White Paper Report

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Proximity Fuse: an exploration of desktop 3D documentary

White paper for the National Endowment for the Humanities
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OpenEndedGroup
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Abstract

This project pursues two intertwined goals. One is formal — to create a radically new kind of documentary, which exploits new techniques of 3D capture and editing that are now possible at a scholar's desktop rather than at a full-fledged film studio. This new form also calls for new strategies of representation, nine of which we implement.

The other goal is thematic — to examine the wartime advances of science that underpin today's digital society, and to do so from the distinctive perspective of Iowa, where space exploration flourished first under the physicist James Van Allen and to this day under Donald Gurnett.

Formally, we propose an alternative to the usual documentary format that shifts back and forth between talking head experts and loosely coupled archival clips, often to tedious effect. This standard structure lends itself poorly to conveying concepts and context, and is by now so familiar visually that it deadens rather enlivens viewers' perception. What's more, the conventional documentary rarely holds up its own methods to examination and reflection, so that the limitations of its materials and the nature of its presuppositions go unremarked.

We also propose a method of working that vastly scales back the cost and complexity of typical documentary production, which is visible in the astonishing length of rolling credits that follow even the most basic of documentaries. Rather than dozens of people involved in production, we aim for a model that necessitates just a handful — that is, the same number as typify most collaborations in the humanities.

We have prototyped an immersive 3D documentary form that takes as one of its basic forms the active sketching of diagrammed explanations, a kind of vastly augmented blackboard lecture. This mode of diagrammatic framing allows us to visually annotate and contextualize our subject, both to zoom out to look at the larger interrelationships of things than is ordinarily possible in documentary but also to zoom in, to diagram the exact workings of a device. This approach encourages the viewers' truly active reading of the evidence and concepts rather than their passive acquiescence to what is presented.

Our prototype is a rough 41 minute draft of the first part of an envisioned three-part documentary entitled *Proximity Fuse*, which takes its title from the first form of smart bomb, invented in World War Two with a key contribution by James Van Allen at the very start of his celebrated career.

The title also evokes the kinds of intersection of cultures, careers, ideas, and advances that we trace along three axes: geopolitical, technological, and Iowa. We rely on striking juxtaposition to defamiliarize not only our historical awareness of World War II and the Cold War (and prior eras) but also of our technological present.

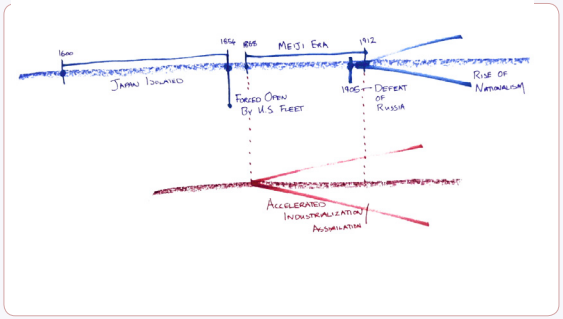
Our story is told by closely examining key sites and artifacts in all their materiality, including: the pocket-size notebooks kept by Van Allen as a young Navy lieutenant; the Raytheon transistor Van Allen adapted for the proximity fuse; the actual pages of the books we consulted; and 3D captures of Van Allen's recently uprooted boyhood home. We also compare *kinds* of artifacts and look at what those comparisons tell us — for example, we examine a blueprint of the kind Van Allen used to rebuild a Model T Ford as a boy and then we physically dissect a contemporary iPhone that blocks such scrutiny both visually and legally.

NOTE ON ILLUSTRATIONS

This report tells its story as much in pictures as in words. But since our images are rendered in 3D space on a predominantly dark ground, the flat white page presents us, and you, with a challenge.

2D images on the page lack all means we have for seeing depth. In our workflow, we use active-shutter 3D, which produces a near-perfect illusion of depth with no color distortion — and the images come alive.

Most of our illustrations are still frames taken from the prototype 3D film, which we signal graphically with a rounded frame like this:



In many of the smaller reproductions, we invert the ground from black to white, as can be seen primarily in the storyboard chapter.

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Overview

What keeps the conventional film documentary from being as nimble as the written essay? And what limits the range of material the documentarian somehow feels comfortable engaging?

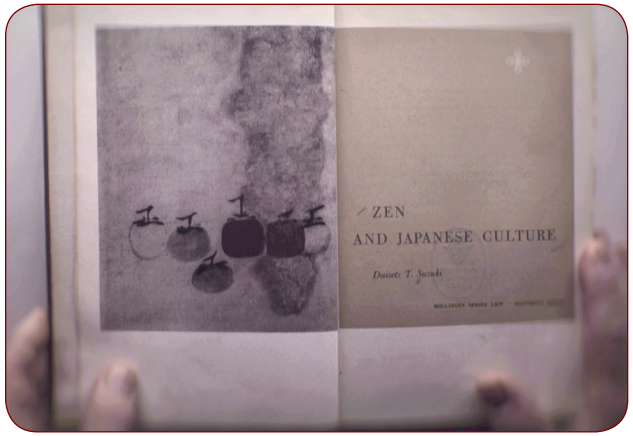
Let's look first at the essayist's abilities. In tracing the motions of mind as he or she ponders a question, the writer can examine aspects of that question from as many vantage points as seem advantageous, moving at will from one association to another as they advance the argument. The essayist has no trouble crossing boundaries of place or time or subject or discipline, drawing freely upon a wide range of examples and evidence.

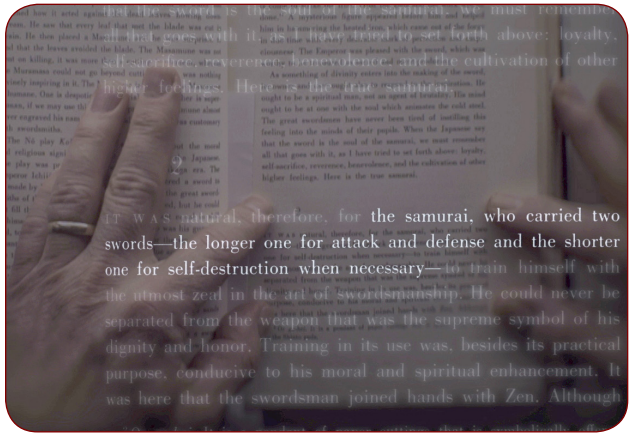
It's not just the path but also the speed of thought that the essayist conveys. On the one hand the writer may move rapidly across a range of considerations within the span of a single paragraph (or even sentence); on the other, he or she can dwell on a particular matter at great length when needed, staging a close examination that refuses to be hurried across its many paragraphs or even pages.

The nimbleness of the essay is a consequence not only of its protean form, but also of its minimal practical necessities: all it requires is a writer at a desk. And if that writer relies on researchers or editors or colleagues to further the work in some way or other, these will rarely number more than three or four. It's all easily manageable.

For reasons both of its typical form and of its practical requirements, the conventional documentary often fails to match the speed, versatility, and precision of the written essay.

Documentaries typically alternate between talking head shots of experts and loosely coupled archival clips or documentary footage. Since the talking head experts are rarely recorded as they





examine the same visual material now being projected on the screen to the viewer, there is often a disconnect between they say and what the filmmaker shows. One might argue that this scarcely matters if the general point gets across, but this is simply to lower the bar well below excellence, as is easily seen by comparison with a masterful essay that fuses subject and form with graceful precision.

But why the reliance on the talking head in the first place? Often it is to convey information originally formulated more exactly in a book or essay. The documentarist feels the need for that text to be translated to what he or she deems to be a more visual or at least friendly format — and so a face and a voice are put to the information, as if to make it more immediate and accessible.

Still, one has to wonder — or at least *we* did — why not go straight to the book itself? Won't the actual written words tell us more than the talking head? And isn't the physicality of the book also an important thing to convey, especially now that texts are increasingly taking digital form and we become ever more conscious of books as artifacts? Isn't the way in which information is embodied telling?

So not only do we go back to show the books we consulted in *Proximity Fuse*, but we also show the turning of their pages, the pointing to the exact passage in question — a procedure peculiarly distinctive to the contemporary mind now that we just as often scroll down a webpage to find the passage in question or examine the highlighted passage that our digital search has alighted upon.

The book is just one example of an artifact best examined directly and self-consciously in all its particularity; we'll review others further below, showing how drawing allows us to analyze and annotate them.

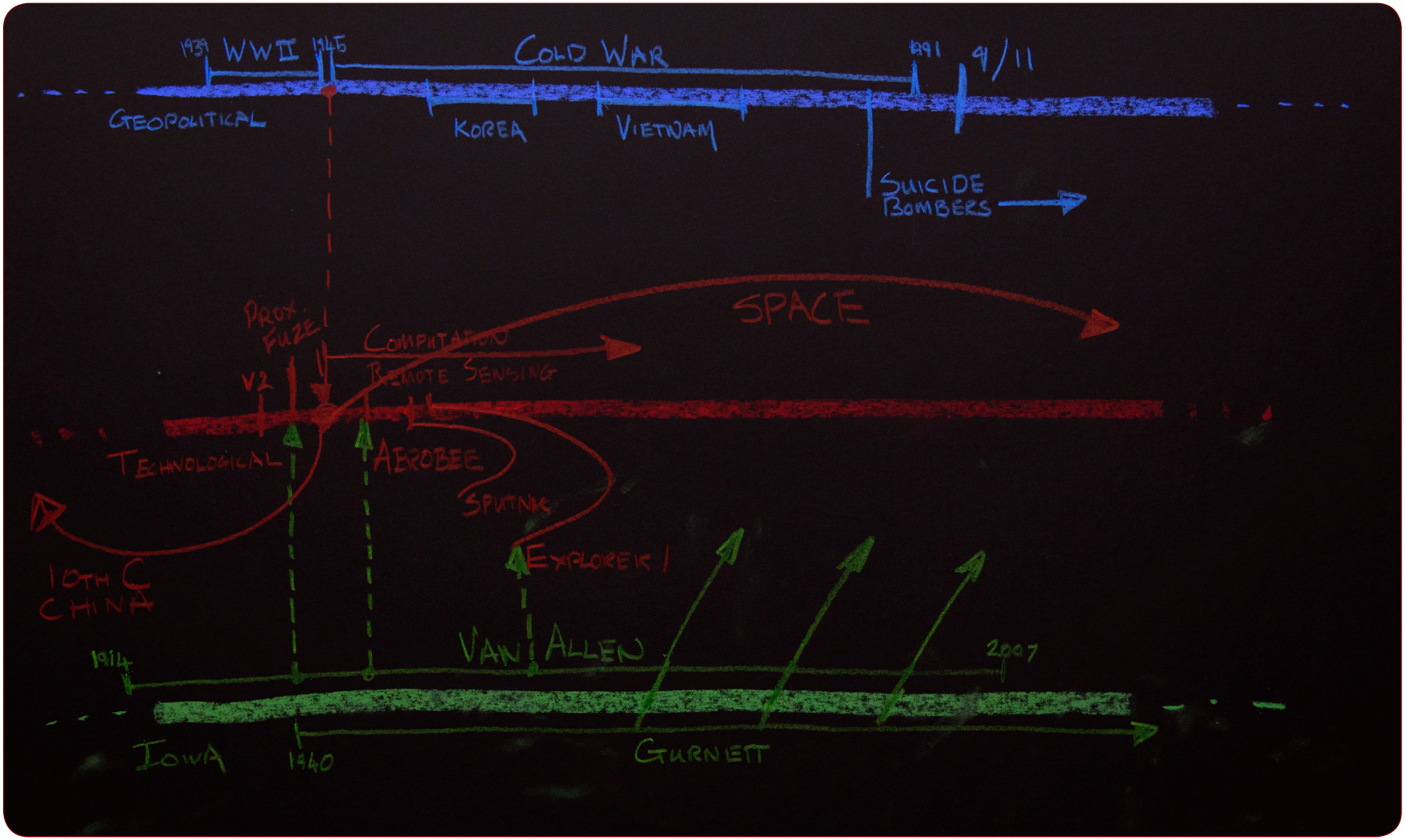
For now let's note that this way of examining an artifact is something a film documentarist can do differently, and often better, than the essayist. Showing an object is often more illuminating than describing it.

There is another category of self-imposed restriction that film documentarian typically embrace — that is, the way they limit themselves to a certain kind of distance or vantage point from which they survey their subject. It's as if they condemn themselves and their viewers to uniformly middle-distance views, neglecting to step back enough to gain a broad overview of their subject.

This is a matter both of conceptual framework and of visual strategy. Since documentarians typically accept the conventions of their form as a given, they feel no need to make its structure visible or explicit, though this would be as useful to themselves as it would to their viewers; and they all too rarely resort to visual strategies of diagram and outline.

By contrast, near the start of *Proximity Fuse* we sketch out the three axes on which we construct our piece, showing in rough form the over-all shape of our inquiry (*see full illustration on following page*).

This lets the viewer in on our approach, alerting them to the fact that we will not be shy about jumping across time (10th century China to 21st century terrorism) even as our main focus in this first part of the documentary is on events, technologies, and people of the mid-20th century.


1939
WWII
1945
COLD WAR
1991
9/11
GEOPOLITICAL
KOREA
VIETNAM
SUICIDE BOMBERS
SPACE
PROX. FUZE
COMPUTATION
REMOTE SENSING
V2
TECHNOLOGICAL
AEROBEE
SPUTNIK
EXPLORER I
10TH C CHINA
VAN ALLEN
1914
2007
IOWA
1940
GURNETT

Rolling credits

The ungainly complexity of even a simple and relatively low-budget documentary is revealed in the rolling credits at its end, which in addition to identifying the director typically name the producer(s), the director of photography, the camera operator, the key grip, the editor, the sound designer, the post-production team, some production assistants, and various others. This can run to the dozen or even dozens of people.

The practical circumstances in which most documentaries are made pose a further obstacle to the nimble expression of thought. Too many specialized roles, too unwieldy an organization, and too great a budget required all make it difficult to move quickly in the pursuit of an idea. Though advances in technology — portable video cameras and digital audio recorders, and editing programs that run on desktop or even laptop computers — have improved this picture, much more can be done.

With the *Proximity Fuse* prototype, we've attempted to forge a form that we call "desktop 3D documentary," which re-conceptualizes the structure of the documentary at the same time that it recasts the means for making it.

This paper continues in sections devoted respectively to:

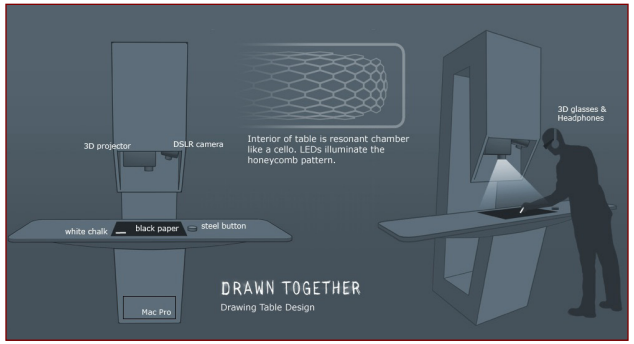
- the *tools and techniques* we devised for this project;
- the *strategies of representation* we created for this new form of documentary, the utility of which we demonstrate here to explore and plumb specific aspects of our topic;
- the *storyboard,* showing our treatment of the subject matter of *Proximity Fuse*, which absorbed us at least as fully as the creation of our tools and visual approaches.

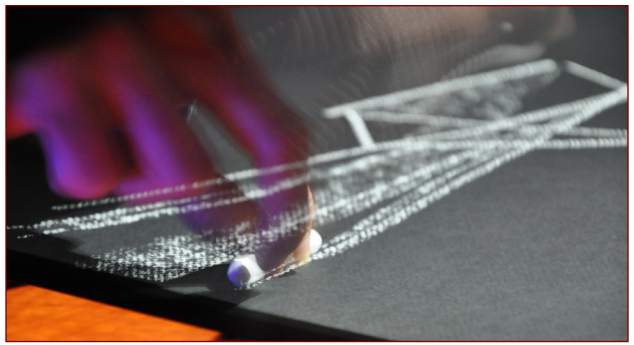
We conclude by summarizing the scope of our work activity on this project; reflecting on the obstacles we encountered; outlining the project's advances and potential as well as its limitations and shortcomings; and speculating about next steps to be taken.

Since the added dimension of 3D imagery makes possible a much richer visual and informational space, we are intent on employing methods of 3D capture that were *affordable* within our limited production budget and *customizable* to the exact requirements of our subject.

We employed three such techniques — one for tabletop capture in the studio, the other two for 3D capture in the field.

These tools were all integrated into the open source platform, *Field*, that we use to author all of our work (scholarly, scientific, and artistic).





3D CAPTURE TABLE

The key innovation in this project is our refinement of the 3D capture table, which allows us to record in 3D both the act of drawing, tracing, or annotating and the manipulation of small tabletop objects such as books and documents.

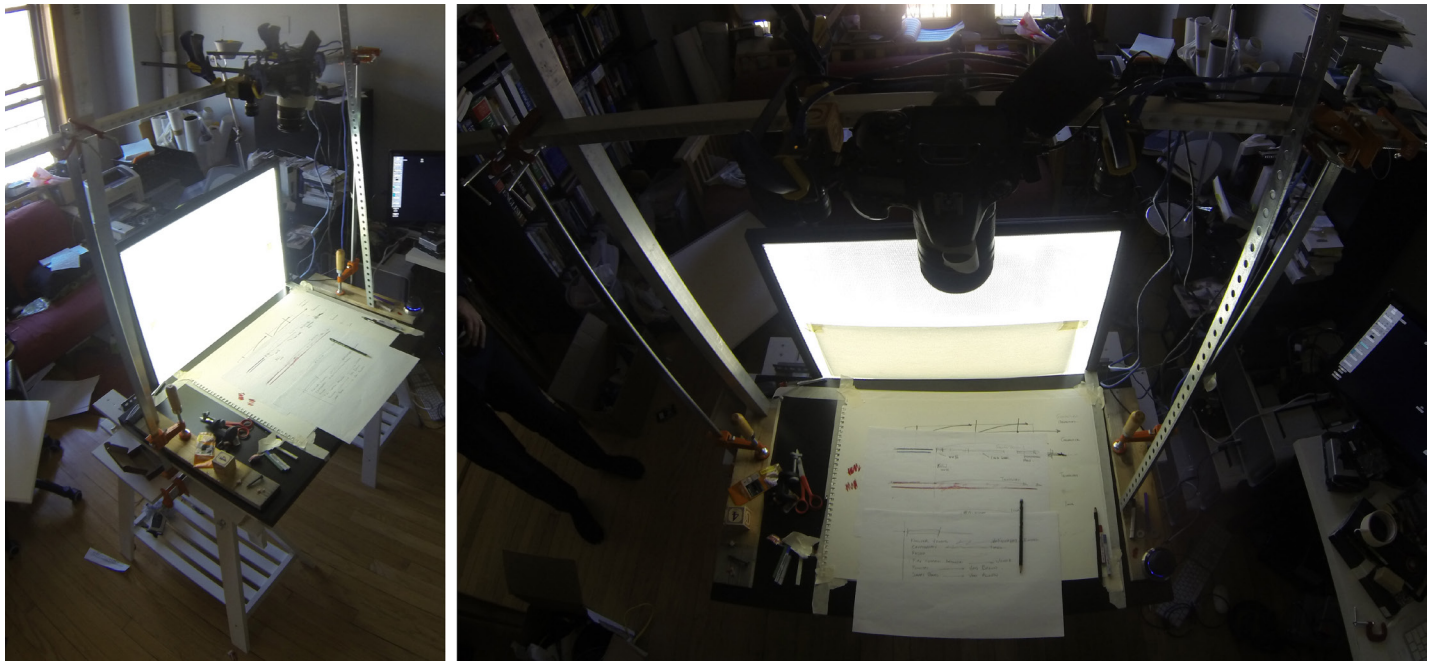
This builds on a previous project, *Drawn Together*, that we created in 2011-12 at the Georgia Tech Institute of Technology with Dr. Gil Weinberg (whose fields are music, computation, and robotics) and Tristan al-Hadad (an architect and designer).

