2.6 Synthetic Vision Systems

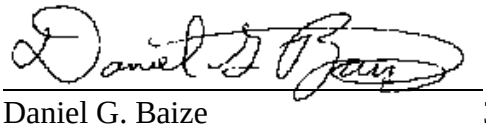
Project Plan

Version 2.1

March 15, 2000

2.6 Synthetic Vision Systems

Submitted By:



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ABBREVIATIONS AND ACRONYMS

AvSP	Aviation Safety Program
CAST	Commercial Aviation Safety Team
CFIT	Controlled Flight Into Terrain
CM	Configuration Management
DoD	Department of Defense
EFIS	Electronic Flight Instrument System
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FTE	Full-Time Equivalent
FY	Fiscal Year
GA	General Aviation
GAJSC	General Aviation Joint Steering Committee
GPS	Global Positioning System
HUD	Heads-up-Display
ICAO	International Civil Aviation Organization
IRL	Implementation Readiness Level
JSAT	Joint Safety Analysis Team
JSIT	Joint Safety Implementation Team
LaRC	Langley Research Center
LOC	Loss of Control
MOA	Memorandum of Agreement
NAR	Non-advocate review
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NIMA	National Imagery and Mapping Agency
NOAA	National Oceanic and Atmospheric Administration
NRA	NASA Research Announcement
NTSB	National Transportation Safety Board
R&D	Research and Development
RASCAL	Rotorcraft Aircrew System Concepts Airborne Laboratory
RTCA	Requirements and Technical Concepts for Aviation
SRTM	Shuttle Radar Topology Mission

SVS	Synthetic Vision Systems
TRL	Technology Readiness Level
U.S.	United States
WBS	Work Breakdown Structure

1.0 INTRODUCTION

The work plan herein describes activities to be sponsored by the NASA Aviation Safety Program's (AvSP) WBS 2.6 Synthetic Vision Systems (SVS) Project intended to develop and support the implementation of a synthetic vision system(s) for commercial transport, business jet, general aviation (GA), and rotorcraft applications to greatly improve aviation safety and efficiency of operations.

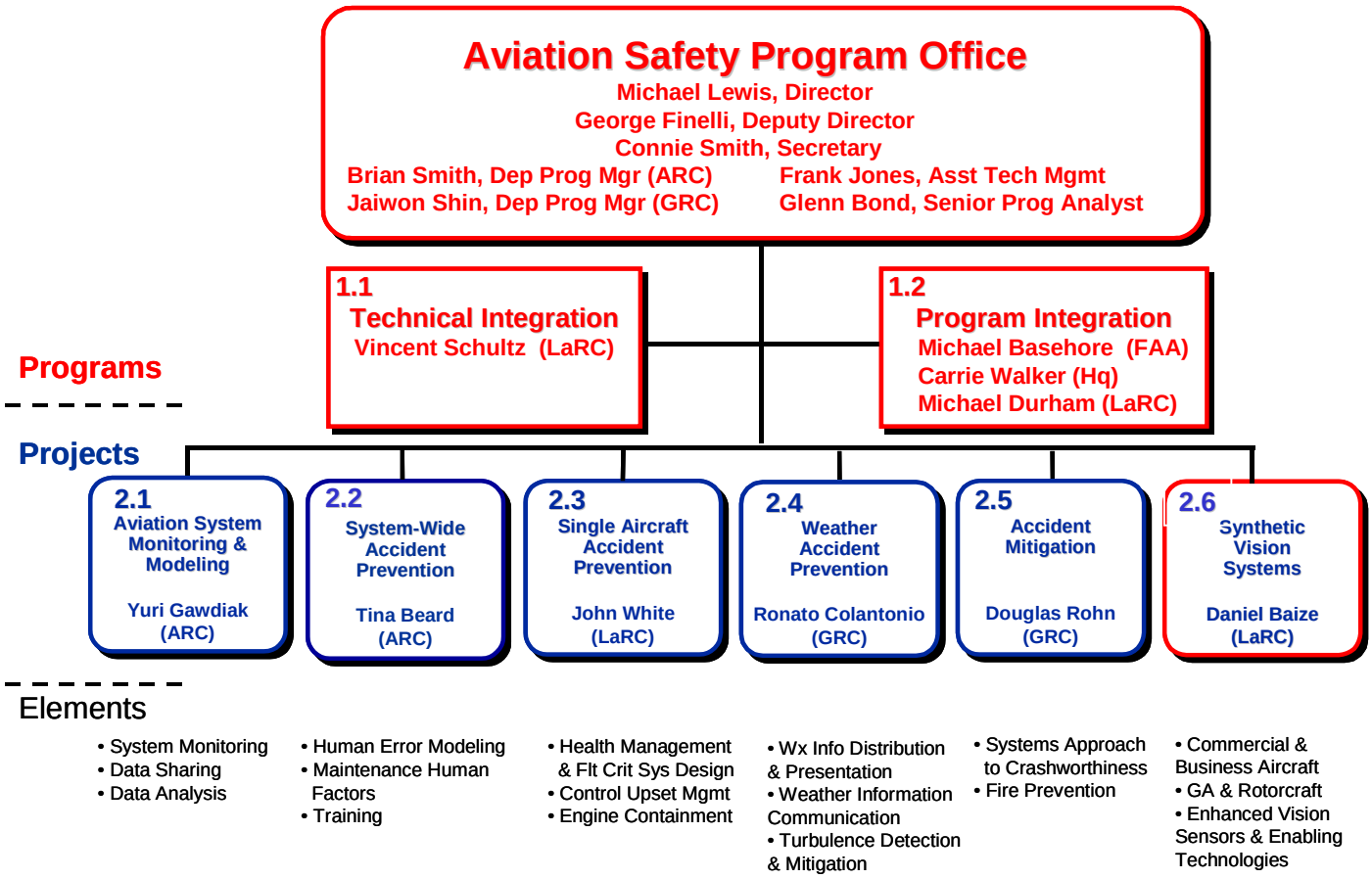


Figure 1.0 NASA's Aviation Safety Program Organization

1.1 Project Overview

In August 1996, following the wake of several high-visibility commercial transport accidents, a White House Commission on Aviation Safety and Security was established to study matters involving aviation safety and security. The Commission findings concluded that although the worldwide commercial aviation major accident rate is low and has been nearly constant over the past two decades, increasing traffic over the years has resulted in the absolute number of accidents increasing. Given the very visible, damaging, and tragic effects of a single major accident, this situation could become an unacceptable blow to the public's confidence in the aviation system. As a result, the anticipated growth of the commercial air-travel market would not reach its full potential. In February 1997, in response to the Commission's recommendations, President Clinton set a national goal to reduce the aviation fatal accident rate by 80% within ten years.

NASA's role in civil aeronautics is to develop high risk, high payoff technologies to meet critical national aviation challenges. Currently, a high priority national challenge is to ensure U.S. leadership in aviation in the face of growing air traffic volume, new safety requirements, and increasingly stringent noise and emissions standards. NASA has a successful history of leading the development of aggressive high payoff technology in high-risk areas, ensuring a proactive approach is taken to developing technology that will both be required for meeting anticipated future requirements, and for providing the technical basis to guide policy by determining feasible technical limits. Therefore, NASA has stepped up to the challenge of addressing the President's national aviation safety goal by forming the new, focused Aviation Safety Program.

As a first step to establish a focused safety program, NASA sponsored a major program planning effort to gather input from the aviation community regarding the appropriate research to be conducted by the Agency. This activity called the NASA Aviation Safety Investment Strategy Team (ASIST), held four industry- and government-wide workshops to define and recommend research areas, which would have the greatest potential impact for reducing the fatal accident rate. One of the significant recommendations from ASIST was to establish a project to eliminate visibility-induced errors for all aircraft through the cost-effective use of synthetic/enhanced vision displays, worldwide terrain databases, and Global Positioning System (GPS) navigation. Therefore, on March 25, 1999 the Associate Administrator for Aero-Space Technology, Spence Armstrong, signed the Project Formulation Authorization for the Synthetic Vision Systems Project. The Project will emphasize the cost-effective use of synthetic vision displays (both tactical and strategic), worldwide navigation, terrain, obstruction and airport databases, integrity monitoring and forward looking sensors as required, and Global Positioning System-derived navigation to eliminate "visibility-induced" (lack of visibility) accident precursors for all aircraft and rotorcraft.

1.2 Customer Definition and Advocacy

The primary SVS customers are the Avionics Manufacturers for commercial and business aircraft as well as for general aviation aircraft and rotorcraft. In addition, the end users of the SVS technologies such as air carrier and air cargo operators, business and corporate operators, general aviation aircraft owners and rotorcraft operators should also be considered as important

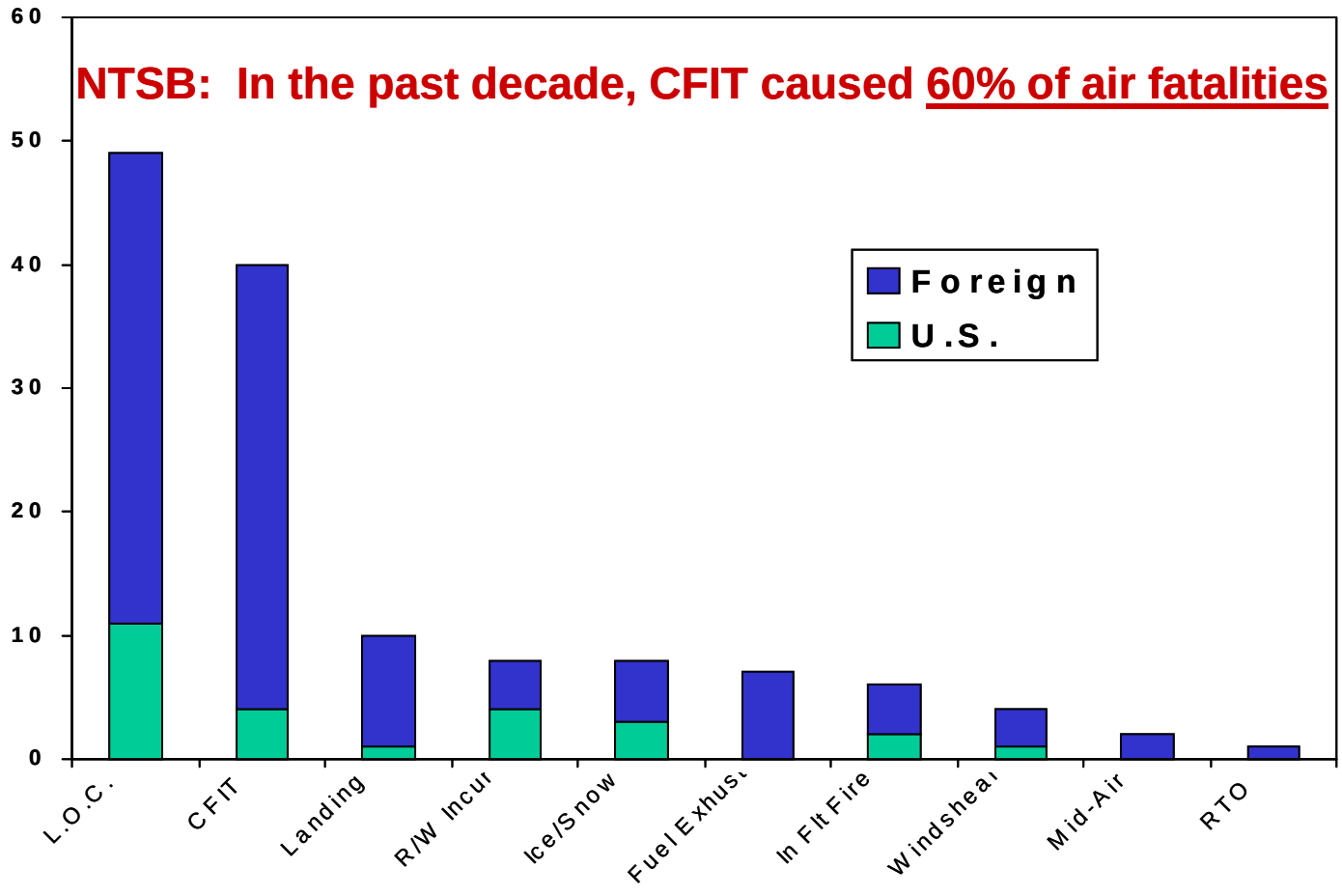
customers since they ultimately have the authority to implement SVS. Therefore, the SVS Project will work with these customer sets to ensure the successful future implementation of SVS technologies.

Customer involvement in SVS development is critical for ensuring that the Synthetic Vision Systems will meet the requirements set forth by the unique operational requirements for each vehicle class. Early planning activities will rely upon customer involvement and input to identify the appropriate concepts of operations and the resulting Synthetic Vision System's requirements. Customers, as partners, will be involved for the duration of the Project through the use of 50-50 cost share Cooperative Research Agreements.

2.0 PROJECT GOALS AND OBJECTIVES

2.1 Project Goals

Limited visibility is the single most critical factor affecting both the safety and capacity of worldwide aviation operations. In commercial aviation, over 30-percent of all fatal accidents worldwide are categorized as Controlled Flight Into Terrain (CFIT)- accidents where a mechanically normally functioning airplane is inadvertently flown into the ground, water, or an obstacle. In general aviation, the largest accident category is 'Continued Flight into Instrument Meteorological Conditions', in which low experience pilots continue to fly into deteriorating weather and visibility conditions and either collide with unexpected terrain or lose control of the vehicle because of the lack of familiar external cues. Finally, the single largest factor causing airport flight delays is the limited runway capacity and increased air traffic separation distances



resulting when visibility conditions fall below visual flight rule operations.

