DOI: https://doi.org/10.3217/978-3-85125-530-0-06

Real World Steps from Legacy Siloed Systems into Computer Mediated Reality

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1 Iran flight 655

July 3, 1988.

Somewhere in the Persian Gulf, nearby the strait of Ormuz, there was a flotilla of north American battleships sailing on patrol. Iran and Iraq were at war since 1981. Iranian gunboats had lately been attacking neutral oil tankers and US ships in the region and so US dispatched substantial Navy forces to the Gulf. One of the battleships dispatched was USS Vincennes, a very recent and high-tech guided-missile cruiser, equipped with AEGIS, the most advanced electronic combat management system (CMS), using the most advanced tracking radar technology at that time.

Broadly speaking, battleships have 2 main areas from where almost everything is controlled: The bridge, to manouver the ship and the CIC (Combat Information Center), typically a well protected room deep inside the battleship, from where all mission decisions and combat actions are taken. The CIC it's a computers room, the "brain" of the ship, usually operating in dimmed lights, with computer screens, radar screens, sonar screens, communications equipment, weapon firing controls, etc. Depending on the battleship type, size, alert status, mission, etc, some 15 to 30 military staff can be working in this highly secure room at any given time.

There are two major staff roles within the CIC: The Frontline staff in charge of collecting and analysing incoming data from radars, sonars, etc (air, surface, sub-surface, land) and to provide a complete and confirmed scenario to the Officials line, which in turn will take all decisions on ship manoeuvring, weapons engagement, mission next steps, etc, based on the reality that is presented to them, on their computer screens and audio.

So, it's July 3, 1988.

At a given point USS Vincennes got to know that Iranian gunboats were attacking neutral cargo vessels in their vicinity. To make a long story short USS Vincennes and another frigate maneuvered to intercept the gunboats and at a certain point got engaged with them. While involved in this gunfire USS Vincennes crossed Iranian waters. At 10:47 AM the radars in the CIC reported an Aircraft approaching the ship. Several actions taken to try to identify the aircraft (IFF, radio, EM, etc) were inconclusive at that point and so the air track was classified as "Unknown - Assumed Enemy". At 10:49 Vincennes warned the aircraft on military frequency with no response. At this point staff within the CIC believed the aircraft was an Iranian F-14 even though there was no positive confirmation of that. Warnings were repeated on both military and civilian frequencies and then the aircraft was warned it would be shut down at 20 nautical miles range unless change on its course.

At 10:53 Vincennes issued a final warning. At this point there was some confusion about whether the aircraft was climbing or descending…finally at 10:54 Capitan

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Rogers, the Capitan of USS Vincennes, gave the order to engage and fire two missiles to destroy the aircraft. The aircraft was destroyed. But was in fact a civilian airbus A-300 from Iran airlines, that took off from Bandar Abbas Airport in Iran with destination to Dubai, with 290 passengers and crew onboard. All died.

Later, a formal investigation to the incident ran by the US Navy, concluded that the disaster was caused by multiple Human behaviour and Machine behaviour contributing factors. On the Human side there was poor decision making and erroneous expectations and erroneous understanding, confusion, stress and team communication faillures during the 7 minutes of the event. On the Machines side there were deficiencies on the HMI of the AEGIS Combat system that ultimately led the military in charge to take the decision to bring down IR655.

As with any other tragedy there were many small details to this incident, a lot of small events and pieces of conflicting or missing information that contributed to the sad outcome. It's beyond the scope of our talk to dissect this incident. Our case in point is: during these 7 minutes of intense stress the state of the art Aegis combat system, operated by trained and highly disciplined professionals, was not enough to create an accurate picture of the reality "out there", humans and machines working together were not able to understand what was going on outside the ship. The staff, inside that dark room, experienced and lived an illusion, while experiencing very high levels of stress. The "computer mediated reality" created that day was… fictional.

But the outcomes were very real.

I'm bringing this very dramatic example because this is the type of mission-critical systems I've been working with for the past 15 years or so, this is to say, systems that may bring severe consequences to a lot of people if they fail. I will showcase a few from my own experience working with Critical-Software.

