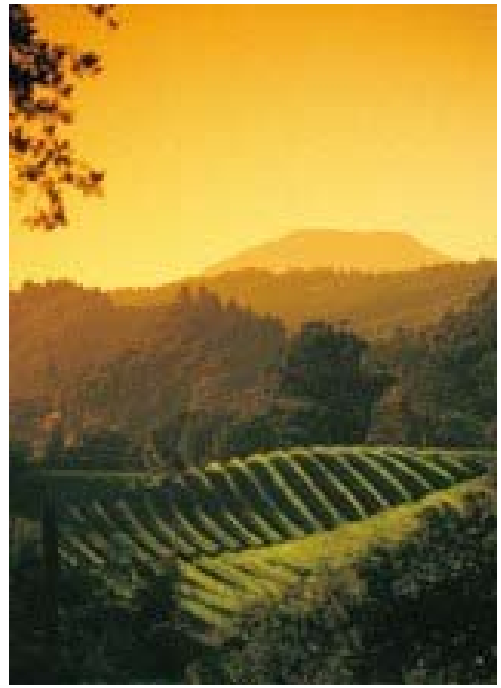
ATM Seminar 2009
Napa, California, USA
June - July 2009



TIMES IN ATM

Jean-Marc Garot

Francisco de Goya.
Saturn Devouring One of His Children. c. 1820-23.
Oil on canvas, Museo del Prado, Madrid, Spain

