Design Thinking as a Non-Linear Method for Frugal Engineering: A Ground-Station Case

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Abstract*– Design Thinking (DT) is widely recognized as a human-centered, iterative approach, yet it is often oversimplified as a rigid, linear sequence. This paper challenges this view by providing empirical evidence of DT as a non-linear method in a high-pressure, resource-constrained engineering environment: the José Trinidad Cabañas ground station in Honduras. Facing a critical failure in an antenna-rotor controller just days before an international supervisory visit, the team bypassed procurement delays by reframing the problem from "obtaining a spare part" to "replicating a function." Through three to four non-linear iterations, in which early failures were treated as progress, the team developed a low-cost "parasitic" device that reconstructs position feedback from timing and drive-line data. The resulting prototype achieved a low operational error, suggesting that DT can effectively absorb technical uncertainty. The case positions DT as a connective method that aligns agile practices with frugal innovation, offering a viable model for engineering resilience in the Global South.

Keywords*-- Design thinking; non-linear problem-solving; iterative prototyping; agile methodologies; multidisciplinary teams.

I. Introduction

Design Thinking (DT) has become a widely adopted approach for addressing ill-defined, "wicked" problems that resist purely linear analysis [1]. In the management literature, it has been heralded as a human-centered problem-solving methodology suited to the innovation and growth challenges that organizations face [2]. Yet DT is frequently reduced to a fixed sequence of stages, which conceals what practitioners repeatedly observe in practice: progress is iterative and non-linear, and the knowledge produced during testing feeds back into how the problem itself is framed.

In this respect, DT converges with agile methodologies, which likewise abandon linear, plan-based development in favor of short, iterative cycles and continuous responsiveness to change [3], [4]. The two are complementary: DT helps frame the right problem, while agile builds and refines the solution incrementally through rapid prototyping and testing [5]. This paper treats that convergence as central to how the Morazán team resolved engineering problems in practice, and returns to it in Section II.D.

The Morazán Project is a Central American initiative for regional integration through space, led by Honduran institutions (UNAH) with partners in Costa Rica and Guatemala, that develops the MRZ-SAT CubeSat (the first Honduran experience in space) whose scientific mission is an early-warning system for floods and landslides in a region highly exposed to natural disasters [6]. The space segment is paired with an academic ground station, the Cabañas station, the first university ground station built in Honduras for small-satellite missions [7], and with an explicit educational component intended to build local capacity and widen participation in space technology [8]. This resource-constrained, high-uncertainty effort spanning the space and ground segments offers rich empirical material to examine how DT operates under real constraints, since technical problems have arisen that the team resolved by trying different ways of thinking and building.

This paper pursues three objectives. First, it synthesizes the state of the art across three domains: design-thinking-driven innovation, innovation methodologies, and the strategic management of R&D, innovation, and entrepreneurship. Second, it argues that DT functions as the connective method that links these domains. Third, it illustrates this through a ground-station (GS) case, the functional replacement of a failed antenna-rotor potentiometer with a decoy device, which demonstrates the non-linear, iterative nature of the process. The contribution provides situated evidence from a resource-limited Central American context, addressing a gap identified in recent literature [9].

II. Related Work and State of the Art

A. The Core of Design Thinking

Buchanan characterized design as a field concerned with "wicked problems", indeterminate problems that have no definitive formulation, and proposed the doctrine of placements as a way for designers to frame and reframe such problems [1]. Dorst locates the core of DT in framing and frame-creation, underpinned by abductive reasoning, that is, reasoning toward what might be created rather than deducing from fixed premises [10]. Consolidating a fragmented literature, Micheli et al. conducted a systematic review and identified ten principal attributes of DT—abductive reasoning, ability to visualize, blending analysis and intuition, creativity and innovation, a gestalt (holistic) view, interdisciplinary collaboration, iteration and experimentation, problem solving, tolerance for ambiguity and failure, and user-centeredness—together with the tools and methods that activate them [3]. Two of these attributes (iteration and experimentation, and tolerance for ambiguity and failure) are central to the non-linear behavior this paper documents.

