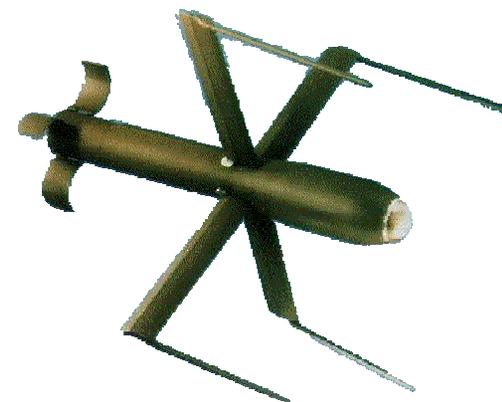




BAT Seeker IR Calibration Process Improvement



LAI Plenary Session March 25, 2003

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Background



- **BAT is a terminally guided, dual mode (acoustic and infrared) submunition that autonomously seeks out and destroys armored vehicles without human interaction.**
- **It is an unpowered, aerodynamically stable vehicle, approximately 36" long, 5.5" in diameter, and weighs 44 pounds.**
- **Multiple submunitions are projected deep into enemy territory by the Army TACMS missile and are dispensed over a large target array to selectively attack and destroy military targets.**
- **Not only had BAT transitioned from EMD to LRIP 1 to LRIP 2, but had physically moved from Andover, MA to Tucson AZ**

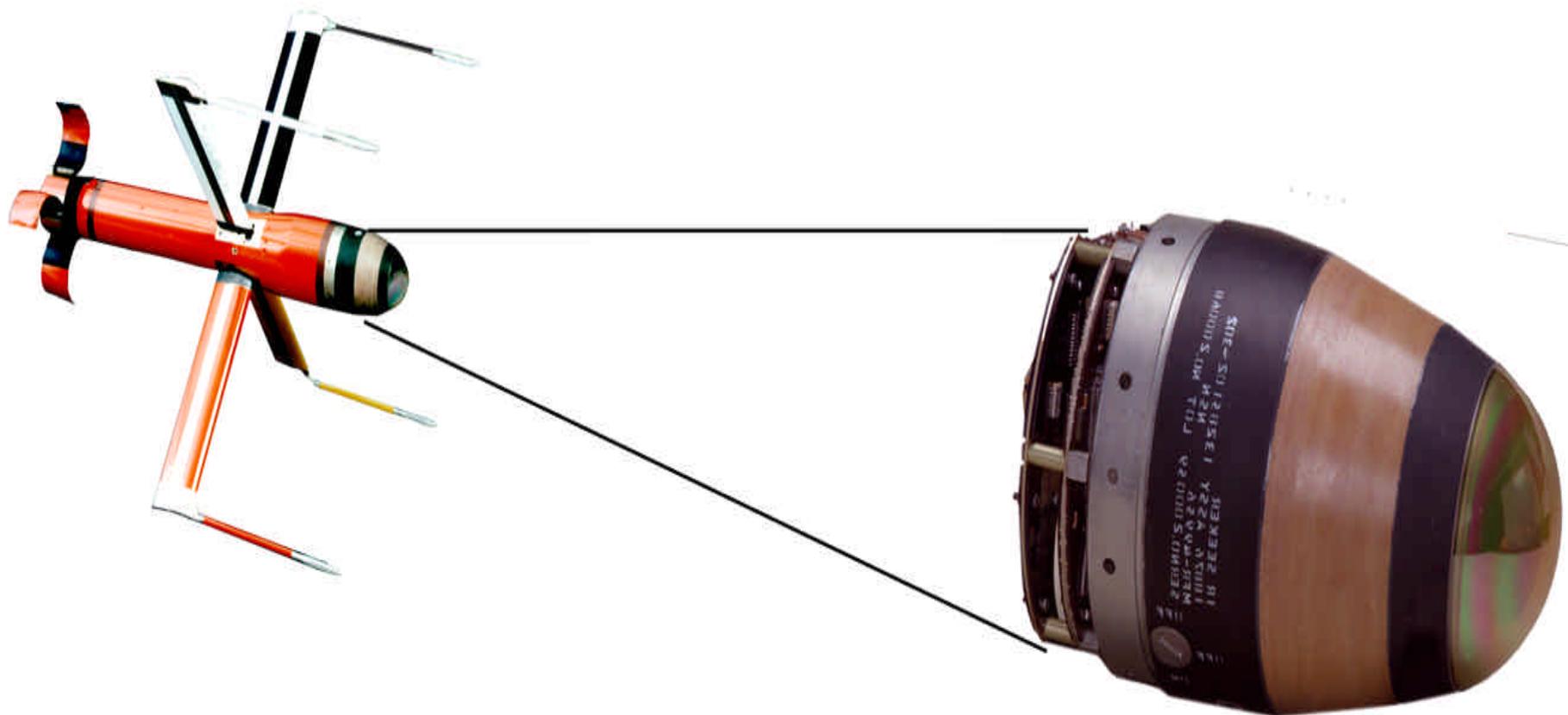
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What the Process is About

