Helping Engineers and Scientists Avoid PowerPoint Phluff

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Abstract—Dr. Edward Tufte has published an essay on *The Cognitive Style of PowerPoint*, [1] in which he blames PowerPoint's ready-made templates for astonishingly thin, nearly content-free briefings. Such slideware, he says, helps speakers to replace serious analysis with chart junk, over-produced layouts, cheerleader logotypes and branding, and corny clip art. He has coined the phrase PowerPoint Phluff to describe this phenomenon.

Dr. Tufte writes about what ***not*** to do and provides suggestions on giving PowerPoint-free presentations. And in the postscript to his essay, he states "I can recommend three books on how to present visual evidence!"—no doubt referring to the Tufte-authored: *The Visual Display of Quantitative Information,* [2] *Envisioning Information,* [3] and *Visual Explanations: Images and Quantities, Evidence and Narrative.* [4] As an admirer of Dr. Tufte and someone who agrees with much of his essay, I propose to suggest some ways to improve PowerPoint presentations for engineers and scientists.[1][2]

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1. INTRODUCTION

The problem of PowerPoint Phluff arises, in part, because PowerPoint was designed by computer programmers with apparently little or no input from graphic designers. And most engineers and scientists who use PowerPoint lack graphics training—a bad combination. Let us explore our problem.

First, the default PowerPoint template uses disproportionately large type sizes for both titles and first-level bulleted items. Why should the title blast you out of your seat, while the bulleted and sub-bulleted ***content*** fades away in ever-diminishing size? Only about one-third of the available space is used to show unique content. Next, many of the design templates employ overwhelming backgrounds, too many kinds of bullets, and ineffective or garish color combinations—demonstrating a real lack of good presentation design. In addition, slides by their very nature force tabular statistical data to be broken into many slides, thereby making comparisons of data difficult and discussion clumsy. And last, we are locked into the slideware's computer-projected format. Rarely do I see a presentation consisting of separate segments of narrative and slideshow, accompanied by detailed handouts to guide discussion.

Engineering problems are complex and cannot always be accommodated with simple PowerPoint slides. For example, comparing competing infrared sensors for a reconnaissance satellite system requires analysis and evaluation of complex systems such as power, vibration damping, control, thermal protection, and data transmission. Such a comparison requires materials tailored to the subject that have high data content, accompanied by painstakingly detailed discussions. Rather than being locked into using a specified format, we scientists and engineers should use the tools most appropriate—whether tables, graphs, text, photos, and/or video—to effectively deliver a meaningful, convincing message.

This paper will address the critical topics that Dr. Tufte presents in his essay (e.g., clip art, logotypes, chart junk) and show before and after examples of each problem. The needs of differing audiences will be discussed (e.g., engineers, scientists, managers) and approaches presented to better communicate with them. In addition to the content of presentations, this paper will illustrate some techniques helpful in designing visuals to convey the message.

2. POWERPOINT AND STATISTICAL EVIDENCE

Using data from *The Lancet*, [5] Dr. Tufte presents a table of estimates of relative survival rates by cancer type. He then applies PowerPoint templates for statistical graphics to the tabular data to produce the six analytical disasters appearing on page 17 of his essay. [1] In contrast to Dr. Tufte's approach, I suggest using the same data to produce four bar

[1] 0-7803-8870-4/05/$20.00© 2005 IEEE
[2] IEEEAC paper #1427, Version 1, Updated October 27, 2004

charts (Figure 1 provides a sample) to present the 24 cancers and the 96 survival rate numbers ***and*** show both the visual relationship of one cancer to another ***and*** how the numbers change for 5-, 10-, 15-, and 20-year survival rates. In this way the audience can quickly grasp the trends over time and still have the individual numbers for comparison.

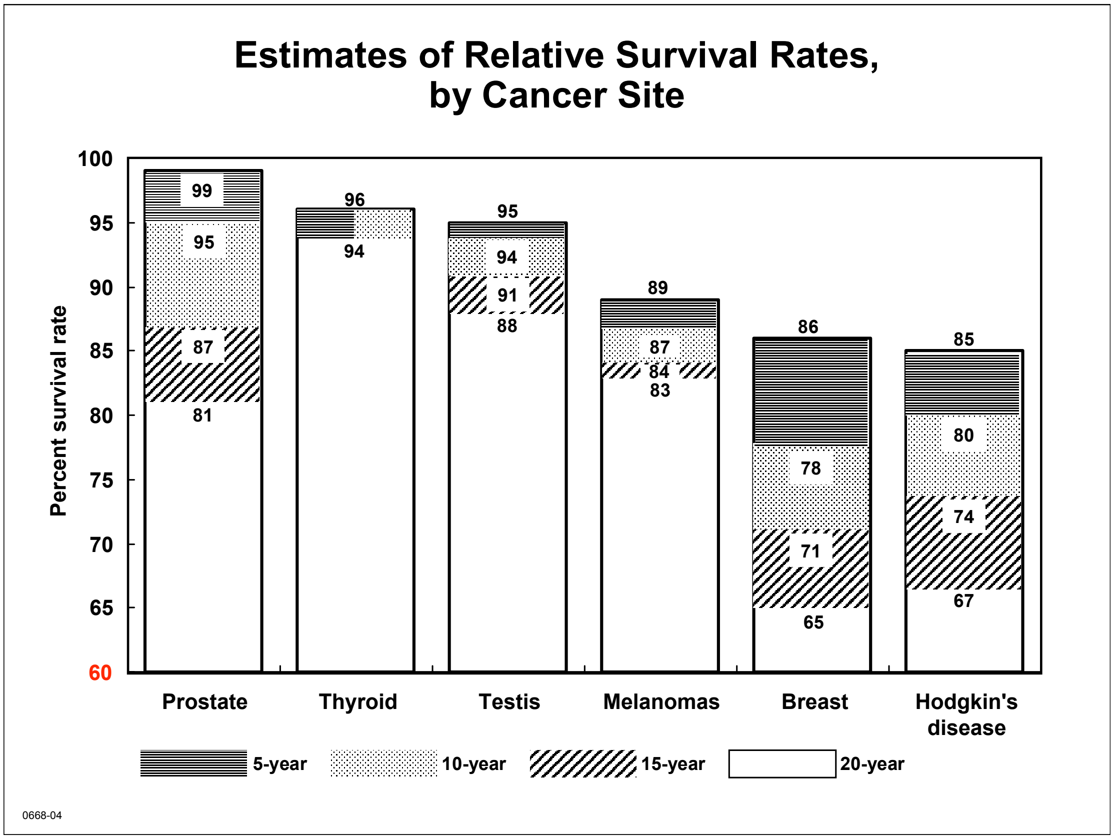

Figure 1 - Sample Cancer Bar Chart

This portion of the slide presentation would be followed by a dual-screen projection (Figure 2) of the table, with 12 cancers on each of the two charts. The presenter could highlight the trends with the four visual charts and lead a discussion of the cancer data in the original table, which has an excellent comparative structure, and reports standard errors.

3. THE *CHALLENGER* DISASTER

On January 28, 1986, space shuttle 51L—*Challenger*—exploded 73 seconds after liftoff. Extremely low ambient temperature at launch had caused two rubber O-rings to leak, allowing hot gasses to escape from the aft field joint on the right solid rocket motor and strike the external tank, resulting in a catastrophic explosion. The subsequent investigation, conducted and documented [6] by representatives from the fields of engineering, management, sociology, and statistics, delved into possible causes: inconclusive tests or misreading of test results; qualification by similarity to the successful Titan IIIC field joints; failure to communicate, extreme political and media pressure, or groupthink; NASA's culture and bureaucracy; and risk management and simulation.

In *Visual Explanations*, [4] Dr. Edward Tufte provides a comprehensive analysis of the attempts by Morton Thiokol engineers and managers to convince their NASA counterparts to delay the launch because of temperature concerns related to the O-rings. Figure 3 is a reproduction of the title chart faxed by Morton Thiokol to NASA's Goddard Space Flight Center the night before the Challenger launch. Dr. Tufte criticizes this chart because it does not identify the authors' names or positions (the minimum amount of data that should have been provided is noted). As originally sent, the audience knows nothing about the author(s). Authors should provide the information listed as a courtesy, to establish credibility and to show who is accountable. Although it can be argued that personnel at Marshall Space Flight Center knew who prepared the data, it would have been useful for the presidential commission, led by former Secretary of State William R. Rogers, to have that documented.

Estimates of Relative Survival Rates, by Cancer Site

% survival rates and their standard errors

Cancer	5-year	10-year	15-year	20-year
Prostate	98.8 0.4	95.2 0.9	87.1 1.7	81.1 3.0
Thyroid	96.0 0.8	95.8 1.2	94.0 1.6	95.4 2.1
Testis	94.7 1.1	94.0 1.3	91.1 1.8	88.2 2.3
Melanomas	89.0 0.8	86.7 1.1	83.5 1.5	82.8 1.9
Breast	86.4 0.4	78.3 0.6	71.3 0.7	65.0 1.0
Hodgkin's disease	85.1 1.7	79.8 2.0	73.8 2.4	67.1 2.8
Corpus uteri, uterus	84.3 1.0	83.2 1.3	80.8 1.7	79.2 2.0
Urinary, bladder	82.1 1.0	76.2 1.4	70.3 1.9	67.9 2.4
Cervix, uteri	70.5 1.6	64.1 1.8	62.8 2.1	60.0 2.4
Larynx	68.8 2.1	56.7 2.5	45.8 2.8	37.8 3.1
Rectum	62.6 1.2	55.2 1.4	51.8 1.8	49.2 2.3
Kidney, renal pelvis	61.8 1.3	54.4 1.6	49.8 2.0	47.3 2.6

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Estimates of Relative Survival Rates, by Cancer Site – continued

% survival rates and their standard errors

Cancer	5-year	10-year	15-year	20-year
Colon	61.7 0.8	55.4 1.0	53.9 1.2	52.3 1.6
Non-Hodgkin's	57.8 1.0	46.3 1.2	38.3 1.4	34.3 1.7
Oral cavity, pharynx	56.7 1.3	44.2 1.4	37.5 1.6	33.0 1.8
Ovary	55.0 1.3	49.3 1.6	49.9 1.9	49.6 2.4
Leukemia	42.5 1.2	32.4 1.3	29.7 1.5	26.2 1.7
Brain, nervous system	32.0 1.4	29.2 1.5	27.6 1.6	26.1 1.9
Multiple myeloma	29.5 1.6	12.7 1.5	7.0 1.3	4.8 1.5
Stomach	23.8 1.3	19.4 1.4	19.0 1.7	14.9 1.9
Lung and bronchus	15.0 0.4	10.6 0.4	8.1 0.4	6.5 0.4
Esophagus	14.2 1.4	7.9 1.3	7.7 1.6	5.4 2.0
Liver, bile duct	7.5 1.1	5.8 1.2	6.3 1.5	7.6 2.0
Pancreas	4.0 0.5	3.0 1.5	2.7 0.6	2.7 0.8

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Reprinted with permission from Elsevier (**The Lancet**, 12 October 2002, 360, pages 1131-1135) [5].