Figure 2.1 U.S. and Foreign Carrier Fatal Accidents (FAA Data: 1987-1996)

Since the beginning of flight, the aviation system has introduced numerous technological and operational developments to overcome the issues resulting from limited visibility (attitude indicators, radio navigation, instrument landing systems, etc.). Now, synthetic Vision technology will allow this *visibility* problem to be solved with a *visibility* solution, making every flight the equivalent of a clear daylight operation. Fully implemented, successful synthetic vision technologies will be a revolutionary improvement in aviation safety and utility. The promise of synthetic vision has made its development a top recommendation of the FAA/NASA/Industry Commercial Aviation Safety Team (CAST), the Flight Safety Foundation's Approach and Landing Task Force, and other key analyses.

Better pilot situational awareness during low visibility conditions will be provided by synthetic vision display systems. These display concepts allow for presentation of three dimensional, perspective scenes with necessary and sufficient information and realism to be equivalent to a bright, clear, sunny day, regardless of the outside weather condition, for increased spatial awareness (terrain, attitude, and traffic). Symbolic information can be overlaid on these scenes to enhance situational awareness and tactical guidance capability through, for example, presentation of an artificial horizon, heading, attitude indications, and pitch and/or velocity vector references. Therefore, in support of the Aviation Safety Program goal, **the Synthetic Vision Systems Project will develop technologies with practical applications that will eliminate low visibility conditions as a causal factor to civil aircraft accidents**. Specifically, Synthetic Vision Systems will substantially reduce the following accident precursors: loss of vertical and lateral spatial awareness; loss of terrain and traffic awareness on approach; unclear escape or go-around path even after recognition of problem; loss of attitude awareness; loss of situation awareness relating to the runway environment; and unclear path guidance on the surface. In addition, Synthetic Vision Systems will greatly increase the efficiency of the National Airspace System by allowing operations to many more runways, and to lower weather minimums than current technologies allow.

2.2 Project Objectives

The general objective of Synthetic Vision Systems is to develop cockpit display systems with intuitive visual cues that replicate the safety and operational benefits of flight operations in clear day Visual Meteorological Conditions.

The following specific objectives advance the development of synthetic vision display and infrastructure technologies, provide the supporting empirical evidence of the efficacy of this approach for eliminating the targeted accident categories, and advance the implementation readiness levels for this technology:

- Develop and demonstrate affordable, certifiable display configurations (including retrofit) to provide intuitive out-the-window terrain and obstacle information suitable for commercial transports, business jets, GA aircraft, and rotorcraft.

- Develop and demonstrate synthetic vision display concepts, which provide enhanced terrain awareness for proactive avoidance of CFIT precursors.

- Develop and demonstrate enabling technology to provide intuitive guidance cues with necessary terrain and obstruction information for precision approach and landing using terrain, obstacle, and airport databases and GPS derived navigation.

- Develop and demonstrate enabling technology to enhance airport surface awareness, including displays of surface routing information, other traffic information, and runway incursion alerts obtained from surface surveillance systems and automated incursion-alerting systems.

- Validate through high fidelity simulation studies that proposed display concepts reduce CFIT, runway incursion (RI), and other visibility-induced fatal accident rates.

- Develop and demonstrate the operational benefits (compelling business case) of synthetic vision systems that will motivate the commercial aviation industry to invest in SVS development, acquisition, and implementation while improving CFIT avoidance.

- Support the implementation of developed technologies through systems engineering, integration and certification planning and demonstrate conformance of technologies with the evolving Communication, Navigation, and Surveillance (CNS) environment and the evolving National Airspace System (NAS).

2.3 Work Breakdown Structure

The Synthetic Vision Systems Project work breakdown structure (WBS) is a product-oriented family tree subdivision of the Project by vehicle class and key enabling technologies. The WBS is in essence a product-based, hierarchical division of deliverable items and associated services (ref. NASA Systems Engineering Handbook). Groupings have been made which maximize the synergistic nature of Synthetic Vision System requirements for like vehicle classes.

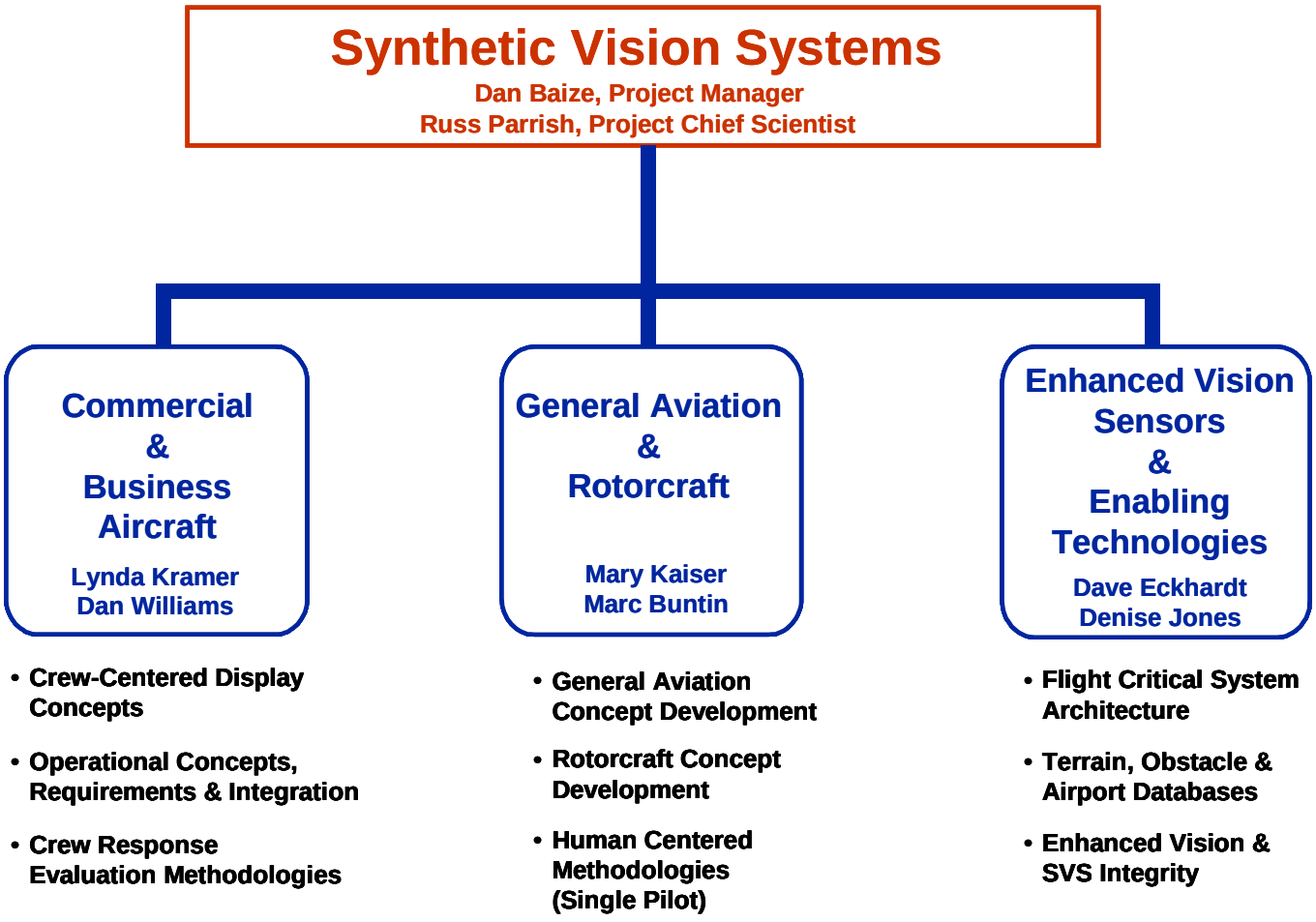


Figure 2.3 Work Breakdown Structure

AVSP-WBS 2.6 Synthetic Vision Systems Project Elements

2.6.1 Commercial and Business Aircraft SVS
- 2.6.1.1 Crew-Centered Display Concepts
- 2.6.1.2 Operational Concepts, Requirements, and Integration
- 2.6.1.3 Crew Response Evaluation Methodologies

2.6.2 General Aviation and Rotorcraft SVS
- 2.6.2.1 General Aviation Concept Development
- 2.6.2.2 Rotorcraft Concept Development
- 2.6.2.3 Human-Centered Methodologies

2.6.3 Enhanced Vision Sensors and Enabling Technologies for SVS
- 2.6.3.1 Flight Critical System Architecture
- 2.6.3.2 Terrain, Obstacle, & Airport Databases
- 2.6.3.3 Enhanced Vision & SVS Integrity

2.4 Project Schedule

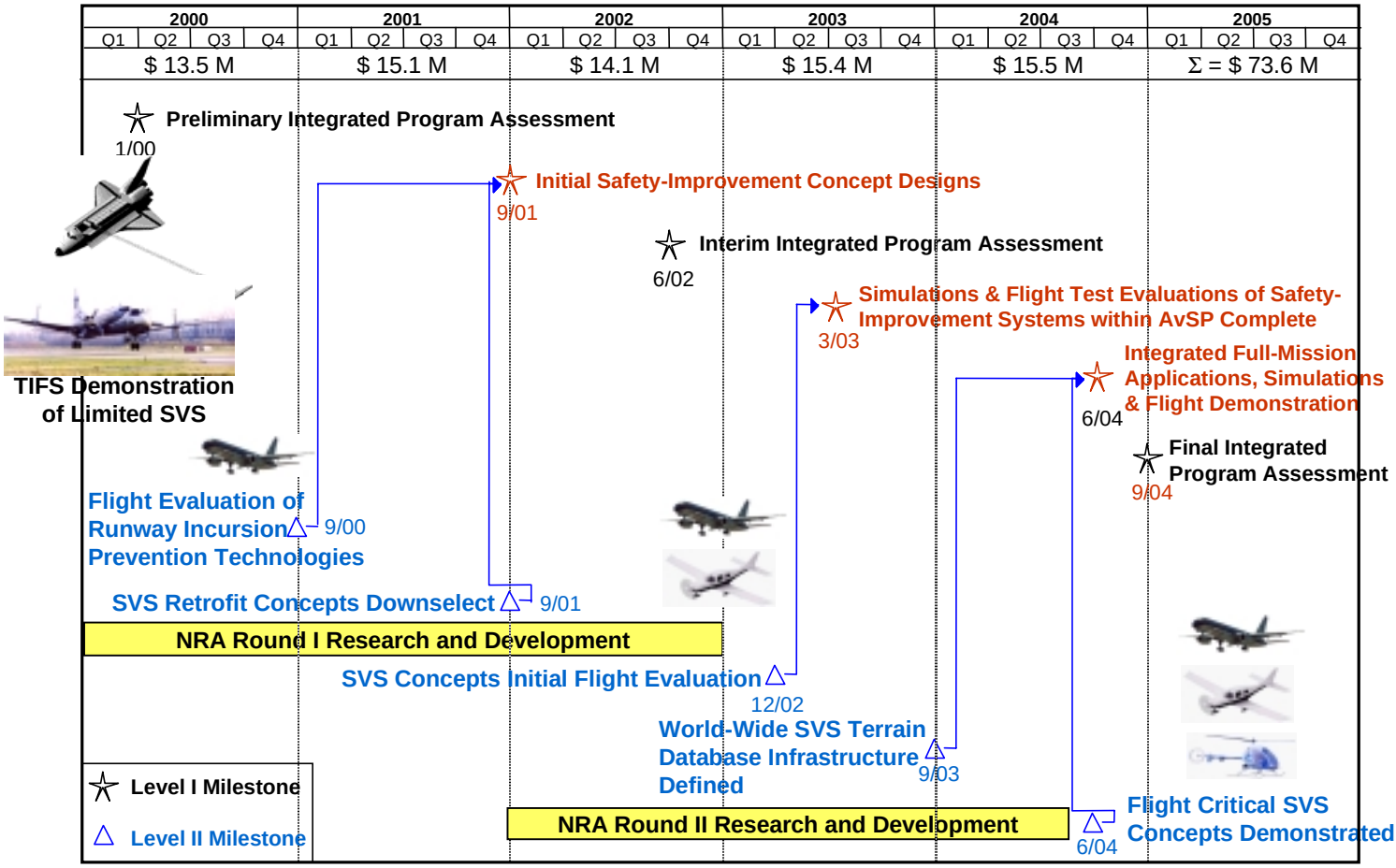


Figure 2.4 Project Schedule

3.0 PROJECT AUTHORITY / MANAGEMENT

The AvSP Office is at NASA LaRC, which has Lead Center responsibilities for the Program. The AvSP Office is led by the AvSP Program Director, who reports to the LaRC Director. The six Projects are led by managers from multiple NASA Centers. The Synthetic Vision Systems Project is led by the SVS Project Manager at NASA LaRC.

3.1 Management Responsibilities

Project Manager

The Project Manager is responsible for implementation of this AvSP project with full authority to manage the project within the defined objectives, technical scope, schedules, and resources. Project Managers report to the AvSP Program Director. Specific responsibilities include:

- Defining and implementing the technical project within the technical, cost, and schedule constraints established by the program plan.
- Executing project control, with authority to reprogram element resources across Centers as necessary to address technical, schedule, and resource metrics.
- Management of all resources (facilities, workforce, and funding) required to meet the milestones identified for the project.
- Providing advice and recommendations for changes to the Program Plan to the AvSP Program Director, and implementing changes upon approval.
- Preparing periodic element reports, annual AvSP Office reviews, and other reviews as required.
- Acting as primary interface with outside customers and partners to ensure effective technical direction and implementation of the project elements.
- Representing technical plans, objectives, approaches, and progress to Headquarters management, other government agencies, interagency coordinating committees, technology committees, and working and steering groups.
- Maintaining cognizance of related program activities (including NASA base and focused programs, as well as FAA, industry, and international efforts) and periodically reporting on their status and relevance.