Les Très Riches Heures du Duc de Berry
The Book of Hours

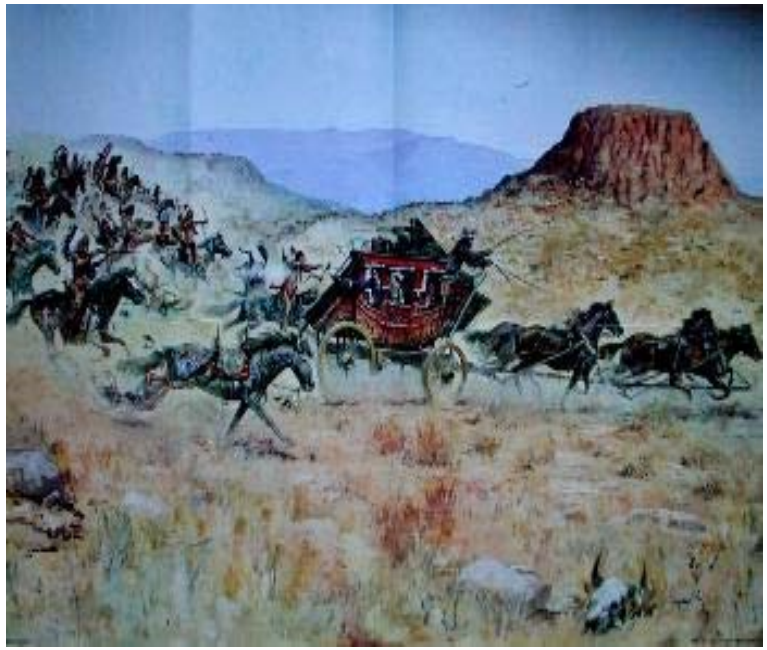
Synchronisation of time

TIMES
IN
PUBLIC TRANSPORTATION

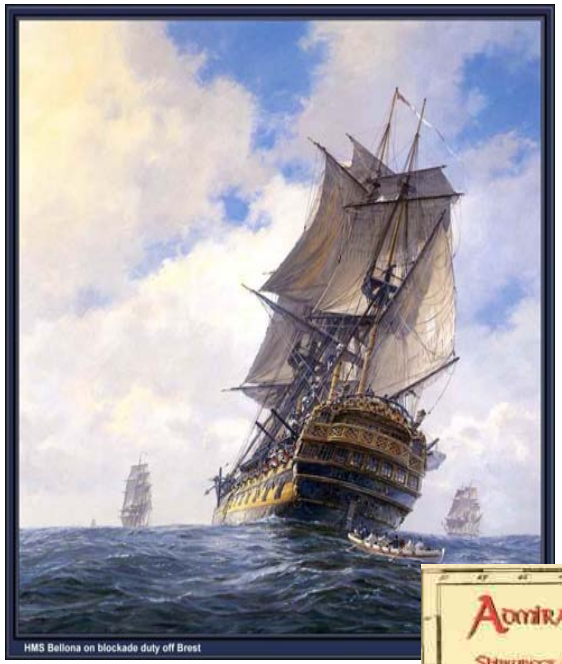
STAGECOACH

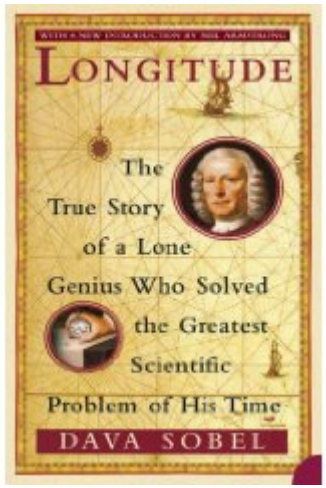
Timetable : the day of the week

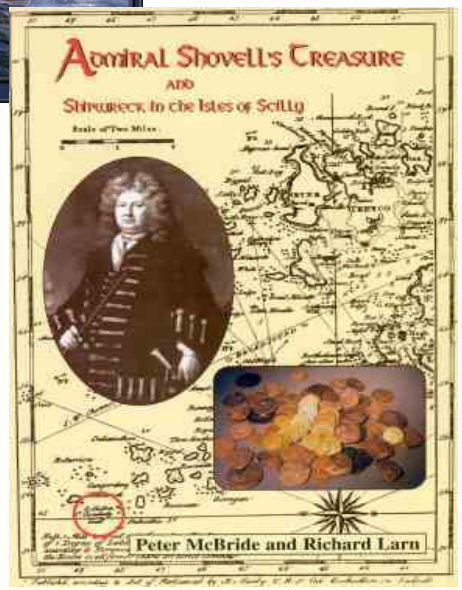
Security

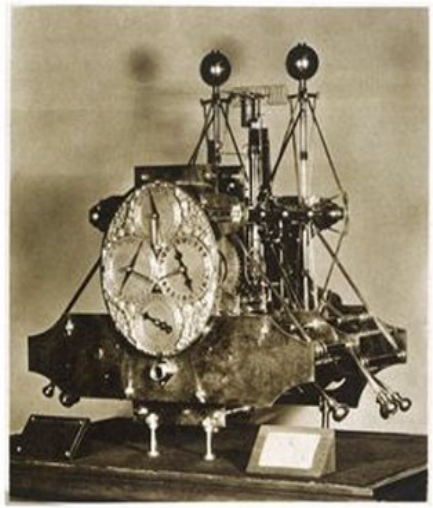


TIME & SAFETY

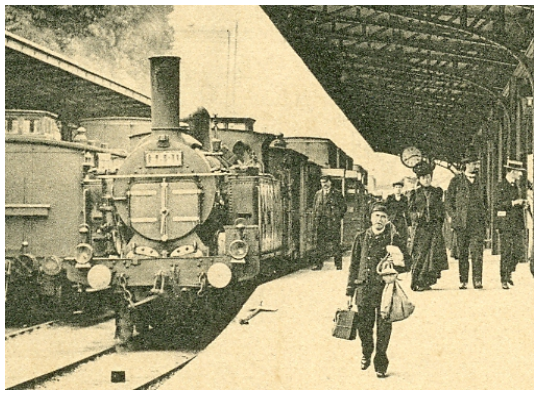

HMS Bellona on blockade duty off Brest


LONGITUDE
The True Story of a Lone Genius Who Solved the Greatest Scientific Problem of His Time
DAVA SOBEL


Admiral Shovell's Treasure
and
Shipwreck in the Isles of Scilly
Peter McBride and Richard Larn



Railways and clocks



Railway time

- name given to the standardised time arrangement first applied by the Great Western Railway in England in November 1840
- first recorded occasion when a number of different local times were synchronised and a single standard time applied: the ‘London Time’(widely known as Greenwich Mean Time)
- France & Ireland were the only countries which decided not to officially adopt Greenwich Time
- objectives:
  - to overcome the confusion caused by having non-uniform ’local times’
  - to reduce the incidence of accidents and near misses

