THE FIRST 50 YEARS

John E. Green

ICAS President 1996 - 1998

Ladies and Gentlemen, this is the 26th ICAS Congress. The first Congress was held in Madrid in 1958. It ran from 8 to 13 September, closing fifty years and one day before this Congress opened in Anchorage on Sunday. The Final Programme booklet for the present congress includes a short account of the history of ICAS to date. Fred Sterk, who was the Executive Secretary of ICAS from 1990 to 1998, has written a much fuller account which will shortly be published on the ICAS web site and in book form. Today, I will give you my own perspective on these fifty years.

ICAS was the brainchild of two great men, Harry Guggenheim and Theodore von Kármán.

The Fathers of ICAS

Harry F. Guggenheim

Theodore von Kármán

Photos courtesy of the Daniel and Florence Guggenheim Foundation Collection, National Air and Space Museum and the von Kármán Institute

In 1956 they conceived the idea of bringing together, at regular intervals, all the scientific bodies of the aeronautical world to discuss common problems “without regard to immediate military or political interest”. At that time, it was a bold – you might even say crazy – idea.

Most of you were not yet born in 1956. I was in my first year at university. It was 11 years after the end of World War II, deep in the so called Cold War. It was a time of great distrust between the powers of NATO and the Warsaw Pact. Each side had developed massive nuclear strike capability based on their fleets of long-range bombers.

1956

A world in tension

There was said to be a strategic balance but we all lived under the shadow of a possible third world war and the destruction of most life on earth that would follow. In the period from October 1956 to January 1957 there were crises in Suez and Hungary and the fear of World War III was probably the highest that it had ever been until then. It was during this time that representatives of the aeronautical societies of nine countries received letters inviting them to New York to consider the idea – the crazy idea – of a regular international congress on aeronautics that would be open to all nations.

Let me say something about the two men who began it all.

Harry Frank Guggenheim was a distinguished industrialist and philanthropist. He was born in New Jersey in 1890. His grandfather, Meyer Guggenheim, had emigrated from Switzerland to America at the age of 19 in 1847 and, with the assistance of his seven sons, had built an industrial dynasty in mining, smelting and refining. Harry was educated at Yale and Cambridge, spent his early postgraduate years in the copper mining industry, served as a pilot in World War I, was the American ambassador to Cuba from 1929 to 1933, founded a New York newspaper, bred racehorses and, amongst other things, from 1929 to 1938 was a member of the National Advisory Council for Aeronautics, NACA – now NASA.

Harry Frank Guggenheim, 1890 - 1971

- •Yale and Cambridge
- •Copper mining
- •WWI seaplane pilot
- •US Ambassador to Cuba 1929 - 33
- •Served on NACA 1929 – 38
- •Managed Daniel Guggenheim Fund for Aeronautics and in 1926, gave grants to Aeronautics Schools at
  New York, Caltech,
  Stanford, Michigan,
  MIT, Washington,
  Georgia Tech
- •supported Lindberg and Goddard
- •In 1926 founded GALCIT and in 1930 recruited von Kármán to be its director

Aviation was his great interest. From 1924 onwards, through the funds of the Daniel and Florence Guggenheim Foundation (named after his parents) and the Daniel Guggenheim Fund for the Promotion of Aeronautics, he supported a wide range of aeronautical activity in the USA. In 1926, the Daniel Guggenheim Fund made substantial grants to seven universities to establish aeronautical engineering schools and laboratories. This had a fundamental impact on the development of American aviation. By 1940, the graduates from these schools – at New York, Caltech, Stanford, Michigan, MIT, Washington and Georgia Tech – provided most of the aeronautical engineering research, design and management capability in the USA. Today, many of you in this audience are graduates of one of these schools. Harry Guggenheim also supported many research projects and pioneers such as Lindberg and Goddard. In particular, in 1926 he established the Guggenheim Aeronautical Laboratory as a research institute to sit alongside the Daniel Guggenheim School of Aeronautics at Caltech and in 1930 he recruited Theodore von Kármán from Germany to be its director.

Theodore von Kármán was one of the giants of aeronautics in the 20th century. He was born in Budapest in 1881 and studied mechanical engineering at the city's Royal Technical University, graduating in 1902. In 1906 he went to study under Ludwig Prandtl at the University of Göttingen, received his PhD in 1908 and continued research and teaching there until 1912. In 1913 he moved to Aachen to become director of the Aeronautical Institute of the RWTH, the Technical University, and stayed there until 1930. In that year he moved to the United States to become the director of the Guggenheim Aeronautical Laboratory at Caltech.