Drawn Together is an interactive artwork in which the participant takes turns making a 3D drawing in collaboration with an artificially intelligent software agent. The human makes his or her marks physically on a piece of paper; the software agent responds by projecting its marks as 3D overlays on the same piece of paper.

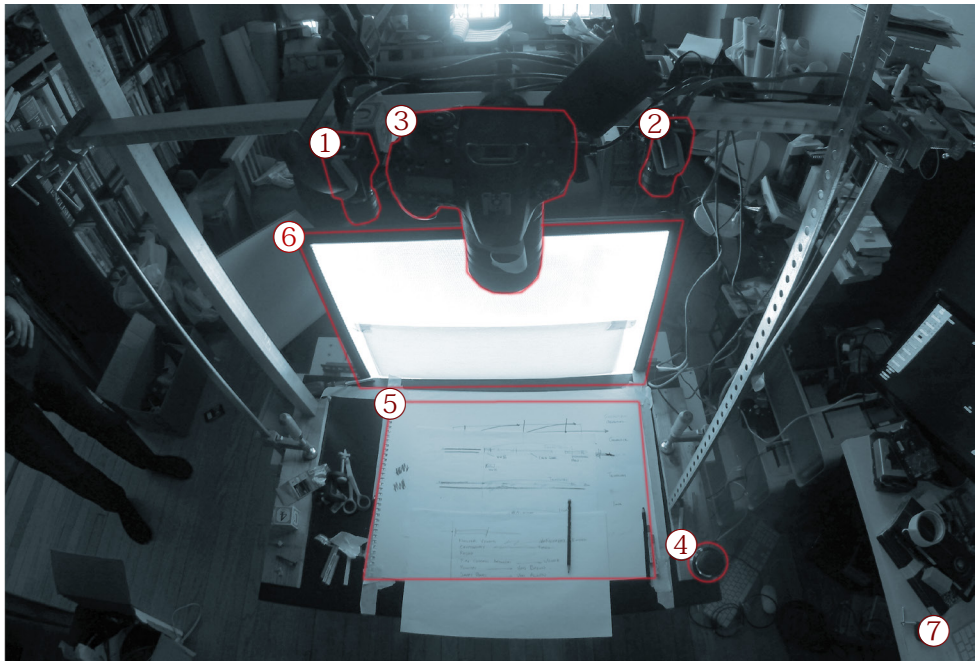
The *Drawn Together* set-up relied on a single high-resolution DSLR camera to capture the drawing each time the user pressed a button to signal the completion of his or her turn.

For *Proximity Fuse* we added two video cameras to record the movement of the hand as it drew each line, and then refined our software analysis to allow the subtraction of the hand from the image sequence, thus yielding a clean animation of the drawing as it unfolded.

By synthesizing the movement data from the video cameras and the drawing information from the DSLR camera we can yield a "cinema quality" image sequence using commodity cameras.



Two views of the 3D capture table set-up, here with cameras adjusted to capture drawings — an alternate arrangement allows the capture of 3D objects such as books and small artifacts.



① ② **GIGABIT ETHERNET CAMERAS** — 1 megapixel each, streaming live to computer. These track movement of the hand and the animation of drawing.

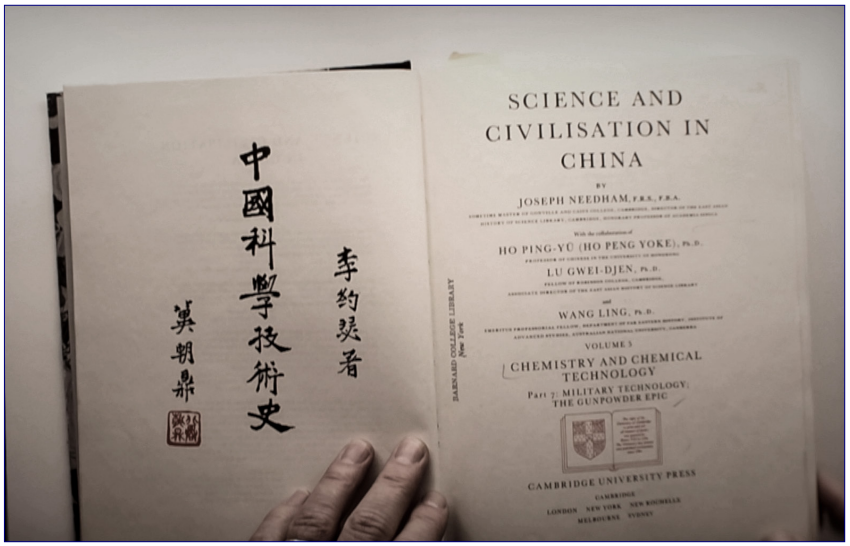
③ **DSLR CAMERA (CANON 60D)** — 20 megapixel resolution. Tethered to the computer, it photographs drawing on command.

④ **BUTTON (CONNEXION SPACE NAVIGATOR)** — remote shutter release for DSLR camera.

⑤ **DRAWING CAPTURE AREA** — for drawing on 22 x 34" paper.

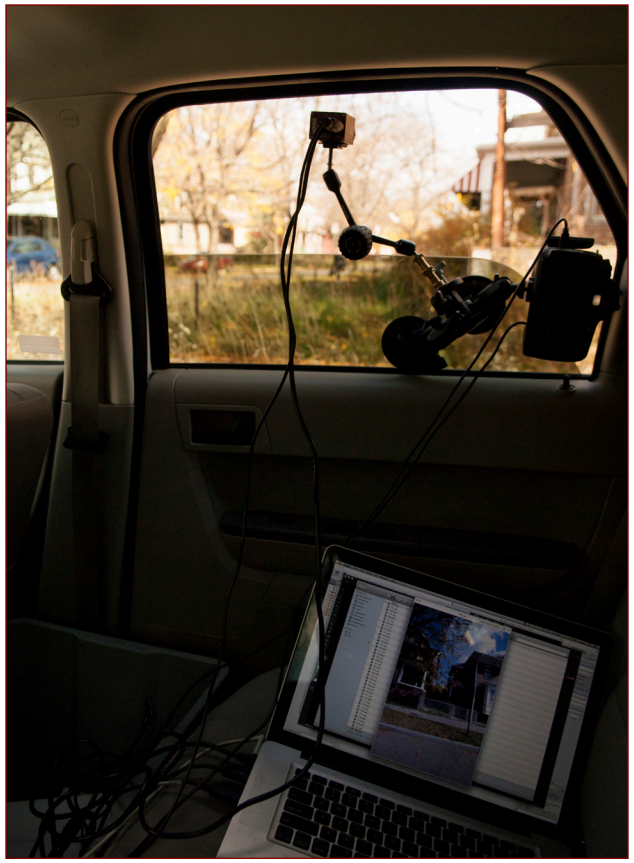
⑥ **LIGHT** — LED panel provides broad bright diffused light.

⑦ **WORKSTATION (MACPRO RUNNING LINUX WITH NVIDIA TITAN GTX GRAPHICS CARD)** — running custom software (Field) to stream input from video cameras, to trigger camera on command, and to store both sources of image as RAW image files.



Unprocessed captures of a book and a drawing, representing the two kinds of material that the drawing table can record in motion in 3D — the turning of the page and highlighting of passages, on the one hand, and the drawing and annotation of illustrations on the other.

AVT/Prosillica 1290GC



3D VIDEO

For high-resolution stereoscopic video recording, we paired two small scientific cameras at eye-distance apart to approximate left and right eye views.

These cameras have superb optics; they also dispense with the rolling shutter that mars the recording of fast movement on most of the affordable video cameras.

The miniaturization of these cameras rule out internal batteries and storage. And so we plugged their power cable into our rental car's lighter jack and tethered their data cables to an ethernet hub that in turn linked them to a MacBook Pro laptop computer.

The laptop's screen then served as our viewfinder, and we streamed the video recording directly to a high-speed solid state drive connected via Thunderbolt to the laptop.

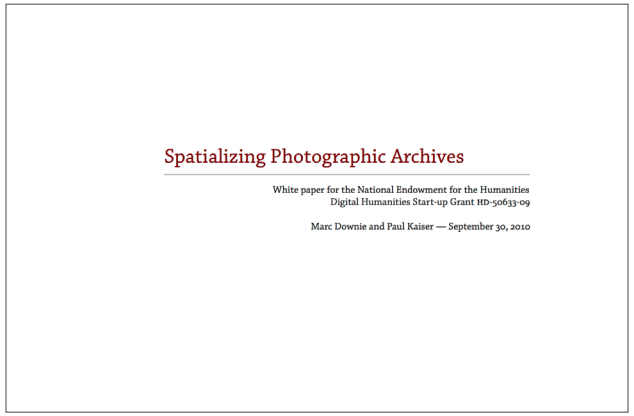
(This set-up is imperfectly illustrated at left, for it shows a single video camera rather than the paired units we deployed for this project.)

It was with this set-up that we captured the Van Allen home *(see stills on next page)*.

Experimenting with this kind of stereoscopic capture on the road led us to create a separate experimental film, *All sides of the road*, which we premiered at the Rome Film Festival in 2012 *(see Appendix 1)*.

These samples of the left/right stereoscopic pairs are from our capture of the relocated Van Allen home now sited next to the vacated school he once attended.

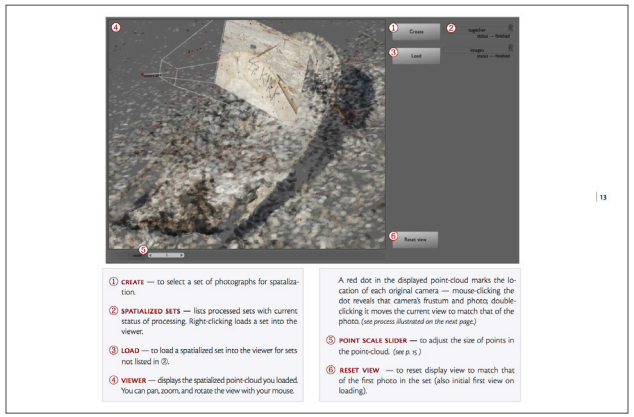
The cropped enlargement at bottom shows the image fidelity of these high-resolution frames (1920 × 1080 pixels).



Spatializing Photographic Archives

White paper for the National Endowment for the Humanities
Digital Humanities Start-up Grant HD-50633-09

Marc Downie and Paul Kaiser — September 30, 2010



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① CREATE — to select a set of photographs for spatialization.

② SPATIALIZED SETS — lists processed sets with current status of processing. Right-clicking loads a set into the viewer.

③ LOAD — to load a spatialized set into the viewer for sets not listed in ②.

④ VIEWER — displays the spatialized point-cloud you loaded. You can pan, zoom, and rotate the view with your mouse.

A red dot in the displayed point-cloud marks the location of each original camera — mouse-clicking the dot reveals that camera's frustum and photo; double-clicking it moves the current view to match that of the photo. *(see process illustrated on the next page.)*

⑤ POINT SCALE SLIDER — to adjust the size of points in the point-cloud. *(see p. 15.)*

⑥ RESET VIEW — to reset display view to match that of the first photo in the set (also initial first view on loading).

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Mizrach had pointed out an oddly curved trunk in the original photograph. Dense foliage now shielded it from view from the same angle, but it was easily made out from the other side.

Desert Fire #11 — Mizrach 1982

SPATIALIZED PHOTOGRAPHY

In 2010, we completed the *Spatializing Photographic Archives* project with the support of an NEH Digital Humanities Start-up Grant (HD-50633-09).

The project White Paper describes a refined technique for creating a 3D representation of an object or space from a collection of multiple photographs. Thus:

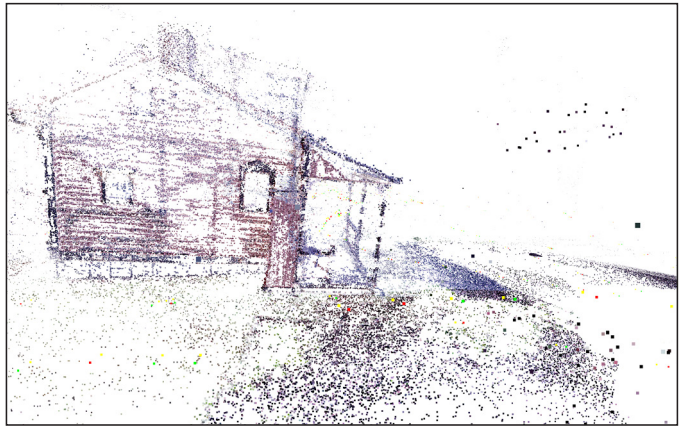
> *Methods have emerged that can extract three-dimensional information from an unstructured, un-annotated collection of related photographs. Specifically, given multiple shots of the same scene, one can now (1) recover the location and angle, in 3d, of the camera that took each shot and (2) reconstruct, in 3d, much of the geometry of the original location. With minimal human intervention, hundreds and thousands of images can be projected back into a shared three-dimensional space.*

The report goes on to describe the software tool we created to run the spatialization process, which operates in the same open-source software platform, *Field*, employed in this project.:

> *We have then created an open-source tool (the Spatialization workbench) that permits scholars to create such reconstructions and that gives them new ways of examining the resulting 3d "point-cloud," with every photograph and the corresponding position of the photog- rapher situated in the three-dimensional space. These visualizations may be inspected in stereoscopic 3d display.*

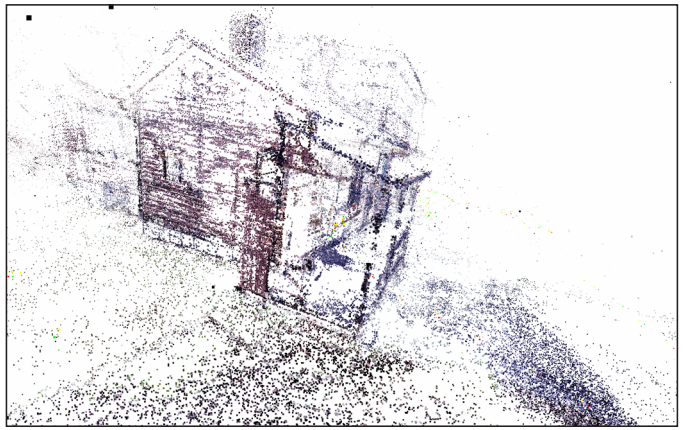
A pdf of the the full 64-page report may be downloaded from a link on this page: *https://securegrants.neh.gov/publicquery/main.aspx?f=1&gn=HD-50633-09.*

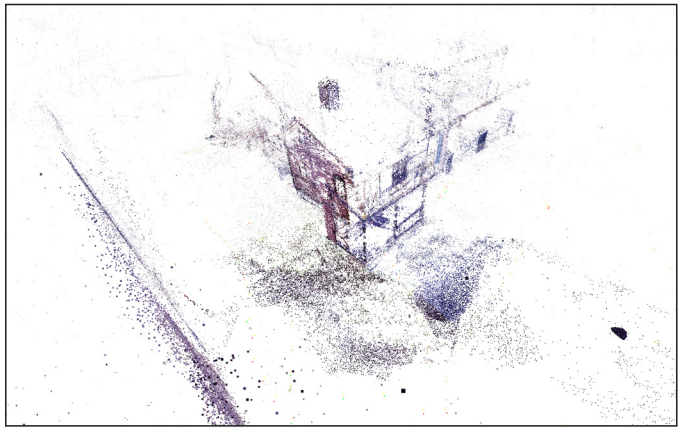
Illustrations of this technique applied to the *Proximity Fuse* subject matter are to be found on the following page.

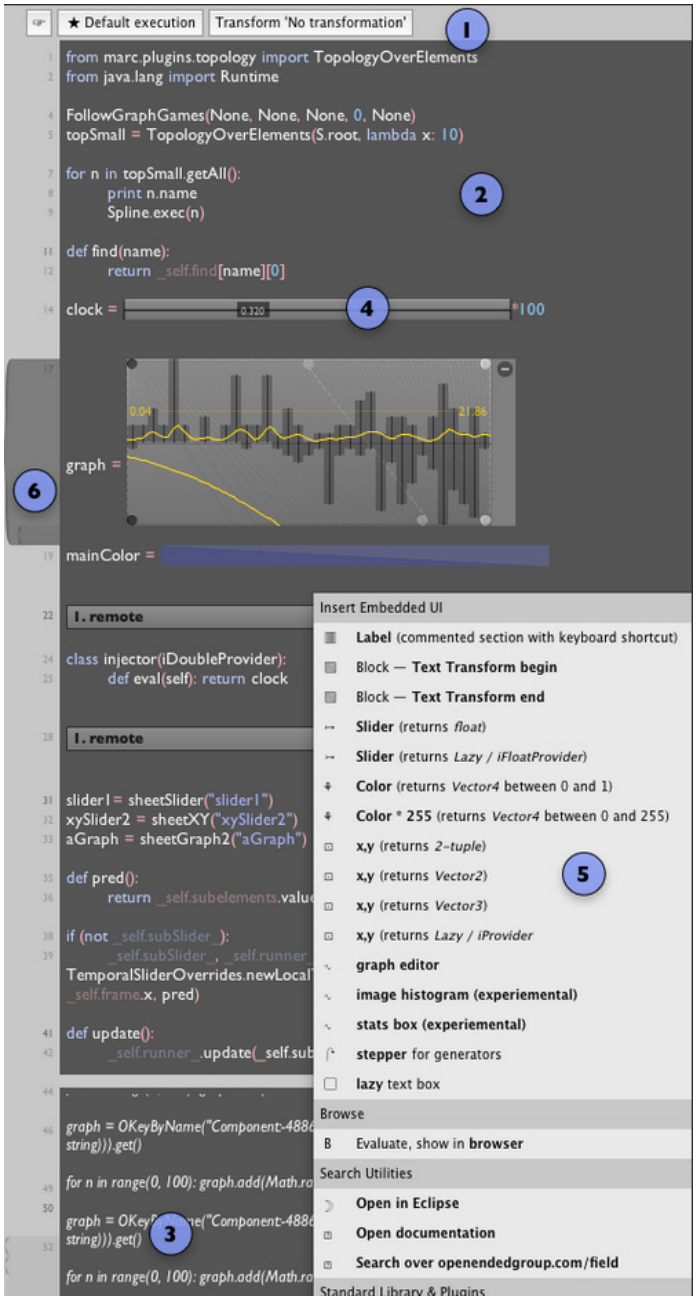


This series of studies derives from a raw 3d point-cloud of the Van Allen home, rendered in the plainest of styles.

Though we opted to use 3d video rather than spatialized photography to evoke this scene in the prototype, these rough stills do demonstrate one of the more striking capabilities of this technique, which is to extrapolate viewpoints that were never reached — as seen below with the two bird's eye perspectives on the house.







