"GSFC FSB Application of Perspective-Based Inspections"

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"GSFC FSB Application of Perspective-Based Inspections": Overview

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Introduction

The "GSFC FSB Application of Perspective-Based Inspections" Research Infusion Collaboration was performed by the Fraunhofer Center -- Maryland under Grant NAG5 12556. The Project was a joint effort at the National Aeronautics and Space Administration (NASA) Goddard Space Flight Center with participation from the Flight Software Branch, including Branch Head Elaine Shell, Mike Tilley, and other personnel.

The "GSFC FSB Application of Perspective-Based Inspections" Final Report describes the collaboration and documents the findings, including lessons learned.

Problem statement

Our primary objective was to produce Branch-baselined process standards for software inspections, which could be used across three new missions within the Flight Software Branch. The standard was developed using the Perspective-Based Inspection approach, then tested on a pilot Branch project. Based on our experiences on the pilot, we would decide whether the standard was suitable for roll-out to other Branch projects.

The relatively short time scale for this collaboration meant that we would not be able to directly measure the reduction in rework effort (expected because improved defect detection guidelines will result in increased phase containment). Instead, within this timeframe we relied on a more qualitative measure: Whether or not the standard received high ratings from Branch personnel as to usability and overall satisfaction.

The project used for piloting the tailored Perspective-Based inspection approach was the Core Flight Executive (cFE), a reusable multi-mission framework that will provide a flight software (FSW) operating environment and a set of services that host and support FSW applications.

Application of the technology to the target project

The perspective-based approach was applied to produce an inspection procedure tailored for the specific quality needs of the Branch. The technical information to do so was largely drawn through a series of interviews with Branch personnel, each of less than an hour. As a result, a set of the key perspectives was created (i.e. which technical viewpoints need to be represented during the inspection), along with a specific quality focus for each.

Due to the relative complexity of the Perspective-Based inspection standard produced and the desire to get buy-in from Branch personnel, we did not enforce the use of the standard all at once. Instead, we advocated its use over a series of cFE requirements inspections. At each inspection, a member of the technology infusion team was present and charged with understanding which parts of the standard were being followed and which were dropped, and observing the effects of both aspects. Observing its use over a series of inspections gave us an opportunity to allow the Branch personnel to not feel overly restricted in using the standard but to follow the recommendations that made sense to them and then to understand the effects of following or not following the various guidelines. Over time, we have seen more and more of the guidelines adopted by the cFE inspection team and feel we are well-positioned for further usage by our three target Branch projects.

There were no negative effects of the technology that in any way impacted our ability to achieve our cFE project deliverables. On the contrary, the inspections were useful for showing problems with our current approach on the cFE pilot project, which led to changes in the development project plan.

Data Collection and Analysis

Over the time period of this grant, we relied primarily on qualitative measures: How Branch personnel rated the standard, and whether it was adopted at the Branch level. We also collected quantitative data for monitoring whether the effects of the perspective-based technique were within acceptable limits. We intend to continue our collaboration with the technology infuser (Dr. Shull) past the end of this grant, to allow a more rigorous quantitative evaluation to be done.

Qualitative Measures. *Did the development team (branch head and project representatives) give a positive rating for products delivered by the technology infusion team?* This is by nature a subjective, qualitative measurement. The standard produced during this collaboration went out to Branch project representatives in two rounds of reviews, which yielded the following:

- In the first round, the eight Branch personnel who reviewed the perspective-based standard had no changes to request. One said: "I really like the guide and wish I had it for past reviews!"
- In the second round, the standard was disseminated more broadly; feedback identified important changes to be made. Analysis by Branch personnel of the feedback revealed that the primary issue was that the perspective of Attitude Control System (ACS) developers was not adequately represented. We feel however that this problem was a result of the specific personnel chosen for Dr. Shull to interview, in which ACS personnel were not represented, rather than a deficiency in the inspection approach itself. We feel that this deficiency is easily correctable.

For what it's worth, we also report that our independent CMMI lead assessor was extremely positive about the inspection standard and asked to take it as an example of good process documentation.

Were the guidelines produced by the technology infusion team adopted as Branch standards? At this time, we have not included the perspective-based standard as part of the approved Branch standards since 1) Some rework was identified as needing to be done (described above), and 2) We decided that there was a need to better synchronize the roll-out of new Branch standards, including the inspection standard as well as others outside the scope of the technology infusion project.