Element Managers

The Element Managers are responsible for implementation of the SVS Project within their Element, with full authority to manage their element within the defined objectives, technical scope, schedules, and resources. Element Managers report to the SVS Project Manager. Specific responsibilities include:

- Defining and implementing the technical activities within the technical, cost, and schedule constraints established by this project plan and their respective element plans
- Authority to reprogram project funding resources up to 15% of guideline across sub-element activities as necessary, to address technical, schedule, and resource metrics.
- Ensuring technical integration is implemented across all sub-elements.
- Providing advice and recommendations for changes to the respective element plans to the SVS Element Manager, and implementing changes upon approval
- Preparing monthly project reports, technical highlights, annual SVS project reviews, and other reviews as required
- Representing technical plans, objectives, approaches, and progress to AvSP management, other government agencies, interagency coordinating committees, technology committees, and working and steering groups
- Maintaining cognizance of related program activities (including NASA base and focused programs, as well as FAA, industry, and international efforts) and periodically reporting on their status and relevance.
- Ensuring that a Risk Management Process in place for the element.

4.0 TECHNICAL APPROACH

To achieve the goal of eliminating low-visibility conditions as a causal factor in aviation accidents, certain key challenges must be addressed. The first and largest challenge is the worldwide terrain database development, certification, and maintenance issues including liability concerns and real-time integrity monitoring. The Enabling Technologies SVS thrust will address this challenge with a strategy which accelerates the development of certifiable database requirements and supporting infrastructure. A second key challenge is certification of flight critical Synthetic Vision Systems and their integration into the overall National Aerospace System. Both Commercial and Business Aircraft and GA & Rotorcraft thrusts will form cooperative partnerships with industry and the FAA to facilitate the expedient certification of SVS products. Finally, the challenge of retrofitting the fleet with affordable Synthetic Vision Systems looms large. This will be addressed through early NASA support of an iterative development, assessment, and validation of candidate SVS concepts. Design issues and requirements will be established with the help of NASA simulation studies and flight test evaluations. This early government participation in technical risk reduction will serve to both improve the end SVS products, and to lower their eventual costs to the airline or airframe customers.

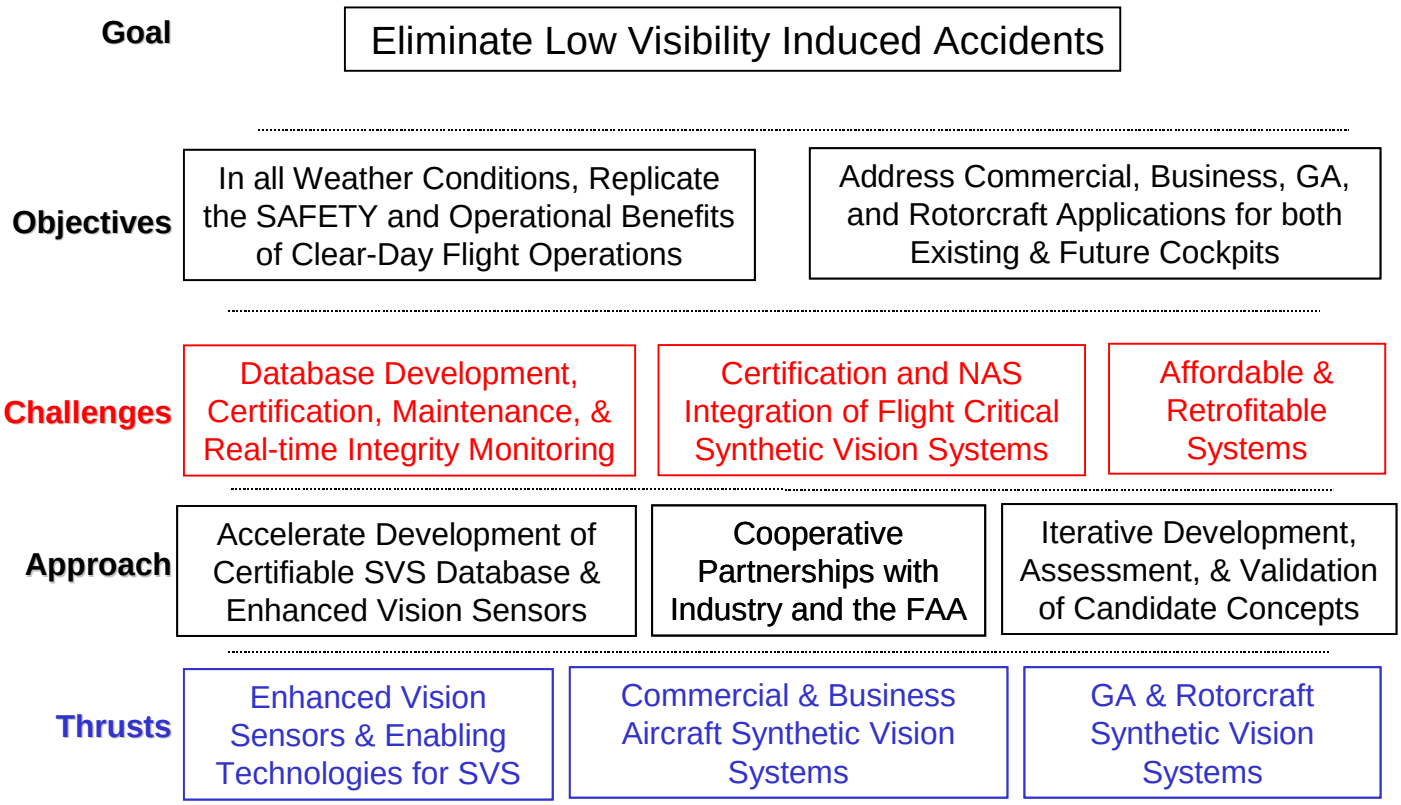


Figure 4.0 SVS Project Goals, Objectives and Challenges

4.1 Project Requirements and Milestones

The following SVS characteristics must be present to ensure success of Synthetic Vision Systems:

- SVS must provide perspective terrain data to the flight crew

- SVS must meet tactical guidance requirements

Results in a flight critical system
For transport category, contains all PFD functionality

- SVS must be an autonomous system utilizing internal databases and be GPS position driven

Applicable regional to global terrain databases required
Obstacle database requirements vary between vehicle class (rotorcraft most stringent)
Airport database contains a minimum of runway end points and edges
Navigational database requirements are driven by other Flight Deck systems
GPS WAAS/LAAS utilized for position determination

- SVS must be economically viable for intended utilization

Retrofit and forward-fit cases are unique
General Aviation affordability requirements are most severe

The following SVS characteristics are projected to enhance the capability and benefits of Synthetic Vision Systems:

- SVS strategic planning functions

Including all current Navigation Display functions plus:
terrain features (3-D map possible)
traffic information
weather data

- SVS surface operations data (ownship Runway Incursion prevention)

- SVS addition tactical functionality

pathway guidance
critical and/or selected traffic
alert functions (weather, etc.)
Advanced Approach Guidance (curved, alternate gluideslopes)

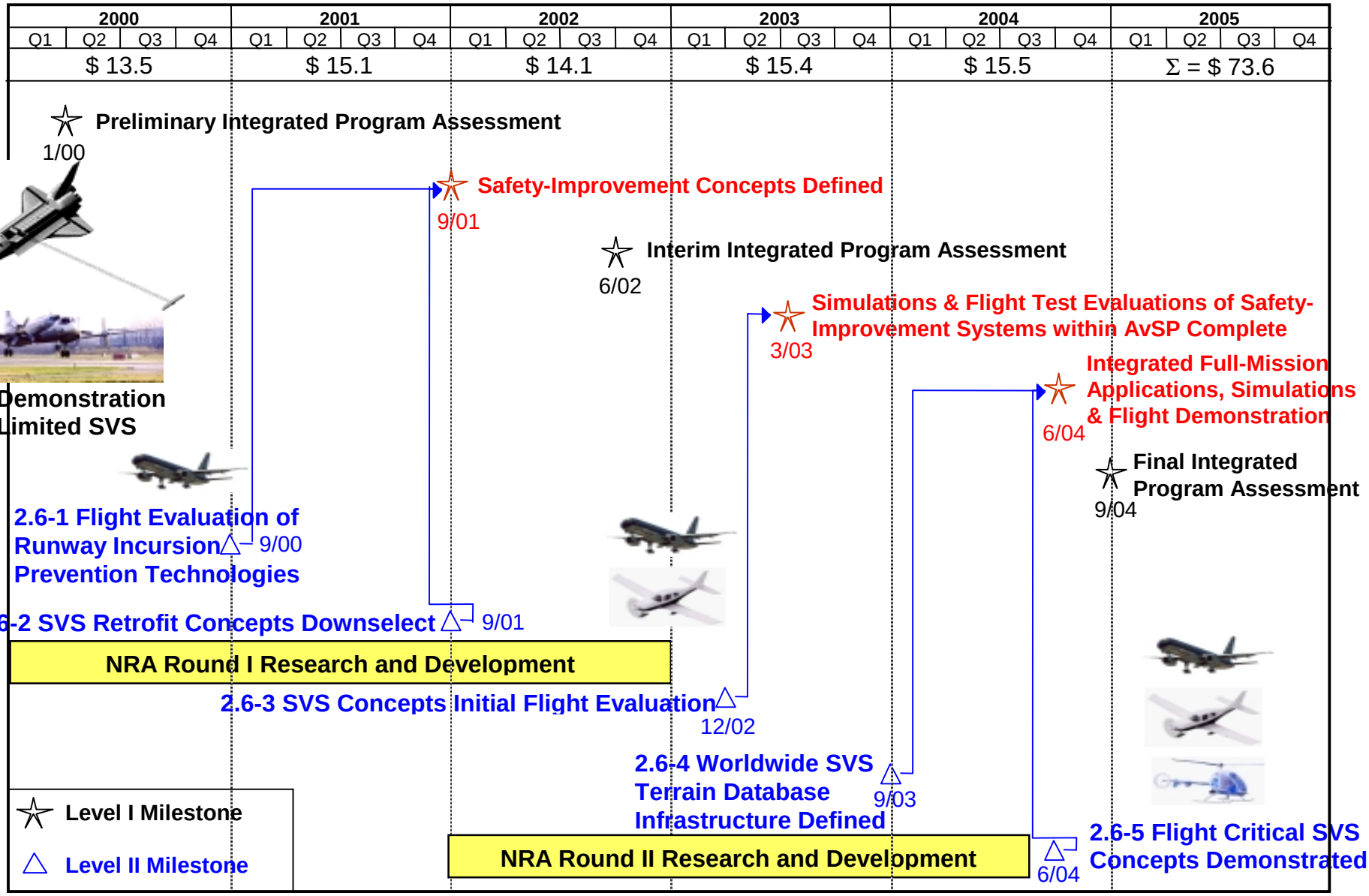
- SVS advanced display media technologies

TABLE 4.1 Project Milestones

No.	Milestones	Exit criteria	TRL/IRL	Mo/Yr
6.1	**Flight Evaluation of Runway Incursion Prevention Technologies**: Concept flight evaluation of FAA ground based Runway Incursion Reduction Program technologies integrated onto an aircraft flight deck. Activity will provide technical and operational system performance assessment for feasibility of generating airport surface database and incorporating runway incursion warning systems into current technology cockpits.	1. NASA input to RTCA SC-193/EUROCAE WG-44 "Industry Requirements for Airport Mapping Information" complete 2. Dallas/Fort Worth database complete in conformance with RTCA SC-193/EUROCAE WG-44 requirements 3. Flight validation of ARIES flight-deck integration with FAA Runway Incursion and Surveillance Information complete 4. Runway Incursion Prevention System performance analysis and benefits assessment complete 5. Flight evaluation of limited tactical SV HUD concept complete	6/1	09/00
6.2	**Synthetic Vision Retrofit Concepts:** Downselection of Synthetic Vision Systems (SVS) concepts suitable for retrofit in commercial, business, and general aviation aircraft. These concepts will be evaluated in simulations and flight tests utilizing situation awareness measurement tools developed for the analysis of SVS retrofit concepts.	1. Downselected conventional-media tactical SV concept suitable for retrofit in commercial and business aircraft (both analog &EFIS cockpits) 2. Downselected conventional-media tactical SV concept suitable for retrofit in general aviation aircraft 3. Downselected strategic EFIS SV concept suitable for retrofit in commercial and business aircraft 4. Downselected integrated tactical/strategic SV concept suitable for retrofit in commercial and business aircraft (both analog &EFIS cockpits) 5. Situation awareness measurement tools suitable for analysis of retrofit SV concepts developed	4/2	09/01
6.3	**Synthetic Vision Concepts Initial Flight Evaluation:** Initial flight evaluations of SV concept for controlled-flight-into-terrain and runway incursion elimination including commercial, business, and GA aircraft systems.	1. CFIT accident flight test scenarios developed and delivered 2. Flight test evaluation of downselected conventional-media tactical SV concepts suitable for retrofit in commercial and business aircraft (both analog &EFIS cockpits) complete 3. Flight test evaluation of downselected conventional-media tactical SV concept suitable for retrofit in GA aircraft complete; 4. Flight test evaluation of downselected strategic EFIS SV concept suitable for retrofit in commercial and business aircraft complete 5. Flight test evaluation of downselected integrated tactical/strategic SV concept suitable for retrofit in commercial and business aircraft (both analog & EFIS cockpits) complete 6. Flight test evaluation of terrain database integrity monitoring and flight path guidance system complete	5/3	12/02

6.4	**Worldwide SV Terrain Database Infrastructure Defined:** U.S. Government/Industry roles in infrastructure to support Worldwide terrain database availability, including standardized database format (as per RTCA SC 193) defined as required for synthetic vision applications. Terrain databases will be delivered to support flight evaluations at selected terrain-impacted geographic locations.	1. U.S. Government/Industry roles in worldwide SV terrain database infrastructure defined 2. Certification path for worldwide SV terrain database clearly defined 3. Selected terrain-impacted databases delivered for flight test demonstration of flight critical commercial and business aircraft SV concepts 4. Selected terrain-impacted databases delivered for flight test demonstration of flight critical GA and rotorcraft SV concepts	5/5	09/03
6.5	**Flight Critical SV Concepts Demonstrated:** Flight demonstrations of integrated, flight-critical SV concepts, which eliminate low-visibility conditions as an accident causal factor.	Flight test demonstration of integrated, flight-critical SV concepts for commercial and business aircraft complete (for both retrofit and forward-fit applications); Flight test demonstration of flight-critical SV concepts for GA aircraft and rotorcraft complete; Flight-critical equipage and flight standards usage certification path identification complete; SV concepts safety and operational benefits demonstrated Terrain database flight demonstrated and performance assessment complete	6/6	06/04

4.2 Project Roadmap



4.3 Project Capabilities and Products

1. Synthetic Vision Technology- Commercial & Business Aircraft

Product form: Demonstration avionics H/W, S/W, test results, design guidelines, and certification strategy

Product Definition: Situational awareness enhancement system utilizing database, sensor, and hazard (terrain, traffic- surface and airborne, weather, etc.) detection technologies merged with flight display symbologies and precise GPS navigational information to create synthetic views of the aircraft's external environment for display to the flight crew.