Field — open source software

Field is the open source software platform created by Marc Downie. It is primarily an environment for writing code to rapidly and experimentally assemble and explore algorithmic systems.

It is beyond the scope of this paper to describe the full scope and workings of *Field*, but interested readers will find a summary history of *Field* in Appendix 2, while interested programmers will find exhaustive documentation of the software on the Field website: *www.openendedgroup*.

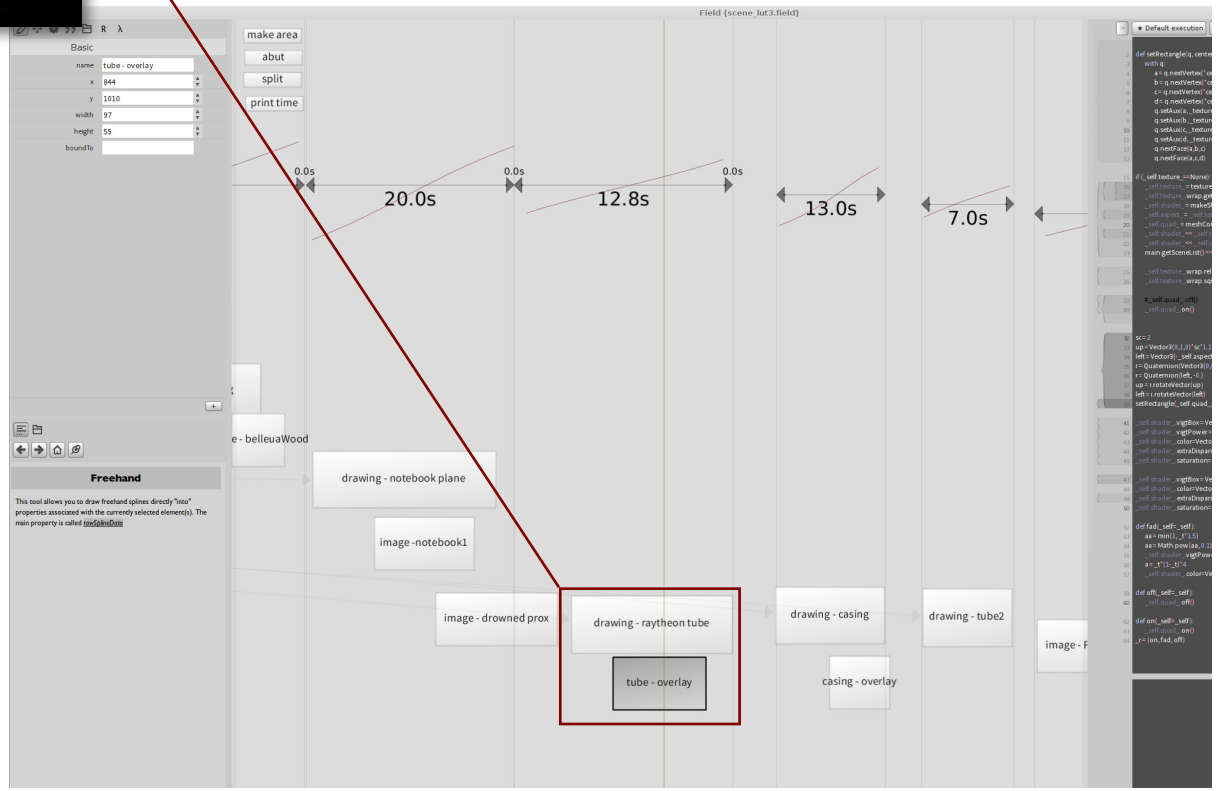
Proximity Fuse was authored entirely in *Field*. We may single out two key areas in which the program proved crucial in the creation of the prototype:

1. the 3d capture process, as described above. In particular, Downie worked out a key technique of computer vision — an effective background-subtraction algorithm — which permitted us to record the act of drawing pristinely, with the presence of the hand removed and any variable lighting on the paper itself evened out.
2. the incorporation of all the heterogenous media types we collected — 3D video, animated drawings, archival video, and high-resolution stills — into a single project with a unified timeline that we could edit in real-time. "Edit" is used here in its broadest sense, for it included color correction; 3D compositing; blurring, sharpening, and vignetting; time warping and frame-blending of video sequences; and much more.

Field works in OpenGL, which delegates visual processing tasks to a graphics card vastly outperform the computer's own CPU. (Downie ported *Field* from the Macos to Linux specifically to take advantage of the most recent and advanced graphics cards, which Apple lags behind in supporting.)

Here we show *Field* configured as a timeline editor.

In this illustration we see a frame produced by overlaying a drawing on an archival photograph. The frame is positioned at an exact time in the sequence, where it matches the timing of the voice-over.



Since *Proximity Fuse* ranges across such a rich mix of historical topics and materials, we sought ways to renew and sharpen our perceptions of the past — and to juxtapose those perceptions with those we make of the present-day world surrounding us.

Each method takes advantage of the distinct perceptual qualities of stereoscopic 3D.

In this section, we illustrate nine strategies of representation for the *Proximity Fuse* prototype:

- *sketch a timeline*
- *diagram + draw*
- *trace + annotate*
- *simulate*
- *dissect an object*
- *scan + clarify*
- *spell out illogic*
- *juxtapose shots*
- *evoke past in present*

Of course, what these still illustrations cannot convey is the actual unfolding of these visual elements in animation.

Viewers benefit especially when they are taken step-by-step through an explanatory diagram, for the same reason that a teacher diagraming and explaining a concept on a blackboard is often vastly more effective than the same diagram reproduced as a hand-out with still picture and explanatory text.

SKETCH A TIMELINE — *Japanese history*

Having established the three color-coded axes of our inquiry (*geopolitical*/blue, *technological*/red, and *Iowa*/green) on the over-all timeline illustrated on page 4, we can quickly sketch out smaller spans of history within the same framework. Here we diagram the interaction of geopolitical events with technological advances in Japan. (We omit the green axis since Iowa played no role here.)

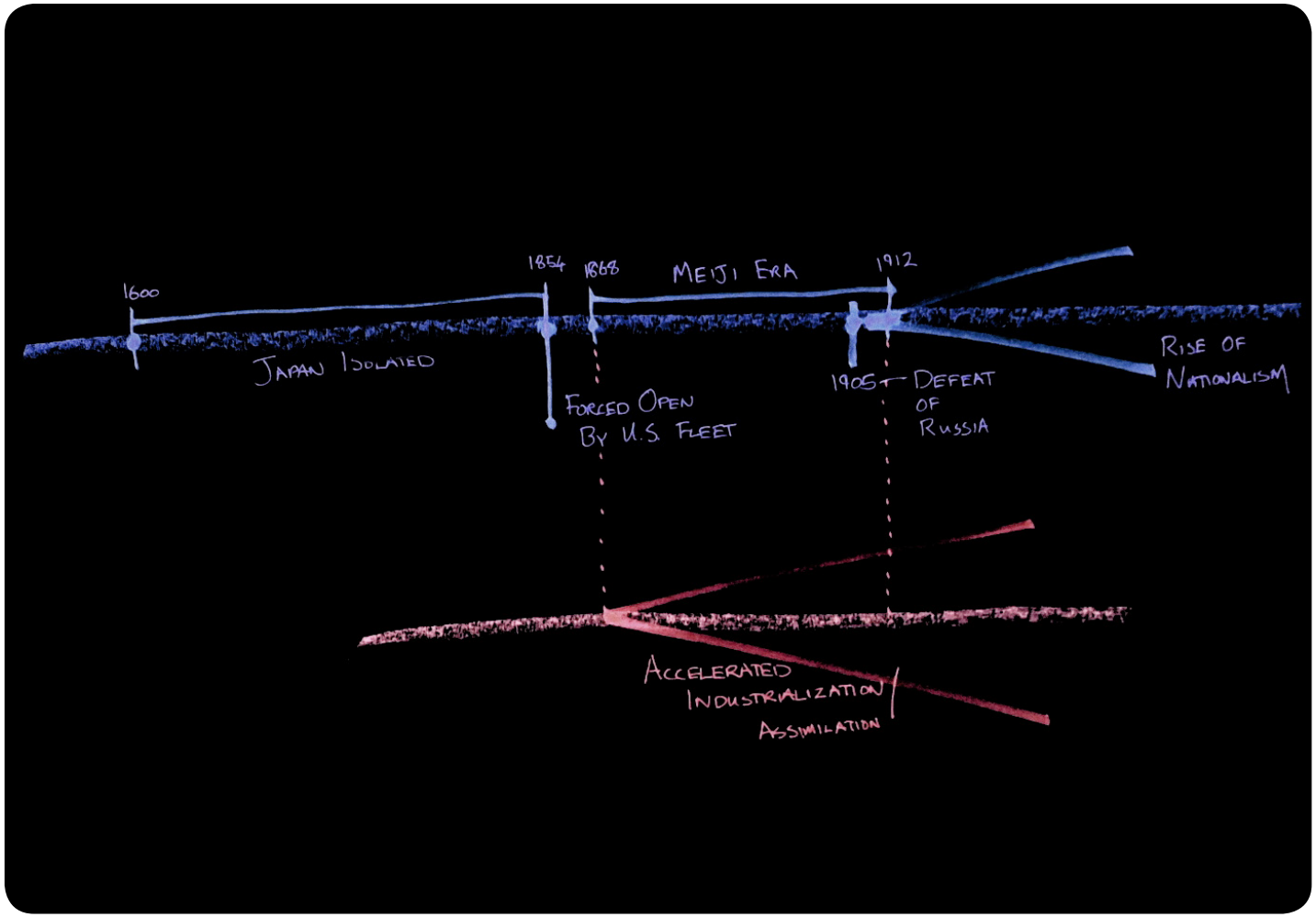


DIAGRAM + DRAW — *V2 trajectory*

This animated diagram illustrates the trajectory of a V2 rocket from its launch in Germany to its plummet from space down into England.

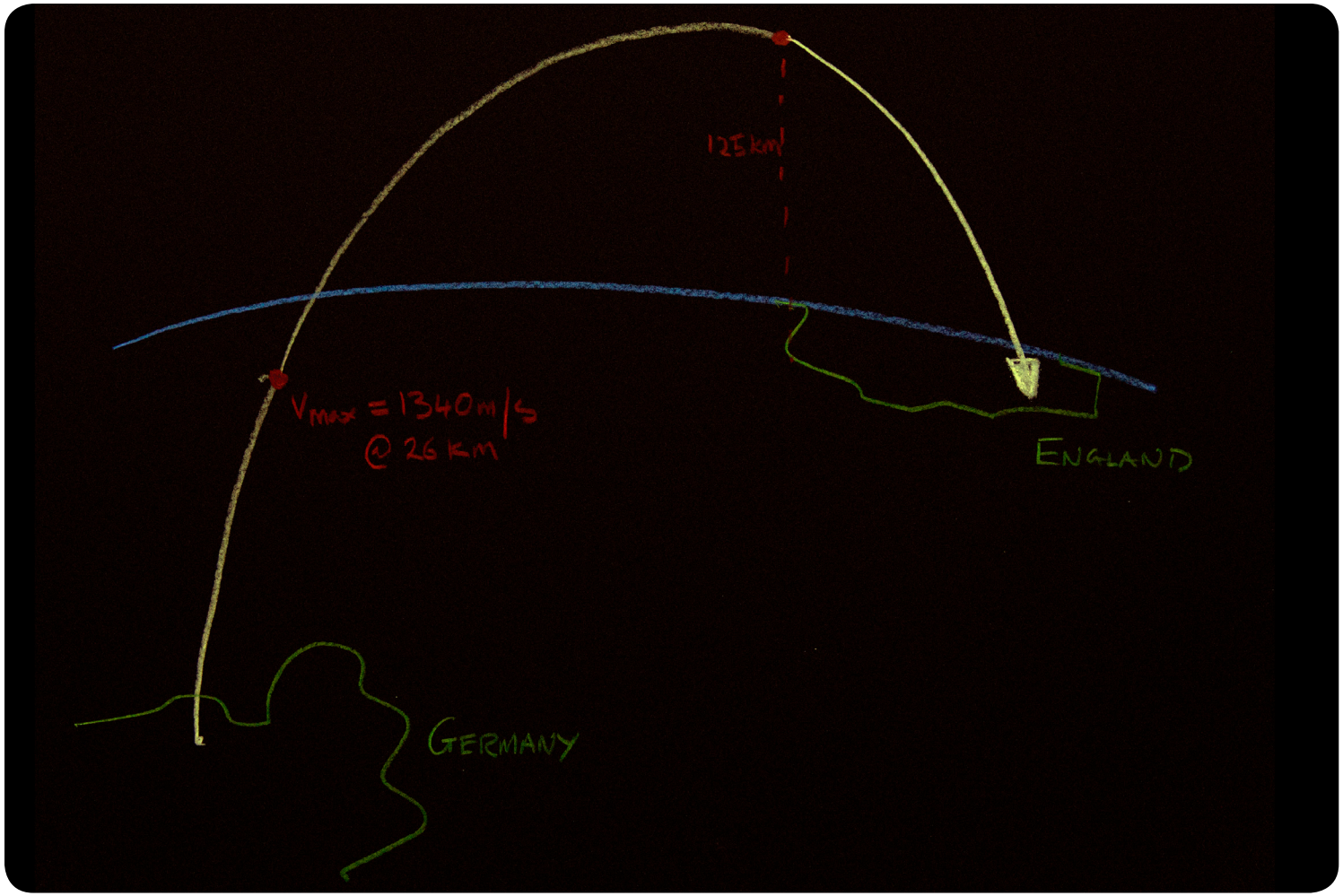


DIAGRAM + DRAW — *V2 rocketeers' surrender route*

This animated map shows the route followed by the V2 rocketeers as the Allied forces closed in on Germany from east and west. Von Braun had decided to surrender to the US forces, from whom he expected (and soon received) preferential treatment.

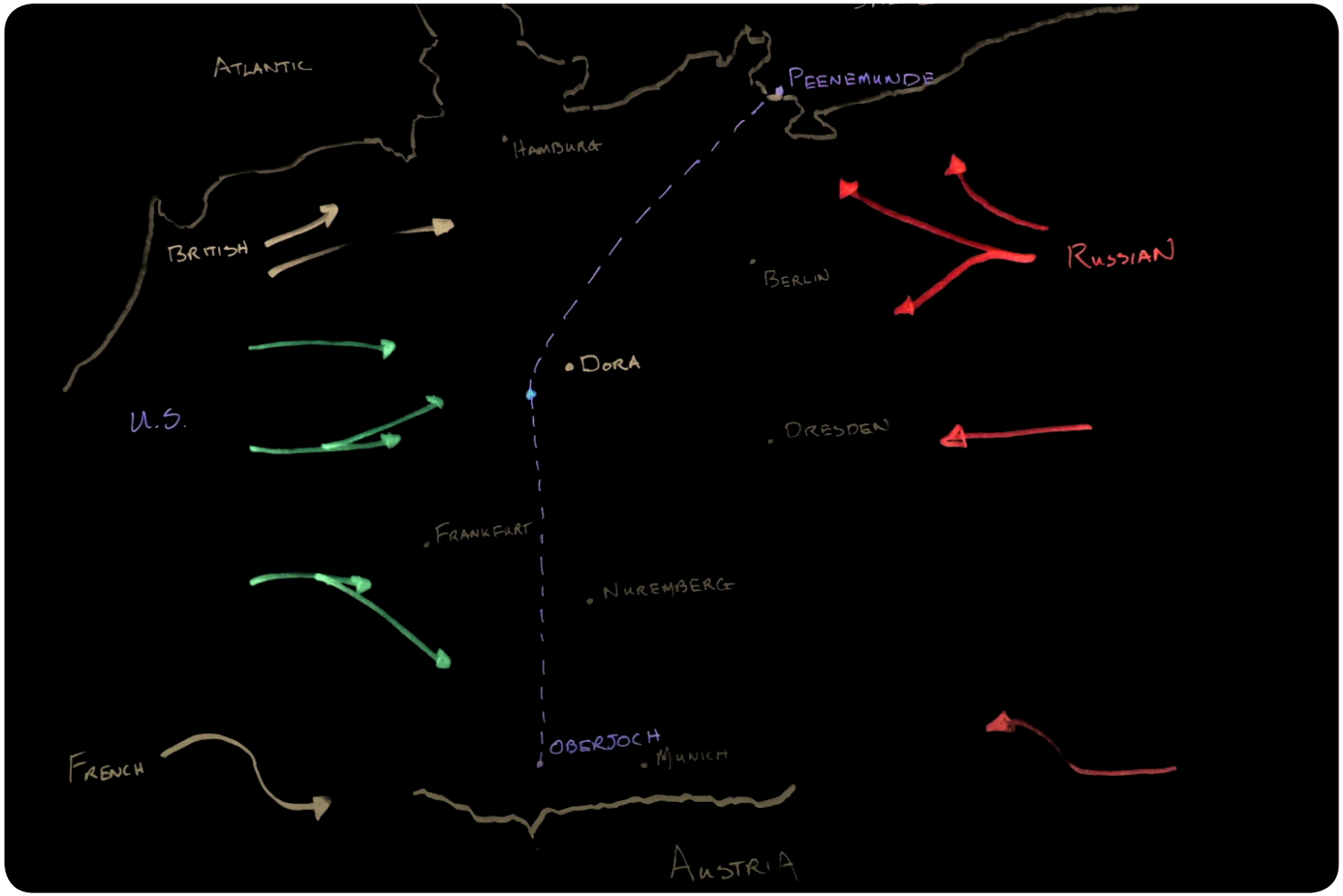
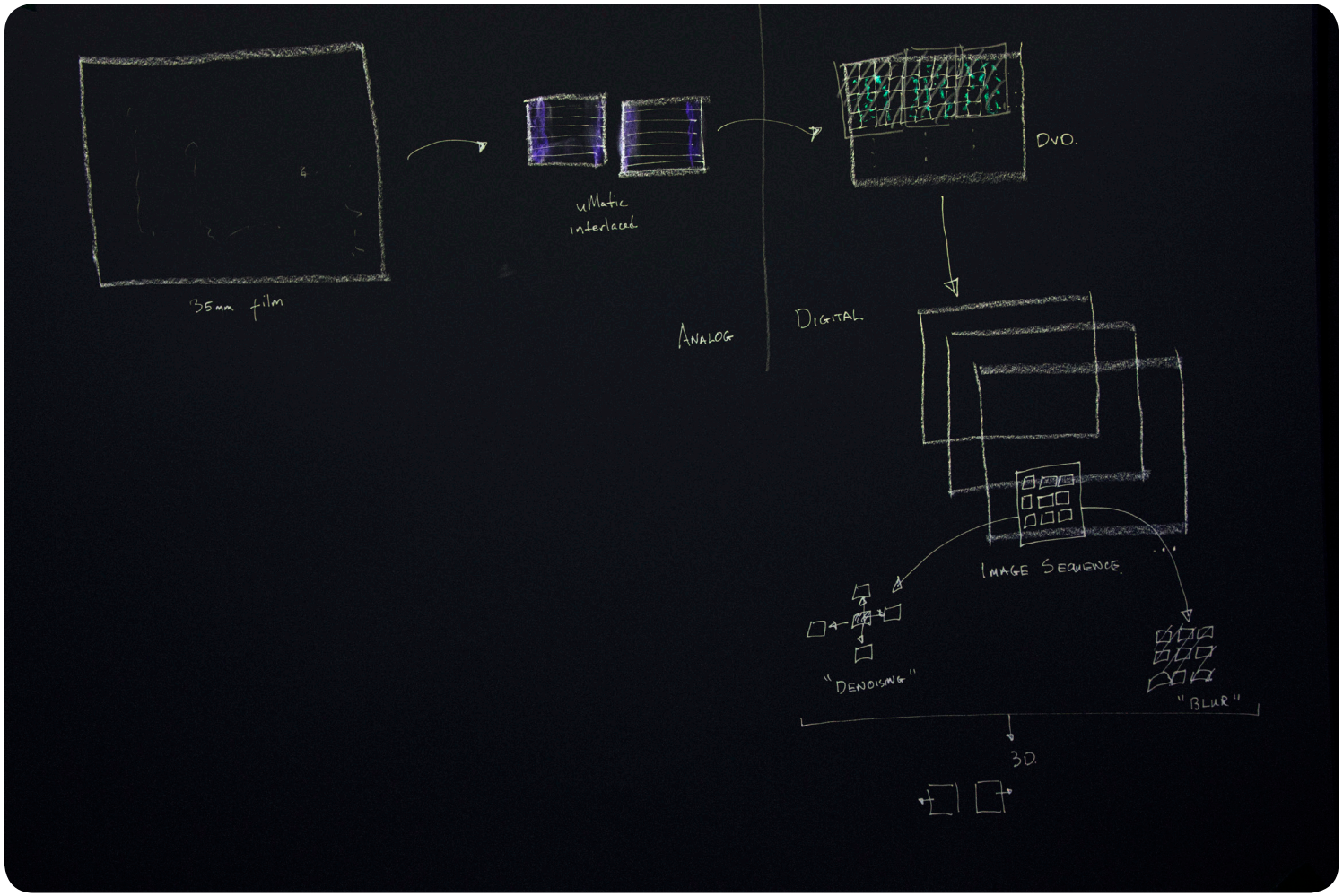
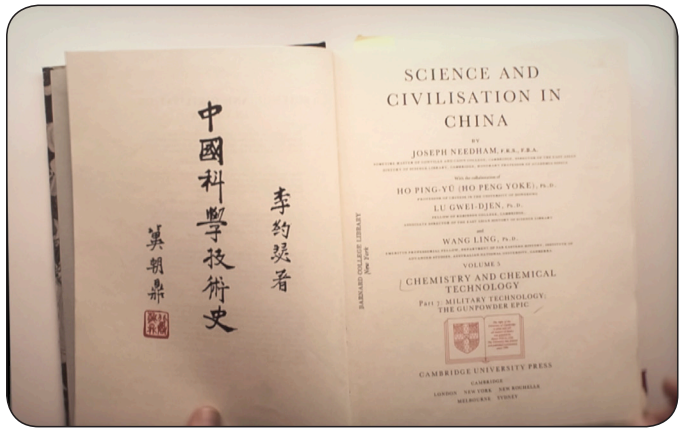
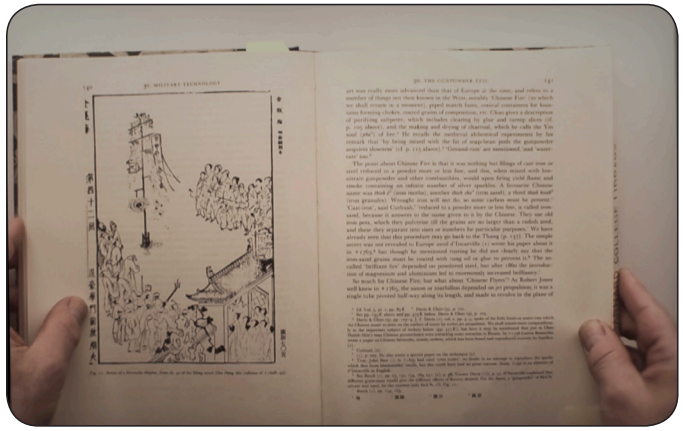