Timetables in public transportation

Stage coach : the day

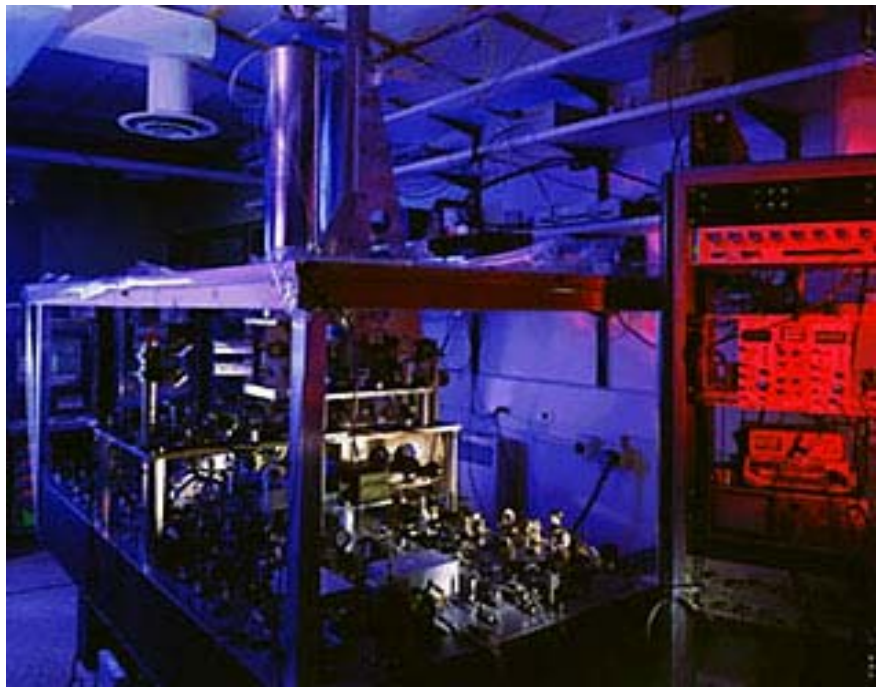
Boat : the day

Railways : the minute

ATOMIC CLOCK

Accuracy :10-9 seconds per day

Cesium Fountain NIST-F1



TIMES IN ATM

Number of DIFFERENT « TIME ITEMS » in ATM Seminar 2009 selected papers

	Network		Separation		Approach		Airports		Safety		Human Factors		Weather		Envmnt		Perf Mgmt		Finance		
	N°		N°		N°		N°		N°		N°		N°		N°		N°		N°		
	128	1	158	0	61	0	151	2	72	0	114	0	91	0	84	0	121	0	82	0	
	105	2	52	0	132	0	7	3	19	0	126	0	75	0	43	0	102	0	155	3	
	147	4	89	3	37	0	44	5	12	1	21	0	8	1	122	1	73	1	86	4	
	141	4	94	4	110	1	145	7	67	3	27	2	124	3	48	2	17	3			
	149	5	138	4	14	4	79	7	130	5	28	3	125	4			115	6			
	152	5	101	5	38	4	153	8					99	5							
	55	5	148	6	59	5	81	9													
	85	5	146	7	116	5	30	9													
	33	6	41	7	64	5															
	143	7			92	5															
	15	8			16	5															
	134	8																			
	97	10																			
TOTAL		70		36		34		50		9		5		13		3		10		7	237
nb papers	13		9		11		8		5		5		6		4		5		3		69
average		*5*		*4*		*3*		*6*		*2*		*1*		*2*		*1*		*2*		*2*	

135 « times items»