Customer: Avionics manufacturers

End user: Operators of turbo prop/jet A/C, air carrier operators

Targeted problem: CFIT, approach and landing errors, and runway incursions (self or others)

2. Synthetic Vision Technology General Aviation and Rotorcraft

Product form: Demonstration avionics H/W, S/W, test results, design guidelines, and certification strategy

Product Definition: Situational awareness enhancement system utilizing database, sensor (FLIR, low-light-level CCD, MMW RADAR, PMMW camera, etc.) and obstacle avoidance technologies merged with flight display symbologies and precise GPS navigational information to create synthetic views of the current external environment for display to the flight crew. Differing requirements will likely result in one product for GA, and a different product for rotorcraft with more sensor reliance for real-time obstacle detection.

Customer: Avionics manufacturers

End user: Operators of GA (focus on single/multi-engine piston) and Rotorcraft

Targeted problem: CFIT, approach and landing errors, and spatial disorientation upset (loss of control)

3. Enhanced Vision Technologies

Product form: Demonstration avionics H/W, S/W, test results, and design Guidelines

Product Definition: Situational awareness enhancement system utilizing imaging sensor (FLIR, low-light-level CCD, MMW RADAR, PMMW camera, etc.) technologies merged with flight display symbologies and precise GPS navigational information to create images of the current external environment for display to the flight crew.

Customer: Avionics manufacturers

End user: Operators of turbo prop/jet A/C, operators of Rotorcraft

Targeted problem: CFIT, approach and landing errors, and runway incursions by other vehicles

4. Worldwide Geospatial Databases

Product form: Methodologies and processes and example regional geospatial databases

Product Definition: Certifiable methodologies and processes and example regional databases to provide (acquire, verify, maintain, and distribute) worldwide geospatial databases suitable for synthetic vision applications.

Customer: Avionics manufacturers

End user: From low-end GA through transport category operators and rotorcraft operators

Targeted problem: CFIT, approach and landing errors, runway incursions, and spatial disorientation upset (loss of control)

5. Runway Incursion Prevention Technologies

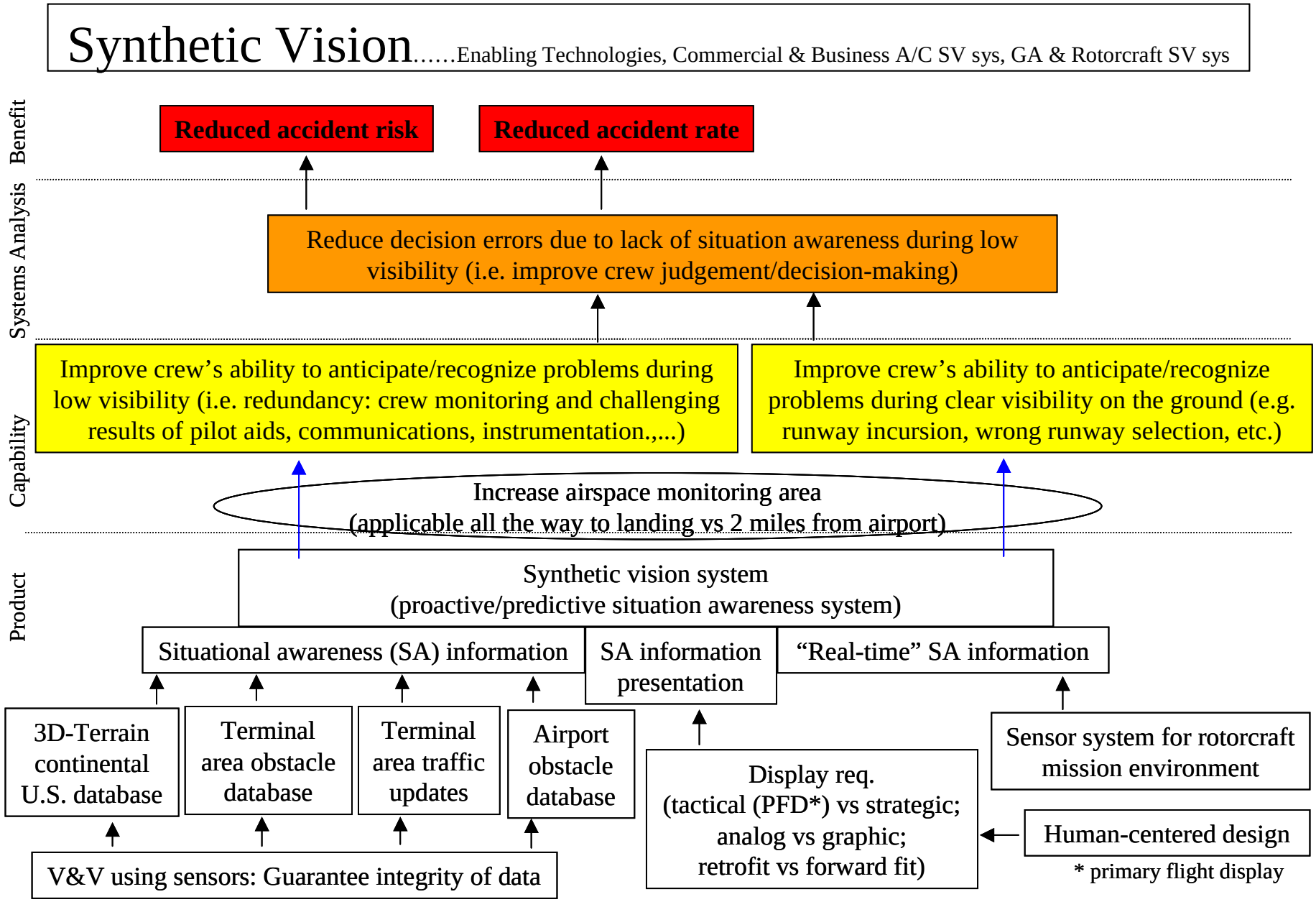
Product form: Runway incursion detection and avoidance algorithms.

Product Definition: Utilizes ownship and other A/C or vehicle positions to alert the flight crew of potential runway incursion events.

Customer: Avionics manufacturers

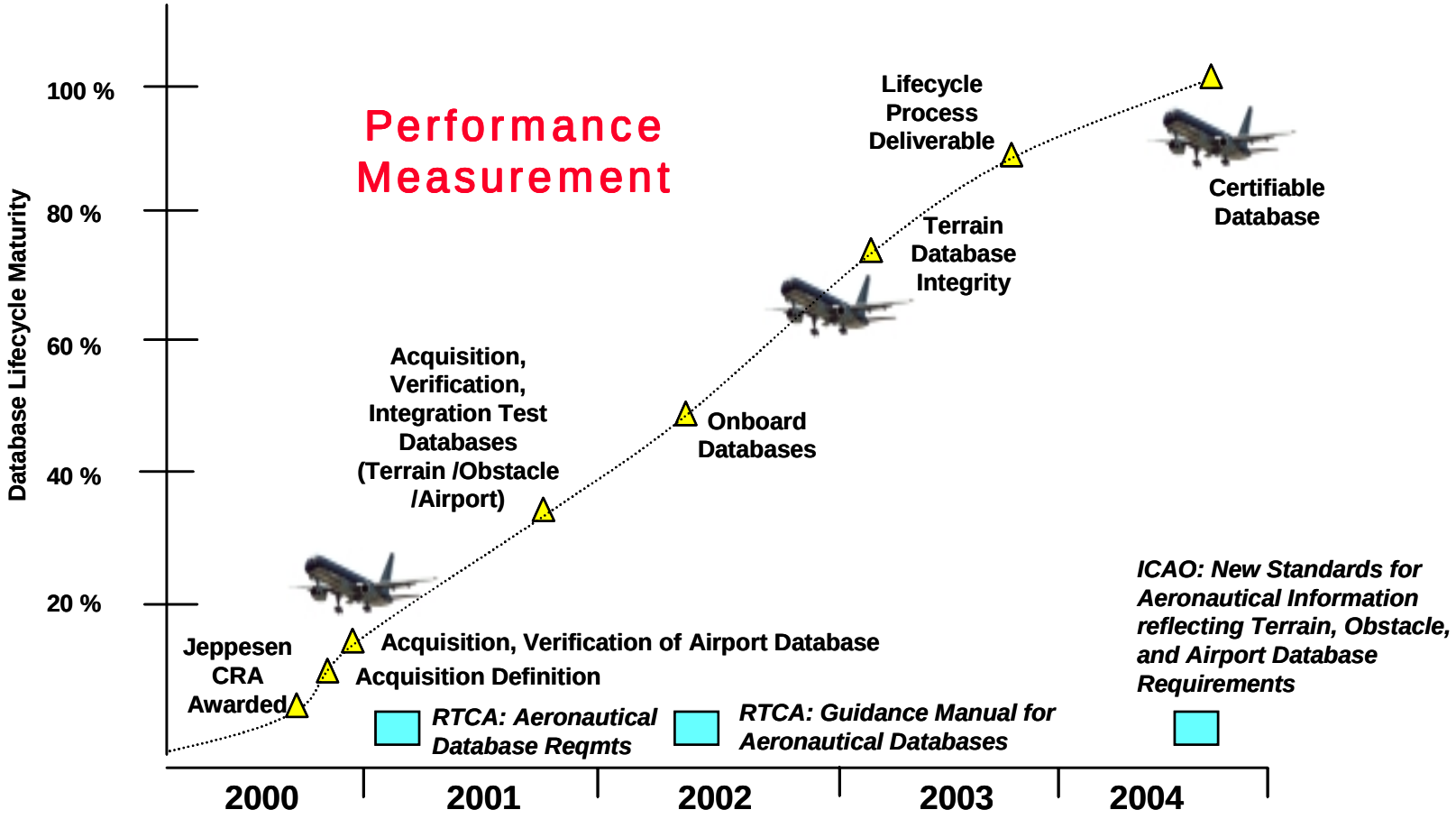
End user: Turboprop/jet operators, air carrier operators

Targeted problem: Runway incursions


Synthetic Vision……Enabling Technologies, Commercial & Business A/C SV sys, GA & Rotorcraft SV sys
Benefit
Systems Analysis
Capability
Product
Reduced accident risk
Reduced accident rate
Reduce decision errors due to lack of situation awareness during low visibility (i.e. improve crew judgement/decision-making)
Improve crew's ability to anticipate/recognize problems during low visibility (i.e. redundancy: crew monitoring and challenging results of pilot aids, communications, instrumentation.,...)
Improve crew's ability to anticipate/recognize problems during clear visibility on the ground (e.g. runway incursion, wrong runway selection, etc.)
Increase airspace monitoring area
(applicable all the way to landing vs 2 miles from airport)
Synthetic vision system
(proactive/predictive situation awareness system)
Situational awareness (SA) information
SA information presentation
"Real-time" SA information
3D-Terrain continental U.S. database
Terminal area obstacle database
Terminal area traffic updates
Airport obstacle database
Display req.
(tactical (PFD*) vs strategic;
analog vs graphic;
retrofit vs forward fit)
Sensor system for rotorcraft mission environment
Human-centered design
* primary flight display
V&V using sensors: Guarantee integrity of data