DIAGRAM + DRAW — *film transfer process*

This diagram accompanies a spoken explanation of the steps whereby a historic 35mm film (the first taken of earth from space) has been transferred through different formats into its present digital form — a process mainly of destructive down-sampling. In the prototype, this animation contextualizes the clip just presented to the viewers.





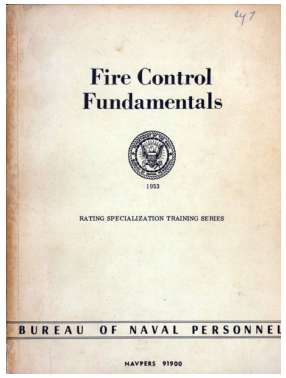


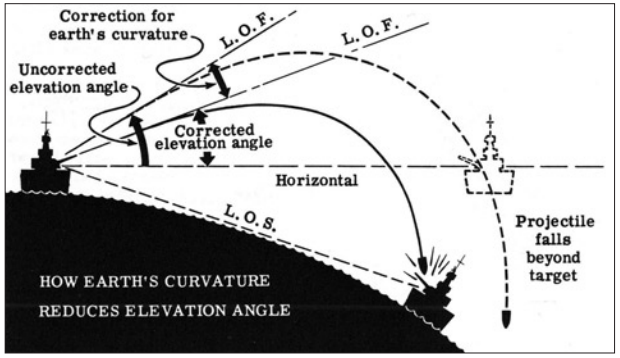
TRACE + ANNOTATE — *Science and Civilisation in China*

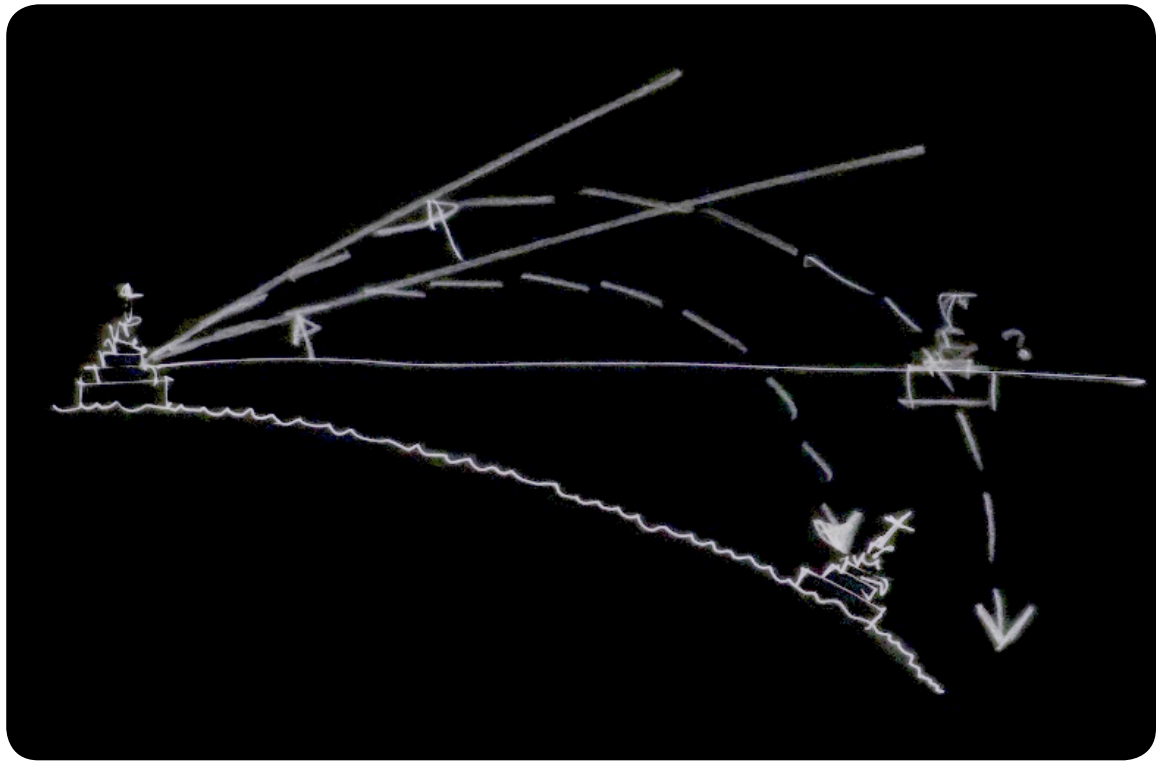
We show hands opening a book and finding an illustration, which then draws in on the screen, its colors evoking the fireworks it depicts.

TRACE + ANNOTATE — *Fire Control Fundamentals*

A diagram from a US Navy artillery manual is redrawn as a 3d animation to accompany a narrated explanation of its workings.



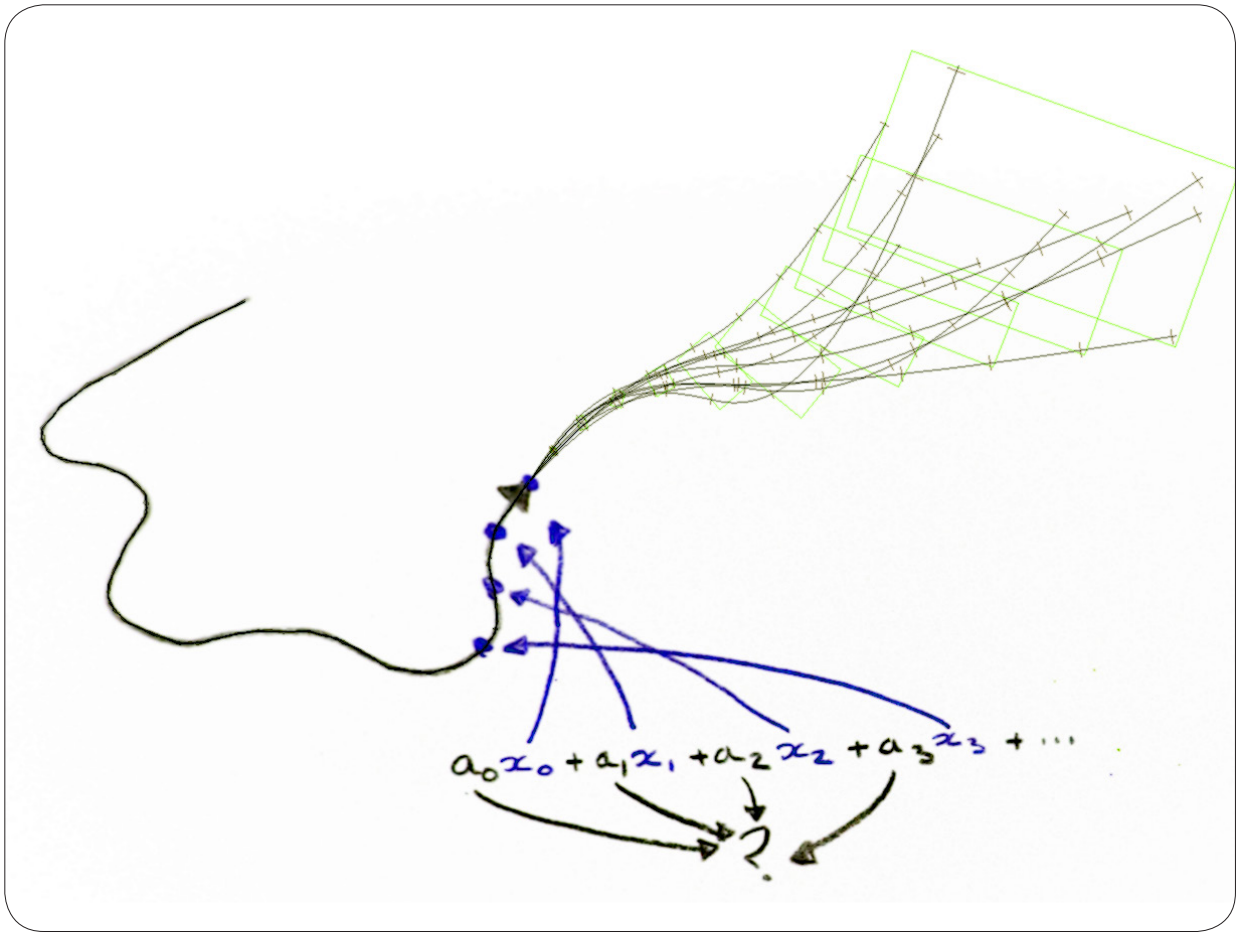


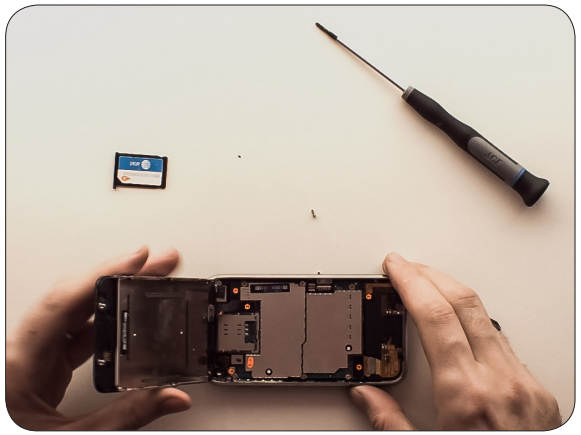


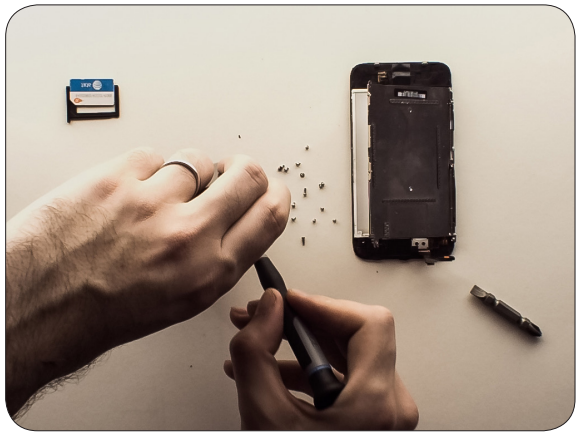
Simulate graphically — *Norbert Wiener's predictive line*

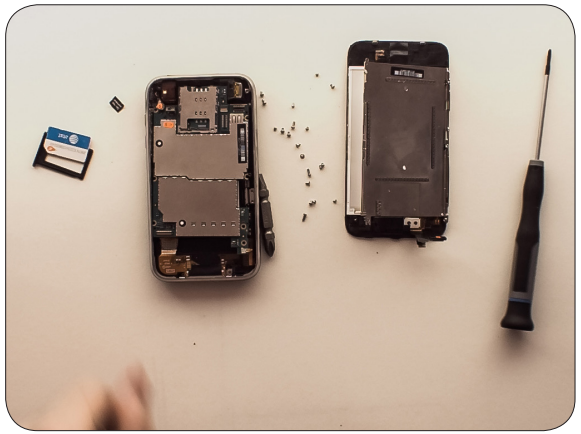
The field of cybernetics began in World War 2 with Norbert Wiener pondering machine-enhanced intelligence for anti-aircraft guns.

Here we simulate his calculations graphically, showing how the probabilities of the future points of a trajectory may be extrapolated from its past points. In this case, we substitute the path of a line drawn in 3D for that of an airplane executing evasive action. *(Screen colors inverted).*







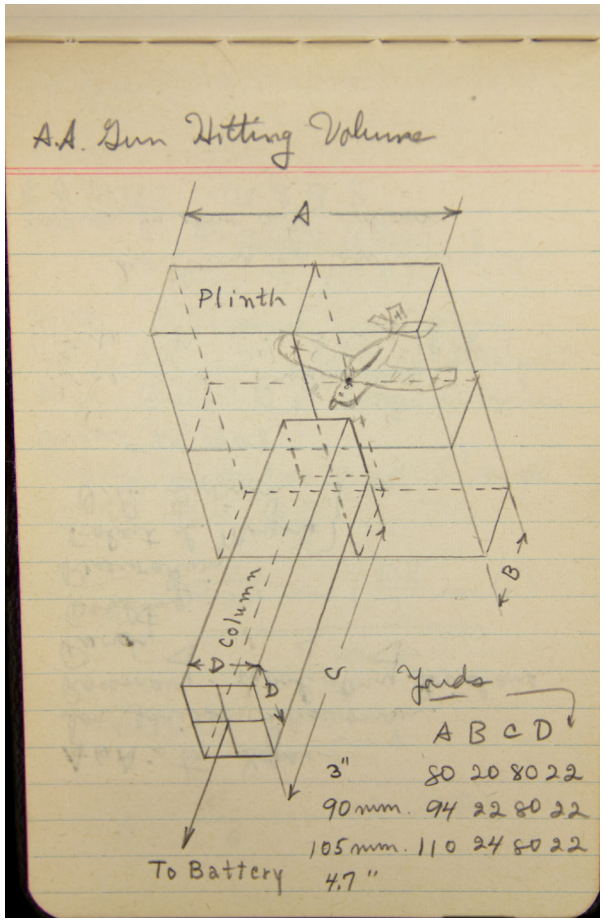


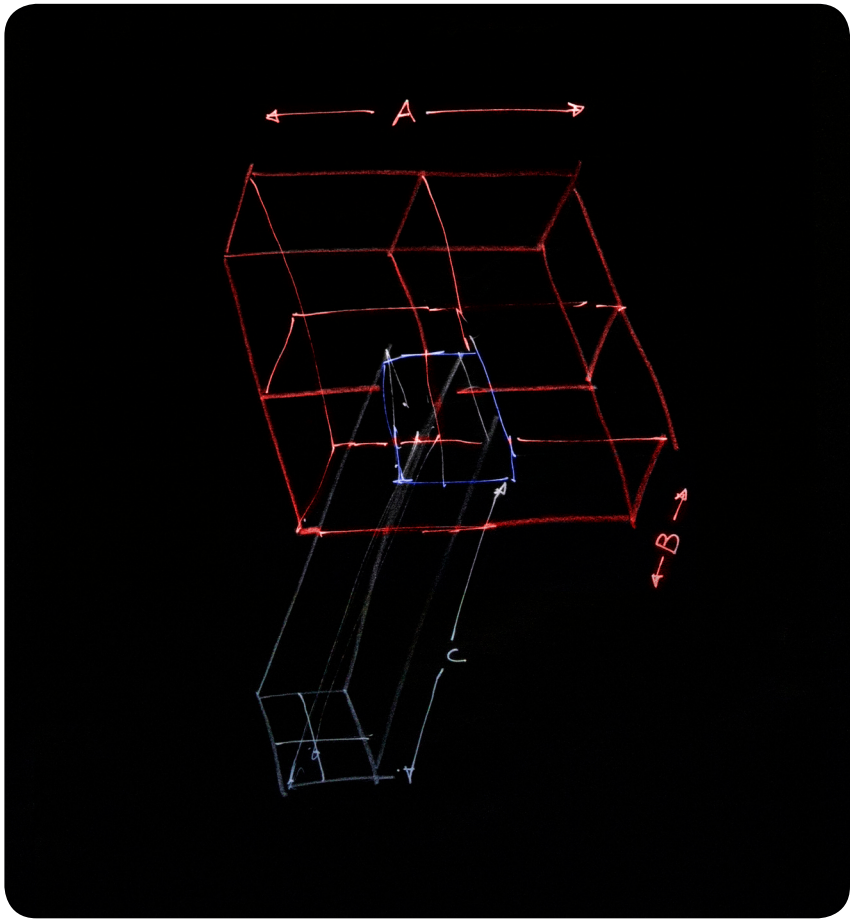
DISSECT AN OBJECT — *iPhone*

This time-lapsed 3d film shows us dissecting a contemporary iPhone — to demonstrate how difficult it is to do so, and to show how little your eye can then tell you about its inner workings.

