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Reusable Launch Vehicle Operations and Maintenance Guideline Inputs and Technical Evaluation Report: Approval - Volume 5

Final Report

Prepared for
Department of Transportation
Federal Aviation Administration
Associate Administrator for Commercial Space Transportation
AST-200 Licensing and Safety Division
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Reusable Launch Vehicle Operations and Maintenance Guideline Inputs and
Technical Evaluation Report:
Approval - Volume 5

Final Report

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Executive Summary

Development of commercial Reusable Launch Vehicles (RLVs) continues to be of great interest to many private companies. The appeal rests in an RLV's ability to be reused allowing multiple uses taking people and equipment to and from space (e.g., cargo and "tourism") and amortize development costs over the life of the operational vehicle. Commercial RLV companies plan to use both existing and new technologies in the design/development of a launch system. RLV Operations and Maintenance (O&M) of new launch systems have the potential to affect public safety; therefore, the Federal Aviation Administration's Office of Commercial Space Transportation (FAA/AST) is in the process of developing guidelines for RLV O&M activities. These guidelines may be used to evaluate an RLV developer's/operator's license application.

This Guideline Input and Technical Evaluation Report is intended to capture an initial set of Guideline Inputs (GIs) and Guideline Input Considerations (GICs) specific to the various functions associated with RLV approval for any RLV concept, large or small, orbital or suborbital. This volume is the fifth of five such volumes; the first volume addressed RLV Subsystems; the second, RLV Operations; the third, RLV Maintenance; and the fourth volume, RLV Training functions.

A total of four functions within the approval domain have been identified for development of approval guideline inputs. Each of these functions relate to a unique set of sub-functions for RLV approval. The focus and intent of this task, Order (0002), has been to capture potential public safety risks that should be considered relative to RLV approval. In order to ensure these guidelines have been considered by the RLV developer/operator, RTI proposes that a series of manuals be required as part of the final license application: Operations, Maintenance, Training, and Approval. These manuals would allow an RLV developer/operator to specify how they intend to address FAA/AST O&M Guidelines and the current requirements contained in the RLV Mission License Rule in the Code of Federal Regulations (CFR) (14 CFR Part 431). In this way, the RLV developer or operator has the ability to stipulate which of these guidelines are relevant to their vehicle design and ensure that public safety considerations associated with RLV O&M tasks, such as those in this Approval volume, have been fully addressed.

In summary, the Guideline Inputs in this volume, and in the other four Guideline Input volumes, are intended to contribute to a common set of criteria by which the FAA and the RLV Industry can assess public safety aspects of RLV O&M processes. As the industry matures, it is expected that additional guidelines will be developed. These Guideline Input volumes are considered to be living documents that will be developed as the RLV industry matures.

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1.0 Introduction

Reusable Launch Vehicles (RLVs) will require guidelines and regulatory language to be developed for new approaches in both Operations and Maintenance (O&M). These approaches may have a direct effect on public safety where RLVs are being operated and maintained. This Guideline Input and Technical Evaluation Report is intended to capture an initial set of Guideline Inputs (GIs) and Guideline Input Considerations (GICs) centered around the various functions associated with RLV approval, for any RLV concept, large or small, orbital or suborbital. This volume is the fifth of five such volumes: the first volume addresses RLV Subsystems; the second, RLV Operations; third, RLV Maintenance; and the fourth volume addresses RLV Training Functions. The inputs identified in this volume, and in the other four Guideline Input volumes, contribute to a common set of criteria by which the FAA and the RLV industry can assess public safety aspects of RLV O&M processes. As the RLV industry matures, it is expected that additional guidelines will be developed; making these living documents that will evolve as the RLV industry evolves.

1.1 Purpose

The purpose of this document is to provide basic Guideline Inputs and Considerations for RLV approval based on top-level “pertinent” RLV approval functions. The intent is for these Guideline Inputs and Considerations to be general enough to be applicable for any RLV concept. In this context, “pertinent” approval is considered any activity associated with RLV approval process development, actual approval tasks for personnel, facilities, equipment, material, and procedures, and reporting & recording that has a potential public safety impact. The functions identified here encompass activities associated with a variety of Concept of Operations (CONOPS) being proposed by the industry.

1.2 Background

These Guideline Inputs are the result of a focused effort by Federal Aviation Administration’s Office of Commercial Space Transportation (FAA/AST) to facilitate a common understanding between both regulator and industry on what is expected from RLV Operators in order to ensure public safety. The creation of these Guideline Inputs was prompted by the response to an FAA/AST presentation of an RLV O&M White Paper to the Commercial Space Transportation Advisory Committee (COMSTAC) in October of 1999¹.

Industry feedback to that paper, along with FAA-directed research activities, led to the initiation of an information-only Rulemaking Project Record (RPR) intended to establish formal rules for RLV O&M. These Guideline Inputs represent an interim step toward a Notice of Proposed Rulemaking (NPRM) for RLV O&M and are intended to serve as a means by which those items requiring formalization as a rule can be identified and validated both by the FAA and by industry. However, it should be recognized that an NPRM would only be developed after the RLV industry is sufficiently mature.

RTI used the Systems Functions and Procedural Items identified during previous FAA tasking² as a starting point. It was determined that a general model was needed to place the Systems Functions and Procedural Items in context. These have been further developed in a subsequent tasking and now in this Order (0002). A context diagram, Figure 1 in Section 1.5, was developed to provide this contextual framework, as well as provide a means of marrying the O&M top-down analysis, being completed by RTI, with the bottom-up analysis, being accomplished internally within the FAA.

1.2.1 Statement of Understanding

A Statement of Understanding (SOU) between the FAA and the RTI Team has been developed to govern each of the RLV O&M tasks. The following text presents the SOU developed for this effort:

“The RTI Team will continue to support FAA/AST-100 in the development of RLV O&M guidelines and technical evaluation criteria.

This task will build on the work accomplished in the RLV O&M Top-Down Analyses performed under DO2 and DO3 and complement the RLV O&M Guidelines developed under DO4 of the reference contract. In particular, the RTI Team will develop material to aid FAA/AST-100 identify the O&M technical evaluation criteria and performance standards for safety-critical RLV maintenance, training, and approval functions. In performing the specified work, particular attention will be made to any unique features, including proven and unproven RLV O&M activities, and their correlation to any historic lessons-learned in the Space Shuttle, airline and RLV research community.

Under Order 0002, RTI will deliver the final guideline input volumes: Maintenance - Volume 3, Training – Volume 4, and Approval - Volume 5.

The following summarizes specific topics that will be addressed:

1. Guideline inputs and rationale:
The major RLV O&M subsystem and function safety items, as they pertain to the subject volumes, will be developed into guideline inputs along with the supporting rationale. These will be presented in the format approved by FAA/AST under DO4.
2. Further refinement of the Subsystem and Functional Decomposition:
A number of modifications to the current Functional Decomposition diagrams have been identified including the need to add Functions for Contingency Operations, Vehicle Configuration Management, and Simulation Requirements. The Functional Decomposition diagrams will be modified to reflect the functional refinements, as required.
3. Continued data collection from the aviation and space domains:
Continue to extract information from traditional aviation, the Space Shuttle, and other RLV programs in support of the guideline and technical evaluation criteria development.”

1.3 Scope

The following Guideline Inputs are intended for use by the RLV Industry and the FAA's Office of Commercial Space Transportation in the preparation and evaluation of commercial RLV license applications and O&M plans. The scope of these Guideline Inputs is bounded by the jurisdictional authority provided to the FAA by Congress 112 STAT. 2848 (Public Law 105-303-Oct. 28, 1998). Additionally, these Guideline Inputs do not affect or amend the content of the licensing rules, but rather are designed to help the FAA and RLV Industry jointly ensure the rules are both followed and applied in a consistent manner.

1.3.1 Guideline Input Philosophy

These Guideline Inputs have been developed to serve as a repository for best/recommended practices. It is expected that a portion of these practices will ultimately be formalized in a federal regulation that will govern the commercial RLV Industry. Some inputs may be revisited as newer technologies are developed and better procedures emerge as the industry matures.

A wide variety of sources were reviewed and analyzed to develop the content of these Guideline Inputs. Primary consideration was given to lessons-learned drawn from the aviation and space community. In some cases, these lessons are explicit and are clearly technology-independent public safety issues and thus could be written as a requirement. In these cases, Guideline Inputs (GIs) have been developed and the term "shall" is used. These GIs are numbered sequentially with a Approval Function prefix (e.g., the first Develop Approval Process Guideline Input is numbered Dev App Process GI-1.) It is reasonable to assume that these items will be included in any subsequent rule development governing RLV O&M.

In many cases, however, the lesson or issue being evaluated is less clearly defined and sufficient experience or research is not available to validate the lesson or issue. Others are technology dependent and only apply to a narrow set of RLV concepts. For these cases, Guideline Input Considerations (GICs) have been developed and the term "should" is used. These GICs are numbered sequentially with a Approval Function prefix (e.g., the first Dev Approval Process Guideline Input Consideration is numbered Dev App Process GIC-1.) While these are candidates for inclusion in any subsequent rulemaking, it is reasonable to assume that further work may be required.

Please note that there are many additional safety issues that an RLV Operator should consider for the safety of trainers and students; FAA/AST is only currently charged with public safety concerns. Further, no delineation of when and how rules would be applied is made in these considerations. Some guidelines may be considered during the licensing stage while others may be considered as repeated launches are executed for the same RLV under a launch license.

Within the following sections, the Occupational Safety and Health Administration (OSHA) is highlighted in many of the Inter/Intra Agency Considerations subsections. Although OSHA is concerned with worker safety and not the general public, the authors of this document believe that jurisdictional issues need to be addressed for cases where a worker safety situation escalates into a public safety concern.

1.3.2 Suggestion Form

It should be noted that these Guideline Inputs are expected to evolve as the industry matures and additional data becomes available, either from research or through actual flight activity. The reader is encouraged to share their experiences and knowledge through use of the Suggestion Form in Appendix B: RLV Guideline Input Suggestion Form. It is the FAA's intent to periodically review these Guideline Inputs to ensure they are current, particularly with respect to issues that are technology dependent or unique RLV concepts appear.

1.4 Relationship to RLV Licensing

The impetus for this effort was to provide a common set of criteria related to O&M that could be used by FAA/AST to evaluate RLV operator license applications. While approval may be considered less important than operations and maintenance from a public safety perspective; it is the mechanism by which safe operations and maintenance are conducted. The Guideline Inputs and the related Guideline Input Considerations contained in this volume are focused on RLV approval with particular emphasis placed on issues unique to the function being addressed. Failure to follow these guidelines could pose a potential risk to the public. RLV developers/operators are expected to explain how each Guideline is satisfied for their particular vehicle design.

In a previous tasking, the RTI team proposed a formal set of readiness reviews, one for operations and one for maintenance. In addition, the concepts of Instructions for Continued Flight-worthiness (ICF) and an Operations or Flight Manual were introduced. The reviews were intended to be focused activities within the context of the overall mission readiness review required by the RLV licensing rule.