However, we in the Branch see no problems with the inspection standard itself that would prevent its roll-out and we expect it to happen in the near future. As Branch Head, I have been involved in reviewing the standard during several phases of its construction and am quite happy with the overall direction and the progress to date.

Quantitative Measures. We also collected quantitative metrics during the four cFE requirements inspections in which the perspective-based standards were applied. We determined that the inspection rate during the meetings (i.e., how much of the requirements document could be inspected in a given time) met typical norms for NASA project environments (as specified by the "NASA Formal Inspections Training," created by Dr. John Kelly). The above data shows that the use of the perspective-based standard developed on this project does not impose additional costs in terms of increased meeting time.

We analyzed the Requests for Action (RFAs) generated by the requirements inspections to understand in which areas the defects were concentrated. Defects of "missing functionality" were by far the largest category; defects of "extraneous" (i.e. over-specified) functionality were also found. Together, these defects made up 75% of the total found. This result makes for an interesting comparison with an earlier analysis we did of change requests on previous Branch projects, in which missing/extraneous functionality formed a small minority of the total set. This result is consistent with the unique difficulties of the cFE project (namely, designing a system for maximum reusability rather than to support a specific mission), and may indicate corroboratory evidence that the inspection techniques were able to address the quality needs of the project.

Summary and Lessons Learned

The upfront tailoring process that was used in the perspective-based approach turned out to be crucial. The small effort spent on interviews and past defect history seemed to help improve effectiveness and relevance and help get buy-in from Branch personnel – by showing that the guidelines were relevant for Branch concerns.

Although the technique has not yet become a Branch standard (for reasons unrelated to the technique itself), it will be the core of whatever standard we do eventually adopt. We feel that we need only an incremental fixing process to make the current perspective-based standard suitable for adoption by the Branch.

We have already addressed the primary challenge we encountered, which was due to not fully considering all of the technical perspectives that really should have been included. We note that the perspective-based approach *does* seem to have been effective at achieving the buy-in of the Command and Data Handling (C&DH) personnel who were included in the upfront work. The lesson to be learned from this, we feel, is that it is extremely crucial to consider *all* interested stakeholders in the tailoring process, and to check whether assumptions about which technical roles have similar interests in the inspection process are in fact true.

Table of Contents

1.0 INTRODUCTION **5**

1.1 PROBLEM STATEMENT 5
1.2 TARGET PROJECT 5
1.3 COLLABORATION SCOPE 6
1.4 APPLICATION OF THE TECHNOLOGY TO THE TARGET PROJECT 7

2.0 METHODOLOGY **8**

3.0 DATA COLLECTION AND ANALYSIS **10**

4.0 SUMMARY AND LESSONS LEARNED **13**

5.0 ACRONYMS AND DEFINITIONS **15**

1.0 Introduction

The "GSFC FSB Application of Perspective-Based Inspections" Research Infusion Collaboration was performed by the Fraunhofer Center -- Maryland under Grant NAG5 12556. The Project was a joint effort at the National Aeronautics and Space Administration (NASA) Goddard Space Flight Center with participation from the Flight Software Branch, including Branch Head Elaine Shell, Mike Tilley, and other personnel.

The "GSFC FSB Application of Perspective-Based Inspections" Final Report describes the collaboration and documents the findings, including lessons learned.

1.1 Problem Statement

The primary objective of the Project was to produce Branch-baselined process standards for inspection-related activities, which could be used across three new missions within the Flight Software Branch. A pilot application of these standards had the objectives of:

- Showing that the Perspective-Based approach could incorporate relevant lessons learned from past Branch inspections and defect history;
- Demonstrating the usefulness and feasibility of the Perspective-Based standards to Branch personnel and obtaining their buy-in;
- Using the experiences from the pilot to refine the standards and increase their effectiveness.

As discussed in our original proposal, the relatively short time scale for this collaboration meant that we would not be able to measure the reduction in rework effort (expected because improved defect detection guidelines will result in increased phase containment – i.e. defects are less likely to slip from one phase to the next, and are much more likely to be caught before the testing phase, when they are the most expensive to correct). Instead, within this timeframe we relied on a more qualitative measure: Whether or not we received high ratings from Branch personnel as to the usability of the standards, and their satisfaction with the output produced.