Theodore von Kármán, 1881 - 1963

One of the great aeronautical scientists of the 20th Century

Royal Technical University, Budapest

Göttingen University under Prandtl

Director Aeronautical Institute, RWTH Aachen

Director Guggenheim Aeronautical Laboratory, California Inst Technology

Co-founder and director of Jet Propulsion Laboratory

Proposer and Chairman of AGARD

Proposer and Chairman of NATO postgraduate school in Brussels, now the von Kármán Institute for Fluid Dynamics

Over the next thirty years his achievements were exceptional – as a teacher, leader of research, government advisor and promoter of international collaboration. He founded the Jet Propulsion Laboratory in 1944, persuaded NATO in 1952 to found its Advisory Group for Aeronautical Research and Development (AGARD) and then, as Chairman of AGARD, persuaded the Belgian Government to establish a centre – now named the von Kármán Institute – devoted to training and research in aerodynamics for young engineers and scientists of the NATO countries. He was a long standing colleague and friend of Harry Guggenheim.

In 1956, Harry Guggenheim had sold the Guggenheim Estate on Long Island and gifted the funds to the IAS (the Institute of the Aeronautical Sciences, now the AIAA). He suggested that the funds be used to support a programme of congresses in the aeronautical sciences, open to all nations with a contribution to make.

Guggenheim Estate, Sands Point, Long Island

- Sold by Harry Guggenheim to US Government
- Proceeds gifted to IAS (Institute of Aeronautical Sciences, now AIAA)
- Funds to be used to support programme of international conferences
- Conferences to be open to all countries “without regard to immediate military or political interest”
- International meeting to discuss during IAS Annual Meeting
- von Kármán to chair

To take the idea forward, he suggested inviting a group of international scientists to come to New York, at the time of the IAS Annual Meeting, to discuss the possibilities. The meeting would be chaired by von Kármán who, at that time, at the age of 75, was Chairman of AGARD.

The meeting was held, over dinner, on January 29 1957. There were representatives from nine counties there and the meeting lasted five hours. Harry Guggenheim said that he wanted the fund to be used "with a pioneering intent", possibly in the form of an international congress. He felt that, "we should be looking 100 years ahead and not on a short term basis".

1st ICAS meeting, 29 January 1957 in New York, 5 hours over dinner

- 9 countries represented
- International Conference, open to all, every 2 years
- Harry Guggenheim…..the fund to be used "with pioneering intent"…… "we should be looking 100 years ahead and not on a short term basis"
- von Kármán…… every Congress to include a survey research lecture on the state of the art, to be known as the "Daniel and Florence Guggenheim Lecture"
- After the meeting, the proceeds of selling the estate on Long Island became "The Daniel and Florence Guggenheim Memorial Fund for the Promotion of International Cooperation in the Aeronautical Sciences"

By the end of the meeting the general principles had been agreed and von Kármán had proposed a meeting in Paris four months later to take the project forward. On his recommendation, it was agreed that every congress would have a research survey lecture to be known as the "Daniel and Florence Guggenheim Lecture" in honour of Harry's parents.

A second meeting was held in Paris in May 1957. This time there were representatives from 10 counties. They revised and then adopted a document, drafted shortly after the first meeting, which was in effect an outline constitution. This declared as its purpose:

"The establishment of an International Council of the Aeronautical Sciences whose objective is to encourage free interchange of information in areas which have a bearing on the advancement of knowledge in all phases of mechanical flight."

On participation, it said:

"The organized national associations of the world dedicated to the advancement of aeronautical sciences, technology and engineering shall be eligible to participate, subject to the approval of the Council."

The main activity would be to organise an International Congress every two years. The decision on the location of future congresses would be made by the Council. The first congress would be held in Spain, in Madrid, in September 1958.

2nd ICAS meeting, Paris, May 1957

- 10 countries represented
- Agreed “The establishment of an International Council of the Aeronautical Sciences”
- Open to “The organised national associations of the world dedicated to the advancement of aeronautical sciences, technology and engineering”
- Council – one member and one vote per country – main task to organise two-yearly Congress.
- First Congress to be in Madrid in September 1958
- National representatives present in Paris to constitute “Provisional Council”

The Council would be made up of one representative from each of the participating organisations – that is, from each member country – and each member country would have one vote. It was decided that those present in Paris would constitute a Provisional Council. Theodore von Kármán was elected Honorary President and a permanent member of the Council in his own right, i.e. not representing any country.

Provisional Council, May 1957

A M Ballantine	UK
H Blenk	Germany
H Dryden	USA
G de Faget	France
G Gabrielli	Italy
J J Green	Canada
R Greinacher	Switzerland
J Jarry	France
S Paul Johnston	USA
E T Jones	UK
Th von Kármán	Hon President
Bo K O Lundberg	Sweden
A J van der Maas	Netherlands
A Perez-Marin	Spain
Maurice Roy	France
Frank L Wattendorf	USA

And so the first ICAS Congress was held in Madrid, 50 years and a week ago. There were about 500 delegates there. Those who crossed the Atlantic to be there came either by ship or by piston-engined aircraft. Both were available – the ship took longer but was perhaps more reliable.