Figure 2 - Dual Screen Technique Showing 12 Cancers on Each

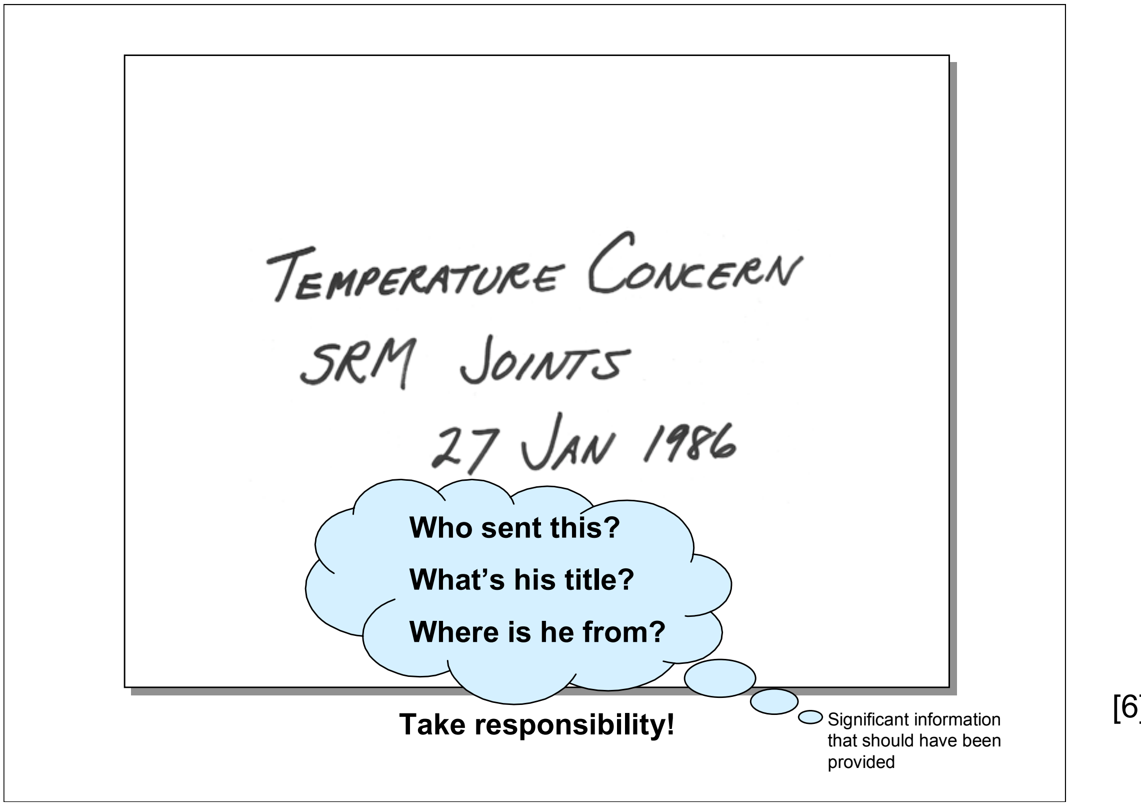

Figure 3 - The Thiokol Chart [6]—Who? What? Where? Take Responsibility!

Dr. Tufte goes on to show two more charts prepared for the Rogers commission. Focusing on the second chart (Figure 4), we see that it had no code (the code was on the first chart, not shown here) that portrayed results from tests of five development motors and four qualification motors. He accurately calls this *the disappearing legend*, points out the *chart jun*k of the 48 "cute" rocket motor outlines that clutter the visual image, *lack of clarity* in depicting cause and effect by turning the temperatures numbers sideways, and finally, the *wrong order* in which the data was sequenced (by launch date, which hides the relationship between temperature and O-ring damage).

Figure 5 was prepared after the *Challenger* explosion and published in the commission's report. It is incomplete. It shows only the seven launches with O-ring damage and the ambient temperature; it does not show the 17 damage-free launches and temperatures. Figure 6 shows the *Visual Explanations* [4] chart, redrawn in color to highlight the seven launches with significant O-ring damage, to emphasize the 26–29 F temperature forecast for the *Challenger* launch, to show Thiokol's recommended mimimum launch temperature (53) vs. the contractual requirement (40ºF), and to include one launch at 80ºF that was not shown on Dr. Tufte's original.

Had Thiokol's charts juxtaposed temperature and O-ring damage in elementary, two-variable plots, they would have demonstrated the causal connection. Such a juxtaposition would have shown that in the 24 flights before *Challenger*, the temperature was 66ºF or above for 20 of them, and of these 20 flights there were problems with field-joint O-rings in only three. In contrast, there were O-ring problems in all four of the flights launched when temperatures were below 63ºF. Moreover, the predicted launch temperature of 26–29 F for the *Challenger* was 3.6 standard deviations below the average launch temperature of 68.4ºF. [7] Armed with this information, NASA and Thiokol engineers would have known that the launch would be far outside previous shuttle experience and therefore very risky. Presentation of accurate data is most important when human life is involved.

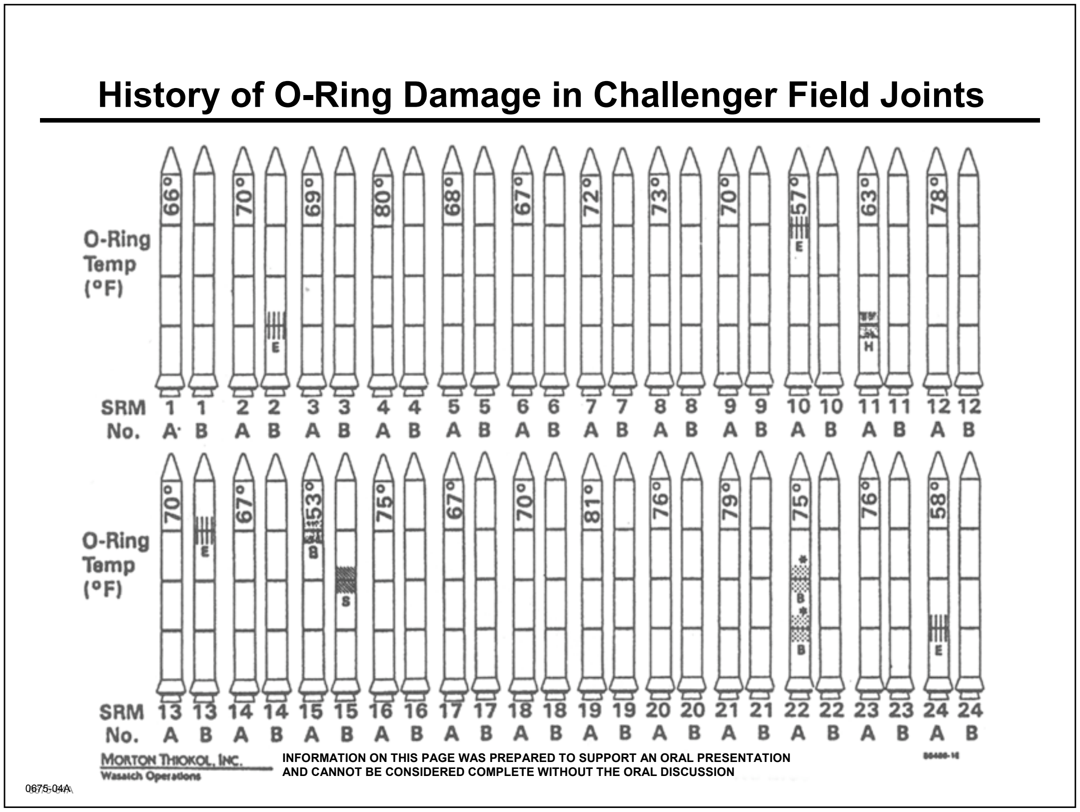

Figure 4 - The Cute Little Rockets [6]

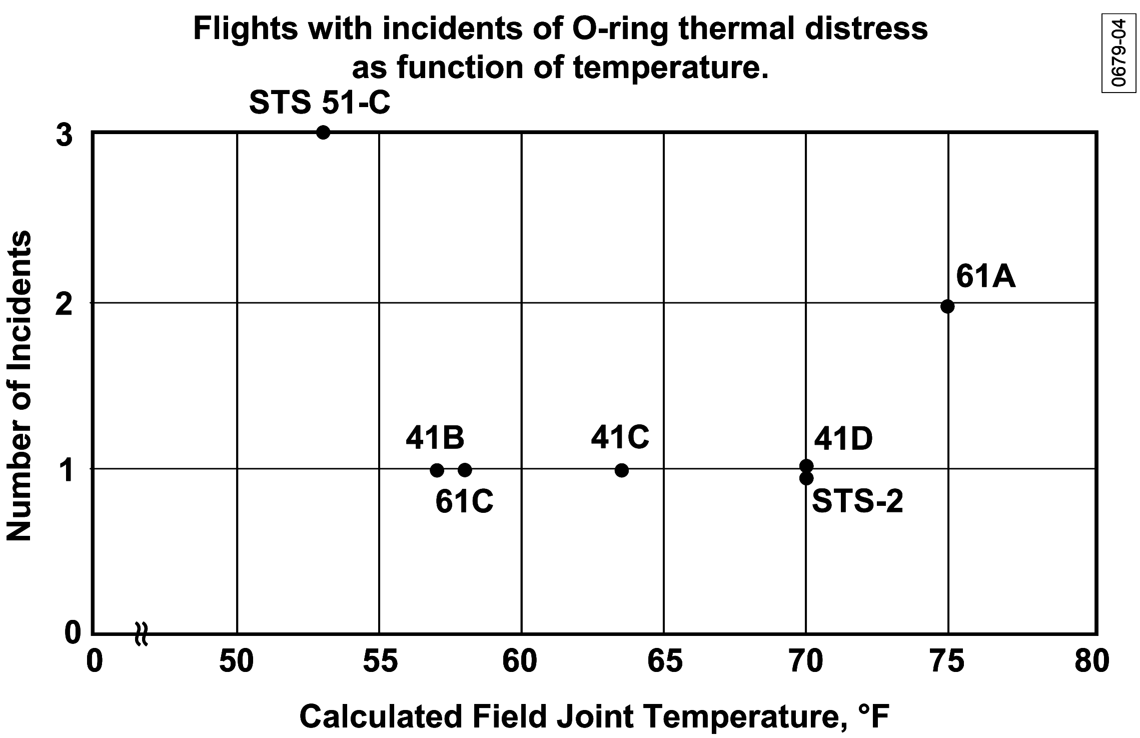

Figure 5 - Incomplete Chart Published in the Challenger Accident Commission's Report [6]