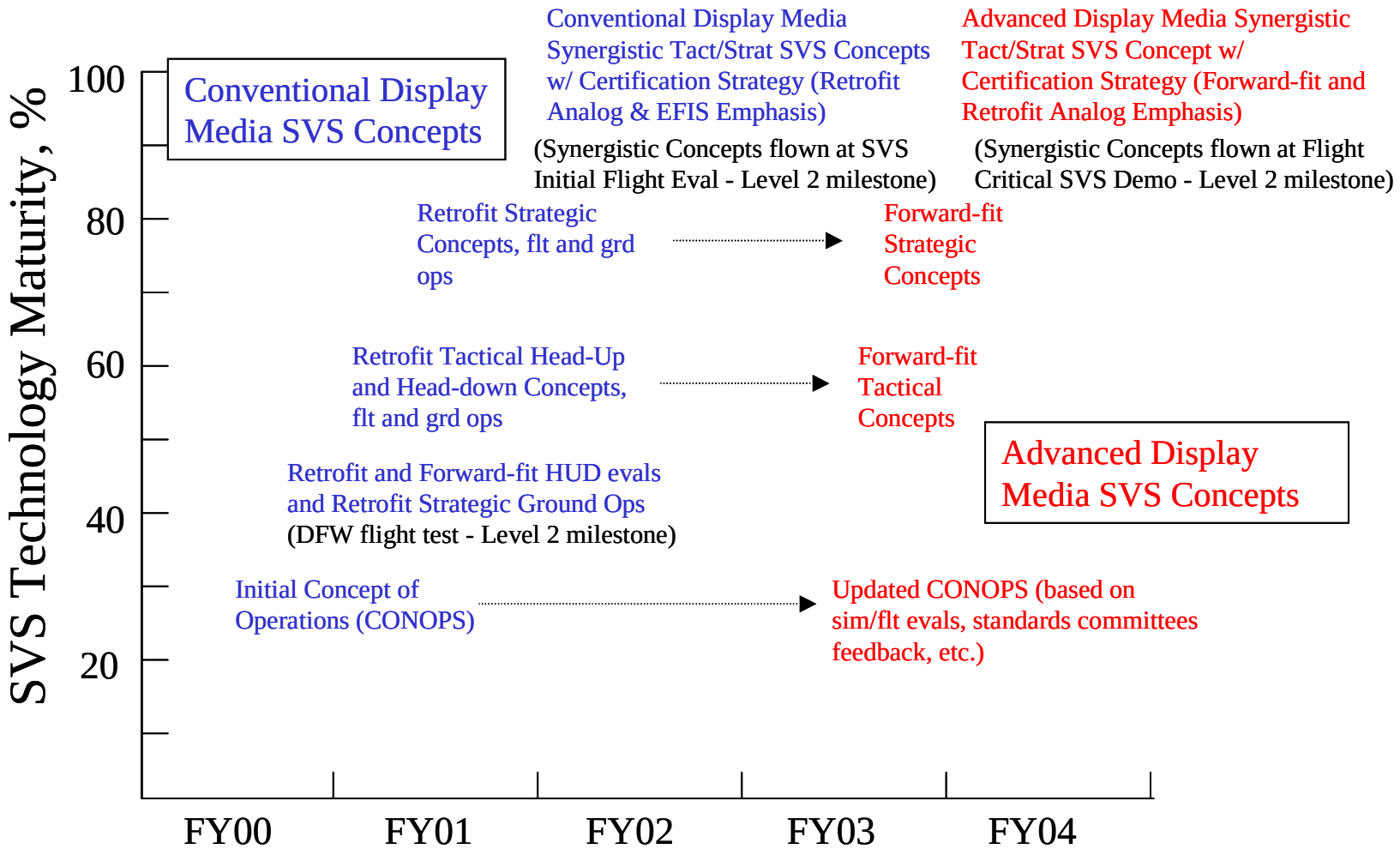
SVS Database Lifecycle Process Validation

Acquisition, Verification, Integration, Onboard DB, Distribution, Maintenance, Certification



SVS Technologies Development

Certifiable, Synergistic Tactical and Strategic SVS Concepts for Commercial and Business Aircraft- Retrofit & Forward-fit



4.5 Implementation Strategy

NASA and others have demonstrated synthetic vision system concepts in research environments. Existing Primary Flight Displays (PFD's) and Navigation Displays (ND's) may be capable of displaying perspective scenes of terrain and traffic or the runway-airport environment with situational awareness and warning information. In addition, Head-Up Display (HUD) systems are installed in a very small percentage of the U.S. commercial transport fleet that may be capable of displaying limited synthetic vision data. Current terrain, obstacle, navigation, and airport databases are not of sufficient quality to provide the level of information required for a Synthetic Vision System.

System Implementation	9 Actual System "Flight Proven" through Successful Mission Operations
	8 Actual System Completed and "Flight Qualified" through Test and Demonstration
System/Subsystem Evaluation	7 System Prototype Demonstration in an Operational Environment
Technology Development & Demonstration	6 System/Subsystem Model or Prototype Demonstration in a Relevant Environment
	5 Component and/or Breadboard Validation in a Relevant Environment
	4 Component and/or Breadboard Validation in Laboratory Environment
Research to Prove Feasibility	3 Analytical and Experimental Critical Function and/or Characteristic Proof-of-Concept
Basic Technology Research	2 Technology Concept and/or Application Formulated
	1 Basic Principles Observed and Reported

Table 4.7 Technology Readiness Level Definitions

TRL Profile:

Current TRL:	2
End of Program (EoP) TRL:	6
Year of EoP TRL:	2004
Year of TRL 6:	2004
Year of TRL 9:	2010

Technology Target Impact(s):

Eliminate low-visibility as a causal factor in aviation accidents.
Increase flight operations by decreasing approach minimums for SVS-equipped aircraft.
Eliminate need for reactive action to avoid obstacles through enhanced situational awareness.

5.0 AGREEMENTS

5.1 NASA

The Synthetic Vision Systems Project is not directly dependent upon the other AvSP projects. However, Weather Accident Prevention technologies, when developed, may be integrated into both tactical and strategic synthetic vision system displays as research determines appropriate.

NASA's AGATE Program is completing Highway –in-the-Sky technologies which will be incorporated into Synthetic Vision Systems for both general aviation and commercial aircraft.

5.2 Non-NASA

- FAA - Runway Incursion Reduction Program (MOA)
- FAA – SVS Project (proposed MOA)
- NIMA – SVS Database Development Coalition (proposed MOA and personnel exchange)
- NOAA – SVS Database Development Coalition (proposed MOA)

5.3 Partners

A NRA has been used to solicit proposals for innovative approaches to developing fully operational and certifiable synthetic vision systems (see chosen industry teams below). Business motivations and certification issues will be addressed as part of the development effort. For example, precision approach and curvilinear approach capabilities (Cat II & III capabilities at Cat I-equipped runways) may provide a business case in addition to safety benefits. Additionally, the partnership teams will be encouraged to involve Designated Engineering Representatives (DER's) early in the project to provide effective, continuing certification plans covering both type certification and operational certification paths. Cooperative Research Agreements have been signed with the following:

- Team led by BAE Systems, Inc. CNI Division, Wayne, NJ.
  Members: Canadian Marconi Company and Marconi Astronics
- Team led by Rockwell Collins, Inc., Cedar Rapids, IA.
  Members: Jeppesen-Sanderson, Inc., The Boeing Company, American Airlines, Delft University of Technology, Embry-Riddle Aeronautics University, and Flight Dynamics, Inc.
- Team led by AvroTec, Inc., Portland, OR.

Members: Avidyne Corp., Lancair/PAC USA, Massachusetts Institute of Technology, Raytheon Aircraft, Seagull Technologies, Inc., and FAA-Civil Aeromedical Institute.

- Team led by Research Triangle Institute, Research Triangle Park, NC.
  Members: Archangel Systems, Inc., Flight International Inc., Seagull Technologies, Inc., Dubbs & Serverino, Inc., Crew Systems, Inc., and FLIR Systems, Inc.

- Team led by Jeppesen-Sanderson, Inc., Englewood, CO.
  Team members: Marconi ADR, Darmstadt University of Technology, Allied Pilots Assoc., American Airlines, Alaska Airlines, and Lufthansa German Airlines.

- Avionics Engineering Center of Ohio University, Athens, OH.

- Rannoch Corp., Alexandria, VA.

- Seagull Technology, Inc.

5.4 Related Projects

Synthetic Vision applications are highly dependent on the availability of a worldwide terrain and obstacle database. Consequently, synthetic vision researchers are and will continue to be active members of Joint RTCA Special Committee 193/ EUROCAE Working Group 44 chartered to develop guidelines for preparation of terrain databases for aeronautical use; one researcher serves as Chair of Sub Group 3 – Airport Mapping Databases.

Airborne Separation Assurance (ASA) has been defined within the international aviation community as safe aircraft-based separation from hazardous weather, terrain and obstacles, proximate traffic, and other hazards external to an aircraft, as well as from established airspace boundaries. As such, activities like those of the RTCA Task Force 3 on Free Flight Implementation, the RTCA SC-186 on ADS-B, the SAE G-10 Multifunction Display group, and the SAE G-10 Aeronautical Charting group could be classed as ASA activities. Synthetic Vision Systems are potentially the most effective enabling display mechanism for both airborne and surface operation applications of these technologies. Consequently, close interaction of synthetic vision researchers with these current aviation community initiatives is imperative.

Traffic separation activities during flight operations utilizing ADS-B and CDTI, such as the Alaska Capstone program and the CDTI Ohio Valley Trials, will continue and are being extended to surface operations. The FAA's Surface Products Research and Development Team is developing airport infrastructure that provides real-time surface surveillance, traffic identification, and runway conflict alerting to air traffic controllers. This information will also be available to pilots and ground vehicle operators. The FAA system will be tested at Dallas/Fort Worth International Airport (DFW) during the spring of 2000.

The NASA Synthetic Vision Project is developing flight deck technology that utilizes the FAA surveillance information for alerting flight crews of runway conflict threats. NASA is also extending the flight deck system to include on-board enhanced runway situation awareness and alerting that could make use of other surveillance sources, such as ADS-B. This would also include runway object detection using aircraft sensor information. The NASA B-757 research aircraft will conduct coordinated tests with the FAA of the integrated aircraft/ground system at DFW in late summer of 2000. This work is a continuation of coordinated FAA/NASA research that was conducted at the Atlanta-Hartsfield International Airport in 1997.
(ref: http://www.faa.gov/faa_office/rirp/HTML/NASA_TAP/index.htm)

Synthetic vision researchers will work with FAA Safe Flight 21 and RTCA to develop the Operational Concepts for Enhanced Runway Situation Awareness. This activity is in the early stages of discussion. Safe Flight 21 is planning flight tests during 2000 to demonstrate Cockpit Display of Traffic Information for the Airport Surface (CDTIS). This will be an opportunity to transfer NASA CDTIS technology to industry for these tests.

6.0 PROJECT RESOURCES

6.1 Funding Requirement: $'s (Net + PS)

Synthetic Vision
528-60
($ in K)

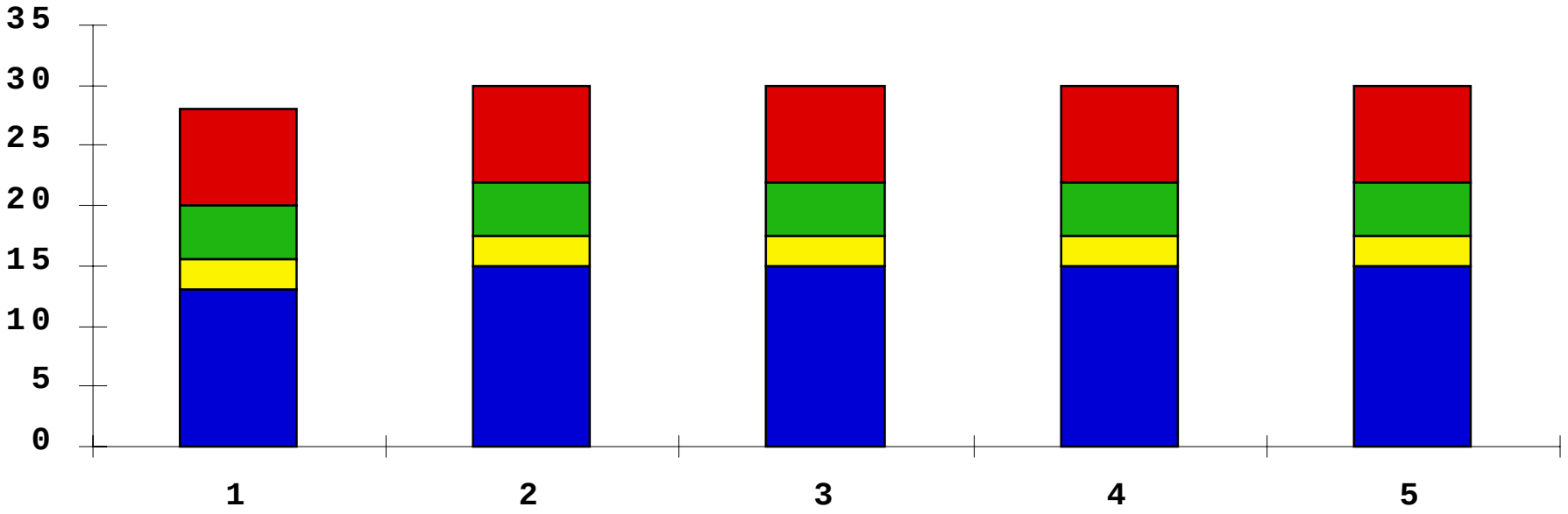
		FY 00	FY 01	FY 02	FY 03	FY 04	Total
2.6.1 Commercial and Business Aircraft	-10	4.712	4.674	4.739	5.552	5.593	25.270
	LaRC	4.712	4.674	4.739	5.552	5.593	25.270
2.6.2 GA & R/C	-20	2.668	2.106	1.975	1.959	1.973	10.681
	ARC	1.050	0.875	0.975	0.975	0.975	4.850
	LaRC	1.618	1.231	1.000	0.984	0.998	5.831
2.6.3 Enabling Technologies	-30	2.739	4.545	3.861	4.039	4.059	19.243
	LaRC	2.739	4.545	3.861	4.039	4.059	19.243
Net Totals		10.119	11.325	10.575	11.550	11.625	55.194
	ARC	1.050	0.875	0.975	0.975	0.975	4.850
	LaRC	9.069	10.450	9.600	10.575	10.650	50.344
Program Support		3.375	3.775	3.525	3.850	3.875	18.400
	ARC	0.350	0.292	0.325	0.408	0.408	1.783
	LaRC	3.025	3.483	3.200	3.442	3.467	16.617
Gross Totals		13.494	15.100	14.100	15.400	15.500	73.594
	ARC	1.400	1.167	1.300	1.383	1.383	6.633
	LaRC	12.094	13.933	12.800	14.017	14.117	66.961

6.2 Acquisition Strategy

The Synthetic Visio Systems Project will utilize a mixture of Interagency Agreements, contracts, cooperative agreements, and grants to accomplish the Project objectives with its partners.