SCAN + CLARIFY — *anti-aircraft hitting volumes*

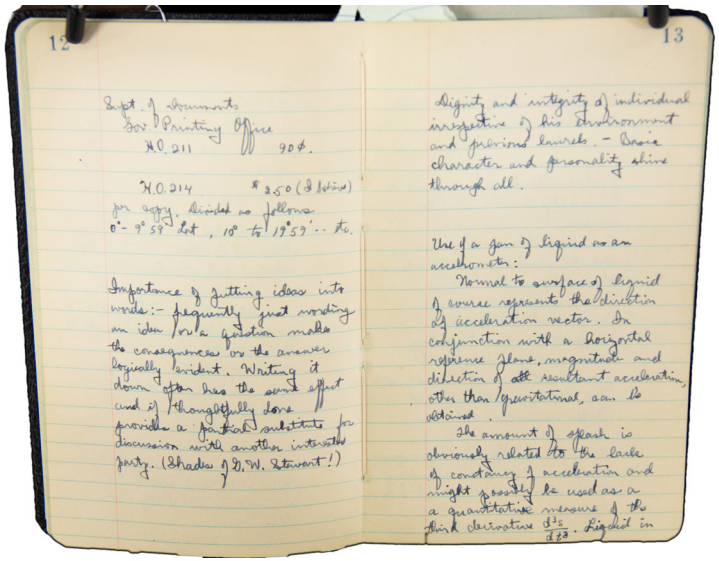
Here we transform a working diagram that Van Allen sketched in his wartime notebook into a 3d drawing, adding color to identify the illustration's key parts and matching them to the explanation we give in the voice-over.





SCAN + CLARIFY — *diary entry*

We select, highlight, and transcribe a particular passage in Van Allen's wartime diary.



Importance of putting ideas into words:— frequently just wording an idea or a question makes the consequences or the answer logically evident. Writing it down often has the same effect and if thoughtfully done provides a partial substitute for discussion with another interested party. (Shades of of D.W. Stewart!)

-1 × -1 = +1

not bad = good

Spell out illogic — *twisted reversals of the McCarthy era*

Sometimes simply spelling out the misuse of logic can clarify whole categories of injustice.

Here, the logic of the double negative in mathematics and grammar *(at left)* is misapplied to the taking of sides and determination of allegiance *(at right)* — an egregious error at all times, and particularly prevalent in Cold War America.

The enemy of my enemy
is my friend.

If you aren't with us,
you're against us.

Juxtapose shots — *kamikaze strike*

Two different angles on a kamikaze striking a US ship are juxtaposed in 3D space. Rather than cutting from one shot to the other, we place them in rough perspective to each other, with the closer angled shot made larger than the distant.

Juxtapose shots — *Von Braun in custody / Dora survivor*

Contrasting fortunes at war's end: the self-satisfied expression of Von Braun in US custody is juxtaposed with the traumatized pallor of a Dora slave labor survivor as he is borne off on a stretcher by American soldiers.

CONJURE PAST IN PRESENT — *Van Allen's Mount Pleasant*

To conjure up a sense of the presence of the past, we captured Van Allen's hometown and family house in 3d video.

The motion clips are color-shifted, decelerated, frame-blended, and vignetted so that the everyday somehow seems suspended in timelessness.

Proximity Fuse takes its title from the first form of smart bomb, which was invented in World War Two with a key contribution by James Van Allen at the very start of his celebrated career. The device name was in fact spelled with a z ("*fuze*"), but for our title we revert to the more conventional spelling since we intend it to evoke the kinds of intersection we trace between cultures, careers, ideas, and advances.

We rely on striking juxtapositions to defamiliarize not only our historical awareness of World War II, the Cold War, and prior eras but also of our technological present. Our thematic strategy is to link far-flung developments across the three axes we identify as structural underpinnings — *geopolitical*, *technological*, and *Iowa*.

We identify unusual cross-currents running between east and west, often across long periods of time and geographical distance:

— *first, between Asia and the West:* gunpowder and rocket technology making their way west from ancient China, on the one hand; and then industrialization and philosophy traveling the opposite way to Japan, where they combined in unique and ultimately self-destructive ways with the samurai and Zen mind-sets.

— *second*, *between Europe and the United States,* where the ascension of American science was intensified by the encounter of homegrown American minds with pre-eminent Jewish scientists fleeing the Nazis; and then by the slightly later encounter with Nazi scientists who had embraced America to escape the devastation of their homeland and possible capture by the Russians.

Our especial interest is to juxtapose the young minds found in the different cultures entangled in the war — from the Midwestern practical ingenuity of Van Allen, to the very young but highly educated and idealistic kamikaze pilots he worked to defeat in the Pacific, to the aristocratic German rocketeer Wernher von Braun, with whom Van Allen was later to collaborate in the Cold War space race.

Unbracketed titles appear as section headings on screen. All text is spoken as voice-over except italicized notes enclosed in parentheses and inset quotes from other sources, which in the prototype appear on the screen.

[Prelude sequence]

(Shots of Iowa rural highway ___ with bird on sign-post and then in flight over corn fields.)

PROXIMITY

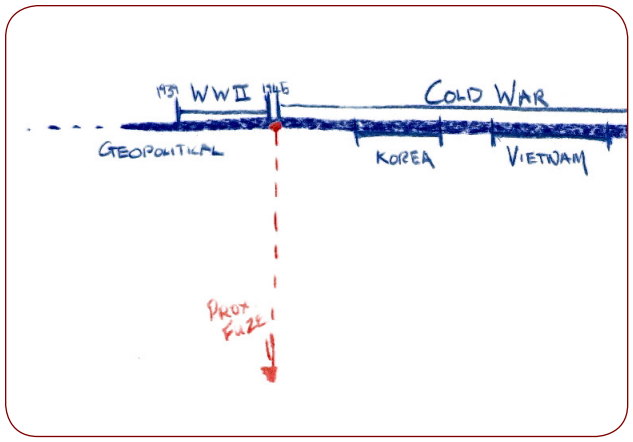
FUZE

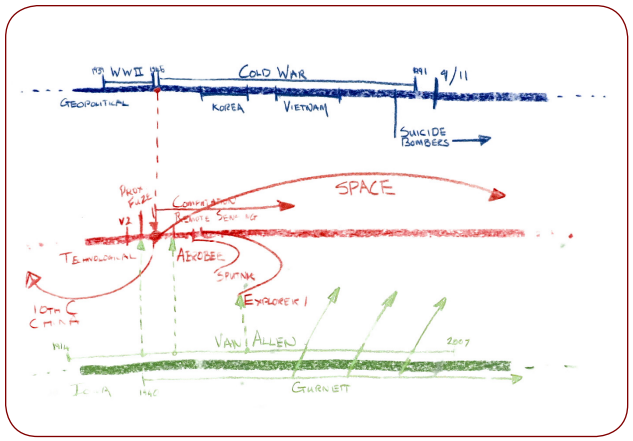
[Title sequence]

Proximity fuze, spelled with that strange z, refers to an advanced triggering mechanism, invented in World War 2: the earliest form of smart bomb.

Spelled with an s, fuse has a broader meaning, which makes for a better title.

The idea is that things other than bombs can go off when brought together — people and ideas, for example, can suddenly spark and ignite.





Three lines

Now we start by drawing three lines —

Geopolitical (mainly of wartime), our chief interest here being World War II and the Cold War that followed, hard on its heels.

The second line is for technological advances, those beginning in World War II especially since that war drove so many discoveries and inventions that led directly to the future — that is, directly to where we are today.

There was the proximity fuse itself, of course, but also the looping feedback of artillery fire control mechanisms; the first penetration of space by long-range ballistic rockets; the formulation of information theory; and, of course, the creation of the first digital computers.

The third line we draw is for Iowa, an unexpected axis for this story.

We mark these two main figures on it: James van Allen; and then Donald Gurnett — both remarkable physicists, whose intersections with the wider world we'll trace.

By the end of the first part of the story, this over-all web of interconnections will have emerged.

Weapon intelligence

Going back to 10th century China you can find a really strange example of weapon intelligence.

This, believe it or not, is an incendiary device, and the mind of this weapon is that of a poor bird. To its tender neck, a warrior ties a little cup filled with glowing embers,and the bird is let slip to fly over to an enemy encampment.

When it lands on a roof there, the thatch ignites and the whole building goes up in flames — the bird along with it, presumably, sacrificed as an expendable soldier and an unwitting suicide. This ancient weapon has its counterparts today, though these exploit people rather than birds to direct and deliver the damage.

Starting in the 1980s, suicide bombers like those of Hezbollah in Beirut and the Tamil Tigers in Sri Lanka would blow themselves up in order to kill everyone around them.

In asymmetric warfare, this sometimes allows the weaker side to prevail over vastly superior forces.

Divine Wind

The vastly superior forces that the Japanese faced in 1944 were those of the revamped American Navy. The tide of war had turned decisively against Japan.

But twice, back in the 13th century, the tide of war had turned their way at the very last minute — twice an overwhelming force of Mongols had been repulsed by two devastating typhoons in the Sea of Japan, saving the outnumbered Japanese from sure defeat and conquest.

These miraculous storms were called kamikaze— for divine wind.

Hoping for a similar turn of fortune now, the Japanese command resorted to a last desperate measure, unleashing suicide flights called kamikazes against the American battleships and aircraft carriers that were closing in.

Strapping their young pilots into planes they had them dive directly into the allied ships. With only enough fuel to reach its target,not to return, a kamikaze was more guided missile than actual airplane.

Kamikaze attacks were terrifying and deadly, especially in the largest battle of the Pacific, Okinawa. There the US sustained greater losses than it had at Pearl Harbor, with more than 30 of its ships put out of action, and almost 5,000 sailors killed.

On their side, in the course of losing the battle at large,the Japanese sacrificed about 1500 kamikaze pilots and planes. These mere numbers, however, can't measure the extent of that loss, for they lost the brightest part of their future.

Since professional airmen had, sensibly enough, refused these hopeless kamikaze missions,the brass plucked some of the best young minds from their university classes, and, playing upon their lofty ideals, sent them to their certain deaths.

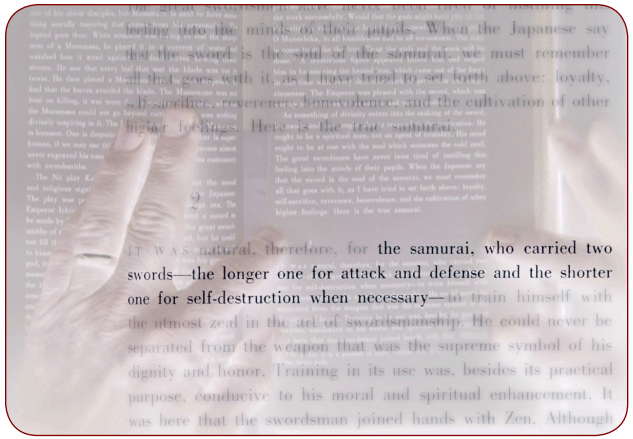
...

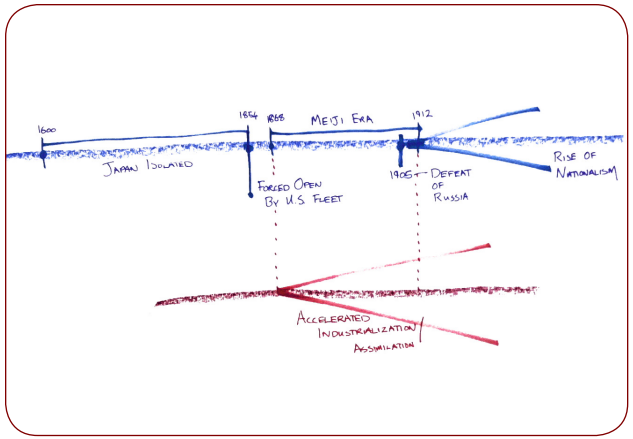
Every springtime in Japan,cherry trees blossom in clouds of pink.

With blooms lasting two weeks or less, this fleeting beauty is a prized moment in Japan, a poignant reminder that life comes and goes all too quickly.

The loaded metaphorical power of the cherry blossom was applied to the young kamikaze pilots, who were said to scatter their lives like cherry petals, which made their deaths seem like beautiful and poetic moments rather than the gory and bewildering wastes they were.

The roots of such self-sacrifice lie in the Japanese samurai tradition, which requires that the warrior be ready not only to lay down his life for his master but to kill himself if he fails in his mission.





It may surprise Westerners to find this tradition backed by Zen Buddhism —as in this book by DT Suzuki, the respected Zen scholar who after the war brought Zen to America, where he exerted a powerful influence over some of the best minds of the day.

I doubt, however, that his students really paid apt attention to chilling passages like this one —

> "the samurai, who carried two swords—the longer one for attack and defense and the shorter one for self-destruction when necessary."

... or this.

> "For it is not really he but the sword itself that does the killing. He has no desire to do harm to anybody, but the enemy appears and makes himself the victim."

But as it turns out the kamikaze pilots hadn't mastered this kind of spiritual detachment themselves. Their inner states were much closer to what you or I would feel: anxiety, fear, and dejection.

...

Some historical context may explain why: After two and a half centuries of near-complete isolation from the world, Japan had been forced to open its ports to international trade by a US Navy fleet under the command of Commodore Perry.

What followed was the incredibly rapid Japanese assimilation of the west — accelerated industrialization complete in about 50 years, and capped by the shocking defeat of Russia, a major European power, in 1905.

And it wasn't just practical matters that the Japanese absorbed. Some of their best minds also immersed themselves in Western literature and philosophy.

308 *Appendix*

	Hayashi	Nakao	Sasaki	Wada
Books				
French (187)	54	100	28	5
German (170)	41	39	78	12
English (83)	22	19	39	3
Russian (70)	11	37	19	3
Classics (42)	11	20	10	1
American (15)	2	8	4	1
Italian (14)	1	5	8	0
Other Western (36)	7	12	15	2
Chinese (9)	2	3	4	0
Japanese (731)	107	356	253	14
Total (1,356)	258	599	458	41
Western Music (37)	0	2	30	4

In the following entries, the dates are in month-day-year format and are foll

You can see a vast range of study in this summary of just four kamikaze pilots' reading — Kant, Mann, and Nietzsche, from the German

— Chekhov, Dostoevsky, Gogol from the Russian.

Amazing erudition, all this brilliance snuffed out with their planes plunging into the Pacific.

Cybernetics

On the other side of the ocean, America didn't lack for great minds either, and it certainly had better ideas about how to put them to use.

Among other things, they were challenged to figure out more intelligent weapon systems, ones that didn't simply put a smart man inside a dumb machine, like this famously fraudulent mechanical chess-player(or like a kamikaze).

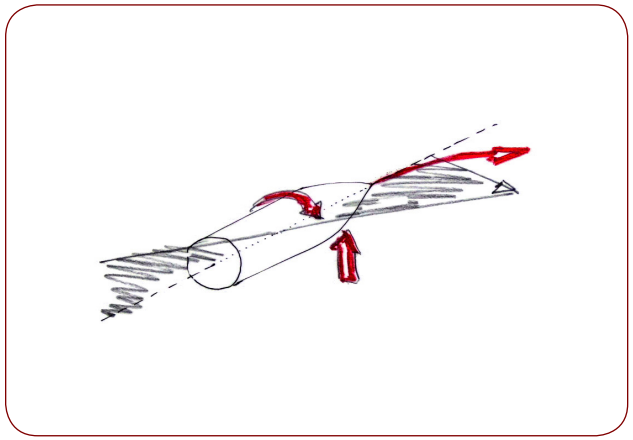
Instead they started devising new kinds of intelligent man / machine hybrids that could do together what neither could do alone.

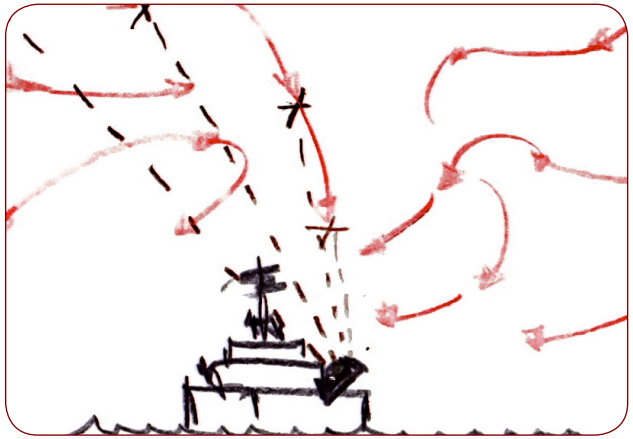
You can find on line an old training manual for US Navy gunners called *Fire Control Fundamentals*.

The authors clearly expected their gunner trainees to be intelligent,if not technically trained — and their manual brings you step by step through all the complexities to be accounted for when taking aim from a gun on your ship at an enemy ship coming into range

— such factors as:

The spin and wobble of the shell as it travels through the air;





Range winds that blow in the direction the shell is traveling, and *cross winds* that move it side to side;

Winds that vary by altitude along the shell's trajectory;

Air density, which likewise varies by the altitude of the shell as well as by the *prevailing weather conditions*.

Furthermore you must correct for d*ifferences in position between the ship's sensors and the ship's guns*;

And you even have to take into account *the curvature of the earth*!

And over a really long shooting range, you're even instructed to allow for *the earth's rotation.*

As complicated as that is, imagine something even more so: trying to shoot down a squadron of fast-moving airplanes, all aiming to dive right into you. On their own, the gunners simply couldn't aim and adjust their fire fast enough to keep up.

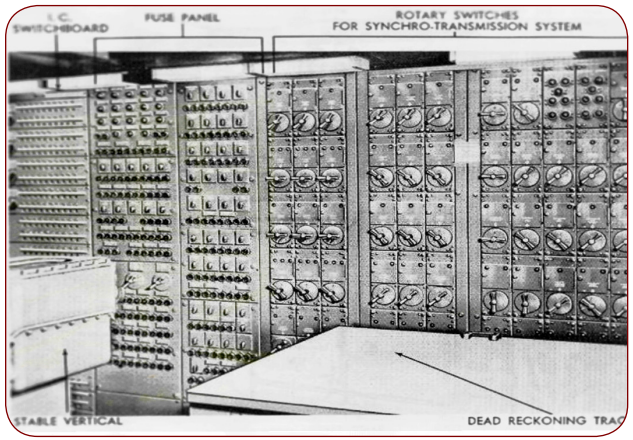
What they needed was a new kind of weapon, one with a useful complement of mechanical intelligence built right into it.

It was Norbert Wiener who after the war gave a name to the sort of science he and others were developing to solve this and related problems: Cybernetics.

It was Wiener who during the war solved the problem in theory with methods to calculate predictions — in this case the probabilities of an airplane's future position.

We can show his approach hereby taking this line we've drawn with a pencil and, incorporating Wiener's mathematics into our code, first draw samples from the path of the line,

then build a model of that path's tendencies,



and finally use that model to predict the line's future path,

producing this range of guesses.

