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UK studies add to concerns over GPS reliability

Two of the most extensive studies yet completed of GPS reliability appear to demonstrate that the system falls well short of what would be acceptable for sole-means navigation. The trials by the UK CAA's National Air Traffic Services (NATS) threw up a range of problems including unexplained outages, inadequate availability, possible software bugs, and questionable integrity. One of the problems noted had the potential to affect multiple receivers simultaneously, implying that even receiver-redundancy would not cure it. NATS concludes that "considerable" improvements will have to be made before GPS can be considered suitable for sole-means.

The first of the two studies, both presented to the Royal Institute of Navigation's 1996 International Conference in London, examined the performance of a GPS-receiver fitted to a revenue-service Boeing 747-400 from April 1994 to December 1995. NATS believes the project is probably the most extensive survey ever of the performance of GPS on typical revenue flights. The work was a by-product of the experimental automatic dependent surveillance (ADS) programme run by NATS and British Airways using the same aircraft. Programme manager Sarah Sharkey described how, over the period looked at, the aircraft operated a variety of services almost literally worldwide, including legs as long as London-Mexico City – at 12h, and as short as Sao Paulo-Rio de Janeiro at about 1h. The data is mostly from the cruise segment, although some is virtually from take-off to landing, and was collected by day and night. It was transmitted via satcom data-link to the Goonhilly, UK ground earth station, passed to the ATM Development Centre at Bournemouth, UK and analysed by consultants Lambourne Navigation. ➔

Even "valid" positions were in error

➔ NATS used several techniques to identify GPS outages – primarily comparisons with the flight management system-derived position; examination of the change of GPS position with time; and "sanity" checks for gross errors. The position reports were broken down into three types: messages with an INVALID GPS integrity flag; messages with a VALID integrity flag but where there was actually an outage; and "good" positions with a VALID flag. The results are shown in the table below.

Sharkey explains that all the erroneous messages came in blocks of consecutive reports, some clearing themselves and others persisting until landing. A total of 28 outage blocks occurred, with a mean outage time of 81min during which the aircraft would have moved more than 600nm (1,110km).

Sharkey notes that there is no uncontroversial evidence that the outages were due to failures of the avionics or signals in space. But she adds: "What is certain is that an ATM system cannot be based on position reports in which more than 3% of the messages hold a useless GPS position report. In that sense it does not matter much whether the origin of the failures lies in the GPS signals in space, the receiver, or in the communication system that brings the data to the ATC unit."

NATS' work did not generally identify generic causes, but there were some significant observations. In particular, 64% of the outage blocks occurred between 2200UTC and 2400UTC on Saturday nights which, says Sharkey, "shows some systematic problem likely to be linked to inadequately debugged

Group	No of messages	% of total
(a) "Invalid" type outages	759	2.21
(b) "Valid" type outages	487	1.41
(c) "Valid" and good	33173	96.38
Total	34419	100.00

Source: UK NATS

software". Comparison with potential sources of interference was mostly inconclusive, but some repeated locations did turn up. There was no correlation, however, between outages and satcom transmissions from the aircraft.

The study's weakness is that it used a receiver which had not undergone certification to the relevant US Technical Standard Order (TSO). Nevertheless, Sharkey points out: "The counter argument must be that if any avionics manufacturer has in place an effective quality control system, then he is unlikely to allow out through his factory gates any system with a mean time between outages (MTBO) of 54.6h as was the failure rate found for [this] receiver." And she adds: "This suggests that the programme has shown up an undue haste in implementing GPS in civil aviation." →

Airport trials also showed worrying results...

→ The second study did use TSO'd equipment. Four receivers – two each from two different manufacturers – were installed at a fixed location at London Stansted airport with separate antennas all clear of obstructions. NATS collected 31,604h of data from the experiment between 22 August 1995 and 21 August this year. It observed 20 outages, giving a MTBO of 1,580h, with respectively seven, four, five and four outages per receiver. Outages known to have been due to power transients or mains failures have been excluded – but some could remain, and NATS has indulged in a degree of qualitative "detective work" to try to pin down the causes of the problems.

