TP 12932E
APEC Transportation Safety and Security Project
Satellite Navigation and Communications

Element 2 - SN&C Technology and Safety Review in the APEC Economies
Part 2: Safety Review

Prepared for
Transportation Development Centre
Safety and Security
Transport Canada

by
Hickling Corporation

January 1997

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CAVEAT

This document summarizes the proceedings of a one day expert panel examining issues which may arise from the use of satellite navigation, communications and surveillance in marine transportation. The contents consist of comments from panel members. While the panel members are knowledgeable in their fields, their comments are personal opinions and do not necessarily represent the positions or policies of Transport Canada or any other department or agency of the Government of Canada or any other organization. The panel members were required to cover a large subject area in a short period of time, and therefore some comments may not be fully developed.

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Un sommaire français se trouve avant la table des matières.

Transport Canada / Transports Canada

PUBLICATION DATA FORM

1. Transport Canada Publication No.	2. Project No.	3. Recipient's Catalogue No.
TP 12932E	8862	

4. Title and Subtitle

APEC Transportation Safety and Security Project
Satellite Navigation and Communications
Element 2 - SN&C Technology and Safety Review
in the APEC Economies
Part 2: Safety Review

5. Publication Date

January 1997

6. Performing Organization Document No.

7. Author(s)

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8. Transport Canada File No.

ZCD1450-183-3

9. Performing Organization Name and Address

Hickling Corporation
350 Sparks Street, 6th Floor
Ottawa, Ontario
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10. PWGSC File No.

XSD95-00149-(621)

11. PWGSC or Transport Canada Contract No.

T8200-5-5532/01-XSD

12. Sponsoring Agency Name and Address

Transportation Development Centre (TDC)
800 René Lévesque Blvd. West
6th Floor
Montreal, Quebec
H3B 1X9

13. Type of Publication and Period Covered

Final

14. Project Officer

James Reid

15. Supplementary Notes (Funding programs, titles of related publications, etc.)

APEC Transport Working Group - Safety and Security Project.
One of a series of reports produced on Satellite Navigation and Communications.

16. Abstract

Canada is a member of the Asia-Pacific Economic Cooperation (APEC) which comprises 18 economies: Australia, Brunei Darussalam, Canada, Chile, the People's Republic of China, Chinese Taipei, Hong Kong, Indonesia, Japan, the Republic of Korea, Malaysia, Mexico, New Zealand, Papua New Guinea, the Republic of the Philippines, Singapore, Thailand and the United States. In support of APEC, Transport Canada undertook a study of the implementation of satellite navigation and communications (SN&C) for both air and marine. This study consists of the following elements:

- Element 1 - Inventory of Existing and Planned SN&C Systems in APEC economies;
- Element 2 - SN&C Technology and Safety Review; and
- Element 3 - Costs and Benefits of SN&C for Air and Marine Transportation.

This report presents the results of Part 2: Safety Review of Element 2. The Safety Review report records the results of two Expert Panels held concerning the safety issues arising from the use of satellite navigation, communications and surveillance; one for marine transportation and one for air transportation.

The panels considered the following questions:

- What are the "Areas to be Addressed"/Safety Concerns which will result from the introduction of future communication, navigation and surveillance systems?
- Which are the most important "Areas to be Addressed"/Safety Concerns?
- What are others doing to mitigate any concerns? What can APEC do?

17. Key Words	18. Distribution Statement
Air navigation, marine navigation, APEC, safety	Limited number of copies available from the Transportation Development Centre

19. Security Classification (of this publication)	20. Security Classification (of this page)	21. Declassification (date)	22. No. of Pages	23. Price
Unclassified	Unclassified	—	xx, 26, apps	—

Transports Canada Transport Canada

FORMULE DE DONNÉES POUR PUBLICATION

1. N° de la publication de Transports Canada	2. N° de l'étude	3. N° de catalogue du destinataire
TP 12932E	8862	

4. Titre et sous-titre	5. Date de la publication
APEC Transportation Safety and Security Project Satellite Navigation and Communications Element 2 - SN&C Technology and Safety Review in the APEC Economies Part 2: Safety Review	Janvier 1997
	6. N° de document de l'organisme exécutant

7. Auteur(s)	8. N° de dossier - Transports Canada
David Arthurs, David Low	ZCD1450-183-3

9. Nom et adresse de l'organisme exécutant	10. N° de dossier - TPSGC
Hickling Corporation 350 Sparks Street, 6th Floor Ottawa, Ontario K1R 7S8	XSD95-00149-(621)
	11. N° de contrat - TPSGC ou Transports Canada
	T8200-5-5532/01-XSD

12. Nom et adresse de l'organisme parrain	13. Genre de publication et période visée
Centre de développement des transports (CDT) 800, boul. René-Lévesque Ouest 6e étage Montréal (Québec) H3B 1X9	Final
	14. Agent de projet
	James Reid

15. Remarques additionnelles (programmes de financement, titres de publications connexes, etc.)

Groupe de travail de l'APEC chargé des transports - Project Sûreté et Sécurité.
Un des rapports réalisés sur les systèmes de navigation et de communications par satellite.

16. Résumé

Le Canada est membre de l'APEC (Organisation de la coopération économique Asie-Pacifique), qui comprend les 18 pays suivants : Australie, Brunei Darussalam, Canada, Chili, République populaire de Chine, Chine de Taipei, Hong Kong, Indonésie, Japon, République de Corée, Malaisie, Mexique, Nouvelle-Zélande, Papouasie-Nouvelle-Guinée, République des Philippines, Singapour, Thaïlande et États-Unis. À l'appui de l'APEC, Transports Canada a entrepris une étude sur la mise en oeuvre de systèmes de navigation et de communications par satellite (NCS) pour l'aviation et la marine. Cette étude comporte les éléments suivants :

- Élément 1 - Inventaire des systèmes actuels et prévus de NCS dans les pays de l'APEC;
- Élément 2 - Examen de la technologie et de la sécurité des systèmes NCS;
- Élément 3 - Coûts et avantages des systèmes NCS pour les transports aériens et maritimes.

Le présent rapport contient les résultats de la partie 2 : Examen de la sécurité, de l'élément 2, soit les conclusions de deux réunions de Comités d'experts, l'un pour le transport maritime, l'autre pour le transport aérien, sur les questions de sécurité qui découlent du recours à la navigation, aux communications et à la surveillance par satellite.

Les Comités ont examiné les questions suivantes :

- Quels sont les problèmes à examiner et les préoccupations en matière de sécurité qui découleront de l'introduction des systèmes de communication, de navigation et de surveillance?
- Qu'est-ce qui importe le plus, l'examen des problèmes ou l'étude des préoccupations en matière de sécurité?
- Que peut faire l'APEC pour atténuer les préoccupations et que font les autres organisations?

17. Mots clés	18. Diffusion
Navigation aérienne, navigation maritime, APEC, sécurité	Le Centre de développement des transports dispose d'un nombre limité d'exemplaires.

19. Classification de sécurité (de cette publication)	20. Classification de sécurité (de cette page)	21. Déclassification (date)	22. Nombre de pages	23. Prix
Non classifiée	Non classifiée	—	xx, 26, ann.	—

Related APEC Transportation Safety & Security Project Reports

TP 12928 APEC Transportation Safety & Security Project
Satellite Navigation and Communications
Summary Report for Study Elements 1, 2 and 3

TP 12929E APEC Transportation Safety & Security Project
Satellite Navigation and Communications
Element 1 - Inventory of Existing and Planned
SN&C Systems in the APEC Economies
Part 1: Trade, Traffic and APEC

TP 12930E APEC Transportation Safety & Security Project
Satellite Navigation and Communications
Element 1 - Inventory of Existing and Planned
SN&C Systems in the APEC Economies
Part 2: Implementation Plans

TP 12931E APEC Transportation Safety & Security Project
Satellite Navigation and Communications
Element 2 - SN&C Technology and Safety Review
in the APEC Economies
Part 1: Technology Review

TP 12932E APEC Transportation Safety & Security Project
Satellite Navigation and Communications
Element 2 - SN&C Technology and Safety Review
in the APEC Economies
Part 2: Safety Review

TP 12933E APEC Transportation Safety & Security Project
Satellite Navigation and Communications
Element 3 - SN&C Costs and Benefits Assessment
in the APEC Economies

Executive Summary

INTRODUCTION

APEC Satellite Navigation and Communications Study

The Asia-Pacific Economic Cooperation (APEC) comprises 18 economies: Australia, Brunei Darussalam, Canada, Chile, the People's Republic of China, Chinese Taipei, Hong Kong, Indonesia, Japan, the Republic of Korea, Malaysia, Mexico, New Zealand, Papua New Guinea, the Republic of the Philippines, Singapore, Thailand, and the United States. These economies have agreed to cooperate in four areas: global and regional economic development, global trade liberalization, and regional cooperation in specific sectors. One of the sectors identified is transportation. The Transportation Working Group (TPT/WG) was created to coordinate that effort.

The ambitious agenda for liberalizing trade in the region will bring about a rapid increase in air and marine traffic and a requirement for higher levels of aircraft and shipping throughput. This demand for increased capacity is driving the application of satellite communications, navigation and surveillance technologies and systems. It is apparent from discussions in the TPT/WG that the economies of APEC share an interest in introducing new technologies and systems in a way that maintains or improves transportation safety.

The Canadian Minister of Transport has made a commitment to APEC Ministers of Transportation to lead the promotion of transport system safety in the APEC region. To that end, Transport Canada proposed a study on the implementation of satellite navigation and communications (SN&C) for both air and marine. The study is a component of the APEC Action Program in Transportation.

The study consists of the following elements:

- Element 1 - Inventory of Existing and Planned Satellite Navigation and Communication Systems in the APEC Economies;

- Element 2 - Satellite Navigation and Communication Technology and Safety Review; and

- Element 3 - Costs and Benefits of Satellite Navigation and Communications for Air and Marine Transportation.

Hickling Corporation was contracted to carry out the work. This report presents Part 2: Safety Review Report of the final report for Element 2. A separate report presents the first part, Part 1: Technology Review Report.

MARINE

This report records the results of an Expert Panel concerning the safety issues arising from the use of satellite navigation, communications and surveillance in marine transportation. The Panel was in support of an international effort by APEC economies to increase marine traffic in a safe manner. It was held in Ottawa on June 28, 1996.

The satellite navigation, communication and surveillance technologies of interest can be summarized as follows:

Position determination - Provided by a Global Navigation Satellite System (GNSS), consisting of satellite constellations (GPS and GLONASS), augmentation systems providing differential corrections and integrity monitoring, and on-board equipment for receiving and processing the signals.

Charts, displays, and information updates - Electronic charts (ECS and ECDIS) of geographic, hydrographic, and navigational information; updates to the electronic charts by remote communications; and display of dynamic information such as advisory notices, weather, ice, and positions of other craft.

Position communication - Automated Identification Systems (AIS) which use ship transponders to keep Vessel Traffic Services (VTS) and other ships informed of the position of a ship. Ships operating beyond VHF coverage can use the INMARSAT satellite communication services.

Search and Rescue alerting - Emergency Position Indicating Radio Beacons (EPIRBs) which transmit a signal to a satellite indicating an emergency to authorities and indicating the position of the transmitter.

The Panel considered the following questions:

Problem Identification: What *safety problems* do you expect from future communication, navigation and surveillance systems?

Problem Prioritization: Which are the *most important* safety problems?

Problem Mitigation: What are *others* doing? What can *APEC* do?

The process which the Panel followed was:

- Describe the changes in technologies,
- Identify the resulting changes in operating conditions,
- Forecast potential system deficiencies given these changes in operating conditions,
- Group these system deficiencies into major safety issues,
- Prioritize these safety issues, and
- Discuss possible options for mitigation.

The top ten safety issues identified by the Panel were the following:

1. Lack of training capacity & training of mariners.
2. Lack of standards.
3. Infrastructure not in place, needs improvement, management.
4. Lack of chart availability and accuracy.
5. Economic forces on mariner.
6. Inability of regulations to keep up with technology.
7. Reliance on sub-standard equipment, doubtful data, etc.
8. Increase in traffic, congestion.
9. Ability of VTS to handle increased data requirements.
10. Different cultures/risk capacities in APEC countries.

Recommendations for APEC action focussed on the following themes:

- Training,
- Infrastructure,
- Standards, and
- Regulations.

And consisted primarily of encouragement for:

- Cooperation with international organizations, and
- Support of domestic agencies.

AVIATION

This report records the results of an Expert Panel concerning issues arising from the use of satellite navigation, communications and surveillance in air transportation. The Panel was in support of an international effort by APEC economies to increase aviation traffic in a safe manner. It was held in Ottawa on July 24, 1996.

The satellite navigation, communication and surveillance technologies of interest can be summarized as follows:

Position determination - Global Navigation Satellite System (such as GPS and GLONASS); accuracy and integrity augmentation of the basic GNSS signal (such as WAAS and LAAS); and avionics for reception and processing of the signal.

Charts, displays, and information updates - electronic charts of geographic, and navigational information; updates to the electronic charts by remote communications; and display of dynamic information such as advisory notices, weather, and positions of other aircraft.

Position communication - Automatic Dependent Surveillance (ADS) which uses aircraft transponders and data communication links to keep Air Traffic Control (ATC) and other aircraft informed of the position and status of an aircraft.