As research continued, RTI proposed the need for an Operations Plan, an Operations Manual, a Maintenance Plan and a Maintenance Manual to further clarify the RLV developer/operator's approach as it applies to public safety. Similarly, RTI advocates that the RLV developer/operator should provide Training and Approval Plans/Manuals. The Approval Manual identifies how the RLV Operator will implement the pertinent requirements and guidance that are documented in the RLV developer/operator's Approval Plan. The Approval Plan is considered by RTI to be similar in scope and breadth to the Operations and Maintenance Program Plans. Note that the Approval Manual can be packaged as part of the Operations Manual, the Maintenance Manual, a combined document, or as an individual document. This is at the discretion of the RLV

developer/operator, provided that the data is clearly identified. The four documents (Operations Manual, Maintenance Manual, Training Manual, and Approval Manual), taken together, will give individual RLV developers/operators a venue to communicate how they will address FAA Guidelines. At the same time, the use of a common set of manuals will help FAA/AST evaluate the appropriateness and completeness of the provided data in a uniform manner.

1.5 Subsystem and Functional Context

Functional Guideline Inputs have been developed for those activities associated with operations and maintenance, as well as the related areas of training and approval. Figure 1 illustrates how these four areas relate to one another and where they fit into the broader scope of RLV licensing, approvals, and RLV development. It should be noted that this effort considers only the items to the right of the vertical line in Figure 1. This relationship is highlighted in Figure 2.

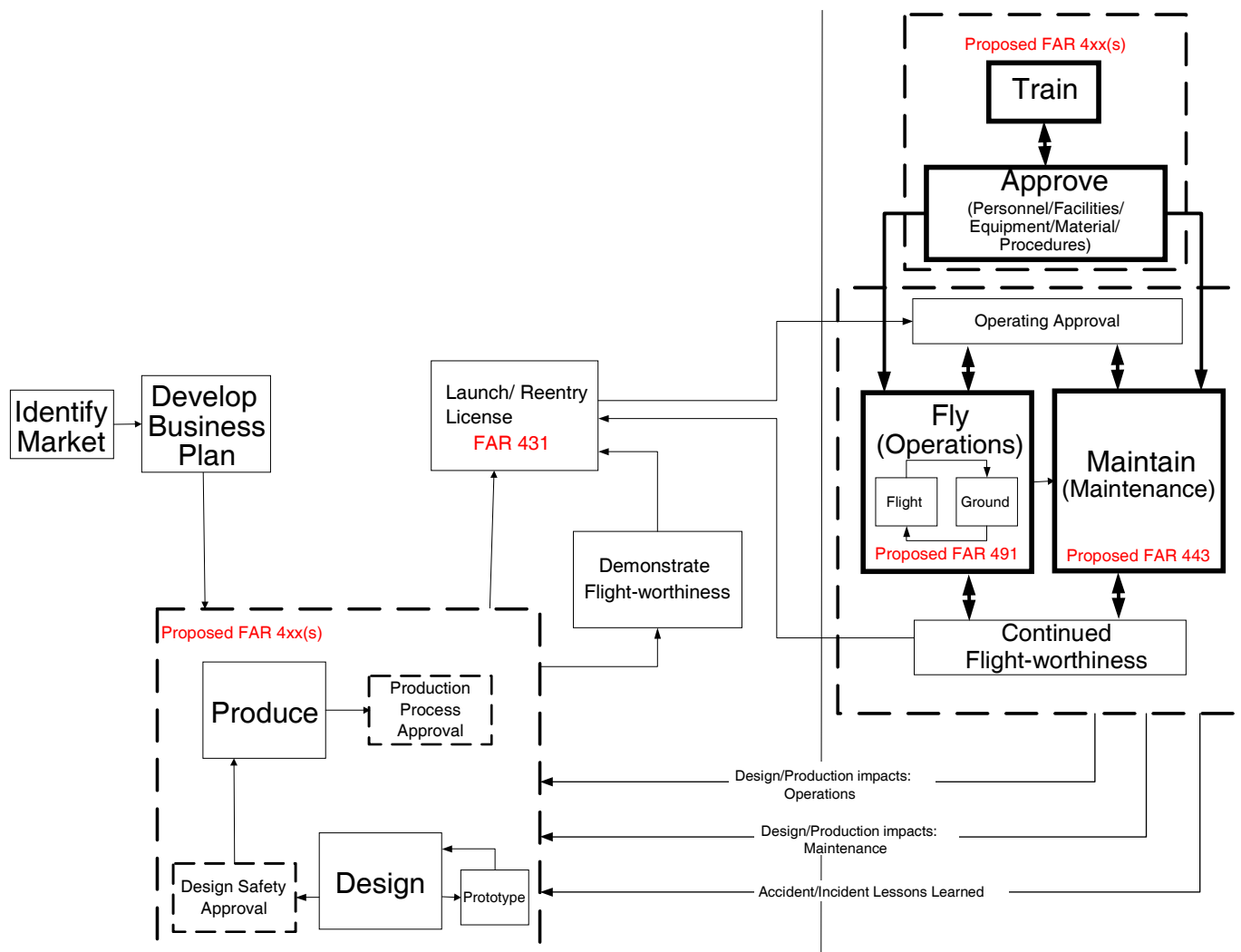


Figure 1 RLV Context Diagram

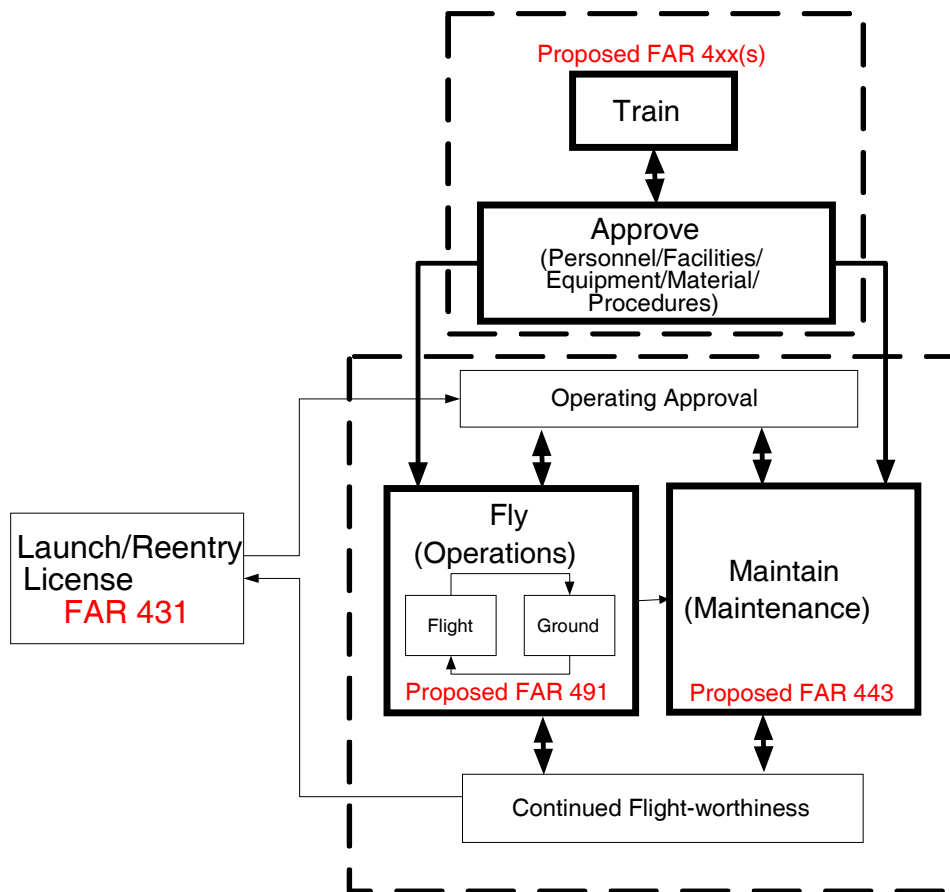


Figure 2 RLV O&M Context

It should also be noted that this top-down analysis is being supplemented by a bottom-up analysis effort being conducted by FAA/AST. The two efforts taken together are intended to serve as the basis for guidance development in the area of RLV O&M, see Figure 3.

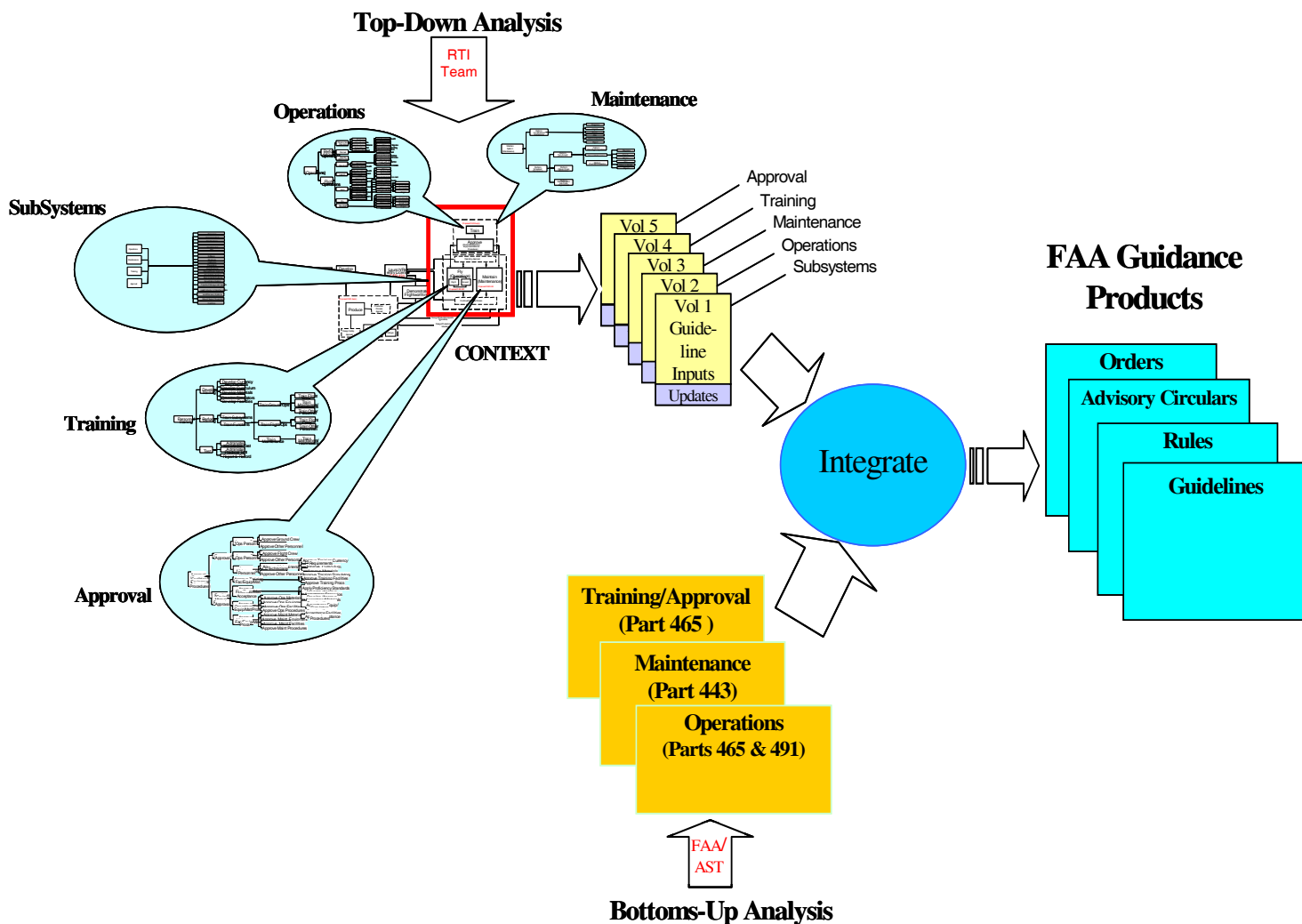


Figure 3 Guidance Document Process

As shown in Figure 3, the ultimate product of this activity is expected to be one or more guidance documents from the FAA. The FAA has realized that given the current level of maturity within the commercial RLV industry, the best approach to take in the near-term is the production of guidelines that can be employed by both the FAA and industry to evaluate proposed RLV's O&M activities effect on public safety. With this in mind, the top-down analysis has been organized around a "divide and conquer" approach where individual subsystems and functions are examined for their potential contribution to public safety.