1st ICAS meetings

Transatlantic travel options

There were delegates from 23 countries at the congress and 44 invited papers were given. The congress opened with the Daniel and Florence Guggenheim International Memorial Lecture given by Theodore von Kármán. His subject was “Some significant developments in aerodynamics since 1946”. He received a modest honorarium, as have all Guggenheim lecturers since.

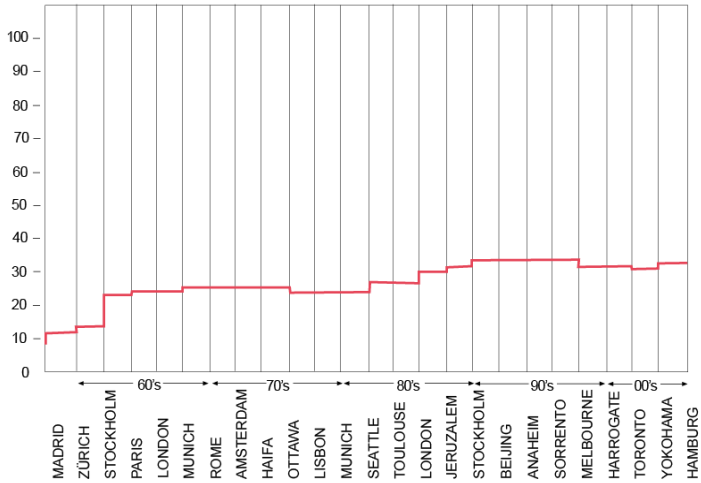
1st ICAS Congress
Madrid 8 – 13 September 1958

- Delegates from 23 countries
- 44 invited papers
- Opened with Daniel and Florence Guggenheim Lecture by von Kármán on “Some significant developments in aerodynamics since 1946”
- New members:
  - Russia, Japan
  - Poland, Belgium
- Under consideration
  - Hungary, Brazil

By the time of the Council meeting at the first congress, four new countries had joined ICAS – Russia, Japan, Poland and Belgium – and two countries – Hungary and Brazil – were under consideration.

Over the next few congresses the number of member countries in ICAS grew steadily and has been approximately 30 for the past 40 years.

ICAS membership 1958 - 2006



The ICAS Congress was not the only important innovation in the autumn of 1958. Less than a month after the congress opened, on 4 October, the first scheduled passenger jet service across the Atlantic was inaugurated with BOAC flying the Comet 4 from London to New York via Gander. Within the same month, on 29 October, Pan American inaugurated its service from New York to Paris, also with a refuelling stop at Gander. ICAS and the age of transatlantic jet travel are twins.

1st Congress
8 – 13 September 1958

4 October 1958

BOAC Inaugurates
London – Gander - New York with
Comet 4

29 October 1958

Pan-Am Inaugurates
New York – Gander - Paris
with Boeing 707

The first congress was held in a 'neutral' country, Spain, which did not join NATO until 1982, and the second and third were also in neutral countries, Switzerland (Zurich) in 1960 and Sweden (Stockholm) in 1962. Von Kármán's called these his three S's. Since then, congresses have been held all over the world. From the beginning, the pattern was established of holding the congress either the week before or the week after the SBAC air show in Farnborough, which was always the

first week in September. For congresses in Europe, this pattern remained unchanged until 2000, when the Farnborough show was moved to July but the ICAS Congress stayed in September.

At the first congress, simultaneous translation was available into four languages – English, German, French and Spanish – but this was expensive and from 1974 onwards all lectures were in English – in what von Kármán had called "bad English – the language of the engineers." We might also say the language of international collaboration.

Languages

1958	Simultaneous translation into: Spanish, French, German, English
1960 – 1970	Simultaneous translation into: French, German, English
1972	No translation papers given in English and French
From 1974	No translation, all papers given in English

von Kármán: "Bad English is the language of the Engineers"
- and of international collaboration too**!**

At the first meeting in January 1957, von Kármán had envisaged that the second meeting, in Paris in May 1957, would "consolidate ideas, adopt a constitution and by-laws, establish operating procedures and confirm dates and places for further meetings." Not all of these were achieved in Paris.

Constitution

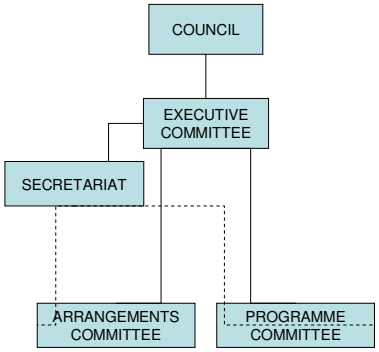
- All the key principles agreed in January 1957 but never converted into formal constitution
- First written constitution agreed by all members in 1975 but already put into effect at 1974 congress
- Revised constitution adopted in 1985
- New constitution adopted in 1995 establishing ICAS as a legal entity under Dutch Law

In fact, ICAS managed to operate successfully without a written constitution and by-laws for its first 18 years – its first constitution was adopted by the Council, after a postal ballot, in July 1975, this was revised in 1985 and finally, in 1995, ICAS was established as a legal entity under Dutch Law.