B. Design Thinking as an Iterative, Multidisciplinary Method

Grots and Creuznacher describe design thinking as a step-by-step process (understanding/definition, observation,

synthesis, ideation, prototyping, and testing) but emphasize that its defining characteristic is openness: the steps "should be understood more as an orientation than as a strict sequence" [11]. Furthermore, they point out that the deliberate use of prototypes fosters a very fertile "error culture", in which errors identified early are treated as progress [11]. Liedtka links design thinking to improved innovation outcomes through a different mechanism: its hypothesis-driven experimental tools help decision-makers reduce cognitive biases at the individual level [2]. Studying novice multidisciplinary teams, Seidel and Fixson show that formal design methods (needs identification, brainstorming, and prototyping) are beneficial when combined but also reveal limitations when used in isolation [12]. Complementary evidence from case studies indicates that DT helps multidisciplinary teams overcome innovation challenges by fostering empathy, creativity, and iteration [5], as illustrated in Fig. 1.

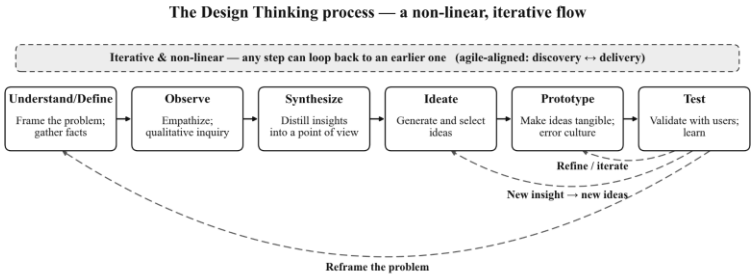


Fig. 1. The Design Thinking process as a non-linear, iterative flow.

C. Design Thinking as Innovation Capability, Culture, and Strategy

Beyond the project level, Design Thinking (DT) has been framed as an organizational innovation capability whose values and effects are typically long-term [13]. Elsbach and Stigliani review the relationship between DT tools and organizational culture, finding that they are mutually reinforcing and that the use of DT tools produces emotional experiences and physical artifacts that help maintain a supportive culture [14]. In line with this, Grots and Creuznacher position DT as a method for organizational change and cultural transformation [11]. Empirically, Roth et al. find that a higher level of DT application is associated with greater success in innovation projects, mediated by team-level mechanisms [15]. Finally, Martínez Casanovas links DT to the United Nations Sustainable Development Goals and identifies persistent gaps: the lack of standardized evaluation frameworks and weak ethical and contextual adaptation, particularly in vulnerable or resource-limited communities [9], gaps to which the context of this article directly refers.

D. Correlation with Agile Methodologies

Agile methodologies and DT share a common epistemological root—iteration as a means of progressing under uncertainty—and therefore operate as complementary rather than competing approaches [3]. Both reject the linear logic of "analyze → design → implement": agile product development is explicitly opposed to linear, plan-based innovation and is characterized by iteration, experimentation, and a clear focus on user requirements [3], [4], while DT treats its stages as an orientation rather than a strict sequence [11]. In both, the prototype or increment converts assumptions into fast, inexpensive evidence that reduces risk before resources are committed [3], [11]. DT is thus frequently implemented through agile practices such as rapid prototyping and testing, which let multidisciplinary teams validate and refine ideas incrementally [5], and reliance on such small, quick experiments fosters a more agile organizational way of learning from both successes and failures [11], [14]. What DT adds to the agile mindset is the abductive framing of the problem itself: whereas agile focuses on activities within the process, DT questions assumptions and meanings before the search for alternatives begins [3]. Section IV shows both intertwined in practice, with each functional test acting like the review that closes an agile sprint [5], [11].

III. METHOD

A. Research Design

This study adopts a qualitative single-case design, appropriate for understanding a contemporary phenomenon in depth and in its real-world context when the boundaries between the phenomenon (the use of Design Thinking) and its context (an operating aerospace ground station) are not clearly defined. Because DT is enacted rather than merely described, and its defining characteristic is a non-linear movement between definition, ideation, prototyping, and testing [10], [11], a process-oriented case study allows the iterative returns between stages to be observed directly rather than inferred from results. The design is exploratory and theory-based: the constructs used to interpret the case—DT phases, DT attributes, and the DT–agile correspondence—were drawn from Section II and used as an analytical lens rather than as hypotheses to be tested statistically.

