Air Traffic Management Technology Demonstration – 1 (ATD-1)

RTMA Source Code Change Analysis

ATD1-SourceCodeAnalysis-201406-Rev2

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This document is part of the ATD-1Technology Development Activity documentation, controlled by the ATD-1 Change Control Manager at NASA Ames Research Center, Moffett Field, California. Aeronautics Directorate, Aviation Systems Division.

Revision History

Rev	Date	Sections Affected	Description of Change	Author
-	09/20/2013		Baseline document	Michelle Eshow
2	06/17/2014	All	Updated with current software metrics	Michelle Eshow

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1 Introduction

This document provides information on the magnitude of code changes made to the RTMA baseline to implement the ATD-1 Terminal Sequencing and Spacing (TSS) capabilities that were tested by NASA and the FAA in multiple human-in-the-loop (HITL) simulations.

The ATD-1 code change statistics presented here were extracted from a comparison of the ATD-1 changes to RTMA versus the RTMA 3.12 baseline. RTMA 3.12 in turn was derived from TMA version 3.12; it was modified to run in the Linux environment used by NASA. There were no intentional functional changes when moving from TMA 3.12 to RTMA 3.12; the only changes were to make the code operate correctly in the NASA Linux environment.

This analysis compares the RTMA 3.12 baseline achieved when the code was fully functional on Linux, versus the ATD-1 version. The ATD-1 code version analyzed was pulled from the *atd1* branch of the open-source 'git' version control system on 17 June 2014. The *atd1* branch reflects the end state of the code after the FIAT-4 HITL simulation, with some preparation for the FIAT-5 HITL simulation.

For readers who have access to the git repository of RTMA 3.12, the two commit identifiers used for the code comparisons in this document are:

- acdda2c0d47dd88a8a770cc6db1755957b9f9d21 (*dev* branch starting point in git, RTMA 3.12)
- c798c5340148a2732a76ac548ea1321fa99b12a1 (*atd1* branch as of 23 June 2014)

The analysis presented in this report comes from the commercial Understand tool from SCI Tools (http://www.scitools.com/). The tool was run on the two end point states noted above, and the results compared in a simple delta fashion. The comparison is valid under the assumption that no functionality was removed from RTMA 3.12 – functionality was only added. Therefore, for example, if the net number of functions in a process increases by 10, we can be confident there were 10 new functions added, not 5 deleted and 15 added.

The nature of the code changes is not described in detail here other than to note the biggest source of changes in each directory. The changes are detailed in the functional descriptions being delivered in other documents of the ATD-1 technology transfer package. These metrics are intended simply to support cost estimation activities for ATD-1 technologies, in particular the TSS functionality.

2 RTMA Source Code Changes

For every code directory that was modified between RTMA 3.12 and the ATD-1 end state as of 17 June 2014, Table 1 presents the change in source lines of code (SLOC) and in total number

of functions. The definition of a SLOC is the 'CountLineCode' metric from SciTools. An example of how this metric is defined is here: http://www.scitools.com/blog/tag/countlinecode . Comments, pre-processor directives (#define) and blank lines are not included in the SLOC metric.

Table 1 – RTMA SLOC Changes for ATD-1/TSS

Process or Directory Name	New SLOC	New Functions	Language	Primary Changes (not exhaustive)
ADIF	1072	44	C	STARS interface
CM	2784	73	C	Message Processing
DP	2305	46	C	Terminal Scheduling
IS	389	24	C	HDIF/Center Interface
ISM	648	14	C/C++	Flight plan, RNP processing, STARS interface
PGUI	616	29	C	Slot marker, PFSE trajectory display
RA	706	14	C	TRACON trajectory processing
TGUI	115	6	C	
TS	1634	19	C++	RNP and TRACON trajectory processing
COMMON/API	305	4	C/C++	Trajectory archiving, thread-safe time, STARS interface, adaptation interface
COMMON/IMPL	4144	187	C/C++	Trajectory archiving, thread-safe time, STARS interface, adaptation interface
COMMON/RA	5071	123	C/C++	ATC procedures, route capture logic, PFSE integration
TOOLS	209	0	C	
UTIL	559	0	C	Message structures, internal structures
PFSE (new process)	17,938	957	C/C++	New process to generate TSS advisories
TOTAL	**38,495**	**1540**		

As indicated in Table 1, the total new SLOC added to RTMA to achieve the TSS capability was approximately 38,500 in 1540 new functions across ten processes and four libraries. A new process was added, called PFSE (Profile Selector – En Route) that represents about half of all the new code added (nearly 18,000 SLOC). This PFSE is scaled down from the one in the NASA CTAS baseline. All unnecessary classes were removed in the process of porting PFSE to RTMA. The PFSE is similar in purpose to the Schedule Problem Prediction and Resolution (SPPR) being deployed to support the GIM-S function of TMA. PFSE generates advisories that are sent to the STARS displays of TRACON controllers.

While the lines of comments metric is not listed above, the Understand analysis indicates nearly 39,700 lines of comments were added to RTMA for ATD-1, or roughly one line of comments per additional line of code.

3 Adaptation Changes

Adaptation changes were also required to implement the TSS functions of ATD-1. ZAB was the test site for TSS development in the RTMA baseline, so it is the adaptation set analyzed here. Similar changes were made to ZLA and ZFW for ATD-1 HITL simulations conducted using NASA TMA, prior to moving the TSS functionality to RTMA. Those adaptation set changes are not presented here. Following in Table 2 are the primary files that were changed or added in the ZAB adaptation set, versus a typical TMA adaptation. These changes were implemented in the ZAB/P50/system directory, since P50 is the TRACON for PHX, the test airport. Changes to the GUI default files are not included, since those would be specific to the system's users. These changes were derived via use of the 'git diff --numstat' command in the git adaptation repository.

