Combined Vision 2012

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No longer a concept Combined Vision Systems (CVS), are being implemented today in new aircraft platforms. The two primary players are Rockwell Collins with their Bombardier Global Vision Pro Line Fusion and Honeywell with their Gulfstream PlaneView cockpits. Other aircraft and avionic manufacturers are rapidly developing and incorporating versions of vision technology to meet their market niche. As pricing allows, Combined Vision (CV) will migrate into smaller and aftermarket cockpits.

The intent of CV is to conduct flight and surface movement operations in low visibility conditions with or without operational credit.

CV can currently consist of various combinations of four converging technologies integrated to a degree where the whole may exceed the sum of its parts.

Table 1: Shows the four CV technologies

EVS	Enhanced Vision System	External real time imaging using vision sensors such as multispectral, infrared and multi-millimeter wave
SVS	Synthetic Vision System	Computer generated imaging using aircraft altitude, attitude and current position
HUD	Heads Up Display	'Out the window' cockpit optical display system
HDD	Heads Down Display	Flat panel cockpit displays or electronic flight bags

Because of the visibility challenge EVS systems are expanding from the use of infrared into the ability to view a wider bandwidth of the electromagnetic spectrum. Infrared for example cannot see through pure cloud and millimeter wave is restricted to shorter range capability. Multispectral cameras are intended to include and resolve for the best view of the visible/invisible in an airport environment.

Versions of these four technologies have been in the marketplace for a number of years but a combination of innovation, physical parameters and integration are providing benefits beyond which each alone can provide.
The most powerful part of this jigsaw however is the enabler – FAA guidance material. Having the guidance material at hand provides the incentive for product developers to innovate and populate their results into the aviation community. An example of this is the focus of Rockwell Collins to display SVS on a HUD and then seek stand-alone operational credit, or Honeywell seeking the same integrated on the same display with EVS and yet without a HUD.
In 2010 the FAA issued Airworthiness Circulars AC20-167 and AC90-106 one of which provides minimum standard airworthiness criteria and the other used for operational

certification. These documents do not dictate the technology but a set of minimum performance standards that a technology or combination of technologies must meet. Further relevant FAA documents are DO-315A EFVS completed, DO-315B SVS and DO-XXXX 300 ft RVR approaches, both in work via the RTCA SC213 committee.

Current and future solutions are considering multiple stages of flight such as approach to land, taxi and reduced take-off operations during low visibility conditions. This is in addition to other benefits that the various vision sensors can and do provide.

Below are a series of charts showing the various technologies and how they provide for different credits. A credit being a specific operational benefit derived from the application of the FAA Airworthiness Circulars and certification effort.

Table 2: Shows the current and future status of credits in each aircraft operations category

Operation*	Lower landing limits	Lower take-off limits	Approach ban clearance	Surface movement ops
PART 91	Yes	NA	NA	NA
PART 91K or 135	Yes	Yes	Yes	RTCA
PART 121	Yes	Yes	Yes	RTCA

* In EU Ops the same flight rules apply for all 3 different categories of aircraft.
NA – not applicable.
RTCA – refers to being 'in work' by RTCA SC213 special committee.
Part 91K, 135 and 121 approvals are typically issued to specific operators via special authorization (SA) and OpSpecs.

Table 3: Shows the technology combination driving the credit (current and future)

Technology	Lower landing limits	Lower take-off limits	Approach ban clearance	Surface movement ops
EVS w HUD	Yes	Yes	Yes	RTCA
SVS w HUD	RTCA	RTCA	RTCA	RTCA
EVS w HDD	RTCA	RTCA	RTCA	RTCA
SVS w HDD	RTCA	RTCA	RTCA	RTCA

RTCA – refers to being 'in work' by RTCA SC213 special committee

The FAA currently uses the term Enhanced Flight Vision System (EFVS) when an EVS is displayed on a HUD and certified for operational credit.

Table 4: Shows actual and possible near future credits

Technology combinations	Lower landing limits (ft)	Lower take-off limits (ft)	Approach ban clearance	Surface movement ops
CAT I – ILS w/o EFVS	200	NA	NA	NA
CAT I – ILS w EFVS	100 [EU 1/3RVR]	RTCA	Yes	RTCA
WAAS-LPV w/o EFVS	300-200	NA	NA	NA
WAAS-LPV w EFVS	100 [EU 1/3RVR]	RTCA	Yes	RTCA
NPA w EFVS	100 [EU 1/3RVR]	RTCA	NA	RTCA
HUD as CAT II/III + AL	via SA/OpSpecs	via SA/OpSpecs	via SA/OpSpecs	RTCA
SVS w HUD	150 [RTCA]	RTCA	RTCA	RTCA
EVS + SVS w HDD	RTCA	RTCA	RTCA	RTCA
SVS w HDD	RTCA	RTCA	RTCA	RTCA

NA – not applicable
RTCA – refers to being 'in work' by RTCA SC213 special committee
NPA – non precision approach
SA/OpSpecs– special authorization to specific operators via OpSpecs process
AL – auto land

The tables clearly indicate there are a lot of credits still to be had as manufactures posture and RTCA develop, Minimum Aviation System Performance standards [MASP's] by consensus based debate. As the technologies evolve and better integrate they begin to meet the minimum performance standards and so the case for actual credit will be made more compelling.