Search and Rescue alerting - Emergency Locator Transmitters (ELTs) which transmit a signal to a satellite indicating an emergency to authorities and indicating the position of the transmitter.

The Panel was asked to considered the following questions:

Area Identification: What are the "A*reas to be Addressed"* which will result from the introduction of future communication, navigation and surveillance systems?

Area Prioritization: Which are the *most important* "Areas to be Addressed"?

Mitigation: What are *others* doing? What can *APEC* do?

The process which the Panel followed was:

- Identify the changes in operating conditions resulting from the introduction of the new technologies,
- Forecast potential "Areas to be Addressed" given these changes in operating conditions,
- Group these "Areas to be Addressed" into major issues,
- Discuss possible options for mitigation, and
- Reflection.

The group did not feel that it was productive or possible to prioritize the major issues, and so this was not done.

The issues identified by the Panel were the following (in no particular order):

- Training deficiencies and lack of training tools,
- Human limitations to adapt to new interfaces / Human factors,
- Potential for database errors / Integrity of database,
- Air traffic management / Segregation of traffic,
- Inflight Procedures / Reduced margins of error,
- Standards and regulatory environment,
- Software integrity (e.g., many different revisions),
- Universal standards implementation for CNS, and
- Lack of complete CNS standards for performance.

Recommendations for APEC action focussed on the following themes:

- Training,
- Information exchange,
- Standards, procedures and regulations,
- Database and software integrity, and configuration management, and
- Trials and demonstrations.

And consisted primarily of encouragement for:

- Cooperation with international organizations, and
- Support of domestic agencies, and
- Political and financial support.

Sommaire

INTRODUCTION

Étude de l'APEC sur les systèmes de navigation et de communications par satellite

L'APEC (Organisation de la coopération économique Asie-Pacifique) comprend 18 pays : Australie, Brunei Darussalam, Canada, Chili, République populaire de Chine, Chine de Taipei, Hong Kong, Indonésie, Japon, République de Corée, Malaisie, Mexique, Nouvelle-Zélande, Papouasie-Nouvelle-Guinée, République des Philippines, Singapour, Thaïlande et États-Unis. Ces pays ont convenu de coopérer dans les quatre domaines suivants : le développement économique mondial et régional, la libéralisation des échanges mondiaux, enfin, la coopération régionale dans certains secteurs, notamment les transports. Le Groupe de travail chargé des transports (TPT/WG) a été créé pour coordonner cette activité.

L'ambitieux programme de libéralisation du commerce dans la région entraînera une augmentation rapide du trafic aérien et maritime; il faudra donc améliorer la capacité des aéronefs et des navires. Cette demande de capacité accrue favorise le recours aux technologies et aux systèmes de communications, de navigation et de surveillance par satellite. Il ressort clairement des entretiens au sein du TPT/WG que les pays membres de l'APEC ont un intérêt commun dans l'introduction de nouvelles technologies et de nouveaux systèmes de façon à maintenir ou à améliorer la sécurité des transports.

Le ministre canadien des Transports s'est engagé envers ses homologues de l'APEC à mener la promotion de la sécurité des systèmes de transport dans la région. À cette fin, Transports Canada a proposé une étude sur la mise en oeuvre de systèmes de navigation et de communications par satellite (NCS) pour l'aviation et la marine. Cette étude fait partie du programme d'action de l'APEC en matière de transports.

Cette étude comporte les éléments suivants :

- Élément 1 - Inventaire des systèmes actuels et prévus de navigation et de communications par satellite dans les pays de l'APEC

- Élément 2 - Examen de la technologie et de la sécurité des systèmes de navigation et de communications par satellite

- Élément 3 - Coûts et avantages des systèmes de navigation et de communications par satellite pour les transports aériens et maritimes.

On a retenu les services de la société Hickling pour l'exécution des travaux. Dans le présent rapport, on retrouve la partie 2 : Examen de la sécurité, du rapport final de l'élément 2. La partie 1 : Examen de la technologie, est présentée dans un rapport séparé.

MARINE

Ce rapport présente les résultats de l'analyse d'un Comité d'experts sur les questions de sécurité qui découlent du recours à la navigation, aux communications et à la surveillance par satellite pour le transport maritime. Ce Comité était en faveur d'un effort international des pays de l'APEC en vue d'accroître le trafic maritime dans le respect de la sécurité. Le Comité s'est réuni à Ottawa le 28 juin 1996.

On peut résumer comme suit les technologies de navigation, de communications et de surveillance par satellite qui présentent un intérêt :

Détermination de la position - Cette fonction est assurée par le Système mondial de navigation par satellite (GNSS) qui comprend les éléments suivants : constellations de satellites (soit le GPS et le GLONASS), systèmes de renforcement des signaux qui effectuent la correction différentielle et surveillent l'intégrité des signaux, enfin, équipements embarqués pour la réception et le traitement des signaux.

Cartes, affichages et mises à jour de l'information - Ce sont les cartes électroniques (SCE et SVCEI) qui présentent des renseignements géographiques et hydrographiques ainsi que des données de navigation; ces cartes électroniques sont mises à jour au moyen des télécommunications; de plus, on y retrouve des renseignements temporaires (avis du service consultatif, conditions météorologiques, état de la glace et position des autres bâtiments).

Communication de la position - Le Système automatisé d'identification (AIS) utilise les transpondeurs du bord pour indiquer la position du bâtiment aux Services du trafic maritime (STM) et aux autres navires. Lorsqu'ils évoluent au-delà de la portée des communications VHF, les navires peuvent utiliser les services de communications par satellite INMARSAT.

Recherche et sauvetage - En cas de situation d'urgence, les radiobalises de localisation des sinistres (EPIRB) transmettent un signal à un satellite pour alerter les autorités et préciser la position du transmetteur.

Le Comité a examiné les questions suivantes :

Détermination des problèmes : À votre avis, quels seront les *problèmes relatifs à la sécurité* des systèmes futurs de communication, de navigation et de surveillance?

Évaluation des priorités : Quels sont les problèmes de sécurité *les plus importants?*

Atténuation des problèmes : Que font les *autres organisations?* Que peut faire l'*APEC?*

Le Comité a adopté le processus suivant :

- description des changements technologiques;
- détermination des modifications qu'ils entraînent dans les conditions d'exploitation;
- anticipation des lacunes éventuelles des systèmes compte tenu de ces changements dans les conditions d'exploitation;
- regroupement de ces lacunes de système en grands thèmes relatifs à la sécurité;
- établissement de l'ordre de priorité de ces thèmes;
- discussion sur les mesures possibles d'atténuation.

Le Comité a cerné les dix principales questions de sécurité suivantes :

1. manque de capacité de formation et de formation des navigateurs maritimes;
2. absence de normes;
3. infrastructure inexistante; gestion et améliorations nécessaires;
4. manque de disponibilité et de précision des cartes;
5. facteurs économiques du transport maritime;
6. incapacité des organismes de réglementation de suivre l'évolution de la technologie;
7. dépendance envers un équipement inférieur aux normes, des données douteuses et autres;
8. augmentation du trafic et congestion;
9. capacité des STM de traiter les besoins accrus d'information;
10. cultures et risques différents dans les pays de l'APEC.

Les mesures de l'APEC recommandées portaient sur les thèmes suivants :

- formation;
- infrastructure;

- normes;
- règlements.

Elles visaient essentiellement à favoriser :

- la coopération avec les organisations internationales;
- le soutien des organismes nationaux.

AVIATION

Ce rapport présente les résultats de l'analyse d'un Comité d'experts sur les questions de sécurité qui découlent du recours à la navigation, aux communications et à la surveillance par satellite pour le transport aérien. Le Comité était en faveur d'un effort international des pays de l'APEC en vue d'accroître le trafic maritime dans le respect de la sécurité. Le Comité s'est réuni à Ottawa le 24 juin 1996.

On peut résumer comme suit les technologies de navigation, de communications et de surveillance par satellite qui présentent un intérêt :

Détermination de la position - Le Système mondial de navigation par satellite (comme le GPS et le GLONASS); renforcement de la précision et de l'intégrité du système GNSS de base (au moyen des systèmes comme le WAAS et le LAAS); enfin, les systèmes d'avionique qui servent à recevoir et à traiter les signaux.

Cartes, affichages et mises à jour de l'information - Ce sont les cartes électroniques qui présentent des renseignements géographiques ainsi que des données de navigation; ces cartes électroniques sont mises à jour au moyen des télécommunications; de plus, on y retrouve des renseignements temporaires (avis du service consultatif, conditions météorologiques, état de la glace et position des autres aéronefs).

Communication de la position - Le Système automatisé d'identification (AIS) utilise les transpondeurs de l'aéronef et les communications numériques pour transmettre en permanence la position et la situation d'un aéronef au contrôle de la circulation aérienne (ATC) et aux autres aéronefs.

Recherche et sauvetage - Les radiobalises de détresse (ELT) transmettent un signal à un satellite pour alerter les autorités et préciser la position de l'émetteur en cas d'urgence.

Le Comité a été chargé d'examiner les questions suivantes :

Détermination des problèmes : Quels problèmes devra-t-on examiner à la suite de l'introduction des systèmes de communications, de navigation et de surveillance?

Évaluation des priorités : Quels sont les problèmes à examiner *les plus importants?*

Atténuation des problèmes : Que font les *autres organisations?* Que peut faire l'*APEC?*

Le Comité a adopté le processus suivant :

- détermination des changements dans les conditions d'exploitation qui découleront de l'introduction des nouvelles technologies;
- anticipation des problèmes éventuels à examiner, compte tenu de ces changements dans les conditions d'exploitation;
- regroupement des problèmes à examiner en thèmes principaux;
- discussion des diverses possibilités d'atténuation;
- réflexion;

Le groupe n'a pas établi un ordre de priorité des principaux thèmes car il estimait que cette démarche n'était pas productive ni possible.

Le Comité a cerné les questions suivantes (sans ordre particulier) :

- lacunes de la formation et absence d'outils de formation;
- obstacles humains à l'adaptation aux nouvelles interfaces - facteurs humains;
- risques d'erreur de base de données - intégrité de la base de données;
- gestion du trafic aérien - séparation des aéronefs;
- procédures en vol - diminution des marges d'erreur;
- normes et réglementation;
- intégrité des logiciels (p. ex. : de nombreuses révisions différentes);
- mise en oeuvre de normes universelles de CNS;
- absence de normes de rendement CNS complètes.

Les mesures de l'APEC recommandées portaient sur les thèmes suivants :

- formation;
- échange d'information;
- normes, procédures et règlements;
- intégrité de la base de données et des logiciels, gestion de la configuration;
- essais et démonstrations.

Elles avaient essentiellement pour but de favoriser :

- la coordination avec les organisations internationales;
- le soutien des organismes nationaux;
- l'appui politique et financier.

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1. Introduction

1.1 APEC Satellite Navigation and Communications Study

The Asia-Pacific Economic Cooperation (APEC) comprises 18 economies: Australia, Brunei Darussalam, Canada, Chile, the People's Republic of China, Chinese Taipei, Hong Kong, Indonesia, Japan, the Republic of Korea, Malaysia, Mexico, New Zealand, Papua New Guinea, the Republic of the Philippines, Singapore, Thailand, and the United States of America. These economies have agreed to cooperate in four areas: global and regional economic development, global trade liberalization, and regional cooperation in specific sectors. One of the sectors identified is transportation. The Transportation Working Group (TPT/WG) was created to coordinate that effort.

The ambitious agenda for liberalizing trade in the region will bring about a rapid increase in air and marine traffic and a requirement for higher levels of aircraft and shipping throughput. This demand for increased capacity is driving the application of satellite communications, navigation and surveillance technologies and systems. It is apparent from discussions in the TPT/WG that the economies of APEC share an interest in introducing new technologies and systems in a way that maintains or improves transportation safety.

The Canadian Minister of Transport has made a commitment to APEC Ministers of Transportation to lead the promotion of transport system safety in the APEC region. To that end, Transport Canada proposed a study on the implementation of satellite navigation and communications (SN&C) for both air and marine. The study is a component of the APEC Action Program in Transportation.

The study is composed of four elements:

- Element 1 - Inventory of Existing and Planned Satellite Navigation and Communication Systems in the APEC Economies;

- Element 2 - Satellite Navigation and Communication Technology and Safety Review; and

- Element 3 - Costs and Benefits of Satellite Navigation and Communications for Air and Marine Transportation.

Hickling Corporation was contracted to carry out the work for the three elements. This report presents Part 2: Safety Review Report of the final report for Element 2. A separate report presents the first part, Part 1: Technology Review Report .

This report records the results of an Expert Panel concerning the safety issues arising from the use of satellite navigation, communications and surveillance in marine and aviation transportation. The Panels were in support of an international effort by APEC economies to increase marine and aviation traffic in a safe manner. The marine panel was held in Ottawa on June 28, 1996 and the aviation panel was held on July 24, 1996.

1.2 Technologies

1.2.1 Marine

The satellite navigation, communication and surveillance technologies of interest can be summarized as follows:

Position determination - Provided by a Global Navigation Satellite System (GNSS), consisting of satellite constellations (GPS and GLONASS), augmentation systems providing differential corrections and integrity monitoring, and on-board equipment for receiving and processing the signals.

