

## FOREWORD

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Taking the opportunity of the International Astronautical Federation Annual Meeting in Melbourne (Australia) from September 28 to October 2, 1998, the Advanced Propulsion Working Group of the International Academy of Astronautics (IAA/APWG) organized :

- two preparatory meetings (Sept. 29 and 30, 1998)

- a special "open" session on October 2, 1998 morning included in the IAF Congress presenting the status of the findings from the APWG,

- the third IAA/APWG Workshop on October 2, 1998 afternoon.

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## CONTENT

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1. [Minute of the first IAA/APWG session](#) of the International Astronautical Congress

(Session IAA-3.3: "Cooperation and Competition in Space Propulsion")

2. [Minute of IAA/APWG Workshop #3](#) held on October 2, 1998

Room Bellarine 1 - Melbourne Convention Center

3. [Summary of actions](#)

ANNEXES: *not yet available*

A-I Minute of IAA/APWG preparation meeting #1 held in Melbourne,

Room Ortway #1 on September 29, 1998 - 7:00 pm

A-II Minute of IAA/APWG preparation meeting #2 held in Melbourne,

Room Ortway #1 on September 30, 1998 - 7:30 am

A-III Papers presented at Session IAA-3.3

A-IV User's Guide to International Space Propulsion Systems

A-V Microthrusters Requirements

A-VI Reusable Propulsion Systems Requirements

A-VII Evolution of Propulsion Requirements

A-VIII Subgroup #1 - Space Transportation Systems and missions for preparation of Propulsion Requirements - Comments by D. Andrews (Boeing)

A-IX Future Events in Space Propulsion

A-X IAA/APWG Mission and Charter - Subgroups missions and tasks

A-XI World Organizations involved in Space Propulsion (draft)

A-XII Attendance list to the IAA/APWG #3 in Melbourne

A-XIII Updated list of IAA/APWG members (October 1998)

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1 MINUTE OF THE FIRST IAA/APWG SESSION OF THE INTERNATIONAL ASTRONAUTICAL CONGRESS HELD IN MELBOURNE (AUSTRALIA) ON OCTOBER 2, 1998

About 60 people attended this session which was chaired by J. Gilchrist and R. Beichel with Jo Loftus as Rapporteur.

In addition to the five papers scheduled (from each of the five subgroups) a "global" paper was prepared by Rudi Beichel and D.W. Culver (from Aerojet). All these papers are given in Annex III.

® Joe Loftus commented that APWG has not addressed barriers to cooperation, standardization and technology development. He sees them as:

- Cooperation Barriers

. antitrust laws

. export controls

. geographical "just returns" (e.g., as in ESA contracts policy)

. diversity within Companies

- Standardization Barriers

. antitrust laws

. liability laws

. preferred suppliers

- Technology Development Barriers

. return on investment

. cost of money

. alternative investment strategies

. public acceptance

Questions were discussed at the end of the session about introducing Russian rockets development roadmaps, hybrid rockets.

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2 MINUTE OF IAA/APWG WORKSHOP #3 HELD ON OCTOBER 2, 1998 IN MELBOURNE  
(AUSTRALIA)

2.1 AGENDA OF THE WORKSHOP

1. Introduction (Rudi Beichel)

2. Introduction of the new members

3. Comments about IAA-3.3 morning session

4. IAA/APWG: objectives and charter (comments / updates)

5. Review of actions :

a) Transfer of IAA/APWG Website from "The Aerospace Corp." to IAA central Website

- status

- objectives: how to use it for our Group; passwords, etc.

- comments, improvements, suggestions

- APWG members volunteering to coordinate/check/operate it

b) International Propulsion Systems Data Base

- status (Jim Gilchrist)

- Actions, help from APWG members

c) World "Who's Who in Space Propulsion"

- how to implement? Volunteers?

- privacy problems?

- use of IAA Website? with passwords

d) Invitation of new members

e) Coordination with existing Advanced Propulsion Working Groups (NASA, AF, ...)

f) World Propulsion resources, centers of expertise, etc.

- volunteers to build the data base

- use of IAA Website

6. Workshop: "Evolution of Space Propulsion needs/requirements for the coming 10, 20 and 40 years":

a) reusable Propulsion Systems requirements

b) macro and nano satellites propulsion requirements

c) electric Propulsion

d) inputs from the five subgroups

e) discussion - actions

7. Organization/planning of the IAA/APWG Workshop #4

- how to introduce "roadmaps" elements from Japan, Russia, China

- new objectives for the subgroups

- date, place (Europe, Japan, ?), sponsoring organization

8. Future actions and products: who is the "customer"?

- position papers

- publications\*

- participation (papers of full session) to IAA Joint Propulsion & other events?