Also because it is a good example to discuss major concepts and concerns when you're designing computer mediated reality systems, e.g, systems with the goal to assist humans in understanding "reality" better: Situation Awareness, Recognition Primed Decision, Performance load, Cognitive Load, Mental Models, Scenario fulfilment and other bias, but above all on the importance of getting involved with real users trying to get the most clear understanding of what they are trying to accomplish in first place by actually meet them, spending time with them in their offices or work environments, getting to know their tools, their processes, their jobs, their mental models, their difficulties, their real scenarios of work... most of this by actually being "there", exposed and immersed into those same situations and spaces, together. This is the only way, to my experience, to minimize the ever present temptation to do self-design and to minimize the ever present HIPPO effect (Highest Paid Person Opinion).

2 The "Reality" Vs the "Virtual"

Before we dive in the concepts and examples I would like to discuss with you, I guess we need to pause to think a bit about what we usually understand as Reality and Virtuality. Common sense will say Reality is our body and the physical world around it. It's what we can "experience" with our "senses".

On the other side, virtuality is commonly understood as a synthetic reality, an immaterial alternative reality built with computers. We can enter and leave virtual realities at our own will because they do not exist "for real" and because they are controlled by humans, but we cannot escape our own physical Reality because our bodies exist on a very tangible space and time. On the physical Reality we need to eat,

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drink, get together, learn, work, sleep, and so on so we can actually persevere our own existence. On the physical reality if we die, we die for good. On a virtual reality we are set free of our physical bodies and so we can exist forever, be whoever we want to be, do whatever we wish.

Right? Well not so fast.

Remember Capitan Rogers and the crew at the USS Vincennes. For them reality was that there was an F-14 flying into them even though they could not physically see it with their own eyes. Feeling that they were a couple minutes from being attacked - and probably dead - they act accordingly to their military doctrine and also, probably, after their sense of self-preservation. Virtual and Physical Reality merge together in these environments and create a single reality that lives in people minds.

In fact, reality might just well be what we think that reality is…if we move into a reality that has no physical existence that will still be and feel to us just as "real" …

3 On Situation Awareness and Recognition Primed Decision

Situation Awareness has been defined as 3 stage mental process: 1- the perception of information coming from our environment, 2-the understanding of it's meaning and 3- the mental projection of their state in the near future. For instance, we see a biker coming fast on the sidewalk, we understand that we´re on conflicting trajectories and we project we will collide in a few seconds. Based on that we can make a decision on how to act to avoid collision (moving aside, for instance, or stay put and hoping the biker will pass by us).

On the other side RPD is a human behaviour to make good enough decisions when facing complex situations making use of previous experiences - mostly in situations where time is of essence. As soon as a solution seems viable to us, given the pressure of time, most of us will follow it even though it may be a less than ideal course of action. For instance, a firemen will not look for the door keys beneath the doormat when trying to save people from a fire in an appartment building. He knows from previous similar situations that he needs to open that door as fast as he can, so kicking the door down - or using any readily available tool to bring the door down - is likely to be his first solution and that's what he will try to do immediately.

These two concepts are critical to consider when designing mission-critical systems for human use. We need to make sure the systems we design are able to present accurate representations of the environment and - even better - help us in projection future states and help us deciding what to do next.

That was not the case with USS Vincennes. The Combat System was not able to provide crystal clear and unambiguous information about an air track (because it was not designed to do so) and pretty soon an illusory reality emerged in the minds of the crew. Given the pressure of time compression decision makers did what they were trained to do best: deciding quickly with the any available information and making use of their experiences, (e.g. Recognition Primed Decision)

We will go through an example of a system designed for a Major telecom operator in Portugal for their first line support, and a system designed for Battle Management for the army. Both trying to provide users with accurate and complete current information (the elements of the environment), trying to help users in understanding their meaning and also trying to project near future state, so then users can better decide on a course of action.

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4 Often Less is not More, when it comes to industrial mission-critical systems.