A secondary objective of our collaboration was to define and put in place the necessary metric collection mechanisms, which would allow us to undertake a more rigorous quantitative analysis of the inspection techniques over the lifetime of the pilot project.

1.2 Target Project[1]

The project used for piloting the tailored Perspective-Based inspection approach was the Core Flight Executive (cFE). The cFE is a reusable framework that will provide a flight software (FSW) operating environment and a set of services that host and support FSW

[1] Most of the information in this section is taken from the Core Flight Executive requirements document, written by Dave McComas.

applications. By providing a multi-mission general-purpose software solution that supports variable hardware platforms, cFE will allow a broad range of future FSW applications to be built with less effort.

Since cFE is a general-purpose software framework, not designed for a particular mission, cFE has all of the usual challenges faced by NASA software development efforts as well as some unique ones. First, the cFE must specify up-front requirements for FSW functions that have traditionally been left to the designers. Second, the cFE contains many interfaces that are intended to be standardized for multiple missions. Finally, certain functionality to be included in the cFE requirements contain mission-defined and/or optional features.

Validating cFE through testing would require the development of a wide range of test applications and could only be done relatively late in the lifecycle. For this reason, the use of early-lifecycle inspections was felt to be especially crucial for this project with respect to exposing multi-mission assumptions and constraints to effective scrutiny.

1.3 Collaboration Scope

The scope of work described in our proposal consisted of developing inspection standards targeted to Branch-specific types of defects (gained from analysis of Branch project defect histories), and including Branch-relevant perspectives and questions to guide defect detection. The tailored inspection guidelines were to be applied on real Branch projects with support as needed from the technology infusion team. This still accurately describes the scope of work performed.

It was originally proposed that the Perspective-Based inspection standard would be applied on three projects within the Branch: GPM, JWST, and SDO. Rather than apply the proposed standard to all three, we inserted a new step, in which the standard was instead applied on a single pilot project, cFE (described above). This decision was a good match for the Branch goals since, due to the "design for reuse" nature of cFE, inspections played an even more crucial than usual role in that development process. Also, since cFE is being designed to provide general-purpose functionality, key representatives from our target projects were involved in inspections of cFE to provide perspectives from different missions. In this way, they could get some exposure to and the chance to provide feedback on the proposed standards before applying them on their own projects. The Branch-baselined standards will still be applied on GPM, JWST, and SDO, although outside the time frame of this funding.

Finally, we originally proposed using the analysis of Branch defect sources to indicate in which phases Perspective-Based inspections could provide the best potential for future improvement, although experience on previous Branch projects suggested that our efforts would likely be focused on requirements and code inspections. In the actual work, we focused exclusively on requirements inspections, as this was the highest-priority work currently being done on our cFE pilot project.

As stated in the original proposal, due to the short timeframe of this collaboration, benefits due to the technology infusion are being measured via:

- Development team (branch head and project representatives) giving a positive rating for products delivered by the technology infusion team;
- Adoption of guidelines produced by the technology infusion team at the project level.
- Inclusion of the final, tested guidelines produced by the technology infusion team for use in the Branch standards.
- The use by project personnel of data collection mechanisms suggested by the technology infusion team, so that the quantitative project metrics can be analyzed at a later date.

However, over the lifecycle of the Branch projects (outside the timeframe of this funding), mechanisms have been put in place to measure benefits in (1) lower defect density of software artifacts throughout the lifecycle, and hence (2) fewer defects found during testing and (3) less time spent on reworking defects.

1.4 Application of the technology to the target project

Due to the relative complexity of the Perspective-Based inspection standard produced and the desire to get buy-in from Branch personnel, we did not enforce the use of the standard all at once. Instead, we advocated its use over a series of cFE requirements inspections. At each inspection, a member of the technology infusion team was present and charged with understanding which parts of the standard were being followed and which were dropped, and observing the effects of both aspects. Observing its use over a series of inspections gave us an opportunity to allow the Branch personnel to not feel overly restricted in using the standard but to follow the recommendations that made sense to them and then to understand the effects of following or not following the various guidelines. Over time, we have seen more and more of the guidelines adopted by the inspection team and feel we are well-positioned for further usage by our three target Branch projects: GPM, JWST, and SDO.