Charts, displays, and information updates - electronic charts (ECS and ECDIS) of geographic, hydrographic, and navigational information; updates to the electronic charts by remote communications; and display of dynamic information such as advisory notices, weather, ice, and positions of other craft.

Position communication - Automated Identification Systems (AIS) which use ship transponders to keep Vessel Traffic Services (VTS) and other ships informed of the position of a ship. Ships operating beyond VHF coverage can use the INMARSAT satellite communication services.

Search and Rescue alerting - Emergency Position Indicating Radio Beacons (EPIRBs) which transmit a signal to a satellite indicating an emergency to authorities and indicating the position of the transmitter.

Implementation of these technologies is already well underway. The GPS and GLONASS systems are operational and cover the world. DGPS augmentation will cover the coasts of North America, the Great Lakes and Lawrence Seaway, and the Mississippi. DGPS is also being implemented in Australia, China, Singapore, Hong Kong and Japan. Provision of electronic navigational charts is progressing in Canada and the United States, and is planned in Australia, Singapore and Japan. The IMO has now formally adopted the performance standard for ECDIS. Satellite communication for marine users is provided around the world by INMARSAT. Search and rescue alerting is also provided worldwide by COSPAS/SARSAT. While AIS is not yet common, it is now technically feasible.

1.2.2 Aviation

The satellite navigation, communication and surveillance technologies of interest can be summarized as follows:

Position determination - Global Navigation Satellite System (such as GPS and GLONASS); accuracy and integrity augmentation of the basic GNSS signal (such as WAAS and LAAS); and avionics for reception and processing of the signal.

Charts, displays, and information updates - electronic charts of geographic, and navigational information; updates to the electronic charts by remote communications; and display of dynamic information such as advisory notices, weather, and positions of other aircraft.

Position communication - Automatic Dependent Surveillance (ADS) which uses aircraft transponders and data communication links to keep Air Traffic Control (ATC) and other aircraft informed of the position and status of an aircraft.

Search and Rescue alerting - Emergency Locator Transmitters (ELTs) which transmit a signal to a satellite indicating an emergency to authorities and indicating the position of the transmitter.

Nowhere in the world is the transition to CNS/ATM being accomplished more rapidly than the Asia-Pacific region. In the South Pacific, current implementation is focussing on the FANS-1 system. This region has seen the implementation of: 1) GPS for en route, 2) data link via INMARSAT II, and 3) ADS. This is being accomplished primarily by Qantas, Air New Zealand, United Airlines and Cathay Pacific.

Currently, GPS en route is operational in Australia, Canada, New Zealand, and the United States. Work has also begun on the development of GPS overlays for non-precision approaches in Canada, Australia, and the United States. The United States and Japan are currently developing WAAS and MTSAT which will be the backbone of the air-ground

data/voice communication system and GNSS augmentation for North America and the Eastern Pacific.

Many economies have developed implementation plans for the transition to CNS/ATM. These economies include, but are not limited to, Australia, Canada, New Zealand, Thailand, and the United States. A concerted effort is being made by many of the other economies to develop their implementation plans. A detailed regional plan has also been developed through the efforts of ICAO's working group, APANPIRG. By 2005, it is expected that full CNS/ATM services will be available across the region.

1.3 Benefits

The use of these technologies is said to be the greatest innovation in the marine industry since the introduction of radar, bringing safer, more effective, and efficient navigation systems. Anticipated benefits include: better weather routing, reduced congestion in confined waters, reduced pilot services, reduced terrestrial infrastructure, improved environmental controls, and improved search and rescue.

Implementation in the aviation sector, is being driven by anticipated benefits such as: more efficient routing, increased airspace utilization, ability to land in adverse conditions, reduced terrestrial infrastructure, increased controller productivity, and improved search and rescue.

While the use of these technologies will bring both economic and safety benefits, as with change brought about by any new technology, their implementation will present new, and often unforeseen, problems. The purpose of the Panels were to try to anticipate some of those problems and define possible solutions.

1.4 Scope

The subject of the Panel was the impact of satellite navigation, communications, and surveillance on marine and air transportation safety in the APEC economies. The Panel focused on the use of satellite based technologies for determination of the vessel and aircraft positions, communicating that position to others, and relating that position to the surrounding world. The Panel assumed that the space segment of the navigation system exists and is reliable. It was only concerned with communications to the extent that it is part of the navigational and air traffic control systems.

While the study's mandate covered all of the APEC economies, it was realized that the expertise and experience of the panel pertained primarily to North America. Views from the non-North American APEC economies will be obtained from other sources to add to the Panels' conclusions.

1.5 Questions

The Marine Panel considered the following questions:

Problem Identification:

What *safety problems* do you expect from future communication, navigation and surveillance systems? Examples of problem areas include: availability and application of standards, training, back-up systems, duplication of equipment and services, cultural and linguistic differences, and transition situations.

Problem Prioritization

Which are the *most important* safety problems? How would you rank them in terms of their impact on safe marine transport operations. Consideration should be given to both the likelihood of a problem and the severity of the consequences.

Problem Mitigation
What are *others* doing? Maritime administrations, the shipping industry, equipment manufacturers, and international organizations such as IMO have ongoing efforts to mitigate problems concerning the safety of navigation and the protection of the marine environment.

What can *APEC* do? Given the activities of others and the capabilities of APEC as an organization, what are the most effective roles for APEC to pursue.

The Aviation Panel was asked to consider the following questions:

Area Identification: What are the "*Areas to be Addressed*" which will result from the introduction of future communication, navigation and surveillance systems? Examples of areas include: availability and application of standards, training, back-up systems, duplication of equipment and services, cultural and linguistic differences, and transition situations.

Area Prioritization: Which are the *most important* "Areas to be Addressed"? How would you rank them in terms of their impact on safe air transport operations. Consideration should be given to both the likelihood of a problem and the severity of the consequences

Mitigation: What are *others* doing? Organizations such as ICAO, civil aviation authorities, airlines, and manufacturers have ongoing efforts to mitigate issues as they arise. What can APEC do, given the activities of others and the capabilities of APEC as an organization.

The group did not feel that it was productive or possible to prioritize the major issues, and so this was not done.

1.6 Scenarios

To ensure that all aspects of marine transportation were covered, the Marine Panel considered problems which arise in different situations according to the following matrix:

	Oceanic Waters	**Coastal Waters**	**Confined Waters**
Commercial Shipping			
Fishing Boats			
Pleasure Boats			

To ensure that all aspects of air transportation were covered, the Aviation Panel considered problems which arise in different situation according to the following matrix:

	Oceanic Airspace	**Continental Airspace**	**Terminal Airspace**
Commercial Aviation			
General Aviation			

1.7 GDSS

Group Decision Support Software (GDSS) was used by the panel participants to help identify, evaluate, and rank issues arising from the use of satellite navigation and communication technologies in APEC economies.

The GDSS tool consists of a network of computers accessing software designed to support idea generation, idea consolidation, idea evaluation, and planning. Each participant had their own computer terminal from which they interacted with the group electronically. The tool supports, but does not replace, verbal interaction; typically 30 percent of interactions take place on the computers.

Advantages of using the tool over a traditional workshop approach include: better idea generation and alternative evaluation, full and equal participation by group members, and automatic documentation of deliberations. The Panel's experience in using GDSS was very positive.

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2. Process

2.1 Agenda

The following was the agenda for the day. Subsequent sections of this chapter describe briefly the activities of each part. Participants on the Panels are listed in Appendix A.

08:45	Coffee
09:00	Opening Remarks
09:30	Technology Warmup
09:45	Issue Identification
10:45	Health Break
11:00	Issue Identification (continued)
12:00	Lunch
12:45	Issue Prioritization
14:00	Health Break
14:15	Issue Mitigation
15:30	Next Steps & Reflection
16:00	Departure

2.2 Opening Remarks

The project manager and the scientific authority began the day by explaining the background and context for the study. That information is contained in the Introduction to this report.

The panel facilitator then explained the approach to safety analysis which would be used through the day. The overhead slides for the presentations are contained in Appendix B. The objectives were described as:

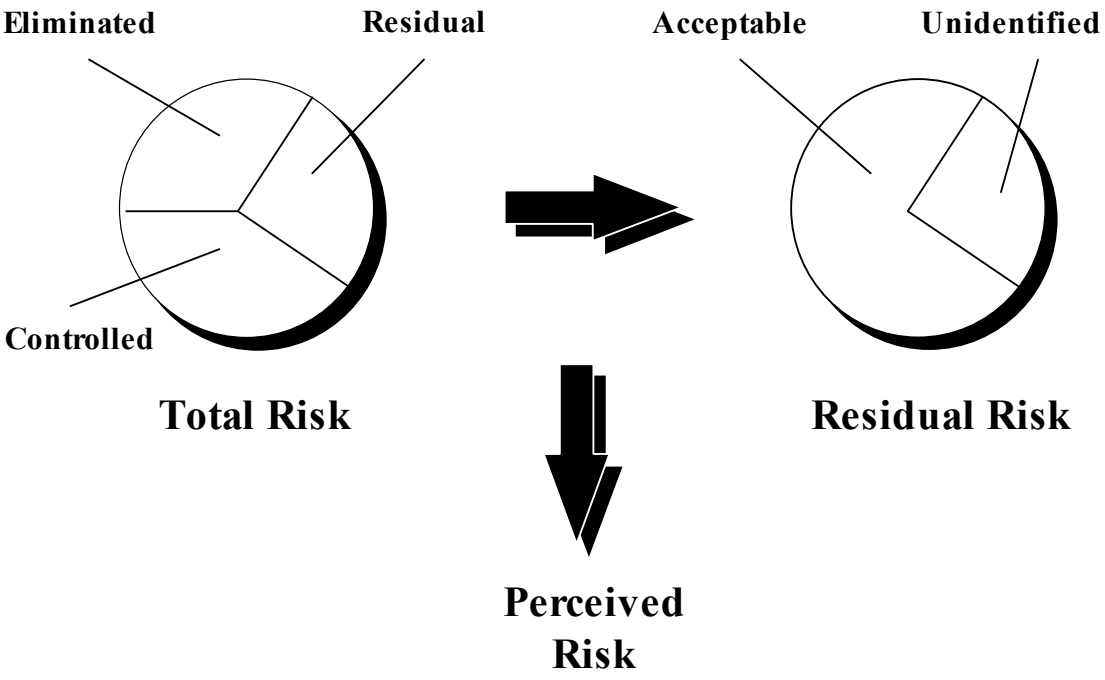
- To identify *system deficiencies* which may result from the *change in operating conditions* created by the implementation of new technologies.

- To assess the *risk* of incidents resulting from those deficiencies.
- To propose actions for *mitigation*.

The following definitions were given:

- *Safety*: A condition achieved through the systematic process of identifying and forecasting risks, and developing facilities, services, programs or procedures to minimize those risks, thereby preventing the loss of resources due to accidents or incidents.
- *Hazard*: An event, condition or circumstance which can lead to a loss.
- *System Deficiency*: The circumstances which permit hazards of a like nature to exist within a system.
- *Risk*: The potential consequence of a hazard measured in terms of probability and severity.
- *Mitigation*: The measures taken to reduce the probability or severity of a risk.

The following diagram was used to examine different types of risk:



This diagram shows risk under equilibrium conditions. Of the total risk, part is eliminated and part is controlled through mitigation efforts. The remaining residual risk is either acceptable or unidentified. Perception of risk by the general public is influenced by total risk and residual risk, but is very difficult to classify and quantify.

The introduction of satellite navigation, communications and surveillance will create a change in the diagram. Most international organizations (e.g., ICAO, IATA, IMO, etc.) expect total risk to decrease. However, the characteristics of that risk will change, and the aspects which can be eliminated, controlled, or accepted will change. Of course there will still be unidentified risks. The purpose of the Panel was to identify the changes which can be expected and to offer suggestions on how best to eliminate and control the new risk situation.

Safety issues are often examined through a process which starts with the identification of hazards and evaluates the risk associated with those hazards. In the present situation, it is operating conditions which have changed and it is not necessary to begin by identifying hazards. Therefore, the process which was used was as follows:

Describe the changes in technologies,

- Identify the resulting changes in operating conditions,
- Forecast potential system deficiencies given these changes in operating conditions,
- Group these system deficiencies into major safety issues,
- Prioritize these safety issues,
- Discuss possible options for mitigation.

The matrix of scenarios described in Section 1.6 was used as an aid to help ensure that all situations were considered.

The Marine Panel prioritized the issues by considering the following factors:

- *Probability*: How likely are the problems for a given activity.
- *Severity*: What will the outcome of the problems be in terms of health, economics, and the environment.
- *Frequency*: How often will the problems occur.
- *Scope*: How widespread are the problems around the world.
- *Controllability*: Can anything be reasonably done to mitigate the problems.

The Aviation Panel did not feel that it was productive or possible to prioritize the issues, so this was not done.

3. Results

3.1 Marine Results

This section summarizes the results of the Marine Panel's efforts.

3.1.1 Changes in Operating Conditions

The first task for the Panel was to list the changes in operating conditions which they foresaw resulting from the implementation of satellite navigation, communications and surveillance. The full list of 91 items is contained in Appendix C. Highlights include:

- Increased access to sophisticated navigation equipment.
- Increased technical skills required.
- Increased training requirements.
- Reduced crew sizes.
- Use of navigation equipment by less knowledgeable people.
- Reduction in traditional navigation services and support.
- Move to commercialization of services and support.
- Increased vessel speed and draft.
- Increased navigation capability.
- Increased navigation in poor conditions.
- Uncertainty over liability.
- Standards lag technology introduction.
- Integration difficulties, lack of uniformity.
- Increased data requirements.