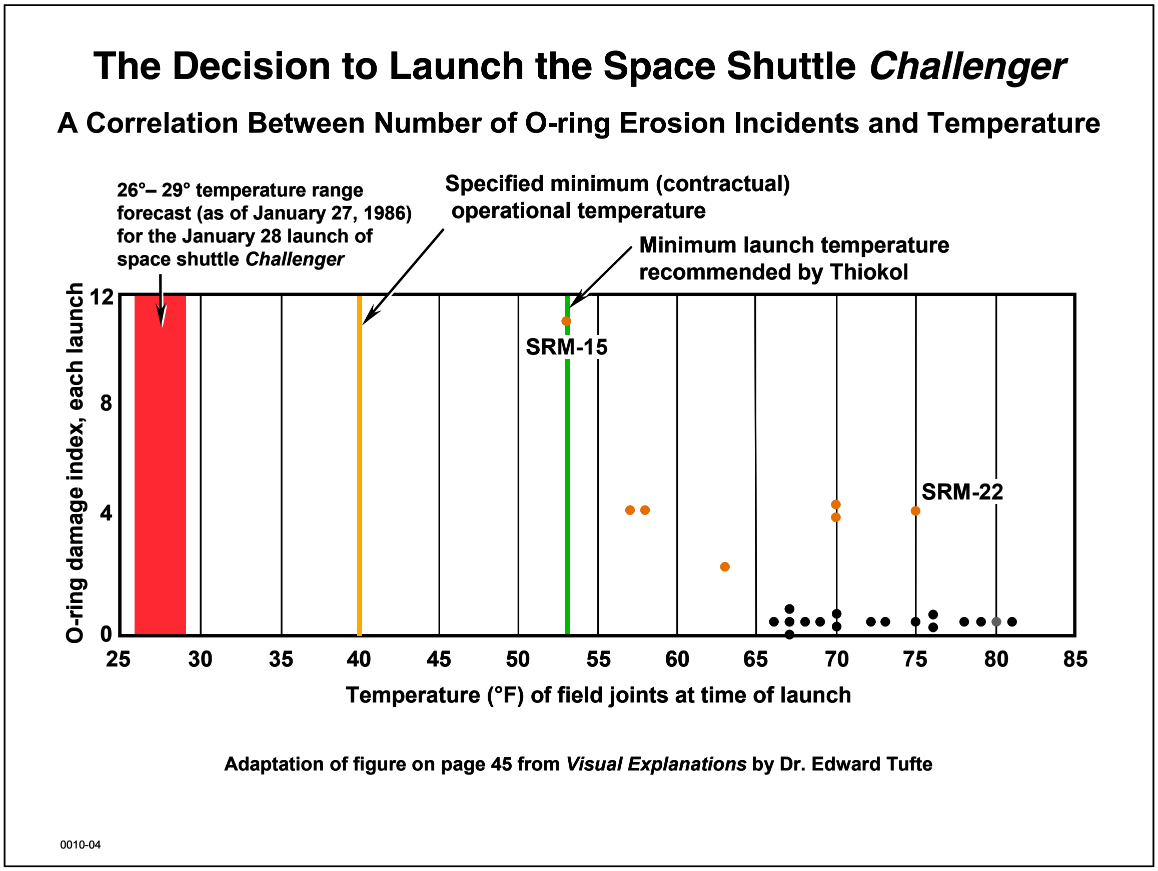

Figure 6 - The Modified Tufte Chart Showing O-ring Damage and Forecast Temperature vs. Recommended and Contractual Launch Temperatures

4. The Dreaded Build Sequence

Dr. Tufte deprecates the value of the slide format's sequentiality in his essay. [1] He writes: "Obnoxious transitions and partitions occur not only slide-by-slide but also line-by-line. Worse is the method of line-by-line slow reveal (at right). Beginning with a title slide, the presenter unveils and reads aloud the single line on the slide, then reveals the next line, reads that aloud, on and on, as stupefied audience members impatiently await the end of the talk."

I disagree with Dr. Tufte on this point. I posit that the build sequence has great value. Let's use the "*Columbia* Accident Investigation Report" [8] as an example.

When the "*Columbia* Accident Investigation Report" was released in August 2003, the Chief Engineers of the USAF Space and Missile Systems Center (SMC) and The Aerospace Corporation were tasked to review it, identify critical findings, and assess the report's findings on the processes SMC uses to do business. About a dozen engineers reviewed Volume I (~250 pages) and produced 75 pages of comments in a format of: Section, Page, Quotation, and Comment/Relevance. A team of three melded the individual findings to identify the high priority entries. This short list was reviewed for accuracy and completeness with the original team and selected SMC and Aerospace managers.

The comments were compiled into two dozen charts that were organized into these categories:

Checks and balances
Cultural issues surrounding disciplined technical analysis
Technical adequacy
Organizational considerations
Communication barriers
Leadership

These charts were again reviewed with the original team and selected managers to ensure the charts were accurate and represented a consensus of those participating.

The results have been presented within the Air Force, Aerospace, industry, and *The Congressional Review*. To illustrate the importance placed on these *Reflections*, the SMC Commander, Lt. Gen. Brian Arnold, devoted two 2-hour sessions to the briefing and discussion.

Let's review a few charts from the briefing (Figures 7, 8, and 9). Each chart has two logos to designate the partners

(SMC and Aerospace) who developed the presentation. The title (Figure 7) has the logo for Columbia (STS 107), the authors, titles, and date. *Reflections* was selected after lengthy discussions—"observations, impact of, applying results of, lessons learned...." The template chart (Figure 8) set the stage for what was to follow. It was shown completely to provide the overview, orally explain what was to follow, and allow dialogue with the audience: "We started with 175 items and reduced them to 18." "Yes, we considered that, but....." "The media emphasized that, but the team decided... "

One detailed chart (Figure 9) is shown as an example of the build sequence. The team was confident that this approach, with complete sentences—that were not read by the presenter—would focus the audience and encourage complete discussion of each template topic. It was implemented as planned, which is why more than 4 hours was spent on 22 charts. The discussion among the General's staff and The Aerospace Corporation's CEO and his staff was probing, thoughtful, and definitive.

At the start of the briefing Lt. General Arnold, SMC Commander, stated that Rick Husband, U.S. Air Force Colonel, and Commander of the *Columbia*, was a friend of his and that he wanted Colonel Husband's life to have a significant impact on how SMC is organized and the processes followed to acquire national security space systems for the nation's warfighters.

