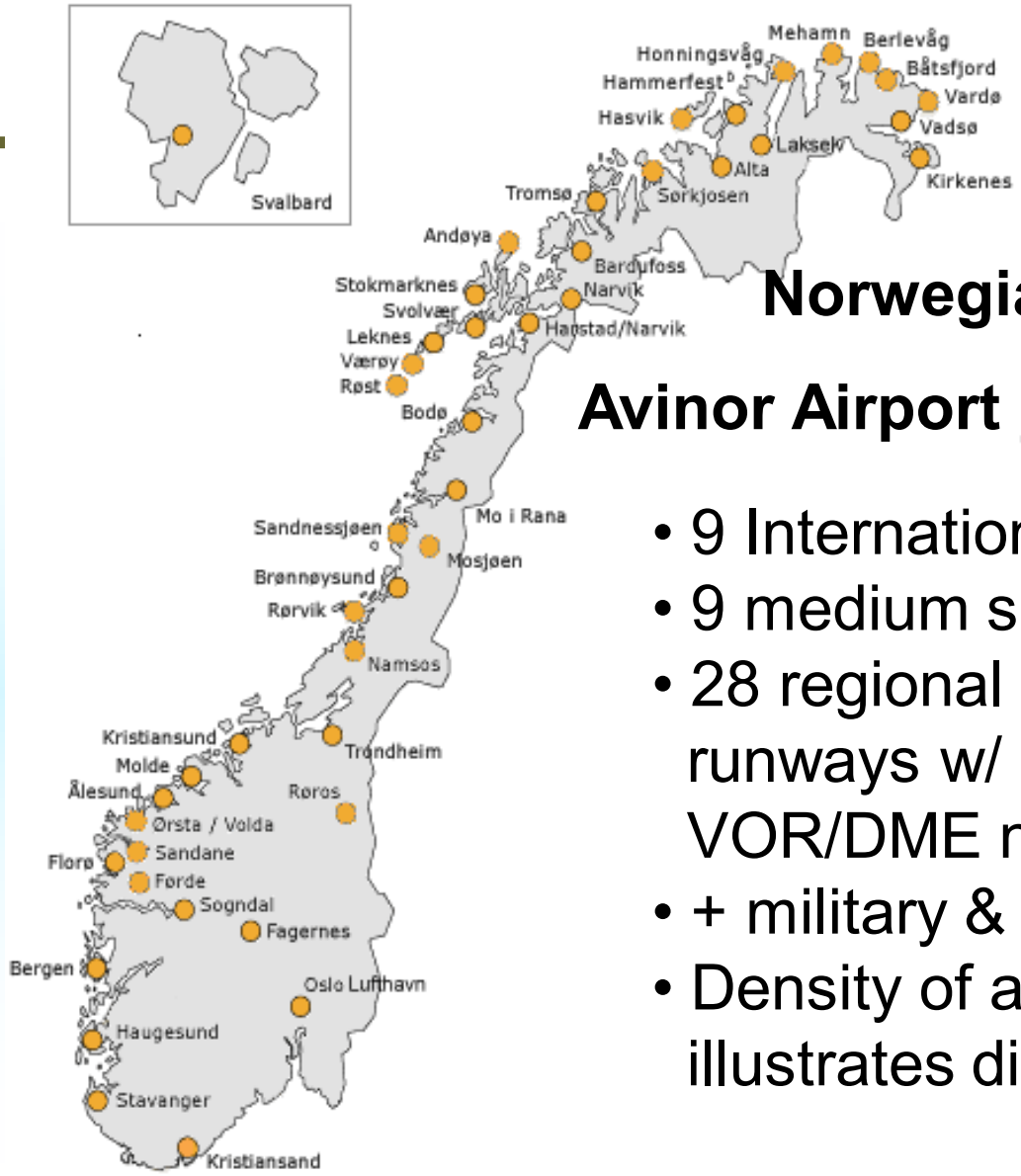
International Flight Inspection Symposium

Oklahoma City, OK USA June 2008

Flight inspection of GNSS-based precision approaches to regional airports in Norway