B. Case Selection and Unit of Analysis

The case was chosen for its theoretical relevance (purposive sampling) rather than its statistical representativeness. The Morazán Project ground station (GS) presents an engineering environment with limited resources and high uncertainty, where components cannot always be replaced, and problems must be reformulated and solved with the available means; precisely the conditions under which the non-linear nature of DT is expected to manifest itself. The unit of analysis is the problem-solving episode: a delimited sequence that begins with the identification of a technical problem and ends when a functional solution is reached and validated.

C. Data Collection

Data were collected through participant observation by members of the development team and are supported by records

produced during the episode: photographs and working notes of the successive circuit versions; hand calculations, simulations, and circuit sketches, including the characterization of the rotor's angular velocity and full-rotation time; the device's firmware; the readings that this firmware displayed on a serial monitor during functional tests, which were used to compare estimated and observed positions; and an internal technical report written at the close of the episode. The demonstration of the working device to the visiting international delegation provides an external observation of its final state.

Design decisions were also verified collectively as they were made. Because the rotor and its controller were critical assets that could not be exposed to further damage, no circuit version was tested before being reviewed by the team members involved—never fewer than three people, and at times more—who checked its voltages and currents and judged whether it worked as intended or whether a different idea should replace it. Configurations that raised doubts were discarded and rebuilt. As a result, each design decision, and each return to an earlier phase, was taken and agreed jointly at the time rather than inferred afterwards.

No formal real-time decision log was kept during the crisis. The episode was therefore reconstructed for this study by team members who took part in it, drawing on their recollection and cross-referencing it, where possible, with the records above—most notably the firmware, which fixes the parameters reported in Section IV.E. This is acknowledged as a limitation, and a structured logging protocol for future episodes is proposed in Section VI.

D. Data Analysis

The episode was reconstructed as a sequence of steps and coded according to two complementary schemes. First, the steps were mapped to the canonical phases of Design Thinking: understand/define, observe, synthesize, ideate, prototype, and test [11]. Second, they were coded according to the Design Thinking attributes identified in the systematic review, particularly iteration and experimentation, and tolerance for ambiguity and failure [3]. The analysis paid particular attention to returns: instances where the outcome of a functional test caused the team to revert to a previous phase. Since these returns are the observable trace of the non-linearity and abductive reframing that constitute the core of DT [10], each was recorded along with its trigger (what the test revealed), the phase to which the team returned, and the change subsequently introduced. This allowed the trajectory of the episode to be represented as a cyclical path rather than a straight line. To make the correspondence between DT and agile methodologies explicit, each functional test was further interpreted as a review point analogous to the closing of an agile iteration, where the results of the work, rather than the documentation, determine the next step [4].

E. Rigor and Ethical Considerations

To strengthen credibility, the findings were triangulated across the data sources described above. The events coded in this study—each design version and each return to an earlier phase—had been reviewed and agreed collectively by the team members involved as they occurred (Section III.C), so the coding rests on joint decisions taken at the time rather than on later interpretation. The reconstruction and coding themselves were carried out by team members who took part in the episode; a formal review of the coded account by participants outside the author group was not conducted, and no modifications to the coding therefore resulted from such a step. This is acknowledged as a limitation and is incorporated into the protocol proposed for future episodes (Section VI).

IV. Case Study: Functional Replacement of an Antenna-Rotor Potentiometer

A. Problem Identification and Framing

The episode arose in March, in the weeks before a supervisory visit by the Japanese space-exploration agency to review the project's progress—a deadline that added considerable time pressure. While preparing the academic ground station (the Cabañas station at UNAH), whose antenna must point accurately to track objects in orbit [7], the GS coordinator noticed that the position-reference needles on the rotor controller had stopped moving and were stuck at fixed, maximum values: the analog position-feedback signal (nominally 0–6 V) had been lost, most plausibly due to an electrical overload of the sensor. Because the satellite is not yet in orbit, the station's immediate objective is to observe other CubeSats in low-Earth orbit, so a controller that cannot report antenna position effectively halts operations. Obtaining the exact replacement quickly was not feasible: administrative and procurement procedures were slow, and the rotor's location atop a tower introduced accessibility constraints that made a like-for-like swap impractical within the available window. In a conversation between the project director and the GS coordinator—later opened to a small, select subteam—the problem was deliberately reframed, from "obtain the exact component" to "replicate the position-sensing function with the means at hand." This reframing is characteristic of the framing at the core of DT [10] and of the define step described by Grots and Creuznacher [11], and it is a form of resourceful *bricolage*—constructing a solution from the resources immediately available [16]—that opened a solution space a spare-part logic would have foreclosed.