3.1.2 System Deficiencies

The Panel was then asked to think of system deficiencies which may result from the changes in operating conditions. A list of 28 possible system deficiencies was created and elaborated upon. The list, with comments, is contained in Appendix D. The headings are:

- Accuracy of chart data less than positional capability.
- AIS technology not yet fully developed.
- Back-up/prediction of quality capability for DGPS failure.
- Chart data/DGPS not universally/uniformly available.
- ECDIS allows for navigation in extreme weather conditions.
- Expertise not available in an emergency situation.
- Fail-safe and back-up standards for ship and shore systems.
- Gap in utilization among users and non-users.
- GPS redundancy on board ship.
- Greater risk of casualties - vessels pushing the limits.
- Increase in stress load on Masters.
- Increased use of non-standard equipment.
- Industry push for greater efficiency.
- Insufficient training available for safe use of ECDIS and GPS.
- Lack of chart availability.
- Lack of information.
- Lack of infrastructure for updating.
- Lack of regulations.
- Lack of standards.
- Lack of system integration.
- Lack of training.
- Lack of training capacity.
- Need ergonomically designed INS.

- Need improved positional accuracy - not two-dimensional.
- Negative human reaction to electronic surveillance.
- Reduced VTS Radar coverage.
- Shore administrations-redesign of navigation system.
- Training and education of mariner.

3.1.3 Safety Issues

Panel members were then asked to group similar system deficiencies into safety issues. Nine safety issues were identified. To ensure completeness, Panel members were asked to reflect on these nine safety issues and consider the matrix of marine transportation scenarios (Section 1.6) in an effort to elicit missing issues. A further 16 issues were identified. The Panel was then asked to rank these 25 issues by picking the eight each felt were most important. The safety issues and their scores are listed here in order of importance:

1.	Lack of training capacity (ability to respond) & training of mariner.	10
2.	Lack of standards: equipment positioning, technical.	9
3.	Infrastructure demands (not in place/needs improvement/management).	9
4.	Lack of chart availability and accuracy.	9
5.	Economic forces on mariner (efficiency, stress).	5
6.	Lack of regulations -> keeping up with technology.	4
7.	Reliance on sub-standard equipment -> doubtful data, etc.	4
8.	Increase in traffic in commercial marine system (->congestion).	4
9.	VTS management system - no longer 1-way flow -> multifunctional IS.	3
10.	Different cultures/risk capacities in APEC countries(for pleasure craft).	3
11.	Need ergonomically designed INS (human-related).	2
12.	Language differences re: software understanding (e.g., multilingual crews).	2
13.	GMDSS - regulation keeping up with pace of technology + conformance.	2
14.	Workload pressures.	2
15.	Technological deficiencies (e.g., high speed craft).	1
16.	Pleasure boat industry no longer part of system (e.g., AIS technology).	1
17.	Interference of GPS signal -> redundancy and backup.	1
18.	Danger of early retirement of existing navigation systems (e.g., LORAN-C).	1
19.	Impact of new mobile sat-com technology on marine systems.	1
20.	Small boater will abuse technology (venture into hazardous areas).	1
21.	Negative human reaction to electronic surveillance.	0
22.	Commercial security (tracking trade routes, AIS).	0
23.	Pleasure craft training issues (e.g., no ability to navigate).	0

24. Smaller boats reliance on nav-aids -> increased pressure on coast guards. 0
25. Lack of accurate information (commercial cruises) that is verified. 0

The list of issues, and their underlying system deficiencies, is contained in Appendix E.

3.1.4 Mitigation

The top ten safety issues were considered further to examine needs and actions for mitigation. Mitigation was considered in terms of:

- What needs to be done.
- What others are doing.
- What APEC could do.

The detailed results of the first two points are contained in Appendix F. The third point is covered in Appendix G. These results are summarized in this section.

Lack of training capacity (ability to respond) & training of mariner.

What needs to be done

- The required curriculum for mariner's certification should be expanded to include training in satellite navigation and ECDIS equipment.
- For mariners currently holding papers, certification for proper operation of satellite navigation and ECDIS equipment should be required from an approved training course.
- Recreational boating organizations, such as the Power Boat Squadron, should be encouraged to offer training in satellite navigation and ECS equipment.

What others are doing

- IMO sets the standards for GMDSS and other training. It has expanded the STCW Convention and is developing a Code of Safe Navigation and Watchkeeping.

- Shipowners, marine training institutes, manufacturers, suppliers, and governments are involved in training.

What APEC could do

- Encourage training to international standards. Economies could pool training resources.
- Sponsor the development of training equipment, such as simulators.

Lack of standards: equipment positioning, technical, INS.

What needs to be done

- Enforce the use of approved equipment on ships.
- Work towards the establishment of standardized VTS/AIS systems.
- Identify gaps in standards and the appropriate bodies to pursue their development.

What others are doing

- IHO S57 standard for ECDIS data. IMO performance standard for ECDIS, developing INS and IBS standards. IALA, ITU-R, IEC also involved.
- Manufacturers are working with standards organizations.
- Maritime Administrations are attempting to enforce standards.

What APEC could do

- Develop training standards

Infrastructure demands (not in place/needs improvement/management).

What needs to be done

- Administrations should develop logical, rational, and long-range infrastructure plans for satellite navigation systems.
- Hydrographic offices should provide digital chart data to IHO standards for their waters, either individually or on a regional basis.
- Arrangements are needed for the updating of electronic charts, Notices to Mariners, etc.

What others are doing

- Governments are working with industry to establish new mobile sat-com infrastructure.
- Private enterprise is recognizing the business opportunities.
- A number of countries are installing DGPS.

What APEC could do

- Encourage the development and sharing of infrastructure plans.

Lack of chart availability and accuracy.

What needs to be done

- Examine the suitability of all paper charts for conversion to ENC. Re-survey areas if necessary to WGS 84. Develop an ENC updating mechanism.
- Create special electronic charts for high traffic areas, and docks and loading facilities.

What others are doing

- Nations are continuing to digitize chart folios. High traffic areas are being given priority.

- IHO is addressing standards problem.

What APEC could do

- Endorse international standards.
- Encourage increased resourcing of hydrographic offices for the purpose of conversion to ENC.
- Support sharing of geodetic and hydrographic information.

Economic forces on mariner (efficiency, stress).

What needs to be done

- Industry and government should work together to develop cost effective infrastructures.
- Government, equipment providers, and the marine industry should exchange ideas on needs and solutions.

What others are doing

- Manufacturers are attempting to provide increased efficiency and reduced stress for mariners through the use of technology.

What APEC could do

- Develop cooperative efforts among APEC economies for the marine transfer of goods.

Lack of regulations - keeping up with technology.

What needs to be done

- International standards setting bodies need to significantly shorten the time required for the introduction of new technical and operational standards.
- National standards setting bodies need to work together to harmonize standards.

What others are doing

- Regulators are moving to establish guidelines instead of laws in an effort to reduce the time lag in regulatory change.
- The need for consensus among IMO membership, and then implementation in individual economies, takes time.

What APEC could do

- Encourage and support cooperation among national standards setting bodies.

Reliance on sub-standard equipment , doubtful data, etc.

What needs to be done

- More international cooperation and interest in resource sharing and standards.
- More information and training.

What others are doing

- IMO is attempting to write standards for equipment.
- Reputable manufacturers are attempting to live by standards.

What APEC could do

- Encourage the use of approved equipment on all vessels.
- Encourage vessels to carry back-up equipment.

Increase in traffic in commercial marine system (congestion).

What needs to be done

- Prioritize the movement of vessels constrained by draft, or which pose a risk to public and environmental safety.

What others are doing

- Some large ports are using GPS to speed harbour movements.

What APEC could do

- Cooperation is needed in multinational/international waters for the provision of infrastructure (VTS, etc.)

VTS management system - no longer one way flow of information.

What needs to be done

- Feasibility trials towards an international AIS standard.
- International integration of VTS systems.
- Regulatory amendments for mandatory carriage of AIS equipment.

What others are doing

- Many operators feel they want to be independent of VTS.
- The European marine community is undertaking a major program to integrate VTS systems across several nations.

What APEC could do

- Support international organizations and encourage continued international cooperation in standards development.
- Support the international VTS cooperation and database sharing.

Different cultures/risk capacities in APEC countries.

What needs to be done

- Identify specific problems created by introducing new technologies in APEC economies.
- Provide solutions through education and regulation, as appropriate.

What APEC could do

- Technical and financial assistance is needed by some economies.

3.2 Aviation Results

This section summarizes the results of the Aviation Panel's efforts.

3.2.1 Changes in Operating Conditions

The first task for the Panel was to list the changes in operating conditions which they foresaw resulting from the implementation of satellite navigation, communications and surveillance. The full list of 45 items is contained in Appendix H. Highlights include:

- New and complex avionics and ATC equipment.
- Database integrity and software configuration control.
- Standards, regulations and procedures.
- Mixtures of aircraft capabilities and airspace traffic segregation.
- WGS-84 surveys and navigational charts.

- System integrity.

3.2.2 Areas to be Addressed

The Panel was then asked to identify "Areas to be Addressed" which may result from the changes in operating conditions. A process of review and discussion resulted in the merging of these areas into nine issues. The list, with comments, is contained in Appendix I. The headings are:

- Training deficiencies and lack of training tools,
- Human limitations to adapt to new interfaces / Human factors,
- Potential for database errors / Integrity of database,
- Airtraffic management / Segregation of traffic,
- Inflight Procedures / Reduced margins of error,
- Standards and regulatory environment,
- Software integrity / Configuration management,
- Universal standards implementation for CNS, and
- Lack of complete CNS standards for performance.

3.2.3 Mitigation

The nine issues were considered further to examine needs and actions for mitigation. Mitigation was considered in terms of:

- What needs to be done.

- What others are doing.

- What APEC could do.

The detailed results are contained in Appendix J. A summary, which focusses on possible APEC action, is covered in Appendix K and reproduced here:

1. Training deficiencies and lack of training tools

- Appropriate training programs must be in place for all involved (state would oversee / establish a process for certification; need to have the experts establish the programs not the state).
- Need for information exchange between CAAs.
- APEC should be made aware of need to train CAAs and encouraged to do it.

2. Human limitations to adapt to new interfaces / Human factors

- Support development of common interface standards (e.g., avionics and ATC displays).
- Clearly stated operating procedures required.

3. Potential for data base errors / Integrity of database

- One problem is the inconsistency/incompatibility between software.
- To enhance database integrity, manufacturers need to share information on errors, etc.
- Standard for database process currently being developed.
- Communication of an error that has been detected. Need to have a feed to CAA in the state where the error occurred (using internet, perhaps).

4. Air traffic management / Segregation of traffic

- Fundamental shortfall: lack of an infrastructure in APEC region.
- Must have a harmonization of systems in APEC region.
- Offer benefits to users such as more efficient routes.

5. Inflight Procedures / Reduced margins of error

- Route offset issue: may need further study on exactly how the problem is defined.

- Need to identify inflight procedures by approved company operating procedures, e.g., there would be an approved company manual to handle inflight problems.

6. Standards and regulatory environment

- TC has put their information on their own web page. Perhaps ICAO can have on their home page some references to related sites. Need to encourage states that have expertise in the relevant area to get their info on the web site (tied to ICAO web site).

- Problem: notification of a state's non-compliance to any particular standard; maybe on ICAO home page

7. Software Integrity (e.g., many different revisions)

- Support the RTCA and ICAO development work.

8. Universal standards implementation for CNS (e.g., world wide planning)

- APEC should support development of international standards through these agencies.

9. IN GENERAL: What needs to be done?

Five areas where APEC can help:

- Training (planning, promoting seminars etc.)
- Trials and demonstrations
- Cooperative arrangements (to resolve conflict, funding mechanisms, to facilitate ICAO SARPS implementation, costing issues, to facilitate ATM in region, etc.)
- Support ICAO activities and other international organizations
- Funding for WGS84.

- APEC might assist/intervene at the political level to encourage regional adoption of CNS/ATM technology and support their CNS/ATM implementation committees.

- CNS/ATM global planning and regional implementation benefits to be gained by incremental implementation.

- Info exchange and supporting communications systems across APEC states could be improved (Informatics, Internet, computers, fax, etc.).

3.2.4 Reflection

Panel members were given a final opportunity to provide input during a period of reflection on the following points:

1. Initial FEELINGS, INTUITION, EMOTIONS for the Program...

2. Other SUGGESTIONS, IDEAS, POSSIBILITIES you have...

3. CONCERNS, PROBLEMS, RISKS, DANGERS and DIFFICULTIES...

4. BENEFITS? GOOD POINTS of the Program...

The results of that reflection are contained in Appendix L.

Appendix A

Participants

MARINE EXPERT PANEL

Members of the Marine Expert Panel were selected to represent users, providers, and regulators of satellite based navigation, communications and surveillance technologies for marine transportation. All of these people should be commended for attending, often from very far away, and working very hard all day, especially since the panel was held on the Friday before a long weekend. In addition to the Panel members, there were two facilitators.