Steinar Hamar
Avinor AS



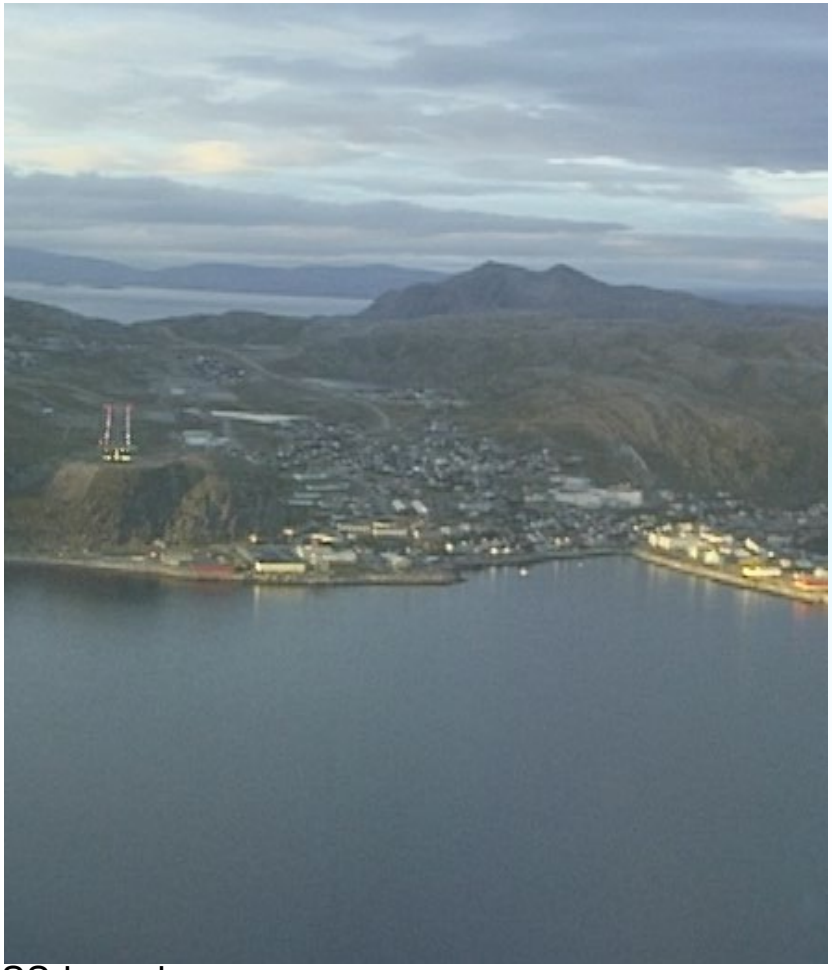
Norwegian

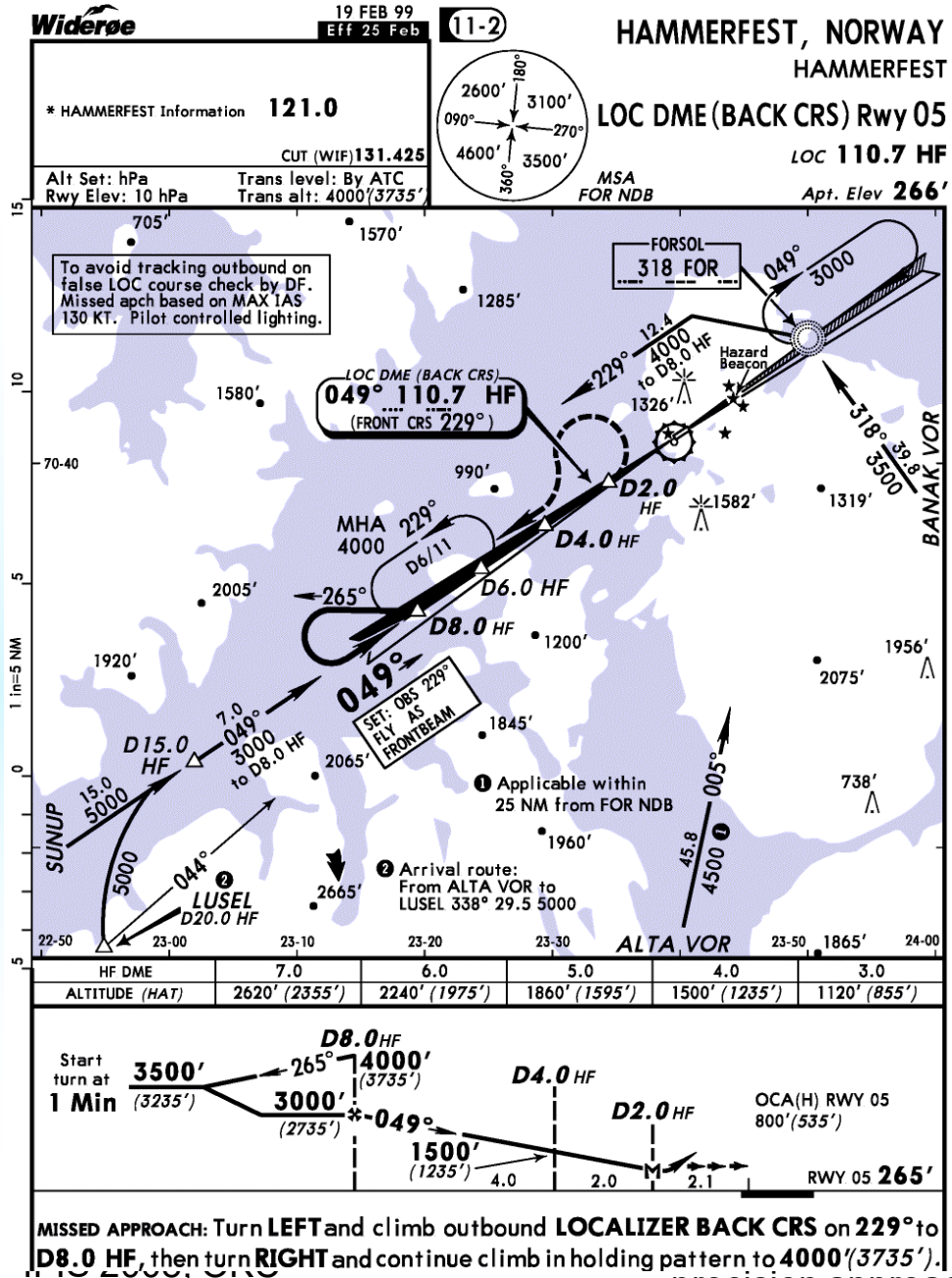
Avinor Airport Network

- 9 International
- 9 medium sized
- 28 regional w/800 m runways w/ LLZ/DME or VOR/DME nav aids
- + military & private
- Density of airports illustrates distances