Figure 7 - SMC Reflections on the *Columbia* Accident Investigation Results

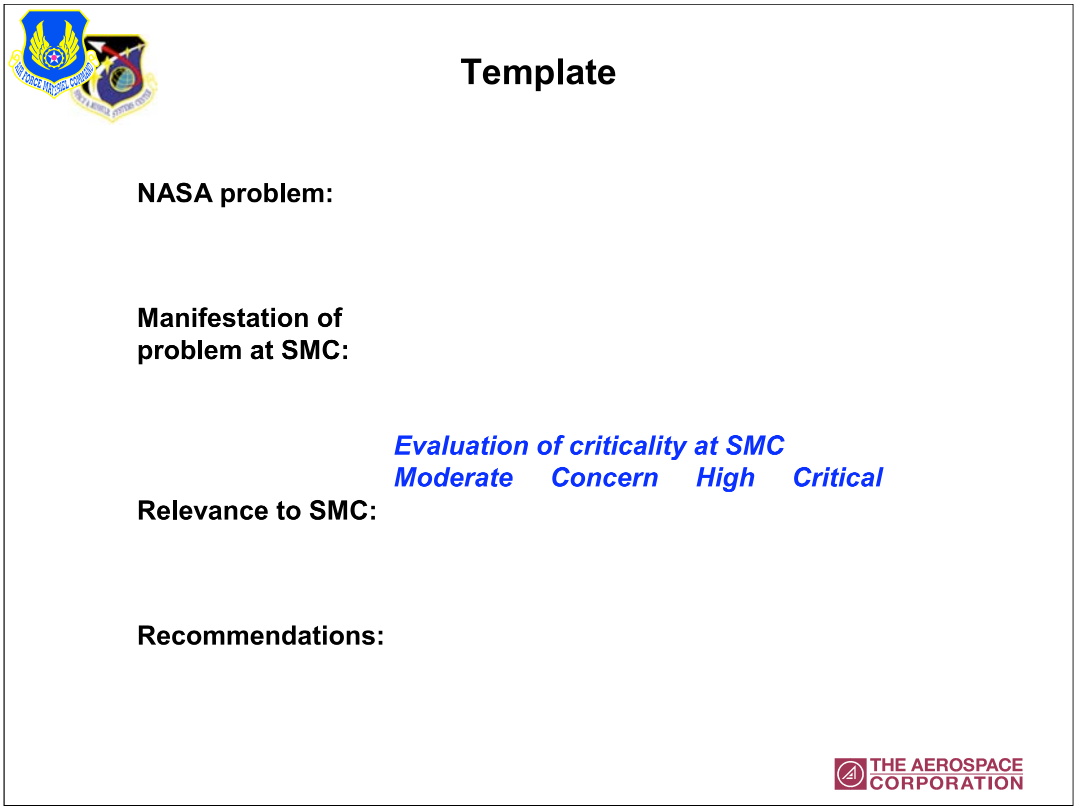

Figure 8 - Template followed in *Reflections* charts

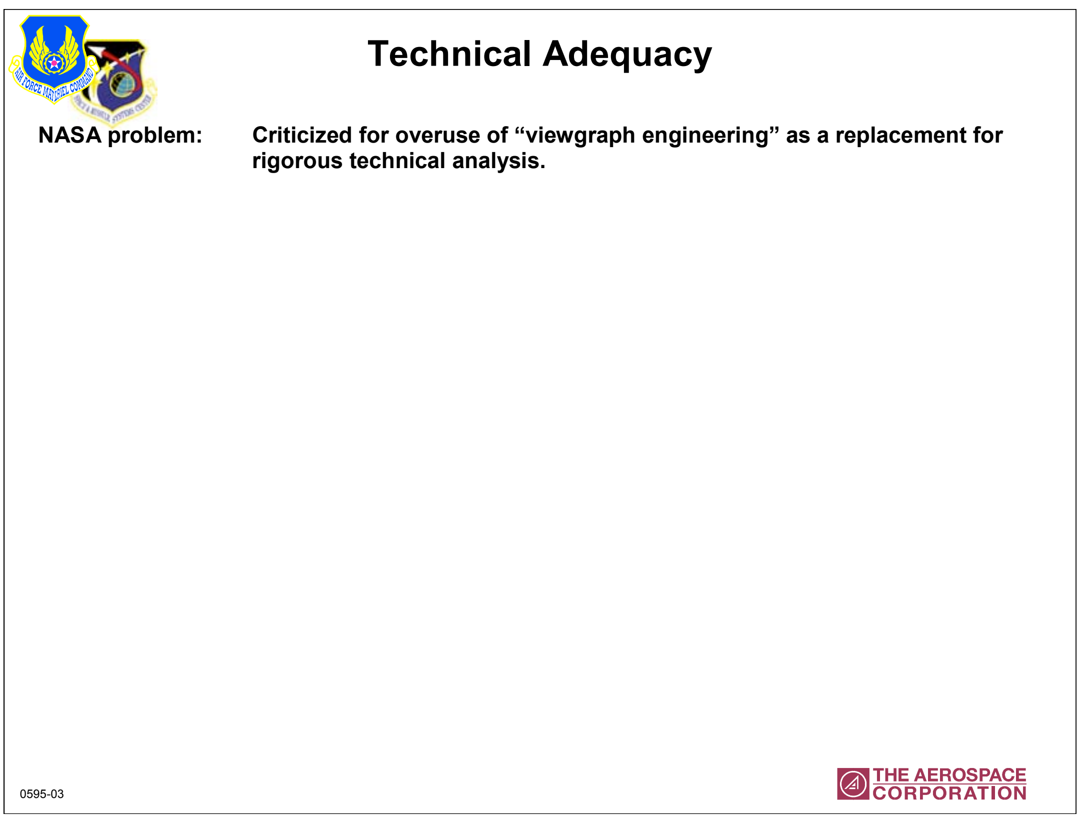

Figure 9 - Representative “Reflections” chart—NASA Problem (Sheet 1 of 5)

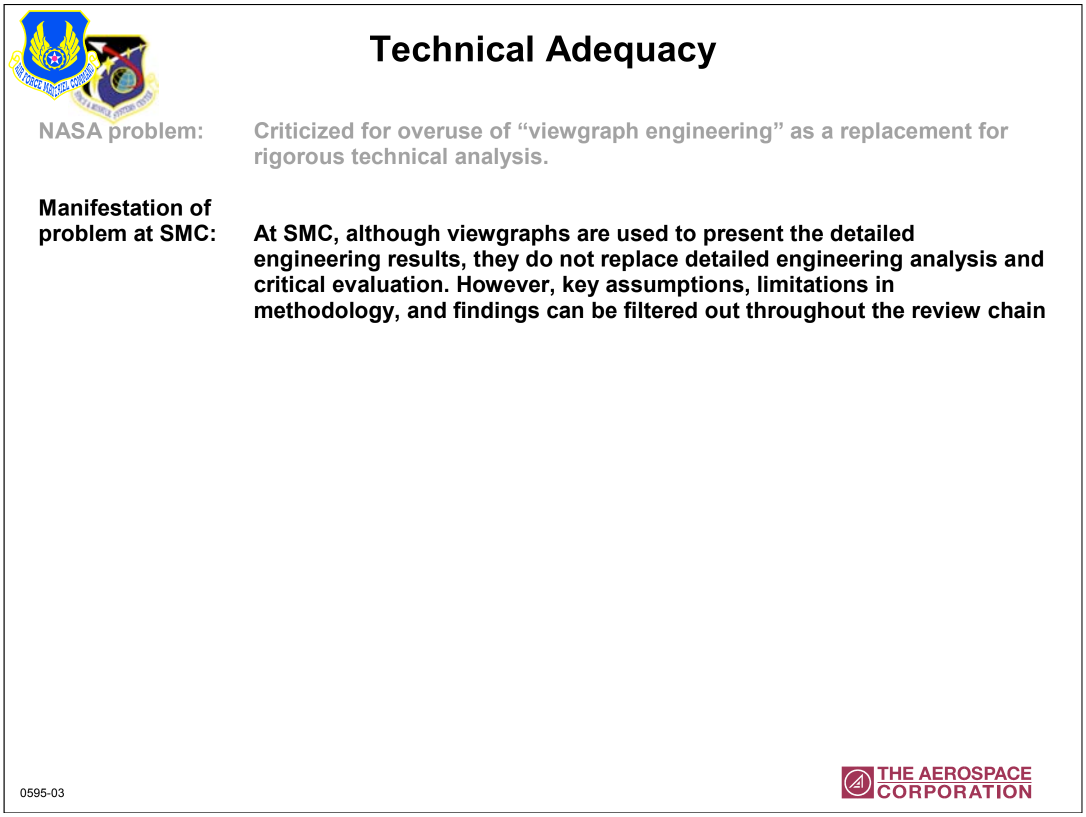

Figure 9 - Representative “Reflections” chart—Manifestation of problem at SMC (Sheet 2 of 5)

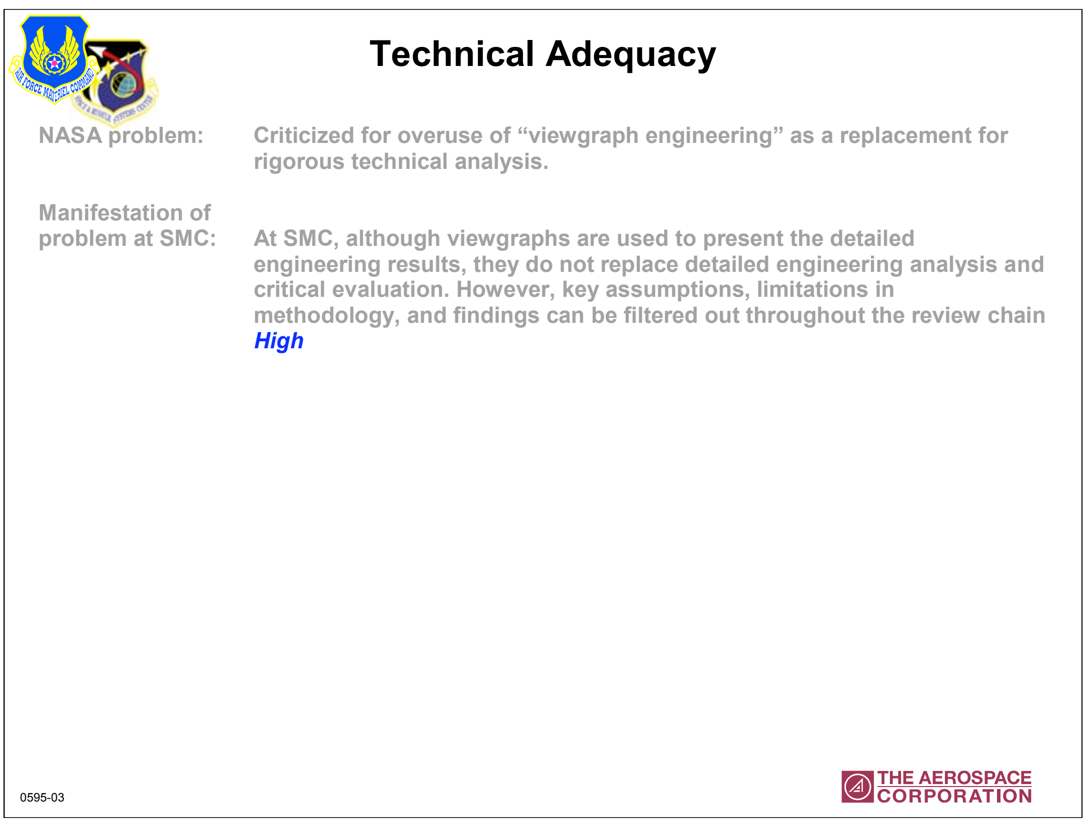

Figure 9 - Representative “Reflections” chart—Evaluation of Criticality at SMC (Sheet 3 of 5)

Technical Adequacy

NASA problem: Criticized for overuse of "viewgraph engineering" as a replacement for rigorous technical analysis.

Manifestation of problem at SMC: At SMC, although viewgraphs are used to present the detailed engineering results, they do not replace detailed engineering analysis and critical evaluation. However, key assumptions, limitations in methodology, and findings can be filtered out throughout the review chain *High*

Relevance to SMC: Although viewgraphs are the transmission tool, detailed engineering analysis should not be solely documented with them. Over time, the number of technical reports delivered has diminished. Without that archiving, lessons learned are lost and "new" studies are conducted decades later. Further, since almost everyone prepares his/her own viewgraphs, few experienced eyes review them

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Figure 9 - Representative "Reflections" chart—Relevance to SMC (Sheet 4 of 5)

Technical Adequacy

NASA problem: Criticized for overuse of "viewgraph engineering" as a replacement for rigorous technical analysis.