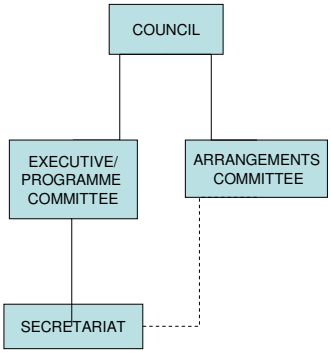
At the May 1957 meeting a committee structure was adopted with the Council as the top body. Under this would be an executive committee and under the executive committee would be two committees, a programme committee and an arrangements committee. Their respective tasks would be to determine the technical content of the congress and the administrative and social arrangements for it. The Secretariat would respond to the executive committee and service both the programme and arrangements committees.

Having adopted this three-committee structure, the council immediately chose a more practical, two-committee alternative which it kept for four congresses.

STRUCTURE
PROPOSED MAY 1957

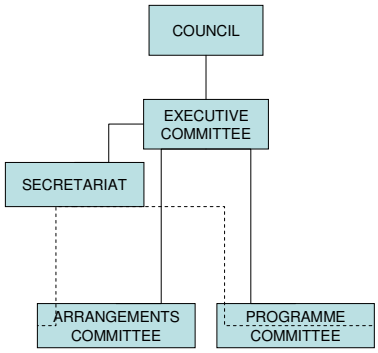


STRUCTURE ADOPTED
MAY 1957 – SEPT 1964

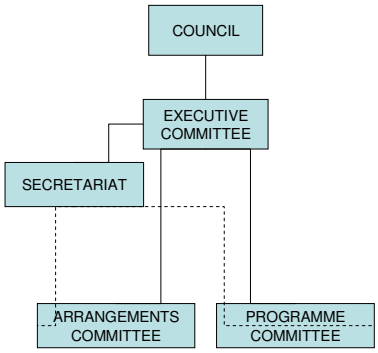


At the 1964 congress it reverted to its original plan, which it kept for two congresses.

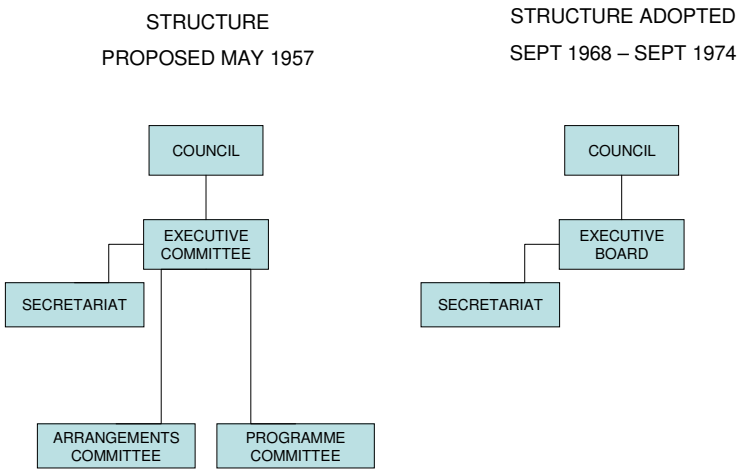
STRUCTURE
PROPOSED MAY 1957



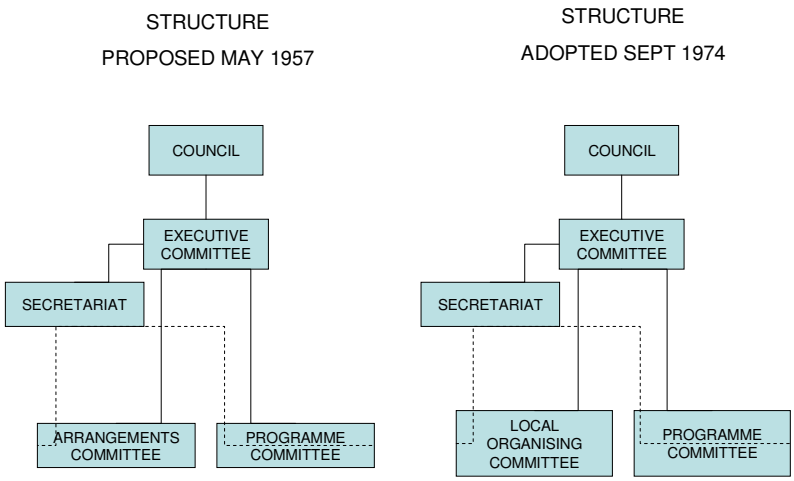
STRUCTURE ADOPTED
SEPT 1964 – SEPT 1968



In 1968 it rolled all three committees into one.



Finally, on the adoption of a formal constitution, it returned to the structure agreed in May 1957, but with the Arrangements Committee called the Local Organising Committee. This structure has now remained unchanged for 34 years.



