ON THE WAY TO ZERO – ZERO ADVANCED VISION SYSTEMS & EQUIVALENT VISUAL OPERATIONS

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- ADVANCED VISION SYSTEMS & EQUIVALENT VISUAL OPERATIONS
- WHERE ARE WE TODAY
- WHERE WE AIM TO BE TOMORROW
- REGULATORY STATUS
- A TEST PILOT`S EXPERIENCE AND PERSPECTIVE

WHY ADVANCED VISION SYSTEMS? - THE PROBLEM

500ft RVR OTW - CAT III VISIBILITY – VERY RESTRICTED – HUGELY EXPENSIVE

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SAME 500ft RVR – MUCH LESS RESTRICTED – AN AFFORDABLE VISUAL OPERATION

ADVANCED VISION SYSTEMS (AVS)

AVS technologies provide a representative real time actual or synthetic image of the outside scene and operating environment.

Flight crew always sees where they are and where they are going – a new game in situational awareness and a new capability for low visibility TO, approach and landing.

AVS are being developed as a means of addressing the current problems and restrictions associated with Low Visibility Operations (LVO).

Recognised as a significant contributor to both the FAA NextGen and European SESAR Master Plans.

For most business aircraft operators current LVO are too restrictive and too expensive. LVO have to be available on a wide number of runways and have to be affordable.

It is the same for Air Transport operators.

Hence the development of Advanced Vision Sytems (EVS/SVS/CVS) for **Equivalent Visual Operations.**

EQUIVALENT VISUAL OPERATIONS (EVO)

EVO is the creation of a virtual visual flight environment for the flight crew, independent of the actual outside weather and visibility conditions - virtual VMC throughout all phases of flight.

EVO provides the ability to significantly improve access to airports and runways to **suitably equipped performance based aircraft with affordably trained flight crews** when operating in low visibility conditions.

The EVO concept is to mitigate currently required ground infrastructure for LVO (CAT II/II ILS,etc) by use of airborne systems.

A wide ranging, flexible and cost effective alternative to many current CAT II/CAT III/autoland operations.

EVO opens up and significantly impacts the international regulatory worlds of airworthiness, low visibility operations, flight crew training, instrument procedures and airport operations.

- Enhanced Flight Vision System (EFVS).
  - An electronic means to display in real time on a HUD the forward scene topography. Performance is weather dependent.

- Synthetic Vision System (SVS).
  - A computer generated image of the forward external scene. Performance is independent of the weather; i.e. weather agnostic.

- Synthetic Vision Guidance System (SVGS).
  - A SVS that has additional features enabling its use to extend the instrument segment to a lower than standard DH/MAP.

- Combined Vision System (CVS).
  - The combination of enhanced and synthetic imagery into a single display.

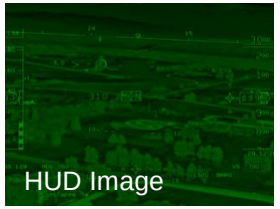
- Combined Vision Guidance System (CVGS)
  - The combination of SVGS and EFVS into a single system and operation for EVO.

BASIC AVS TECHNOLOGIES

Advanced Vision Systems (AVS)

Synthetic Vision System (SVS)

Enhanced Vision System (EVS)



Description	A computer generated image of the external scene	An electronic means to display the actual forward scene topography
Image Source	Synthetic vision computer database	Forward looking sensor
Image Display	Primary Flight Display (PFD, most installations) Head Up Display (HUD, some installations)	Multifunction Flight Display (MFD, Co-Pilot Side) Head Up Display
Benefits	Enhanced situational awareness	Enhanced situational awareness Enhanced operational flexibility (Ops. Credits)
Strengths	High quality image, low cost solution, weather agnostic	Real–time image of spectrum visible entities, totally independent image source
Weaknesses	Image limited to database content (no intruders, human/animals, service carts, etc.), image source not independent	High cost, weight impact, limited visibility & benefits in high water content atmosphere

CVS embraces both SVS and EVS technologies as each provides a different set of benefits to the pilot