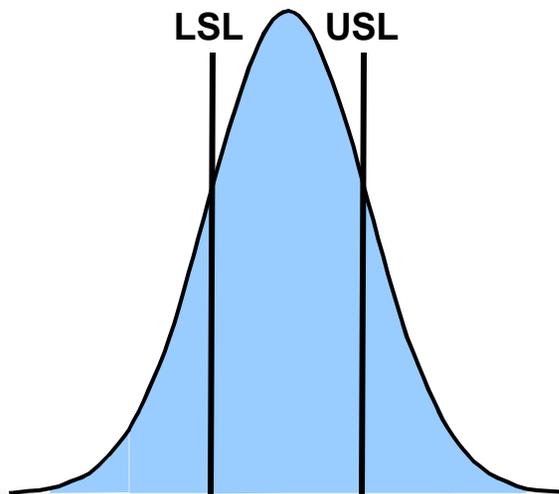


The BAT seeker requires that numerical constants be generated and uploaded to calibrate infra-red performance. These are called Seeker Dependant Constants (SDCs). This process is called IR Calibration (IR Cal.)

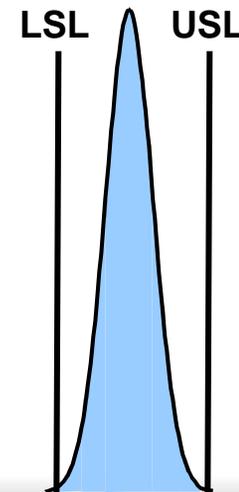




SDCs are numeric values that reside in a table in the seeker computer memory that compensate for hardware variation in the calculation of guidance commands. A test position loads a set of default values into the seeker then takes seeker performance measurements. If a measurement is out of spec the the related SDC is recalculated and reloaded and the measurement is repeated. This process is repeated until the seeker is operating within spec.



**Seeker Performance
With Default SDCs**



**Seeker Performance
With Final SDCs**



The BAT Challenge



- The IR Seeker Calibration process (IR CAL) was a constraint on seeker deliveries:
 - Running 24 hours / 7 days a week, the maximum capacity was 56 seekers/month at 100% yield (yield was a lot less) against a requirement of 70 seekers/month within 3 months.
 - The current process was causing rework downstream
- The BAT program had one of the highest overtime rates
- No capacity to recover from “show stopper” technical problems. Only recourse was to renegotiate schedule.

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First Encounter With the Program



- **Our best Electro-optical Engineers had been working on improving yields and throughput for some time, and considerable progress had been made to get where we were in July 2001.**
- **The Program Manager was skeptical at first meeting with R6sigma experts because he had the best technical support available - was not sure R6sigma could help.**
- **HOWEVER he had only three months to hit 70, did not see that he would get there, so was willing to give it a try.**
- **He agreed to stand up a small part time team and assigned his Operations Manager responsibility.**

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The Six Steps of R6Sigma



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R6Sigma BAT Project Baseline/Characterize Process



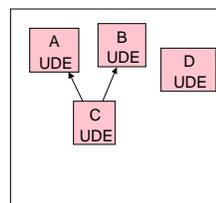
First Steps

- Vision
- Secure management commitment (Contract for Support)
- Scope project process
- Form and train team