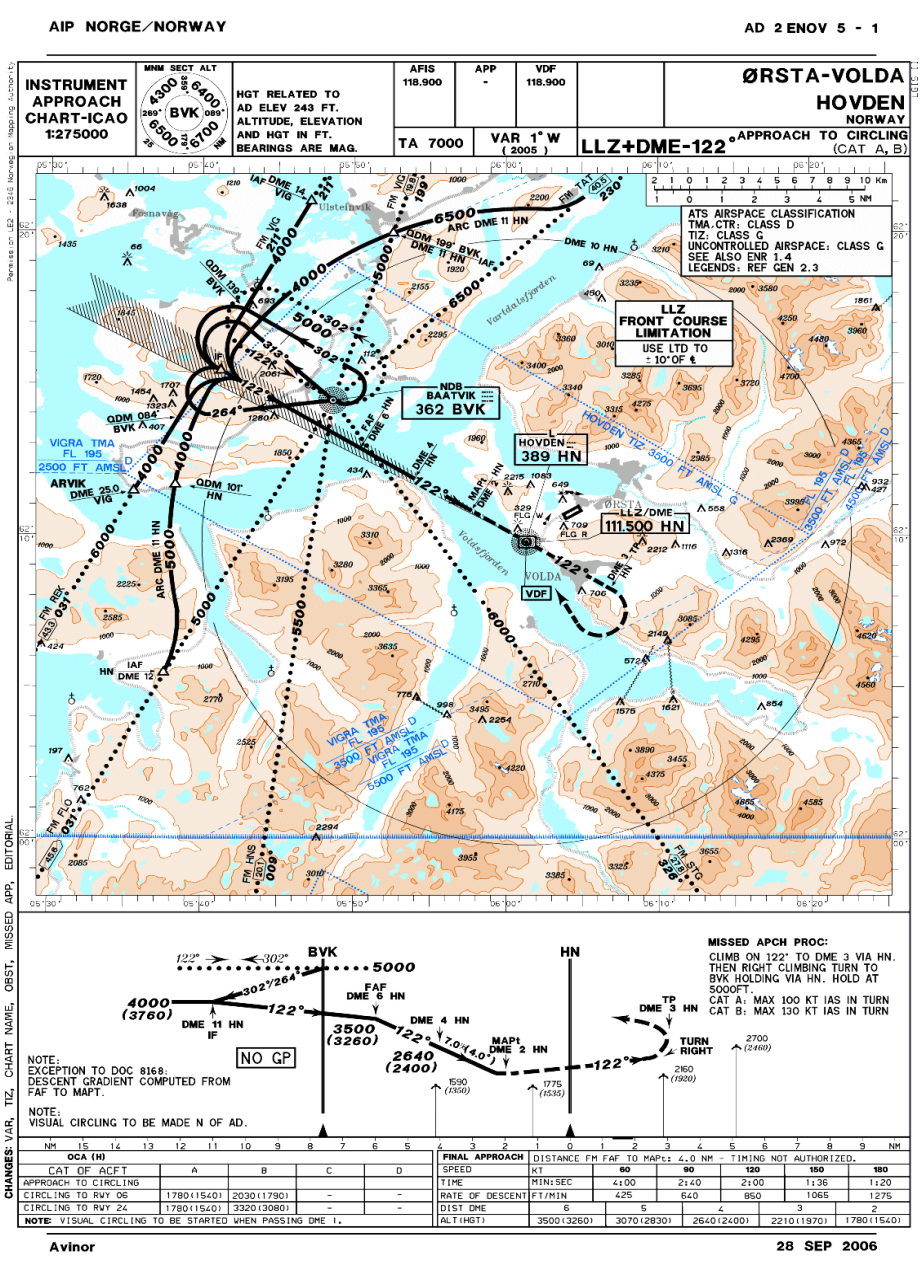
Hammerfest

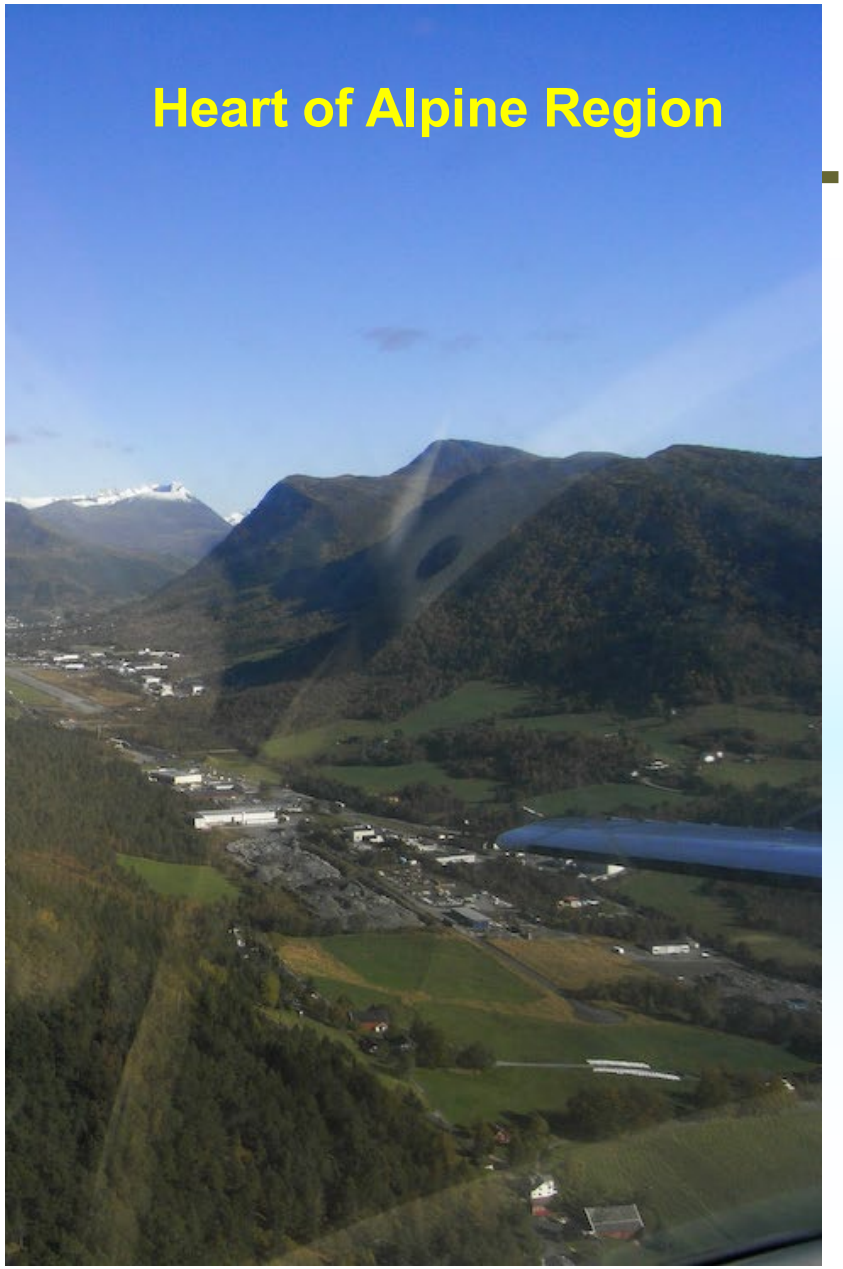
70°39′





SS-based precision approaches


AIP NORGE/NORWAY
AD 2 ENOV 5 - 1
INSTRUMENT APPROACH CHART-ICAO 1:275000
HGT RELATED TO AD ELEV 243 FT. ALTITUDE, ELEVATION AND HGT IN FT. BEARINGS ARE MAG.
AFIS 118.900
APP -
VDF 118.900
TA 7000
VAR 1° W (2005)
ØRSTA-VOLDA HOVDEN NORWAY
LLZ+DME-122
APPROACH TO CIRCLING (CAT A, B)
ATS AIRSPACE CLASSIFICATION
TMA.CTR: CLASS D
TIZ: CLASS G
UNCONTROLLED AIRSPACE: CLASS G
SEE ALSO ENR 1.4
LEGENDS: REF GEN 2.3
LLZ FRONT COURSE LIMITATION
USE LTD TO ± 10° OF ℄
NDB BAATVIK 362 BVK
HOVDEN 389 HN
LLZ/DME 111.500 HN
VDF
VIGRA TMA FL 195 2500 FT AMSL
ARVIK DME 25.0 VIG
HOVDEN TIZ 3500 FT AMSL
MISSED APCH PROC:
CLIMB ON 122° TO DME 3 VIA HN. THEN RIGHT CLIMBING TURN TO BVK HOLDING VIA HN. HOLD AT 5000FT.
CAT A: MAX 100 KT IAS IN TURN
CAT B: MAX 130 KT IAS IN TURN
NOTE: EXCEPTION TO DOC 8168; DESCENT GRADIENT COMPUTED FROM FAF TO MAPT.
NOTE: VISUAL CIRCLING TO BE MADE N OF AD.
NO GP
OCA (H)
CAT OF ACFT A B C D
APPROACH TO CIRCLING
CIRCLING TO RWY 06 1780(1540) 2030(1790) - -
CIRCLING TO RWY 24 1780(1540) 3320(3080) - -
NOTE: VISUAL CIRCLING TO BE STARTED WHEN PASSING DME 1.
FINAL APPROACH
DISTANCE FM FAF TO MAPt: 4.0 NM - TIMING NOT AUTHORIZED.
SPEED KT 60 90 120 150 180
TIME MIN:SEC 4:00 2:40 2:00 1:36 1:20
RATE OF DESCENT FT/MIN 425 640 850 1065 1275
DIST DME 6 5 4 3 2
ALT(HGT) 3500(3260) 3070(2830) 2640(2400) 2210(1970) 1780(1540)
Avinor
28 SEP 2006


Heart of Alpine Region

Widerøe STOL-port operations in 2007

30 Dash-8 in all

17 Dash-8 for STOL-ports

85000 STOL-port cycles/year

(a take-off every 4th minute)