The following sections describe each top-level function and major sub-functions; provide definitions for each function and sub-function; and provides a brief treatment of the major public-safety considerations for each function. It should be noted that the functions depicted and discussed are presented in terms of an action, hence the term "function".

2.0 Approval Decomposition

Figure 4 displays the current RLV Approval functional decomposition. The Approve function is broken into four major sub-functions: Develop Approval Process, Approve Personnel, Approve Facilities/Equipment/Material/Procedures (FEMP), and Record & Report. It is envisioned that the RLV Operator's Approval Plan will document the approval strategy for an operator's individual RLV program vehicle type, see Section 3.0.

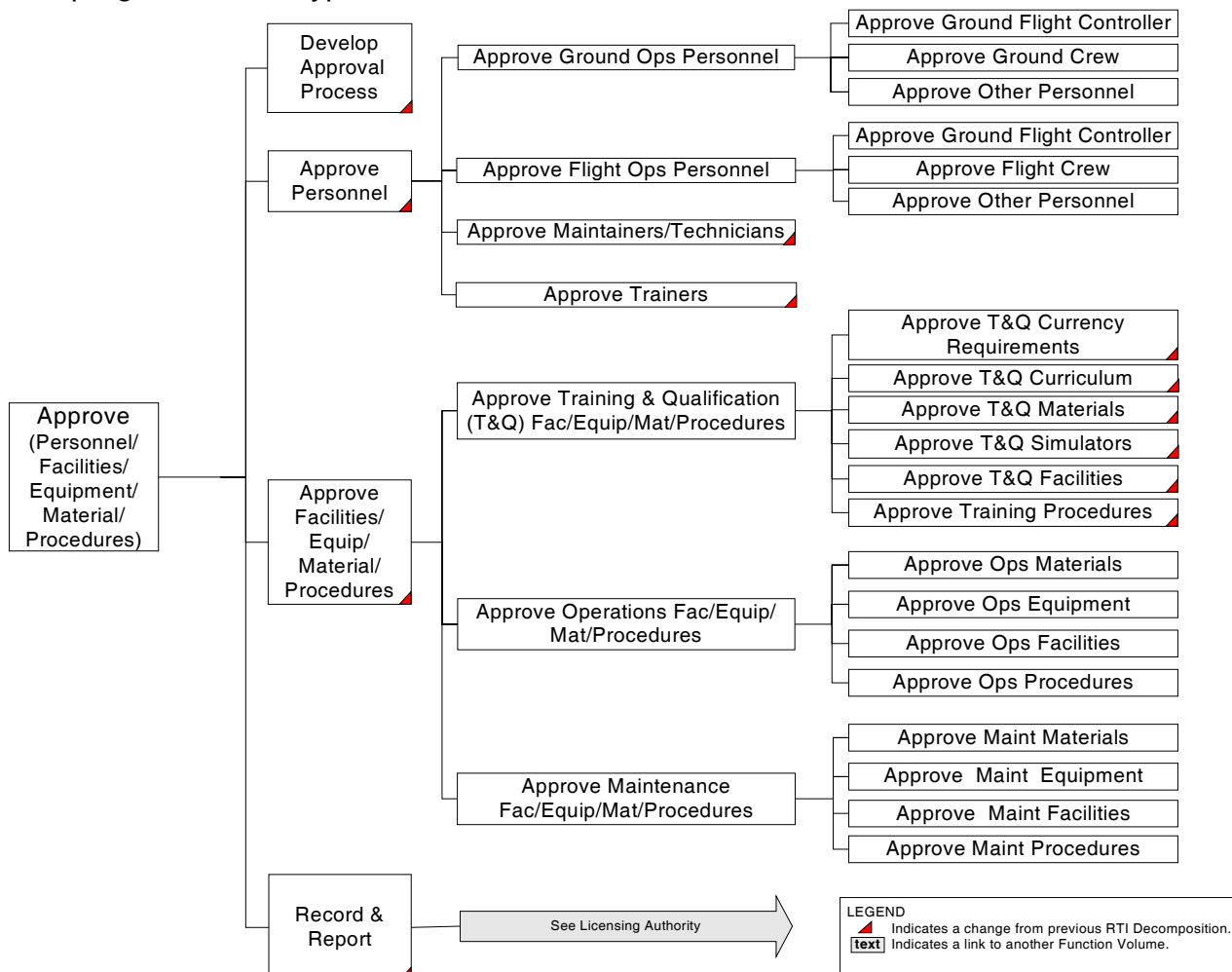


Figure 4 Approval Functional Decomposition

The results of the CFR reviews, as well as the data collected during previous efforts, were used as a starting point for deriving these functions. RTI then collected and analyzed several references to further characterize approval. Previous work presented the first functional decomposition of RLV Approval Functions. These approval functions and sub-functions have been further analyzed and refined in this task. While many functions remain the same, there are several new sub-functions and a reorganization of sub-functions has occurred. See Appendix C: Traceability of Approval Function Decomposition for function and sub-function traceability from the previous Approval Decomposition to the current Approval Decomposition.

3.0 General Approval Guideline Recommendations

The following Guideline Inputs (GIs) were developed to reflect those tasks or procedures that are general in nature and apply to the Approve Function.

General App GI - 1. RLV Operator Approval Plan

Guideline Input

RLV Operators shall develop an Approval Plan for each vehicle type.

Rationale

The Approval Plan is comparable to the RLV Operator's Concept of Operations Document and Maintenance Program Plan. In order to account for the differences in RLV design and operations, each RLV Operator must provide an Approval Plan that describes the operator's intent and/or assumptions relative to their compliance with FAA/AST's guidelines. This plan will include general strategies associated with developing approval processes and reporting & recording. This will include approval tasks associated with ground operations, flight operations, maintenance, and training.

Although the Approval Plan will be implemented through a procedural Approval Manual, the Approval Plan's value to the FAA lies in the additional clarity of purpose it will provide.

Specifically, the Approval Plan will highlight to the FAA general assumptions and intent that may affect public safety; and it will provide the FAA with necessary insight into the following items of interest:

1. General public safety assurance and environmental hazard mitigation
2. Approval accreditation
3. Personnel approval requirements
 - a. schedule of recurring approval
 - b. "type-specific" approval
4. Periodic update to account for new tasks required to be approved based on design changes or lessons-learned
5. Frequency and type of initial and recurring approval tasks

General App GI - 2. Approval Manual

Guideline Input

RLV Operators shall develop an FAA/AST-approved vehicle-specific Approval Manual.

Rationale

Since many RLV concepts include ground-breaking/novel technologies, there is minimal commonality between current industry approval procedures and those required for specific RLV approval procedures. This lack of commonality hinders the development of common technology-specific approval guidelines; therefore, each RLV Operator must develop a vehicle-specific Approval Manual and provide it to FAA/AST for acceptance.

This manual will provide the approval specifications and procedures associated with the specific RLV type and its GSE/facilities. It will also meet FAA/AST's approval guidelines for conducting the approval process for personnel, facilities, equipment, materials, and procedures.

Minimally, the following items will be included in the Approval Manual:

1. Safety critical RLV and GSE/Facilities sub-systems, operations, and maintenance approval procedures for knowledge and performance
2. Hazardous material types and handling procedures during approval
3. Personnel/training approval implementation will include:
 - a. knowledge evaluation
 - b. performance evaluation
 - c. associated personnel/operator requirements
 - d. aeromedical compliance
4. Approval documentation process to include record/report and feedback of lessons-learned

4.0 Develop Approval Process

The following sub-functions were developed to reflect those tasks or procedures that apply to the Develop Approval Process activities. Table 1 highlights the general definitions for Develop Approval Process Sub-functions.

Table 1 Develop Approval Definitions

Develop Approval Process	<i>[Approve (Personnel/Fac/Equip/Mat/Procs) → Develop Approval Process]</i> Development of the approval process is defined as development of tasks and procedures to conduct approval for personnel; Operations, Maintenance, and Training & Qualification (T&Q) facilities/equipment/materials/procedures; and to record and report approval/non-approval status.
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4.1 General Discussion

Development of the approval process includes an assessment of capability in core job functions and skills that were taught during training. An assessment of safety implications of certain job functions and the corresponding training to mitigate risks found in the curriculum and materials must be evaluated for approval.

4.2 Guideline Input Considerations

The following Guideline Input Considerations (GICs) have been identified for the Develop Approval Sub-function:

Dev Appr GIC - 1. The capability should exist to allow FAA/AST to waive Aeromedical Requirements.

Dev Appr GIC - 2. The capability should exist to allow FAA/AST to waive approval currency requirements.

4.2.1 Inter/Intra Agency Considerations

There was no Develop Approval Sub-function inter/intra agency considerations identified.

4.3 Guideline Recommendations

Dev Appr GI - 1. FEMP Fidelity During Approval

Guideline Input

Personnel being approved shall be evaluated using facilities, equipment, materials, and procedures (FEMP) that provide a realistic operations and maintenance environment.

Rationale

Due to the unique nature of each RLV concept, the approval of personnel may be conducted in an operator/developer facility in order to provide the most fidelity to real-world operations and maintenance. Thus, an approval of the environment may go hand-in-hand with the personnel approval process in order to ensure public safety aspects are fully addressed.

Fidelity of the approval environment, FEMP, should match as closely as possible to the real-world environment. This will enable the personnel to be assessed accurately and minimize the distraction and complications during an approval process. The fidelity in the environment will have a positive effect on job performance in accuracy and speed of performance. This mitigates possible confusion, improves reaction times in assessing anomalies, and decreases the possibility of an incident or accident.

5.0 Approve Personnel

The following sub-functions were developed to reflect those tasks or procedures applicable to RLV Approve Personnel sub-function. Table 2 outlines the general definitions for the Approve Personnel Sub-functions.