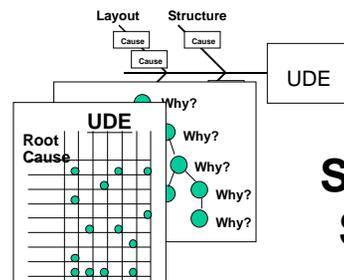
Data Collection



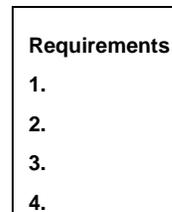
Identify Undesirable Effects



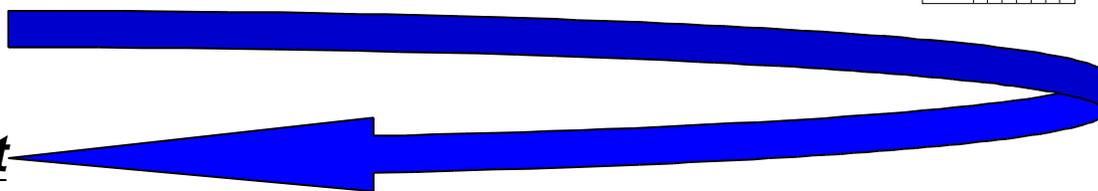
Root Cause Analysis



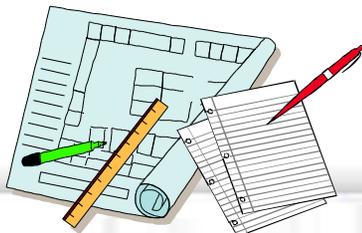
Solution Spec's



Implement



Detailed Action Plans



Detailed Project Plans



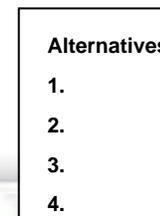
Contract for Change



Final Solutions



Preliminary Solutions





First Encounter With the Team (“Visualize” and “Commit”)



- The team consisted of Test Engineers (good at Electronics and Software), an advanced hourly Tester (called a “Rambo”) The Operations Manager, and the Expert.
- Despite being strongly convinced that the problems were technical they agreed to a vision of reducing process time (they only agreed to a goal of one hour out of eight) using R6sigma tools (it didn’t hurt that the Expert was a EE).
- The team came up with “run rules” to accommodate their 60-70 hour work weeks. They would only meet one hour a week and do actions individually. “Visualize” and “Commit” done.

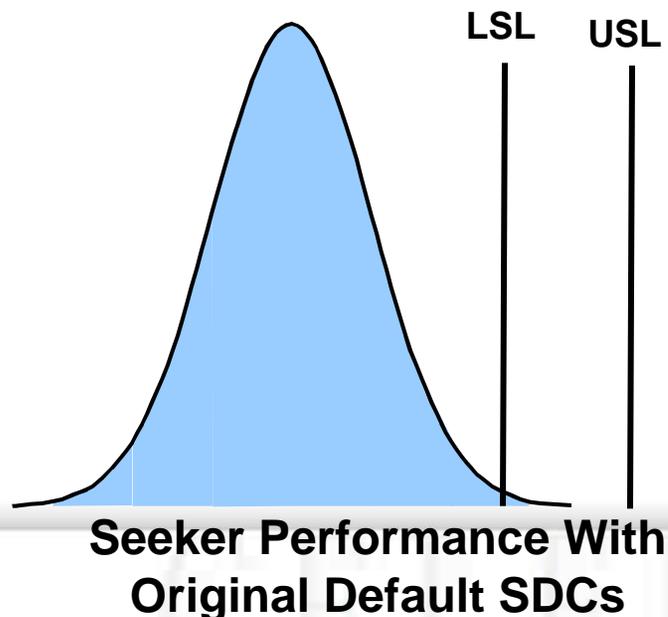
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Brainstorm and "Prioritize"



- There was a half hour left in the first meeting to brainstorm and "Prioritize".
- One of the first observations - Seekers almost never work with the Default Constants. After asking why about three times it occurred to everyone that maybe the Defaults were no good.



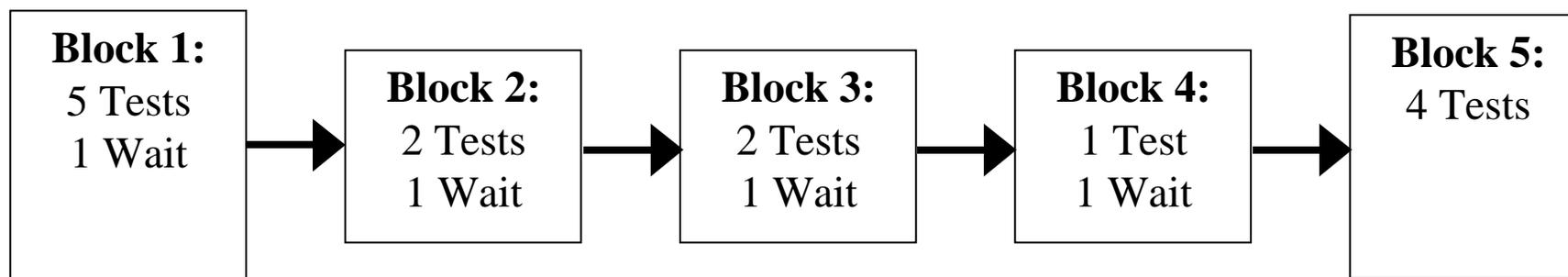
- Ten more "solutions" identified.
- An action was assigned to do some analysis and come up with constants centered on the hardware mean and test them.
- At the next meeting, it was reported that it worked, and would save at least two hours per unit. Epiphany!