The last five outages of one of the receivers, for example, coincided with a Notice Advisory to Navstar Users (NANU) stating that satellite PRN01 was unusable. Oddly, however, the affected receiver failed on five of the six affected days, while the other receiver of the same type did not fail at all. Sharkey comments that it would "be helpful" if NANUs contained more detail about the reasons for unusability. Whatever the cause, one of the receivers was able to track six satellites and provide a fix, while the other could track only four. →

...including simultaneous receiver outages

→ More alarmingly, the project discovered that it was possible for two identical receivers to fail simultaneously – implying that "the redundancy in a dual installation" could be lost. The one occasion when that happened was on 18 October 1995 between 1600 and 1700UTC when two similar receivers suffered respectively four and five outages, and then recovered without intervention. The NANUs showed that two satellites were misbehaving but, nevertheless, the other two receivers in the trial operated normally.

Sharkey remarks that the performance of the receivers on the ground performed much better than the airborne system on the 747, but she adds: "A MTBO of 1,580h is extremely poor. Even if a few of the outages were in fact caused by environmental problems such as power transients or nearby lightning strikes, rather than by bad receiver design, this would still leave a performance considerably worse than that expected from other modern electronics." →

"Far too many GPS failures...for sole means" – NATS

→ She points out that the existence of systemic errors triggered by in-specification signal-in-space events are particularly important, since they could affect multiple receivers simultaneously. Sharkey says: "This would mean that the failure protection achievable through redundancy would offer no protection at all. This would be extremely serious in a busy volume of airspace. The seriousness is further increased in

an environment where surveillance is effected through a GPS-dependent surveillance system." NATS plans further work on establishing the probability of simultaneous outages of the kind found in the Stansted trial. Sharkey warns that, depending on the results of that, NATS might have to insist that GPS-performance be improved before it can be relied upon.

The NATS paper concludes by saying that "there is no doubt that GPS will have a significant role in civil aviation", but it also declares: "The projects...have illustrated clearly that there are far too many failures in the GPS receivers examined. A considerable reduction in such failures will need to be achieved before GPS can be considered a reliable sole means system." ■

Inertial input is possible solution for GPS worries...

The UK researchers who produced the GPS-outage data reported above suggest that one solution may be to couple the on-board GPS equipment to an inertial platform. That is essentially the option being pursued by Litton Aero Products with the Autonomous Integrity Monitor Extrapolator (AIME) now certificated for primary means of navigation on the Airbus A330/340 models. The system also integrates barometric altitude into its navigation solution and is intended to be certifiable for true "sole means" operation. Airline take-up of the system, however, is going to depend heavily on the operational community's perception of the weaknesses of GPS. In particular, the industry's view of the adequacy of remote autonomous integrity monitoring (RAIM) to keep aircraft out of trouble will be crucial. ➔

...but opinions differ on size of the problem...

➔Right now views are divided, and conversations with airline officials strongly suggest that few are comfortable that they thoroughly understand the issue. The difficulty they face appears to be in reconciling the industry's generally excellent experience with GPS to date – albeit in the en route phase – with the system's weaknesses, about which less is known. Perhaps the biggest problem is the threat of jamming and spoofing, which is an undoubted concern but which is almost impossible to quantify.

Litton is pressing enthusiastically ahead with AIME development, and is currently working with Collins to add AIME to its multi-mode receiver for Airbus types (AN/2/18). The company notes itself that the sales effort is not a simple one. Director of marketing, James Govostes, says: "AIME is an attempt to use something that was on the aircraft already. It is only software, but it goes against the grain a little bit at the moment." He adds bluntly: "None of the alternatives have ways of coping with spoofing etc, casting considerable doubt on GPS as a safe means of navigation with no redundancy." ➔

...with Litton warning of dire consequences

➔Litton accepts that AIME is not attractive for aircraft that are not already equipped with – expensive – inertial systems. Its primary market is aircraft that have modern inertial reference systems (IRS) already on board. Govostes says: "Where nothing else exists it is better to fly with RAIM, but there is no advantage for an aircraft flying anywhere with three IRS. How can we as an industry be backing a system that performs significantly worse than what we have today?" The problem, he says, is serious but can be tackled. He relates how Litton performed category III landing trials with Airbus, and says: "What we saw versus accuracy was fine. Your problem was continuity and integrity. One of the things that can happen to you on a GPS landing is

that you can lose the signal. If it is just GPS you are going to have to wait for the signal to come back. What happened with inertial added was that they decoupled at 700ft and the inertial was able to bring it down." He even suggests that some major certification authorities may allow category III approaches only with inertial back-up.