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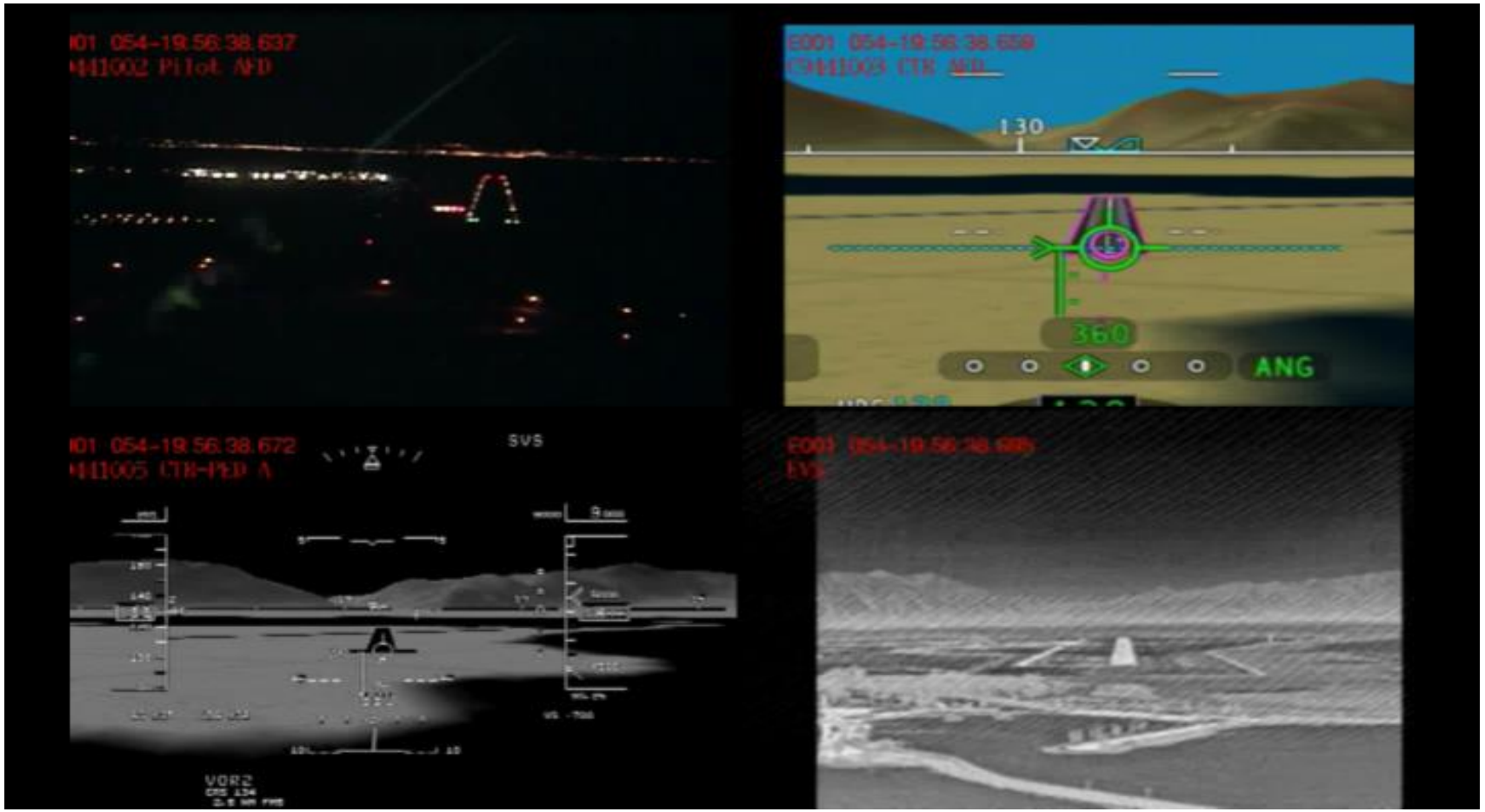
WHERE ARE WE TODAY – BA GLOBAL AIRCRAFT