22 STOL-ports

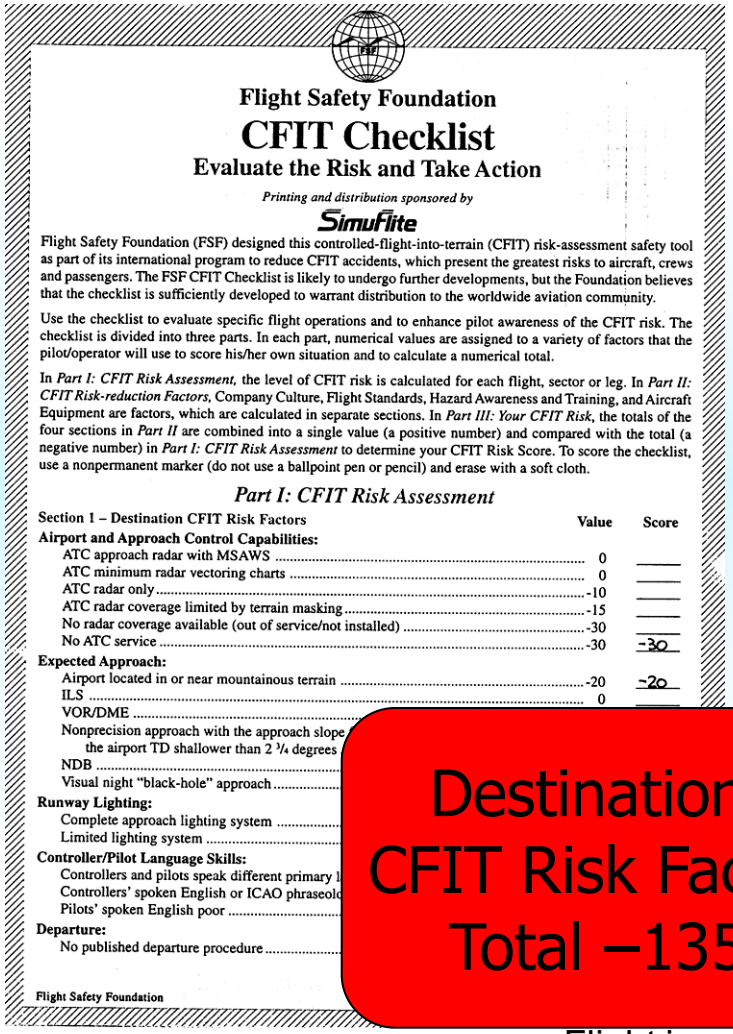
1,2 mill pax to STOL-ports

2.8 mill landings since 1968

STOL-ports Summary

- Short runways (800 m)
- Non-precision step-down approaches
- High minima – black hole effect
- Many circlings
- Turbulence & rapidly shifting inclement weather
- Long periods of winter darkness
- Uncontrolled, non-radar environment
- CFIT prone

CFIT Hazards – Grave Statistics



Flight Safety Foundation

CFIT Checklist

Evaluate the Risk and Take Action

Printing and distribution sponsored by

SimuFlite

Flight Safety Foundation (FSF) designed this controlled-flight-into-terrain (CFIT) risk-assessment safety tool as part of its international program to reduce CFIT accidents, which present the greatest risks to aircraft, crews and passengers. The FSF CFIT Checklist is likely to undergo further developments, but the Foundation believes that the checklist is sufficiently developed to warrant distribution to the worldwide aviation community.

Use the checklist to evaluate specific flight operations and to enhance pilot awareness of the CFIT risk. The checklist is divided into three parts. In each part, numerical values are assigned to a variety of factors that the pilot/operator will use to score his/her own situation and to calculate a numerical total.

In *Part I: CFIT Risk Assessment,* the level of CFIT risk is calculated for each flight, sector or leg. In *Part II: CFIT Risk-reduction Factors,* Company Culture, Flight Standards, Hazard Awareness and Training, and Aircraft Equipment are factors, which are calculated in separate sections. In *Part III: Your CFIT Risk,* the totals of the four sections in *Part II* are combined into a single value (a positive number) and compared with the total (a negative number) in *Part I: CFIT Risk Assessment* to determine your CFIT Risk Score. To score the checklist, use a nonpermanent marker (do not use a ballpoint pen or pencil) and erase with a soft cloth.

Part I: CFIT Risk Assessment

Section 1 – Destination CFIT Risk Factors	Value	Score
Airport and Approach Control Capabilities:		
ATC approach radar with MSAWS	0	
ATC minimum radar vectoring charts	0	
ATC radar only	-10	
ATC radar coverage limited by terrain masking	-15	
No radar coverage available (out of service/not installed)	-30	
No ATC service	-30	-30
Expected Approach:		
Airport located in or near mountainous terrain	-20	-20
ILS	0	
VOR/DME		
Nonprecision approach with the approach slope the airport TD shallower than 2 ¾ degrees		
NDB		
Visual night "black-hole" approach		
Runway Lighting:		
Complete approach lighting system		
Limited lighting system		
Controller/Pilot Language Skills:		
Controllers and pilots speak different primary l		
Controllers' spoken English or ICAO phraseolo		
Pilots' spoken English poor		
Departure:		
No published departure procedure		

Flight Safety Foundation

Two CFIT Accidents

May 6, 1988: Dash-7 flew into mountain – step-down fix missed

October 27, 1993: DHC-6 crashed before runway – black hole effect

Destination CFIT Risk Factor Total –135

CFIT Risk 10 to 15 times higher than for larger airports

Glide slope – DGPS – 'SCAT-1'

- Norwegian Parliament Mandate to install electronic glide slopes at STOL-ports (1996) following the CFIT accidents
- ILS GS ?
  - Inadequate due to unique geographic features which makes conventional ILS GS impossible to install & operate
- Norwegian CAA Task Force Recommendation:
  - **DGPS approaches at STOL-ports**
  - **Concept / Technology: SCAT-I**