Table 2 Approve Personnel Definitions

Approve Personnel	<i>[Approve (Personnel/Fac/Equip/Mat/Procs) → Approve Personnel]</i>	
	The Approve Personnel Sub-function is defined as the approval of various personnel involved in RLV O&M (i.e. ground operations personnel, flight operations personnel, maintainers/technicians, and trainers). This sub-function is strongly connected to the Training Function. Note that the term “Approval” is used here to denote the required formal FAA approval. Some approval aspects may be processed during licensing of an RLV.	
	Approve Ground Ops Personnel	<i>[Approve (Personnel/Fac/Equip/Mat/Procs) → Approve Personnel→Approve Grd Ops Personnel]</i>
		Approval of Ground Operations Personnel is defined as the process to ensure that the personnel are adequately trained. Knowledge and skill level of individual personnel are assessed using records from knowledge tests and practical tests. This shall be a quantitatively verifiable means subject to approval by FAA/AST.
		Approve Ground Flight Controller
		<i>[Approve (Personnel/Fac/Equip/Mat/Procs) → Approve Personnel→Approve Grd Ops Personnel→Approve Ground Flight Controller]</i>
		The Approve Ground Flight Controller sub-function is defined as the approval of personnel who are trained to perform specific flight operation tasks that are performed on the ground.
		Approve Ground Crew
		<i>[Approve (Personnel/Fac/Equip/Mat/Procs) → Approve Personnel→Approve Grd Ops Personnel→Approve Ground Crew]</i>
		Approve Ground Crew is the approval of RLV personnel who support Ground Operations. During Ground Operations these personnel are involved in the ground movement of the vehicle (to include ground traffic control), proper handling of the vehicle and the payload, and proper precautions for any associated HAZMAT.
	Approve Other Personnel	<i>[Approve (Personnel/Fac/Equip/Mat/Procs) → Approve Personnel→Approve Grd Ops Personnel→Approve Other Personnel]</i>
		Approve Other Personnel is defined as the approval of personnel other than ground flight controller and ground crew (e.g. RLV operations director). These may include trainers and approval personnel.
Approve Flight Ops Personnel	<i>[Approve (Personnel/Fac/Equip/Mat/Procs) → Approve Personnel→Approve Grd Ops Personnel→Approve Flight Ops Personnel]</i>	
	The Approve Flight Operations Personnel sub-function is defined as approval of ground flight controller, flight crew, and other personnel that are involved in flight operations of the RLV.	
	Approve Ground Flight Controller	<i>[Approve (Personnel/Fac/Equip/Mat/Procs) → Approve Personnel→Approve Grd Ops Personnel→Approve Flight Ops Personnel→Approve Ground Flight Controller]</i>
		The Approve Ground Flight Controller sub-function within flight operations is defined as the approval of personnel on the ground controlling the flight of the RLV who either augment the flight crew or who have sole flight control of an RLV (e.g. unmanned).

		Approve Flight Crew	<i>[Approve (Personnel/Fac/Equip/Mat/Procs) → Approve Personnel→Approve Grd Ops Personnel→Approve Flight Ops Personnel→Approve Flight Crew]</i> The Approve Flight Crew sub-function consists of the approval of personnel on-board and in control of the RLV during flight. Flight Crew includes RLV pilot and other RLV flight support positions.
		Approve Other Personnel	<i>[Approve (Personnel/Fac/Equip/Mat/Procs) → Approve Personnel→Approve Grd Ops Personnel→Approve Flight Ops Personnel→Approve Other Personnel]</i> The Approve Other Personnel (Flight Operations) sub-function consists of the approval of personnel other than ground flight controller and flight crew. These may include trainers and approval personnel.
	Approve Maintainers/Technicians		<i>[Approve (Personnel/Fac/Equip/Mat/Procs) → Approve Personnel→Approve Maintainers/Technicians]</i> The Approve Maintainers/Technicians sub-function includes the approval tasks of those personnel who perform maintenance, repair, and servicing of the RLV during ground operations using appropriate GSE/facilities.
		Approve Trainers	<i>[Approve (Personnel/Fac/Equip/Mat/Procs) → Approve Personnel→Approve Trainers]</i> The Approve Trainers sub-function is defined as the set of tasks for the approval of trainers to ensure that these personnel have the knowledge and skill set to train the O&M activities.

5.1 General Discussion

Approve Ground Operations Personnel

Ground operations include all vehicle preparation and movement prior to take-off/launch and all post-flight activity following touchdown. Additionally, this function involves the operation of ground support equipment and facilities. Ground operations also include replenishing of consumables such as propellants in preparation for the flight.

Ground operations may vary from RLV concept to RLV concept depending on the design and flight profile. The training and approval are expected to be tailored to the knowledge and skills needed to perform the jobs as defined by the RLV operator. Ground operations personnel include Ground Flight Controllers, Ground Crew, and other personnel as defined by the concept of operations (CONOPS) for a specific RLV. Where ground operations may involve handling of HAZMAT or dangerous chemicals, whether it is for the RLV or for a particular payload, the ground personnel are expected to have the knowledge and skill necessary for safe handling of such materials. When personnel are found to be inadequately trained for the job (an indication may be the job performance evaluation by the RLV operator and/or incidents/accidents), the personnel should be required to perform additional training and approval activities. When specifics of the job description, methods or tools change, personnel should be required to attend supplemental training and be reevaluated for approval. Records are expected to be kept for each individual regarding training, retraining, and evaluation/approval. All of which will be subject to FAA/AST inspection.

In aviation, FAA inspectors are trained by the FAA in approval activities as well as the knowledge required for such inspections. Training for aviation FAA inspectors does not change very frequently given the maturity of technology. For FAA/AST personnel involved in RLV approval activities, any training/curricula developed at present should be revisited frequently for coverage of new technology as well as use of new technology in this field. Triggers for revisiting training/curricula should be the introduction of new technology; changes in operations or maintenance activities; and incidents or accidents. Given the fast-paced growth of technology and the varied technologies used in RLVs, such training for inspectors could be intense and ongoing.

Approve Flight Operations Personnel

RLVs have varied take-off, launch, flight, and landing profiles that affect the job function of flight operations personnel. Each RLV operator should be responsible for adequately training the flight operations personnel with specific knowledge and skill sets needed for the operation of that RLV. The ground flight controller, who is familiar with flight profiles, may have to interface with the controller team in collaborative decision making of spaceport operations. This approval function should ensure that personnel involved in flight operations have been adequately trained and evaluated. In cases of job function change, new technology introduction, or new regulations, supplemental training may be needed. When incidents/accidents occur due to inadequate training or inadequate learning, retraining or remedial training may need to be applied. All of the reports and records regarding personnel skills and training, including test results, should be open for inspection by the FAA.

FAA inspectors performing these approvals must be knowledgeable about the flight profiles, job functions, and training requirements for the subject RLV. Such knowledge for all of the RLVs may constitute a sizeable effort for the FAA to keep their inspectors current and well trained in various technologies. Further, there may be an interface between the FAA ATC and other external entities with the flight operations personnel. RLV Flight Operations personnel should be familiar with Collaborative Decision Making (CDM) process already used within the FAA. It is important that personnel involved in all of these interfaces are knowledgeable in the specific RLV operations and performance. This approval function does not cover these interface functions.

Approve Maintainers/Technicians

RLVs have varied concepts and designs, which implies that the maintenance of a specific RLV may depend upon a specific knowledge set, skill set, and use of certain tools and techniques. Although such techniques may be transferable between different RLVs, retraining of maintenance personnel for a specific RLV is to be expected. Maintenance personnel are expected to be trained in their job functions and in the knowledge of specific subsystems as well as interrelated subsystems. This training includes initial training, supplemental training, recurrent training and remedial training. Knowledge and skill sets are ensured using tests

or other quantitative evaluation method subject to FAA/AST approval and inspection. These test records and reports of class attendance (training duration) are subject to FAA/AST approval inspections. No one set of approval rules applies to all of the RLVs in terms of specifics on knowledge and skill set.

The FAA inspectors responsible for these approvals must be knowledgeable about the specific RLV systems and proper maintenance techniques. For example, the structure used for an RLV may be a composite, which requires special techniques for repair and fatigue discovery. The FAA/AST inspectors are expected to stay current in the technologies used in these RLVs to be capable of detecting unsafe practices.

5.2 Guideline Input Considerations

The following Guideline Input Considerations (GICs) have been identified for the Approve Personnel Sub-function:

- Appr Personnel GIC - 1. Approval activities should impose or check the appropriateness of skill levels. There may be incidents/accidents that may result in public safety issues if this is not done.
- Appr Personnel GIC - 2. The Approval function should detect inadequately trained personnel. RLV maintenance may not be properly performed and may result in incidents/accidents that may jeopardize public safety. Improperly maintained vehicles may cause uncontrolled vehicles, vehicle breakup, or dispensing of hazardous materials into the atmosphere.
- Appr Personnel GIC - 3. Proper handling and disposal of hazardous materials should follow EPA guidelines and OSHA guidelines.
- Appr Personnel GIC - 4. Proper securing of payload should be accomplished following instructions from the owner of that payload.

5.2.1 Inter/Intra Agency Considerations

The following Perform Approval Sub-function inter/intra agency considerations were identified:

1. The approval of hazardous material handling may be a concern to OSHA and/or EPA. OSHA /AFOSH guidelines to insure worker safety on federal and nonfederal ranges should be followed.
2. DOT coordination should occur with appropriate rail, air, and roadway transportation offices for safe practices and regulations associated with the transportation of hazardous materials on public routes.

3. Federal Communication Commission (FCC) coordination should occur for all frequency assignments used in RLV operations, particularly those employed in emergencies.
4. The Department of Defense Explosive Safety Board (ESB) should be consulted to provide a source of lessons learned for FAA/AST for conducting RLV safety evaluations, storage of propellants, and chemical agents.³
5. National Fire Protection Agency (NFPA) coordination should be required for procedure development to ensure that fire safety and mitigation procedures are in place for launch/takeoff preparations.
6. Particular payloads may require coordination, security, and technical evaluation from external agencies to the FAA such as Department of Defense (DoD), the National Aeronautics and Space Administration (NASA), and the Nuclear Regulatory Commission (NRC) for those payloads which employ nuclear power.
7. Internal to the FAA several divisions may be called upon. These include the Regulatory Support Division (FAA/AFS) for such items as training and testing and FAA Flight Standards (FAA/ASI) for RLV flight standards.

5.3 Guideline Recommendations

Appr Personnel GI - 1. Technician/Mechanic Approval

Guideline Input

Technicians and mechanics shall be approved based on training/skill/experience criteria outlined in the Approval Plan.

Rationale

Specific experience and/or training are required for mechanics /technicians working on RLVs, particularly safety critical systems. Given the immature state of the RLV industry, it may be that approval is initially based on the experience level of the personnel versus a formal training/evaluation.

Appr Personnel GI - 2. Ground Flight Controller Approval

Guideline Input

The Ground Flight Controller shall be approved based on both RLV flight control tasks and ATM NAS responsibilities.

Rationale

This requirement is to both insure proper RLV operations and to insure incorporation as a part of the ATS Collaborative Decision Making (CDM) team. Inspections will be based upon guidelines developed by FAA/AST that will be minimum performance criteria for approval.

6.0 Approve Facilities/Equipment/Materials/Procedures

The following sub-functions were developed to reflect those tasks or procedures that are applicable to RLV Facilities/Equipment/Materials/Procedures (FEMP) activities. Table 3 highlights the general definitions for these Sub-functions.

