HYBRIDGE

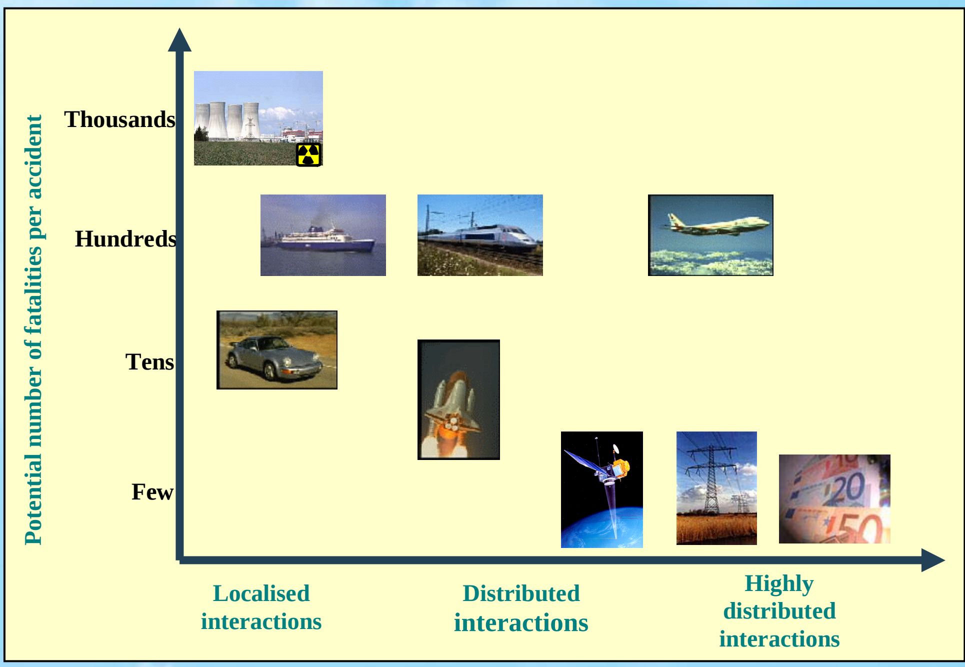
Distributed Control and Stochastic Analysis of Hybrid Systems Supporting Safety Critical Real-Time Systems Design

Project funded in 2002-2005 by the European Commission IST (Information Society Technologies).

The 21st century finds Europe facing a number of remarkable changes, many of which involve safety critical complex operations that have to deal with uncertainty, and air traffic is one of them. The management and control of these operations are undergoing a natural trend of becoming more and more distributed, while at the same time their safety criticality for human society tends to increase. Nonetheless, it is human beings who continue to bear the responsibility for safety, and hence they need ways to manage the uncertainties in a predictably safe way.

Within the European Commission project HYBRIDGE, some 50 system theorists and mathematicians from 6 universities (Cambridge, Twente, L'Aquila, NTU Athens, Brescia, Patras and Milan) and from 3 research institutes (NLR, INRIA and CENA) have studied the development of innovative approaches to handling uncertainty in complex safety critical operations. These theorists have brought together state of the art mathematical and computer science approaches to handling uncertainty in automation, finance, robotics and transport. In collaboration with experts from AEA Technology, BAE Systems, and Eurocontrol Experimental Centre, these approaches have been elaborated for air traffic. The very reason for selecting air traffic is the interactions between the many main agents (humans and systems) are so highly distributed in comparison with other safety critical operations.

HYBRIDGE selected Air Traffic management as application



http://www.nlr.nl/public/hosted-sites/hybridge/

In mathematical terms the innovative approaches to handling uncertainty are based on esoteric but powerful studies of stochastic hybrid systems, where ‘hybrid’ refers to the integration of computer science and control theory. The resulting study reports and papers are available on the HYBRIDGE web site. Because of these powerful underlying concept studies, the basic results obtained add significantly to what is known in safety critical industries. And for air traffic in particular, these results have been elaborated into the following innovative approaches:

- **Managing the combinatorial nature of non-nominal safety critical conditions**. The application of mathematics towards handling combinatorial situations is well known. The key novelty however is the recognition that the larger part of the combinatorial safety critical conditions have to do with Situation Awareness (SA) differences between multiple agents (humans and systems), and the systematic modelling and evaluation of the resulting SA and SA error propagation. This innovative approach is illustrated for two well known safety issues in air traffic: i) Runway incursions, and ii) Level busts.
- **Accident Risk Assessment of air traffic designs by Monte Carlo simulation**. The key behind this development is an innovative way in modelling non-nominal events and responses by pilots, controllers and systems, which connects the resulting simulation code unambiguously to a stochastic and discrete event mathematical model. This connection allows using mathematically powerful tools to speed up Monte Carlo simulations by several orders of magnitude. Such a large speed up factor makes it possible to estimate the probability of a collision between aircraft through Monte Carlo simulations. The effectiveness of this innovative approach is demonstrated for an Airborne Separation Assistance System based en-route operation.
- **Monte Carlo simulation based optimisation of air traffic management**. The optimisation problems that arise in air traffic management are formidable. They involve multiple and complementary objectives in terms of safety, economy and environment, whereas there are major sources of uncertainty such as weather and traffic demand. Recent advances in randomized optimization methods provide an innovative approach in addressing such complex problems. Within the HYBRIDGE project, randomized optimization methods have been further developed and initially applied to collaborative decision support problems that arise in conflict resolution and flight scheduling.

HYBRIDGE partners:

Partner	Contact person	Telephone	Email
National Aerospace Laboratory NLR, NL	Henk Blom	+31 20 511 3544	blom@nlr.nl
University of Cambridge, UK	Jan Maciejowski	+44 1223 332 732	jmm@eng.cam.ac.uk
University of Patras, GR	John Lygeros	+30 2610 996458	lygeros@ee.upatras.gr
National TU Athens, GR	Kostas Kyriakopoulos	+30 10 772 3595	kkyria@central.ntua.gr
University of l'Aquila, IT	Maria Di Benedetto	+39 0862 434 402	dibenede@ing.univaq.it
Politecnico di Milano, IT	Maria Prandini	+39 02 2399 3441	prandini@elet.polimi.it
University of Twente, NL	Arunabha Bagchi	+31 534 89 34 06	a.bagchi@math.utwente.nl
University of Brescia, IT	Marco Campi	+39 030 3715 458	campi@ing.unibs.it
Eurocontrol, FR	Richard Irvine	+33 1 69 88 73 29	richard.irvine@eurocontrol.int
CENA, FR	Pascal Lezaud	+33 5 62 25 95 44	Pascal.Lezaud@cena.fr
AEA Technology, UK	Stephen Kinnersly	+44 1305 202039	steve.kinnersly@aeat.co.uk
INRIA, FR	François Le Gland	+33 2 998 47362	Francois.legland@irisa.fr
BAE Systems, UK	Ted Lewis	+44 1634 204 728	ted.lewis@baesystems.com

For more information on HYBRIDGE, see the web site at:

http://www.nlr.nl/public/hosted-sites/hybridge/

This Flyer is printed by NLR
21-04-2005 nr1