The papers at the first Congresses were all invited. In the early days, the Council debated what topics to include in the next congress and the Programme Committee then invited appropriate speakers. There were 44 papers at the first congress and an average of around 55 for the first ten, presented in two or three parallel sessions.

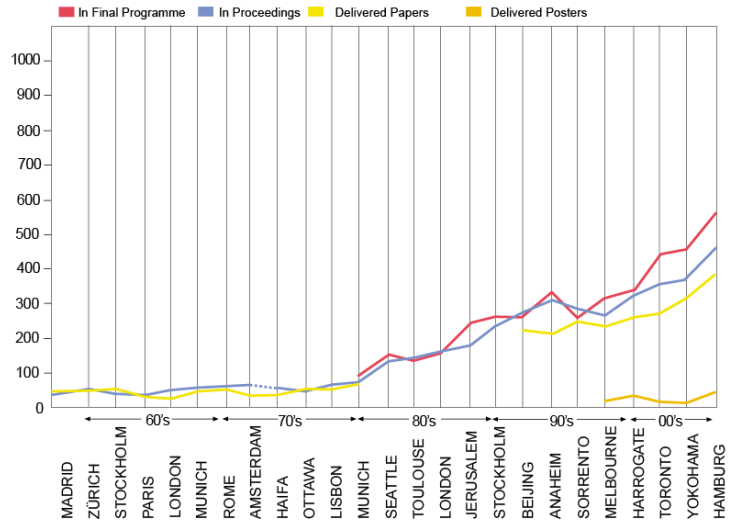
It was the concept of von Kármán, Maurice Roy and the other founding members that the ICAS Congress should be limited to invited papers in order to maintain its high quality. In 1976, however, and after an intense debate, the Council agreed to ICAS issuing a call for papers for the 1978 congress.

This was the first step in a process of transformation in the character and scale of the ICAS Congress. Since the last 'all-invited' congress in 1976, with 59 papers, the number of papers has increased by an order of magnitude.

Growth of the Congress

- Early congresses, all papers invited
- 44 papers at first congress
- Average around 55 for first ten congresses
- 1976, after intense debate in Council, decision to issue Call for Papers
- First step in changing character and scale on the ICAS Congress

Congress papers 1958 - 2006



With the change to a call for papers, the number of specialised papers increased and the average age of the presenters decreased. The congress became increasingly a place where young scientists and engineers had the opportunity not only to hear papers by the leading figures in their field but also to meet and discuss technical matters with them and to give papers in front of them. A special session for papers by students was introduced at the congress in London in 1986.

In 1990, in Stockholm, a prize was given for the best student paper. The prize was donated by Mrs Camille McCarthy in honour of her late husband, John McCarthy, who had served on the Programme Committee for many years. At every congress since Stockholm two McCarthy Awards have been made, for the best and second best student papers. Initially, there were separate sessions for the student papers but, in response to a plea from young delegates, student papers were embedded within the main programme at the Toronto Congress in 2002 and at every congress since.

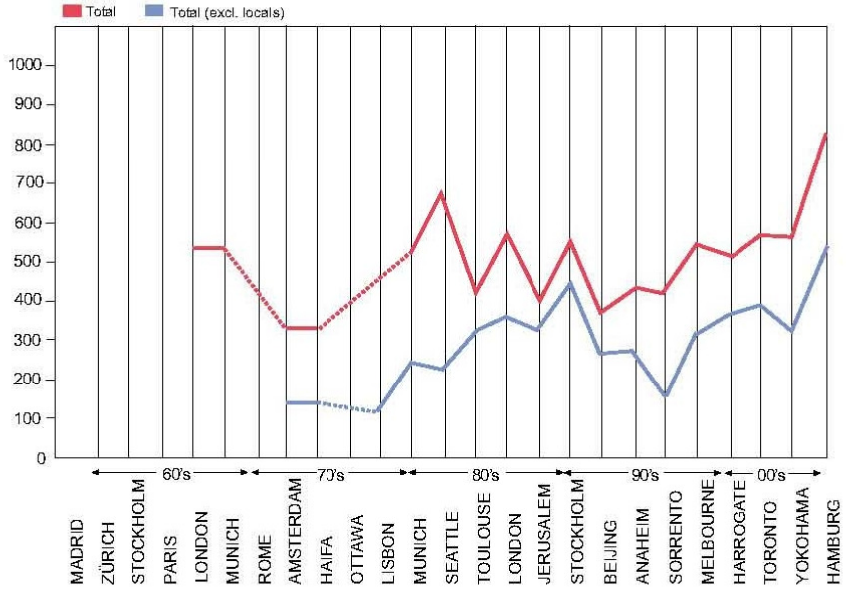
The programme booklets for the congresses in 2002 and 2004 identified the embedded student papers but this has not been done since. In 2006, after twenty years of evolution, the treatment by ICAS of student papers reached full maturity in the recognition that a good student paper can stand squarely alongside papers by older colleagues without any apology.