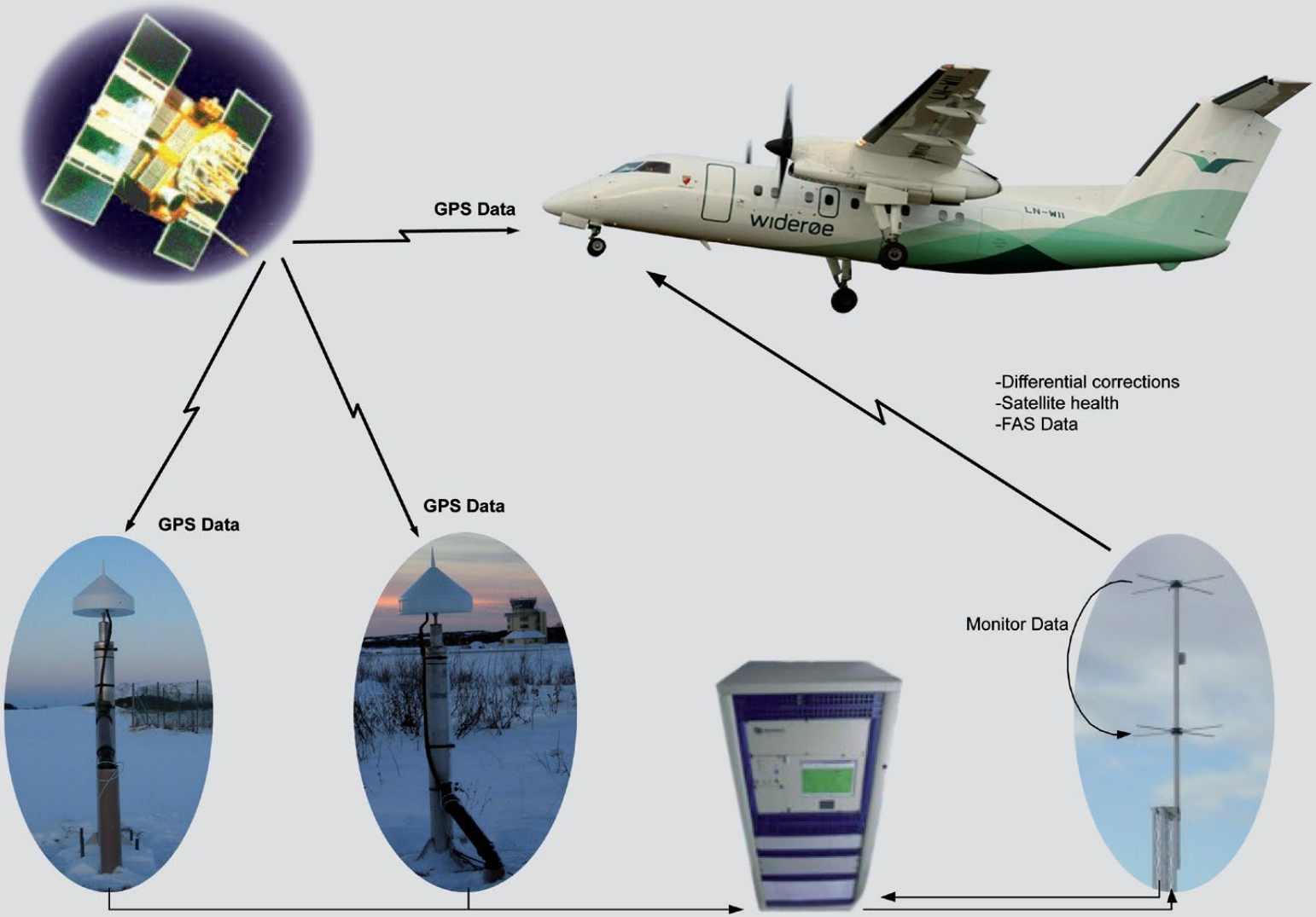
Four Party Team established

- **Avinor**
  - Project owner – project management
- **Universal Avionics Systems Corporation**
  - Airborne equipment
- **Raytheon (now: Park Air Systems)**
  - Ground station
- **Widerøe**
  - Operator

DGPS – 'SCAT-I'

- **Proof-of-concept (1997)**
  - Used a Dash-8 with non-certifiable avionics and ground station
  - Very promising results
  - Benefits were clearly demonstrated to airline, service provider and regulators

The SCAT- I Concept



2001 Test Flights

- LN-ILS (Avinors Flight Inspection Aircraft) was equipped with:
  - 2 GLS 1250 GPS landing sensors from Universal
  - Glide slope truthing functions in Flight Inspection System (new SW for EL/AZ deviation)
- NM8005 SCAT-I Ground Station at Torp Airport
- Testflights were performed, accuracy evidenced and results declared very satisfactory
- Commercial Participants were determined to proceed with remaining development and certification efforts - - - **future looked bright !**

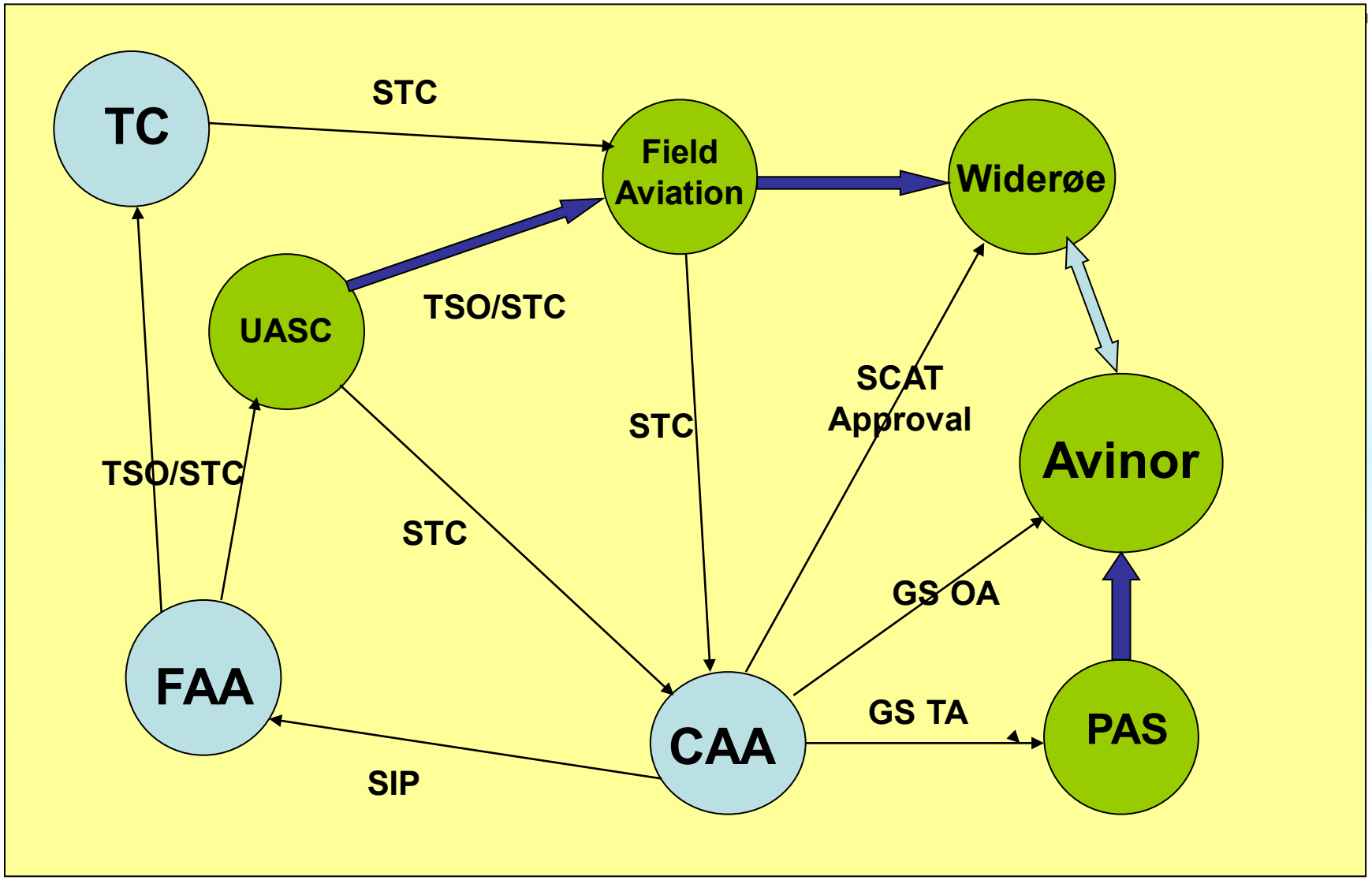
Certification stall – project dormant

- Late 90s saw many manufacturers leave SCAT-I for the greener grass on the LAAS side of the fence
- In 2001 FAA withdrew and it's LAAS Integrity Panel (LIP) was withdrawn from the program
- Program went dormant - Avinor looked for other options
- Outcome of Dec 2003 high level meeting with FAA in DC:
  - FAA will do TSO and STC baseline certifications for the airborne equipment (LA ACO appointed)
  - N-CAA will do the type approval for the ground station
  - N-CAA's SCAT Integrity Panel (SIP) to work airborne and ground based systems

Memorandum of Understanding

- Meetings in FAA LA ACO's back yard in May 2004 produced a truly international "treaty" that obliged the participants to finalize developments and have the various elements of the SCAT-I concept certified within an agreed timeframe.