The remainder of this section is organized around the specific points we were asked to address in this report.

a. Did the project proceed according to the plan, including schedule?

No schedule delays were introduced due to using the Perspective-Based inspections. However, due to the results of the inspection meetings it was decided to put more Branch personnel effort into a restructuring of the requirements document, in addition to making the more specific changes that were also suggested by the inspection team members.

b. How much time was required to introduce and apply the technology?

The majority of extra development team effort was spent on the upfront tailoring of the technology to the Flight Software Branch, as described in Section 2.0. The extra effort imposed for the introduction of the technique was limited to the inspection participants reviewing the documentation of the inspection standard. (Since Branch personnel already had experience with non-Perspective Based inspection processes, we did not feel that a dedicated training session was required.) Branch personnel began applying the Perspective-Based approach in the cFE inspections, with observations and recommendations made afterwards by the technology infusion team. These inspections did not take appreciably longer than ones using a more traditional approach (see Section 3.0).

c. What risks, including those you specified in Section 7, Management Plan, of your proposal, plus any others) needed to be addressed, what mitigation strategies were applied, and were they successful?

The primary risk identified in the proposal was that too much effort might be required by the development team for non-development tasks. This threat was mitigated by 1) Allowing the infusion team to provide suggestions based on ongoing use of the Perspective-Based standard on real inspections of real development artifacts, rather than taking upfront time for training; 2) Not enforcing 100% process conformance to the standard in the beginning, but allowing Branch personnel to adopt those recommendations over time.

d. Evaluate the responsiveness of the technology vendor. Did the vendor provide the materials, training and user support in a timely manner?

The technology infuser was appropriately responsive. The Branch was happy that Dr. Shull was able to adapt the work to the scheduling needs of the Branch and the pilot project.

e. Were you successful in meeting your deliverables on schedule? If not, indicate why not.

Regarding the planned deliverables of the technology infusion, the Branch and research infusion team jointly decided to change the deliverables and due dates to better suit the needs of the Branch and pilot project. (See Section 3.0 for detailed information on this.)

Regarding the deliverables of the pilot development project, no project deliverables were missed due to any negative effects of the technology. Some of the inspections were useful for showing problems with our current approach on the cFE pilot project, which led to changes in the development project plan.

2.0 Methodology

Broadly speaking, the Perspective-Based inspection approach was first tailored to the FSB, then codified in a suitable format for a Branch standard, then introduced and piloted on cFE. Our collaboration proceeded through the following activities:

1. Reviewed Branch data collection guidelines and recommended changes based on data that would have to be collected throughout the project lifecycle to adequately evaluate the research technology. To do so, Dr. Shull reviewed our procedures for handling Discrepancy and Change Reports on Branch software development projects, to see if there were any metrics needed to evaluate the inspection techniques that were not already being collected.
2. Analyzed Branch-specific defect sources, from project defect histories, in order to better focus the inspection techniques. Dr. Shull and his colleagues at FC-MD analyzed the change reports generated over the development lifetime of Swift BAT, a previous Branch project. This gave us a list of the types of problems typically seen on Branch projects, and hence an initial set of defect types on which the inspection procedure should focus.

3. Proposed a first set of Branch-specific perspectives, identifying key stakeholders who should be represented in any inspection in the Branch, that should be accounted for in the standard. This was done via initial conversations among Branch representatives Elaine Shell (Branch head) and Mike Tilley, other GSFC personnel (Mike Stark), and Forrest Shull, representing the technology infuser. These conversations resulted in identifying two initial perspectives: developer and tester.
4. Refined the set of perspectives and targeted defect types through interviews with Branch personnel. This was done through five interviews, each of less than an hour, with personnel recommended by Elaine Shell. The result was to add a third perspective, representing experts in hardware or other product interfaces, and to add detail to the inspection guidelines for each perspective.
5. Finalized the first draft of the inspection standard, through revisions suggested by Elaine Shell.
6. Provided the standard to Branch personnel for comment.
7. Held four cFE inspection meetings, with a member of the "infusion team" (either Forrest Shull or Mike Stark) present at each. In all cases Requests for Action (RFAs) were obtained and analyzed afterwards.
8. Analyzed RFAs generated during the inspections to analyze defect sources, for future improvements to the focus of the inspection techniques.