Manifestation of problem at SMC: At SMC, although viewgraphs are used to present the detailed engineering results, they do not replace detailed engineering analysis and critical evaluation. However, key assumptions, limitations in methodology, and findings can be filtered out throughout the review chain *High*

Relevance to SMC: Although viewgraphs are the transmission tool, detailed engineering analysis should not be solely documented with them. Over time, the number of technical reports delivered has diminished. Without that archiving, lessons learned are lost and "new" studies are conducted decades later. Further, since almost everyone prepares his/her own viewgraphs, few experienced eyes review them

Recommendations:
- **Document discussions and decisions throughout the acquisition cycle (e.g., at major milestone reviews)**
- **Insist that study and analysis results be documented – as a minimum as an Aerospace Technical Memorandum**
- **Commander's Policies are being reinstated, but need to be institutionalized so they are not person-dependent**
- **Need to have a better process for infusing center-wide policies or decisions into the SMC culture**

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Figure 9 - Representative "Reflections" chart— Recommendations (Sheet 5 of 5)

5. Examples of Information-Rich PowerPoint

Figures 10, 11, and 12 are examples of high-data-content illustrations prepared in PowerPoint. These examples illustrate PowerPoint's capability—when correctly applied—to show highly technical content clearly. Figure 10 illustrates the evolution of scanning remote sensing instrument configurations as a function of improvement in focal plane technology. The first sensing instrument (a) is a panchromatic imager configured with a single pixel operating in a "whiskbroom" scan configuration to form a continuous strip image. Next to this sensor (b) we see a "hyperspectral" modification of this single pixel concept by the use of a dispersion element and a one dimensional focal plane array that detects spatial/spectral information for each ground sample.

The next sensor configuration (c) is a panchromatic "pushbroom" construct that avoids the complexity of a scan mechanism perpendicular to the platform track direction by using a large linear focal plane. The segue from single (or a few) pixel focal plane technology to large linear array focal plane technology allows for this far more sensitive pushbroom approach. The final configuration (d) represents an extension of the pushbroom imaging construct to hyperspectral capability. This is accomplished by including a light dispersion element and associated optics and a 2-dimensional focal plane to capture spatial/spectral information in parallel from the strip image indicated by the line of ground samples in the figure.

The two color plots in Figure 11 show the response of a single 9 x 9 micron pixel from a JPL active pixel focal plane sensor to a tightly focused (1.5 micron diameter) scanned Helium Neon laser spot. The laser spot is moved in steps of 0.3 microns, thus providing a 2-dimensional response grid of 27 x 27 data points across the pixel. The spot scan data reveals the internal structure of the pixel. The photocapacitor used for light detection corresponds to the area outlined in white, red, yellow and green. The other regions indicate light absorption due to pixel electronic structures (i.e. transistors), metal buses and data lines.

The amount of spectral radiance observed on the surface of the Earth due to reflected sunlight (assuming a ground albedo of 0.20) is illustrated in Figure 12 as a function of solar elevation angle (i.e. the angle of the sun above the horizon). From these plots we see that the spectral radiance increases with increasing solar elevation angle, as would be expected.

