMD as the Paul Chrisman Iribe Professor of Computer Science," May 9, 2018. https://www.cs.umd.edu/article/2018/05/dinesh-manocha-joins-umd-paul-chrisman-iribe-professor-computer-science.\

Article demonstrating University of Maryland connection to Paul Iribe.

Glazar, Arthur. "A Virtual Analog Computer for Your Desktop." *EDN* (blog), June 29, 2012. https://www.edn.com/a-virtual-analog-computer-for-your-desktop/.

Article discussing the LTSPICE circuit simulator. This could provide a means of simulating *Hutspiel*/GEDA's circuitry on digital computers, allowing the game to be reimplemented as a digital computer application.

Harrison, Jr, Joseph H..*Computer-Aided Information Systems for Gaming*. Advanced Research Division, RAC-TP-133. McLean, VA: Research Analysis Corporation, 1964.

Chapter from a book intended for publication regarding computer information systems. The section on *Hutspiel*is the most complete description of *Hutspiel*outside of ORO's project report. Most secondary sources which mention *Hutspiel*refer to Harrison's description here.

Lowood, Henry. "War Engines: Wargames as Systems from the Tabletop to the Computer." In *Zones of Control: Perspectives on Wargaming*, edited by Matthew G Kirschenbaum editor and Pat Harrigan, 83–105. Game Histories. Cambridge, Massachusetts: The MIT Press, 2016. https://ebookcentral.proquest.com/lib/nyulibrary-ebooks/detail.action?docID=4509808.

Essay on the early history of commercial wargaming in the United States post-WWII, focusing on games published by Avalon Hill and, later, Strategic Publications, Inc. Useful for Lowood's analysis of Charles S. Roberts's anecdote regarding his visit to RAND, which interrogates alleged early connections between military and commercial wargaming communities.

MacNee, A.B. "An Electronic Differential Analyzer." *Proceedings of the IRE* 37, no. 11 (November 1949): 1315–24. https://doi.org/10.1109/JRPROC.1949.229676.

Conference paper describing implementation of an electronic differential analyzer, a kind of analog computer. Description of circuitry for feedback mechanisms is instructive for understanding how analog computing development worked.

Office of Technology Assessment. *A History of the Department of Defense Federally Funded Research and Development Centers*. Background Paper. Washington, DC: Office of Technology Assessment, Congress of the U.S. : For sale by the U.S. G.P.O., Supt. of Docs, 1995.

Book detailing the history of DoD FFRDCs; provides an overview of Johns Hopkins ORO, and of the myriad restrictions on FFRDC activities.

"PyAnalog: A Pythonic Analog Computer Demonstrator Interface." Mathematica. 2020. Reprint, Anabrid GmbH, November 5, 2022. https://github.com/anabrid/pyanalog.

Github repository for PyAnalog project. Documentation describes a digital computer interface which can be used to operate an Analog Paradigm Model-1 analog computer. Could provide one potential avenue for re-implementation of *Hutspiel*on some form of analog hardware.

Reed, Aaron A. “HUTSPIEL and Dr. Dorothy K. Clark.” Substack newsletter. *50 Years of Text Games* (blog), January 26, 2022. https://if50.substack.com/p/hutspiel-and-dr-dorothy-k-clark.

Substack newsletter detailing the involvement of Dorothy K. Clark in the *Hutspiel*project. Provides information on the areas of expertise of the *Hutspiel*project staff. Incidentally, Reed uploaded the ORO *Hutspiel*project report to the Internet Archive earlier this year.

Santos, Rui. "Electronics Basics - How a Potentiometer Works | Random Nerd Tutorials,” August 11, 2016. https://randomnerdtutorials.com/electronics-basics-how-a-potentiometer-works/.

Basic description of principles behind rotary potentiometers, which *Hutspiel*’s special display board used for player inputs.

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Book detailing early history of operations research in the United States, spanning OR efforts during WWII, the creation of early FFRDCs. Provides an overview of ORO’s history, including its dissolution and replacement with the Research Analysis Corporation in 1961.

Smith. Alexander. “Shall We Play a (War) Game?” In *They Create Worlds: The Story of the People and Companies That Shaped the Video Game Industry*, 1: 1971-1982:17–29. Boca Raton, FL: CRC Press/Taylor & Francis Group, 2020. http://proxy.library.nyu.edu/login?url=https://www.taylorfrancis.com/books/9780429423642.

Book chapter detailing early wargames, in the context of a pre-history of the commercial videogame industry. Description of *Hutspiel*is provided, citing Harrison's paper, as well as an overview of ORO's other wargaming projects designed for digital computers.

Charles A. H. Thompson. *The Research Analysis Corporation: A History of a Federal Contract Research Center*. McLean, VA: Research Analysis Corporation, 1975.

Book published by RAC, detailing its history; contains chapters on ORO's history and transition into RAC. Provides more information regarding ORO's relationship with the Army

"Univac_Scientific_1103A_Reference_Manual_1956.Pdf." Sperry-Rand Corporation, 1956. Accessed November 29, 2022. http://www.bitsavers.org/pdf/univac/1103/Univac_Scientific_1103A_Reference_Manual_1956.pdf.

Operational manual for the UNIVAC 1103 an early digital computer; variously referred to as the ERA 1103 or the Sperry-Rand 1103. As described in other sources, ORO would reserve computer time on this model of digital computer from governmental agencies.

von Hilgers, Philipp. *War Games: A History of War on Paper*. Translated by Ross Benjamin. Cambridge, Mass.: MIT Press, 2012. http://proxy.library.nyu.edu/login?url=https://muse.jhu.edu/book/19774.

Book detailing the history of wargaming prior to the introduction of computers and intersection with operations research. Useful for descriptions of Leopold von Reiswitz's*Kriegsspiel*cabinet.

Visco, Eugene P. "The Operations Research Office." *Army History*, no. 38 (1996): 24–33.

Article detailing history of ORO; contains unique information regarding institutional culture under Director Dr. Ellis Johnson.

Wildhack, W. A. "New Instruments." *Review of Scientific Instruments* 23, no. 11 (November 1952): 651–58. https://doi.org/10.1063/1.1746131.

Review & description of Goodyear's L3 GEDA, likely the model of GEDA used on the *Hutspiel*project.

Wolf, Mark J. P. *The Video Game Explosion: A History from PONG to Playstation and Beyond*. Westport, Conn.: Greenwood Press, 2008.

Book on the history of the commercial videogame industry with a brief chapter on military wargaming, akin to Alexander Smith's *They Create Worlds*. Notable for its claim that *Hutspiel*is the first theater-level wargame designed for computers.