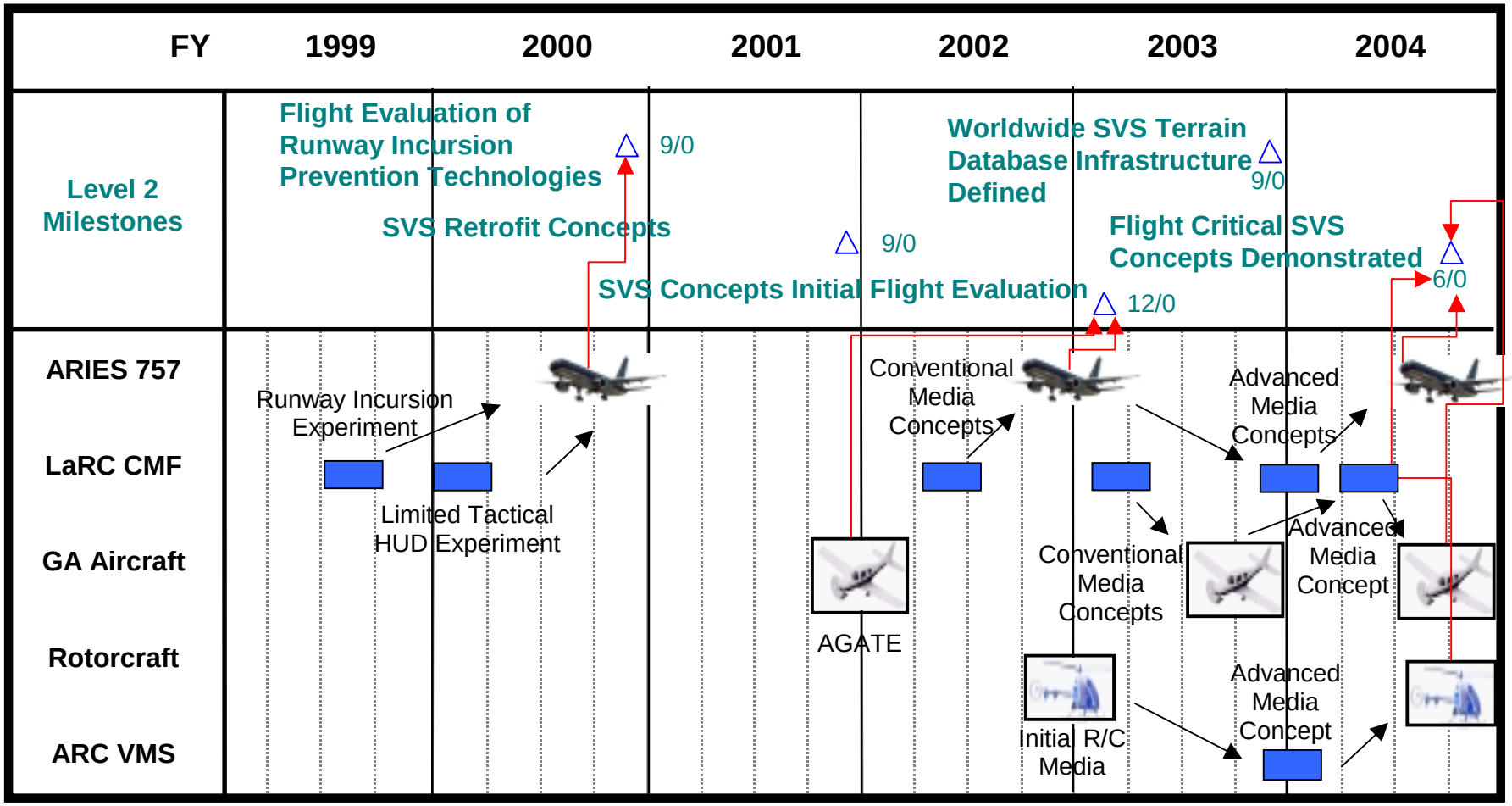
Project /CTR (1)	Contractor Name: (2)	Proc Vehicle Type (3)	Proc No. (4)	Description of Effort: (5)	$ Value: (6)	Period of Performance (7)	PY 00 $ (8)	PY 01 $ (8)	PY 02 $ (8)	PY 03 $ (8)	PY 04 $ (8)
C&B/ LaRC	Rockwell Collins	CRA	GKE 1193	Complete SVS for CAB	2,121	11/99-12/02	671	800	650		
C&B/ LaRC	Marconi	CRA	OJ 1009	Complete SVS for CAB	2,121	11/99-12/02	671	800	650		
C&B/ LaRC	Advanced Media	CRA	TBD	Adv Media Assessment for applicability in Retrofit and forward-fit SVS		03/00-09/00	381				
C&B/ LaRC	CSC	PBC	TBD	S/W devp for in-hous SVS research; Sys Admin for SVS Lab		10/99-09/99	445	400	400	400	400
C&B/ LaRC	Boeing	CO	OJ 1010	SVS Concept Assessment, Operational Inputs, & Flight Integration		10/99-06/01	100	100			
C&B/ LaRC	SGI	PBC	TBD	H/W and S/W Maint		10/99-09/04	200	200	200	200	200
C&B/ LaRC	Lockheed	PBC					300	300	300	300	300
C&B/ LaRC	Adystech	PBC					120	120	120	120	120
C&B/ LaRC	Operations	PBC					221	200	200	200	200
C&B/ LaRC	ODU	CA	TBD			11/99-08/99	110				
C&B/ LaRC	CUA	CA	TBD			11/99-08/00	80				
C&B/ LaRC	Unisys	PBC	TBD		125	10/99-09/04	25	25	25	25	25
GARC/ LaRC	RTI	CRA		Cooperative Agreement for Phase 1 dev of retro/forward fit syntetic vision solution for GA A/C	476	11/99-12/00	476	79			
GARC/ LaRC	AvroTech	CRA		Cooperative Agreement for Phase 1 dev of retro/forward fit syntetic vision solution for GA A/C	675	11/99-12/00	555	120			
GARC/ LaRC	Seagull	CRA		Cooperative Agreement for dev of a low-cost Attitude and heading Reference System	400	TBD	400				
EN/ LaRC	Ohio Univ	CRS		DB Integrity Dev	1,665		320	766	579		
EN/ LaRC	Ohio Univ			DB Integrity Dev	1,000					500	500
EN/ LaRC	Jeppesen	CRA		Database Dev	3,640		640	1800	1200		
EN/ LaRC	Jeppesen	CRA		Database Dev	3,000					1500	1500
EN/ LaRC	Rannoch	CRA		RI Avoidance	1,170		306	470	394		
EN/ LaRC	Lockheed	PBC		In-house tasks	2,591		405	609	638	439	500
EN/ LaRC	Rockwell	CA		Elec Scanning Radar	800		100	100	200	200	200
EN/ LaRC	Rockwell	CA		ESA Integrity Alg	1,000		200	300	100	200	200
EN/ LaRC	TBD			Flight Operations	809		200		250		359
EN/ LaRC	FAA	MOA		Surface Infrastructure	475		475				
EN/ LaRC	Ohio Univ	Grant		Surface Ops Workstation	55		55				
EN/ LaRC				FAB			35				
EN/ LaRC	NIMA	MOA		SRTM Data Acq	800			200	200	200	200
EN/ LaRC	NOAA	MOA		Obstacle/AP Data	800			200	200	200	200
EN/ LaRC	TBD			Sys Integrity/Cost Anal	800			100	100	400	200
EN/ LaRC	TBD			Sys Cert Anal	600					400	200
Total							7491	7689	6406	5284	5304

6.3 Workforce; NASA Direct FTE's



	FY 00	FY 01	FY 02	FY 03	FY 04	Totals
Commercial & Business A/C	13.0	15.0	15.0	15.0	15.0	73
GA & Rotorcraft (LaRC)	2.5	2.5	2.5	2.5	2.5	13
GA & Rotorcraft (ARC)	4.5	4.5	4.5	4.5	4.5	23
Enabling Technologies	8.0	8.0	8.0	8.0	8.0	40
Totals	28	30	30	30	30	148

6.4 Facilities Usage Chart



6.5 Test and Verification

The SVS project and elements may have particular needs for test and verification. In some cases, hardware, software, or integration system testing, or some combination, is an output or significant component of the project/element. Test and verification plans will be developed and referenced in the project plan. In those cases, established processes will be applied to the components under development. The Office of Safety, Environment, and Mission Assurance at the appropriate Center will monitor these processes.

7.0 TECHNOLOGY TRANSFER / COMMERCIALIZATION

Synthetic Vision Systems technology transfer is a continuous and unending process facilitated though the use of Cooperative Research Agreements (CRA), workshops, and on-site meetings with our industry teaming partners.

8.0 RISK MANAGEMENT

Personnel from the Synthetic Vision project will be trained in the Continuous Risk Management. They will use the Risk Management Process described in the AvSP Technical Integration Plan. They will use the risk management/tracking software acquired by the Office of Mission Assurance to support the Agency Risk Management requirements. The Office of Mission Assurance agreed to provide support to the Synthetic Vision project in the following risk management areas:

a. Training
b. Consulting

8.1 Safety and Mission Assurance

The Office of Mission Assurance OMA will provide support to the Synthetic Vision project in the areas of systems safety, reliability, quality assurance and environmental. OMA will perform safety analyses as required by safety review board(s) for tests of any Synthetic Vision Systems Project hardware to be conducted in a government facility, including aircraft. OMA will coordinate with the appropriate Offices of Safety & Mission Assurance for Tests schedule at other NASA Centers. The analyses will be prepared following the appropriate format(s) to help the project develop a good safety data information package to be provide to the industry partners to facilitate or expedite their certification of the technology.

The Environmental Engineering Office performed a National Environmental Policy Act (NEPA) assessment regarding Synthetic Vision Project in 1999.

8.2 Specific Risks & Mitigation Strategies

Potential Risks	Mitigation Strategy
Full Cost Facility charges for Simulators or Aircraft may require more than the budgeted 25% SVS Project Program Support charges assumed for such facilities.	First, negotiate with Service Pool Managers to minimize facility charges to the Safety Program. Second, descope lessor priority Synthetic Vision System Project milestones.
Constraints on installation of equipment in ARIES (B757) coupled with the lack of an aft research flight deck may limit the use of the ARIES B-757 for SVS Project flight tests.	Work to minimize the number of constraints. If constraints prove too limiting, consider alternate flight test facilities.
The proposed construction of the new General Aviation Research Deck for the Cockpit Motion Facility may not be fully funded and construction might be delayed.	Rely upon existing simulation facilities including VISTAS-1 to complete general aviation SVS Project objectives.
The Shuttle mission may not produce the worldwide terrain database information.	No mitigation strategy available within NASA AvSP resources to replace this critical data. A more limited terrain database would be utilized for initial Synthetic Vision Systems.

9.0 REVIEWS

Various reviews have been established to communicate the aviation safety information to AvSP management and committees.

9.1 Monthly

The Project Manager will prepare a monthly report for the AvSP Manager. This report is an integrated technical, cost, and schedule assessment of progress versus plans and will contain significant technical highlights. The monthly report will be prepared in a standard, consistent electronic format, including appropriate graphics and accompanying explanatory text. A narrative description will also be developed to identify any problems, issues, and concerns (along with potential impact and proposed action) and any major interactions with industry

9.2 Independent Annual Review (IAR)

The Project Manager will support IAR reviews held yearly to assess progress/milestone achievement against original baseline. In addition, the Project Manager will present technical, cost, and schedule status in order to assess life cycle program/project stability.

9.3 Aviation Safety Program Executive Committee (AvSPEC)

The Project Manger will be prepared to present to the AvSPEC that would meet at least twice a year. The Project Manager, as required, will present technical, schedule status and acceptability of the project's objectives.

9.4 Program/Project Management Council (PMC)

The Project Manager will support PMCs as required by the Program Manager and Deputy Program Manager.

9.5 Other Project Meetings

The SVS project personnel will participate in FAA/International working group meetings related to Controlled Flight Into Terrain as requested and as appropriate. Other workshop and technical information meetings with partners and customers will be held as necessary.

10.0 TAILORING

Based on the descriptions, definitions, and requirements in NPG 7120.5a, the following tailoring has been applied to this plan:

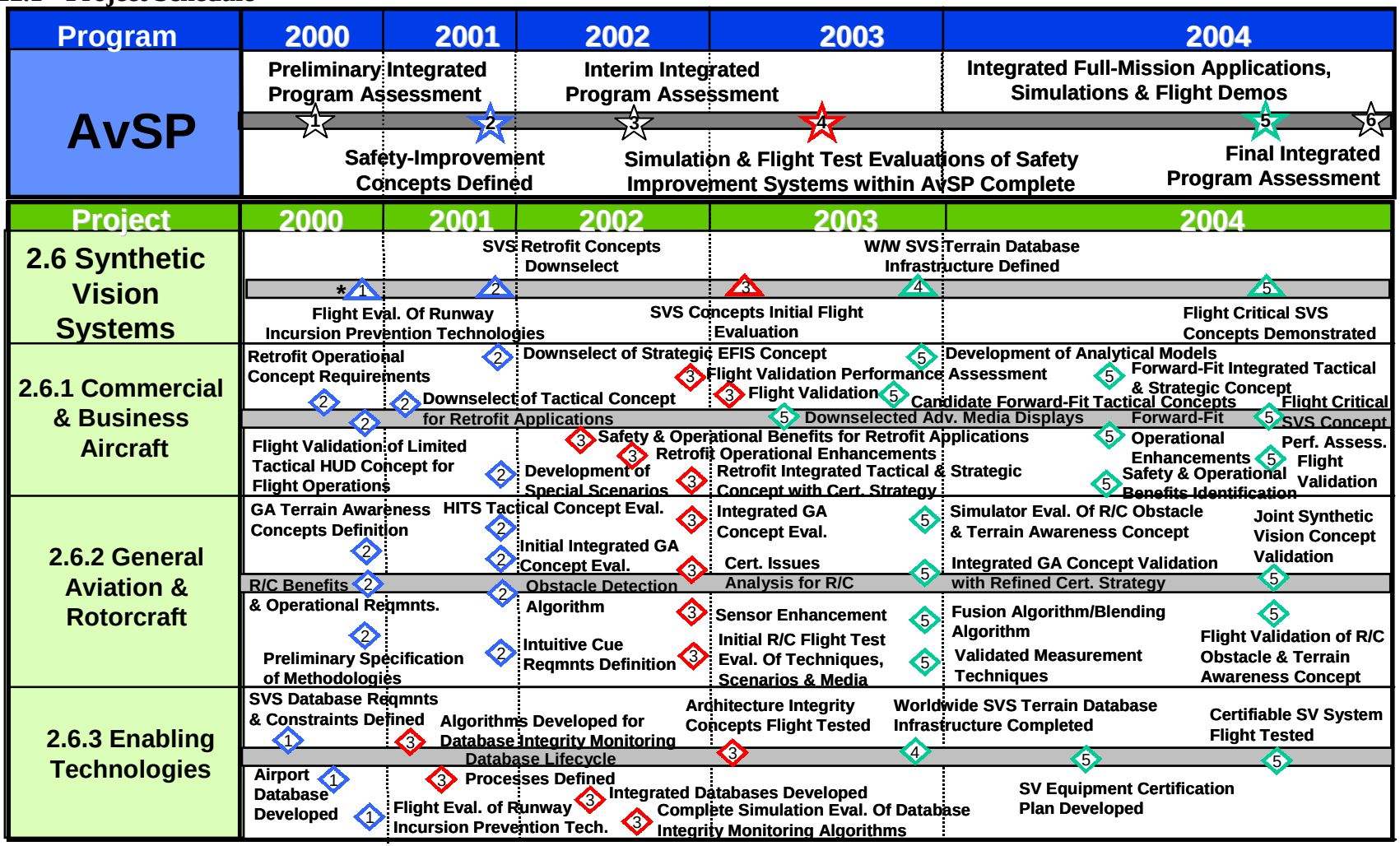
- Customer Definition and Advocacy is discussed under Section 1.0, Introduction.
- Project Authority, Management and Control are discussed under Section 3.0, Project Authority/Management.
- Technical Summary, Schedules, Implementation Approach and Technical Assessments are discussed under Section 4.0, Technical Approach.
- Agreements and Program/Project Dependencies are discussed under section 5.0, Agreements.
- Resources and Acquisition Summary are discussed under Section 6.0, Resources.
- Commercialization is discussed under Section 7.0, Technology Transfer/Commercialization.
- Performance Assurance, Environmental Impact and Safety are not considered applicable to the Aviation Safety Program, except as noted in Section 8.4.