Table 2 – RTMA Adaptation Lines Added or Deleted for TSS

File	Lines Added or (Deleted)
analysis_categories	(1250)
category_definitions	(1850)
configurations	500
meter_reference_points	120
dp_options	20
atc_proc_tree (new)	250
atc_proc_definitions (new)	170
TOTAL	**4160**

As shown in the table, the analysis categories were greatly simplified for the ATD-1 effort, with most categories for flights in the CENTER-TRACON and TRACON areas removed. This was done because the TRACON routing for ATD-1 needs to be determined by the atc_proc_tree

categories. This simplification may or may not be relevant for a deployed system. Also, the routes defined in the atc_proc_tree and atc_proc_definitions files functionally replaced the TRACON routing defined in the route_definitions_with_pars file, although that file was not modified.

4 Summary

The Understand product was used to analyze the amount of code added to RTMA to implement ATD-1, in particular the Terminal Sequencing and Spacing functionality. The analysis showed that approximately 39,000 SLOC were added to RTMA to implement the TSS functionality. Further, there were about 4200 lines of adaptation added or deleted for the simulation test site, ZAB ARTCC and P50 TRACON, for PHX airport.

Title of Package:(*edit*)
ATD-1 TMA DOCUMENTS FOR APPROVAL (NINE DOCUMENTS)
Routernumber:21936

Group this package under:
HQ_ARMD_ASP

Routing Package Administrator:Angela Boyle(*edit*)
Comments:(*edit*)

****URGENT REQUEST TO COMPLETE APPROVAL PROCESS FOR THE TMA DOCUMENTS PRIOR TO FRIDAY MORNING, SEPTEMBER 27, 2013****

Nine items enclosed:
1. ATD-1 Scheduling Algorithm Overview Version 2.0 (HSwenson & LChen, September 2013) / 7.01 ATD1-TMAlgDescription-20130913-V2.0.pdf

2. Controller Managed Spacing Tool Advisory Algorithm (CLee & LChen, September 2013) / 7.02 ATD1-CMSAlg-201309-Rev-.pdf

3. Overview of TMA RNP Route Processing (SChan, September 2013) / 7.03 ATD1-RNPRouteProcessing-201309-Rev-.pdf

4. Overview of RTMA Trajectory Synthesis Changes (SChan, September 2013) / 7.04 ATD1-TSSoftwareChanges-201309-Rev-.pdf

5. Overview of RTMA Dynamic Planner Changes (LChen, September 2013) / 7.05 ATD1-RTMADynPlannerChanges-201309-Rev-.pdf

6. STARS-RTMA Functional Description (Cisek, September 2013) / 7.06 ATD1-STARS-RTMAFuncDesc-201309-Rev-.pdf

7. Required Navigation Performance (RNP) Radius Fix (RF) Leg Implementation for Aero Tech Demo 1 (ATD-1) (ALee, et al) / 7.07 ATD-1 RNP RF Leg Changes-20120316-Rev7.pdf

8. Staggered Parallel Approaches Algorithm in TMA (LChen, September 2013) / 7.08 ATD1-StaggerAlgorithmTMA-201309-Rev-.pdf

9. RTMA Source Code Change Analysis (Eshow, Sep 2013) / 7.09 ATD1-SourceCodeAnalysis-201309-Rev-.pdf

This Package started routing on:9/26/2013 4:10:01 PM
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1		**Mirna Johnson** **Title:**Systems Engineer mirna.g.johnson@nasa.gov **Phone:**650.604.1026 **Comment From Reviewer:** 9/26/2013 4:11:51 PM **Response To Reviewer Comments:** (Add/Edit) Email Sent	Yes- 9/26/2013 4:11:51 PM				✉
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3		**John Robinson** **Title:**ATD-1 Chief Engineer john.e.robinson@nasa.gov **Phone:**650.604.0873 **Comment From Reviewer:** All of the documents with Rev #"s should have Rev 1.0 assigned. There seems to be 7 such documents in the package. 9/26/2013 4:43:22 PM **Response To Reviewer Comments:** (Add/Edit) Email Sent	Yes- 9/26/2013 4:43:21 PM				✉
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Add Reviewer										
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Files Attached to this Package

Name	Description	Add/View Revision	Delete
21936_7.01-ATD1-TMAlgDescription-20130913-Rev2.0.pdf	1. ATD-1-Sched Alg.	Add Revison	
21936_7.02-ATD1-CMSAlg-201309-Rev-.pdf	2. CMS Alg	Add Revison	
21936_7.03-ATD1-RNPRouteProcessing-	3. RNP Route Processing	Add	

201309-Rev-.pdf	3. RNP Route Processing	Revison	
21936_7.04-ATD1-TSSoftwareChanges-201309-Rev-.pdf	4. TS Software Changes	Add Revison	
21936_7.05-ATD1-RTMADynPlannerChanges-201309-Rev-.pdf	5. RTMA Dyn Planner Changes	Add Revison	
21936_7.06-ATD1-STARS-RTMAFuncDesc-201309-Rev-.pdf	6. STARS RTMA Func. Desc.	Add Revison	
21936_7.07-ATD-1-RNP RF-Leg-Changes-20120316-Rev7.pdf	7. RNP RF Leg Changes	Add Revison	
21936_7.08-ATD1-StaggerAlgorithmTMA-201309-Rev-.pdf	8. Stagger Algorithm TMA	Add Revison	
21936_7.09-ATD1-SourceCodeAnalysis-201309-Rev-.pdf	9. Source Code Analysis	Add Revison	
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