Though Wiener's approach partly shaped American war-time anti-aircraft systems, the proof of concept for that feedback-driven aiming system, which he built with a brilliant young engineer, Julian Bigelow, was still too complex to manufacture in time during the war

— as you can see from this ship-borne fire control computer system that the US Navy built a little later on, a diagram that in turn evokes the ever-expanding cybernetic interconnectedness of the digital world we live in.

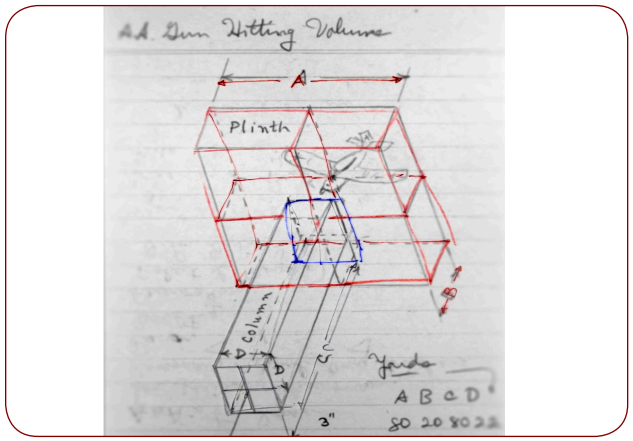
Lieutenant Van Allen

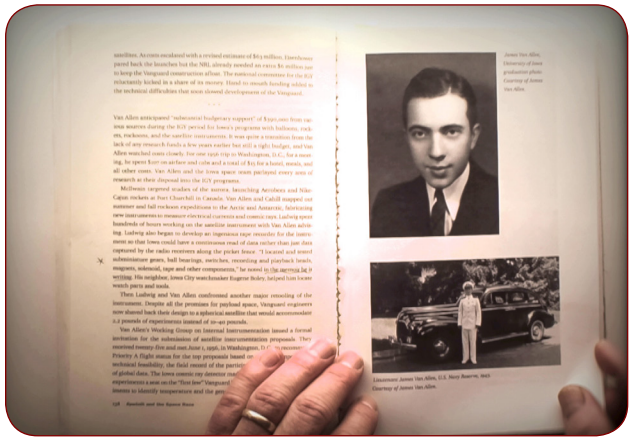
In 1942 James Van Allen was young and unknown. He was about the same age as the kamikaze pilots whom he had turned his considerable intelligence to defeating.

Allied gunners had been making do with timed fuse anti-aircraft shells — which had to get to the right place at the right time to destroy their targets. But against kamikaze attacks,this was proving insufficient.

The idea for a more sophisticated fuse, the proximity fuze, was for it to trigger the explosion whenever it sensed that the target plane was nearby.

As Van Allen diagrammed it in his notebook, it didn't target just the small area presented to it by the airplane, but the much larger volume surrounding it. Exploding anywhere within that volume, it was sure to blow the airplane right out of the sky.





By the time Van Allen entered the picture, the problem had been solved in theory but not in practice. Using miniature vacuum tubes just invented by Raytheon, Van Allen assisted in the creation of the radio proximity fuze

... but now he had to figure out how to get the laboratory models to work in the field.

The trouble was that when fired, the fuzes had trouble withstanding an acceleration of up to 20,000 times the force of gravity.

So he had to find a way to ruggedize them, which he did by devising a clever little spring to protect the vital part of the shell.

Eventually he got the proximity fuses workings devastating effect, as you can see in this annotated photo of his.

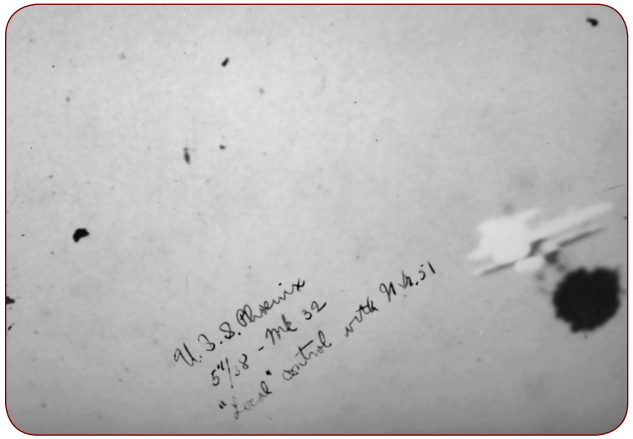
But this success didn't come till he'd enlisted as a second lieutenant and shipped out into the thick of the war to fine-tune and trouble-shoot the proximity fuse deployment.

Studying the notebooks now archived in Iowa City, you soon see they were journals, not personal diaries. For example, you'll find no mention of his surviving a kamikaze attack in the Battle of the Philippines Sea or even of VJ day at the war's end.

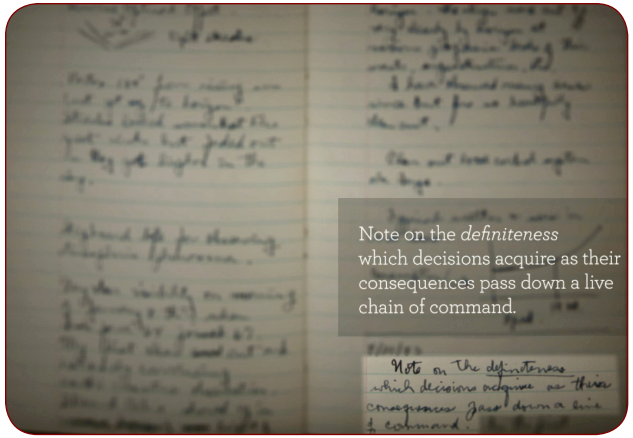
However, the notebooks do let you peer into Van Allen's thinking as you see him deliberately working out his ideas in a form of inner dialogue.

> Importance of putting ideas into words: — frequently just working an idea or a question makes the consequences or the answer logically evident. Writing it down often has the same effect and if thoughtfully done provides a partial substitute for discussion with another interested party.

Some pages are simply straightforward records of the business at hand: for example, these charts of lethal values.



On other pages, like this one, Van Allen would simply note down his atmospheric observations.



But down on the same page, we find him making a different sort of note. Keeping his eye on how things worked in organizations, here he observes how a decision becomes a firm command when passed down by a superior:

> Note on the definiteness which decisions acquire as their consequences pass down a live chain of command.

and here he makes a similar point:

> Psychology of command — positiveness, right or wrong.

Observations he was to put to good use after the war,when he became a leader himself.

Life at sea immersed Van Allen in the complicated dealings of a diversity of men, all continually adjusting to each other and to the conditions of war,

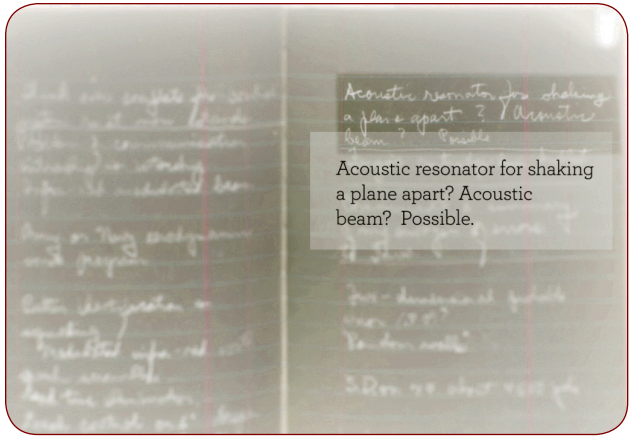
> Leveling influence of wardroom, uniform and uniform living conditions, completeness of knowledge of each others' lives, same food, rooms quarter, pay, outlook on life etc.

and he contrasted the useful social leveling of wartime with the stable conditions of peace, which could reward mediocrity.

> Systematized recreation, freedom, security, continuous advancement in pay, authority, prestige, living conditions, responsibility. Reward for mediocrity — Simple virtues. Difficult to judge relative ability (under peacetime conditions in particular).

And so he stressed the value of keeping oneself open to a wide range of contacts valuing the individual over his rank and station. (The American ideals of democracy.)

> Worldly experience and varied associations and acquaintances are essential to the realization of what is opportune and practical of those vari-



Acoustic resonator for shaking a plane apart? Acoustic beam? Possible.

> ous devices, processes and ideas which appear to one as being sound and worthwhile. Therefore, one should not slight general acquaintances as distinguished from professional associates.

Here he observes that the practical work of the artisan is as crucial to success as the theoretical work of the physicist,

> Fundamental blunder of Section T in continuing and persisting to believe that prematures (and duds, less true) in particular were to be remedied by fundamental change of design. — not by improved workmanship and quality control. This is a physicist's point of view, to be sure. It is now to be realized that a considerable admixture of the artisan's point of view would have been desirable, and would have removed months from the delivery date. This lesson should be well learned.

resolving to balance both sides in himself.

Some of the most fascinating notebook entries are speculative.

This terse idea, for instance,

> Acoustic resonator for shaking a plane apart? Acoustic beam? Possible.

which has been toyed with since by weapon designers, unsuccessfully so far as anyone knows…

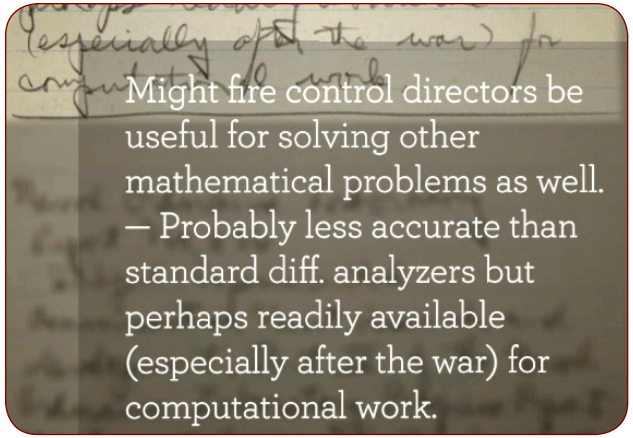
Or this idea,

> Use of star traces as reference system. Very good idea.

which was soon to be used for intercontinental ballistic missile guidance.

In 1944 we see Van Allen somehow learning of Wiener's still-top-secret approach to computing artillery fire,

> Wiener's psychological approach to AA fire control. What will the pilot do next? Assuming a certain type of error — say to the right.



and his hunch that such a system would have a much wider use once the war ended.

> Might fire control directors be useful for solving other mathematical problems as well. — Probably less accurate than standard diff. analyses but perhaps readily available (especially after the war) for computational work.

In 1945, with the Nazis already defeated in Europe, Van Allen even gets wind of allied efforts to analyze and appropriate the V2 rockets captured from the Nazis.

> Excellent report on functioning of V-2 (and discussion of airbursts) obtained mainly by interrogation of German Engineers.

> Good dope on operation of V-2 components — as contrasted to "Backfire" which is mainly a pictorial description of equipment.

This was soon to be the next chapter in his life.

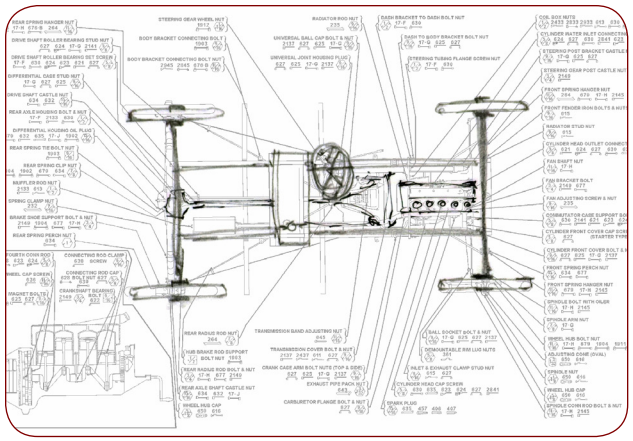
But first, we'll flip back briefly to his earlier days and see where he'd come from.

from Mount Pleasant

We drove down to Mt Pleasant, Iowa, looking for the past,but thinking of the Space Age.

That's van Allen's boyhood home right there, which looks like it's been dropped from the sky and is now resting on makeshift underpinnings.

Not long ago the house stood on a different street and had a different address. To save it from scheduled demolition,it was lifted from its foundation and set down here — here being the grounds of the now-abandoned elementary school that Van Allen once attended....now a vanished world.



Van Allen later recalled that as a boy he liked to tinker with machines.

> I was intensely interested in mechanical and electrical devices. Popular Mechanics and Popular Science were my favorite magazines. I built elementary electrical motors, primitive (crystal) radios, and other devices described therein. Two highlights were the construction of a Tesla coil which produced, to my mother's horror, foot-long electrical discharges and caused my hair to stand on end and the complete disassembly and re-assembly of those mysterious "black boxes" -- the engine and planetary transmission of an ancient Model T Ford which my older brother and I had bought for $25 (later recovered on resale).

With his brother, he took apart and reassembled a Model T Ford, the workings of the car revealing themselves completely to the eye so that there was nothing you couldn't figure out about it by careful inspection.

Which isn't so for the machines of our age.

Perhaps the last microprocessor you could understand with your eye was the 6502 chip of the early 1980s.

Marc remembers it fondly, for it powered the Commodore 16 he had as a boy, already obsessed with computers.

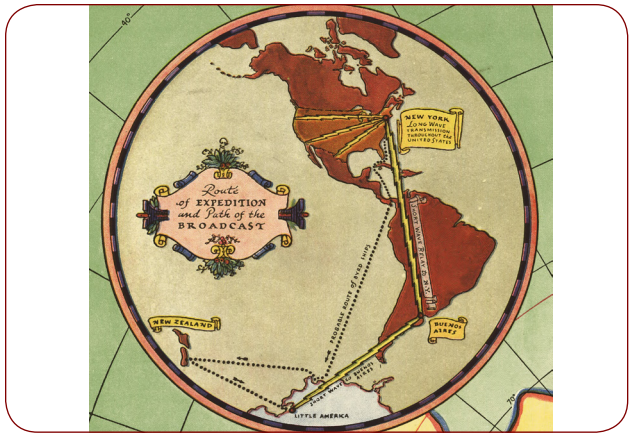
The chip was designed by hand with blueprints, roughly the same design process as for the Model T — a process inconceivable now for contemporary chips,which rely on sophisticated computer routines to sort out vastly more complex arrangements.

The workings of a modern device like this iPhone are impossible to see. In part this is because of its complexity and its miniaturization (which packs about half a billion transistors, we suspect, compared to the 3,500 of the 6502).

They're also impossible to see because of the defenses that Apple has erected in both the hardware and the software of the phone, not to mention in the intellectual property laws.

But back in Van Allen's day, things were still open to direct investigation so when he went on to college— right there in Mount Pleasant — he could tinker with and then use advanced scientific instruments like this magnetometer

—which let him take precise measurements along three axes of the invisible force of the earth's magnetic field all around us..



From the End of the Earth

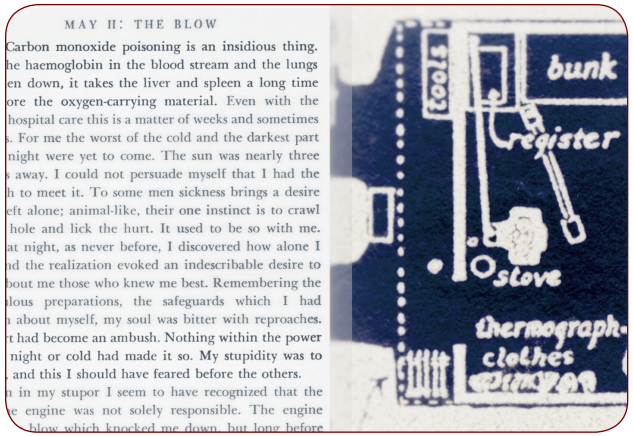
In 1933, the famous explorer, US Admiral Richard Byrd, asked Van Allen's physics professor, Thomas Poulter, to be his chief scientist on his second expedition to Antarctica, — to a base camp brazenly called Little America. (Scientific exploration and national stakes often go hand in hand.)

Poulter in turn asked the 21-year-old Van Allen to join him on the mission, so this fellow you see here with the magnetometer would have been Van Allen had his parents not forbidden him from going.

Even so, Van Allen followed the expedition closely by tuning in to popular broadcasts relayed from Little America. (The world was already getting smaller.)

While the world knew that Byrd had gone alone to the advance weather base — about as remote from civilization as, say, a space station is now — they didn't know what he was determined to keep to himself:

> Carbon monoxide poisoning is an insidious thing...



MAY 11: THE BLOW

Carbon monoxide poisoning is an insidious thing. he haemoglobin in the blood stream and the lungs en down, it takes the liver and spleen a long time ore the oxygen-carrying material. Even with the hospital care this is a matter of weeks and sometimes s. For me the worst of the cold and the darkest part night were yet to come. The sun was nearly three s away. I could not persuade myself that I had the h to meet it. To some men sickness brings a desire eft alone; animal-like, their one instinct is to crawl hole and lick the hurt. It used to be so with me. at night, as never before, I discovered how alone I nd the realization evoked an indescribable desire to bout me those who knew me best. Remembering the lous preparations, the safeguards which I had about myself, my soul was bitter with reproaches. t had become an ambush. Nothing within the power night or cold had made it so. My stupidity was to , and this I should have feared before the others. n in my stupor I seem to have recognized that the e engine was not solely responsible. The engine blow which knocked me down, but long before

that he was soon fighting for his life in this little dwelling of his, dug into the snowpack.

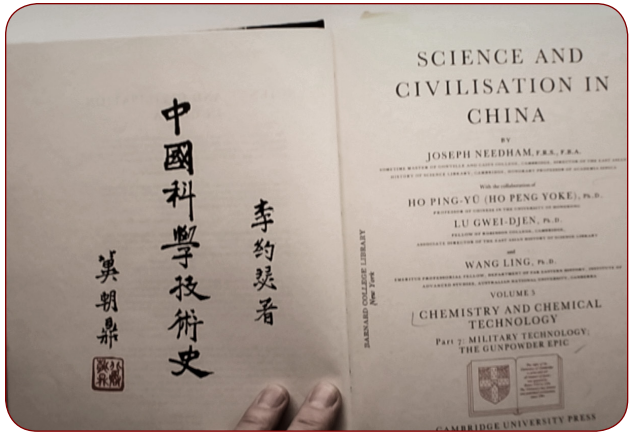
> My fort had become an ambush. Nothing within the power of the night or cold had made it so. My stupidity was to blame, and this I should have feared before the others.

The heating system had started leaking fumes and Byrd eventually realized that carbon monoxide was slowly poisoning him. And he just barely lasted till his rescue four months later.

All the while, though, he put up a brave front, his standing as American hero so great that he tapped in from Antarctica with a message for the Chicago World Fair.

And though technical problems intervened, Byrd's Morse Code message was supposed to be translated into a gigantic fireworks display, with his dots and dashes lighting up the night skies over the fairgrounds of the city.

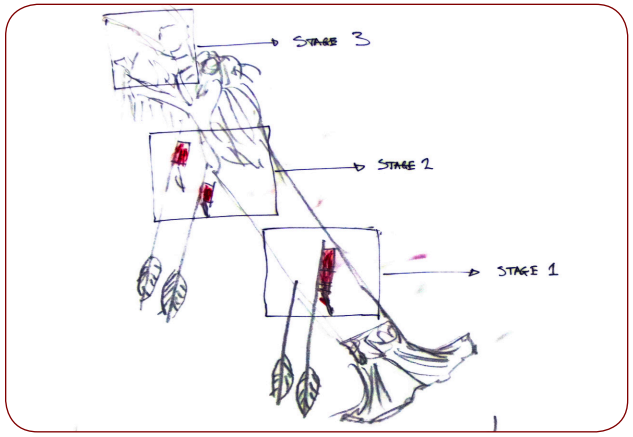
Action at a distance



We can trace those Chicago fireworks back to their distant origins on the other side of the globe.