- next meetings (IAF program meeting is on March 24-25, 1999).

## 2.2 DISCUSSIONS DURING THE MEETING

Marcel Pouliquen acknowledges the presence of many new APWG members in the audience; in total, there are now about 100 members, but still not enough representatives from non-US et non-EU countries:

- they should be encouraged to participate.

The list of members is given in Annex XIII and the list of attendees to the Workshop in Annex XII.

Jim Gilchrist thanks all the authors of the subgroups papers presented in the morning.

## AGENDA ITEM 4

J. Gilchrist points out the importance of the remarks by Joe Loftus ("barriers") and asks "who is the end user" and "what is the output" of the work done and originating from our Working Group in this APWG. He thinks that in Japan the end user would be NASDA; in the US maybe the House Space and Technology Committee; the output would then be a position paper that the APWG should write. Jim raises the issue of whether we should have a separate Subgroup on policy to address these issues. M. Pouliquen recalls the APWG Charter main goal (see Annex X) which is to promote space propulsion.

David Fearn comments that before writing a position paper we must know/agree on what is the direction to take. A technical basis is needed. Roger Lo says he is not sure that everybody knows/agrees about how to proceed to achieve the goals in the APWG Charter. To encourage discussion on this important point,

- M. Pouliquen will see to have the subgroups papers put on the Web, and also sent by "slow" mail to Members without email and ask all members to give their comments through the website.

M. Pouliquen recalls the formal structure of APWG: Chairman is Rudi Beichel; Vice Chairman is M. Pouliquen, the Steering Committee is formed by Roger Lo, Claudio Bruno, Claude Johnson, Jim Gilchrist, Bill Gaubatz. Other countries should be represented in the future in this Group.

M. Pouliquen recalls also the goals of each subgroup and that this information is in the APWG website and can be accessed. He thinks that the international nature of APWG gives more freedom to express positions and ideas than actually available to many members in his/her home organization.

Regarding what to do, and in response to the issues raised by Jim Gilchrist and Roger Lo, Marcel Pouliquen informs the audience of Chuck Chase's suggestion the previous day to have a plenary session at the next AIAA Joint Propulsion Conference (JPC), to be coordinated between AIAA and APWG. Invited talks by selected speakers from Insurance, Satellite and telecommunications companies should be solicited. In this respect there will be a full session (4B) devoted to "Reliability for Space Applications" in the "International Symposium on Product Quality and Integrity", January 18-21, 1999, Washington DC (see <http://www.rams.org> for more information).

Carpenter asks about standardization as a new subgroup topic and suggests we compare different propulsion systems based on standard missions (e.g., Earth to LEO, or to GEO, ...). This is also Bob Sackheim's suggestion: concentrate on specific missions in order to be more realistic and effective in proposing new systems or drawing conclusions about systems.

Marcel Pouliquen asks whether we should change/reconfigure the current subgroups (see Annex X). Roger Lo comments that his subgroup, for instance, shares common issues with subgroup #5, and could be/become a duplicate or redundant. Allen Goldstein, C. Bruno comment that the structure format does not really matter, as long as we agree on and keep in mind our common Charter (Annex X).

After much discussion, the consensus is that there is no need to restructure subgroups for the time being; however a suggestion is that subgroup #3 and #5 get together and discuss potential overlapping, in order to decide a clear sharing of the concepts between the subgroups.

Dana Andrews suggests to re-group all revolutionary concepts into subgroup #3 and all near-term concepts into subgroup #5 since at this stage we still don't know where we are really going to go in a technical sense.

- subgroup #3 and #5 should sit down to look at how to divide technical issues between them.

In the future should problems of overlapping appear between subgroups, it will be possible to revisit the fields covered by each subgroup.

#### AGENDA ITEM 5A:

Website transfer from The Aerospace Corp. to IAA. Web address was until now:

[www.aero.org/apw](http://www.aero.org/apw).

Password is HOberth

(named after Hermann Oberth)

Future website address will be [www.iaanet.org/apw/index.html](http://www.iaanet.org/apw/index.html) with the same password

- a message about the future address will be put on the old website.

The IAA person responsible for the change, etc. is Fabrice Dennemont in Paris. He is listed in the updated Members Directory distributed by Marcel. His email address is: [fabricedennemont@hotmail.com](mailto:fabricedennemont@hotmail.com)

- for the time being the point of contact between IAA and APWG is still Marcel Pouliquen until somebody will volunteer to replace him.

Next, Marcel shows a Table containing future propulsion events.

- if members have events to report, they should bring them to the website in order to keep it updated.

A possible event that can be associated to the next Workshop is the Spring IAF Program preparation meeting in Paris, March 24-25, 1999.