access time/actual arrival time of one flight./actual wheels off time/actual wheels on time at the arrival airport/aircraft dwell time/anticipation time/appointment time/arrival bank delay time/arrival time at the sector/available approval request release time/average departure queuing time/average flight time/average flight time delay/average travel time between two airports/block time/breakout time/capacity clearing time/capacity windfall time/CFMU time period acceptance/conflict free time horizon/conflict start time/controlled departure time/controlled time of arrival/controlled time of overfly/crossing time/current time-of-arrival/departure release time/departure time/departure time window/desired time of arrival/destination airport closure time/dwell time prediction/earliest runway access time/early clearance time/estimate of en route time/estimated departure clearance time/estimated remaining flying time/estimated time of arrival/estimated time over/estimated time over the IAF/excess time/expected approach time/expected departure clearance time/extra flying time/first loss of separation time/flight counts in a period of time/flight crews execution time/flying time/forecast time/future time/gate arrival time/gate out time/ground time required after flight/ground transportation time/inter-arrival time/kick off time/lead time/look ahead time/maturing time/minimum runway occupancy time/minimum time separation/minimum time track/on-time performance database/original destination closure time/pairing time window/passenger extra transportation time/peak time period/planned landing time/planned off block time/predicted sector crossing time/probabilistic clearing time/projected fix crossing time/push back time/queue output time/reaction time/ready to-go time for a departure/refueling time/required time of arrival /response time/runway occupancy time/runway threshold crossing time/scheduled arrival time/scheduled departure time/scheduled flight time/scheduled push back time from the gate/sector entry time/sector exit time/separation assurance time horizon/space-time constraints/spacing time/standard time for the landing and take-off cycle/start time/strategic off block time/stratus clearing time/take off time deviation/takeoff time/target start up time/target take off time/target time of arrival/task time/taxi out time/taxiing time/time available for ATCO intervention/time based control/time before initial loss of separation/time before touch down/time conformance requirements/time distribution of arrivals/time for loading baggage/time from anti-icing/time horizon/time interval/time of aircraft integration/time of arrival/time of closest approach/time slice/time slot/time step/time synchronization/time window/time-based metering/time-based-spacing/time-critical decision-making/time-to-conflict/time-to-go/time-to-turn back/timeout/total delay time/total performance time/transaction time/travel time/turn time/turnaround time/variable taxi time/velocity-distance-time calculations

???

Should we / could we come up with a reduced and standardized set of « times »?

Should we / could we synchronize them?
Or
Should we (only) predict/forecast ?

Which accuracy?

Some TIMES
&
Some ACTORS

Passenger

- What is the meaning of time of departure?
  - Closure of enplannement?
  - Register bank? Internet registering?
  - Security check
  - Transport time to the airport?
- Scale of passengers fear, experience, expectation, ...
- Time of arrival
  - Landing
  - Luggages
  - Passport check
  - Friends/ relatives/ etc meeting

Passenger : a blind game ?

Clocks in airport?

Airport departure

- « Notional times »
  - Official Airline Guide
  - Airlines schedule
  - Airport slot allocation
  - ATFM slot
  - Arrival of the aircraft
  - Turn around time (cleaning , etc)
  - Luggage loading
  - Refueling time
  - Catering time
  - De icing time
  - Time to take result of check list into account

CDM a bluff game ?

Is any of the actors actually bound by the

- Actual times one can measure
  - Push back
  - Take off

Application of Reinforcement Learning Algorithms for Predicting Taxi-out Times

Poornima Balakrishna, , Rajesh Ganesan, Lance Sherry

Year 2007 Date	Time Period of Day	Dec 4th	Dec 5th	Dec 6th	Dec 7th	Nov 29th	Dec 9th
		Low		Medium		High	
Prediction accuracy within ± 5 min (%) Average predicted TO- Average actual TO	Before 4:00 P.M	70.00	67.50	72.50	77.50	100.00	95.00
	After 4:00 P.M	20.69	41.38	62.07	58.62	55.17	55.17
	Across Whole Day	49.28	56.52	68.12	69.57	81.16	78.26

Figure 5. Prediction accuracy at JFK airport

Flight time

- Airlines
  - Schedule : punctuality ?
  - Operation :fuel consumption versus punctuality
  - Hub process
- Crew
  - Time equal money

A cheat game ?

ATM

In a fuzzy environment

The only actor who

- Cares for
- Pretends to impose
- Is supposed to manage
- etc...