OUTSIDE VIEW

HEAD DOWN SVS



HEAD UP SVS

HEAD UP EFVS

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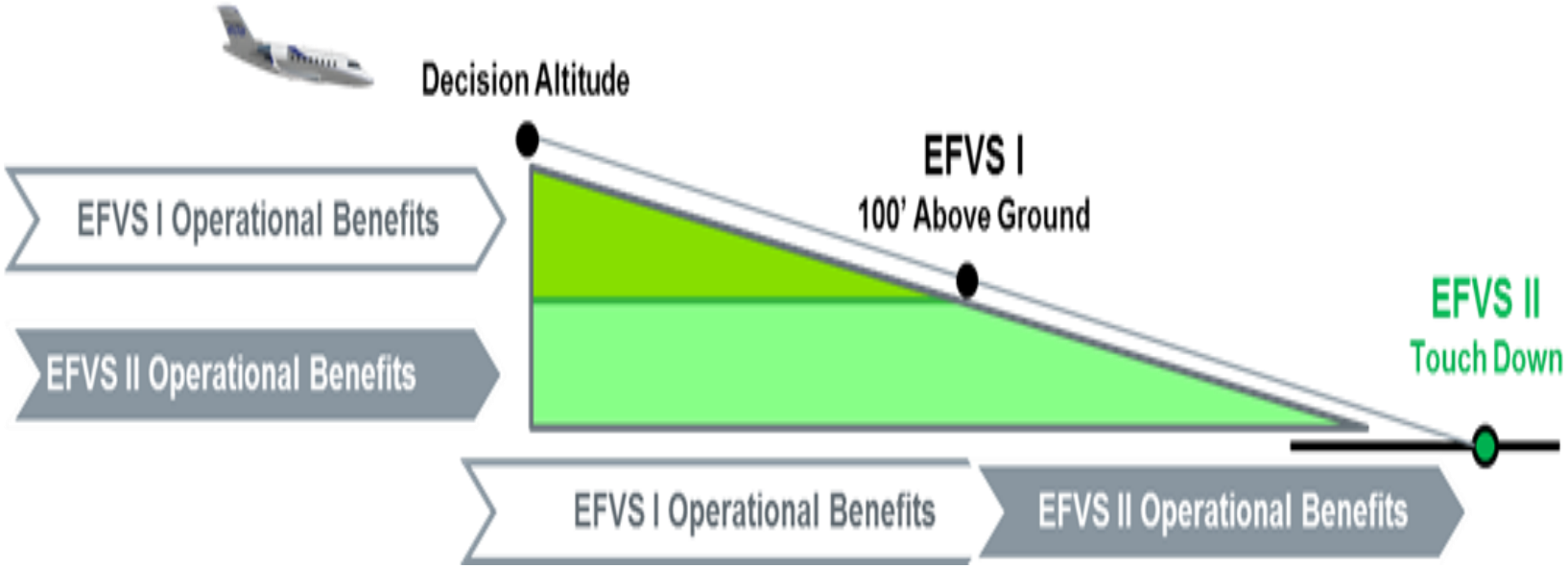
- EFVS I
  - Currently in service on Bombardier, Gulfstream, Dassault, Embraer, Boeing, Airbus and FedEx platforms.
  - EFVS image used to visually descend below published DA to 100ft above TDZE.
  - Natural vision of prescribed runway items required below 100ft.
  - Was FAR 91.175(l) and (m): now 91.176(b).

- EFVS II
  - Extends the EFVS I operation.
  - EFVS image used to visually descend below published DA to the runway and rollout to a safe taxi speed.
  - Enhanced vision of prescribed runway items allowed below 100ft.
  - FAR 91.176(a).
  - Gulstream certified. Bombardier in flight test for certification.

- EFVS II will also allow part 121 and part 135 commercial operators to:
  - Use EFVS operational minimums to dispatch, release, or takeoff a flight when the forecast visibility at the destination airport is below the visibility minimums prescribed in the IAP, i.e. TO when others are on ground hold.
  - Use EFVS operational minimums to begin the Final Approach Segment (FAS) when the current reported visibility at the destination airport is below the visibility minimums prescribed in the IAP, i.e. benefit from reduced approach ban limits.