B. Ideation

The decoy concept emerged as one of the "wild" ideas floated during an open ideation session: rather than sensing shaft position directly, the team would synthesize a feedback signal that reproduced the original sensor's 0–6 V range and the shape of its response curve, inferred from observing the rotor's

behavior. Several alternatives were weighed—among them a DAC-based generator, generic potentiometers, and even laser-pointer schemes—and the choice was guided by three practical criteria: low cost, availability, and technical feasibility. The pivotal design decision was to leave the controller untouched and instead adopt a "parasitic" scheme that taps the rotor's power lines and, exploiting the fact that the rotor turns at a stable angular velocity, measures elapsed time to infer angular position and then feeds the controller a synthesized signal that drives its needles as the original sensor would (the final architecture is shown in Fig. 2). The work was led by electronics and software, and it was informed by preliminary characterization—angular velocity, time for a full rotation, and the timing behavior needed to program the microcontroller and its DAC.

C. Prototyping

The first prototype—optocouplers to sense and isolate the motor drive lines, resistors, and a DAC output stage—was assembled on a breadboard from components already on hand, with the team committing its own resources. Prototyping was deliberately incremental, moving from simulations, supporting calculations, and candidate topologies to added protection and signal-conditioning stages, with each version reducing the error further. An early setback proved instructive: several DACs were destroyed, teaching the team that protection circuitry is essential even under rapid prototyping—the kind of early, identified mistake that the “error culture” of prototyping treats as progress [11].

D. Testing, Iteration, and Non-Linearity

Functional testing anchored acceptance in the rotor’s existing calibration and in reference points verifiable by eye—elevation at 45° and 90°, azimuth at 90° and 180°—rather than in exhaustive metrological rigor, a choice imposed by the time and access constraints. Tests surfaced improvements not apparent in the initial design: a robust protection scheme (after the burned DACs), amplification to raise the voltage levels, and a shift from discrete DACs to a single integrated DAC device. Further findings came from the reviews that preceded each test, in which configurations with anomalous voltages or currents were discarded and rebuilt before reaching the controller. Each finding sent the team back to ideation and prototyping—a form of reflection-in-action that turned each test into the starting point for the next design [17]—in a cycle that ran through three to four iterations before converging. The episode thus instantiates the iteration-and-experimentation attribute of DT [3] and the open, non-linear process described in [11]. The work was also multidisciplinary: electrical-engineering students and engineers carried out most of the design, while mechanical, industrial, and chemical engineers validated elements such as the rotor-motion model, illustrating the value of combining perspectives [5], [12]. The low-cost decoy, with an estimated 2–5% error, was placed in service and shown in operation to the visiting delegation, as documented in an internal technical report; a newly procured rotor has since replaced it.

E. Resulting Architecture and Performance

Fig. 2 summarizes the architecture on which the design converged. Four optocouplers (one per direction and axis) galvanically isolate the controller's ±25 V motor drive lines, whose polarity sets the direction of rotation, and convert each direction into a 3.3 V logic signal. A microcontroller then estimates position by dead reckoning: while a direction signal is active, it integrates the elapsed time at 1 ms resolution (adding it for forward motion, subtracting it for reverse motion, and bounding it between 0 and 65 s) and maps the result linearly onto its 12-bit DAC, so that 65 s corresponds to full scale (450° in azimuth, 180° in elevation). The controller itself is left unmodified.