Synchronization

- Global
  - ATFM
- Local
  - En route anti collision
  - Arrival management

Therefore it should demonstrate its feasibility

Regional GDP — Extending Ground Delay Programs to Regional Airport Systems

Yu Zhang Mark Hansen

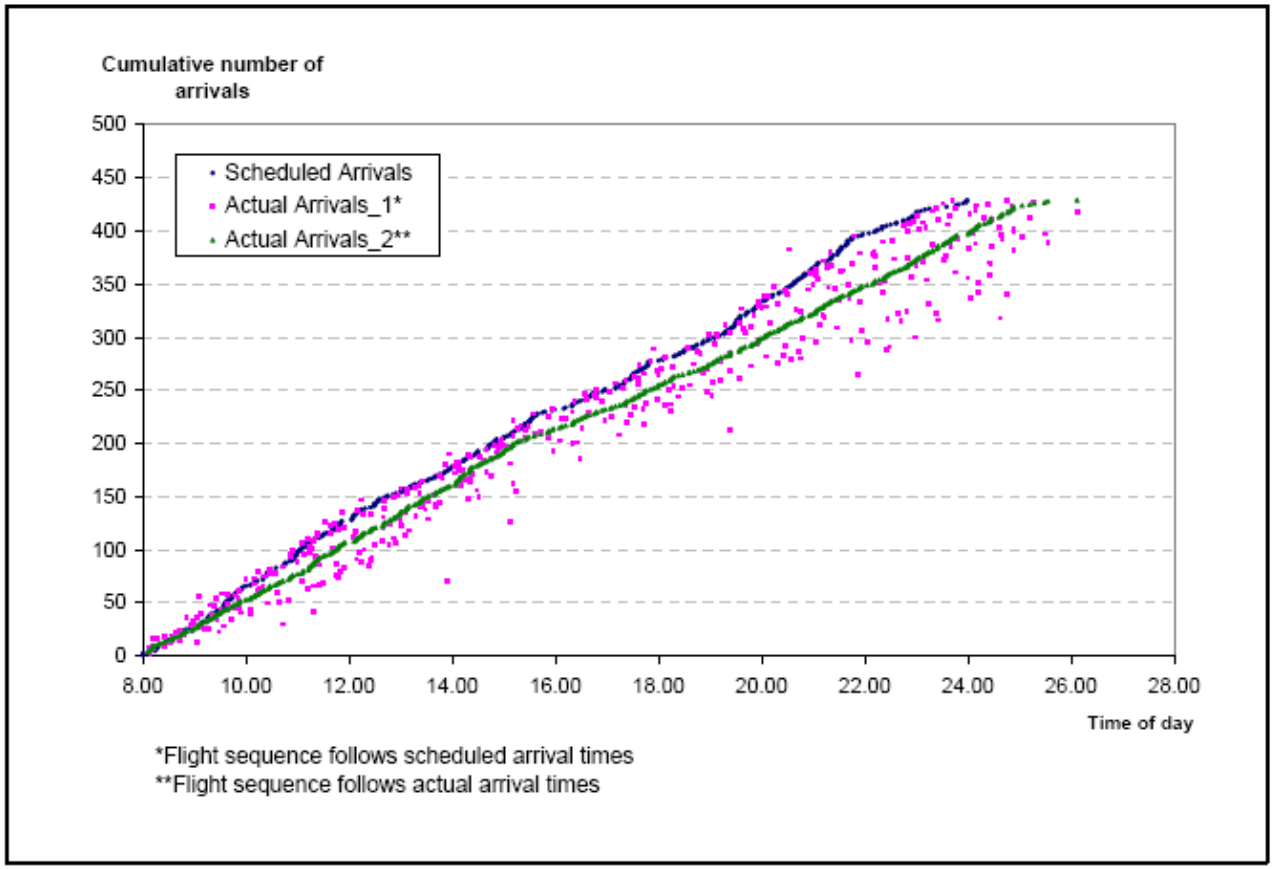


Figure 3 Cumulative Numbers of Arrivals at SFO

ATFM

Analysis of the accuracy of ATFM forecast

A study of over-deliveries made by the EEC on a sample of traffic over France in the last six months of 1999 showed that

- 43 % of differences in sectors counts were due to difference in routes (17 %)
- level slices (26 %)
- the remainder being attributable to cheaters and problems of adherence.

ATFM

Independent Study for the improvement of ATFM

The Performance Review Commission (PRC) presented a special Performance Review Report on delays to the Eurocontrol Provisional Council in November 1999, .

The report contained a number of recommendations including one proposing an independent study into optimizing the use of existing capacity.