Another advantage of AIME is that it is immune to external radio frequency interference (RFI). Govostes says: "You are going to have Litton saying that a guy can go by with a box and put you into the ground. Spoofing and jamming is extremely dangerous. We are probably going to go down the path that we are going until an aircraft goes into the ground." He explains: "GPS has a very, very narrow frequency limit which makes it very, very easy to pick up and jam. AIME can get you through spoofing and jamming down to non-precision levels." Litton's message is somewhat apocalyptic, saying essentially that the industry is ignoring a fundamental, potentially lethal problem which will ultimately prove unignorable. Govostes says: "Take today's premise that GNSS is supposed eventually to take the place of all the other aids that we have – that is to say sole means. That ignores to an extent – although there is some talk about interference – jamming and spoofing of the signals. If I am right about the RFI problem then we are heading down a path towards a sole means system that will not exist and we will not have any other system." ➔

Airframers disagree on GPS vulnerability

➔ Litton's major success so far has been with Airbus Industrie, where director of air traffic systems, Peter Potocki, says: "You can deny the use of a radio or you can deception-jam it. You can do that with any radio, GPS or ILS or, if you put your mind to it, with the microwave landing system (MLS). To spoof an ILS requires fairly simple computing but a fairly high powered transmitter. To do the same with GPS requires a low-powered transmitter but probably more computing."

Airbus' own work on the subject showed that, of the possible landing systems under consideration, "MLS was the most robust system and is 30dB less susceptible than GPS – that is a thousand-fold – which is also due to the range of the transmitter". It found ILS also to be "fairly robust", describing it as "not as good as MLS, but significantly better than GPS". Potocki believes that spoofing GPS would be "quite difficult" but jamming would be simpler, so that "a 1w jammer in central London, costing about £10.00, would deny the use of GPS at all the London airports".

Boeing has been less inclined to go on the record about the vulnerability of GPS, but privately officials say they are sceptical about the alleged weaknesses. Its line to customers is that AIME is not necessary and that Litton is overstating the problem. It points in particular to the robust performance of GPS in practice. A knowledgeable official says that, in FANS-1 operations over the Pacific, one of the major carriers involved sets an "actual navigation performance" (ANP) alarm at 0.4nm and has never triggered it. In practice the ANP is "virtually always less than 0.2", says the official. ■

FAA follows tough line on GPS approach funding...

Just as the pace of work begins to pick up on the US FAA's GPS local area augmentation system (LAAS), it is becoming increasingly clear that funding for the programme is going to be tight. The agency appears to be committed to the development effort to produce at least a prototype of the system, but its message on further activity is ambiguous to say the least. Most importantly, there is a definite lack of commitment to seeing the project through to a Category III-capable status. There are no funds presently earmarked for any kind of acquisition – even for a more basic system – and

there is serious doubt as to whether the agency's programme will ever generate a Cat III system. Associate administrator for research and administration, George Donohue, is reported to have recently been telling interested contractors that if there is a "constituency" that wants Cat II/III LAAS "then they are going to have to pay for it themselves". That is a decidedly tougher message than the FAA's current public position that its cost benefit analysis shows that "a modest deployment" would be justified

There is much more to the LAAS situation than merely the technical exercise of producing a workable solution. Although the question of GNSS' ability to provide at least basic Cat III accuracy is pretty much settled – repeated trials have shown that that can be achieved – numerous doubts surround the issues of integrity and availability. Aircraft coming off production lines in future are generally going to be equipped with multi-mode receivers (MMR), but the retrofit equation is more complicated and airlines still do not know for sure what approach system to expect at any given airport in the next century. At some point somebody is going to have to demonstrate that an assured Cat III GNSS system is practicable – otherwise alternatives will have to be preserved or implemented. ➔

...and makes early technology choices

➔The FAA's current schedule (see chart p5) envisages the implementation of a Cat I LAAS by the start of 2002, with a Cat III system emerging in 2005. There is a long way to go from today's conceptual status. The proposed LAAS architecture should by now have just been released, but several key features have become apparent already. The first is that the basic differential technique favoured is the so-called carrier-smoothed code (CSC) method rather than the more accurate but also more complex carrier phase (CP) technique. CP as envisaged for operational use has run into a series of objections as work has progressed on LAAS, the major ones being: it would use integrity beacons off the airport – contrary to the LAAS design guidelines; there is a risk of aircraft passing the final approach fix with position ambiguities still unresolved; and it still uses remote autonomous integrity monitoring (RAIM) to check the signal in space – putting unacceptable onus on the avionics and making them too different from ILS equipment.