AVS will also provide an EFVS Take-Off System (ETOS) per DO-374.

Based on DO-315A EFVS.

- ETOS-1000
  - No RVR reporting required.
  - Visible RCLM required. If the RCLM is not visible then either MIRLs or HIRLs are required.
  - No CLL.

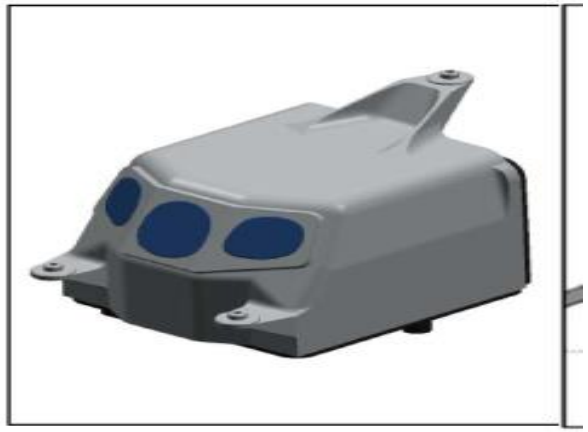
- ETOS-500
  - RVR reporting required.
  - Visible RCLM required plus either MIRLs or HIRLs.
  - Electronic definition of centreline required if the RCLM is not visible.
  - No CLL.

- EVS Sensors

Transitioning from cooled wide spectrum IR sensors to uncooled multi-spectral IR sensors.

Single extended MWIR sensor

Cyrogenically cooled



Visible, SWIR and LWIR sensors

Uncooled sensor technology

Easier installation

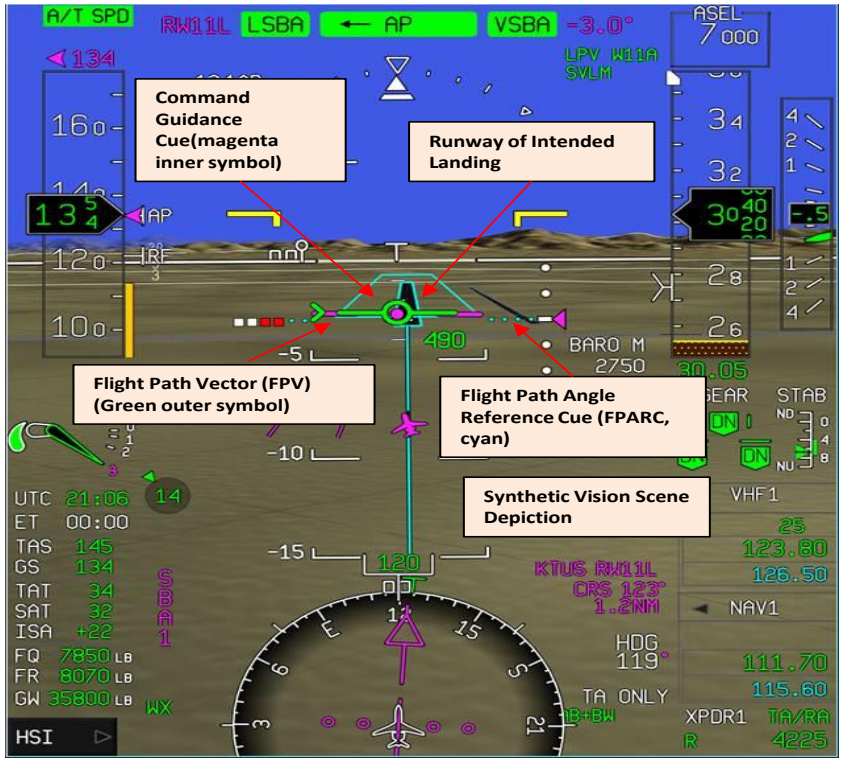
Lower weight, size and power

Improved reliability

- SVS
  - Currently in service on numerous general, business and commercial aircraft.
  - Currently for situational awareness only.
  - No operational credit.