IR CAL - Legacy Process



- The legacy IR CAL process included five Test Blocks:



- The R6Sigma team identified eleven possible methods for improving IR CAL, and chose the three that provided the most value:
 - Improving the Default SDCs.
 - Reordering tests to improve efficiency.
 - Evaluating the necessity and number of wait times.

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IR CAL - Analysis ("Characterize")



- Improve the Default SDCs:
 - Original SDCs were derived from EMD hardware. Hardware changes since EMD had shifted the SDCs.
 - Each individual test in a Test Block checks to see if a parameter falls within specification. If it is within specification, the test does not modify the constant, and continues to the next test. If it is not within specification, the test takes data and calculates a new constant.
 - Using SDC data from sold seekers in the LRIP 1 contract, new default constants were derived.
 - Implementation on the new default SDCs reduced test time by 2 hours per unit, mainly from tests being able to pass spec with default constants.
- Reorder tests to improve efficiency:
 - Since IR CAL cannot optimize all SDCs at once, it goes through an iterative process to arrive at the final SDCs.

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IR CAL - Analysis (Cont.)



- Test Blocks 3 and 4 are the second iteration of the SDCs modified by Test Blocks 1 and 2.
- Experiments conducted with the original IR CAL and default SDCs and an engineering version of IR CAL with the new default SDCs determined that the new default SDCs could take the place of the first iteration of SDCs, thus allowing Test Blocks 3 and 4 to be removed.
- Evaluate the necessity and number of wait times:
 - Wait times allow the seeker to return to ambient temperatures during IR CAL. This was originally required because of temperature coefficient concerns with different seeker materials.
 - The material issue was eliminated in EMD, but the wait times had not been revisited.
 - Thermal tests were conducted to determine which waits were necessary and which could be reduced without affecting seeker calibration and performance.
 - The 30 minute wait time in Test Block 1 was removed.

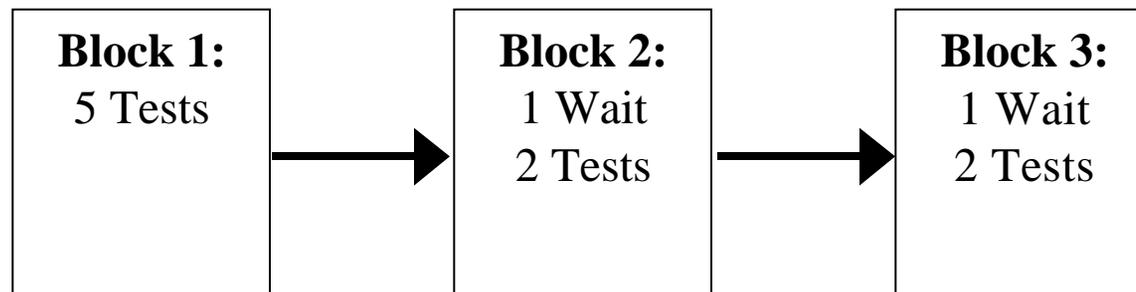
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IR CAL - Optimized Process ("Improve")



- IR CAL was reduced to a three Test Block process.
- Immediate test benefits:
 - Greater throughput
 - Less touch time meant reduced potential for rework
 - Faster turnaround times for rework



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Results ("Achieve")



- Outcome Exceeded Goals
- Reduced the IR CAL/IATP test cycle time from 8 hours to 2.5 hours/unit.
 - IR Calibration Test capacity increased by 220%
 - Actual deliveries more than doubled (73 in Oct. 2001)
 - Labor Performance improved 54%
- Financial Impact:
 - Working capital substantially reduced
 - Program went from financially red to black
 - Enabled collection of large milestone payment early
- Quality of Life improved:
 - Third Shift production was eliminated
 - Weekend overtime was reduced
- Had a great celebration dinner at a really good steakhouse!

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Lessons Learned



- **Common Vision between Program Director and Team**
 - Importance of sponsor “buy in”
 - Integration of team efforts enable big gains
 - Sponsor as a team member
 - immediate feedback on proposed tasks
 - prioritize tasks to sponsor requirements (BAT production needs Integrated with R6Sigma project requirements)
 - allocation of resources (e.g., Test Station time - provided to team when required - pay now - big benefit later)
- **Opportunities for further improvement:**
 - Two R6Sigma follow on projects were completed
- **Take away: Do this process during transition from EMD to LRIP.**

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