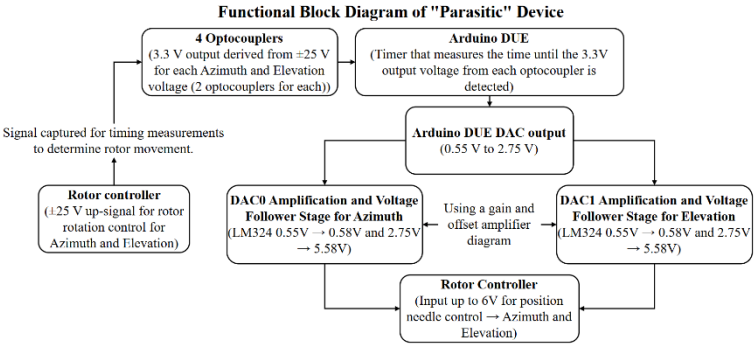


Fig. 2. Functional block diagram of the "parasitic" device.

Fig. 3 relates the synthesized signal to the nominal 0–6 V output of the original potentiometer. The DAC alone provides only 0.55–2.75 V, too narrow for the controller meters, which require a span of at least 5 V; a gain-and-offset stage per axis therefore scales it to 0.58–5.58 V, and the residual offset and span difference are absorbed by the meters' zero and full-scale adjustments. The signal chain does not limit accuracy: the 1 ms timing resolution corresponds to about 0.007° in azimuth and 0.003° in elevation, and one DAC step (≈1.22 mV after amplification) to 0.11° and 0.044°—at least an order of magnitude below the 2–5% error estimated at the reference positions marked in Fig. 3. The dominant error sources lie in the estimation principle: the assumption of a constant angular velocity in both directions; speed variations with load and, in elevation, with gravity; the brief coasting of the motors after each stop, whose effect accumulates over successive movements; and the visual calibration of the meters. Calibration against observed angles compensates for a constant speed mismatch but not for these variable effects, which is why the reported error is an estimate and metrological validation is left to future work.

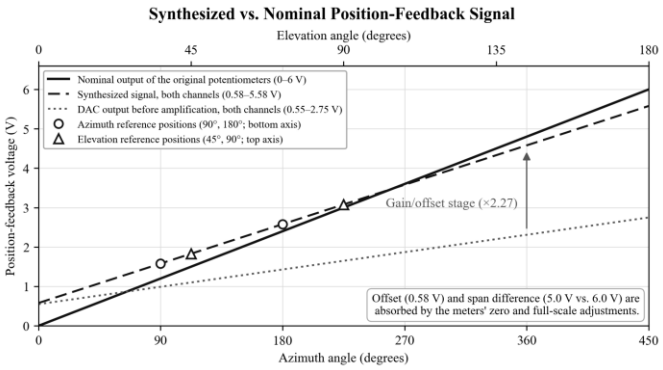


Fig. 3. Position-feedback signal versus antenna angle.

V. Discussion

The case reinforces a view of Design Thinking whose value, under real engineering constraints, lies less in isolated creativity than in a disciplined capacity to absorb uncertainty [18]. The decisive move—turning a missing spare part into a function to be replicated—is a textbook instance of problem reframing with deep roots: planning and design problems are "wicked," lacking a definitive formulation [19]; design is the devising of courses of action that change existing situations into preferred ones [20]; and Buchanan's doctrine of placements [1] and Dorst's account of abductive framing [10] describe precisely the cognitive operation the team performed.

A second theme is experimentation as a mode of learning. Each functional test did not merely verify a design; it produced knowledge that reshaped it, in the manner Schön describes as reflection-in-action [17]. The clearest evidence is the sequence triggered by the destroyed DACs: an early, costly mistake that nonetheless taught the team that protection circuitry is essential even under rapid prototyping, and that pushed them from discrete converters toward a single integrated-DAC device and toward added amplification. Treating early prototypes as cheap experiments is exactly how organizations de-risk innovation before committing resources [21], and it is the mechanism through which DT is argued to improve outcomes by countering bias [2]. The "error culture" that Grots and Creuznacher associate with prototyping [11] was, in practice, the enabling condition for this learning: failures surfaced during testing were treated as progress rather than as reasons to abandon the approach.