The FAA expects to have different architectures for Cat I, II, and III LAAS installations respectively, mostly adding redundancy, but, more fundamentally, making use of airport pseudolites for Cat II and III. The Cat III solution is likely to use a pseudolite and as many as four ground stations. In the remainder of this year and next year flight trials will get underway at Stanford and Ohio Universities, which have been

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responsible for much of the most significant development work to date. The FAA's Ray Swider told the Royal Institute of Navigation's Annual Conference: "We have several fairly critical experiments to be performed by Stanford and Ohio. These are to take a very good look at pseudolites for augmentation and then to establish once and for all the system we will use for integrity. We also intend to produce some basic products – a signal model for example – and with those tools in our hip pocket we can go and write the specifications." The agency will work with the RTCA to produce minimum operational performance standards (MOPS) by the end of 1998. ➔

Flight tests proceed

➔ At Stanford the world will include testing of the university's "in-track" airport pseudolite which opens the possibility of adding some unambiguous CP information close to the runway ends with resulting integrity of perhaps better than 10^{-8} . That work will use a nose-mounted antenna on the FAA's Boeing 727 flying test-bed. Ohio will continue refining its own design including the addition of a pseudolite ranging signal and the development of a promising multipath mitigation technique. The FAA is itself building a replica of the Ohio system at its Technical Center in Atlantic City to help it become more involved in hands-on design work.

Meanwhile the FAA is trying to work with the various developers of Special Cat I (SCAT-I) systems to harmonise their systems as far as possible and then to see if they can be built on to produce the public use Cat I LAAS. How far that can be done is far from clear. Ron Braff of the Mitre Corporation, which is closely involved with the FAA, says: "Hopefully there could be an evolution from SCAT-I to LAAS but we don't know." The FAA is less concerned about the Cat I situation because, by the time LAAS is available, it

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hopes to fulfil the Cat I requirement with the Wide Area Augmentation System (WAAS – ANI 2/21). ■

Germany lays out navaid retirement plan

Germany's Radio Navigation Plan is intended by now to be formal policy and has considerable significance for the aviation community. The plan – known as the DFNP – is a product of the German Ministry of Transport (BMV). It applies to all modes of transportation as well as the surveying world, which has extensive interests in GNSS use. Germany has been particularly enthusiastic in pursuing a satellite-based aviation navigation infrastructure and the DFNP backs its ambitions in that field. A key element of the plan is that it means that Germany now joins the USA (ANI 2/21) in laying out a public timetable for the decommissioning of certain conventional navigation aids (see chart). It makes the key assumption that the Omega system will be closed down, as seems likely, in 1997 as the US stations are terminated. Germany itself does not host an Omega station, but the plan notes that the Omega-user community appears to be reducing. In aviation that is significant because Omega-users are generally switching to GPS.

Germany currently operates 116 non-directional beacons (NDB) which, like its VOR/DMEs, and ILS come under the control of the DFS privatised ATC authority. Under the DFNP, NDB approaches will begin to be phased out "at the earliest" in 2003, and the en route use of NDBs will be discontinued "at the earliest" in 2008. That is more conservative than the US plan which sees NDBs disappear between now and 2006.

Germany sees its VOR/DME stations, however, continuing in operation until "at least" 2008, and the 14 en route TACAN stations on its soil will also have their DME