Younger scientists, engineers and students

- Following introduction of Call for Papers and growth in number of papers, average age of delegates reduced.
- First student sessions introduced in 1986
- McCarthy Student Award first presented 1990
- Student papers embedded within main programme from 2002 onwards, but identified
- Student papers treated on same footing as other submissions from 2006 – status not shown in programme

The attendance at the congress fluctuated around 500 for the first 46 years but increased sharply for the 2006 congress in Hamburg and is likely to be high again for this joint congress in Anchorage.

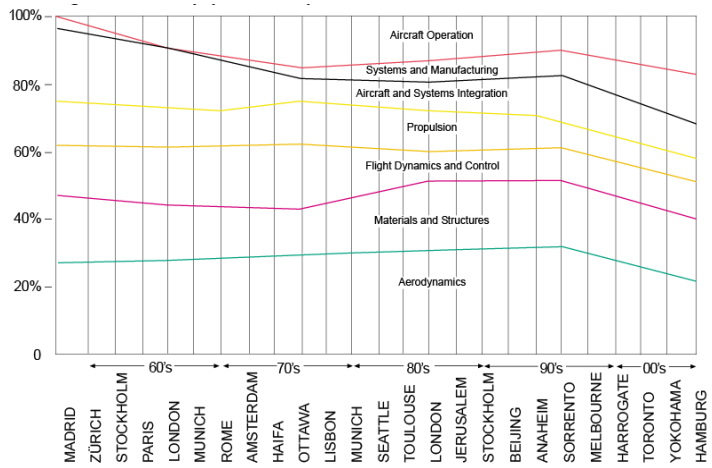
Delegates 1958 - 2006



In the early years, a higher proportion of the delegates appear to have been from the host country, though the data before 1980 is patchy. Also, at the first congress, less than 10% of the delegates came to present papers and the ratio of delegates to papers remained high through into the mid 1970s. There was a downward trend in the number of observers through the 70s and 80s, offset by the steady rise in the number of papers, made possible by the introduction of the Call for Papers, and the overall attendance at the congress remained fairly steady until its recent increase.

Over the life of ICAS, the proportion of papers in particular disciplines has not varied greatly. The basic disciplines – aerodynamics, materials and structures, propulsion, flight dynamics and control – have dominated the programme. Aerodynamics – the subject of von Kármán's Guggenheim

Distribution of papers by topic area



Lecture that opened the first Congress – has always had more papers than any other topic. There has been a steady growth in the areas of aircraft operations and in systems and manufacturing, from a low base in 1958 to nearly one third of the programme in 2006.

If we consider project themes rather than scientific disciplines, the picture is a little different.

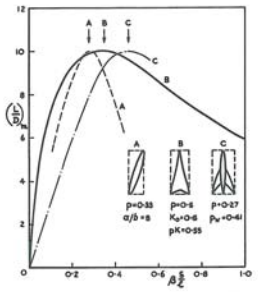


FIG. 7. LIFT – DRAG RATIOS OF THREE CONFIGURATIONS AT M = 2.

The Supersonic Debate

2nd Congress 1960

D Küchemann

Aircraft shapes and their aerodynamics for flight at supersonic speeds

3rd Congress 1962

Bo Lundberg (Guggenheim Lecturer)

Speed and safety in civil aviation

Bo Lundberg, from the floor, addressing von Kármán, at the podium

In the early congresses, the possibility of supersonic air travel was a very big theme. At the second congress in 1960, Küchemann of the Royal Aircraft Establishment gave a seminal paper on aircraft shapes for flight at supersonic speeds. He concentrated on flight at around Mach 2.0

and concluded that the slender wing – planform B on the chart – is a natural solution for supersonic aircraft. A similar planform was finally used on Concorde.

At the third ICAS congress, in Stockholm in 1962, the Swedish member of the ICAS Council, Bo Lundberg, who had been present at the founding meeting in January 1957, opened the Congress with the Guggenheim Lecture. Its title was “Speed and Safety in Civil Aviation” and it marked the beginning of a campaign by Lundberg of opposition to supersonic air travel, on environmental and economic grounds. He kept up his campaign for more than a decade, with a further controversial paper to the eighth Congress in Amsterdam in 1972.

However, by the third Congress the die was almost cast. A mock-up of the as yet unnamed Anglo-French design was shown at the Farnborough Air Show in the week adjacent to the congress and in November 1962 Britain and France signed the treaty committing them to the project. In June of the following year, President Kennedy launched the National Supersonic Transport programme and in July the Soviet Council of Ministers approved the launch of the Tupolev 144 project.

In the United States there were two candidate aircraft designs, the Lockheed L-2000 and the Boeing B2707. In December 1966 the Lockheed design was dropped and the Boeing design chosen for further government funding. This was stopped however in 1971 and the programme terminated with two prototypes partly built.