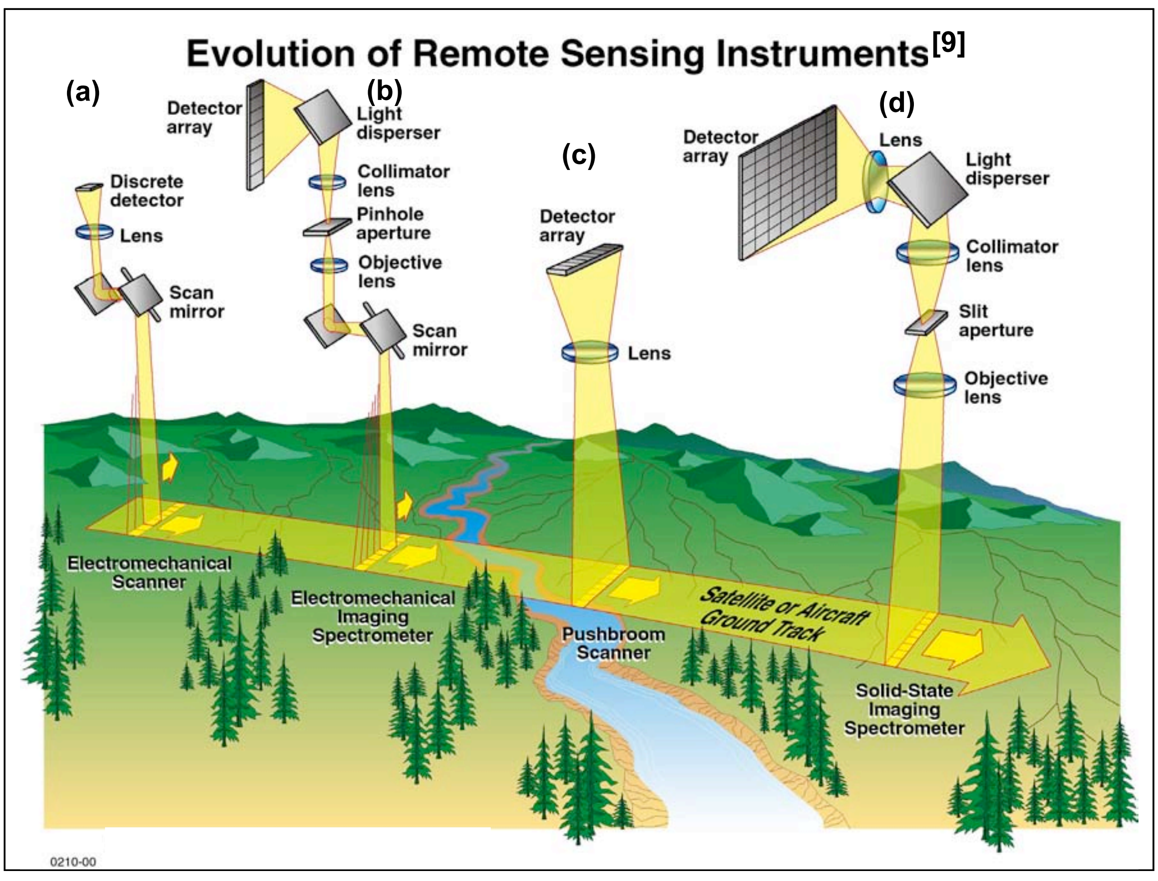


Figure 10 - Evolution of Remote Sensing Instruments

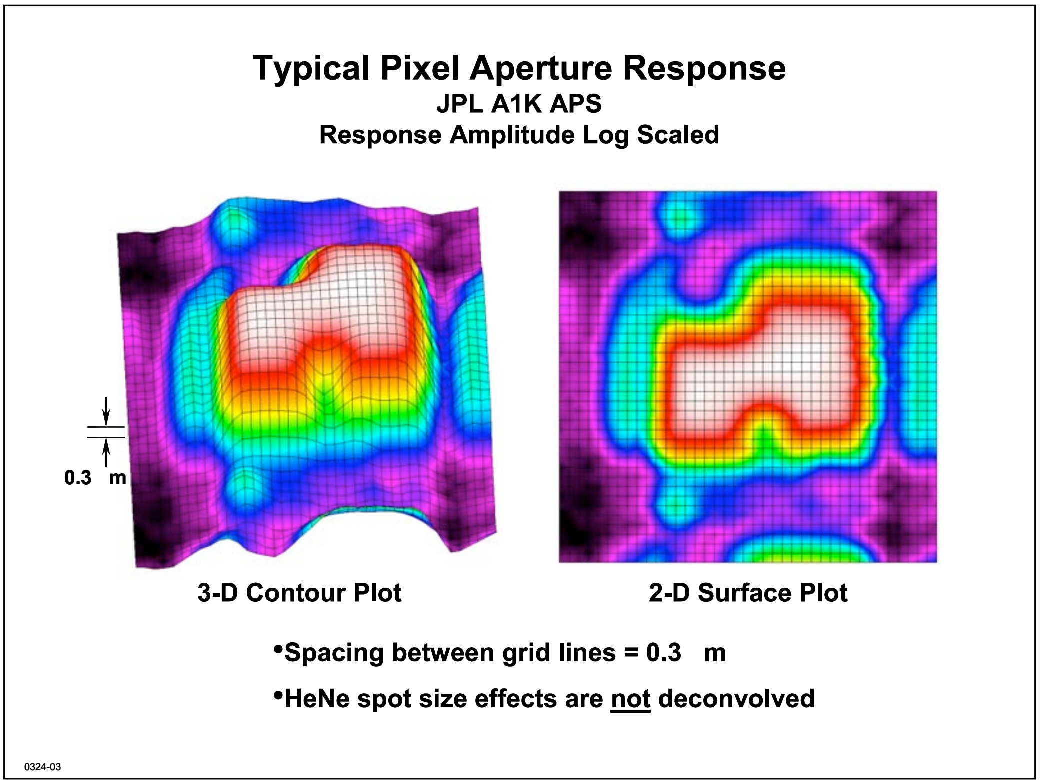


Figure 11 - Typical Pixel Aperture Response

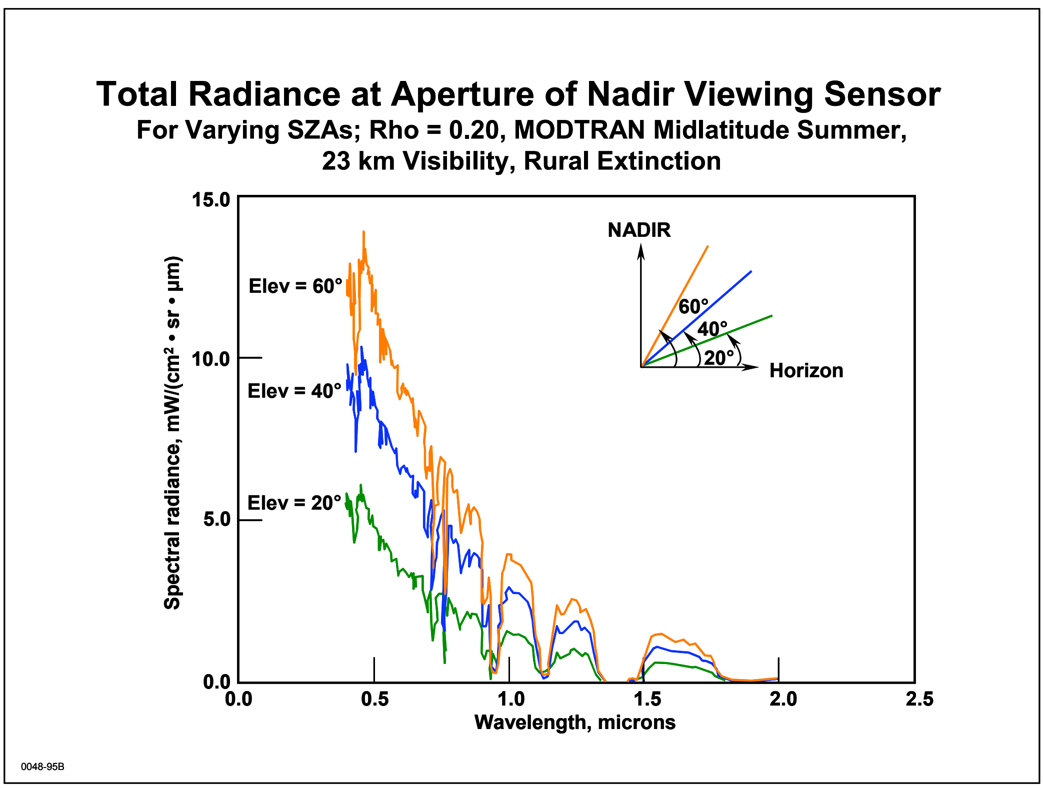


Figure 12 - Total Radiance at Aperture of Nadir Viewing Sensor

6. IMPROVING OUR PRESENTATIONS

Dr. Tufte makes a strong case against using too many logos; clever sayings, such as "We can change the world," "Let's partner for success" or "You won't believe what we can do"; or marketing department branding. Figure 13 is a chart used by Secretary of State Colin Powell in a briefing to the Security Council at the United Nations. It is also shown on the inside cover of *The Cognitive Style of PowerPoint*. [1] We have introduced a title chart (Figure 14) that removes much of the phluff shown on Figure 13, and included a revised exhibit chart (Figure 15). Note: the United Nations or the State Department may have regulations or style sheets that preclude these modifications.

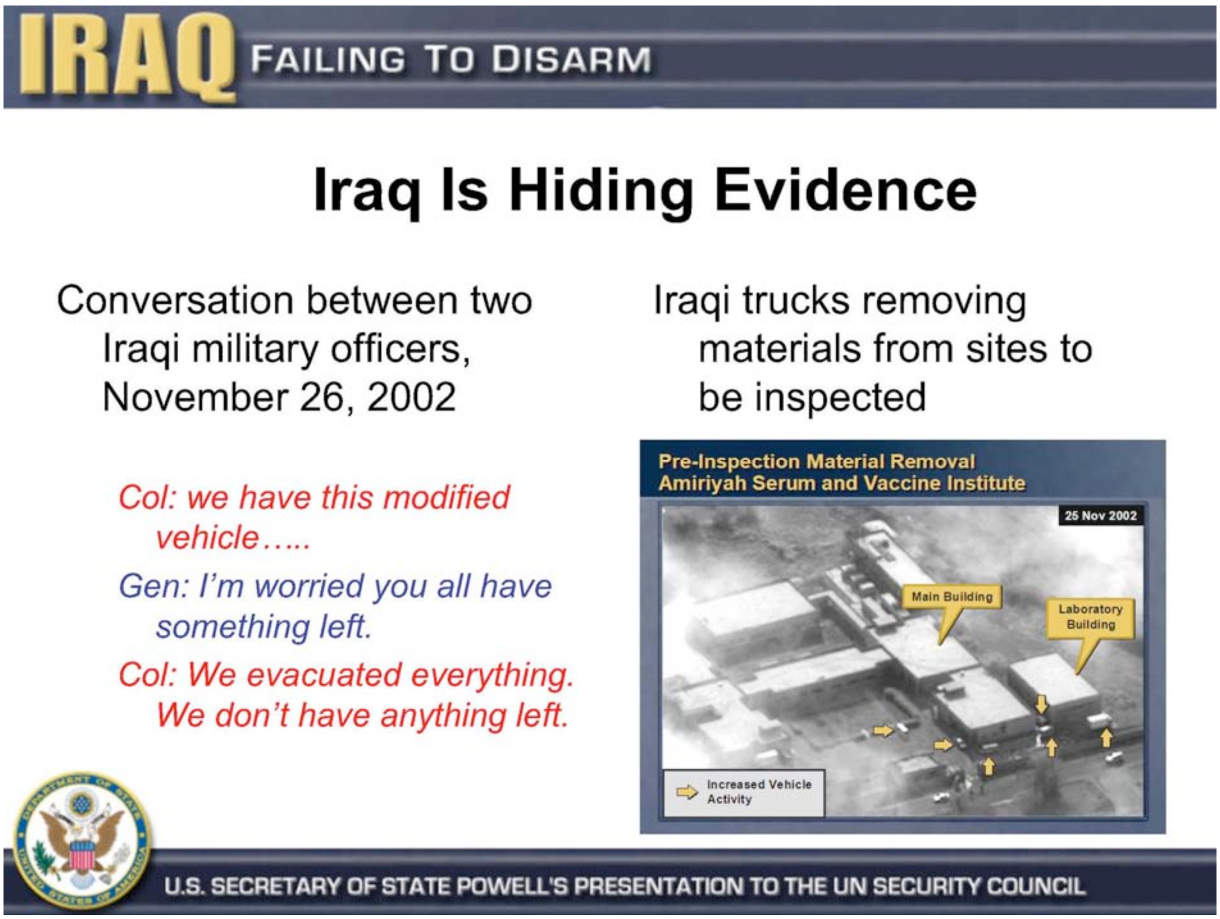


Figure 13 - Chart Used by Secretary of State Colin Powell to brief the U.N. Security Council

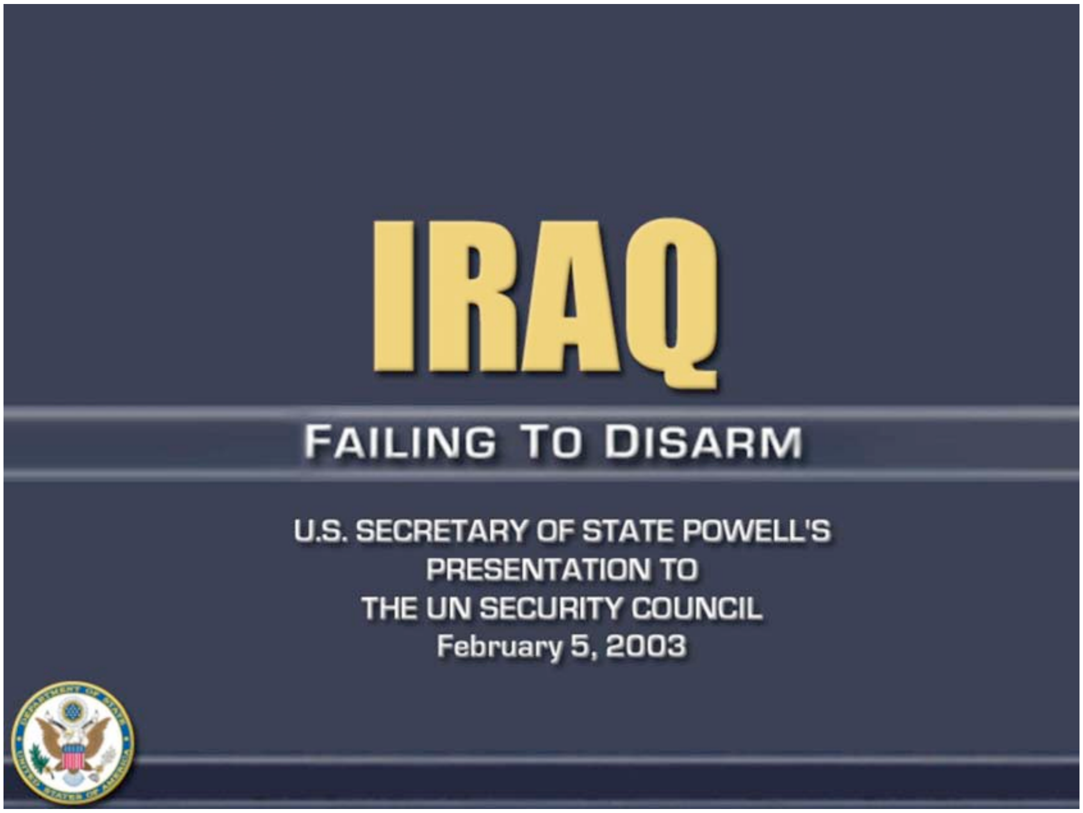
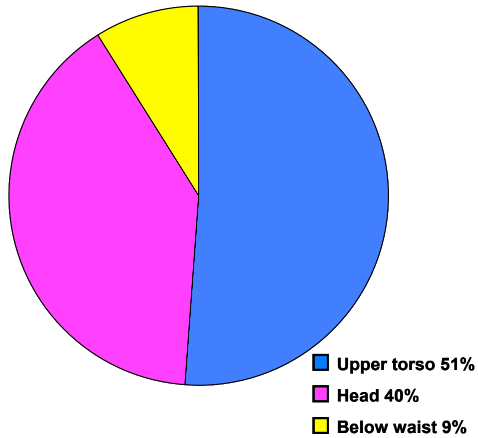


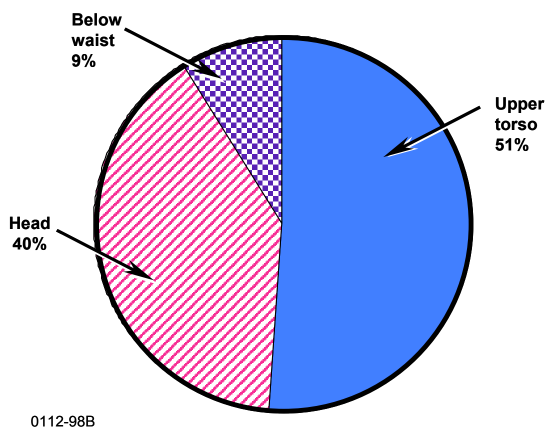
Figure 14 - New Title Chart Puts All the Phluff in One Place and Removes the Clutter from Individual Charts