Turning again to this volume of Joseph Needham's vast and astonishing history of science and technology in China, we find this illustration of fireworks, and of the large crowd gazing up at the spectacle. And then this later European visualization of Chinese pyrotechnics that so impressed the west.

In their search for controlled ignition and explosion, Chinese alchemists had invented gunpowder as early as the 9th century and while, as Needham notes, they were looking for elixirs of life, soon gunpowder's main use was to make deadly weapons deadlier.



A key strand running through Chinese science, Needham says, is on "action at a distance," and gunpowder certainly enabled lethality at ever-increasing ranges.

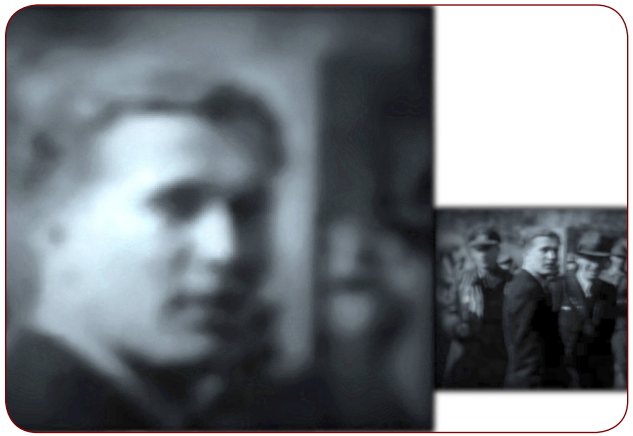
For example, here you find the first instance of a multistage rocket — a strange-looking affair, with booster rockets that first propel the thing over the span of its range and then set off smaller rocket-arrows, which shoot out of the dragon mouth to rain down on enemy forces below.

...

Now it's a long way from Imperial China back up to modern rocketry, and the route goes by way of Nazi Germany…

[graphic symbol of swastika]

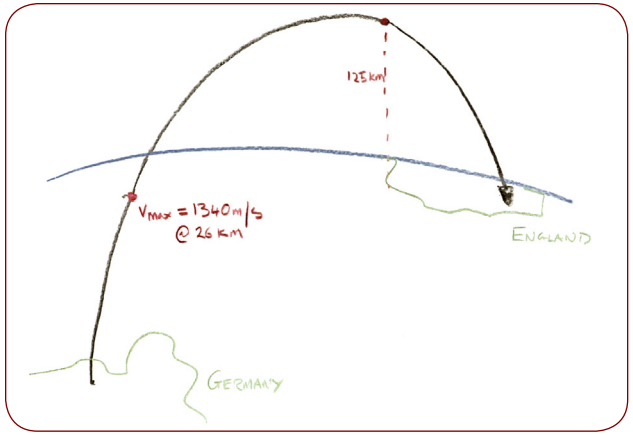
(Silent archival clip of Von Braun watching V2 launch)



That insolent face belongs to Wernher von Braun, the silent and superfluous "h" in Wernher marking him as an aristocrat, a rarity among rocket enthusiasts, not to mention Nazis.

With his life quest for rocketry already begun at an early age, and soon to result in the V2 rocket, Von Braun can take his place in our gallery of brilliant young minds alongside Van Allen and the idealistic kamikaze pilots.

He's a unique figure, this famous fellow, but his name also serves as shorthand for the others around him, like Walter Dornberger, above him here as his military superior and long-time collaborator; Hermann Oberth as a key but by now receding influence; and under Von Braun this whole team of scientists and engineers,all contributing their designs and ideas to the V2 program.



But why rockets for the Nazis?— rockets, rather than proximity fuse bombs or atomic weapons, both within their theoretical grasp? (Though actually they'd already shot themselves in the foot.. Rejecting so-called "Jewish physics," the Nazis had scared the best scientific minds of Europe across the Atlantic to America.)

Regardless, though,the Nazis had a special place in their hearts for rockets. They knew that spectacles in the sky could exercise a peculiar power over crowds, as in this so-called cathedral of light at a Nazi rally in Nuremberg. And they had used gigantic German zeppelins— big as the Titanic — to command the world's attention, with flights over the Olympics they'd staged in Berlin and in journeys over the Atlantic, where it's astonishing to realize that a swastika once flew over New York, that most Jewish of American cities.

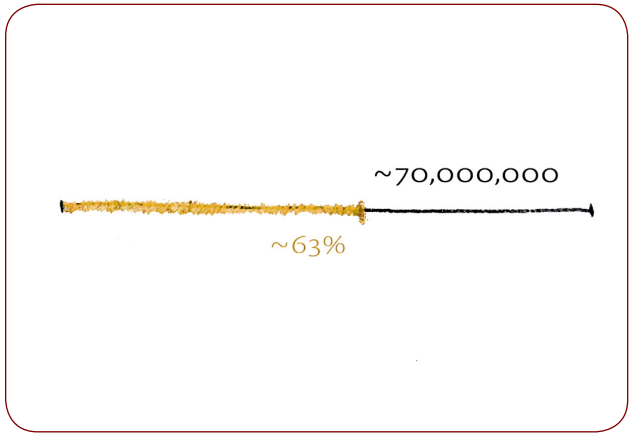
The Hindenburg explosion was a more spectacular aerial spectacle than any seen before, especially since, when broadcast, it electrified the entire world. A tragic disaster, though for some New Yorkers cause for grim satisfaction at seeing Nazi power punctured.

With rockets, of course, such an explosion could be turned into a terrifying attack —imagine the Hindenburg not as a fat zeppelin but as sleek rocket, blowing up not by accident in New Jersey but on target in Manhattan —or at least in London, where Von Braun's V2 did eventually reach.

V2

The V2 was a brilliant piece of German engineering. At blast off, it would fire intensely for just over a minute and then sail into space at supersonic speed,

its momentum arcing it over the earth till it re-entered the atmosphere again to plummet down onto its target.



The V2's guidance system was still very crude: the thing could only be aimed roughly — shot off in the general direction of London or Antwerp to fall where it may, much more likely to hit innocent civilians than legitimate military targets.

What President Harry Truman said after the war about the atom bomb

> You have got to understand that this is not a military weapon... It is used to wipe out women and children and unarmed people, not for military uses.

was already true of the V2 before that, but also true of the deadly fire storms ignited by allied bombings of Hamburg, Dresden, and Tokyo.

War was now aimed at much larger targets — not just enemy armies but entire enemy populations. Out of a total of 70 million people killed in the war (give or take 10 or so million) more than half were civilians.

Traveling faster than sound, the randomness of the V2 rocket was terrifying — its explosion came sooner than the sound of its flight.

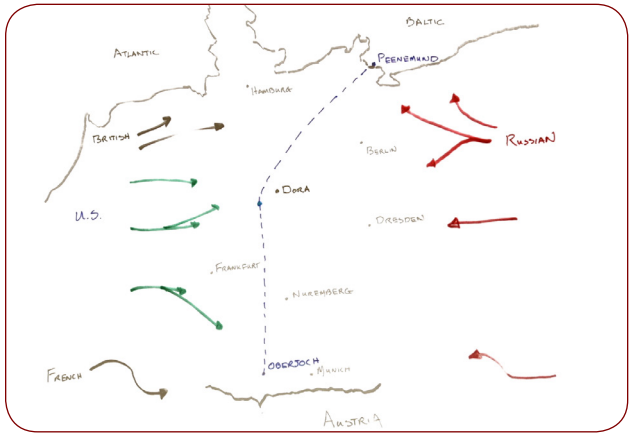
...

These images of a V2 bombing in London are from an English genealogy website where they're accompanied by this caption and by this note, which singles out three individuals who would otherwise go anonymous among facts and figures like these:

On average,the V2 rocket killed only two people. But in all, its toll reached approximately 21,000 people. Of these, a minority of 9,000 were the intended victims in the targeted cities. The majority of those killed were the workers manufacturing it, a first in the history of warfare.

These remaining 12,000 deaths are of slave laborers taken from Nazi concentration camps and put to work in the deep tunnels of the Dora-Mittelbau complex, where under unimaginably unbearable conditions, many died of starvation, exposure, illness,and direct abuse. Meanwhile the V2 had done nothing to slow Germany's defeat.

Von Braun and the V2 engineers had long been based up here, in Peenemunde, up on the Baltic coast, even after British bombings had forced



the relocation of their V2 factory, to Dora Mittelbau, here, in the middle of the country.

Now, with defeat approaching, von Braun, Domberger, and the others bet the Americans were their best chance for the future, not that they were fully in control of their own fates yet.

With the Russian army closing in from the east, and the British French and US armies from the west — the V2 team was ordered to shift their operations to a spot a little southwest of Dora.

Then, just as American forces were about to overrun even this area, the team was evacuated again —by sheer luck ordered to find refuge in the mountains near Austria, where they found themselves in the little resort town of Oberjoch, near what was then still called Adolph Hitler Pass.

Though their own homeland of Germany now lay in complete and utter ruin,the rocketeers themselves were in weirdly high spirits.

Here's how Dornberger recalled that interlude later:

> We are proud of our technical achievements. In those days of quiet meditation at Oberjoch, when I recalled the times in which we were developing the long-range A-4 rocket and let all the discoveries, images, and impressions of the years from 1930 to 1945 unfold again in my mind's eye, I was filled with boundless happiness and gratitude.

(Clips of Von Braun as captive of American military intelligence)

Von Braun's expression confirms Dornberger's account: here he is, shortly after turning himself into the Americans, who for their part were delighted that these prize German rocketeers had just fallen into their laps.

Though Von Braun's arm is in a cast from an earlier car accident, as you can see he and everyone around him here are all smiles…

[juxapose Von Braun clip with US Army footage of Dora rescue]

though they weren't here at Dora-Nordhausen, three weeks earlier, when the surviving V2 slave laborers (what few of them remained)were finally borne away on stretchers by the shocked GI's who'd found them...

White Sands

The atom bomb, soon to be dropped to devastating effect on two cities in Japan, quickly ending the war, was first tested just three weeks earlier, at a site in the desert code-named Trinity.

This was on a vast military zone that's now known as the White Sands Missile Range, which is in the state of New Mexico.

The Mexican border is just to the south, which an errant missile was later to cross, gouging a big but harmless crater on Mexican soil. The town of Truth or Consequences is to the west, at that time called Hot Springs but renamed in the 1950s for a quiz show contest.

Roswell, New Mexico, is to the east, notorious site for UFO conspiracy theorists, probably because it was a place of strange sightings and odd debris, starting in the 1930s with the early rocket experiments of Robert Goddard, seen here, whose pioneering designs had been taken up much

more avidly by German enthusiasts like Von Braun overseas than by any American followers closer by.

Look to the north, and above Albuquerque, and just above Santa Fe, is Los Alamos, the top-secret atomic lab, set atop a remote mesa,that gave birth to the Bomb.

...

You can hover over the present Trinity site with commercial satellite views as you can over this site here about 90 miles south, where earth views of this sort were captured for the first time ever, as we'll see.

It's to this remote desert region that in 1946 the Americans set up shop with Von Braun and his German team, jump-starting the US rocket program with scavenged V2 rockets and German brains.

It's here, in fact, that Van Allen first encountered Von Braun, the two men, so different in background and character, who were soon to share in the early triumphs of the American space race.

Nazi member #5,738,692
(1937)

SS rank: Sturmbannführer
(major; 1943)

Professor von Braun
(1942)

Bad equations

In math, minus one times minus *one equals plus one*. And in grammar, a double negative makes a positive

not bad = good

Which is all perfectly logical, but the logic can be twisted easily for example in the saying: T*he enemy of my enemy is my friend*

— an idea that took firm root in America's Cold War policy, starting early on with the odd elevation of Von Braun from Nazi villain to American pop culture hero. Having whisked the Nazi scientist into the country, the US also "bleached" his record, so that it was well into the 1950s before anyone knew Von Braun's membership number in the Nazi party

V2 team in America
Fort Bliss, Texas

or his ultimate rank in the SS or even the fact that his preferred title of"Professor" was bestowed upon him not by the trustees of any university but by the whim of his Fuhrer, Adolf Hitler…

No doubt the records of many of his colleagues, assembled for this portrait on American soil, were also bleached.

But even as the records of these recent enemies were being whitewashed, the records for some great Americans were being compiled —

the flip side of the same dubious logic being: *If you aren't with us, you're against us.*

And so, for example, the physicist who successfully led the creation of America's atom bomb, Dr. Robert Oppenheimer, now fell under FBI suspicion of being a commie: here, incredibly, because he expressed his misgivings about thermonuclear warfare to high government officials.

The FBI also built up its suspicions of Norbert Wiener, who was making persuasive (and prescient) arguments against the thick layers of government secrecy that were starting to choke off the otherwise accelerating exchange of scientific ideas.

And so two Americans who'd helped their country prevail in the war just ended now fell now under clouds of suspicion

— for in the crazy calculations of the Cold War, down could be up and up could be down.

Aims

Even with the loftiest of aims, scientists can end up making bargains with the devil; their curiosity gets the best of them.

One such scientist was Erich Regener, the leading German figure in pre-war atmospheric physics.

In 1936, with the Nazis having risen to power three years earlier and having instituted their"aryanization" of German society, Regener stood up to them by refusing to recant "Jewish physics"and by not divorcing his Jewish wife,which led the Nazis to strip him of his professorship.

And yet, there he was, just a few years later, designing instrumentation for the V2 rocket, which promised to carry his experiments so much higher than his usual test balloons could.

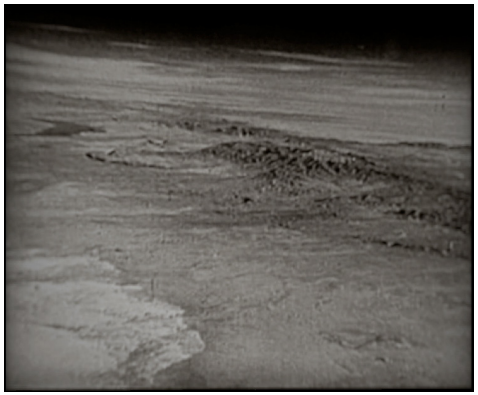
His Regener-Tonne packed advanced instruments into the tip of the V2, where it was to be ejected and parachuted down from far up in the sky.

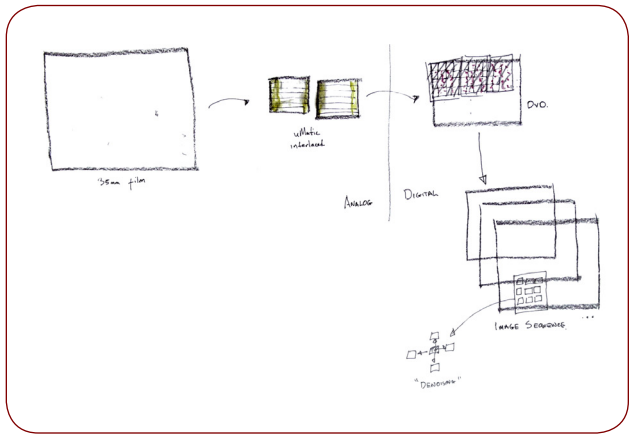
Though German defeat cut this effort short, Regener's data would have answered many important scientific questions — but also many practical questions for intercontinental rocketry.

Such was still the case after the war for the Americans, which is what brought Van Allen to White Sands in 1946 to work on the V2s. He now headed the High Altitude Research Group of the Advanced Physics Lab, APL, which had originally been created for perfecting the proximity fuse.

No longer a naval officer, Van Allen had turned from weapon design back to his real love, pure science, though as in Regener's case the split can never be clean.

In White Sands, Van Allen drew on his powers of patience and perseverance, much needed for these troublesome V2 launches which often blew up in mid-air or crashed so hard as to scatter or destroy all instruments.





Eventually he and other scientists managed the practical rather than theoretical work of ruggedizing their instruments (as he'd done before for the proximity fuse).

His group was then able to retrieve a stunning film of take-off which gave the first glimpse of the earth from space.

(archival footage of V2 film of earth as it blasts off from White Sands)

...

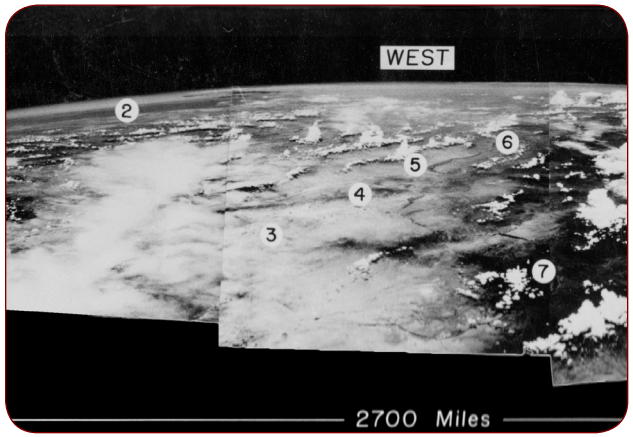
It's fascinating to see how this key cultural artifact has suffered in its translation from the analog age to the digital:

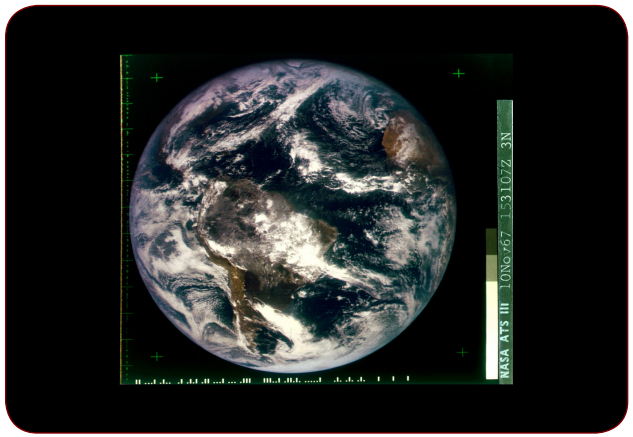
From the stills of the original 35mm film,which has the equivalent digital resolution of something like 10 to 15 million pixels,the data was once converted to three-quarter-inch U-matic videotape, an unstable magnetic medium, which interlaced each frame over a mere 250 horizontal lines, thereby reducing the over-all resolution by a ridiculous factor of 20 to 30 times.

Next the movie crossed over from the analog videotape to digital form, here to the lossy block-encoding scheme of DVD compression.

Which is where we came in. Re-encoding the DVD as a series of digital stills, we applied de-noising algorithms in an attempt to reclaim at least a bit of the original 35mm quality.

When we then set the clip into 3D, we increased the apparent resolution of the image, a surprising effect that comes from the fact that we humans favor seeing things with both our eyes rather than as if from just one.





Originally the v2 film was intended mainly for diagnostic use, for judging such things as the spin of the missile.

But it soon captured the imagination of the press and the public, and with its frames stitched together by scissors and paste into a photomontage like this one, showing the curve of the earth, it foreshadowed the famous shot that NASA finally captured in 1967

— which opened our eyes to the fact that this planet of ours is a small, beautiful, and fragile body, floating in space.