Facilitators

David Arthurs,	Hickling Corporation
Erik Lockhart,	Queen's Executive Decision Centre

Panel Members

1.	David Low,	Hickling Corporation (Project Manager)
2.	James Reid,	Transportation Development Centre (Scientific Authority)
3.	David Jenkins,	Transport Canada
4.	David Jackson,	Canadian Coast Guard
5.	Byron Dawe,	Canadian Centre for Marine Communications
6.	Kent Malone,	Nautical Data International
7.	Michael Casey,	Canadian Hydrographic Service
8.	Andrew Rae,	Canadian Marine Pilots Association
9.	Barry Allcock,	Offshore Systems Limited
10.	Bert Tepper,	Canadian Coast Guard

AVIATION EXPERT PANEL

Members of the Aviation Expert Panel were selected to represent users, providers, and regulators of satellite based navigation, communications and surveillance technologies for air transportation. All of these people should be commended for attending, often from very far away, and working very hard all day. In addition to the Panel members, there were two facilitators and two observers.

Facilitators

David Arthurs,	Hickling Corporation
Erik Lockhart,	Queen's Executive Decision Centre

Panel Members

1. Ron D'Ambrosio, Transport Canada
2. Doug Ballantyne, Transportation Development Centre
3. Michael Beamish, Pelorus Navigation Systems
4. Ross Bowie, Transport Canada
5. Judimar Das Chagas, International Civil Aviation Organization
6. Frank Flood, Canadian Air Line Pilot's Association
7. Don MacKeigan, Transport Canada
8. Barry Myers, Transportation Development Centre
9. Howard Posluns, Transportation Development Centre
10. Jack Squires, Air Transport Association of Canada

Observers

David Low, Hickling Corporation
Heather Roy, Hickling Corporation

Appendix B

Overheads

(Not available in electronic format/
Non disponible en format électronique)

Appendix C

Changes in Operating Conditions

1. Cheaper, more available to less knowledgeable people.
2. Accuracy of data (charts) less than positional capability.
3. AIS implementation reduces traditional VTS radar coverage.
4. Arguments may arise between VTS and ship operators re. actions to take.
5. Backup and alternative positioning systems needed for DGPS.
6. Backup system for ECDIS needs fast switchover.
7. Blind navigation transits increasing.
8. Calling in points (VTS) could be eliminated.
9. Can a computer virus affect an ECDIS?
10. Can SAR authorities manage rise in EPIRB alerts?
11. Canadian industry has dominant position in ECDIS/ECS in APEC.
12. Captains have too many individual equipments to integrate.
13. CCG/CHS need a means to address huge increase in reported notices.
14. Chart data & DGPS not available uniformly throughout trade route.
15. Cheaper versions of ECDIS.
16. Closer monitoring of operations personnel is possible(black box).
17. Common navigational systems with aviation.
18. Cost recovery means cost sharing scenarios between gov't and private sector.
19. Current technology inadequate for HSC.
20. Decreased interest in "human factor" as expense of training increases.
21. Demand for different types of data to be presented on ECDIS.
22. Demands for new types of data to be presented on ECDIS.
23. DGPS alarms on board vessels when threshold reached.
24. DGPS becomes fully commercial service.
25. ECDIS/AIS/Radar integration reduces bridge compliment-workload up.
26. Electronic charts around the globe.
27. Fast ships create new problems.
28. GPS will become commonplace on all marine craft.
29. Greater emphasis on bridge design.
30. Greater emphasis on international standardization.
31. Greater navigation capability in confined waters/adverse weather.
32. Greater risk of larger incidents as ships "push the limit".
33. HSC changing whole new ship management/navigation regime.
34. HSC craft require collision regulations to be revised considerably.
35. Improved positional accuracy impacts vessel operating speed/draft.
36. Improved relationships between manufacturers/shipowners/govts.
37. Increased capital investment required.
38. Increased education requirement for personnel.
39. Increased focus on technological problems involved in accidents.
40. Increased requirement for shore-based information.
41. Increased stress level of Ship's Master.

42. Increased technical skills required for service and support.
43. Inexpensive raster based ECDIS backups need evaluation.
44. Just-in-time ship berthing requirement.
45. Lack of education in 3rd world crews -technology problems.
46. Lack of up-to-date and accurate chart information renders ECDIS unsafe.
47. Language problems with multilingual crews.
48. Large scale chart info needed for docking.
49. Less crew - less ship maintenance.
50. Liability for GPS navigation errors major problem.
51. Made-in-Canada solutions are practical, do-able and sustainable.
52. Marine technology reduces shore-based support systems(VTS/Pilotage).
53. Mariner wants technology to be independent of VTS.
54. More information available at a single bridge location.
55. Multi-modal transportation issues need to be addressed.
56. New systems are introduced without proper certification.
57. New technologies are introduced to help gov't meet cost reductions.
58. New technology will allow collaboration of data gathering, ships will gather.
59. Not all ships may have the latest technologies, lack of uniformity.
60. Officers faced with very complex equipment.
61. One-man bridge will mean need for data from bridge to be displayed throughout.
62. Operators are afraid to accept the technology for fear of losing job.
63. Over-familiarity/confidence with equipment can lead to problems.
64. Paper notices and ECDIS updates need to be fused.
65. PC commercial system robustness/availability leads to failures.
66. Pilots need carry-on ECDIS to handle foreign ships.
67. Port information (facilities) need to be integrated real-time into ECDIS.
68. Radar and ECDIS will be integrated to simplify bridge operations.
69. Reduced people on bridge.
70. Reduced stress levels on bridge.
71. Reduced workload for mariner.
72. Reduction in fixed and floating Aids to Navigation.
73. Refocussing of mariner training.
74. Regulators can't keep up with standards implementations.
75. Ship owners demand VTS efficiency to serve their needs.
76. Shipping companies need economic motivation to implement new technology.
77. Standardization severely lags technology introduction.
78. Technology proceeding well beyond scope of average understanding.
79. Too much communication, not enough understanding-AMOCO CADIZ.
80. Traditional control by master eroded by instant shore-based comm.
81. Traffic congestion in critical areas will rise substantially.
82. Training centres trying to provide necessary training.

83. Training issues must address shortcomings in data.
84. Training must address system limitations.
85. What are reasonable levels of short range navigational aids ?
86. What is the effect of nutation on WGS 84 ?
87. What safe guards are necessary to protect GPS receivers from EMI ?
88. Who tracks vessels in disputed waterways?
89. Will Loran C be approved as a backup for DGPS?
90. Automated berthing and unberthing systems will come into common usage.
91. Real-time water level prediction will allow more economical shipping.

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Appendix D

System Deficiencies

1. Accuracy of chart data less than positional capability.

- Chart positional accuracy varies from 5m to 50m. DGPS 3 to 5m.
- Charts frequently used in overscale e.g. at locks, berthing, and channel navigation.

2. AIS technology not yet fully developed

- Currently some proposed systems do not have the required capacity to handle ship position reports.
- Misuse of this sensor for general data transmission could lead to overloading of the communication channel. Transmission priorities have not fully been established.
- Schemes for system adaptability in response to dynamic ship manoeuvres need to be developed .

3. Back-up/prediction of quality capability for DGPS failure.

- Essential for passage planning (restricted waters). e.g. low visibility operation, e.g. berthing of VLCC

4. Chart data/DGPS not universally / uniformly available.

- For effective world wide navigation, data must be standard and differential services provided. Many areas where no data or DGPS e.g. West Africa

5. ECDIS allows for navigation in extreme weather conditions

- Permits navigation when the vessel would otherwise have remained at anchor or tied-up.

6. Expertise not available in an emergency situation.

- Officers of the watch may not be fully trained or experienced in alternative methods of navigation.

7. Fail-safe and Back-up standards for ship and shore systems

- ECDIS and DGPS need fail-safe or "fail-soft" designs to handle cases of loss of power, fatal system errors or other. ECDIS/DGPS under stress in periods of docking in poor visibility conditions, navigating narrow passage areas etc. will require a means to switch to a new mode of operation in case of failure. Users will need advance warning of failure (fail-soft) in order to prepare alternatives. Back-ups for DGPS will not be Loran C unless US changes position. GPS/GLONASS will require western funding support.

8. Gap in utilization among users and non-users

- Non-uniform fitting of marine craft could lead to increased traffic hazards.
- New problems could arise in the VTS area.

9. GPS redundancy on board ship

- With the ever increasing use and almost total reliance on GPS there is an urgent requirement to ensure redundant systems.
- The planned elimination of terrestrial systems e.g. Loran-C needs to be reviewed.
- There has to be a clearly defined main GPS system security check.

10. Greater risk of casualties - vessels pushing the limits.

- Increased operation in adverse conditions in confined waters/overconfidence in system. e.g. Narrow channels, fog, rain, etc.

11. Increase in stress load on Masters

- Masters will become more stressed as they will carry traditional responsibilities (already stressful) as well as the stress of assuring that systems are functioning properly. Masters will have to ensure that bridge crew are properly trained and are attentive to requirements. Masters will be held culpable to failures as increasingly shipowners are beyond the reach of gov't authorities. One man bridge designs will increase requirement for bridge crew to be attentive and not lulled into sense of false security. System design will have to consider human factors issues that address these concerns. Additionally training programs will have to be re-designed for ECDIS/DGPS accreditation.

12. Increased use of non-standard equipment.

- Market forces and user eagerness encourages the proliferation of non-standard equipment.

- In the interest of safety full effect to the efforts of international standardization should be given. At the same time the international standardization bodies need to find a mechanism to carry out their work more quickly.

13. Industry push for greater efficiency

- Inadequate redundancy, smaller craft face new hazards, greater risk of incidents in the near term.

14. Insufficient training available for safe use of ECDIS and GPS

- Potentially more serious for recreation and fishing than for large commercial operators who employ professional mariners.

15. Lack of chart availability

- Charts may either not be available or be of indeterminable accuracy and content.

16. Lack of information

- Charts, coverage, accuracy, errors. Need more accurate charts-ECDIS does not run without an ENC, with current digitization and surveys mariners are using a positioning system that is more accurate than the chart in use. ENCs are not yet universal, many areas of the world are not covered, in fact most areas. World wide hydrographic information standardization is a necessity.

17. Lack of infrastructure for updating

- Infrastructure is required for the assimilation, creation and distribution of electronic updates.

18. Lack of regulations

- Do not have adequate navigation technology - e.g. HSC

19. Lack of standards

- ECDIS/ECS and other navigation, communications systems have poor human-machine interfaces and lack standards

20. Lack of system integration

- CCG captains acknowledge the usefulness of modern navigation equipment but have repeatedly stated that the diverse equipment must be fully integrated on the bridge at a central station such as an ECDIS.
- To achieve this objective requires the preparation of appropriate interface standards.

21. Lack of training

- Officers not trained to handle integrated bridge systems

22. Lack of training capacity

- The rapid introduction of new technology systems leads to an overload on qualified training facilities.
- Questions arise as to who is responsible for training: governments, ship owners, equipment suppliers, IMO, ITU-R.

23. Need ergonomically designed INS

- With new and increased technology, the standard, simple operation of navigation equipment is essential. e.g. Open bridge wings.

- New technology demands standardisation of positioning, controls, etc. e.g. Open bridge wings.

24. Need improved positional accuracy - not two-dimensional.

- Need to take into account hydrodynamic influence on vessel. e.g. various effects such a increased draft in turns, squat etc.

25. Negative human reaction to electronic surveillance.

- Vessel operations monitored through AIS, fleet tracking, or 'black box' capabilities of ECDIS.

26. Reduced VTS Radar coverage.

- Reliance on transponders, vessels without would be undetected.

27. Shore administrations-redesign of navigation system

- With the advent of such high tech wonders as ECDIS, DGPS etc., the vessel has the ability to position itself to an unheard of degree in real time, thereby obviating traditional safety margins and being able to operate closer to the limit. This obviates the need for traditional navigation systems in say an area such as Voisey's Bay. A shore administration (say CCG) may now be able to shift the investment in navigation ability back to the private company, instead of having to provide buoys, lighthouses, fog signals etc. CCG may now say they provide the positioning system, but all ships entering this area MUST have the following: ECDIS, integrated gyro, echo sounder, speed log, radar overlay, communications equipment, AIS etc. This may then be a "test case" for other areas. It should also be understood that shore administrations are suffering from a cash shortage, but a vast increase in "information-supply" requirements. All the statements about "more port information; more multi-modal information; more tide information; more this; more that etc." have to come from somewhere and be provided and input by someone.

28. Training and education of mariner

- With the vast increase in technology, a firm understanding of its limitations and uses is required. This requires a training program that is holistic. Not only technology needs to be understood, but operational practices with that technology. Another concern is with the lifecycle of high tech ships. Ships these days generally have a life of 5-7 years, after which they are sold, usually to some third world shipping power. What about the crews for these ships designed for highly trained mariners? You can bet that the company that buys them will not be able to hire the same quality crew.

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Appendix E

Safety Issues

1. **Lack of training capacity (ability to respond) & training of mariner**
   Score: 10

- System Deficiencies: 6, 14, 21, 22, 29.

2. **Lack of standards: equipment positioning, technical**
   Score: 9

- System Deficiencies: 3, 7, 8, 9, 12, 19, 20.