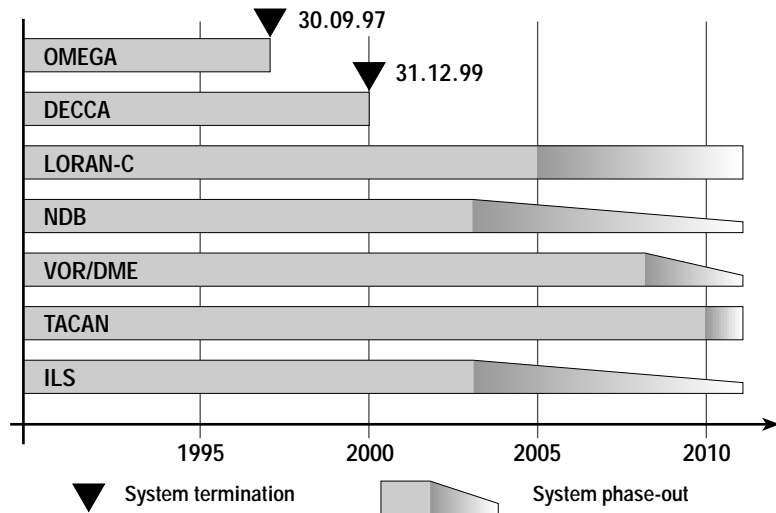


functionalities protected – even if the military which owns them decides they are not needed. The USA, by comparison, hopes to drop all its VORs progressively by 2010; to lose TACAN in 2005; and to have no DME after 2008.

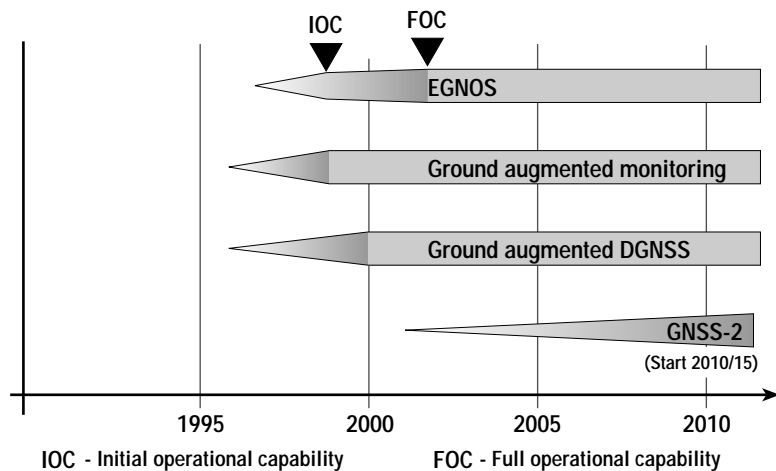
The position with the instrument landing system (ILS) is obviously contingent on how the precision approach debate evolves. But, for now at least, Germany proposes not to limit the use of Category I ILS before 2003, and will similarly protect Cat II/III use until 2010. Germany has 28 Cat II/III ILS installations and another 20 that are only Cat I. The microwave landing system (MLS) is seen only as a fallback “in cases of insufficient capacity and safety constraints”.

At the same time, Germany is moving towards implementing satellite-based systems. The DFNP, which is to be updated every two years, envisages “short-term and mid-term augmentation systems” leading to the so-called GNSS-2 under the control of civil authorities. The plan is vague about those systems, but it is worth noting that the BMV believes that it could be as far away as 2015. ■

System planning of radio navigation systems in Germany



German system planning for GNSS-1/2



Source: GERMAN MINISTRY OF TRANSPORT

British Aerospace picks AlliedSignal for 146 GPS Rnav kit...

Early next year British Aerospace should obtain certification for a GPS-based area navigation (Rnav) installation that will go a long way towards preparing its earlier BAe 146 regional jets for the airspace of the future. The company has chosen AlliedSignal's GNS-XLS system to equip 90 aircraft that it owns through its Asset Management-Jets (AM-J) leasing unit. A further 70 similar aircraft owned by customers are also candidates for the system if their operators are interested.

The result is that the entire range of Bae regional jets will either be equipped, or be eligible for avionics that will let them meet impending Rnav requirements and use GPS

as a substitute for Omega and other disappearing aids. BAe, like AlliedSignal, has virtually turned weird corporate nomenclature into a product differentiator, but the following is a summary of how the latest plan will leave the product range. The first 160 146s, all electromechanically equipped, can benefit directly from the new modification kit with the GNS-XLS, GPS antenna, and scanning DME. Those aircraft came with AlliedSignal's GNS-500 Omega as standard originally. AM-J director of business support, Phil Rogers, explains that the remaining 146s after aircraft number 160 were equipped with electronic flight instrument systems (EFIS) and came with the GNS-X Rnav as basic, also using Omega. Finally, the RJ70, RJ85 and RJ100 types, mostly sold under the Avro International Aerospace name, with their improved engines, interiors and cockpits came – and still do under the AI(R) name – with an updated GNS-X integrated with the inertial reference system, DME and other navigation sensors. The newest models have a more advanced dual installation. It should be noted that the GNS-XLS, despite its name, is not a multi-mode receiver and has no precision approach functionality. AlliedSignal has shipped some 500 units to other customers. →