- SVGS
  - Enhanced SVS for operational credit.
  - High precision system performance and aircraft position assurance monitors.
  - Specific symbology requirements.
  - High integrity databases.
  - Currently allowed for Special Authorisation (SA) CAT I ILS approaches to a150ft DH/MAP at 1400RVR minimum.
  - Runways have reduced lighting requirements.
  - Number of certifications are in process.

While SVS is primarily applied to the PFD, BA have also incorporated SVS on the HUD



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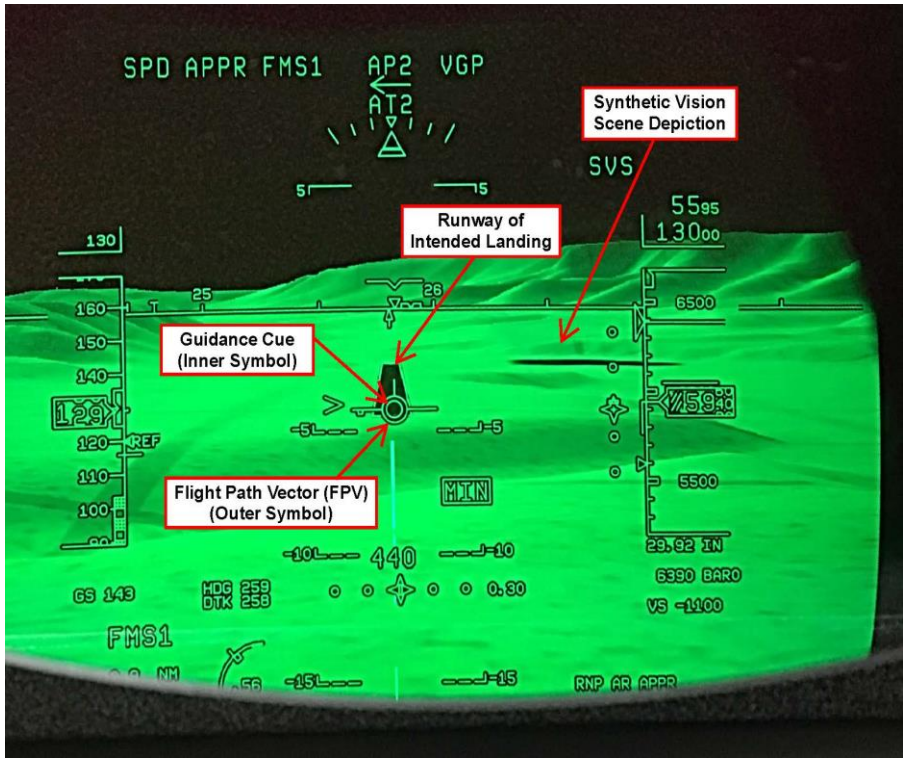

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AIRCRAFT STATE AWARENESS (ASA) SVS

Mandated by Commercial Aviation Safety Team (CAST) and FAA, RTCA/SC.213 has produced MASPS DO-371 for an ASA SVS that is intended to reduce the occurrences of Loss of Control – Inflight (LOC-I).

The MASPS is in response to a CAST Safety Enhancement (SE.200) and will be issued later this year. CAST "determined lack of external visual references was associated with flight crew loss of attitude awareness or energy state awareness".

Addresses the implementation of ASA SVS plus specified energy state symbology on the PFDs and HUDs on Part 121 air transport aircraft.

The members of CAST, have "committed" to implement CAST SEs resolving actions on new build aircraft:

- Airbus (CAST member)
- Boeing (CAST member)
- Bombardier (member through the Aerospace Industries Association)
- Embraer (member through the Aerospace Industries Association)

CVS is being actively developed by Rockwell Collins, Honeywell and Elbit.

- Elbit/Dassault FalconEye Head Up CVS was certified in October 2016.