11.0 CHANGE LOG

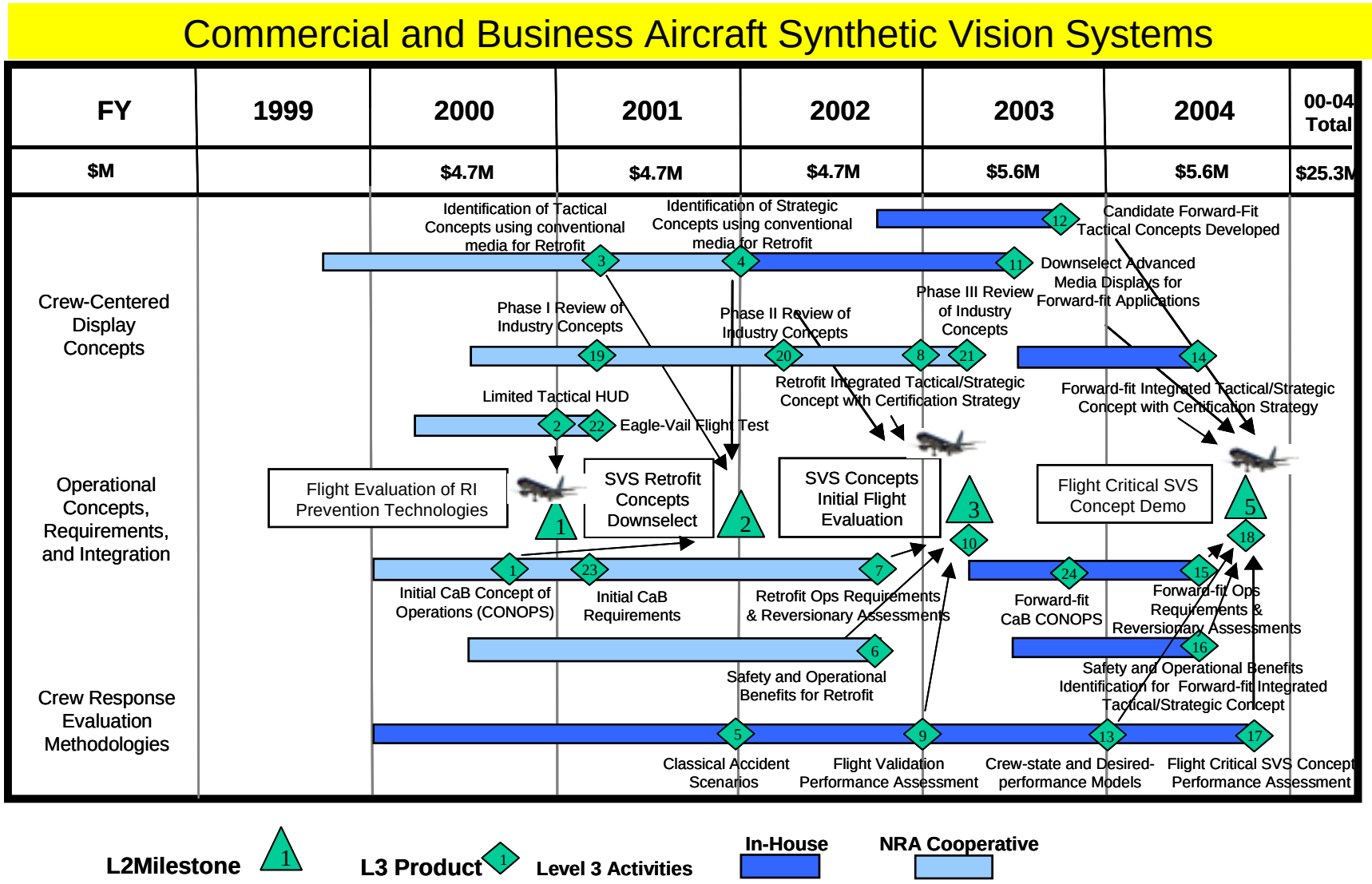
Date	Change Description	Resulting Version #
2-21-00	Reformat of Project Plan to comply with new AvSPO template	2.0
3-15-00	Incorporate AvSP Review Comments	2.1

12.0 APPENDIX

12.1 Project Schedule



12.2 Commercial and Business Aircraft Level III Roadmap

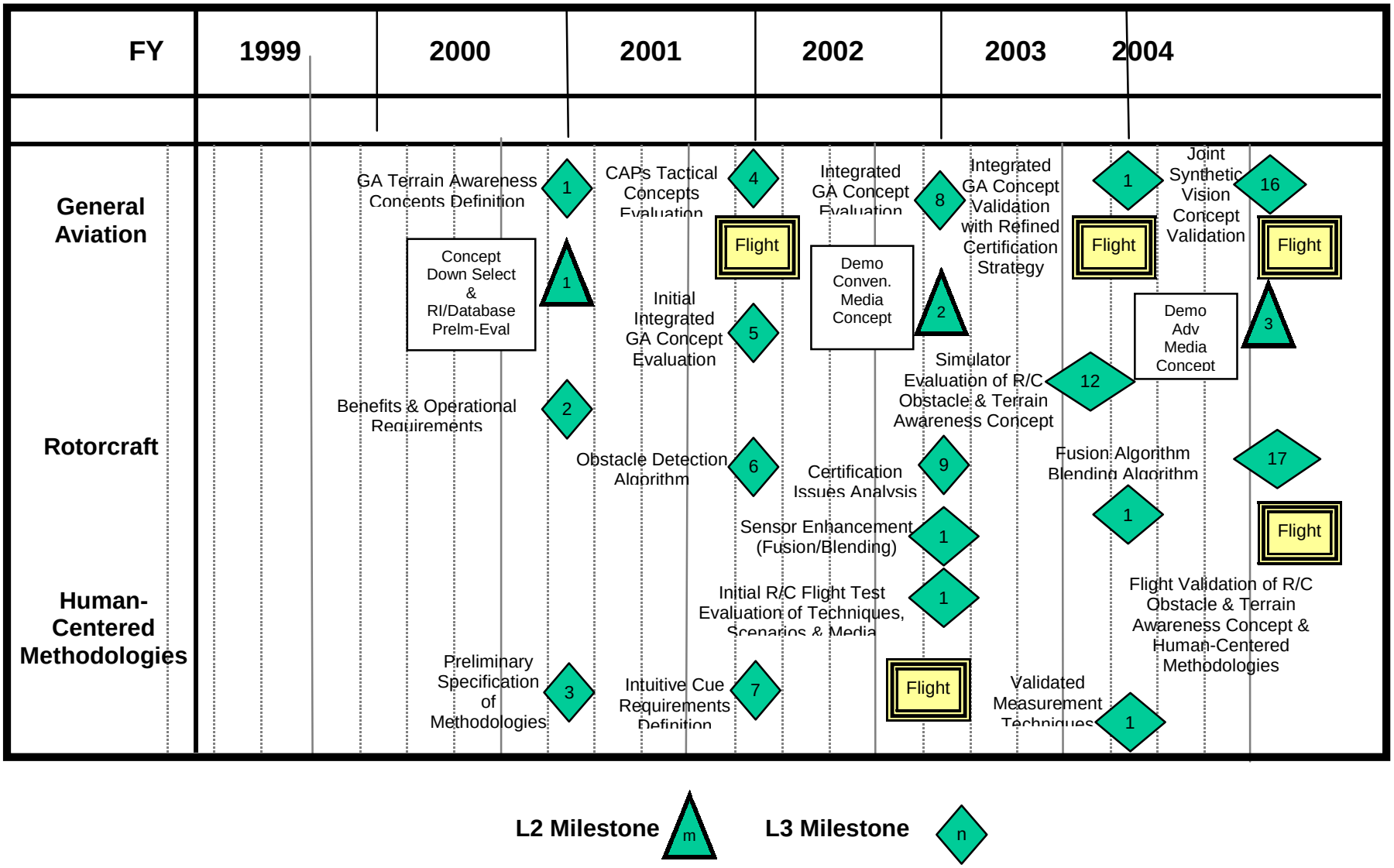


12.3 Commercial and Business Aircraft Level III Milestones (3/15/00)

LIIIMS #	Title/Description	Exit Criteria	TRL/IRL	QTR/FY	Level II Rollup
2.6.1-1	Initial CaB SVS Concept of Operations (CONOPS)	General CONOPS describing "how to use" SVS Documented.	2/1	Jun-00	2.6-2
2.6.1-2	Flight Validation of Limited Tactical HUD Concept for Flight Operations	Tactical HUD Concept Implemented in Simulator. Flight Test Validation of preliminary Tactical HUD Concept.	3/1	Sep-00	2.6-2
2.6.1-22	Eagle-Vail Flight Test	Flight Simulation Evaluation of Terrain and Situational Awareness Gains of Multiple Tactical Terrain Awareness Concepts Completed. Flight Test Validation of Rockwell Collins SV concepts in realistic operational environment. Flight Test Validation of In-house Tactical Terrain Awareness concepts in realistic operational environment.	3/1	Dec-00	2.6-2
2.6.1-23	Initial CaB Requirements	General SVS CaB Requirements Documented.	2/1	Dec-00	2.6-2
2.6.1-19	Phase I Review of Industry Concepts	Phase I Review of Rockwell Collins concepts Phase I Review of Marconi concepts	NA	Jan-01	2.6-3
2.6.1-3	Identification of Candidate Tactical Concepts employing conventional media for Retrofit	Conventional Media Tactical Concepts for Retrofit Analog Identified. Conventional Media Tactical Concepts for Retrofit EFIS Identified. Tactical Terrain Awareness Concepts Tested in TIFS. Initial Assessment of Size/FOV Effects on Head-down Tactical Retrofit Concept Completed. Flight Simulation Evaluation of Terrain and Situational Awareness Gains of Multiple Tactical Terrain Awareness Concepts Completed.	4/1	Mar-01	2.6-2
2.6.1-4	Identification of Candidate Strategic Concepts employing conventional media for Retrofit	Strategic (Proactive Terrain Awareness) EFIS Concepts Developed. Enhanced Operational Capabilities and AWIN Information into Retrofit (EFIS and analog) Concepts Implemented. Development of Integrated Tactical and Strategic EFIS Concepts for Surface Operations Completed. Simulation to Evaluate Terrain and Situational Awareness Gains of Strategic EFIS Concepts for Both Flight and Surface Operations Completed.	4/1	Sep-01	2.6-2
2.6.1-5	Development of Special Scenarios for SV Concept Evaluation (Classical Accident Scripting)	Flight Profile Scripts Generated and Available for Simulation and Flight Evaluations (include rare event and/or accident antecedent conditions). Situation Awareness Probes and Methods Readied and Documented.	4/1	Sep-01	2.6-2
2.6.1-20	Phase II Review of Industry Concepts	Phase II Review of Rockwell Collins concepts Phase II Review of Marconi concepts	NA	Jan-02	2.6-3
2.6.1-6	Safety and Operational Benefits for Retrofit	Safety and Operational Benefits Documented for Retrofit CaB.	3/1	Jun-02	2.6-3
2.6.1-7	Retrofit Operational Requirements and Reversionary Assessments	Retrofit Operational Requirements/Enhancements and Reversionary Modes Evaluated in Simulator.	4/2	Jun-02	2.6-3
2.6.1-8	Retrofit Integrated Tactical and Strategic Concept with Certification Strategy	Integrated Tactical and Strategic EFIS Concept Developed. Simulation Evaluation of Situational Awareness Gains, Operational Feasibility and User Acceptance of an Integrated Strategic and Tactical EFIS System . Refinement of Draft Requirements Completed. Retrofit Integrated Tactical and Strategic EFIS Concept Certification Strategy Documented.	4/2	Sep-02	2.6-3

