Configuration Management

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Configuration management is a vital part of the safety of any space system, and a staple to those in the safety business. What is configuration management? It's simply knowing exactly what the piece of equipment is and what it does at any point in its life, cradle to grave. This includes knowing which software version is being used and how changes might affect the desired effect.

Remember the scene in the movie Apollo 13 in which the space craft experienced an O2 tank explosion and left the crew with insufficient breathable air?

The NASA engineers on the ground first had to bring in every piece of equipment that was on the spacecraft and begin working on how to fix the problem. That's configuration management! They had to know every hose, pump, widget, and paperclip on the spacecraft, at the time it launched, and what they had to accomplish with them...create breathable air. By the way, it's useful to note that for quite some time, organizations of all different kinds have recognized that solving problems in a structured, orderly manner is more efficient and effective than random, "fly-by-the-seat of your pants" problem solving. There are many different problem solving processes that exist for different purposes, and the USAF has adopted an 8-Step Problem Solving Model based on Boyd's OODA Loop (Observe, Orient, Decide, Act). Coupled with the concept of configuration management, the 8-Step Problem Solving Model increases the opportunity for both risk reduction and mission success. If you happen to watch Apollo 13 again, you'll notice they basically follow the above problem solving construct. Always remember when using any problem solving methodology, "a good solution in time, is better than the perfect solution too late."

The 8 Step Problem Solving Model, now adopted by the AF, can help simplify the configuration management dilemma. The eight steps are:

1. Clarify and validate the problem

    a. Recognize the correct problem using tools such as: "Go and See", Value Stream Mapping, Voice of Customer. Recognize how the problem aligns to the SA&D (Strategy, Alignment and Development Plan).

    b. State the problem by identifying when, where, how and the significance of problem.

2. Breakdown the problem and identify performance gaps
    a. Gather and review key data by using tools such as: gap analysis, value vs waste analysis and SWOT (Strengths, Weaknesses, Opportunities and Threats) Analysis

    b. Understand which metrics or goals in the SA&D are not being reached.

3. Set improvement targets

    a. Strategic, Tactical Targets

    b. Consider breakthrough objectives as target – these are the long range goals on the SA&D.

    b. Tools: Ideal-state and Future-State Mapping

4. Determine root causes

    a. Ensure the root cause of the problem is addressed and not only the symptom/s.

        1. 5 Whys is a good tool to identify the root cause; when the last 'why' is answered, ensure *this* is the root cause by repeating the answers of the why's backwards with 'therefore'

        2. Brainstorming is a great tool to begin root cause analysis because it narrows the focus of the problem however, usually other tools such as 5 Whys or a Fishbone Diagram is needed.

        3. Cause and Effect Diagram (Fishbone) is a great tool for root cause analysis, especially for difficult problems; additionally, it helps determine the data gaps.

5. Develop countermeasures (pick a solution)

    a. Analysis of Alternatives using a PICK (Possible, Implement, Consider, Kill) chart helps to prioritize the countermeasures.

    b. Action Plans should include a specific point of contact, estimated completion date and should address the performance gap.

6. See countermeasures through (implement the solution)

    a. Collect Data to ensure the countermeasures of the new process are working.

    b. Provide training

7. Confirm results and process

    a. Review and reassess the solution

    b. If not meeting targets, consider returning to Step 4

8. Standardize successful processes (follow up)

    a. Standardize such as in Tech Orders or instructions.

b. Document and disseminate successful processes so others can benefit.

b. Restart OODA Loop

Let's look at a couple examples where configuration management issues caused problems.

On 30 August 2007 there was an unauthorized transfer of nuclear warheads between Minot Air Force Base, North Dakota, and Barksdale Air Force Base, Louisiana. A B-52 aircraft left Minot with nuclear-capable cruise missiles loaded on one of its pylons unbeknownst to the crew. This situation was enabled by elimination of several levels of verification by the Minot munitions maintenance squadron in accordance with local changes in nuclear handling processes and procedures. In addition, there was no written directive that specifically described the required identifying means, making visual detection of a nuke, conventional, or dummy bomb difficult at best. The latter practices were allowed to migrate away from those formerly identical to Intercontinental Ballistic Missile (ICBM) warhead handling procedures; which remained stringent, and are still practiced in parallel at Minot to handle ICBM warheads. The procedural configuration changed, unchecked by oversight during a period of more than a decade following the Cold War, under the auspices of ideas such as the "value added" savings gained by decreasing processing time. Having used the 8-step process would have helped focus the problem, understand how the current process was failing and eventually standardizing successful processes and would likely have saved the day. Having a documented goal of configuration management and follow-up to maintain successful practices and stable processes would have maintained the "why" for marking the bombs in the first place and would have helped inspection teams keep them on track.

So maybe configuration management is important to air and nuclear operations today, but "space is different", right? After all, the nuke mission doesn't reside with the space world anymore. Well, let's discuss the *Mars Climate Orbiter*, September 23, 1999. The Mars Climate Orbiter's signal was lost during Mars Orbital Insertion 49 seconds before the expected occultation loss of signal and the signal was never recovered.

> "On September 29, 1999, it was discovered that the small forces '*Delta*' V's 'velocity changes' reported by the spacecraft engineers for use in orbit determination solutions was low by a factor of 4.45 (1 pound force=4.45 Newtons) because the impulse bit data contained in the AMD file was delivered in lb-sec instead of the specified and expected units of Newton-sec" (Mars Climate Orbiter Mishap Investigation Board, 1999, p. 13).

It seems space is just as susceptible to configuration management issues. There were several opportunities to mitigate the mishap; however, ad hoc operations and program management (which bypasses configuration management policy) fostered haphazard rules of engagement, and decreased the probability of mission success. Steps 5 thru 7 of the 8-step problem solving process are of particular interest here (this is not saying anyone should bypass Steps 1-4). These steps are focused on documented action plans that have the responsible agents checking progress

and verifying results on a consistent basis. A simple difference in units would likely have been caught by the use of accepted configuration management practices.

Hopefully now you're convinced that configuration management is vital to system safety and using a defined process for solving problems and improving processes/systems is important to today's AF. If you're in AFSPC you'll be using the 8-step process. If not, hopefully you'll adopt the approach that's been outlined. For the full technical paper, please visit the AFSC CoP at https://wwwd.my.af.mil/afknprod/ASPs/CoP/EntryCoP.asp?Filter=OO-SE-AF-01.