#### AGENDA ITEM 5B: PROPULSION DATABASE

Jim Gilchrist reports on progress. AIAA is interested in publishing and selling it as a book. Issue date: about Summer 1999. Letters requesting information on their engines were sent by Jim to a list of manufacturers (see Annex IV). Some haven't replied yet. Others have declined to respond.

- members should add/submit promptly additional companies/entities potentially interested in contributing to the database. Send this information to Jim Gilchrist directly. Responses should be prompt because of the '99 publication deadline .

Note : this AIAA book will be APWG first product !

#### AGENDA ITEM 5C: WHO'S WHO IN PROPULSION DIRECTORY

The audience agrees such a book could be useful.

Jim Gilchrist says that this information is partially contained in the AIAA Roster (on the AIAA website and accessible to AIAA members). It could be copied/sorted.

The discussion that follows ends with the announcement that a page on the APWG website will be available for APWG members who want to fill it in with their data.

- APWG members who are interested in giving their coordinates should access this new page.

#### AGENDA ITEM 5D:

New APWG members are invited to register and all members are invited to make recommendations to bring additional members in order to cover all (or most of) the world countries and organizations involved in space propulsion.

#### AGENDA ITEM 5E: CHUCK CHASE'S SESSION ON RELIABILITY PROPOSED AT NEXT AIAA'S JPC

Chuck has proposed to have a joint IAA/AIAA Session at the '99 JPC dedicated to the topic of Improving Launchers Reliability (from the propulsion view point). Views on this critical issue should be requested from providers of:

- satellites
- launchers
- propulsion systems
- insurance
- telecommunication services

A suggestion from the floor is to check also with the SAE G-II Reliability Committee about Propulsion Systems reliability.

The joint session, Chuck suggests, could have a forum format where the invited speakers viewpoints would be followed by a public or a panel discussion.

It is suggested from the floor that the reliability topic be broadened to include also Lifetime and Refurbishment/Maintenance.

Note: the deadline for organizing such a session is October 19.

- Chuck will check with Terry Murphy (AIAA JPC General Chairman) how to organize a session on Reliability

- Max Calabro volunteers to organize Lifetime and Maintenance also in the proposed session.

#### AGENDA ITEM 5F

Marcel Pouliquen shows a first draft of world organizations table (institutes, laboratories, companies, etc.); this table is also on the website.

- APWG members should comment and add/propose to M. Pouliquen by email, companies not included in the table.

AGENDA ITEM 6 : Presentations from subgroups follow

#### AGENDA ITEM 6A

Jay Penn stresses the need for increasing margins as "THE" crucial point for future propulsion (see presentation in Annex VI). The audience strongly agrees.

#### AGENDA ITEM 6B

Jim Gilchrist gives a talk about thrusters for micro- (1-100 kg), nano- (1-1000 g) and pico- (1-1000 mg) satellites (Annex V). MEMS will produce future microthrusters by the millions, on a single wafer. David Fearn says current ion thrusters are capable of 1 mN/sq.cm, going to 10 mN/sq.cm in the future. Plasma codes will be more and more important in designing future thrusters.

Dana Andrews presents Boeing's Phantom Works launch market estimates (Annex VIII); the "Elastic Market" will begin below US\$ 1,00/lb. For \$ 100/lb Boeing's predictions are of some 4 x 1.E7 lb into orbit/yr. Roughly speaking, this cost range is assumed to mean the beginning of widespread Space Tourism.

For launch costs of order \$ 10/lb we could see airline-like space services beginning.

For all this to happen: reliability, standardization, safety must be drastically increased. Boeing's study substantially agrees with The Aerospace Corporation 1997 Launchmarket report.

Bill Gaubatz stresses the need to design for safety and to spend more time on upper stages design.

Roger Lo shows a market study done at TU-Berlin (Annex VII) indicating slow spacemarket growth to be expected, except in case of lunar/mars new developments and space tourism.

Fokke Dijkstra says that Airbreathing propulsion is one way of getting propulsion costs down because it is inherently more robust and provides more margins than conventional RE propulsion. History of Boeing's 747 and of the PC is instructive and we should learn from it.

#### AGENDA ITEM #6E

- Bob Sackheim will compile a list of US working groups dealing with APWG issues.

- Marc o Caporicci will do the same in Europe.
- Prishniakov will provide a list of Russian and Ukrainian companies/groups also involved in this area.
- Bill Gaubatz will help with the US list.
- Marcel Pouliquen will send subgroups chairs these lists.

Following suggestions from the floor and general discussion other action items are discussed in Item 7.

#### AGENDA ITEM 7: CONTENT AND ISSUES FOR NEXT APWG WORKSHOP

Much discussing about what to do. Some recommendations follow:

- subgroup #1 will produce a set of reference missions and their requirements.