3.0 Data Collection and Analysis

This section is organized around the specific points we were asked to address in this report.

a. **What benefits were observed, including, but not limited to, those described in Section 8, Metrics, of your proposal?**

Qualitative measures.
The metrics described in Section 8 of our proposal as suitable for the timeframe of this collaboration were introduced in Section 1.3 of this report. Here we describe our experiences in each of those areas.

Development team (branch head and project representatives) giving a positive rating for products delivered by the technology infusion team. This is by nature a subjective, qualitative measurement. The standard produced during this collaboration went out to Branch project representatives in two rounds of reviews, which yielded the following:

- In the first round, of the eight Branch personnel asked to review the Perspective-Based inspection standard, none had any changes to request. One said: "I really like the guide and wish I had it for past reviews!"
- In the second round, the standard was disseminated more broadly; feedback identified important changes to be made. Analysis by Branch personnel of the feedback revealed that the primary issue was that the perspective of Attitude Control System (ACS) developers was not adequately represented. We feel however that this problem was a result of the specific personnel chosen for Dr. Shull to interview, in which ACS personnel were not represented, rather than a deficiency in the inspection approach itself. We feel that this deficiency is easily correctable.

For what it's worth, we also report an additional qualitative response from personnel not employed directly by the Branch: Our independent CMMI lead assessor was extremely positive about the inspection standard and asked to take it as an example of good process documentation.

Adoption of guidelines produced by the technology infusion team at the project level. Inclusion of the final, tested guidelines produced by the technology infusion team for use in the Branch standards. At this time, we have not included the perspective-based standard as part of the approved Branch standards since 1) Some rework was identified as needing to be done (described above), and 2) We decided that there was a need to better synchronize the roll-out of new Branch standards, including the inspection standard as well as others outside the scope of the technology infusion project.

However, we in the Branch see no problems with the inspection standard itself that would prevent its roll-out and we expect it to happen in the near future. As Branch Head, I have been involved in reviewing the standard during several phases of its construction and am quite happy with the overall direction and the progress to date.

The use by project personnel of data collection mechanisms suggested by the technology infusion team, so that the quantitative project metrics can be analyzed at a later date. Dr. Shull analyzed the current Branch policies for Discrepancy and Change Reports in May 2004 to ensure that defects and problems found in downstream development phases could be traced back to their starting point. A few minor modifications were recommended and the forms and database updated as a result. As a result we will be able to trace any future problems on the project to their origin and understand if they should have been caught by the Perspective-Based inspections or not. Having these data collection mechanisms in place allows us to develop a more quantitative and rigorous evaluation of the Perspective-Based inspection standard.

Quantitative measures. We also collected quantitative metrics during the cFE requirements inspections in which some (although not all) of the perspective-based standards were applied. We determined that the inspection rate during the meetings (i.e., how much of the requirements document could be inspected in a given time) met typical norms for NASA project environments: Based on literally hundreds of inspections at JPL and GRC, the recommended rate for NASA requirements inspections is 10 to 30 pages in a 2-hour meeting.[2] The four inspection meetings for cFE covered:

- 18 pages in 3.5 hours
- 14 pages in 3 hours
- 12 pages in 2.5 hours
- 12 pages in 2.5 hours

The above data shows that the use of the standard developed on this project does not impose additional costs in terms of increased meeting time. The page rate for each inspection was about 5 pages per hour, at the low end (although not outside) of the recommended range of 5 to 15 pages per hour cited above. This was likely a combination of getting used to the inspection procedures as well as the unusual nature of the cFE project (i.e., designing for reuse). Much of the time in earlier inspections was spent discussing the range of possible future missions that should be supported by cFE, which was a necessary prerequisite before the requirements themselves could actually be reviewed. Over time, based on earlier experiences, we made more of an effort to keep inspection meetings to around two hours duration, in line with the standard.