3. **Infrastructure demands (not in place/needs improvement/management)**
   Score: 9

- System Deficiencies: 2, 4, 27, 28.
- Management of infrastructure; PLBs, IPRBs, pleasure boats, false alerts, does SE Asia have infrastructure in place to handle all the alerts?
- Handling bi-directional info flow, bandwidth and use of channel, reporting is one thing - response is another, e.g. buoys out of position
- Contested waterways -> who is tracking the coordination of info systems?

4. **Lack of chart availability and accuracy**
   Score: 9

- System Deficiencies: 1, 4, 15, 16.
- Accuracy of hydrographic data (Resurveying required)

5. **Economic forces on mariner (efficiency, stress,)**
   Score: 5

- System Deficiencies: 5, 10, 11, 13.

6. **Lack of regulations - keeping up with technology**
   Score: 4

- System Deficiencies: 18.

- Collision avoidance regulations
- Misuse of AIS channels

7. Reliance on sub-standard equipment -> doubtful data, etc.
Score: 4

- e.g. small ECS, track plotters,

8. Increase in traffic in commercial marine system (->congestion)
Score: 4

9. VTS management system - no longer one way flow -> multifunctional IS
Score: 3

- Vessel information systems

10. Different cultures/risk capacities in APEC countries (for pleasure craft)
Score: 3

11. Need ergonomically designed INS (human-related)
Score: 2

- System Deficiencies: 20, 23, 24.

12. Language differences re: software understanding (e.g. Multilingual crews)
Score: 2

13. GMDSS - regulation keeping up with pace of technology + conformance
Score: 2

14. Workload pressures
Score: 2

15. Technological deficiencies (e.g. high speed craft)
Score: 1

- System Deficiency: 25.

16. Pleasure boat industry no longer part of system (e.g.. AIS technology)
Score: 1

- Dealing with introduction of AIS technology

17. Interference of GPS signal -> redundancy and backup
Score: 1

- UHF tv, faulty IPRBs, poor installation, substandard receivers, local ships, electromagnetic interference from on board equipment

18. Danger of early retirement of existing navigation systems (e.g.. LORAN-C)
Score: 1

19. Impact of new mobile sat-com technology on marine systems
Score: 1

20. Small boater will abuse technology (venture into hazardous areas)
Score: 1

- e.g., weather hazards

21. Negative human reaction to electronic surveillance.
Score: 0

- System Deficiency: 26.

22. Commercial security (tracking trade routes, AIS)
Score: 0

23. Pleasure craft training issues (e.g.. no ability to navigate)
Score: 0

24. Smaller boats reliance on nav-aids -> incrs'd pressure on coast guards
Score: 0

- Creates vacuum for recreational boaters

25. Lack of accurate information (commercial cruises) that is verified

Score: 0

- e.g. ecotourism industry

Appendix F

Mitigation

1. Lack of training capacity (ability to respond) & training of mariner

IMO setting training standards for GMDSS and other training. Shipowners actively getting involved in training for ECDIS,BRM, GMDSS.

Marine training institutes expanding curriculums to include new tech. Manufacturers providing training for promotion and product satisfaction.

Some countries e.g. Canada have training at government expense. Training by equipment suppliers is also common.

Action is needed by IMO, regional groupings of countries to pool training resources.

Courses need to be developed to certify ships officers in the use of DGPS and ECDIS. Some preliminary work has been done on this in Canada but the issue is stalled at the moment. The CSA is contracting with a Marine Institute in the US to provide its members with the training. Course content will need to address limitations in the chart data - an issue not addressed to date. Training is not a national issue in Canada, nor throughout the world.

IMO a) expanded STCW Convention to improve training standards, b) developing Code of Safe Navigation and Watchkeeping (SNW Code)

A full appreciation that the system is an aid to navigation and not a stand alone system. That the system is intended as an enhancement of existing methods of navigation. A complete understanding of errors inherent in the system as an INS. A understanding for the need of redundancy.

NEEDS: More interest and resources for training of mariners. Greater investment in basic education infrastructure. More effective insurance rates/coverage for companies employing well trained mariners.

what is being done - NDI - training Chilean Hydrographic on production of S57 data.
what needs to be done - training Hydrographic offices on S57 data production.

needs to be done:
focus group training on use of ECDIS/ECS & GPS/DGPS.
certification required for specific classes of ships/crafts
part-task simulation capability to provide for training on-demand, anywhere, anytime.

2. Lack of standards: eqpt positioning, technical, INS

what are others doing: ECDIS data - IHO S57 standards, ECDIS - IHO S57, IMO performance standard.

what needs to be done: Raster data, Raster ECS system.

IMO/IHO drafting regulations. Other regulatory and standard setting agencies such as DNV. Government environment and safety regulations.

IMO trying to keep up by issuing standards. Manufacturers working with standards organizations - recognizing that liability is a major issue

Maritime Administrations attempting to enforce standards.

IMO preparing performance standards. Equipment manufacturers developing industry led standards.

Action to identify gaps in standards and responsible bodies to develop them.

1. IMO, IALA, ITU-R Initiatives: The above organizations are currently in the process of defining draft operational performance standards as well as the associated technical requirements standards, in particular for AIS systems. The problem with this process is that often the content of draft papers are coloured by national interest. For example if a specific nation has a manufacturer that has designed a specific navigation system there is a tendency to push that system. The positive aspect of this international standard setting process is the open debates that highlight the corresponding positive and negative issues. However, the process is slow and many nations are want to proceed uni-laterally to introduce systems. Often this haste is a result of international industry pressures.

   System standards for ECDIS and ENCs have got ahead of the technology and in some cases limited some functionality. System manufactures need (and will find) some way to differentiate themselves from the competition. Data standards are difficult to achieve for HOs and are therefore being neglected until the situation improves. There are few standards for GPS equipment and for low cost ECS. Market pressures will rule. Issues such as backup facilities, chart updating etc. are being pursued now and will not be solved for another 1 to 2 years.

IMO: Developed Performance Standards for ECDIS, Developing Standards for INS and IBS systems. Developed Performance Standards for GPS and LORAN C receivers and is developing further standards for eventual inclusion in international regulation.

IEC: Developing technical/type approval standards for the above.

IHO: Developing var intl standards.

IMO: Looking at future internationally controlled satellite navigation systems (GNSS)

Canada: Conducting R.& D. on ECDIS user interface.

Needs to be done:

1. As in the aircraft industry, only type approved marine navigation equipment is fitted on passenger vessels, product tankers and others operating under an elevated risk scenario. Other operators using non-standard nav. equipment must have hot-standby redundancy or equivalent.

2. Bridge Integration: The CCG currently supports a development project directed at standardizing the equipment layout on CCG ships.

3. ISIT=Integrated ship information terminal. This is a major development project run by some 9 companies to develop a computer system on board ships to make the use of different technology systems (e.g. communication systems) transparent to the user. This will result in a major integration level on board ships.

Full and independent appraise and testing of equipment necessary along with revisions as problems arise. The certification of onboard installation by an independent body and the developing of onboard inspection schedules.

International cooperation is the only way to create viable accepted standard. Unilateral departure from international cooperation is an incorrect philosophy and ultimately futile, and should be discouraged. This is only, in Canada anyway, the result of internal pressures from private industry in the interests of their own gain. In fact, if they had it their way, they'd no doubt abolish all standards and international cooperation, unless it was profitable.

NEEDS TO BE DONE: increase level of international cooperation and funding. Stress the requirement for working internationally, reaffirm the commitment to IMO, IHO and other international maritime bodies.

3. Infrastructure demands (not in place/needs improvement/management)

Infrastructure-Impact of new mobile sat-com technology on marine systems. Governments working with industry to establish. IMO encouraging administrations to provide infrastructure.

Those responsible for old infrastructure being proactive. ex: CHS/NDI Coast Guards. Private enterprise recognizing business opportunities. ex: INMARSAT.

A number of countries installing DGPS e.g. Canada, US, Australia, China.

needs to be done: vessel operational profile (speed, loading, sea-state) should be commensurate with the level of services available along trade route and experience of bridge crew in operating on that trade route. Mandatory carriage of critical navigation aids should be in place for high risk waterways (i.e. VTS radar coverage not available ? Then AIS transponder mandatory for all vessels 5,000 GRT and above (say))

what are others doing: CHS - project to develop infrastructure for electronic Notices to Mariners generation and distribution.

ENC creation is slow, expensive and error prone with current technology and thinking. Full ENC coverage in Canada will not be in place for many years due to low demand in many areas. DGPS coverage is also limited to the areas of the highest traffic. A means to get ENC updates to ships will initially follow land lines and then be made available to ships at sea. The complete Marine Navigation System in Canada needs re-thinking to optimize the use of new technology. Foreign vessels will need carry-on equipment in order to fit the Canadian model. Gov't agencies in other parts of the world are likely to follow the Canadian model as all share similar problems. Canada is in a leadership position (whether it wants to be or not).

Governments working to change and respond to new pressures. Difficulties lie in trying to change too much too fast, e.g.: reductions in budgets and available personnel as well as complete changes of philosophy occurring concurrently.

NEEDS: well thought out infrastructure requirements, think what we would like, then try to reach it. This can not be done in current climate of continuous battering of those employees still left. To date, any "strategic" planning has been done virtually on the back of a napkin, and panders to political pressure and individual whims. This is unacceptable.

IMO: Currently investigating and developing systems and equipment standards for AIS. Looking at future GNSS- technical, operational, institutional considerations.

IHO: Developed standards for international digitized data. Also full charting requirements - S 57, etc. Updating standards developed.

Admins: Various administrations in APEC have differential GPS services in place - including Cda, USA, Hong Kong, Australia,[Singapore?] etc. Japan planning WAAS system (MTSAT)-may be multi modal. Also INMARSAT III satellites. Various administrations anxious to put internationally compatible AIS systems in place.

1. See comments on VTS infrastructure. i.e. VTS-management

Various admins including in APEC are upgrading LORAN C chains.

4. Lack of chart availability and accuracy

Nations continuing to digitize chart folios. IHO addressing standards problem.

NEEDS: Resurvey many areas in the world, using most accurate available methods. Areas include all high volume shipping channels. More resources to digitization.

Hydrographic authorities trying to at least map high traffic areas Manufacturers attempting to provide systems for efficient cost effective mapping to take place. Vessels of opportunity being considered to provide data.

what are others doing: data availability - CHS starting S57 version 3. NDI/CHS - raster chart production. data accuracy - CHS - ground truthing.

what needs to be done: data availability - need new chart compilations from source. need new surveys. need data capture from chart base. data accuracy - new chart compilations from source, new surveys.

CHS/NDI being proactive. Manufacturers responding to customer demand for superscale detail of docks and loading facilities. Over scale validation in critical chart areas. ex: Channel navigation, locks.

Some countries well advanced in converting nautical charts to ECs but the problem is the lack of continuity of electronic charts in maritime routes.

Action is needed to target marine routes and areas and ensure availability of ECs. Perhaps a move within IMO away from voluntary action to mandated action is needed.

needs to be done: chart system must warn when chart accuracy does not match positioning system capability. overscale display warnings. notice to mariners regarding poor charting in specific regions.

The system should be capable of issuing an alert as to the reliability of the data use or if the source information has been compiled on a different datum and transferred to WGS 84 for display.

Ship owners taking own actions to resurvey in some cases.

there are distinct problems here: 1) existing charts which can be converted to ENCs but require funding. 2) existing charts with horizontal datum problems which will require some degree of field work to improve before conversion. 3) there are some charts which are inappropriate for conversion due to large uncertainties in the datum and with the contained data; these will require extensive surveying. 4) there is additional information to add to ENCs to make them more suitable; chief among these is the creation of very large scale (so-called "superscale" charts >1:1.000) for docking purposes and in confined waters. There are two issues here: i) the data exists within the port authorities and is in digital form ii) the information exists on paper form (engineering drawings) but needs conversion to digital. In each case the following issues flow: i) is the information accurate ? how can it be calibrated ? ii) can the data be converted to the ENC format ? what tools
are required. iii) how is this work to be funded ? can ports share their information with HOs in order to cost recover. iv) who/how will this data be kept up to date

5. Economic forces on Mariner (efficiency, stress,)

needs to be done: ensure adequate trials are performed under the expected navigation conditions to assess effects , then relax requirements gradually as experience dictates.

Manufacturers providing technology, Shipowners implementing the technology because they recognize the economic benefit IMO providing standards.

Manufacturers striving to produce accurate, reliable systems with built in alarms for abnormal conditions or deteriorating positional accuracy. Government agencies supporting the initiative

The Canadian marine industry is keenly interested in reshaping the VTS environment as set by the CCG. The industry argues that adopting new technology will result in economic benefits in terms of cargo carried. Due to their current attitude they wish to proceed independently of the CCG. To mitigate this problem a concerted effort should be made to ensure complete co-operation among these parties. It is entirely feasible to introduce new marine technologies jointly. This will result in the best technology being applied to meet

both operational and technical requirements as well as economies of scale. At the present time a pilot project in AIS shows a way on how this might be done.

Poor judgement decision can be the result of too much economic pressure placed on the mariner. i.e., failure to see the full picture, being too focused.

The shipowner will always want more and more for less and less, therefore there will always be stress on the mariner/master of a ship. In some cases this is healthy, in others it is not. The stresses that must be eliminated are: tighter and tighter timetables, less and less crew, less trained crew to sail his ship.