The APWG will keep its current structure, but,

- must share more among different subgroups,
- to maintain Chair continuity in space and time, a third co-chair should be added in each subgroup. Marcel and the audience suggest the following third co-chairmen:

subgroup #1: a person from Lockheed-Martin

subgroup #2: tbd

subgroup #3: Roger Lo will find someone

subgroup #4: Paul Donguy (Snecma)

subgroup #5: tbd.

- send comments about this to the APWG website.
- input needed from everybody about the major issue of roadmaps toward the future.
- put minutes of this Workshop on the website.

About input/roadmaps from non-US, non-Europe countries:

- Fukushima-San will be focal point for Japanese Government Organizations and Industries
- Prishniakov will be focal point for Russia and Ukraine
- Jim Gilchrist will find a suitable China representative.

- a written article about this Workshop should be sent to Peter de Selding ("Space News") and AW & ST in the US so they can write about what APWG is doing.

Note that our second APWG Workshop in California on January 20-21, 1998 was the subject of an article in "Air & Cosmos" (see Annex XIV). It is hoped that in doing so our membership can increase and that more non-US, non-EU members will join.

Dates for next Workshop: the IAF preparatory meeting in Paris will be on March 24-25, 1999. APWG next workshop could take place during the 2 days preceding that, March 22-23, 1999. Marco Caporicci says that ESA will host the meeting (to be confirmed).

The question is raised of roadmaps, the data needed to produce them and the strategy: top-down or bottom-up input?

Roger Lo says that what we are wrestling with is really System Analysis, so system analysis techniques should be used, albeit with due caution. Using questionnaires, etc. could be useful. Dana Andrews says that we are dealing with a) needs and b) what is done right now to meet them. a) and b) MAY NOT match right now (hence our charter goals and why we are working). The mismatch between a) and b) is a sign, or indication, or can provide roadmaps toward "what to do".

In practical terms, the questions behind a working logic are:

- what are the missions
- what are the vehicles that can do them
- what are the required propulsion systems
- what are the required technologies
- is some cooperation possible in developing them.

#### AGENDA ITEM #8: WHAT TO DO AND FOR WHOM

Discussion on this item is lively. A common proposal is to do the obvious, i.e. prepare a position paper reflecting consensus from APWG as the world's expert group on propulsion. But who is the end user ? UN is a potential customer. Ulf Palmnas says that what to write should be tailored and addressed, presumably, to whom controls moneys; in other words our findings should be tailored to the customer. Bruno says that we should be professional and report about our findings, or opinions, straight, without trying to suit them to the particular customer, and after reaching APWG consensus. If we believe in our conclusions the next step should then be to lobby. Bill Gaubatz reminds the audience that we were already committed to present our APWG position to world's leaders at the 2000 IAF. Bruno says that any future position paper should be pitched to agencies/organizations that can provide means (i.e. funding) to implement our conclusions.

A question raised is whether we should issue every year a report containing APWG findings. No decision is adopted on this issue.

M. Pouliquen says that a periodic survey/overview of roadmaps from different countries will be very useful and can favour standardization. Murray notes that it would be very valuable if what we produce will foster international cooperation. Bob Sackheim thinks that position papers, often ignored by policymakers, will only frustrate us.

Alan McDonald from Thiokol says that the UN is a good potential customer since they pay much attention to environmental issues and we are dealing with them (as far as launchers and propulsion) in the US right now. We should find ways to show that what APWG is doing will benefit humankind, NOT just companies and industry. Dick Culver suggests to think of what to do in terms of a standard marketing plan (e.g. what we have to offer? To whom? Check market size, penetration, etc.). Bill Gaubatz suggests a briefing to worldwide space agencies directors and CEO of large corporations.

Adam Siebenhaar invites to set our goals very high, so that the payoff of doing what APWG wants to do becomes crystal clear. APWG must show concrete payoffs can be produced by what we propose. Payoff is what convinces people to act. Since ours is an international group we must look for payoffs in a broad sense.

SNB Murthy ("BG") says that we should assess clearly our goals and then what to do about reaching them. So far we still haven't done much about this.

Wrapping up the discussion, Marcel Pouliquen invites all members to:

- send individual position, ideas/suggestions to the website; also
- those who spoke today, please send statement(s) in one or two pages to Marcel.

The last statement is from Adam Siebenhaar who says that the last hour of the discussion was the most important one.

Adjournment : about 5:30 pm.

Report from notes of Claudio Bruno, Fokke Dijkstra, Marcel Pouliquen.

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### 3 SUMMARY OF ACTIONS

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Next APWG Workshop (#4) will be held in PARIS (ESA Headquarters)

On March 22-23, 1999