Honeywell HDD

Elbit HUD

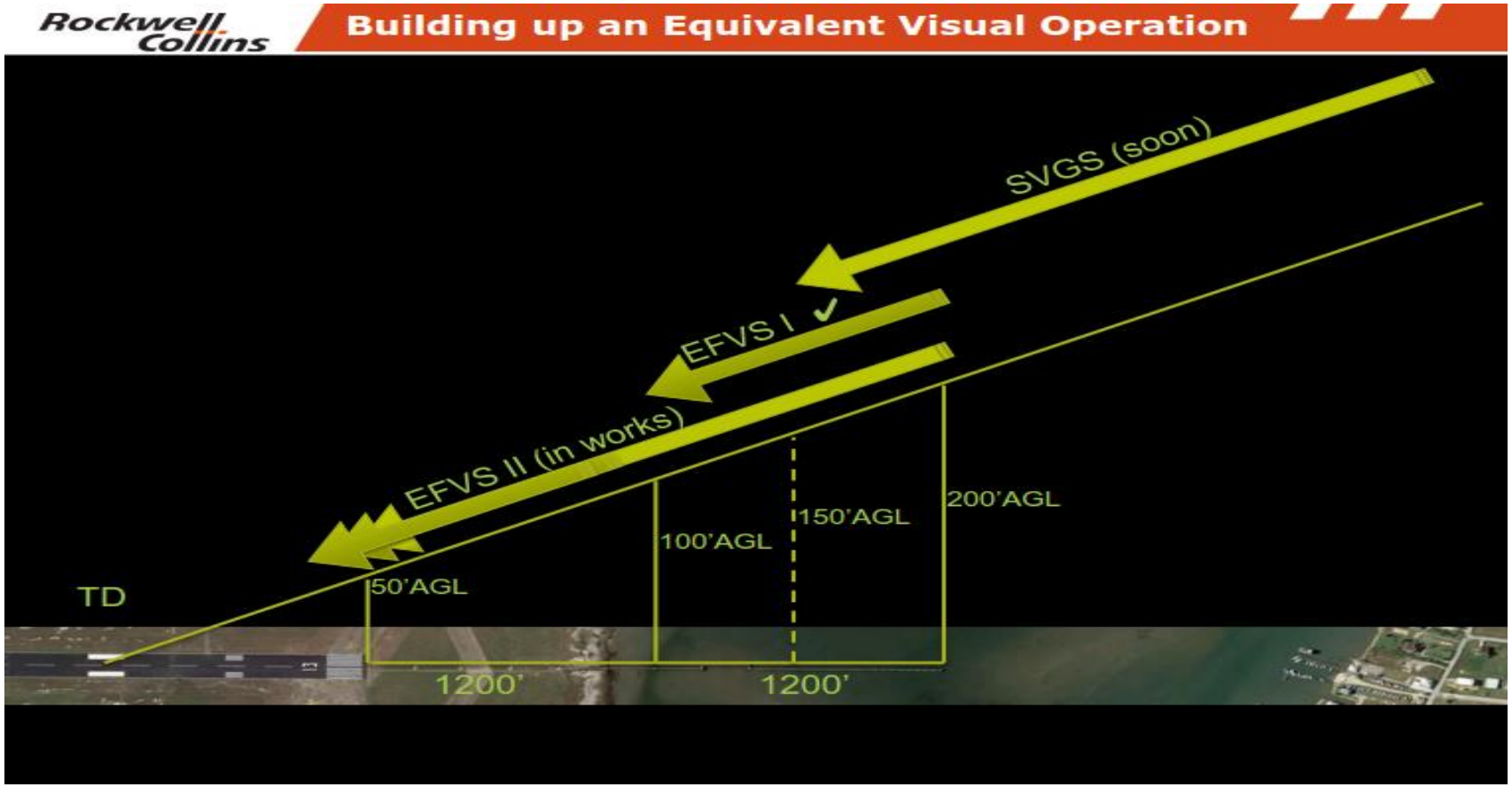
- **CVGS** SVGS + EFVS = CVGS

  - CVGS combines SVGS and EFVS into a single application/display.
  - SVGS gets the aeroplane down to a DH/MAP where EFVS can take over to enable the enhanced viual segment to touchdown with a high success probability.
  - SVGS is impervious to weather, but has common source integrity issues.
  - EFVS is significantly affected by weather, but has no common source integrity issues.
  - Combining the two gives a system with an image that is impervious to weather and which also addresses any common source integrity issues.