Difficult to overcome concept of "freedom on the high seas" in requiring ships to indicate position. Represents a culture change which will take time and will come with the impact of technology on decision making on the bridge.

Action will probably be dictated by the self interest of ship owners to stay abreast of technology and pursue safety.

There are two dynamics at play. Shipowners in general want their systems loaded in order to improve efficiency. This moves the ship closer to the bottom increasing risk. Regulators in general want to reduce risk and keep the ship away from the bottom reducing their risk. Over regulation will cause political problems as will any incident. regulators will struggle with keeping their ports and waterways efficient (heavy traffic, max loading) while assuring public that risks are contained. Ship masters will require training programs developed to ensure their bridge crews are adequately trained to make the right decisions.

6. Lack of regulations -> keeping up with technology

others: Health & Safety officials are moving to establish guidelines instead of acts of parliament in an effort to reduce the time lag in regulatory change.

needs to be done: establish appropriate guidelines re adoption of specific navigation technologies and attempt to harmonize with other economies in parallel.

Shipowners being cautious in adopting new technology. Maritime Admins and IMO recognizing future problems and attempting to delay with them.

Other industry groups working hard to develop and encourage adoption of standards (NMEA, RTCM)

IMO: the Regulatory will is there, but the need to satisfy or at least consider all international positions means that procedures take a long time. ADMINS: IMO members incorporate Convention provisions in their own legislation - this all takes time.

The importance of not allowing market forces to dictate operational requirements and procedures.

If we wish ships to embrace new technology or encourage the use of technology without mandatory carriage, tie it to the pocket book, say by virtue of lower insurance rates if that equipment is carried or a discount on port fees or the like. The equipment however, should only be internationally type approved. Again, more support for international standards development and cooperation.

7. Reliance on sub-standard equipment -> doubtful data, etc.

IMO attempting to write standards for equipment. National Maritime Administrations follow IMO lead.

NEEDS: More effective international cooperation, resource sharing. More interest in regulation, and standards development.

Training and information necessary to help eliminate this problem, i.e. identify the risks in such equipment.

IMO setting standards, Maritime admins enforce standards, Reputable manufacturers recognize liability issue and attempt to live by standard

Regulatory or authoritative agencies adopting regulations or interim regulations to restrict or discourage the use of substandard equipment.

as per "lack of standards" section

This is primarily a Training issue but must consider that many systems are in operation today. Gov'ts in the 1990's will be reluctant to issue regulations in areas where the public feels they are unwarranted (e.g. systems for pleasure craft).

IMO: Currently looking at the development of Standards /guidelines for non-ECDIS equipment. Circulars issued warning of the dangers of the use of non-official data - particularly with precise positioning systems. Admins: Canada has issued Ship Safety Bulletin on above.

8. Increase in traffic in commercial marine system (->congestion)

Countries tightening up VTS (?)

NEEDS: Better, more efficient VTS. Better information availability. Still needs radar (good point brought up at CHS conference recently- "who will provide the objective third party viewpoint in a court case?")

Civil Maritime Admins working with marine industry to identify appropriate systems to deal with issues of safety and efficiency.

Some large ports e.g. Singapore, Rotterdam use GPS to speed up harbour movement.

Action needed to identify congested passageways and ports and seek cooperation in installing new infrastructure.

needs to be done: In order to minimize high density traffic (congestion points) passage plans must be submitted to improve traffic lane utilization and promote the objectives of JIT shipping

The need for over all port management ,i.e. prioritize movement of depth draught vessels, vessels with hazardous and dangerous cargoes etc.

9. VTS management system - no longer 1 way flow -> multifunctional IS

Maritime Admins working with industry to develop an acceptable system

The CCG and the marine industry are debating the new era of VTS provisions. Many marine operators feel that they want to be independent of VTS. This desire if executed could indeed precipitate the type of problems identified by this topic.

Because of the new paradigm in this area it is essential that both government and industry find a mechanism for true co-operation and abandon the current somewhat confrontational approaches. Progress is being made in this area through the mechanism of the Marine Advisory Council. This body assists the CCG in setting priorities w.r.t. the introduction of new technologies in the VTS field.

2. The European marine community is undertaking a major development and technology program called POSEIDON which is directed at integrating VTS system across several nations. Under this program many European nations will develop and assess various VTS technologies (e.g. AIS) and develop integration standards. AS well they will assess the interoperablity of diverse and national VTSs systems. The project scope is 6.7M ECUs.

IMO: Considering AIS systems with complementary information capabilities.

10. Different cultures/risk capacities in APEC countries(for pleasure craft)

The current study for APEC on safety implications of new technologies is aimed at some collective action to reduce risks and overcome cultural and economic differences. Difficulties will continue due to major gaps in economic capacity to provide infrastructure and enforce regulations.

Assistance, financial and technical, from developed nations is needed.

Countries are attempting to provide adequate standardized training for mariners. Co-operation occurring in management of traffic in international waterways. One language being put forth for VTS. Silent VTS concept may resolve issue.

educate as to differences and regulate where life, property, or the environment is at risk

Countries obtaining international funds to help where necessary

needs to be done: mount an awareness campaign so that any mariners plying these waters for the first time (or rarely) are abreast of the situation. increased vigilance and situational awareness required. (reminder of some sort when specific waypoint is traversed)

Appendix G

APEC Action

1. Lack of training capacity (ability to respond) & training of mariner

1. The required curriculum for Mariner's certification be expanded to include training in satellite navigation and ECDIS equipment.

2. For mariners currently holding papers, require certification from an approved training course for proper operation of satellite navigation equipment and ECDIS equipment.

3. Recreational boating organizations such as Power Boat Squadron, be encouraged to offer training on the proper operation of satellite navigation and ECS equipment.

What role should APEC play?
==========
1. follow pattern that Canada is taking the lead in
2. Offer Canadian services
3. Understand what is in STCW
4. Encourage training in SE Asia wrt to int'l standards

2. Lack of standards: eqpt positioning, technical, INS

1. Maritime administrations in APEC economies should strenuously enforce the use of type-approved equipment on ships.

2. Apec economies should work towards the establishment of a standardized VTS/AIS system.

3. Identify gaps in the standards and the appropriate bodies to pursue the development.

What role should APEC play?
==========
1. develop standards on training side
2. training equipment (e.g. part task simulators, gmpss)

3. Infrastructure demands (not in place/needs improvement/management)

1. Administrations should develop logical, rational, and long-range infrastructure plans for satellite navigation systems, (e.g. ECDIS,DGPS).

2. Hydrographic Offices should be encouraged to provide digital chart data to IHO standards for their waters, either individually or on a regional basis.

3. Arrangements need to be put in place between H.O.'s and Administrations for the updating/correction of electronic charts, Notices to Mariners etc.

What role should APEC play?
==========

a. should utilize existing models

4. Lack of chart availability and accuracy

1. Examine suitability of all paper charts for conversion to ENC. Resurvey areas if necessary to WGS 84. Develop ENCupdating mechanism.

2. ENCs digitized for high traffic areas.

3. Superscale/Overscale charts: Docks and Loading facilities.

What role should APEC play?
==========

1) Endorse international standards. Encourage increased resourcing of hydrographic offices for the express purpose of resurvey/preparation for paper chart conversion to ENC.

2) Advocate the use of services and training from Canadian companies involved in this work.

5. Economic forces on Mariner (efficiency, stress)

1. Both the mariner and the government (service provider) face economic pressures. The mariner needs to make its operations more economical; the government needs to provide high quality services at reduced cost. At the same time the infrastructure required to meet both parties' operational goals and requirements are nearly identical. It is therefore recommended that both the marine industry and government put aside their traditional controversies and work together in complete cooperation to develop cost effective infrastructures.

2. Government and industry shall regularly carry out technology assessment.

3. Government, manufacturing industry and marine industry shall form an a consultative body that provides a forum for exchanging needs and solutions.

What role should APEC play?
==========

1. Review the principles and see to what degree they can be established within own country

2. develop level of cooperation (similar to European nations) wrt economic transfer of goods and services via marine mode.

6. lack of regulations -> keeping up with technology

1. The international standard setting bodies (IMO, IALA, ITU-R) must be encouraged to review their standard setting processes with the view to significantly shorten the time required for introducing new technical and operational standards.

2. National standards setting bodies (NMEA, RTCM, etc.) shall work together on an international level to harmonize the preparation of international, open system standards.

7. reliance on sub-standard equipment -> doubtful data, etc.

1. APEC economies should encourage/promote the use of type-approved equipment on SOLAS and non-SOLAS vessels.

2. Marine operators using non-standard navigation equipment should be encouraged to have redundant or hot standby equipment.

8. Increase in traffic in commercial marine system (->congestion)

1. The need to prioritize movement of vessel constrained by draft; vessels that pose risk to public safety and the environment. Done in a timely fashion.

2. Administrations need to work closely with industry in developing systems.

9. VTS management system - no longer 1 way flow -> multifunctional IS

1. Conduct pilot/feasibility trials of AIS towards development of an international standard.

2. Internationally integrated VTS system.

3. Regulatory amendments for mandatory carriage.

What role should APEC play???
==========

1) Confirm support of international organizations, and encourage continued international cooperation in standards development,

2) Support the development of international VTScooperation and database development and sharing.

10. Different cultures/risk capacities in APEC countries(for pleasure craft)

1. Identify specific problems created by introducing new technologies to APEC nations.

2. Once clearly identified, undertake to educate as to differences and regulate where life, property or the environment is at risk.

Appendix H

Changes in Operating Conditions

1. Complexity of on-board equipment.
2. Increased complexity of avionics.
3. Controller experience/familiarity with the new technology.
4. Potential for database errors.
5. Unprecedented changes in available navigation technology.
6. Data link onboard.
7. Accurate positioning can lead to collision rather than near misses.
8. Introduction of new terminology.
9. Routine maintenance of equipment infrastructure.
10. Improper integration of SatNav with other avionics.
11. Marketplace adopting technology in advance of standards.
12. Ensure that WGS-84 Surveys are conducted throughout the APEC area.
13. System consists of both ground and air e.g. ATC levels of automation.
14. Automated position reporting vs. voice reports.
15. Lack of appropriate training.
16. Backup navigation to GPS.
17. Improper use of non-standard avionics.
18. Human limitations.
19. Cultural issues - internal as well as external.
20. Regional Augmentation System.
21. Data link interference from uncontrolled sources.
22. Interference with GNSS signals.
23. Maintaining software integrity.
24. Failure to anticipate implementation problems due to rapid implementation.
25. Ensure that new systems meet performance standards.
26. Human factor considerations in display interpretation.
27. Standards for communications performance.
28. Operational requirements must be defined by region & state.
29. Interaction of unequipped aircraft in the system.
30. Mixed navigational capability of a/c within same airspace.
31. CNS/ATM terminal-fit risks.
32. Configuration control of software and databases.
33. Competing requirements from communications service providers.
34. Variety of avionics and software releases.
35. GPS is too good.
36. Reductions in Traffic Separation standards.
37. General aviation vs. commercial equipment compatibility.
38. Data base integrity issues are a significant potential problem.
39. Traffic segregation.
40. Methods needed to track software revisions.
41. Conflict Prediction and Probe Requirements.

42. The application of risk methodology or lack of same by some States.
43. Solar flares.
44. Competition vs. quality assurance.
45. Integration of new technology with existing infrastructure.

Appendix I

Areas to be Addressed

1. Training deficiencies and lack of training tools

- Training programs have to be in place for all components of these new systems.
- Lack of training tools.
- Need for appropriate training and equipment maintenance.
- Could lead to inappropriate use of nav. data resulting in potential for aircraft accidents.
- Lack of routine equipment maintenance could cause the system to be off-line or cause failures in CNS airspace .

2. Human limitations to adapt to new interfaces / Human factors

- Significantly increased data availability means increased risk of error.
- Lack of industry consensus on display and data entry formats.
- Increased complexity of avionics.
- GNSS receivers require more pilot interaction than traditional avionics, where selecting a frequency may be the only action required. Avionics manufacturers have to pay more attention to human factors in designing their avionics.
- Simplified use of on-board equipment for flight crew.
- Human factors relating to man-machine interface issues can cause increased flight operations workload resulting in potential errors and aircraft accidents.
- Overdependence on advanced technology.
- Human is removed from the loop, human skills become dulled in the manual (backup) mode. Applies to pilots, ATC, maintenance.

3. Potential for data base errors / Integrity of database

- The human input error factor.
- Database errors: GNSS ops depend on accurate data.
- Database integrity standards.
- New approaches required to develop database accuracy and integrity standards .
- Globalization of systems would require worldwide consensus on database issues in general.
- Database and ground survey integrity and accuracy.
- Errors in the database can lead to aircraft accidents.
- Errors in ground survey data can lead to navigational inaccuracies and potential aircraft accidents.

4. Air traffic management / Segregation of traffic

- Mixed equipage in same airspace.
- Adds to the complexity of managing airspace.
- Mixed navigational capability of A/C within the same airspace.
- Puts a heavy demand on the air traffic control system to provide separation standards for the different classes of navigational capabilities. This can result in lost efficiencies, particularly for the better equipped aircraft.
- Handling of unequipped aircraft.

- Lack of commonality in ATC Automation, including conflict detection.

- System Safety with respect to the separation of aircraft will be dependant on the ATC FDPS using software to assure separation minima acceptable in one system is based on same criteria in other adjacent systems.