The cFE requirements inspections also resulted in major technical defects being recorded in the following categories:

- 18 of type "missing functionality": Important functionality that should be provided by the cFE has not been described.
- 4 of type "extraneous functionality": Functionality was described that is likely not needed by future applications and/or is infeasible to provide.
- 4 of type "data format": The definition of the format of data handled by the cFE is either missing or incorrect with respect to knowledge about application needs.
- 2 of type "incorrect functionality": The functionality as described in the document is not likely to be appropriately reusable for future applications.

[2] Documented in the "NASA Formal Inspections Training," developed by Dr. John Kelly.

- 1 of type "inconsistency": Functionality or formats for similar items are not consistently described, so it must be decided which if any of the usages are correct.
- 1 of type "hardware": Assumptions regarding the hardware on which cFE will run were not documented, so that the feasibility of requirements cannot be validated.

As can be easily seen, "missing functionality" was by far the largest category; an additional four defects of "extraneous" (i.e. over-specified) functionality were also found. Thus 22 out of 30 defect discoveries had to do with trying to adequately define a sufficiently reusable set of functionality to make cFE sufficiently able to support the range of future missions. This result makes for an interesting comparison with the earlier analysis of Swift BAT defects, in which such defects were only a small minority over the life of the project (namely, 4 out of the 24 requirements-related defects detected). This analysis highlights the difficulty of designing systems for maximum reusability rather than to support a specific mission. An implication of this result may be that we should consider creating a cFE-specific variant of the inspection guidelines that could specifically target such issues.

Tailoring and comparison to other Perspective-Based inspection guidelines. To check the results of the tailoring process that produced the FSB perspective-based inspection guidelines, it is useful to compare to other tailored inspection guidelines that have been produced for NASA projects. Two other sets of perspectives have been created specifically for requirements inspections: An early version in 1994, developed by the University of Maryland in cooperation with GSFC, was intended to be "generic," i.e. reusable by many different NASA projects. Another version was developed for the United Space Alliance (USA) in 2004 (also done on technology infusion funding).

Two of the perspectives created for the Flight Software Branch (tester and developer) correspond to similar perspectives used in both the GSFC and USA techniques. The third FSB perspective (expert in hardware or other product interfaces) was unique to the Branch. This was not unexpected, since Branch projects by necessity have to reflect more of a systems engineering viewpoint so that the software produced is appropriately coordinated with the overall satellite mission. (In contrast, the USA techniques were designed for development of space station simulation software, which did not have tight constraints for interoperability with other hardware or software being developed in tandem.)

At a more detailed level, we also classified the types of quality issues addressed by the guidelines according to the following taxonomy. These definitions are based on the quality standard ISO/IEC 9126 and then refined for the purposes of inspections. Text in quotes are taken directly from the ISO standard.

- Clarity: The ability of the software product to support a unique implementation of the final software, including absence of ambiguity.
- Feasibility: The capability of the system *as specified* to be implemented within the known capabilities and limitations of the system and its environment. Includes both technical aspects (is it possible to achieve the given function with the hardware specified) and organizational/process aspects such as prioritization or increment

definition (is a workable engineering strategy imaginable that could implement the system in reasonable cost).

- Functionality: "The capability of the software product to provide functions which meet stated and implied needs when the software is used under specific conditions." Also includes suitability (appropriateness of the functions to fulfill user tasks), accuracy (correctness).
- Maintainability: "The capability of the software product to be modified" including corrections, improvements, or adaptations. Includes understandability.
- Reliability: "The capability of the software to maintain a specified level of performance [and required functionality] when used under specified conditions." This includes robustness (fault tolerance) and recoverability.
- Testability: The capability to derive valid and useful test cases from the software product, supporting the ability to run these test cases in the test environment at hand.
- Traceability: The capability to identify dependencies among parts of system artifacts.

The FSB techniques addressed all of the above quality attributes. Most of these are in common with the other two sets of tailored techniques. However, the focus on maintainability and traceability were unique to the FSB set. This also should not be surprising, since the cFE project testbed on which we applied the techniques was designing a reusable system that could support many future missions. Thus, an emphasis on maintainability (making sure it was easy to be understood by developers on future missions, as well as appropriately modular to facilitate operating with future mission-specific functionality) as well as traceability (making sure that specific requirements were traced to the high-level goals for functionality to be provided) make good sense in the overall quality context of the project.