It may sound counter-intuitive: most industrial systems often need to process and display considerable amounts of data onscreen. Command and Control systems within control rooms in energy generation facilities, for instance, cannot be as simplistic as iPhone apps. But they need to present data in ways that are contextual and meaningful to their users, and above all, providing them with clear and accurate representations of reality, at all times.

We will go though the example of a system designed for monitoring traffic at sea, and also through the previously mentioned system designed for TELCO. Both provide extensive and contextual information and even more data on demand as users work with them.

5 Performance load, Kinematic load, Cognitive Load and the use of metaphors to decrease their levels

Cognitive load is the mental effort required to accomplish a task with success. Is the effort we make when reasoning trying to make sense of what we see and hear or otherwise feel.

Kinematic load is the physical effort we need to make to accomplish that task.

Performance load is the combination of the former two.

Designing a system for Mission planning for a military aircraft we faced questions such as “what would be a good solution for a pilot to handle fuel? what would be a good solution for a Loadmaster to handle cargo? what would be a good solution offering low levels of cognitive load to present tools for the pilot’s convenience and ease of use?”

Designing a system for water flow balance in a 3 hydraulic Dams system for a major Energy provider in Brazil we faced questions such as “how to simultaneously represent planned and current energy production in three different dams? their respective water flows, reservoir levels and water outputs? how to represent all of that along time, projecting the near future?

The solution for both systems was to use metaphors, images recognizable by its users, symbolic representations of their own realities, so that data onscreen could display in context and with improved meanings with less effort. We will go through both systems to further discuss these solutions.

6 Knowing reality is the only way to be able to design systems to represent…that reality.

Quick exercise on the fallacy and dangers of unproven or misinterpreted User / System requirements: We will try to design/think through a solution for a door for a spaceship.

Understanding what user are trying to accomplish is key and pretty much nothing else matters as much when you’re trying come up with solutions that will be useful and usable.

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Sure, there are times when we are given the opportunity to design systems that ourselves will be able to use. In those situations we can do self-design and pursue what we think is best. But those situations are very rare. We spend most of our time designing systems that will be used by people other than us, systems that we will never use ourselves. For instance I've worked extensively on systems for ophthalmology and I never got to use them myself…i'm not an ophthalmologist… none of the systems covered in this talk will ever be used by the teams that designed them and built them.

We will go through a few examples of onsite functional analysis as a way to better understand what system features shall we design and why.

7 VR interfaces, highly metaphoric, visually rich and microinteractions rich HMIs as an alternative to the mainstream two dimensional human-computer interfaces.

We live in a physical multi-dimensional world. We capture events that happen around us though our senses and we try to make sense of that with our brains and our bodies.

We have memories, past experiences, we learn by habituation and repetition. We make use of all of that for every single action we take, at all times.

Also our behaviour is often pretty much predictable since we often act after behavioural bias. We tend to complete narratives in our heads when data is missing (scenario completion), we tend to stick to the first course of action we can think of based on previous experiences (Recognition Primed Decision), we tend to look into available information to confirm an ideia or decision we've already made (confirmation bias), we tend to see patterns where there are none (apophenia), we tend to favour visually appealing tools (aesthetics-usability effect), etc.

It's only natural that we can relate well with computer mediated reality solutions, complementing and augmenting what we already can obtain through our own body sensors alone (eyes, ears, skin, nose, etc.).

Computer Mediated Reality has the potential to make narratives tangible and understandable onscreen in ways not available to orthodox Graphical Interfaces. The sense of time can be better exploited, by experiencing it rather than by trying to represent it in cartesian graphics and users mental models can be pursued better.

When designing our own CRM at Critical-Software, we got to speak with Business Developers, the population that would be using the new CRM. They spoke a lot about "Goals", "landscapes", "menaces", "opportunities", etc.

We will go through the software that was actually designed and built and also through some sketches on an alternative solution that was trying to create a Virtual Reality landscape where projects and goals and opportunities could be physically represented and where a narrative was immediately apparent.

That brings us to the question "what is a system feature on a computer mediated reality system?"