Table 3 Approve FEMP Definitions

Approve Facilities/Equipment/Materials/Procedures (FEMP)	<i>[Approve (Personnel/FEMP) → Approve FEMP]</i>	
	Facilities/Equip/Material/Procedures Approval Function is defined as the development and application of approval criteria, by the FAA, for facilities, equipment, materials, and procedures. In the current context it is the facilities, equipment, materials, and procedures used for operations, maintenance, training, and approval activities.	
	Approve Training & Qualification (T&Q) FEMP	<i>[Approve (Personnel/FEMP) → Approve FEMP → Approve Training & Qualification (T&Q) FEMP]</i>
		The Approve T&Q FEMP sub-function is defined as the approval of facilities, equipment, material and procedures used in training. This includes training of operators, maintainers, testers, and approval personnel. Further, this includes initial, recurrent, supplemental, and remedial types of training. Components of approval include currency, curriculum, materials, simulations, facilities, and procedures. The intent behind this approval is to ensure personnel are trained sufficiently for the job they are expected to perform with minimal risk of safety implications. An important part of this process is to review the records and reports including results from both knowledge tests and practical tests.
		Approve T&Q Currency Requirements
		<i>[Approve (Personnel/ FEMP) → Approve FEMP → Approve Training & Qualification (T&Q) FEMP → Approve T&Q Currency Requirements]</i>
		The Approve Training Currency Requirements sub-function is the approval of training currency requirements. This relates to recurrent training, its motivation is to maintain proficiency and is required at a defined time interval
	Approve T&Q Curriculum	<i>[Approve (Personnel/ FEMP → Approve FEMP → Approve Training & Qualification (T&Q) FEMP → Approve T&Q Curriculum]</i>
		The Approve Curriculum sub-function is defined as the approval of the set of courses that will be used to train ground flight controllers, ground and flight crew, maintainers/technicians, and trainers. Many of these personnel may be specially trained for specific duties such as a special type of propulsion system or a specific composite material.

		Approve T&Q Materials	<i>[Approve (Personnel/ FEMP) → Approve FEMP → Approve Training & Qualification (T&Q) FEMP → Approve T&Q Materials]</i> The Approve Materials sub-function is the process of approval of materials used in operations, maintenance, training, and approval such as class instructions, references, records, reports, tests, and examinations. These materials may be specific to an RLV and specific to job functions such as ground flight controller, flight crew, maintainers/technicians and other personnel. Other personnel may include trainers and approval personnel. These materials are also expected to be specific to initial training, supplemental training, retraining, and remedial training. For example, supplemental training may be limited to only new tools, technology or techniques. Retraining may be based on the frequency of usage of certain tools and techniques. Remedial training may be individualized. Materials used for these purposes would be tailored to the type of training.
		Approve T&Q Simulators	<i>[Approve (Personnel/ FEMP) → Approve FEMP → Approve Training & Qualification (T&Q) FEMP → Approve T&Q Simulators]</i> The Approve Training Simulators sub-function is the process of approval of models, tools, or other means of representation of reality used in training. The intent is to give a realistic representation and experience to a student while not subjecting the student to real world situations where the risk of inexperience may lead to cost of life and property. A student pilot may practice in a simulation and train for situations without subjecting humans or the actual vehicle to risk of accidents. Simulators are required to model reality in cases where skills learned using the simulator is safety-related. This shall be subject to FAA/AST inspection.

		Approve T&Q Facilities	<i>[Approve (Personnel/ FEMP) → Approve FEMP → Approve Training & Qualification (T&Q) FEMP → Approve T&Q Facilities]</i>
			The Approve Training Facilities sub-function is defined as the approval of facilities used in training of operators, maintainers, trainers, and approval personnel. Training facilities are expected to promote a healthy environment for learning in addition to promoting good work habits, and avoidance of injuries. Adequate light, ventilation, and neatly arranged tools with enough room for each student are expected in the training facilities.
		Approve Training Procedures	<i>[Approve (Personnel/ FEMP) → Approve FEMP → Approve Training & Qualification (T&Q) FEMP → Approve Training Procedures]</i>
			The Approve Training Procedures sub-function is defined as the approval of procedures used for training. These procedures may be different for initial, recurrent, supplemental, and remedial training. These procedures may also be different for various RLVs depending upon the instructor, RLV operator's approach to meet a minimum level of safety expected by FAA/AST, and technology used in a specific RLV.
	Approve Operations FEMP	<i>[Approve (Personnel/FEMP) → Approve Facilities/Equip/Mat/Procs→Approve Operations FEMP]</i>	
		The Approve Operations FEMP sub-function is defined as the set of tasks for the approval of FEMP used in operations. Operations facilities include mission control facilities and those that house the GSE. Materials used may be reports/ records of qualifications for the personnel or instructions for equipment & facilities. The procedures for operations should include checking for both standard operating procedures and emergency/ contingency procedures for ground and flight operations.	
		Approve Ops Materials	<i>[Approve (Personnel/ FEMP)→Approve FEMP→Approve Operations FEMP→Approve Ops Materials]</i>
			The Approve Operations Materials sub-function is defined as the tasks for the approval of materials used in operations. Materials used may be reports & records of qualifications for the personnel or instructions for equipment & facilities.

		Approve Ops Equipment	<i>[Approve (Personnel/ FEMP) → Approve FEMP →Approve Operations FEMP →Approve Ops Equipment]</i> The Approve Operations Equipment sub-function is defined as the set of tasks for the approval of equipment used in ground/flight operations of the RLV. Such equipment includes those used for mission control and for ground operations.
		Approve Ops Facilities	<i>[Approve (Personnel/ FEMP) → Approve FEMP →Approve Operations FEMP →Approve Ops Facilities]</i> Approve Operations Facilities sub-function is the set of tasks for the approval of facilities used for ground and flight operations. Operations facilities include mission control facilities and facilities that house the GSE.
		Approve Ops Procedures	<i>[Approve (Personnel/ FEMP) → Approve FEMP →Approve Operations FEMP →Approve Ops Procedures]</i> The Approve Operations Procedures sub-function is the set of tasks for the approval of procedures used in operations. These procedures may include standard operating procedures used by the various ground and flight operations personnel. The approval is to check if the procedures are complete and correct, and to verify a seamless integration of procedures from a systems perspective to assure safe operation of RLV.
	Approve Maintenance FEMP	<i>[Approve (Personnel/FEMP) → Approve FEMP →Approve Maintenance FEMP]</i> The Approve Maintenance FEMP sub-function is defined as the set of tasks for the approval of facilities, equipment, materials and procedures used in maintenance. Maintenance facilities include repair shops, fabrication facilities, and test centers. Equipment includes those used for repair, replacement, and calibration. Materials used may be reports and records of qualifications for the personnel, instructions for equipment, and facilities. The procedures for maintenance may include standard operating procedures for supporting turn-around and ground operations in both scheduled and unscheduled maintenance functions.	

		Approve Maint Materials	<i>[Approve (Personnel/ FEMP) → Approve FEMP →Approve Operations FEMP →Approve Maint Materials]</i> The Approve Maintenance Materials sub-function is the set of tasks for the approval of materials used in maintenance. Materials used may be reports and records of qualifications for the personnel, instructions for equipment, and facilities.
		Approve Maint Equipment	<i>[Approve (Personnel/ FEMP) → Approve FEMP →Approve Operations FEMP →Approve Maint Equipment]</i> The Approve Maintenance Equipment sub-function is the set of tasks for the function of approving equipment used during maintenance. Such equipment includes those used for repair, replace and calibration.
		Approve Maint Facilities	<i>[Approve (Personnel/ FEMP) → Approve FEMP →Approve Operations FEMP →Approve Maint Facilities]</i> The Approve Maintenance Facilities sub-function is defined as the set of tasks for the sub-functions of approving facilities used for maintenance. Maintenance facilities include repair shops, fabrication facilities, and test centers.
		Approve Maint Procedures	<i>[Approve (Personnel/ FEMP) → Approve FEMP →Approve Operations FEMP →Approve Maint Procedures]</i> The Approve Maintenance Procedures sub-function is defined as the set of tasks for approving procedures used in maintenance. The approval of maintenance procedures may consist of checking standard operating procedures for supporting turn-around and ground operations in both scheduled and unscheduled maintenance functions. The procedures for maintenance may require the maintenance inspections to follow an RLV/Facility specific core checklist developed by the operator subject to FAA/AST inspection.

6.1 General Discussion

Approve Training & Qualification (T&Q) FEMP

Currently in aviation the FAA does not require that all schools be approved. For unapproved schools, the FAA may require a slightly longer duration of training. The FAA provides standards for minimum requirements for certain aspects of training such as curricula, currency, record keeping, etc. However, the FAA encourages operators to be innovative and creative in the training approach. Standards are imposed for knowledge tests and practical tests. For RLVs, since technology is varied between RLVs, and since the pace of technology is so fast, it may be important to not impose a standardized set of requirements for all RLVs. Rather, the FAA/AST should require specific performance criteria. An RLV operator should propose what these training requirements should be for that specific RLV to meet such performance criteria. Additionally, FAA/AST should ensure that the RLV operator is following these requirements by inspection.

Approve Operations FEMP

Operational procedures must clearly indicate roles, responsibilities, and direct accountability, of the various personnel conducting the RLV operation functions. Facilities and equipment used for accomplishing these procedures must be in good operating condition. If certain equipment is not operable, alternative procedures must be approved by FAA/AST and must be readily available. There must be records kept to document personnel qualifications, job descriptions, and instructions for operating the equipment and facilities. The RLV operator's procedure must complement the operational CONOPS for the NAS in sharing the spaceport/landing site as well as sharing the airspace with civilian aircraft, military aircraft, and other RLVs. These shared spaceport, landing sites, and airspace may require handoff procedures between RLV operators, FAA/AST operators, military operators, and FAA (national and international) operator teams. Approval in this context includes these handoff procedures. There may be sharing in the use of ground infrastructure such as communications and navigational guides, which should also be considered in the individual RLV operations. Even the phraseology used currently in Air Traffic Management (ATM) may or may not be suitable or adequate for RLVs. New sets of phraseology may need to be developed and approved by FAA/AST for use in RLV operations (eg. The use of Aerospace Traffic Management (ATM)). Training for flight operators and ground operators may involve training in the use of this common phraseology for all RLVs. RLVs are varied in concepts, flight characteristics, flight profiles, maneuverability, and susceptibility to environmental issues (e.g. high winds, wake vortex, etc.). These properties of an RLV must be made known to the RLV, military, and air traffic controllers to allow for better tactical and strategic planning. Operations must also consider contingencies such as alternate spaceports or landing sites, response to incidents/accidents, protection or courses of least harm from incidents/accidents, emergency preparedness of spaceport officials, etc. Operations procedures must consider the workload issues and the number of operators present for accomplishing a given job. Vehicle specific considerations include operational decisions of

whether the vehicle will be permitted to take-off or launch or land, even if certain subsystems are not considered to be operational.