A combination of different and new sensors may drive bigger benefits but unlikely in the near future to meet a 'zero altitude/zero RVR' goal despite converging improvements. With recent industry acronyms representing significant technology and sensor integration milestones such as Honeywell's Plane View, Rockwell Collins Pro-Line Fusion and Jetcraft's HUD Vision Access, industry is sure to get there eventually.

Table 5: Shows some of the requirements of the two technologies currently in use

Requirement	EVS	SVS
Need GPS	No	Yes [for orientation]
Sufficient real time visibility	Yes	No
Data base	No	Yes
Ground infrastructure	Yes [airport/approach lights]	No

Table 6: Shows some of the 'non-credit' benefits of the two technologies currently in use

Benefit	EVS	SVS
Situational awareness	Yes	Yes
Night into day	Yes	Yes
Accurate landing within TDZ*	Yes w HUD FPV**	No
Unusual attitude display	Yes w HUD	No
Fuel and ops cost saving	Yes	Yes

* Touch down zone ** Flight path vector

Current certifications for operational credit require the integration of the sensor and existing aircraft flight data on a HUD. The certified systems are approved for use under FAR 91.175 that provides an alternative means via EFVS to operate during low visibility conditions that equates to the human eye. Today using IR cameras, only two EVS sensor manufacturers are approved for credit when displayed on a HUD.

Appropriately qualified EFVS operators may conduct WAAS/LPV, ILS or NP approaches and then complete Category I lower landings in poor visibility conditions today.

Over 1200 aircraft are currently outfitted with either Elbit/Kollsman or CMC EFVS systems able to take advantage of various operational credits. Many more aircraft operate in the NAS with stand-alone EVS and SVS configurations.

It has taken around 70 years to break the limit of 200 ft landing minimums for Category I or less, achieved by our old friend ILS. While Category II and III operations are possible for some they require additional aircraft equipage, aircraft, crew and ground infrastructure recertification plus maintenance. Another positive is that CV operations are not limited to certain airports or runways. As with WAAS LPV the limit is the straight-in approach, aircraft equipage and operational certification, not the ground infrastructure. While the WAAS LPV can bring you down to ILS like DH/DA limits, a CVS certified as EFVS can transition the aircraft to land during low visibility. RNP approaches may later provide for the same transition.

NextGen implementation includes CV based operational improvements mapped out for time based implementation. On the FAA NextGen website the reader may access the NextGen Implementation Plan 2012 (NGIP 2012). Appendix B maps the various NextGen operational improvements (OI's) referencing surface, approach and take off, all during low visibility.

Some important points of understanding:

EVS sensors on their own cannot be certified for operational credit but are very useful for situational awareness. There is only one type of sensor currently approved for use with the HUD and together certified as EFVS. This sensor uses cooled InSb technology. This type of technology with a sensitivity level as low as 3mK, provides sufficient sensitivity to perform approved low visibility operations, while able to 'see' the approach lights. Uncooled sensors operating in a different section of the IR band cannot see approach lights and have a lower detection level typically at or above 35mK. An example of an uncooled camera is the Kollsman GAVis using a vanadium-oxide sensor operating between 8-14 µm wavelength and with a sensitivity of 35mk. Its cooled counterpart the Kollsman EVS-II meanwhile, is standard on many Gulfstream business jets and FedEx wide body aircraft. This IR camera operates between 1-5 µm with a published sensitivity of 5mk. Note the sensitivity ratio is not linear so the EVS-II is significantly more sensitive than its uncooled GAVis counterpart.

While you may read and hear of plans for 'heads-down' or 'SVS on HUD heads up' operational credit during low visibility conditions, today only the aforementioned cooled IR cameras displayed on a heads up display, have achieved such credit. Significant effort is underway however to eventually receive credit for 'SVS on HUD' as found in the recently delivered Bombardier Global 5000 Rockwell Fusion cockpit. Effort by Honeywell is also underway for similar credit using a combination of EVS and SVS on a HDD. Recent tests by NASA and others have provided interesting results.

In Europe (EASA), the term EVS applies to systems used for both situational awareness and operational approval. The operational approval though similar, is different in Europe as it is RVR and not DH based. The US is moving in a similar direction with 1,000 ft RVR credit set to replace or supplement the 100 ft DH/DA credit based on the specific aircraft operational category.

In an approach light environment needed for EFVS operations, IR based EVS cannot see LED's. The FAA supported by ongoing SAE G20 committee effort, has two IR-LED prototype solutions about to begin evaluation for introduction into the MALSR environment estimated from 2014. Currently no MALSR (or ALSF), may migrate to LED's until a resolution has been found and approved by the FAA.

From a GA perspective as apposed to business and commercial aircraft, EFVS is not much help today because of size and cost limitations. This is primarily because of the approved sensor technology and the need for a heads up display. Even the new Rockwell HGS 3500 set to enter the upcoming Fusion cockpit markets will most likely be limited to business jet size aircraft. Smaller and lighter low cost EVS sensors by for example; L3, Lexavia, Max Viz, Kollsman and CMC are perfect for situational awareness but to reinforce the point, have no relation what so ever to the higher cost sensors used for EFVS. There are many high quality STC's available for these uncooled EVS stand alone systems. Meanwhile CV in its varied forms will continue to migrate into smaller cockpits providing significant enhancement, even if the systems are not yet to be certified for operational credit during low visibility conditions.