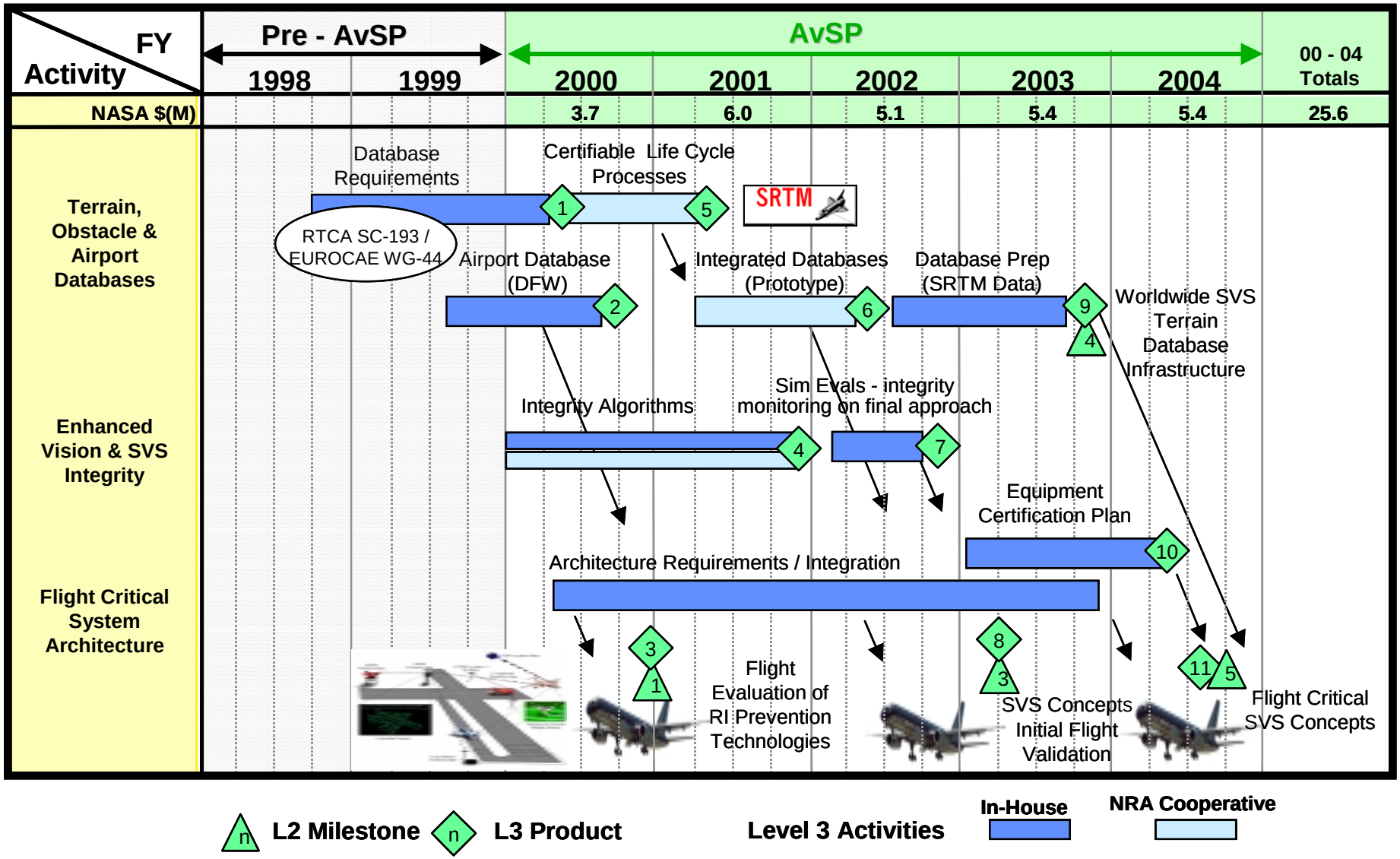
2.6.1-9	Flight Validation Performance Assessment	Flight Scenarios Developed for Flight Tests. Flight Test Performance Assessment Tools Readied and Documented.	6/1	Sep-02	2.6-3
2.6.1-10	Flight Validation of Integrated Tactical & Strategic EFIS Concept, Demonstrating Path to Limited Use Certification Standard	Flight Test Validation of Integrated Tactical and Strategic EFIS System in an Operational Environment Completed. Provision of Direct Data (e.g., requirements) Feedback to Standards Committees and Working Groups Completed. Close Coordination with WBS.2.6.3 (Enhanced Vision Sensors and Enabling Technologies) Is Required. Flight Simulation Evaluation of Retrofit Integrated Tactical and Strategic SVS Completed.	6/2	Dec-02	2.6-3
2.6.1-21	Phase III Review of Industry Concepts	Phase III Review of Rockwell Collins concepts Phase III Review of Marconi concepts	NA	Feb-03	2.6-5
2.6.1-11	Downselected Advanced Media Displays for Forward-fit Applications	Assessment of Advanced Display Media Technology for Forward-fit Applications Completed. Advanced Display Media for Forward-fit Tactical and Strategic Concepts Downselected.	2/1	Mar-03	2.6-5
2.6.1-12	Candidate Forward-fit Tactical Concepts Developed	Advanced Display Media for Forward-fit Tactical Concepts Developed Downselected.	2/1	Jun-03	2.6-5
2.6.1-13	Development of Analytical Models of Crew-state and Desired-performance Across the Flight Regime	Documented Simulator Contrast Between Desired Awareness Requirements and Actual Awareness Across the Flight Regime Using State-of-the-art Human Performance Assessment Tools and Techniques.	4/1	Sep-03	2.6-5
2.6.1-24	Forward-fit CaB CONOPS	Integrated weather hazards reporting concepts and advanced traffic display concepts into the CaB CONOPS.	2/1	Sep-03	2.6-5
2.6.1-14	Forward-fit Integrated Tactical and Strategic Concept with Certification Strategy	Enhanced Operational Capability and AWIN Information Implemented into Applicable Forward-fit Concepts. Flight Simulation to Evaluate Terrain and Situational Awareness Gains of Forward-fit Tactical Concepts Completed. Forward-fit Strategic Concepts Developed. Forward-fit Integrated Tactical and Strategic Concept Developed. Forward-fit Integrated Tactical and Strategic Concept Certification Strategy Documented.	4/2	Mar-04	2.6-5
2.6.1-15	Forward-fit Operational Requirements and Reversionary Assessments	Forward-fit Operational Requirements/Enhancements and Reversionary Modes Evaluated in Simulator.	4/2	Mar-04	2.6-5
2.6.1-16	Safety and Operational Benefits Identification for Forward-fit Integrated Tactical and Strategic Concept	Safety and Operational Benefits Documented for Forward-fit Integrated Tactical and Strategic Concepts.	3/1	Mar-04	2.6-5
2.6.1-17	Flight Critical SVS Concept Performance Assessment	Final Assessment of Situation Awareness and Human Performance Aspects of Candidate SVS Completed. Documented Tools and Methods of Situation Awareness and Performance Assessment Developed and/or Utilized.	6/1	Jun-04	2.6-5
2.6.1-18	Flight Validation of Forward-fit Integrated Tactical & Strategic SVS Concept, Demonstrating Path to Flight Critical Certification Standard	Flight Simulation Evaluation of Forward-fit Integrated Tactical and Strategic SVS Concept. Flight Test Validation of Forward-fit Integrated Tactical and Strategic SVS in an Operational Environment. Provision of Direct Data (e.g., requirements) Feedback to Standards Committees and Working Groups. Close Coordination with WBS.2.6.3 (Enhanced Vision Sensors and Enabling Technologies) Is Required.	6/2	Jun-04	2.6-5

12.4 General Aviation and Rotorcraft Level III Roadmap



12.5 General Aviation and Rotorcraft Level III Milestones

Title/Description	Exit Criteria	TRL/IRL	QTR/FY	Level II Roll-up
GA Terrain Awareness Concepts Definition	Implementation of Candidate Retrofit & Forward-Fit Strategic Concepts Candidate Retrofit & Forward-Fit Strategic Concepts Definition Candidate Retrofit & Forward-Fit Tactical Concepts Definition Implementation of Candidate Retrofit & Forward-Fit Tactical Concepts		Sep-00	**2.6-2**
R/C Benefits & Operational Requirements	Informal Benefits Analysis of Synthetic Vision Systems for R/C Operational Requirements Analysis for R/C		Sep-00	**2.6-2**
Preliminary Specification of Methodologies	Initial R/C-Specific Scenario Development Preliminary Rare-Event Probabilistic Error Model		Sep-00	**2.6-2**
HITS Tactical Concept Evaluation	HITS Concept Flight Test Validation Initial Tactical Concept Certification Strategy Initial Tactical Concept Benefits Analysis		Sep-01	**2.6-2**
Initial Integrated GA Concept Evaluation	Cue Enhancements for Loss of Control Prevention Initial Integrated GA Concept Simulator Evaluation		Sep-01	**2.6-2**
Obstacle Detection Algorithm	Preliminary Obstacle Detection Algorithm for Human/Machine Vision		Sep-01	**2.6-2**
Intuitive Cue Requirements Definition	Preliminary Guidance Cue Definition		Sep-01	**2.6-2**
Integrated GA Concept Evaluation	Integrated GA Concept Simulator Evaluation Integrated Concept Certification Strategy Integrated Concept Benefits Analysis		Sep-02	**2.6-3**
Certification Issues Analysis for R/C	R/C Concept Certification Analysis		Sep-02	**2.6-3**
Sensor Enhancement (Fusion/Blending)	Preliminary Algorithm for Image Fusion and Symbology Blending		Sep-02	**2.6-3**
Initial R/C Flight Test Evaluation of Techniques, Scenarios & Media	Flight Test Evaluation of Candidate R/C Display Media Flight Test Evaluation of Scenarios and Performance Measures		Sep-02	**2.6-3**
Simulator Evaluation of R/C Obstacle & Terrain Awareness Concept	Sim Evaluation of Cue Enhancement Techniques Sim Evaluation of Non-Invasive Performance Measures		Jul-03	**2.6-5**
Integrated GA Concept Validation with Refined Certification Strategy	Integrated Concept Flight Test Validation Refined Certification Strategy		Sep-03	**2.6-5**
Fusion Algorithm / Blending Algorithm	Perceptually Optimized Fusion Algorithm Perceptually Optimized Blending Algorithm		Sep-03	**2.6-5**
Validated Measurement Techniques	Refined Probabilistic Models of Pilot Error		Sep-03	**2.6-5**
Joint Synthetic Vision Concept Validation	Enhanced Forward-Fit Concept Flight Test Validation Enhanced Forward-Fit Concept with Certification Path Forward-Fit Concept Benefits Analysis		Jul-04	**2.6-5**
Flight Validation of R/C Obstacle & Terrain Awareness Concept & Human-Centered Methodologies	Real-Time Image Fusion and Blending Algorithms Flight Test Validation Probabilistic Error Model and Performance Evaluation Systems Flight Test Validation		Jul-04	**2.6-5**



12.6 Enabling Technologies Level III Roadmap (3/15/00)

12.7 Enabling Technologies Level III Milestones (3/15/00)

LIIIMS #	Title/Description	Exit Criteria	TRL/IRL	QTR/FY	Level II Roll-up
2.6.3-1	SVS database requirements & constraints defined: Activity will provide SVS database requirements for inclusion in SC-193 standard requirements for international databases.	Provide SVS requirements to RTCA SC-193 and EUROCAE WG-44 for inclusion in proposed international standards for terrain, obstacles, and airport database applications.	2/2	2/00	2.6-1
2.6.3-2	Airport database developed: Activity will provide technical and operational assessments of processes for generating airport surface database.	Complete development of airport surface database to SC 193 requirements for flight evaluation.	3/2	3/00	2.6-1
2.6.3-3	Flight evaluation of Runway Incursion Prevention technologies: Activity will provide technical and operational system performance assessments for incorporating runway incursion warning systems into current flight decks.	Complete flight evaluations of aircraft flight deck integrated with FAA surface infrastructure for runway incursion prevention.	6/2	4/00	2.6-1
2.6.3-4	Algorithms developed for database integrity monitoring: Activity will investigate the use of altimeter and weather radars as means for monitoring the integrity of SVS databases.	Complete design concepts for evaluating statistical disagreements between SVS databases and observable radar data terrain profile.	3/2	4/01	2.6-3
2.6.3-5	Database Lifecycle Processes defined: Activity will define and detail all aspects of SVS database requirements from acquisition to maintenance.	Document the certifiable life-cycle processes for acquisition, verification, distribution, integration, formatting, and updating of databases.	3/2	2/01	2.6-3
2.6.3-6	Integrated databases developed for initial SVS flight evaluations: Activity will provide life-cycle process validation.	Complete development and integration of terrain, obstacle, and airport databases for SVS test sites.	3/3	2/02	2.6-3
2.6.3-7	Complete simulation evaluations of database integrity monitoring algorithms: Activity will validate design concepts in simulation environment.	Complete development and evaluation of algorithms through analytical and simulation studies.	4/2	4/02	2.6-3
2.6.3-8	Architecture integrity concepts flight tested. Activity will validate design concepts and evaluate performance capabilities.	Complete flight evaluations of Radar Altimeter and Weather Radar as Integrity Assurance monitors for SVS Databases	6/2	2/03	2.6-3
2.6.3-9	Worldwide SVS Terrain Database Infrastructure completed. Activity will provide technical and operation validations for SVS database development.	Complete flight evaluations and life-cycle process evaluations of terrain databases developed to RTCA SC-193 requirements.	6/6	4/03	2.6-4
2.6.3-10	SV Equipment Certification Plan developed: Activity will provide test strategy and certification data for SVS equipment.	Complete certification plan using RTCA SC-186 "Implementation Planning Guide" as template,	3/2	2/04	2.6-5
2.6.3-11	Certifiable SV system flight tested: Activity will provide technical and operational assessments of SVS capabilities in relevant environment.	Complete flight evaluations of Certifiable SVS System,	6/3	3/04	2.6-5