Scope of research and production

The *Proximity Fuse* prototype is a rough draft for part 1 of an envisioned three-part documentary. Its bounds are set by the first part of James Van Allen's life — from his childhood in Mount Pleasant through his experiences at the Pacific front in World War Two and at the White Sands Missile Range in the immediate postwar period — as well as by the associations these conjure up, which range as far back in history as 10th century China.

In addition to the completed scenes outlined in the Storyboard, we nearly completed the production of two further scenes — of the creation of the Aerobee rocket (the more reliable and far less expensive successor to the V2) by Van Allen's team at White Sands and of Van Allen's initial return to Iowa, where he invented and deployed the even more ingenious and inexpensive Rockabee balloon/rocket combination.

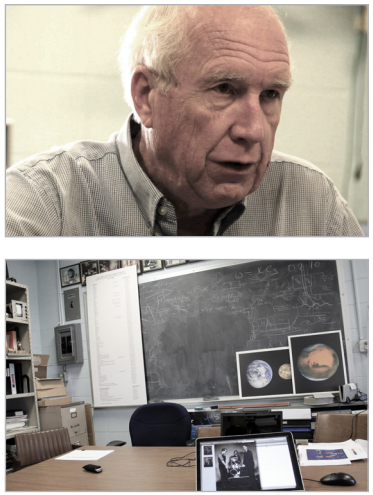
Work activity

Our work on this project was of four kinds.

1. IN IOWA.

In June 2012, accompanied by researcher Rebecca Hersher, we traveled to Iowa, where we:

- Worked in the Special Collections of the University of Iowa archive poring over the paper and audiovisual items in the Van Allen collection. We read and photographed in high resolution every page of Van Allen's notebooks; studied his correspondence as well as related department documents; scanned 100+ photographs, blueprints, schematics, and work diagrams; and arranged for the digitization of several archival films and the reproduction of DVDs and audio tapes.



Donald Gurnett and office

- Traveled to the Figge Art Museum in Davenport to study roughly a dozen artifacts of the Iowa space program (small satellites and scientific instruments), on loan to the museum from the University of Iowa and NASA. We exhaustively photographed several of the artifacts for possible conversion to 3D by means of our spatializing photography method.
- Captured in both photographic and 3D video format the exteriors of Van Allen's boyhood home in Mount Pleasant and of his long-time family residence in Iowa City.
- Filmed (in 2D and 3D) distinctive aspects of the Iowa landscape, including rural highways and farm fields, the town of Mount Pleasant, and an unusual monument for American soldiers fallen in Vietnam — a combat helicopter set off-angle on a pedestal encountered at a rural highway intersection in the middle of the countryside.
- Conducted a two-hour interview with Donald Gurnett, which we recorded three ways: in audio-tape, in high-resolution DSLR video, and with a consumer 3D camera. Dr. Gurnett also shared the visual contents of his laptop with us, including photographs of his lab, scientific instruments, satellite launches, and more. We also continued our conversation with Dr. Gurnett over a long dinner, where he peppered us with as many questions (mainly about artificial intelligence) as we posed to him.

2. IN LIBRARIES, ARCHIVES, AND ONLINE.

This project required a wide range of background research, which we conducted primarily at the University of Chicago and Columbia University. Research topics included the origins of rocketry in ancient China; the nature of the kamikaze program in wartime Japan, including the surprising range of factors influencing it, both eastern and western; the development of the proximity fuse; the creation of the V2 rocket in Nazi Germany and the US appropriation of both the Nazi scientists and rocket parts after the war.

We also sought further visual material, finding some useful photographs, diagrams, and maps in the library books we consulted, but also online, where we also found a number of key archival videos, manuals, and other materials.

Rebecca Hersher conducted further visual research at the National Archive and the US Holocaust Musem in Washington, DC.

3. DEVICE CONSTRUCTION, SOFTWARE PROGRAMMING, AND EXPERIMENTATION.

We devised both the stereoscopic Ethernet camera mount and interface, as well as the 3D capture table; and we developed software both to operate these systems and to author the prototype itself. Both hardware and software aspects allowed us to experiment extensively with novel ways of presenting documentary material in 3D.

4. SCRIPT AND STORYBOARD CREATION, VOICE RECORDING, PRODUCTION, AND DOCUMENTATION.

These resulted in a 41-minute 3D prototype and in this white paper. Our work took place at Downie's studio in Chicago and Kaiser's in New York City; the voice-overs were recorded at Columbia University's Computer Music Center.

Conclusions and Further Plans

Our conception of *Proximity Fuse* expanded as we were drawn into its promise both to re-envision the possibilities of the documentary form and to illuminate the fascinating intersections of two exceptional Iowa scientists — James Van Allen and Donald Gurnett — with world history and with the shifting realities of our still-emerging digital era.

We conclude this report by briefly reflecting on what we accomplished to date, what limitations we encountered, and where we hope to head next.

1. Summary of Accomplishments

The key project goals of *Proximity Fuse* were met as we

- Devised a robust 3D capture table set-up to capture drawing and small objects, worked out methods for inexpensive but high-definition stereoscopic video in the field, and refined a suitable authoring pipeline in our open source software platform *Field*;
- Innovated new visual strategies for presenting documentary content in arresting 3D format;
- Created a 41-minute proof-of-concept, comprising 15 chapters, which serves as a rough draft for the first of three parts of the envisioned *Proximity Fuse* documentary.
- Demonstrated the large range and innovative quality of work that can be carried under conditions that typify most humanities scholarship — that is, by a team and under a budget much smaller than those for even routine documentary projects.

2. Limitations

Given the extent of our ambitions, it comes as no surprise that we did not meet all of them flawlessly.

Given the extent of our ambitions, it comes as no surprise that we did not meet all of them flawlessly.

Much of this is a consequence of our having opted to create a proof-of-concept more than twice as long as we originally proposed. We were unable to gather as much visual material as we would have preferred to create the desired balance and density of elements accompanying the narration, and thus the prototype relies too heavily on information conveyed purely by voice.

It proved surprisingly difficult to obtain high-resolution archival transfers even of federally funded films of high historical value; indeed, we were dismayed at how time-consuming and often either expensive or unproductive it was to go through official channels at the University of Iowa, the National Archives (here hindered by staff cutbacks necessitated by recent federal budget sequestering measures), and the US Holocaust Museum. Even when we were able to obtain such clips, they were usually of a quality no better than that to be found in the disorganized, poorly identified, but vast collection on Google's You Tube website and elsewhere on the Internet.

In the end, we resorted in many cases to using clips we found on the web, judging them to be in the public domain by their likely federal origin but with no certainty on that score. This raises the level of difficulty for rights clearances in the final project.

A key part of our visual strategy was to balance past and present, especially with interludes in which we conjure up a sense of the past in present-day surroundings. In the prototype, we were able to do this only three times — for Iowa farmland, for Van Allen's boyhood town and home, and for the Japanese cherry blossom season (which we happened to have captured concurrently for an entirely separate project).

Ideally budget and logistics would have allowed the capture of equally potent sites — for example, of the White Sands Missile Range in New Mexico, the Dora-Mittelbau V2 factory complex in Germany, and of any one of the numerous kamikaze memorial sites in Japan.

A second limitation was that of personnel. While we remain convinced that most documentary teams are larger than necessary (with roles too specialized and separate), even so we were distinctly understaffed in three areas.

First, it would have been helpful to have been able to afford more research assistance — as it was, we had to make do with the very part-time services of an accomplished researcher, Rebecca Hersher, who out of kindness and curiosity moonlighted in her spare hours from a full-time job as producer at NPR.

Second, the services of part-time sound engineer would have been extremely useful, for while we were able to capture exceptional first-hand visual material in Iowa on our own, we could not do the same with audio recordings, which could have been used to equally telling effect in the prototype.

Third, our budget also didn't cover the services of a good voice artist and we had to make do with Kaiser's inexpert voice renditions. Since the editing of the work relies on a precise counterpoint between word and image, this means that if and when we obtain further funding and are able to record a much better voice-over, we'll also have to revise our edit.

3 Next steps and opportunities

As a continuing project, *Proximity Fuse* still has much to offer — much new ground to uncover in the continuing intersections of Van Allen and Gurnett with the larger world; and many further advances to make in widening the visual and conceptual possibilities for presenting documentary material.

Parts 2 and 3 of *Proximity Fuse* would delve into extraordinarily rich material. To give a few snapshots of what would be in store:

- the surprise launch of the Soviet *Sputnik* satellite, which happened to catch Van Allen conducting scientific research on a Navy ship at sea, where he confirmed the reality of Sputnik's orbit by measuring the Doppler shift of the satellite's radio transmitter relative to his position in the Atlantic.
- Van Allen's key role in collaborating with von Braun to create the successful Explorer 1 satellite, which rescued the US from the humiliation of the very public failure of its first attempt to match Sputnik with Jupiter C.
- after the very public humiliation of the US by the spectacular failure of its Vanguard launch to match Sputnik, the successful launch of Van Allen's Explorer spacecraft propelled by a Redstone rocket that von Braun had championed.
- Van Allen's subsequent discovery of the radiation belt that now bears his name, with the national recognition that followed: his face on the cover of Time magazine and the first of many times he was interviewed by Walter Cronkite on CBS.
- the odd misadventure codenamed "Starfish Prime," in which Van Allen helped the military explode a hydrogen bomb in space to create an artificial extension of the Van Allen belts, evidently with the hope of weaponizing it (in Honolulu, hotels held "Rainbow Bomb Parties" on their rooftops for what was surely the most spectacular and bizarre fireworks show in history).
- Van Allen's scientific exchanges with his Cold War Soviet counterparts, traveling to Moscow to share whatever data their respective governments will allow and then initiating a return visit to Iowa City; he was approached in turn by the CIA and the KGB for secret disclosures.
- the extraordinarily active center that Van Allen created in Iowa City, which not only launched the careers of many protégés,

but even served as the main tracking base for many NASA satellites launched in the 1970s.

- Van Allen's continuing design of cosmic ray detectors, incorporated in the 1970s into Mariner rocket missions, the first of which is now back as headline news as penetrates the very edge of the solar system, its transmitted data causing excited puzzlement and new speculation among astrophysicists.
- the first implementation of digital interplanetary transmission by Van Allen protégé Donald Gurnett — the very transmission system that is currently relaying this data back from the edge of the solar system.
- Gurnett's recordings of the strange sounds of space, which then form the basis for a musical collaboration with avant-garde composer Terry Riley and the Kronos Quartet.

So, no lack of compelling material, with many surprising links to be made to historical and contemporary developments.

What's more, all this material would give us ample opportunity to explore expanded visual techniques — methods of advanced data visualization that we can bring to bear on the very beginnings of the digital era.

It's here that we can apply ideas and techniques that we explored in 2011 for a research project entitled *The Interaction of Large Data-Sets*, which was funded by the National Science Foundation (EAGER grant IIS-1048440) and conducted with data scientists at the Rensselaer Polytechnic Institute.

Acknowledgments

We are grateful to NEH chairman **James Leach** for drawing our attention to the unexpectedly prominent role Iowa played in space exploration and for supporting our project even as it grew in size and ambition.

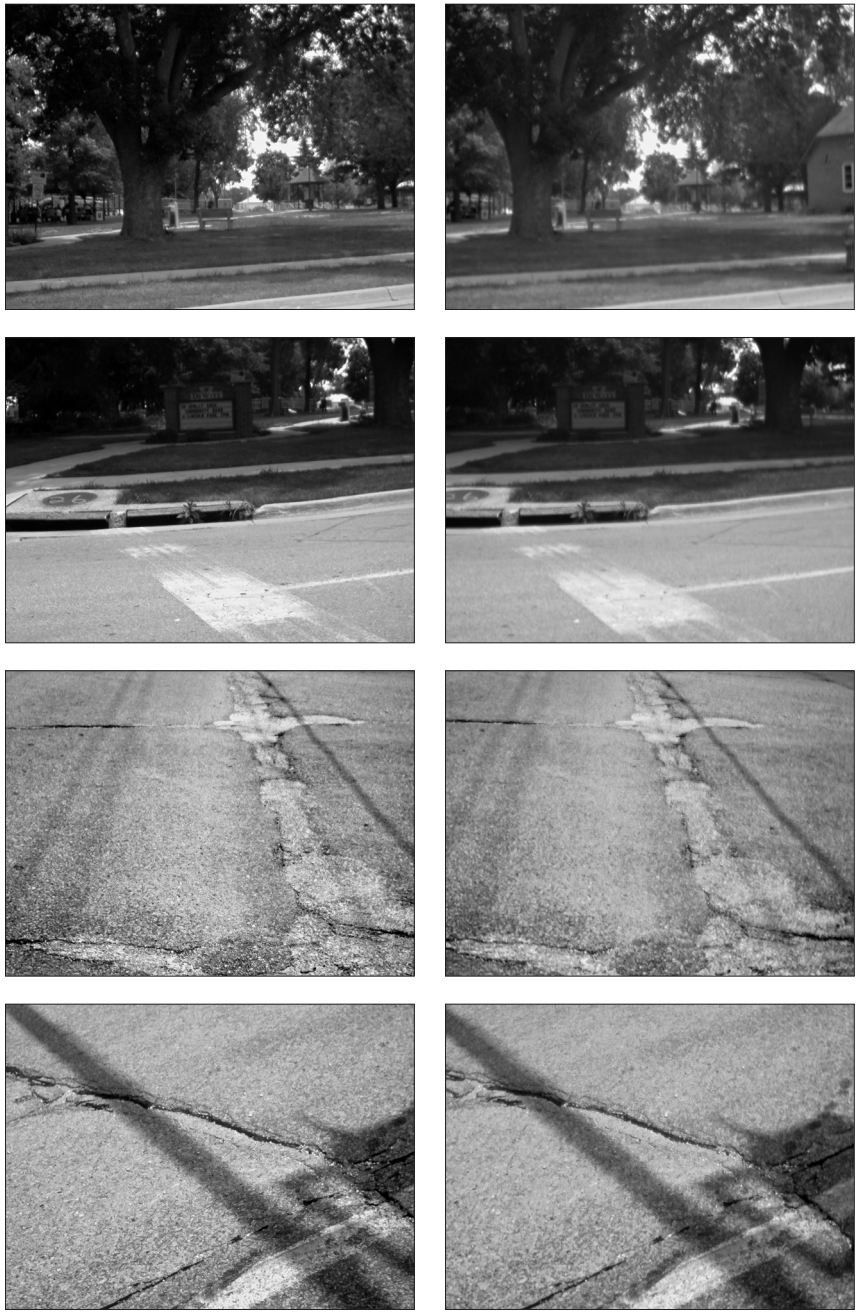
Gil Weinberg of the Georgia Institute of Technology was extraordinarily generous in making a special arrangement to run the NEH grant through his not-for-profit university to us (who, though demonstrably unprofitable, did not meet the tax exempt requirement for this federal grant).

In Iowa City, **James Gurnett** gave generously of his time and knowledge, first in a long interview in his office and later over a wonderfully convivial dinner. Much of our work in Iowa was spent digging into the Van Allen Archives, where University Archivist **David McCartney** gave invaluable assistance. At the Figge Art Museum in Davenport, Iowa, **Andrew Wallace** gave us special access to Iowa space artifacts that had barely been uncrated for a forthcoming exhibition.

For research assistance, no one could have worked more perceptively or quickly than **Rebecca Hersher**, who traveled with us to Iowa and who conducted further research at the National Archives and the Holocaust Museum in Washington DC.

Our long-time collaborator **Terence Pender** of Columbia University's Computer Music Center skillfully performed the thankless job of recording and somehow improving Kaiser's inexpert voice-over narration.

And we are always grateful to our wives, **Alison James** and **Kathryn Kaiser** — in this case especially so for the access they provided not only to decent health care coverage but also to the indispensible research libraries at the University of Chicago and Columbia University.



All Sides of the Road derives from a twelve-minute 3D video capture of Old Highway 101 entering and departing Dewitt, Iowa. After the title image, the cameras are pointed directly down at the highway, which becomes a rushing microcosm of the world that evokes landscapes both of America and of the mind. The resulting spectacle is both utterly photorealistic and phantasmagoric.

In addition to landscape, this digital film also evokes earlier forms of analog film, especially those of the American avant-garde, for the physical properties of the highway resemble those of celluloid. In motion, the textures of asphalt and concrete look a lot like film grain, while the lane markers flickering by are easily mistaken for the lines and letterings on film leader rushing through the projector gate.

The film is framed by this short introductory text: *No hitchhikers on the road anymore. No stories, or silence, between strangers.* It premiered at the 2012 Rome Film Festival.

The development of Field began in 2001 when Downie was a doctoral student at MIT's Media Lab. The code-base he began developing played a key role in interdisciplinary research that combined work in animation, biology, computer science, and robotics. To this day, it represents a platform that has pioneered what is becoming an increasingly mainstream approach to the problems of working with computers — an emphatically real-time, live-coding, exploratory and visual approach to programming.

Following graduation, Downie continued to develop this codebase as a member of the OpenEndedGroup, a digital artists' collective that creates large interdisciplinary artworks drawing upon such fields as dance, music, data-mining, lighting design, live cinema, artificial intelligence, and public art.

For NSF-funded work at Arizona State University, Downie reoriented his codebase to enable the convergence of dance, interaction, live motion capture and analysis, and live digital imagery. The newly organized code, now given its present name of Field, allowed the visual artists to iterate as rapidly with their imagery as their collaborator, choreographer Trisha Brown, could do with her dancers.

In 2007, Field became an open-source project with seed funding provided by the Mellon Foundation. This was to support the *Loops Preservation Project*, which innovated ways to preserve both choreographer Merce Cunningham's signature solo dance *Loops* as well as the advanced digital artwork deriving from it, also entitled *Loops*.

In 2008, Downie published an overview of the software in *Field—a new environment for making digital art* (ACM Computers in Entertainment, vol. 1, issue 4).

While initially centered in creative digital arts, Field and the approaches it embodies have increasingly made inroads in other disciplines.

In 2009-10, Field received related support from two further sources. Portland Green Cultural Projects (with funding from the UK Arts Council) underwrote the development of the *Choreographic Language Agent*, a tool for experimental choreography, the creation of which led to a further refinement of Field — the addition of a multi-modal interface to accommodate expert and novice users.

More recently this work has continued in collaboration with the UK's Arts and Humanities Research Council, the Wellcome trust and Aberdeen University's Anthropology Department culminating in a forthcoming "public performance" of an autonomous, Field-based, Choreographic Agent in the Wellcome museum in fall 2013.

Simultaneously, Field was the basis for Downie and Kaiser's work for an NEH Digital Humanities startup grant — *Spatializing Photographic Archives*. Here their toolchain was developed to produce 3-dimensional models of real physical locations from unstructured collections of photographs was packaged and open-sourced. This allowed, perhaps for the first time, researchers practical and independent access to these sophisticated computer vision algorithms.

In the same period, EMPAC (Experimental Media and Performing Arts Center) of Rensselaer Polytechnic Institute provided indirect support for several extensions to Field, most notably the addition of music analysis and high-definition 3D — the latter especially useful for visualization, which is made far more powerful by the addition of depth and the enlargement of scale.

This work was joined by seed funding from the NSF's Human Centered Computing program to build Field out into a full scale platform for interdisciplinary, exploratory visualizations in the sciences.