DA/H	EFVS SUCCESS PROBABILITY
200ft	<70%
150ft	<90%
100ft	>95%

ACHIEVING EVO VIA A COMBINED VISION GUIDANCE SYSTEM (CVGS)

THE PATH TO EVO **SVGS + EFVS = CVGS = EVO**



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STATUS - REGULATORY - ICAO

Industry and the regulatory authorities are actively working together to embrace vision technologies and to allow their benefits to be utilised to the full.

ICAO, via an All Weather Operations Sub Group and the concept of Performance Based Aerodrome Operating Minima (PBAOM) utilising best equipped – best served advanced aircraft.

Performance Based Aerodrome Operating Minima leverages the higher performance capabilities of improved avionics/on-board equipment to mitigate some of the performance requirements of the ground-based navigation equipment and visual aids, or lack of such.

The combined capabilities of the aircraft equipment and of the ground infrastructure and facilities determines the aerodrome operating minima possible.

The formal basis for PBAOM is contained in Annex 6, Parts I – III. A revised All Weather Operations Manual (AWOM) is in the works.

EASA, under Rule Making Task (RMT) 0379, are issuing a new CS-AWO that embraces vision systems and their operations:

Sect.1	Automatic landing Systems
Sect 2	Head up Displays (HUD)
Sect 3	Enhanced Flight Vision Systems (EFVS)
Sect 4	Synthetic Vision Guidance Systems (SVGS)
Sect 5	Combined Vision Systems (CVS)

The new CS-AWO is harmonised with FAA material.

The NPA was issued in Q2/2018 with the CS-AWO amendment due in Q4/2018.

STATUS - REGULATORY - RTCA

➢ RTCA MASPS DO-315A	EFVS II for 3D approaches.
➢ RTCA MASPS DO-315B	SVGS for SA Cat 1 ILS approaches.
➢ RTCA MASPS DO-359	SVGS for ILS, GLS and LPV approaches.
➢ RTCA MASPS DO-371	SVS for Aircraft State Awareness
➢ RTCA SPR DO-374	ETOS 500/1000

Where next - Beginning Q4/2018 RTCA/SC.213 have launched a programme to review and update the above MASPS.

The FAA have issued the following regulatory material:

➢ FAA AC 20-167A	EVS/SVS/CVS/EFVS.
➢ FAA AC 20-185	Synthetic Vision Guidance System.
➢ FAA AC 90-106A	Enhanced Flight Vision Systems.
➢ FAA AC 120-118	AWO for Take-Off, landing & Rollout.
➢ FAR 91.176(a) & (b)	Enhanced Flight Vision Systems.
➢ FAA Order 8400.13D	Special Authorization Category 1 Operations.