Tu 144 first flight 31 December 1968
Passenger service Nov 1977 – June 1978

Lockheed L-2000

De-selected
December 1966

B2707

Cancelled
March 1971

The Supersonic Adventure

Concorde first flight 2 March 1969
Passenger service Jan 1976 Oct 2003

Meanwhile, the Tu-144 had had its first flight on 31 December 1968 and the Concorde flew two months later on 2 March 1969. The Tu-144 had a troubled existence, with two fatal crashes, and its passenger carrying service was limited to about eight months between 1977 and 78. The

Concorde went into airline service in January 1976 and was withdrawn from service 27 years later in October 2003. That marks the end of an era. There will probably not be a return to scheduled supersonic air travel on a regular airline within the lifetime of most of us here.

Another prominent theme in the early congresses was powered lift, both STOL and VTOL, with the aim of developing fast, efficient transport aircraft that could use city centre airports. There was also a military interest in STOL and VTOL transport aircraft and, besides scientific and engineering studies, a number of prototype aircraft were built. In the end, noise and economics killed the idea of powered STOL or VTOL for civil city centre transport aircraft and so far only the V-22 Osprey, a military tilt-rotor transport, has been put into production.

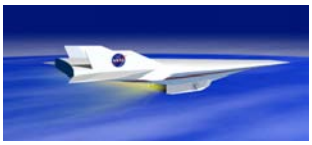
VTOL, STOL and STOVL

VTOL for combat aircraft was used effectively for the Harrier, which entered service in the Royal Air Force in 1969 and which, as the second generation Harrier II, is still in service today with the RAF, the US Marine Corps and the Italian and Spanish navies. The F-35B variant of the Joint Strike Fighter, which is now in its flight development in the United States, is a STOVL aircraft. STOVL stands for short take-off, vertical land, which studies have shown to give a much more effective combat aircraft than one with full VTOL capability.

There were many papers on hypersonics in the early congresses. In fact, the rocket-powered X-15 research aircraft was rolled out for NASA in October 1958, in the month after the first ICAS Congress. During its nine year career it achieved a maximum Mach number of 6.7. More recently, the smaller unmanned aircraft, the X-43A, with air-breathing scramjet propulsion, flew at Mach 9.6.

The Hypersonic Adventure

X-15 rocket powered
1959-1968, Mach 6.7



X-43A scramjet
2004, Mach 9.6

Space Shuttle Endeavour
Landing at NASA Dryden
June 2002

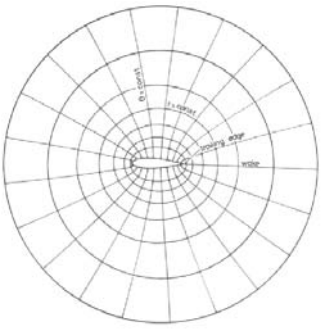
Although the idea of hypersonic travel between continents was a feature of early congresses, and still comes up from time to time, the only important application of the technology so far has been the Space Shuttle.

The greatest advance in theoretical aerodynamics through the life of ICAS has been the development of computational fluid dynamics, CFD. The primary driver was the need for better design methods for aircraft flying at high subsonic speeds, with transonic flow about the wings. In 1966, Nieuwland of NLR gave a paper showing the design of a shock-free aerofoil at transonic conditions. This was a rather specialised approach but in the early 1970s finite-difference methods began to emerge. Given sufficient computing power, these could yield solutions for transonic flow about more general aerofoils and also about wing-body combinations.

Evolution of transonic aerodynamics and CFD

1966 Nieuwland: Shock-free transonic aerofoils

1974 Hall and Firmin: Transonic flow about wing-body by finite-difference methods



Classical CFD aerofoil grid
Typically 5,000 grid points

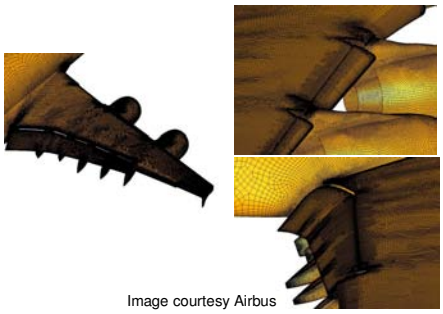


Image courtesy Airbus

Surface mesh for modern RANS computation
Typically 50 million flowfield grid points

The number of papers on CFD has grown steadily and today accounts for about a fifth of the papers on aerodynamics. The power of CFD has advanced tremendously and it is now the key aerodynamic design tool for the industry. As the slide shows, the number of grid points used in a computation has increased from typically 5,000 for a calculation of transonic potential flow about an aerofoil to 50 million for a Reynolds-Averaged Navier-Stokes solution about a complete aircraft – an increase by a factor of 10,000.

Although CFD has made great strides, wind tunnels are still needed. In the 1960s there were a number of serious discrepancies between wind tunnel predictions and the actual aerodynamics of prototype aircraft, some of which nearly led to cancellation of the project. The Lockheed C-141, which first flew in 1963, was the most celebrated but not the only example. The discrepancies were attributed to the difference in Reynolds Number between wind tunnel and flight. In response to the growing concern, in 1971 AGARD established the Large Wind Tunnels Group which played a key part in studies for new high Reynolds number wind tunnels, both low speed and transonic.