...eyeing Australian and European needs

→ Rogers says AM-J was driven by two primary motivations. The first was to ensure that the 146, of which a large proportion are in Europe, would meet the January 1998 Eurocontrol mandate for basic Rnav (Brnav). Indeed, the selected system has an upgrade path to the Precision Rnav (Prnav) requirement due in 2005. But an almost equally important driver was the needs of operators in Australia, where the 146 has also done well, who have seen the demise of Australia's unique DME network followed by the forthcoming ending of Omega service. AM-J assistant chief of avionics engineering, Ken Haynes, says: "It all means that a lot of people there are going to lose their means of navigation. They were very reliant on Omega and so they are desperate for something." He notes that that has left Australia as a leading state in formulating GPS procedures. AM-J, he says, has got a launch customer for the new kit but it is not yet identifying it.

The company says the decision to select AlliedSignal was reasonably easy because of the vendor's history on the aircraft and it believes that, although other vendors are pushing alternatives, most customers will take advantage of the supplemental type certificate for the GNS-XLS kit. It is not quoting the sticker price publicly, but is confident that it will be highly competitive. Rogers indicates that the cost has to be attractive because retrofit customers pay it in full rather than having it hidden in the price as new aircraft customers do. That is one reason why the new RJ is getting a more sophisticated fit.

None of this is likely to do any harm to AlliedSignal's chances of supplying its multi-mode receiver to AM-J or AI(R) when the time comes (*ANI 2/20*). But Rogers insists that that is a different contest. He comments: "We have one or two customers worried about the situation in the UK and Europe. But the jury is still out on that and so we have separated that out. The RJ system has the FM-immune [ILS] modification in already." ■

SAS selects Honeywell TCAS 2000 for new 737s

Scandinavian Airlines System (SAS) has chosen Honeywell's new traffic alert and collision avoidance system (TCAS II) for its ordered fleet of Boeing 737-600s. The airline has 41 aircraft on firm order with options for another 35, and may also retrofit TCAS 2000 to its McDonnell Douglas MD-80 fleet. Honeywell says SAS is the second carrier to

order TCAS 2000 and, although the first is not identified, it appears to be British Airways (ANI 2/3). BA did not specifically say that its purchase was for TCAS 2000, but it did comment that the system's long range – the major differentiator of TCAS 2000 over Honeywell's earlier TCAS – was a key factor in its selection.

Honeywell says TCAS 2000 will track traffic "beyond 80nm", which would more or less double existing TCAS II-ranges. Its rivals are also offering that sort of performance in the near future although the implication of that range is that the system will be used for purposes other than traditional collision avoidance. BA, for example, explicitly says that it sees long-range TCAS as a way of adding en route situational awareness over Africa. For both carriers, the early availability of Honeywell's system is a key advantage. Certification is due in June 1997, allowing a comfortable schedule to meet the European TCAS-equipment deadline of 1 January 2000. Honeywell is playing hard on that factor, with manager of international marketing, Tom Henderson, declaring that it has "a head start on the competition for the enhanced TCAS design".

All three TCAS II vendors – Honeywell, Collins and AlliedSignal – are furiously working to position themselves to take advantage of the system's role in the various iterations of "free flight" now emerging. The fact remains, however, that TCAS' role in that kind of operation is far from clear. AlliedSignal (ANI 2/15) describes TCAS and automatic dependent surveillance-broadcast (ADS-B) as "complementary". It talks of using TCAS to "verify" ADS-B information, while ADS-B's tracking of surrounding traffic could be used to reduce the need for TCAS interrogations and, particularly, for issuing resolution advisories (RA) against traffic with adequate horizontal separation.

Collins, which is promising 100nm range soon, says the simple fact that TCAS is already going on aircraft for safety reasons means that it makes overwhelming sense to also use it for situational awareness. It stresses that the extended range that it is offering is largely at the insistence of the market. It is noticeable, however, that Collins is rather less definite than its rivals in sketching the eventual role of TCAS in free flight – and it may well be that that is the most honest position at a time when the free flight concept is itself so vague.