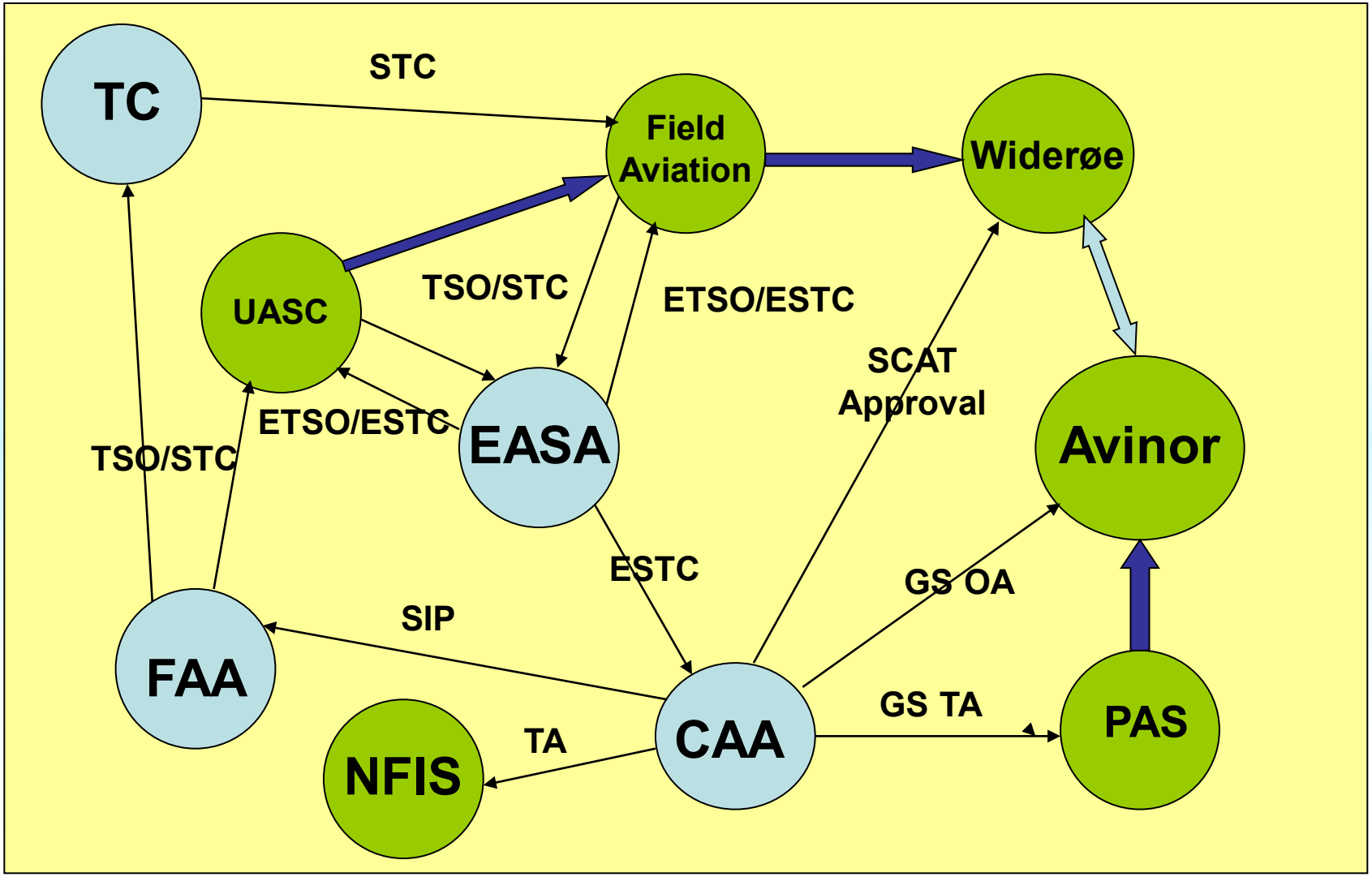
The resurrection



Certification Test Flights

- **FAA and TC flight tests conducted at ENBN airport in May-05**
- **A total of 135 approaches were flown:**
  - 2 aircrafts
    - LN-ILS with single FMS and truthing system
    - LN-WIN with double FMS
  - 3.9° (normal), 4, 4.5, 5 and 6° (steep)
  - Head-, cross- and tail- wind (autopilot /flight director/raw)
- **All were successful – no tunnel penetrations other than forced – accuracy unprecedented**

The certification maze



Certifications

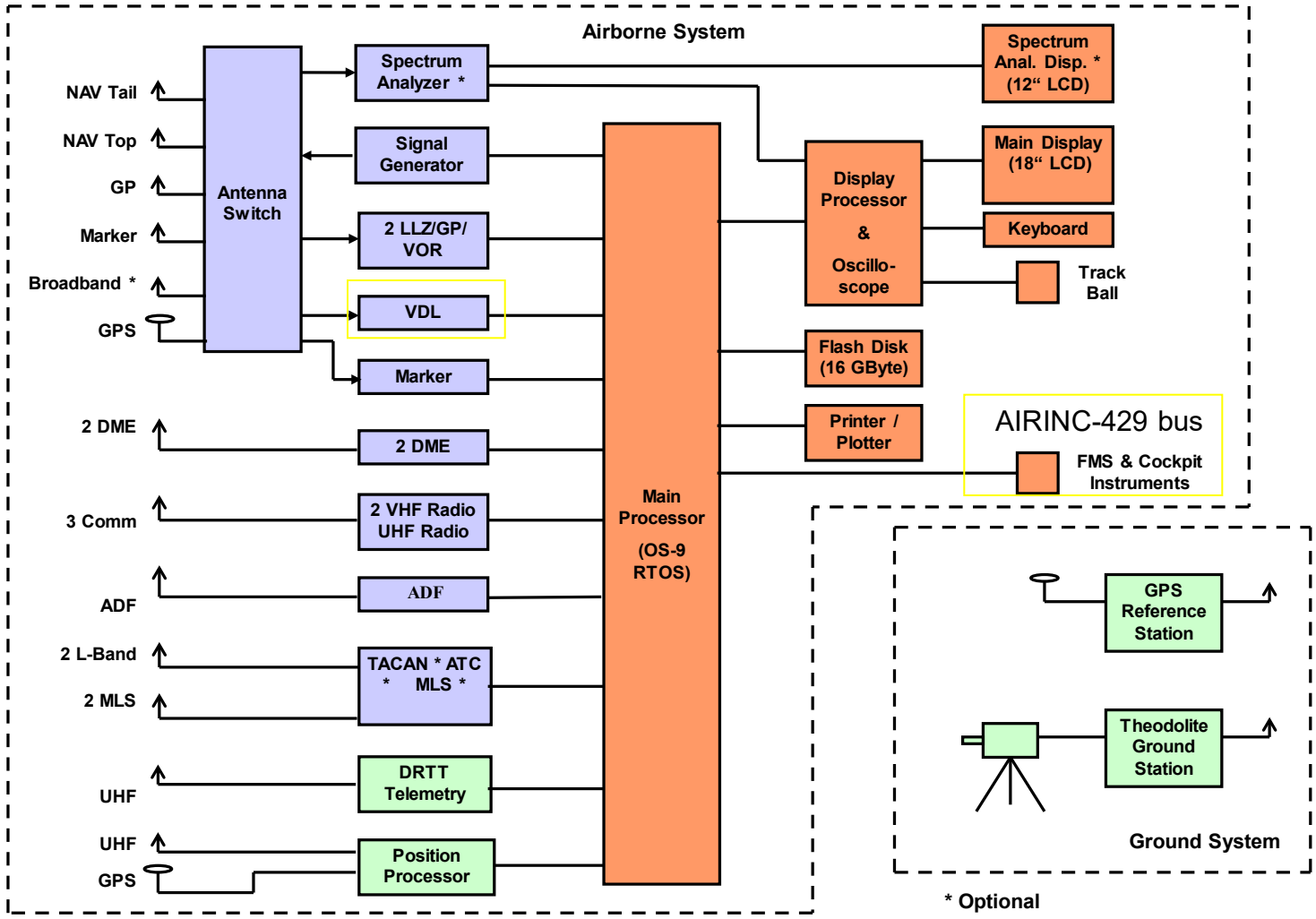
- All in all, it turned out that the SCAT-I program needed **23 regulator approvals** before the inauguration flight could take place on the 29th of October 2007
- The process took 11 years
- Three more regulator approvals are required before the Flight Inspection Unit, its equipment and the King Air B-200 aircraft is certified for SCAT-I flight inspection