A third theme, largely absent from mainstream DT accounts, is resourcefulness under scarcity. Building a functional substitute from components already on hand—and from the team's own resources—is a form of *bricolage*, creating something workable by recombining available means [16], and it mirrors the entrepreneurial logic of effectuation, in which actors start from the resources they control and the losses they can afford rather than from predefined goals [22]. Read at a larger scale, the episode exemplifies frugal, "jugaad"-style innovation [23], which is especially pertinent to resource-limited settings in the Global South, where the scarcity of exact parts, specialized suppliers, and fast procurement is the norm rather than the exception. This situated resourcefulness is exactly the kind of contextual evidence whose absence Martínez Casanovas identifies as a gap in the DT–sustainability literature [9].

At the organizational level, the episode shows how project-level practice connects to capability and culture. The joint director–coordinator decision, the delegation of the work to a small cross-functional subteam, and the tolerance for early failure reflect the culture-and-capability view of DT [13], [14] and its role in organizational change [11]. Interpreted through the resource-based tradition, DT here functions as a microfoundation of dynamic capabilities—an operational routine for *sensing* a problem and *reconfiguring* resources in response [24]—bridging the "how" of method and the "why" of strategy. The association between the application level of DT and project success reported by Roth et al. [15] offers a testable expectation as the Morazán Project accumulates further episodes across its space and ground segments [6], [7].

The case also sharpens the DT–agile relationship in a hardware, rather than software, context. As in agile product development, progress was iterative and driven by working results rather than documentation [3], [4], [25]; each functional test acted as a de facto review point, closing a short cycle, and convergence was reached in only three to four such cycles. What DT contributed beyond the agile mindset was the abductive framing that questioned the problem itself before the search for alternatives began [10]. The episode's multidisciplinary character (Section IV.D) further illustrates the value of combining methods and perspectives [5], [12]. A further, practically important result is transferability: because the decoy derives position from the controller's drive lines rather than from a specific sensor, the team recognized the scheme as adaptable to other rotor types and, by extension, to other subsystems, provided that the rotation speed of each axis is first characterized, since the accuracy of the time-based estimate depends on it (Section IV.E).

Finally, the university setting adds an educational dimension that is easy to overlook. Design thinking is not only a problem-solving method but also a vehicle for engineering learning [26], and the Morazán Project's explicit educational mission [8] means that episodes such as this one simultaneously solves an immediate technical problem, build local human capacity, and advance a socially oriented, disaster-resilience mission [6], [7]—that is, DT operating at three levels at once, in line with the SDG-aligned aspiration of the field [9].

Several limitations qualify these claims. The study rests on a single, context-bound episode; it favors analytical over statistical generalization, and its transferability remains a proposition to be tested rather than assumed. The evidence is qualitative and reconstructed by participant observers, which introduces the risk of hindsight bias. This risk was mitigated by the collective review of every design decision during the

episode and by cross-referencing the reconstruction with the surviving records (Section III.C), although the absence of a formal decision log and of a post-hoc participant validation means that part of the account rests on recollection. By the team's own account, the evaluation prioritized operational stability and visually observable calibration points over exhaustive metrological rigor, so the reported 2–5% error should be read as indicative rather than definitive. As the error budget in Section IV.E shows, this uncertainty stems from the estimation principle rather than from the electronics. And, consistent with the limits Grots and Creuznacher note [11], DT proved well suited to discovering and shaping the solution but not to its long-term implementation: the decoy served its purpose and was later superseded by a newly procured rotor.

One clarification is warranted: why classify this episode as Design Thinking rather than as troubleshooting, reverse engineering, or agile hardware development? The distinction rests first on a single decisive act. Troubleshooting and reverse engineering both take the specification as given—the first restores it, the second recovers it. This team did neither: it declined to reproduce the component and redefined the objective as a function to be delivered by other means, accepting a solution that no longer resembled the original in mechanism, only in behavior. That substitution of the problem statement, before any solution was sought, is abductive framing [10] and is what agile, by construction, does not supply: agile accelerates the delivery of a problem already accepted, whereas the interrogation of assumptions prior to the search for alternatives is the attribute that demarcates DT from agile and lean approaches [3]. A second discriminator is the acceptance criterion. A repair is judged by conformance to specification; here the device was judged by whether the operator obtained a trustworthy pointing reference, verified at angles observable by eye—fitness for the human need rather than fidelity to the artifact [18]. A third is the direction of information flow: the tests did not merely confirm or reject the design, they altered what the team understood the design to be, which is the reflective conversation with the situation that defines design practice [17] and the reason the sequence had to be traversed as an orientation rather than a pipeline [11]. On these three counts—reframing before solving, human need as the criterion, and testing those feeds back into framing—the episode meets the definition of Design Thinking, not an approximation of it.