A number of major wind tunnel projects were launched and by the time of the 1978 Congress papers could be given on all of them, preceded by a Guggenheim Lecture by Ronald Smelt of the USA on the Role of Wind Tunnels in Future Aircraft Development.

Subsonic and transonic scale effects and wind tunnels

1963 C-141 tunnel – flight discrepancy

1971 AGARD Formation of Large Windtunnels Group

ICAS Congress 1978

Smelt (Guggenheim Lecturer)
The Role of Wind Tunnels in Future Aircraft Development

Papers on:

RAE	5m x 3atm low speed tunnel
ONERA	F1 4m x 4atm low speed tunnel
DFVLR/NLR	Large Low-speed Tunnel (LLT)
NASA	NTF cryogenic transonic tunnel
Europe	ETW cryogenic transonic wind tunnel

Britain and France were by then both building large, pressurised low speed tunnels, NASA was building the National Transonic facility, the NTF, which is a pressurised, cryogenic tunnel, Germany and the Netherlands were building the largest un-pressurised low speed tunnel in Europe, the DNW, and four European countries were jointly working towards the European Transonic Wind Tunnel (ETW) which, like the NTF, is a cryogenic pressurised facility. There has been no comparable surge in investment in wind tunnel facilities since the great period of wind tunnel building in the 1940s and 50s.

Several other important themes have continued throughout or emerged during the life of ICAS, too many to discuss in depth but many of them noted on this slide.

Other major themes

- Composite materials
- Structural analysis and design
- Structural dynamics and aeroelasticity
- Fatigue and fracture
- Flight control – fly by wire
- Air traffic management
- Safety
- Human factors
- Noise
- UAVs
- Climate change

I shall just highlight composite materials, which burst upon the scene with five papers at the eighth congress in Amsterdam in 1972 and which now always features in the congress programme, and also climate change, a relatively new topic that I expect to become increasingly prominent in coming years.

International collaboration was first taken as a subject at the fifth Congress in London in 1966. Sir George Edwards, who was then Chairman of the British Aircraft Corporation, gave a lecture on Anglo-French collaboration in the Concorde project. There were further papers on collaborative projects in later congresses and in 1972 ICAS created the von Kármán Award for International Cooperation in Aeronautics. The first recipient was the three-nation Tornado project.

1982 Tornado

The ICAS von Kármán Award for International Cooperation in Aeronautics

1984 Airbus Industries	1996 V 2500 engine
1986 B 767 program	1998 Bombardier Global Express
1988 Intnl vortex flow	2000 HYPR project
1990 CFM 56 engine	2002 F/A-18 Improvement prog
1992 CN-235 aircraft	2003 X-31 Vector project
1994 ETW	2004 GARTEUR

2006 A380

2008 B787

Since then the Award has gone to a variety of aircraft and engine projects, research and demonstrator programmes, the European Transonic Wind Tunnel already mentioned and the wide ranging European co-operative research activity, GARTEUR. The two most recent winners of the Award are the Airbus A380 in 2006 and the Boeing B787 at this Congress.

Which brings me to my last slide, and I shall go back to Concorde, which I believe is the greatest and most important collaborative project in aviation history. Greatest, because Concorde is one of aviation's greatest technical achievements and because, at the time it was launched, the British and French companies were fiercely independent, did not speak each other's language very well and had no experience of collaboration on such a large and technically challenging project.

But they made it work, communicating with each other in bad French and bad English, as von Kármán would have put it. The British drawings were in feet and inches, the French in metric units, with both units shown on interface drawings. The only disagreement which lasted for any time was whether or not Concorde should be spelt with an e on the end. At the roll out of the first prototype, the British government minister conceded to the French on this and Concorde with an e was fully established.

I believe it is the most important collaborative project in aviation history because of its profound influence on aviation today and in the future. The era of supersonic passenger flights has gone, possibly for ever, but the era of international projects is with us to stay.

With Concorde, Britain and France learned that two countries could work together successfully on a major project. The Airbus A300B project followed. I think it is very unlikely that Airbus would have happened without the example of Concorde. Without Concorde, no Airbus. Without Airbus, no effective challenge to the United States monopoly on civil aircraft manufacture. What has now

evolved is a world in which two major companies, one in Europe and one in the USA, compete fiercely for the custom of the world's airlines. The competition improves the products of both and, although the aircraft carry the names of Boeing and Airbus, they are each the fruits of worldwide design and manufacturing effort. They are the products of international collaboration, mostly conducted in English, sometimes bad, but not as bad as it used to be in von Kármán's day, and they are the shape of the future. Over the past 50 years, ICAS has played a valuable role in fostering exchange between the aeronautical scientists and engineers of the world. Over the next 50 years, I believe it has the potential to play an even more valuable role and to fulfil Harry Guggenheim's 100 year vision. Thank you for your attention.