Approve Maintenance FEMP

Approval of facilities and equipment should ensure working conditions to conduct and perform the necessary maintenance activities (e.g. clean-room, minimum or maximum temperatures for curing, etc.). It must be emphasized that some of the equipment and chemicals may need special storing conditions and working conditions. Equipment used should be appropriate for the job. Equipment should also be checked at regular intervals for calibration as appropriate. Records should be kept for personnel qualifications as well as maintenance schedules; unscheduled maintenance; incidents/accidents resulting from inadequate maintenance; or mistakes made in maintenance. FAA/AST approval personnel may use non-destructive inspection methods in order to check suspected defects. Since RLVs use varying technologies, no one maintenance schedule may be appropriate to all RLVs. Maintenance schedules are expected to be proposed by the RLV operator as early as possible in the pre-application process. This schedule should be based on an analysis of reliability of components and the expected life of subsystems. In routine inspections, it may be found that the schedules need to be modified. Maintenance procedures should be clearly documented and the maintainers/technicians should be proficient in these procedures. Maintenance procedures should take adequate precaution for handling of toxic materials.

6.2 Guideline Input Considerations

The following Guideline Input Considerations (GICs) have been identified for the Approve FEMP Sub-function:

- Appr FEMP GIC - 1. Testing of trainers and approvers should include testing for their particular RLV specialization (job) as well as testing as instructors or approvers.
- Appr FEMP GIC - 2. Maximum tolerable safety risk and potential liability issues should be considered, because such situations may lead to incidents and accidents. If the approval process is flawed or if the tools used for approval are not appropriate, RLV O&M may be approved with unknown residual safety risks.
- Appr FEMP GIC - 3. Operations include intensely cooperative actions not only on the part of ground operations personnel and flight operations personnel but also on the part of FAA and other RLV operations personnel while using common resources such as airspace and spaceport/airport. Operational procedures should fully consider the protocol (i.e. hand offs, clear indication of entering an 'air/space traffic sector', decision to abort take-off or landing, etc.) as well as the means (i.e.

phraseology, frequency, etc.) for this cooperative sharing of resources. There may be incidents/accidents exposing the public to risk. The approval process should include an evaluation of the interoperability in these key areas.

Appr FEMP GIC - 4. When deficiencies that pose safety risks are found in operations, there should be a prompt method for changing these procedures, training the personnel, approving the procedures and implementing the new procedures so that risks are mitigated. If such measures are not taken there is a higher chance of incidents/accidents exposing public to risk.

Appr FEMP GIC - 5. Maintenance procedures should clearly depict the RLV configuration at licensing. Any changes to this configuration such as use of different types of replacement parts; use of different types of structural patch-up; use of different chemicals, etc. should be re-approved by FAA/AST and subject to FAA/AST inspection. Any changes to the original configuration should be reassessed for safety and continued maintenance (possibly new maintenance schedule, new types of inspections, etc.). If this assessment is not done there may be risks due to these changes, which may put the public in jeopardy.

Appr FEMP GIC - 6. Performance Specifications of FEMP should be developed by AST, and should be subject to FAA/AST inspection. Due to rapid nature of potential industry developments, these specifications may be waived on FAA/AST review.

Appr FEMP GIC - 7. The oversight document for Approve Operations FEMP should be the RLV Safety-Critical Equipment List (RSEL) currently under development by FAA/AST. Compliance should be monitored by FAA/AST.

6.2.1 Inter/Intra Agency Considerations

The following Approve FEMP Sub-function inter/intra agency considerations were identified:

1. It is possible that new chemicals and new materials may be introduced to support RLVs. DOT, OSHA, and EPA must be involved in formulating safe methods of transporting, handling, and using these chemicals. Formulation of test questions for these types of new chemicals and materials should be performed in cooperation with these agencies.

2. Jurisdictional issues within DOT regarding HAZMAT transportation for chemicals used for RLV operations and maintenance as well as payloads
3. The approval of hazardous material handling may be a concern to OSHA and/or EPA. OSHA /AFOSH guidelines to insure worker safety on federal and nonfederal ranges should be followed.
4. The EPA should be involved with environmental issues with pollutants, disposal of chemicals in the process of operations, maintenance and training.
5. The Department of Defense Explosive Safety Board (ESB) should be consulted to provide a source of lessons learned for FAA/AST for conducting RLV safety evaluations, storage of propellants, and chemical agents.³
6. National Fire Protection Agency (NFPA) coordination should be required for procedure development to ensure that fire safety and mitigation procedures are in place for launch/takeoff preparations.
7. Particular payloads may require coordination, security, and technical evaluation from external agencies to the FAA such as Department of Defense (DoD), the National Aeronautics and Space Administration (NASA), and the Nuclear Regulatory Commission (NRC) for those payloads which employ nuclear power.
8. Internal to the FAA several divisions may be called upon. These include the Flight Standards Service (FAA/AFS) for such items as training and testing. Additionally, FAA Air Traffic Control (FAA/AIR) should be coordinated for shared airspace issues when an RLV is flying through military or civil airspace until such time that there is one aerospace system.

6.3 Guideline Recommendations

Appr FEMP GI - 1. Performance Test Safety
Guideline Input Performance testing shall be conducted in accordance with the FAA/AST approved RLV Operator Approval Manual.
Rationale Tests should be a realistic representation of what personnel would do on the job. If the skill being evaluated requires an environment that may put the public at risk, the testing personnel must adhere to the hazardous procedures guidelines outlined in the RLV Operator Approval Manual.

7.0 Record & Report

The following sub-functions were developed to reflect those tasks or procedures that are applicable to RLV Record and Report activities. Table 4 highlights the general definitions for the Record and Report Sub-functions.

Table 4 Record and Report Sub-function Definitions

Record & Report	<i>[Train Personnel→Record & Report]</i>	
	The Record and Report Function encompasses the tasks and procedures to record approval documentation for each course, facility, simulator, and student. This information is used to improve approval quality as well as pass the student on to the approval process.	
	Licensing Authority	<i>[Train Personnel→Record & Report→See Licensing Authority]</i>
		The Licensing authority (i.e. the FAA) will require the RLV Operator to maintain, and provide access to the records associated with approval documentation for each course, facility, simulator, and student.

7.1 General Discussion

RLV approval plans will have criteria that the student will be measured against. These include both task/performance based items as well as knowledge based items. An individual's achievements and failures will be recorded to provide a complete record of their level of readiness for actual field work. Additionally, the RLV Operator may be required to provide records of use and revisions for course curriculum, approval facilities, and approval simulators to ensure the approved versions of these items are being used in the approval of RLV personnel.

Reporting entails the endorsement of the approval facility to the approval authority that the individual is prepared to be evaluated for licensing, or other approval mechanism.

7.2 Guideline Input Considerations

The following Guideline Input Considerations (GICs) have been identified for the Record and Report Sub-function:

- Record & Report GIC - 1. As the industry matures, approval records should be standardized to the greatest extent possible.

7.2.1 Inter/Intra Agency Considerations

The following Record and Report Sub-function inter/intra agency considerations were identified:

1. DOT coordination should occur with appropriate rail, air, and roadway transportation offices for safe practices and regulations associated with the transportation of hazardous materials on public routes.
2. Federal Communication Commission (FCC) coordination should occur for all frequency assignments used in RLV maintenance procedures, particularly those employed in emergencies.

3. The Department of Defense Explosive Safety Board (ESB) should be consulted to provide a source of lessons learned for FAA/AST for conducting RLV safety evaluations, storage of propellants, and chemical agents.³
4. National Fire Protection Agency (NFPA) coordination should be required for procedure development to ensure that fire safety and mitigation procedures are in place for maintenance.

7.3 Guideline Recommendations

Record & Report GI - 1. Personnel Approval Completion Endorsement

Guideline Input

An approved instructor and/or inspector shall log an endorsement in a student's approval record that attests that an individual has been found proficient in the criteria and requirements associated with a given position.

Rationale

These documents record the results of approval and will include the following information:

1. Name of the individual
2. Name of the course (if applicable)
3. Make and model of the approval equipment used
4. Trainee's prerequisite experience and course time completed
5. Trainee's performance on each lesson and the name of the instructor providing instruction (if applicable)
6. Date and result of each performance test
7. Name of the evaluator conducting the test
8. Endorsement from authorized instructor or inspector
9. Recurring Approval Records

Appendix A: Acronyms/Terminology

AAAF	Association Aéronautique et Astronautique de France	ARINC	Aeronautical Radio, Inc.
A&P	Airframe & Powerplant	ARP	Aerospace Recommended Practice
A/C	Aircraft	ASEE	American Society for Engineering Education
AC	Advisory Circular	ASICS	Application Specific Integrated Circuits
AD	Airworthiness Directive	ASME	American Society of Mechanical Engineers
ADIZ	Air Defense Information Zones	ASQ	American Society for Quality
AETB	Alumina Enhanced Thermal Barrier	AST	Office of the Associate Administrator for Commercial Space Transportation
AFS	Aviation Flight Standards	ASTM	American Society for Testing and Materials
AIAA	American Institute of Aeronautics and Astronautics	ASTWG	Advance Spaceport Technology Working Group
ALARA	As Low As Reasonably Achievable	AWS	Aerospace Worthiness Standards
AM	Amplitude Modulation	ATA	Air Transport Association
AMF	Astronauts Memorial Foundation	ATAC	Advanced Technology Advisory Committee
ANPRM	Advanced Notice of Proposed Rule Making	ATC	Air Traffic Control
ANSI	American National Standards Institute	ATM	Air Traffic Management
AOA	Abort Once Around	ATO	Abort to Orbit
AOG	Airplane on Ground	ATOS	Air Transport Oversight System
APU	Auxiliary Power Unit	ATS	Air Traffic Services
ARAC	Aviation Rulemaking Advisory Committee		
ARC	Ames Research Center		
ARF	Assembly and Refurbishment Facility		

ATSRAC	Aging Transport Systems Rule Making Advisory Committee	CIL	Critical Items List
		CINCSPACE	Commander In Chief, Space Command
AVCS	Air Vehicle Control Station	CMR	Certification Maintenance Requirements
BCSP	Board of Certified Safety Professionals	CO ₂	Carbon Dioxide
BFE	Buyer Furnished Equipment	COFR	Certificate of Flight Readiness
BITE	Built In Test Equipment	COLA	Conjunction On Launch Assessment or Collision Avoidance
BPSK	Bit Phase Shift Keying	COMBO	Computation of Miss Between Orbits
CAA	Civil Aviation Authorities	COMSTAC	Commercial Space Transportation Advisory Committee
CAM	Civil Aeronautics Manual	CONOPS	Concept Of Operations
CAR	Code of Aviation Regulations	CONUS	Continental United States
CASA	Civil Aviation Safety Authority	CRM	Cockpit Resource Management
CASS	Continuous Analysis and Surveillance	CRV	Crew Return/Rescue Vehicle
CAST	Civil Aviation Safety Team	CVR	Cockpit Voice recorder
CBM	Condition-Based Maintenance	dB	Decibel
C-Band	Frequency range between 3.6 and 4.2 GHz	DACUM	Developing A Curriculum
CCAFS	Cape Canaveral Air Force Station	DARPA	Defense Advanced Research Projects Agency
CDM	Collaborative Decision Making	DCC	Division of Community College
CDR	Critical Design Review	DCN	Document Change Notice
CEI	Contract End Item	DFRC	Dryden Flight Research Center
CEO	Chief Executive Officer		
CFR	Code of Federal Regulations		