Finally, a few of the inspection questions were added to account for particular technical areas that may not be as relevant for non-Flight Software projects, specifically, asynchronous event handling and telemetry.

b. **Which benefits from Section 8 were not observed? What negative impacts on the project, if any, were there? For example, "Our most experienced developer spent 20 hours of her time debugging the installation script before the tool could even be applied".**

We didn't really see any negative impacts as a result of this collaboration. The 5 hours total spent by Branch developers and testers on the interviews seemed a good investment considering that the standard was well received, at least among the group who took part in this upfront work. We are confident that the effort needed to respond to the feedback from the ACS group will entail a similarly low investment of Branch personnel effort.

4.0 Summary and Lessons Learned

This section is organized around the specific points we were asked to address in this report.

a. **Evaluate the effectiveness of the technology for your application. Address any success criteria you had established in your proposal or at the start of the project.**

The effectiveness of the technology – as evaluated using the mainly qualitative metrics described in our proposal – was described in Section 3.0. Although the technique has not yet become a Branch standard (for reasons unrelated to the technique itself, as was also discussed in Section 3.0), it will be the core of whatever standard we do eventually adopt. We feel that we need only an incremental fixing process to make the current perspective-based standard suitable for adoption by the Branch.

Both the Branch and the technology infusion team are looking for additional funding that will allow the more rigorous, quantitative evaluation to continue using the metrics collection mechanisms that were put in place as part of the infusion project.

b. **Do you plan to continue to use the technology in your group on this and future projects in the absence of Research Infusion funding?**
    a. **If so, characterize the benefits *vs.* resources required to use the technology that lead you to adopt it.**
    b. **If you do not plan to continue to use the technology, why not?**

As stated in previous sections, we fully intend to roll out the inspection standards in the near future for continued use on cFE and future Branch projects. We in the Branch have been quite comfortable with Dr. Shull's observation and feedback on our pilot project and feel that we have gotten some value already in our interaction.

c. **Do you plan to recommend the technology more broadly; for example, inclusion in your division's, or Center's (company's) software development practices?**

Once it has been accepted by our Change Control Board, which we envision requires only the minor rework already described, the standard will be used by projects across the Branch.

d. **What adoption or use challenges did you encounter? Do you foresee challenges for more widespread use of the technology?**

We have already addressed the primary challenge we encountered, which was due to not fully considering all of the technical perspectives that really should have been included. We note that the perspective-based approach does seem to have been effective at achieving the buy-in of the Command and Data Handling (C&DH) personnel who were included in the upfront work. The lesson to be learned from this, we feel, is that it is extremely crucial to consider *all* interested stakeholders in the tailoring process, and perhaps spending some effort on checking whether assumptions about which technical roles have similar/different interests in the inspection process are in fact true.

e. **What factors do you think aided the adoption and use of the technology?**

Tailoring the inspection standard through interviews and past defect history seemed to help improve effectiveness and relevance and help get buy-in from Branch personnel – by showing that the guidelines were relevant for Branch concerns.

f. Can you offer any suggestions for improving the technology? What changes in the technology would make it more usable to you?

We have not found any major problems. Our experiences certainly show the necessity of spending time upfront on a thorough analysis of stakeholders and perspectives.

We may have additional recommendations from later use of this technique.

g. Can you offer any suggestions for improving the introduction of the technology? For example, help on identifying the right applications for it; changes to the training course; more consulting time by the vendor during technology introduction.

No recommendations at this time.

h. Describe the contexts, if any, for which you would recommend the technology. Consider not only the technical match but other factors as well, for example, the capabilities of the developers or the size of the project, that make the technology match the application. Also, list indicators for not applying the technology.

We feel that the current version of the standard is a valuable resource for C&DH development activities. Due to feedback from Branch personnel, we know that it is not *currently* suitable for ACS inspections. However, we see no reason why the methodology applied to date would be unable to correct this if ACS personnel are included in the development of a fuller perspective-based standard.

5.0 Acronyms and Definitions

ACS	Attitude Control System
BAT	Burst Alert Telescope
C&DH	Command and Data Handling
cFE	Core Flight Executive
FSB	Flight Software Branch
FSW	Flight Software
GPM	Global Precipitation Measurement
JWST	James Webb Space Telescope
RFA	Request for Action
SDO	Solar Dynamics Observatory
USA	United Space Alliance