5. Inflight Procedures / Reduced margins of error

- Closer physical proximity under conditions of system failure results in increased risk (e.g. two aircraft on the same track).

- Navigation accuracy – collision risk.

- Navigation accuracy when other separation (vertical– time) lost increases the risk of collision in some cases.

6. Standards and regulatory environment

- Technology advancing at a rate that is too rapid for regulatory environment to cope with and maintain total control.

- Improper use of system (non-standard avionics).

- Pilots are now using hand-held receivers to fly approaches, for example.

- On a global scale, these concerns around avionics may be different .

- Everyone is using hand-held receivers -> proliferation of non-standard receivers being installed on aircraft.

- Development of timely operational requirements and procedures.

- Users are implementing unapproved and untested navigation tools available in the market.

- Unregulated (i.e. without technical standards) competition could end up in a reduction in quality.
- Market place adopting technology in advance of standards.
- The system in future will have to contend with a multiplicity of equipment fit with differing capabilities.
- The greater multiplicity -> greater complexity .
- Ability to control interference sources sufficiently to reduce risk.
- Lack of worldwide agreement on standards and will to enforce.

7. Software integrity (e.g. many different revisions)

- Problems of maintaining same Revision level.
- Feedback of identified errors.
- Operator could have single box with many different revisions of software.

8. Universal standards implementation for CNS (e.g. world-wide planning)

- Different standards could result in a plethora of equipment, both avionics and the ground infrastructure. Certainly a potential safety factor and loss of system efficiencies.
- Arising from different countries:
  - ground installations in CNS/ATM that had different types of equipment could trigger inconsistencies.
  - difficulty in standardizing between MLS, INS, GNSS.
- Regional adaptation to Global planning for implementation.

9. Lack of complete CNS Standards for performance

- Issues:
  - need for technical standards
  - need for operational requirements for CNS

- Timely development of operational requirements/needs and development of technical requirements.

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Appendix J

Mitigation

1. Training deficiencies and lack of training tools

- Provide funding /venues to assist APEC Economies to train and exchange information on CNS/ATM systems.

- Provide Computer Aided information services (E.G. Internet) to all APEC States for the exchange of information and training.

- Establish appropriate training programs for all involved:
  - .....administration personnel,
  - .....controllers/system operators,
  - maintenance/equipment maintainers, and
  - pilots/flight crews.

- Establish long term system logistic programs, i.e. routine maintenance, configuration control, quality assurance, etc.

- Encourage ATC to view the transition from enroute to terminal approach with FMS arrivals as a Safety enhancement with increased vertical situational awareness on the part of flight-crews.

- State regulating authority must establish a process to certify both service providers and users for CNS/ATM usage. Such a process must require training for all user and provider persons with training programs at least submitted to the authority if not approved by that office.

2. Human limitations to adapt to new interfaces / Human factors

- Reinforce economies' support for their CNS/ATM Committees.

- Appropriate user training required

- This issue is closely related to the need for training and certification of both service provider and flight crew personnel.

- The provision of clear Operating Procedures for all operational personnel must be part of the certification process to be carried out by the regulating authority.

3. Potential for database errors / Integrity of database

- Encourage the world-wide sharing of database errors to be published monthly on a GPS/GNSS news info/internet or other medium for pilots, operators and States.

4. Airtraffic management / Segregation of traffic

- APEC should support the allocation of resources for the acquisition and harmonization of ATM Systems by States concerned to assure that the ground based infrastructure can safely support the acquisition and implementation of the CNS Avionics.

- System / equipment trials and demonstrations will help facilitate the implementation and acceptance of this new technology.

5. Inflight Procedures / Reduced margins of error

- Consult CALPA/IFALPA for GNSS embedded default route offset information (Sioux Lookout accident)

6. Standards and regulatory environment

- Develop an INTERNET home page or news group for sharing standards, workgroup minutes, newsletters etc.

- Closer cooperation and coordination of states requirements relative to communication frequency spectrum management issues.

- Method to enforce the implementation of these accepted global standards through accepted international procedures i.e. flight checking, equipment certification programs, etc.

7. Software Integrity (e.g. many different revisions)

- Support the RTCA and ICAO development work .
- Also maybe include EUROCAE ???
- Why no APEC equivalent of RTCA or EUROCAE?
- Little incentives for others to develop own avionics standards – probably not necessary.

8. Universal standards implementation for CNS (e.g.. world wide planning)

- Utilize ICAO assistance.
- Involve the end users in the development process e.g.: IFALPA & IFATCA, IATA, and others. (comment made by one member)
- Include other international associations/labour groups.

9. IN GENERAL: What needs to be done?

- Provide the information needed by CAAs to regulate this new technology properly.
- Funding for WGS-84 Surveys within the APEC Economies.
- Adopt internationally accepted standards in the following areas: augmentation systems; procedure design; survey and database integrity; avionics standards and installation guidelines.
- Endorse the implementation of consensus standards utilizing satellite communication, navigation and surveillance to enhance aviation safety, training, and efficiency.
- Individual States develop pilot training and certification standards adapted to the new technology.

- Individual States develop programs to complete surveys, develop procedures, complete flight inspections and approve avionics installations in accordance with international standards.

- Field augmentation system components to meet regional and State operational requirements.

- Reinforce Economies Support for their CNS/ATM Committees.

- Provide education assistance to state and local CAA's to acquire GPS/GLONASS (GNSS) knowledge and experience, to implement CNS/ATM and to regulate.

- APEC must be aware of work being done by other bodies in the area, in order not to duplicate efforts now being expended or planned. Only when this information is known can the Group make a meaningful contribution through active support of commitments made by States in the Region.

- Support should be provided to enable States in the area to fully participate in the International Groups tasked with planning, and facilitate the implementation process within sovereign airspace and as well International airspace for which States have been allocated the responsibility for the provision of Air Traffic Services.

- Nothing has been mentioned with respect to cost. Some of these countries can afford the implementation of this technology while others need assistance - this will have a major impact on how the CNS/ATM concept is rolled out.

- Stop wasting energy pursuing the idea of a seamless aeronautical/marine bi-modal GNSS environment - the individual requirements and implementations are totally different and therefore incompatible.

- ICAO and IMO exchange information quite regularly.

- Plan & do CNS/ATM training.

- Support trials & demonstrations.

- Promote co-operation arrangements to facilitate SARPS implementation.
- Support ICAO and relevant Intl Org activities, in particular FREQUENCY ALLOCATIONS including satellite-related frequency issues.
- Provide computer aided information services (Internet) to all APEC States.
- Provide Information Exchange Opportunities including CNS/ATM Seminars, Workshops and courses.
- Ensure that resources are available to planning and implementation efforts.
- Promote harmonization of Regional Airspace System and Rout Structure.
- A representative group to be formed mirroring FAA, JAA (a regional grouping).

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Appendix K

APEC Action

1. Training deficiencies and lack of training tools

- Appropriate training programs must be in place for all involved (State would oversee / establish a process for certification; need to have the experts establish the programs not the state).
- Need for information exchange between CAAs.
- APEC should be made aware of need to train CAAs and encouraged to do it.

2. Human limitations to adapt to new interfaces / Human factors

- Support in development of common interface standards.
- Clearly stated operating procedures required.

3. Potential for data base errors / Integrity of database

- One problem is the inconsistency/incompatibility between software.
- To enhance database integrity, manufacturers need to share information on errors etc.
- Standard for database process currently being developed.
- Communication of an error that has been detected. Need to have a feed to CAA in the state where the error occurred (using internet, perhaps).

4. Airtraffic management / Segregation of traffic

- Fundamental shortfall: lack of an infrastructure in APEC region.
- Must have a harmonization of systems in APEC region.
- Offer benefits to users such as more efficient routes.

5. Inflight Procedures / Reduced margins of error

- Route offset issue: may need further study on exactly how the problem is defined.

- Need to identify inflight procedures by approved company operating procedures, e.g.. there would be an approved company manual to handle inflight problems.

6. Standards and regulatory environment

- TC has put their information on their own Web page. Perhaps ICAO can have on their home page some references to related sites. Need to encourage States that have expertise in the relevant area to get their info on the Web site (tied to ICAO web site).

- Problem: notification of a state's non-compliance to any particular standard; maybe on ICAO home page

7. Software Integrity (e.g.. many different revisions)

- Support the RTCA and ICAO development work.

8. Universal standards implementation for CNS (e.g.. world wide planning)

- APEC should support development of international standards through these agencies.

9. IN GENERAL: What needs to be done?

- Five areas that APEC can help:
  - Training (planning, promoting seminars etc.)
  - Trials and demonstrations
  - Cooperative arrangements (to resolve conflict, funding mechanisms, to facilitate ICAO SARPS implementation, costing issues, to facilitate ATM in region etc.)
  - Support ICAO activities and other international organizations
  - Funding for WGS84 .

- APEC might assist/intervene at the political level to encourage regional adoption of CNS/ATM technology and support their CNS/ATM implementation committees.

- CNS/ATM global planning and regional implementation benefits to be gained by incremental implementation.

- Info exchange and supporting communications systems across APEC states could be improved (Informatics, Internet, computers, fax etc.).

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Appendix L

Reflection

1. Initial FEELINGS, INTUITION, EMOTIONS for the Program...

- This would have been a very worthwhile process to go through if we were not aware of the responsibilities of ICAO. As a result we did not need to go through risk and hazard identification and system deficiencies. Once we got around that in my view the possibilities for APEC to assist ICAO to overcome safety issues has now been well catalogued but could probably have been expanded with some additional time.

- Aviation is built on a base of safety oriented designs and therefore all the recognisable risk areas are being addressed.

- APEC needs to monitor and participate in the existing international bodies concerned with CNS/ATM implementation.

- Believe there are cultural issues that have not been suitably addressed.

2. Other SUGGESTIONS, IDEAS, POSSIBILITIES you have...

- APEC could support initiatives leading at the establishment, in the region, of Regional Aeronautical Corporation to facilitate the co-operative effort of the Region in the provision of SAFE, EFFICIENT and COST-BENEFICIAL aeronautical services.

3. CONCERNS, PROBLEMS, RISKS, DANGERS and DIFFICULTIES...

- Actual impact/influence of this initiative is hard to grasp knowing the political/cultural issues that may effect its acceptance.

- How can APEC determine when and where to introduce ground or provider infrastructure? Must the users show that they have met airborne equipage before the service provider commits to fund CNS/ATM or incremental portions thereof?

- This will only be of use if the APEC States have the political will to create the funding mechanism needed.

- Concern that an additional layer of bureaucracy is added in order to coordinate a non-issue.

4. BENEFITS? GOOD POINTS of the Program...

- Provided report addresses issue of non-compatible aeronautical/marine requirements, the issues raised should be of benefit to the APEC countries in clarifying and prioritizing the safe implementation of CNS/ATM.

Appendix M

Glossary

ADS	Automatic Dependent Surveillance
AIS	Automatic Identification System
APANPIRG	Asia/Pacific Air Navigation Planning and Implementation Regional Group
APEC	Asia Pacific Economic Cooperation
ATC	Air Traffic Control
BRM	Bridge Resource Management
CAA	Civil Aviation Authority
CALPA	Canadian Air Line Pilots Association
CCG	Canadian Coast Guard
CHS	Canadian Hydrographic Service
CMA	Civil Marine Authority
CNS/ATM	Communications, Navigation, Surveillance/Air traffic Management
CSA	Canadian Standards Association
DGPS	Differential Global Positioning System
ECDIS	Electronic Chart Display Information System
ECS	Electronic Chart System
ECU	Equivalent Container Units
ELT	Emergency Locator Transmitter
EMI	Electromagnetic Interference
ENC	Electronic Navigational Chart
EPIRB	Emergency Position Indicating Radio Beacon
FAA	Federal Aviation Administration
FANS	Future Air Navigation Systems
FDPS	Flight Data Processing Systems
GDSS	Group Decision Support System
GLONASS	Global Navigation Satellite System (Russian Federation)
GMDSS	Global Marine Distress Safety System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HO	Hydrographic Office
IALA	International Association of Lighthouse Authorities
IATA	International Air Transport Association
IBS	Integrated Bridge System
ICAO	International Civil Aviation Organization
IEC	International Electromechanical Commission
IFALPA	International Federaltion of Airline Pilots Association
IFATCA	International Federation of Air Traffic Controllers' Association
IHO	International Hydrographic Organization
IMO	International Maritime Organization
INMARSAT	International Maritime Satellite Organization
INS	Inertial Navigation System

ISIT	Integrated Ship Information Terminal
ITU	International Telecommunications Union
JIT	Just-In-Time
LAAS	Local Area Augmentation System
LORAN-C	Long Range Navigation - C
MLS	
MTSAT	Multi-Functional Transport Satellite
NDI	Nautical Data International
NMEA	National Marine Electronics Association
NOTAM	Notice to Airmen
PC	Personal Computer
PLB	Personal Locating Beacon
POSEIDON	European initiative to integrate VTS across several nations
RTCA	Requirements and Technical Concepts for Aviation
RTCM	Radio Technical Commission for Maritime Services
SARPS	Standards and Recommended Practices
SNW	Safe Navigation and Watchkeeping
TWG	Transportation Working Group
VTS	Vessel Traffic Services
WAAS	Wide Area Augmentation System
WGS	World Geodetic System