DMS	Docket Management System	FAR	Federal Aviation Regulation
DNPS	Delaware North Park Services	FCC	Federal Communications Commission
DO	Delivery Order		
DoD	Department of Defense	FEMP	Facilities/ Equipment/ Material/ Procedures
DOF	Degrees of Freedom	FHA	Functional Hazard Assessment
DOT	Department of Transportation	FL	Florida
E _c	Casualty Expectation	FM	Frequency Modulation
EIS	Environmental Impact Statement	FMEA	Failure Modes and Effects Analysis
EFI	Enterprise Florida, Inc.	FMEA/CIL	Failure Modes and Effects Analysis/Critical Items List
ELV	Expendable Launch Vehicle		
EMC	Electromagnetic Compatibility	FMECA	Failure Modes, Effects, and Criticality Analysis
EMI	Electromagnetic Interference	FMS	Flight Management System
EOM	End Of Mission	FOCC	Flight Operations Control Center
EPA	Environmental Protection Agency	FOQA	Flight Operations Quality Assurance
ERP	Emergency Response Procedure	FR	Flight Recorder
ESA	European Space Agency	FRCS	Forward Reaction Control System
ESD	Electrostatic Discharge	FRR	Flight Readiness Review
ESMC	Eastern Space and Missile Center	FSDO	Flight Standards District Office
ET	External Tank	FSO	Flight Safety Officer
ETMS	Enhanced Traffic Management System	FSS	Flight Safety Systems
ETOPS	Extended Twin (engines) Operations	FTA	Fault Tree Analysis
FAA	Federal Aviation Administration	FTD	Flight Approval Devices

FTS	Flight Termination Systems	HMR	Hazardous Material Report
FY	Fiscal Year	HRST	Highly Reusable Space Transportation
G	Gravitation Acceleration at Sea Level	HTHL	Horizontal Take Off and Landing
GLONASS	Global Orbiting Navigation Satellite System	HTVL	Horizontal Take Off and Vertical Landing
GNC	Guidance, Navigation, Control	HW	Hardware
GNSS	Global Navigation Satellite System	IASA	International Aviation Safety Assessment
GOR	Ground Operations Review	ICA	Instructions for Continued Airworthiness
GPS	Global Positioning System	ICAO	International Civil Aviation Organization
GRC	Glenn Research Center	ICF	Instructions for Continued Flight-worthiness
GSE	Ground Support Equipment	ICHM	Integrated Control and Health Management
GSO	Ground Safety Officer	IEC	International Electrotechnical Commission
GSRP	Ground Safety Review Panel	IEEE	Institute of Electrical and Electronic Engineers
GSS	Ground Support System	IFR	Instrument Flight Rules
HAZMAT	Hazardous Material	ILL	Impact Limit Lines
HBAT	Handbook Bulletin for Air Transportation	ILS	Instrument Landing System
HCF	High Cycle Fatigue	IMU	Inertial Measurement Unit
HDTV	High Definition Television	ISO	International Organization for Standardization
HMI	Human-Machine Interface	ISS	International Space Station
HMF	Hypergolic Maintenance Facility		

ITU	International Telecommunication Union	LRU	Line Replaceable Units
		MAKS	Multi-Purpose Aerospace System
IVHM	Integrated Vehicle Health Monitoring	MMEL	Master Minimum Equipment List
IV&V	Independent Validation and Verification	MEL	Minimum Equipment List
JAA	Joint Aviation Authorities	MLP	Mobile Launcher Platform
JAR ₁	Joint Airworthiness Regulations	MMH	Monomethyl Hydrazine
JAR ₂	Joint Aviation Regulations	MNPS	Minimum Navigation Performance Specifications Airspace
JAR-VLA	Joint Aviation Regulations-Very Light Airplanes	MPP	Maintenance Program Plan
JROC	Joint Requirements Oversight Council	MRB	Maintenance Review Board
JSC	Johnson Space Center	MRM	Maintenance Resource Management
Klb	Kilo Pound	MRO	Maintenance, and Repair, Overhaul
Klbs	Kilo Pounds		
KSC	Kennedy Space Center	MSFC	Marshall Space Flight Center
Ku-Band	Frequency Range from 1.7 to 12.76 GHz	MSG	Maintenance Steering Group
LA	Los Angeles	MSI	Maintenance Significant Items
LCC	Launch Control Complex	MSL	Mean Sea Level
LH2	Liquid Hydrogen	N/A	Not Applicable
LOA	Letter of Agreement	NAI	National Aerospace Initiative
LEO	Low Earth Orbit		
LLC	Limited Liability Corporation	NAS	National Airspace System
LOX	Liquid Oxygen	NASA	National Aeronautics and Space Administration
LRCS	Long-Range Communication System		

NASP	National Aerospace Plane	OMI	Operations and Maintenance Instructions
NAT	North Atlantic		
NDE	Non Destructive Evaluations	OMRS	Operations and Maintenance Requirements Specifications
NIDA	NIDA Corporation		
NORAD	North American Aerospace Defense Command	OMRSD	Operations and Maintenance Requirements Specifications Document
NOTAM	Notice To Airmen		
NOTMAR	Notice To Mariners		
NPRM	Notice of Proposed Rulemaking	OMS	Orbital Maneuvering System
NSP	National Simulator Program	OPF	Orbital Processing Facility
NSLD	NASA Shuttle Logistics Depot	ORR	Orbiter Readiness Review
NSTS	National Space Transportation System	OSD/AF	Office of Scientific Development/Air Force
NTSC	National Television System Committee	OSHA	Occupational Safety and Health Administration
O ₂	Oxygen		
O&M	Operations and Maintenance	OSI	Open Systems Interconnect
O&S	Operations and Supportability	P _i	Probability of Impact
OEI	One Engine Inactive	PAL	Phase Alternation Line
OEM	Original Equipment Manufacturer	PCM	Pulse Code Modulation
OJT	On-the-Job Approval	PiC	Pilot in Command
OMD	Operations and Maintenance Document	PLC	Programmable Logic Controller
OMDP	Orbiter Maintenance Down Period	PMA	Parts Manufacturer Approval
		PMD	Propellant Management Devices
		PMI	Principle Maintenance Inspectors or

	Preventative Maintenance Inspection	RPSF	Rotation, Processing & Surge Facility
PoC	Point of Contact	RSO	Range Safety Officer
PRACA	Problem Reporting and Corrective Action	RSRM	Reusable Solid Rocket Motor
PRR	Payload Readiness Review	RSS	Range Safety System
PSI	Pounds per Square Inch	RTG	Radioisotope Thermoelectric Generator
PSRP	Payload Safety Review Panel	RTI	Research Triangle Institute
Pt.	Part	RTLS	Return To Launch Site
PVAT	Position, Velocity, Attitude, Time	RTS	Return To Service
Q-D	Quantity Distance	RTV	Room Temperature Vulcanizing
QD	Quick Disconnects	RVT	Reusable Vehicle Test
QoS	Quality of Service	SAE	Society of Automotive Engineers
QPSK	Quadrature Phase Shift Keying	SATMS	Space and Air Traffic Management System
RCM	Reliability Centered Maintenance	SCAPE	Self-Contained Atmospheric Protective Ensemble
RCS	Reaction Control System	SDP	Safety Data Package
RF	Radio Frequency	SDR	Service Difficulty Report
RLV	Reusable Launch Vehicle	SFE	Supplier Furnished Equipment
RMAT	RLV Aerospace Maintenance Technician	SGS	Space Gateway Support
RNAV	Area Navigation	SIAT	Shuttle Independent Assessment Team
RPM	Revenue Passenger Mile	SLF	Shuttle Landing Facility
RPR	Rulemaking Project Record	SLI	Space Launch Initiative
		SME ₁	Shuttle Main Engine
		SME ₂	Subject Matter Expert

S/N	Stock Number	TOGA	Takeoff/Go-Around
SNPRM	Supplemental Notice of Proposed Rule Making	TOL	Transoceanic Landing
SOH	State of Health	TPS	Thermal Protection System
SOP	Standard Operating Procedure	TSA	Transportation Security Administration
SPST	Space Propulsion Synergy Team	TSO	Technical Standard Order
SRB	Solid Rocket Booster	TSOA	Technical Standard Order Authorization
SRD	Systems Requirements Document	TSPI	Time Space Position Information
SRM	Solid Rocket Motor	TSTO	Two Stage To Orbit
SRSO	Senior Range Safety Officer	TTS	Thrust Termination System
SSA	System Safety Assessment	TVC	Thrust Vector Control
SSB	Single Side Band	UAV	Unmanned Aerial Vehicle
SSME	Space Shuttle Main Engine	US	United States
SSP	Space Shuttle Program	USAF	United States Air Force
SSTO	Single Stage To Orbit	USBI	United States Boosters, Inc.
SSV	Space Shuttle Vehicle	USC	United States Code
STC	Space Traffic Control	VAB	Vehicle Assembly Building
STS	Space Transportation System	VFC/MFC	Maximum Speed For Stability Characteristics
SUA	Special Use Airspace	VDF/MDF	Demonstrated Flight Diving Speed
SUP	Suspected Unapproved Parts	VFR	Visual Flight Rules
SW	Software	VHF	Very High Frequency
TAL	Transoceanic Abort Landing	VOD	Vehicle Operator Dispatcher
TBD	To Be Determined	VOR	VHF Omnidirectional Range (navigation system)
TCAS	Traffic Alert and Collision Avoidance System		

VSP	Vision Spaceport Program	WSMC	Western Space and Missile Center
VTHL	Vertical Take Off and Horizontal Landing	WWI	World War 1
VTVL	Vertical Take Off and Landing	Wx	Weather

Appendix B: RLV Guideline Input Suggestion Form

RLV Guideline Input Suggestion Form

Name: _____ Company Name: _____
Address: _____
City: _____ State, Postal Code, Country: _____
Phone: _____ Date: _____
Email: _____

Document: RLV O&M Guideline Inputs – Vol. 5 – Approval

Sec: _____ Page: _____ Line: _____

☐ Documentation Error (Format, punctuation, spelling)

☐ Content Error

☐ Enhancement or Refinement

Rationale (Describe the error or justification for enhancement):

Proposed change (Attach marked up text or proposed rewrite):

Please provide any general comments for improvements of this document:

Return completed form to:

FAA/AST-100
RLV O&M
800 Independence Ave SW RM 331
Washington DC 20591

Appendix C: Traceability of Approval Function Decomposition

Figure 5 reflects the Approval Functional Decomposition as developed for this effort. The following figure, Figure 6, reflects the Approval Functional Decomposition as developed for a previous tasking effort. The subsequent table, Table 5, provides the sub-function level traceability between the two decompositions. The current decomposition was developed in preparation of a Functional Analysis.