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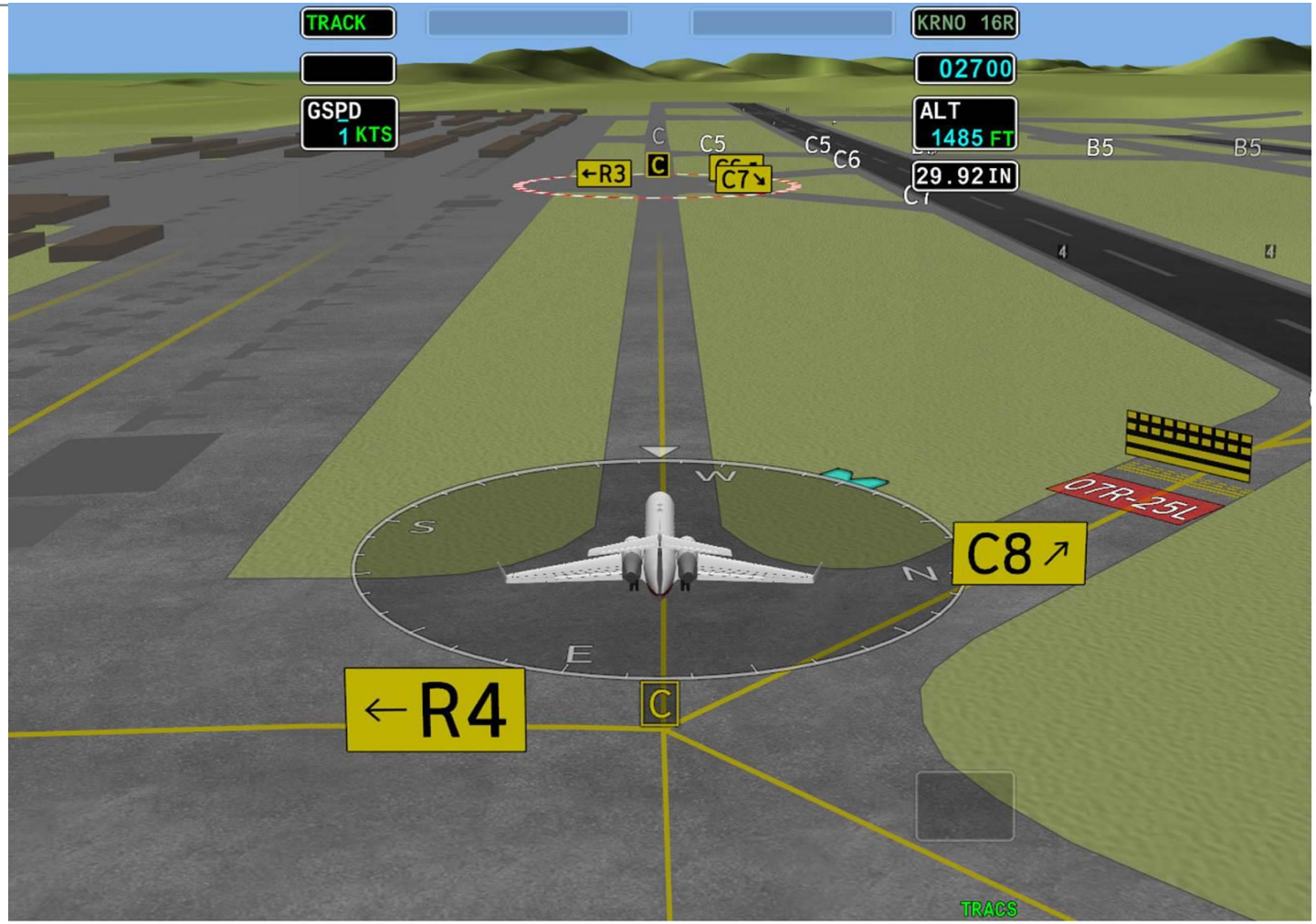
- EVS/EFVS
  - Active radar to replace the IR sensor.
  - Passive radar to augment the IR sensor.
  - EFVS for very low RVR >300ft >1000ft.

- SVGS
  - Lower the DH/MAP.
  - Any unrestricted ILS approach.
  - GLS/LPV approaches.

- CVGS
  - Reduced minima for Very Low Visibility Operations (VLVO)
  - ILS Cat1, GLS and LPV 200 approaches to the ground with a 100ft DH at RVRs <1000ft with a 95% probability of success.

- Surface Management Systems (SMS)
  - Use of EFVS and /or SVS plus moving map displays to allow performance based low visibility ground operations.



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- Head Worn Devices
  - Alternative to HUD in aircraft without sufficient space and/or budget.
  - Augment HUD in larger aircraft?
  - Potential for:
    - Conformal cross wind and/or non-straight in approach.
    - In flight other traffic search and location.
    - Off-axis imagery during taxi.
    - EFVS operations.
    - SVGS operations.
    - CVGS operations.
- Elbit Skylens in-service on ATR aircraft.

Thales (Topmax)

Elbit (Skylens)

QUESTIONS?

ADVANCED VISION SYSTEMS
EQUIVALENT VISUAL OPERATIONS

TRANSPORT CANADA DELEGATES CONFERENCE

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the evolution of mobility

ADVANCED VISION SYSTEMS.

A TEST PILOT`S EXPERIENCE & PERSPECTIVE.

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