VI. Conclusions and Future Work

Understood as a non-linear, iterative method integrated with engineering practice, Design Thinking enabled the Morazán Project team to turn a mission-relevant fault, detected days before an international supervisory visit, into a low-cost, locally developed solution that restored the station's pointing capability until a new rotor was procured. The episode offers concrete, situated evidence for a claim often asserted but rarely documented in engineering practice: that DT's characteristic value is its capacity to absorb technical uncertainty through disciplined iteration.

The study makes three contributions. Theoretically, it positions DT as a *connective* method linking the operational level of problem-solving, the organizational level of capability and culture [13], [14], [24], and the strategic level of mission and sustainability [6], [9]; and it frames DT as a microfoundation of dynamic capabilities rather than a stand-alone toolkit. Empirically, it adds contextual evidence from a resource-limited, university-led Central American space initiative—precisely the kind of setting under-represented in the DT literature [9]. Practically, it shows that bricolage- and effectuation-style resourcefulness [16], [22], [23], combined with an "error culture" [11] and short iterative cycles [4], [25], is a viable route to reliability when exact parts, specialized suppliers, and fast procurement are unavailable.

Future work will proceed along five lines. First, we will extend the study from a single episode to a systematic, multi-episode case base, following the protocol outlined below. Second, we will collect quantitative indicators—the measured rotation speed of each axis and direction, angular error against a metrological reference, number and cause of iterative returns, time-to-working-prototype, and cost avoided—so that the qualitative account can be triangulated with measurable performance. Third, we will formalize the DT–agile integration by mapping functional tests onto explicit iteration and review cadences [3], [4], [25]. Fourth, we will evaluate the approach against the project's educational [8], [26] and disaster-resilience [6], [7] objectives. Fifth, we will develop a lightweight evaluation framework for DT in resource-constrained engineering, responding to the absence of standardized assessment tools identified in recent reviews [9], and test it, together with the drive-line sensing scheme, in other subsystems and small-satellite programs.

The multi-episode case base will be built prospectively rather than retrospectively. Each new hardware problem in the space or ground segment will open an episode record at the moment of detection, completed as the work unfolds, with the problem as initially posed and as reframed; the constraints at play (time, budget, procurement, physical access); the alternatives considered and the selection criteria; and every prototype and test, each dated, with its result and, when applicable, the phase to which the team returned and the change introduced. Episodes will be coded with the scheme used here (DT phases [11], DT attributes [3], and iterative returns), extended to include resource strategies such as bricolage and effectuation [16], [22], and each coded episode will then be reviewed by participants not involved in its analysis, with any resulting changes to the coding recorded. Episodes will be categorized by subsystem (e.g., antenna positioning, radio-frequency chain, power, software), problem type (component failure, integration mismatch, performance shortfall), solution type (repair, replacement, functional substitution, redesign), and constraint profile; comparing them will reveal which

patterns recur—whether functional substitution consistently follows an early reframing, how many iterations each problem type requires, which returns are most frequent—and allow them to be distilled into a repeatable problem-solving framework for resource-constrained engineering teams. Because every future account will rest on contemporaneous rather than reconstructed evidence, these records will also resolve the data-integrity limitation of the present study, moving the work from a single illustrative case toward a validated, transferable account of how Design Thinking operates in socially oriented engineering.

The case therefore belongs to Design Thinking not by resemblance but by construction: its outcome was determined by the reframing that opened the solution space, not by the electronics that later occupied it. Design Thinking is usually documented where it is comfortable—in workshops, product teams, and service design—and is correspondingly easy to dismiss as a facilitation format. Observed instead in an operating ground station, under procurement delays and an external deadline, it appears as what its theorists have always claimed it to be: a mode of reasoning for problems that cannot be definitively formulated [1], [19]—one that scarcity does not weaken but exposes.

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