Figure 15 - Revised Exhibit Chart Eliminates the ALL CAPS Heading and the Footer to Permit a Larger Photograph and Provide More Negative Space

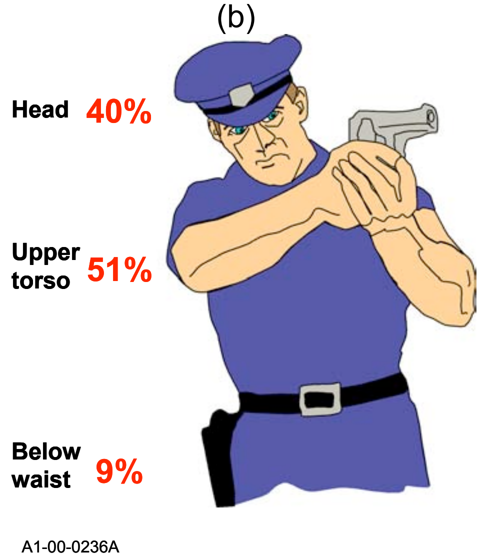
Figure 16 illustrates officer fatalities by wound location. In 16(a) we see that some pictures are not as "visual" as they pretend to be. The code makes the viewer go from the pie chart to the code and back to the pie chart—perhaps several times. 16(b) is an improvement in several ways: the title and percentage of pie are in the same area, if reproduced on a black and white copier everything is readable, and finally if the reader is color blind, the solid, crosshatched, and diagonally lined areas provide a visual cue and are readable when copied in black and white. 16(c) is preferred because it is *visual* and provides a mental image that the viewer will take away from the briefing.



(a)



(b)



(c)

Figure 16 - Lightweight Body Armor Problem Characterization: Officer Fatalities by Wound Location.

Figure 17 shows the importance of layout. By removing the spaghetti, the type size can be increased and there is more "negative" space. Figure 18 is a "build" that illustrates the effective use of color to show components added to a satellite system.

Figure 19 demonstrates the difference between the typical engineer's or scientist's desire to show everything they know (upper portion of the figure) and effectively communicating with your audience (lower portion). This visual was part of a presentation used to help realign the assignment of frequency bands in the spectrum to accommodate advanced [third generation (3-G)] wireless service. It provides an uncluttered view that allows rapid comparison of the approaches used to compute the interference power for 3-G cell phone systems. The use of color quickly and clearly shows that the approach in the right column is superior. The solid and donut shapes ensure that a black and white copy still lets (in this case a reader) make the distinction. Also, eliminating the detail permits use of a larger type size thereby increasing readability.

When faced with text clutter, think table. Figure 20 shows that by organizing a text chart into a table chart it brings organization, removes clutter, and increases readability. This approach doesn't always work, but when it does it is quick and dramatic.

ACKNOWLEDGEMENTS

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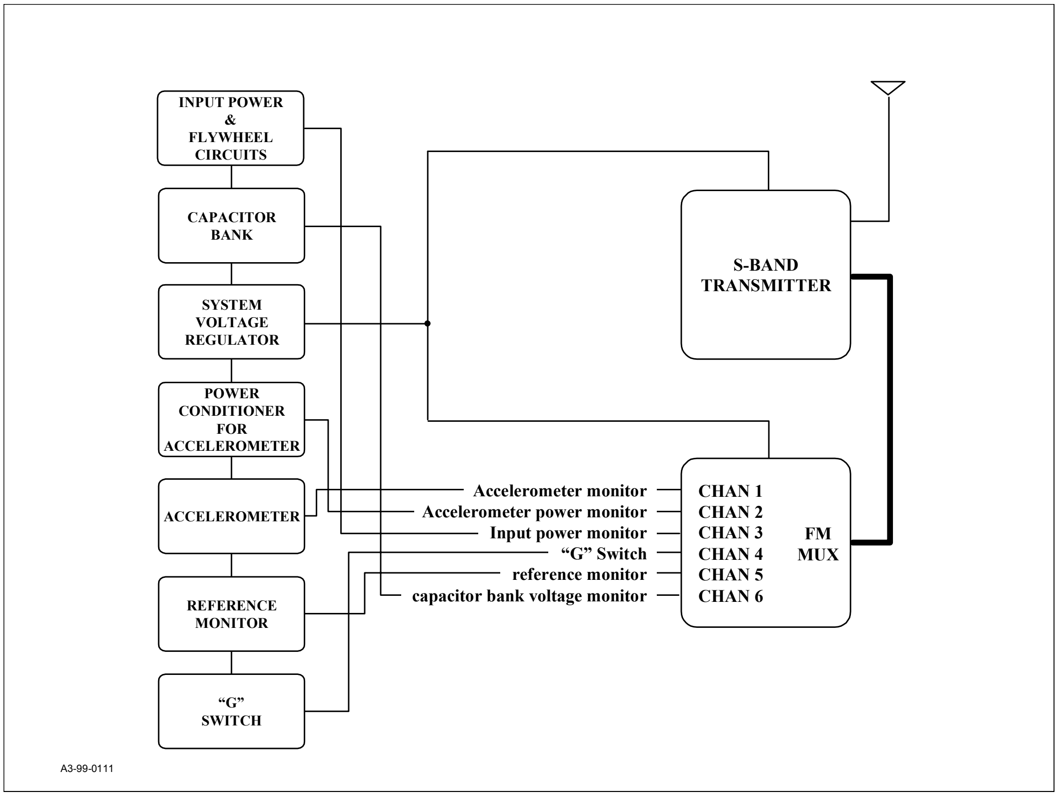
BIOGRAPHY

John "Mig" Mignot *is an Associate Fellow of the Society for Technical Communications. He has been an engineering writer, proposal manager, and senior project engineer. In 1971 he earned a California Teaching Credential and has taught in the business department at El Camino College, was on the industry/university team that developed the technical communications certificate program at UCLA Extension, and was one of a dozen Master Teachers at UCLA Extension. Teaching is his passion: Mig has designed and taught written and oral communication courses and systems engineering classes at Ralph M. Parsons, Xerox, TRW, and Northrop.*



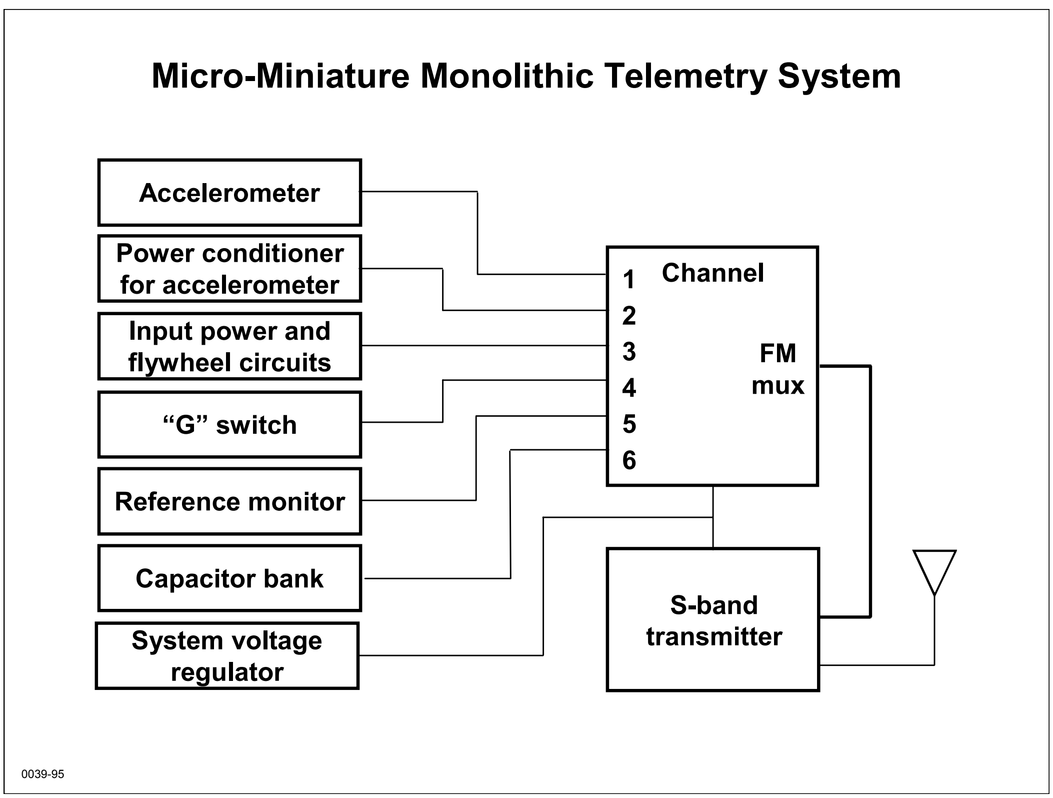
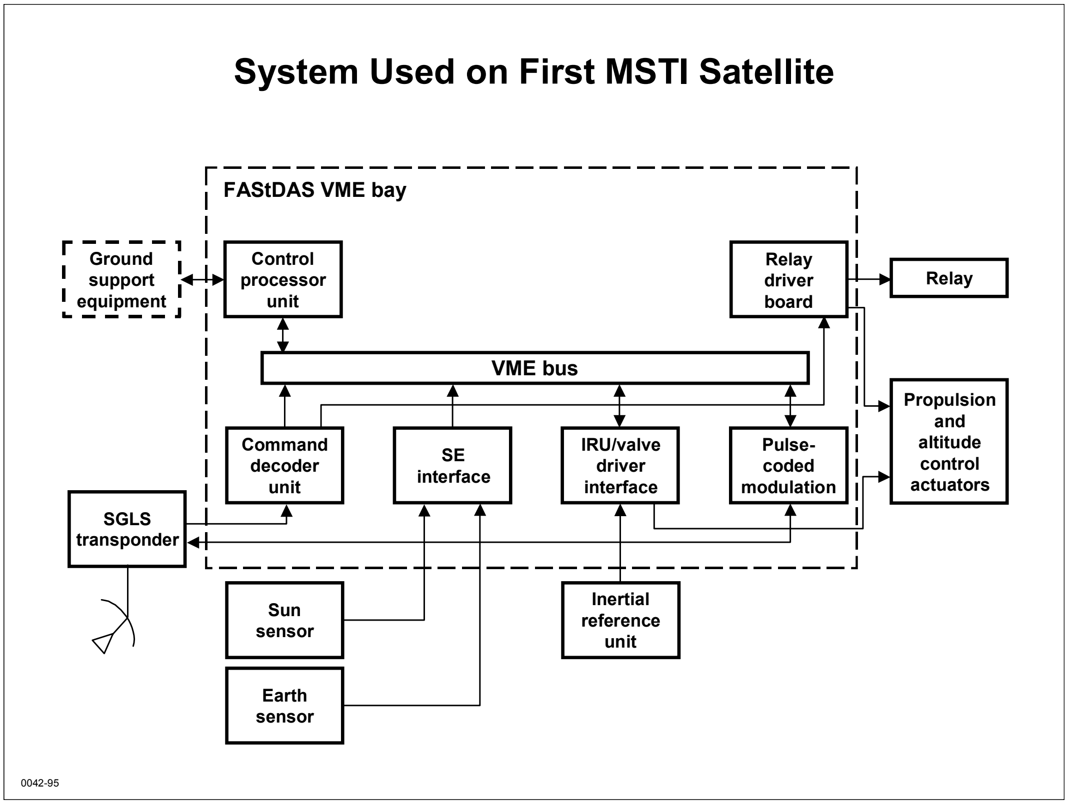


Figure 17 - Design is important. A title, removal of “spaghetti”, larger size type, using capitals and lower case letters rather than all capitals, and having more “negative” space facilitates comprehension.