GNSS Flight Inspection

- Prototype truthing functions were used in the 2001 tests
- An approved version of NFIS was needed for the certification flight tests and commissioning and recurring flight inspection evaluation

- Requirements for equipment upgrade were derived from
  - **FAA Order 8200.41**
  - **Doc 8071 Vol.2**
- *Equipment to be capable of providing corrected aircraft position to a defined accuracy level*
- *For a GNSS based positioning system there must be no common mode errors between the positioning system and the system under test*

Block Diagram of NFIS



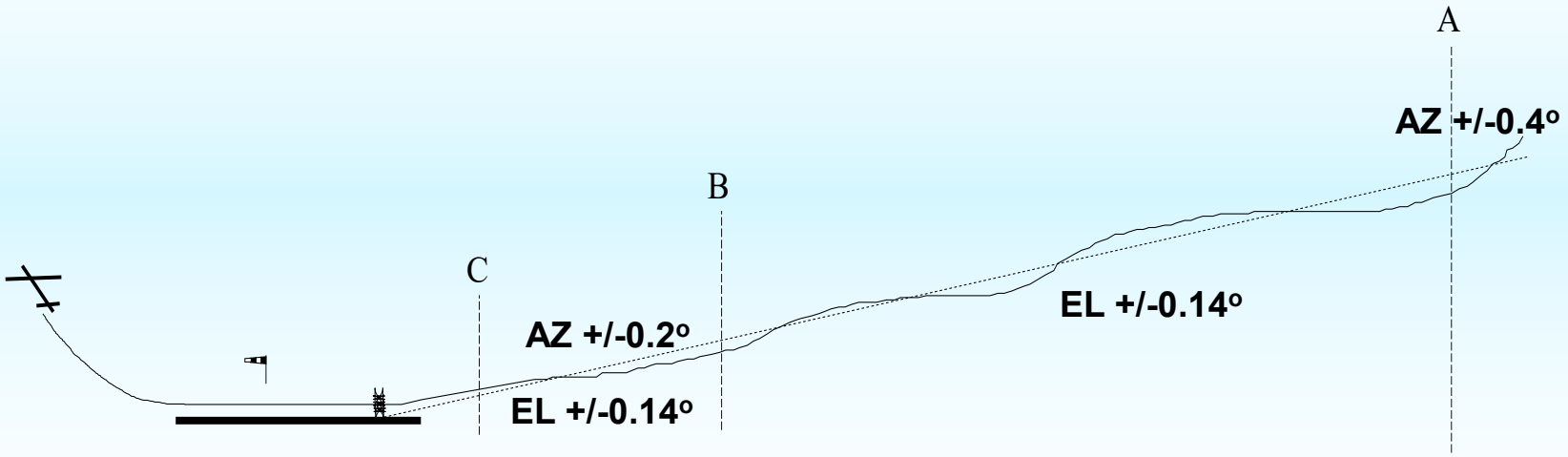
Flight Inspection Requirements

- Commissioning Flight Inspection Evaluation
- VHF Data Link (VDL)
- Initial and Intermediate Approach Segments
- Final Approach Segment
- Missed Approach Segment
- Special Instrument Approach Procedure
- Confirming Flight Inspection
- Periodic Evaluation

Flight Inspection Procedures

- Program and procedures were developed to meet each and every requirement and with additional functions added:
  - Verification of automatic arming of FMS SCAT-I approach function
  - Establishment of approaches via all IAFs
  - Check of potential shadowing of GPS antennas
  - Verification of glide path tunnel position and flags
  - Flyability