In announcing the SAS deal, Honeywell's Henderson says: "The new TCAS will support the anticipated growth in airborne collision avoidance systems in the future air traffic environment. With future operations revolving CNS/ATM, TCAS 2000 will become a necessary aid for enhanced visibility in traffic separation." He suggests that the system "could play a vital role" in reducing oceanic separations. And he explicitly states that "one of the key anticipated updates is ADS-B" with benefits "in congested terminal areas and for parallel approach runways". ■

Thomson takes majority holding in ATM joint venture with Siemens

Thomson CSF of France and Siemens of Germany are to pool all their air traffic management (ATM) activities in a joint venture in which the French company will have a 60% share. A final deal is expected to be concluded within the next few months. The arrangement provides a solution to Siemens' difficulties in getting its ATM unit into profit, and bolsters Thomson's business following its purchase by France's Lagardere Group.

A letter to Siemens employees from its group management says approaches were made to "a number of companies" regarding possible joint ventures and Thomson offered the best way forward. The new venture will include all the ATM activities of Thomson in France, the USA and Australia; as well as all Siemens' ATM business in the

UK, Germany, and the USA. The letter says that the deal will create the "number one ATM supplier in Europe and number two worldwide" with a turnover of about £350 million with 1,700 staff. Primary business sectors involved are: radars and navigation aids; advanced ATC centres based on Eurocontrol standards; CNS products; and airport projects.

Thomson's majority share, details the letter, arises because the French company will contribute "50% more business volume and resources". Siemens will hold 40%, but "overall management control will reside with Thomson CSF". The venture is to be launched in "spring 1997". The two companies have collaborated on ATM projects before, for example on the Operator Input and Display System for Eurocontrol. ■

Horizon leads growing interest in advanced nav systems for regionals

Horizon Air of Seattle is the latest carrier to commit to one of the advanced navigation kits which are rapidly becoming the norm on new regional aircraft. The airline is to fit Universal Avionics Systems' UNS-1C flight management system to 25 Bombardier De Havilland Dash 8 turboprops on order for delivery from February next year. The aircraft will also have Universal's GLS-1250 GPS landing systems and UniLink UL600 data-links. Banner Aerospace of Austin, Texas is performing the installations. The UNS-1 is also being tried out on a British Aerospace BAe 146 of Malmo Aviation in Sweden. Meanwhile, ARINC and the Mitre Corporation have demonstrated free flight concepts on a Cessna 401 twin-prop using ARINC's CNS-12 GPS/data-link equipment; and Aeronautical Radio of Thailand (Aerothai) has bought three CNS-12s for VHF automatic dependent surveillance trials. ■

NEWS IN BRIEF**FAA/NASA research ATM**

NASA and the US FAA have drawn up a joint plan to integrate air traffic management research with an emphasis on improvements that could be implemented within 10 years.

Key areas of the integrated plan include: roles of crews and controllers; integration of flight-decks and ATC; cockpit situation awareness on the ground and in the air particularly using TCAS and ADS-B; conflict detection and resolution; the minimisation of flight restriction; simulation and safety analysis; general aviation and military operations; and cost-benefit assessments. The announcement does not mention "free flight" by name, but most of the technology areas covered lead in that direction.

GPS supplemental approvals

Costa Rica, Mexico and Panama have approved GPS as a supplemental navigation aid, taking the total of countries to 17, with three more in process.

Collins in Chinese GPS link

Rockwell Collins has reached agreement with Shanghai Avionics Corporation and Shanghai Broadcast Equipment Factory to "design, develop, and build" commercial GPS receiver systems. A limited liability joint venture called Shanghai Collins Navigation and Communications Equipment Company Ltd is being formed. It is not clear whether the GPS will be of aviation standard.

DIARY

4 December, US ATC Association, Operations Symposium. Arlington, Virginia, USA.

Contact: Carol Newmaster, tel: +1 703 522 5717; fax: +1 703 527 7251.

14-16 January, US Institute of Navigation National Technical Meeting, Santa Monica, California. Contact: Jennifer Murphy-Smith, tel: +1 703 683 7101, fax: +1 703 683 7105.

25-27 February, ATC '97 conference and exhibition, Maastricht, Netherlands. Contact: Donna Bushell, tel: +44 181 302 8585, fax: +44 181 302 7205.

16-17 January, Civil Avionics Conference and Exhibition, London-Heathrow. Contact Shephard Conferences, tel: +44 1628 604764, fax: +44 1628 664075.



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