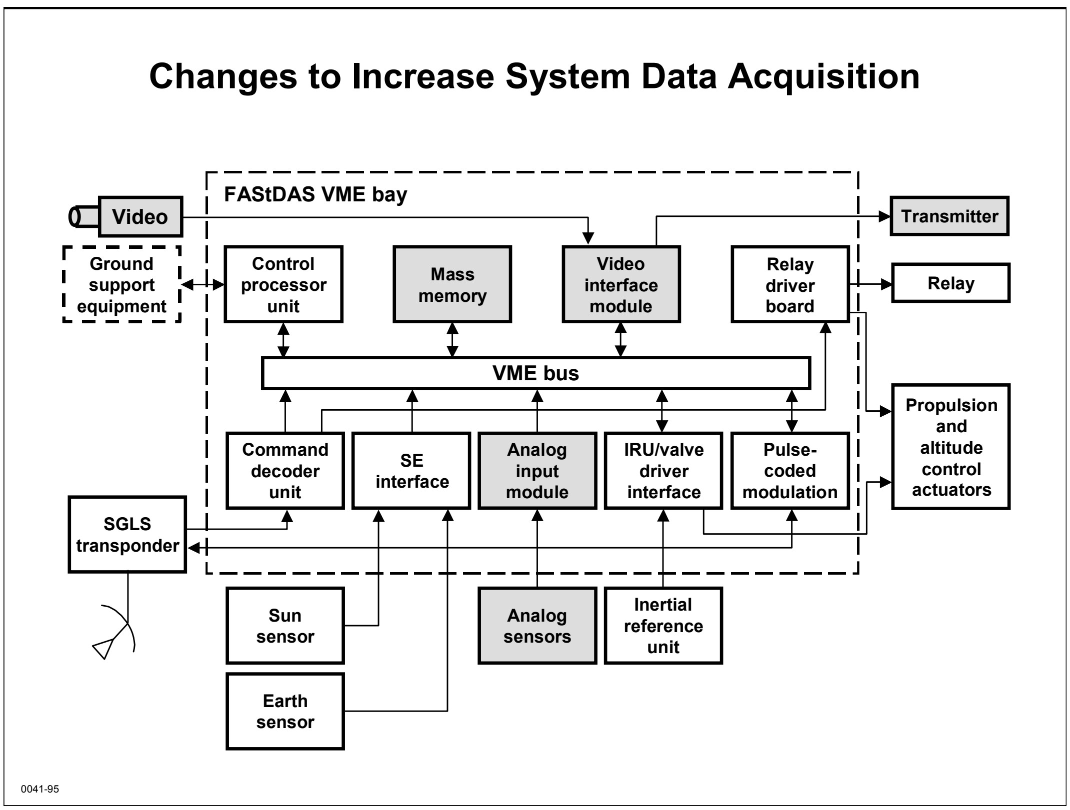


Figure 18 - Using color to downplay items already discussed in the upper chart make the additions stand out and reduce the time needed to describe the lower chart.

Limitations of JSC and IWG Approaches

KEY PARAMETER FOR COMPUTING INTERFERENCE POWER FROM 3-G SYSTEMS		APPROACH		
Parameter	Pros and Cons	JSC	IWG	Aerospace
ITU-R M.687-2 Interference Power Model (ITU-IPM) (0 dBi base station antenna gain)	Cons: -Base station antenna pattern is not included -Does not characterize the percentage of land to be covered by IMT-2000	Yes	No	No
Population Model (PM)	Cons: Standard PM is not accurate Pros: Updated PM is more accurate (Smaller Mean Square Error)	Yes (Standard Model)	Yes (Standard Model)	Yes (Updated Model)
Population Density Model (PDM)	Cons: Standard PM is not accurate Pros: Updated PM is more accurate (Smaller Mean Square Error)	Yes (Standard Model)	Yes (Standard Model)	Yes (Updated Model)
3-G Interference Power Model Using ITU Traffic and Population Density Models	Cons: ITU-IPM does not take into account of the number of IMT-2000 base stations, IMT-2000 deployment factor, and traffic mixes	Yes	No	No
Conversion from Population Model to Number of Circular Cells (CPNC) Model	Pros: -Allow to include actual number of IMT-2000 base station, deployment factor, and traffic mixes -Actual cell shape is hexagonal	No	Yes (Circular Cell)	Yes (Actual Cell Shape)
Base station Deployment (BD) model for Rural areas	Pros: -Allow to include actual number of IMT-2000 rural cells, rural deployment factor, and traffic mixes	No	No	Yes
Transmit Power Model (TPM) from a Deployment Area	Cons: Current TPM does not include accurate propagation path loss Pros: U[dated TPM includes accurate propagation path loss	No	Yes (Current Model)	Yes (Updated Model)
ITU-R F.1336 Base Station Antenna Pattern	Pros: Base station antenna pattern matched with measured pattern	No	Yes	Yes
IMT-2000 Traffic Environment Model and Propagation Loss Model (TM & PL)	Pros: TM and PL models allow for accurate modeling of the IMT-2000 interference power	No	Yes	Yes
Satellite Orbital (SO) Model	Pros: SO allows for temporal modeling of satellite footprint	No	No	Yes
Traffic Type Model (TT)	Pros: TM model includes vehicular, in-building, pedestrian and rural areas	No	Yes	Yes
3-G Interference power Model Using ITU Antenna, TPM, TT & PL and SO Models	Pros: Aerospace model includes features that neither IWG nor JSC considered	No	No	Yes

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Comparison of JSC, IWG, and Aerospace Approaches

Key Parameters for Computing Interference Power from 3-G Systems	Approach		
	JSC	IWG	Aerospace
ITU-R M.687-2 Interface Power Model (ITU-IPM) (0 dBi base station antenna gain)	●	○	○
Population model	●	●	●
	(Standard models)		(Improved models)
Population Density Model (PDM)	●	●	●
3-G IPM using ITU Traffic and PDM	●	○	○
Conversion from PM to Number of Circular Cells (CPNC) Model	○	● (Circular)	● (Actual)
Base Station Deployment (BD) Model for rural areas	○	○	●
Transmit Power Model (TPM) from a deployment area	○	●	●
ITU-R F.1336 Base Station Antenna Pattern	○	●	●
IMT-2000 Traffic Type and Propagation Loss (TT&PL) Models	○	●	●
Satellite Orbital (SO) Model	○	○	●
Traffic Mix (TM) Model	○	●	●
3-G IPM using ITU Antenna, TPM, TT&PL, and SO Models	○	○	●

0153-02 ● = Yes ○ = No

Figure 19 - Comparison of two approaches used to compare the interference power of 3-G cell phone systems: the "Tell 'em Everything" approach (upper) and the "Let's Communicate" approach (lower).

System Safety Program Requirements

- **Program level requirements**
  - **EWR 127-1(T), Eastern Western Range Safety Requirements**
  - **MIL-STD-882C, System Safety Program Requirements**
- **Segment/subsystem level requirements allocation**
  - **EWR 127-1(T) Chapter 1 Range Policies & Procedures – SEIT**
  - **EWR 127-1(T) Chapter 2 Flight Analysis Requirements – SEIT**
  - **EWR 127-1(T) Chapter 3 Launch Vehicle, Payload, and Ground Support Equipment Documentation, Design and Test Requirements – SV IPT**
  - **EWR 127-1(T) Chapter 4 Airborne Range Safety System Documentation, Design and Test Requirements – EELV Launch Vehicle Contractor**
  - **EWR 127-1(T) Chapter 5 Facilities and Structures Documentation, Design, Construction, Test & Inspection Requirements – SV IPT**
  - **EWR 127-1(T) Chapter 6 Ground Support Personnel, Equipment, Systems, and Material Operations Safety Requirements – SV IPT**
  - **EWR 127-1(T) Chapter 7 Flight Control Documentation, System and Procedural Requirements – EELV Vehicle Contractor**

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System Safety Program Requirements

- **Program level requirements**
  - **EWR 127-1(T), Eastern Western Range Safety Requirements**
  - **MIL-STD-882C, System Safety Program Requirements**
- **Segment/subsystem level requirements allocation from EWR-127-1(T)**

Chapter	Title	Responsible
1	Range Policies & Procedures	SEIT
2	Flight Analysis Requirements	SEIT
3	Launch Vehicle, Payload, and Ground Support Equipment Documentation, Design and Test Requirements	SV IPT
4	Airborne Range Safety System Documentation, Design and Test Requirements	EELV Contractor
5	Facilities and Structures Documentation, Design, Construction, Test & Inspection Requirements	SV IPT
6	Ground Support Personnel, Equipment, Systems, and Material Operations Safety Requirements	SV IPT
7	Flight Control Documentation, System and Procedural Requirements	EELV Contractor

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Figure 20 - The original (upper) finished system safety program requirements chart and the conversion (lower) into a table increases readability.