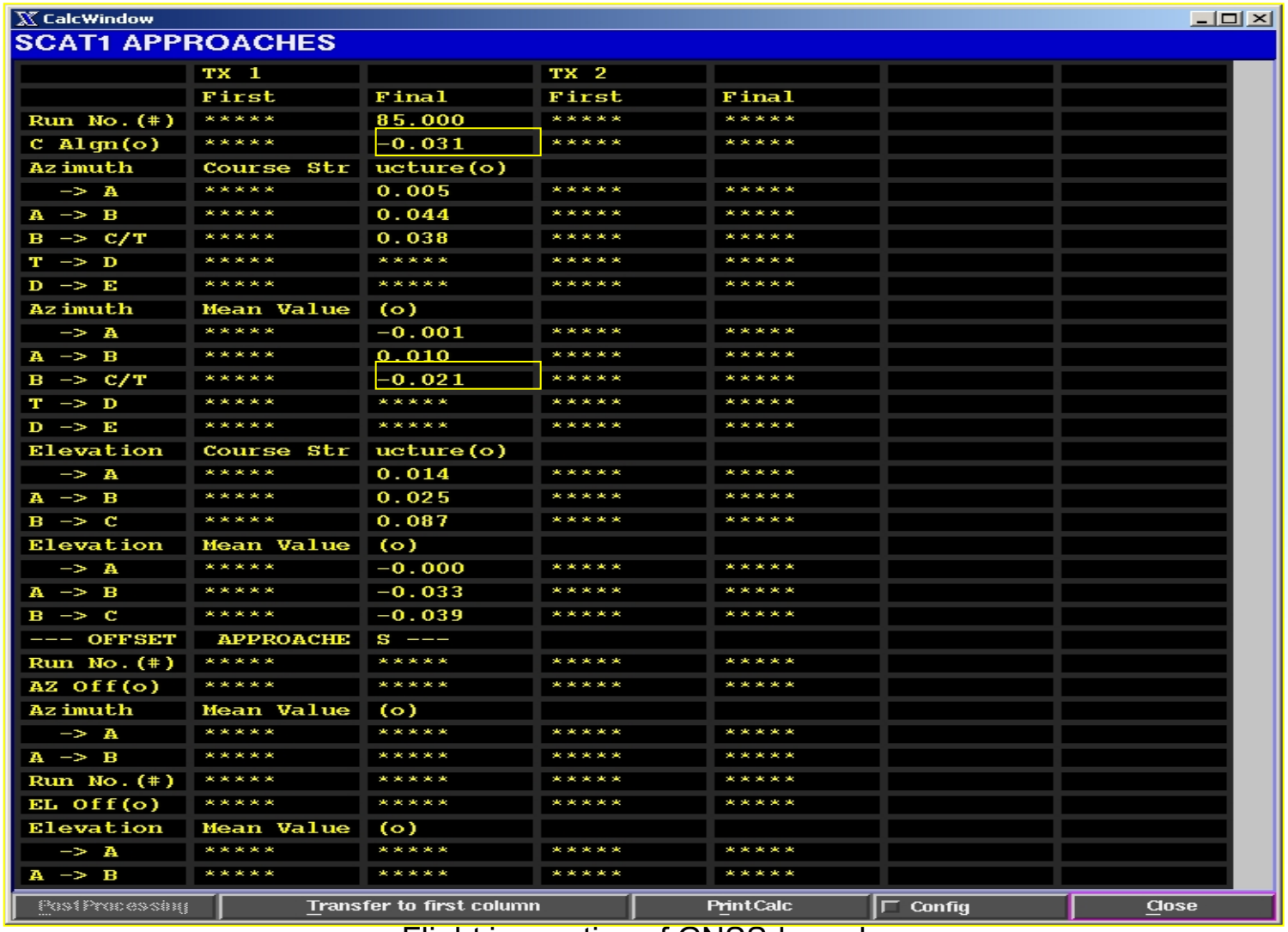
SCAT-I Approach



NFIS in DCH-8 LN-ILS

AZ, EL & VDL curves for one run

Calculated figures same run



NFIS Data Sample

UTC HH:MM:SS	REF DIST	REF ALT	AZ REF DEG	EL REF DEG	AZ DEV FT	EL DEV FT	AZ Tunnel FT	EL Tunnel FT	AZ PEN %	EL PEN %
08:42:21	3,4	1500	0,05	0,08	17,57	29,75	525	172	3	17
08:42:21	3,4	1498	0,05	0,08	17,56	29,74	524	172	3	17
08:42:21	3,4	1497	0,05	0,08	17,54	29,71	524	172	3	17
08:42:21	3,4	1496	0,05	0,08	17,88	29,68	524	172	3	17
08:42:21	3,4	1491	0,05	0,08	17,83	29,59	522	171	3	17
08:42:56	2,2	1000	0,04	0,02	9,77	5,00	358	117	3	4
08:42:56	2,2	999	0,04	0,02	9,75	5,23	358	117	3	4
08:42:56	2,2	998	0,04	0,02	9,74	5,22	358	117	3	4
08:42:57	2,2	996	0,04	0,02	9,72	5,45	357	117	3	5
08:42:57	2,2	995	0,04	0,02	9,71	5,68	357	116	3	5
08:44:01	0,4	205	0,02	-0,08	0,83	3,13	111	32	1	10
08:44:01	0,4	204	0,02	-0,09	0,86	3,17	111	32	1	10
08:44:01	0,3	203	0,02	-0,09	0,89	3,30	111	32	1	10
08:44:01	0,3	201	0,03	-0,09	0,92	3,34	110	32	1	10
08:44:01	0,3	200	0,03	-0,09	0,95	3,42	110	32	1	11

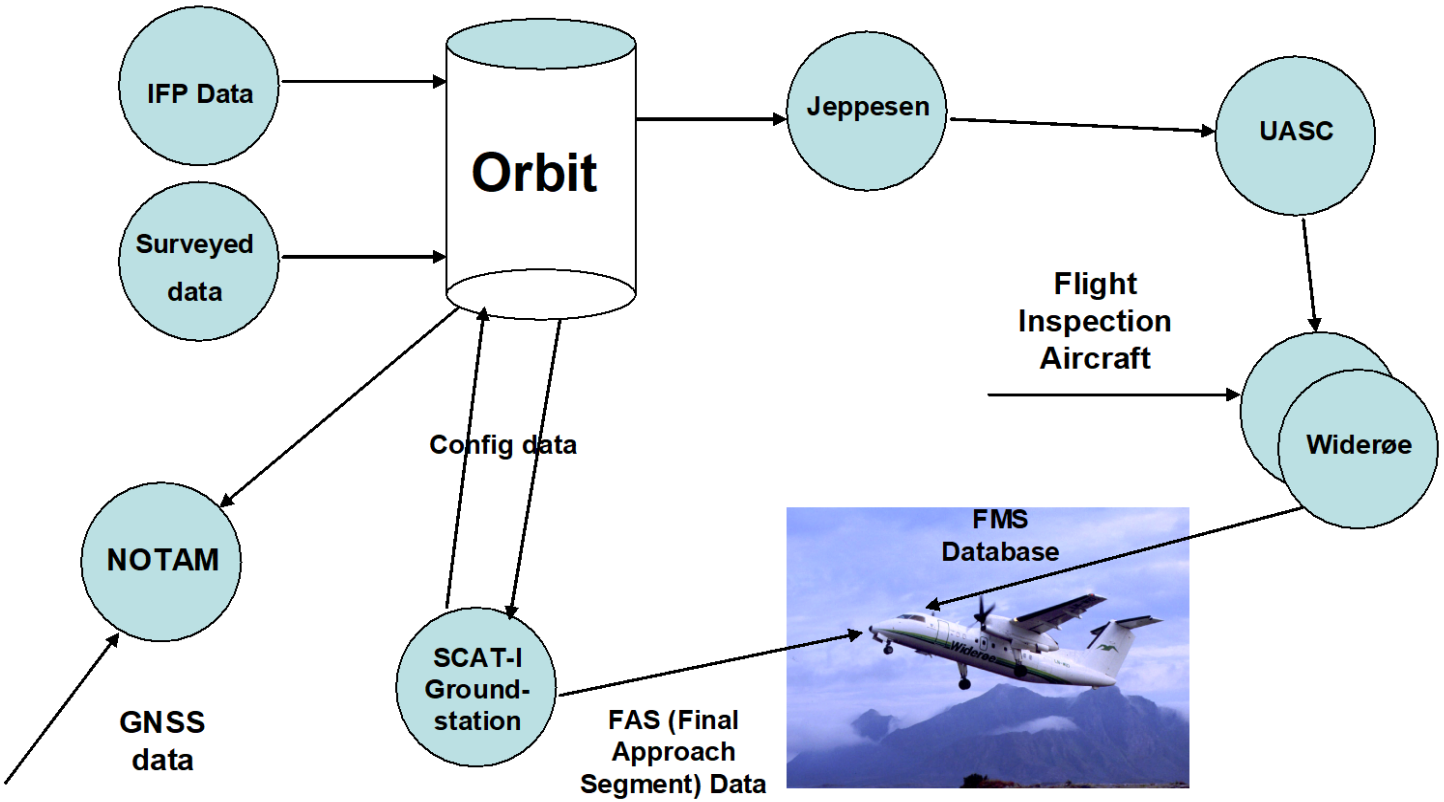
Flight Inspection & Certifications

- The flight inspection system played a key role in the certification process for SCAT-I avionics and ground facilities.
- LN-ILS as testbed for base-line SCAT-I certification with the onboard NFIS provided real time data and a data-base for 100 runs (5 samples/sec) for post test analysis.
- Base-line avionics certification materialized quickly
- Operating approval of the Ground Facility called for another sequence of flight inspection encompassing the comprehensive program and procedures outlined earlier
- The flight inspection test results again provided a firm basis for the N-CAA operating approval that followed

Preparing for SCAT-I operations

- Criteria for procedure design (normal/steep/offset)
- Data generation and distribution process
- Phraseology
- Maintenance Guidelines
- Training requirements (ATC / AFIS / Pilots / Nav aid technicians)
- Availability prediction / NOTAM

Data generation and distribution



Implementation

- **Avinor**
- Brønnøysund inaugurated in Oct 2007
  (having been in trial operation for 6 years)
- Hammerfest operational July 3rd 2008
- 9 Ground Stations in various stages of implementation – all up by end 2009
- 22-24 Ground Stations operational by end of 2011

Implementation

- **Widerøe**
- Pilot training (350) in progress (simulator / line flying with supervisors)
- Aircraft upgrade (17) in progress
- Line flying on SCAT-I equipped airports continuously

Payback

We strongly believe that the persistent pursuit
of certifying SCAT-I
continuously over a period 11 years
will finally pay off in precision approaches
and significant improvement in flight safety
for the STOL-ports

and the pilots love to fly it !