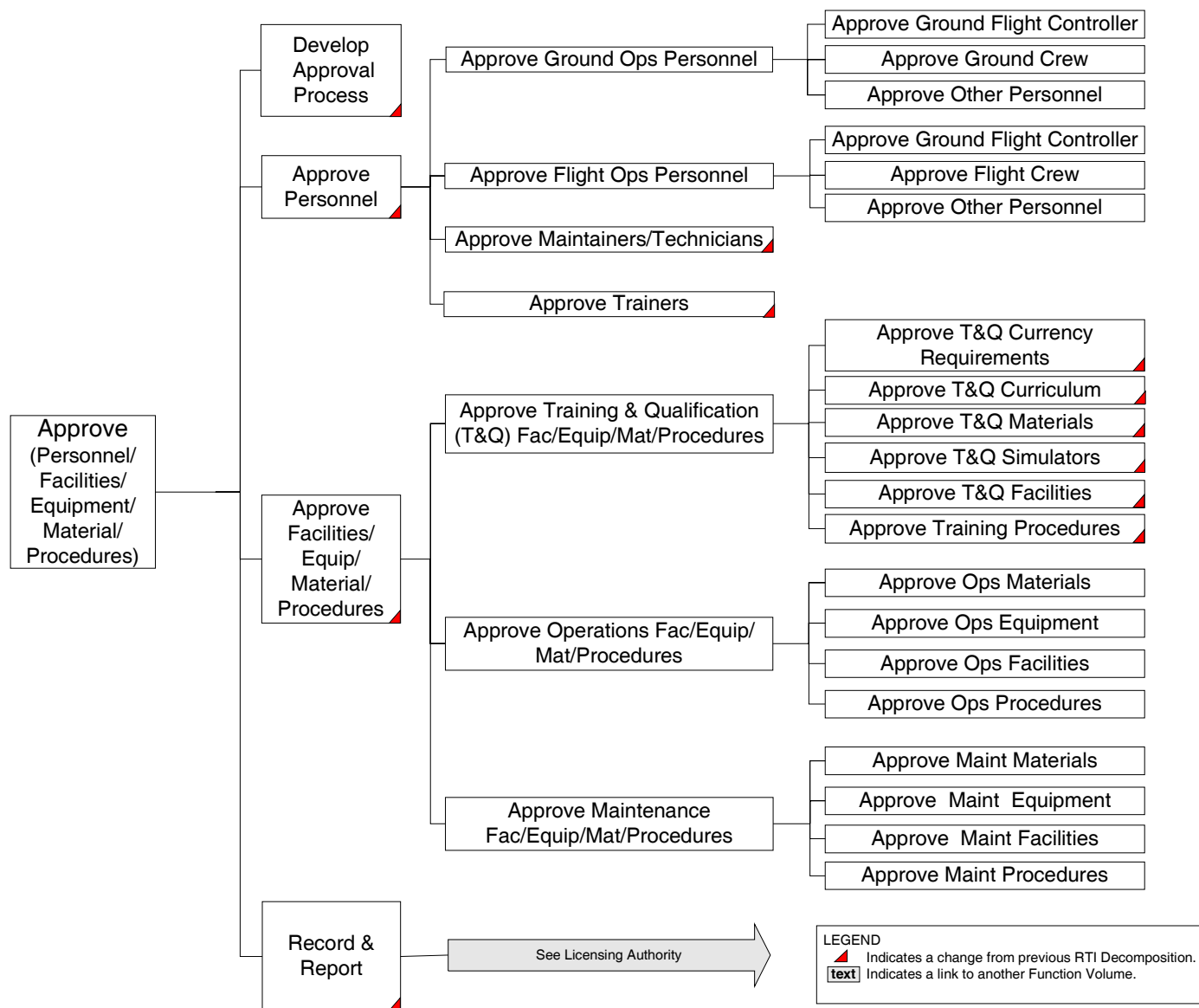


Figure 5 Current Approval Functional Decomposition

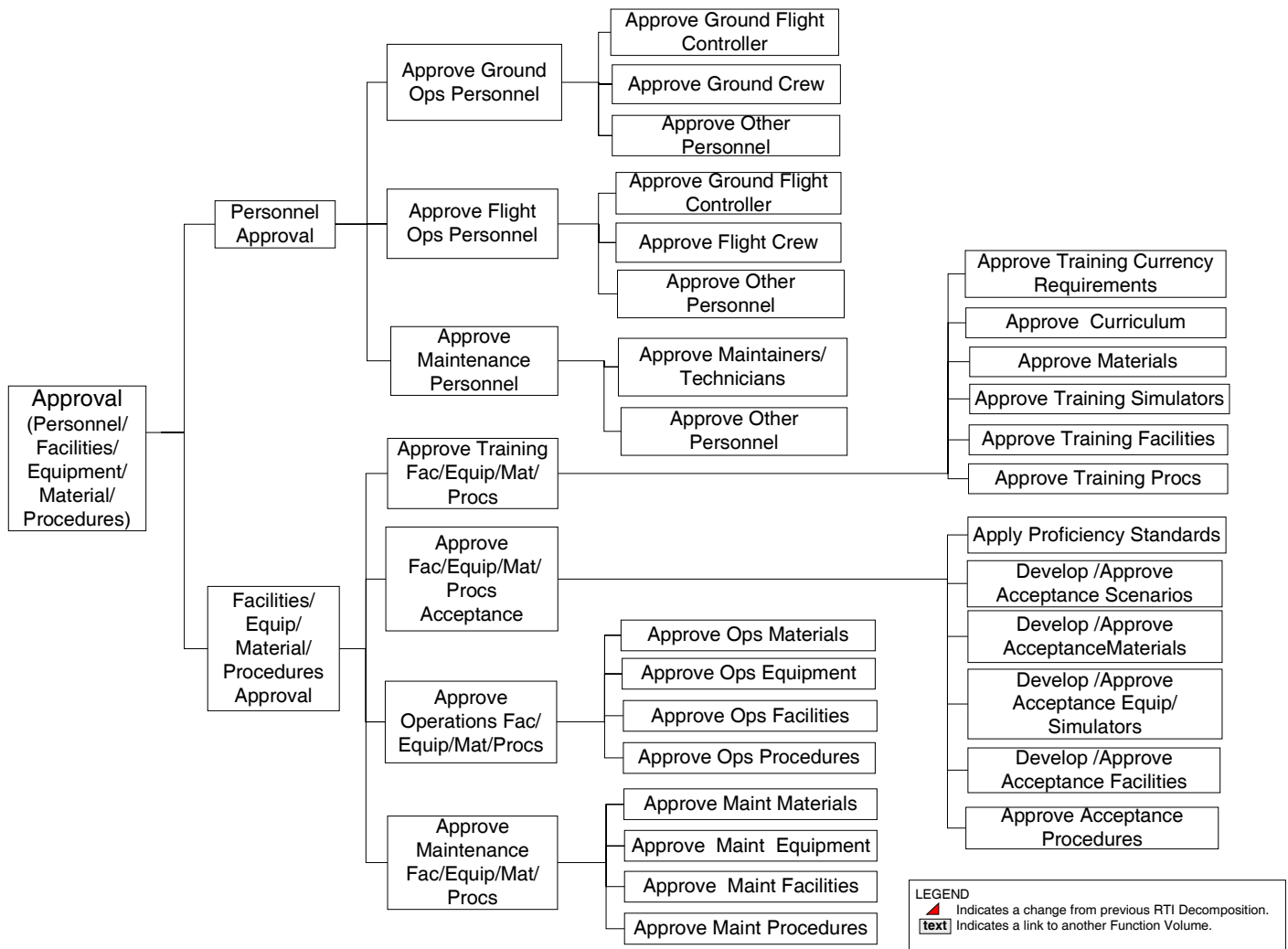


Figure 6 Previous Approval Functional Decomposition

Table 5 Approve Sub-Function Traceability

Indicates Same from Previous to Current				Indicates Move/Change from Previous to Current		Indicates New Sub-Function		Indicates no Previous to Current Correlation		
Current Sub-Functions					Previous Sub-Functions					
High Level Function	Second Level Sub-Function	Tertiary Sub-Function	Fourth Level Sub-unction	Change	High Level Function	Second Level Sub-Function	Tertiary Sub-Function	Fourth Level Sub-unction	Change	
Develop Approval Process				Renamed and Moved from Secondary Level		Approve Fac/ Equip/ Mat/ Procs Acceptance			Renamed and Moved to High Level	
Approve Personnel				Renamed	Approval (Personnel/ Facilities/ Equipment/ Material/ Procedures)				Renamed	
	Approve Ground Ops Personnel			Same		Approve Ground Ops Personnel				Same
		Approve Ground Flight Controller		Same			Approve Ground Flight Controller			Same
		Approve Ground Crew		Same			Approve Ground Crew			Same
		Approve Other Personnel		Same			Approve Other Personnel			Same
	Approve Flight Ops Personnel			Same		Approve Flight Ops Personnel				Same
		Approve Ground Flight Controller		Same			Approve Ground Flight Controller			Same
		Approve Flight Crew		Same			Approve Flight Crew			Same
		Approve Other Personnel		Same			Approve Other Personnel			Same
	Approve Maintainers/ Technicians			Moved from Tertiary Level		Approve Maintenance Personnel				Rename
							Approve Maintainers/ Technicians			Moved to Secondary Level
							Approve Other Personnel			Removed
	Approve Trainers					New				
Approve Facilities/ Equip/ Material/ Procedures	Approve Training & Qualification (T&Q) Fac/ Equip/ Mat/ Procedures			Rename	Facilities/ Equip/ Material/ Procedures Approval	Approve Training Fac/ Equip/ Mat/ Procs			Rename	
				Rename					Same	
		Approve T&Q Currency Requirements		Rename			Approve Training Currency Requirements			Same
		Approve T&Q Curriculum		Rename			Approve Curriculum			Same
		Approve T&Q Materials		Rename			Approve Materials			Same
		Approve T&Q Simulators		Rename			Approve Training Simulators			Same
		Approve T&Q Facilities		Rename			Approve Training Facilities			Same
		Approve Training Procedures		Rename			Approve Training Procs			Same
	Approve			Same			Approve			Same

Current Sub-Functions					Previous Sub-Functions				
High Level Function	Second Level Sub-Function	Tertiary Sub-Function	Fourth Level Sub-unction	Change	High Level Function	Second Level Sub-Function	Tertiary Sub-Function	Fourth Level Sub-unction	Change
	Operations Fac/ Equip/ Mat/ Procs	Approve Ops Materials		Same		Operations Fac/ Equip/ Mat/ Procs	Approve Ops Materials		Same
		Approve Ops Equipment		Same			Approve Ops Equipment		Same
		Approve Ops Facilities		Same			Approve Ops Facilities		Same
		Approve Ops Procedures		Same			Approve Ops Procedures		Same
	Approve Maintenance Fac/ Equip/ Mat/ Procs			Same		Approve Maintenance Fac/ Equip/ Mat/ Procs			Same
		Approve Maint Materials		Same			Approve Maint Materials		Same
		Approve Maint Equipment		Same			Approve Maint Equipment		Same
		Approve Maint Facilities		Same			Approve Maint Facilities		Same
		Approve Maint Procedures		Same			Approve Maint Procedures		Same
Record & Report				New	Record & Report				New
	See Licensing Authority			New		See Licensing Authority			New

Endnotes

¹ White Paper on Commercial Space Transportation Reusable Launch Vehicle Operations and Maintenance, FAA-AST, Chuck Larsen, October 1999

² Reusable Launch Vehicles Operations and Maintenance Top-Down Analysis Final Technical Report, RTI, September 30, 2002 (RTI Report No. 08087.002F)

³ Department of Defense Explosive Safety Board, General Information-Functions, <http://www.ddesb.pentagon.mil/function.html>