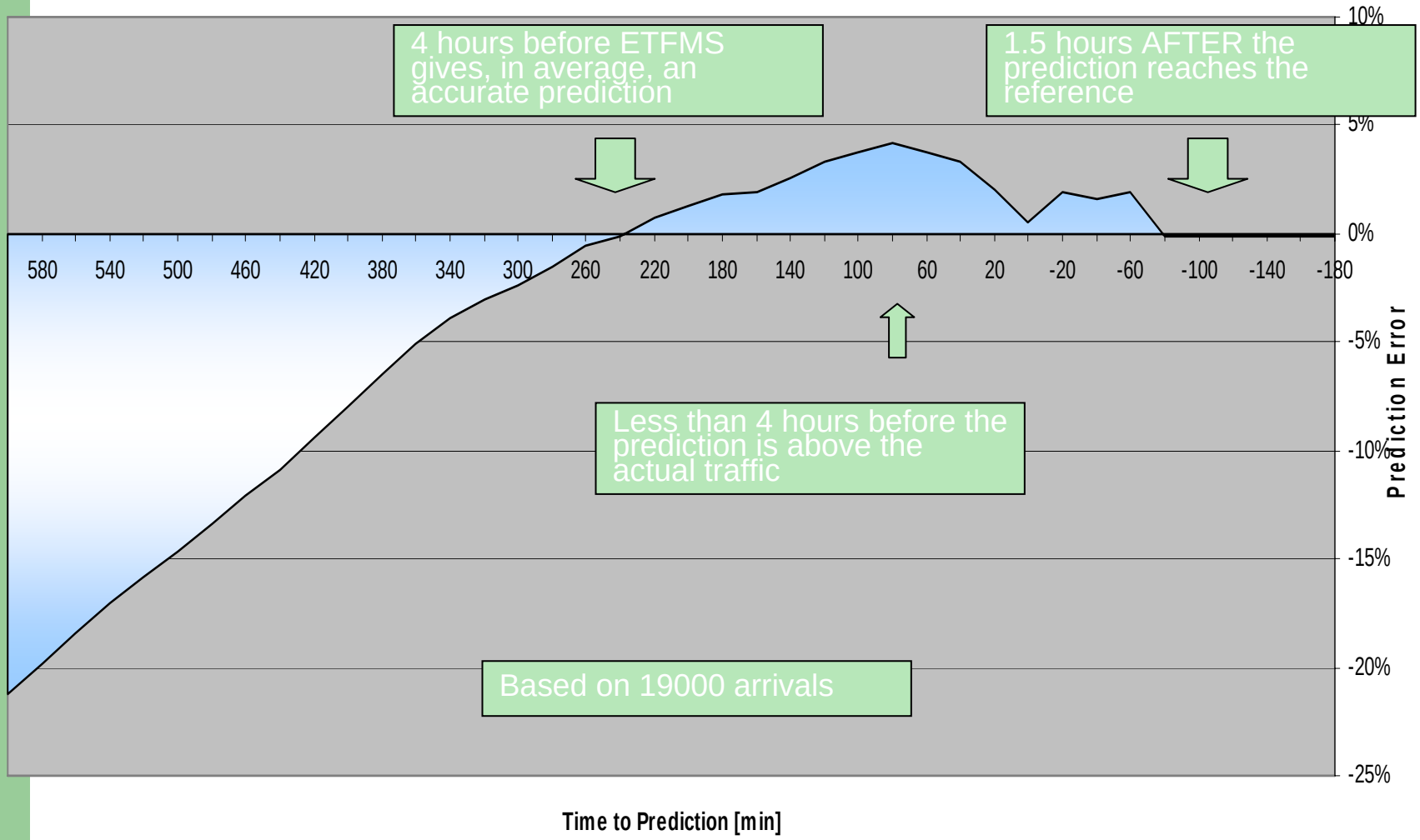
Consequently the Provisional Council requested the Director General of the Agency to commission an independent study into how to optimize the use of existing capacity, and to improve ATM strategy, processes and operation, in order to reduce delay

Chairman Philippe Jaquard

Secretary Patrick Ky

ETFMS

Arrivals Prediction error average evolution



En route anti collision

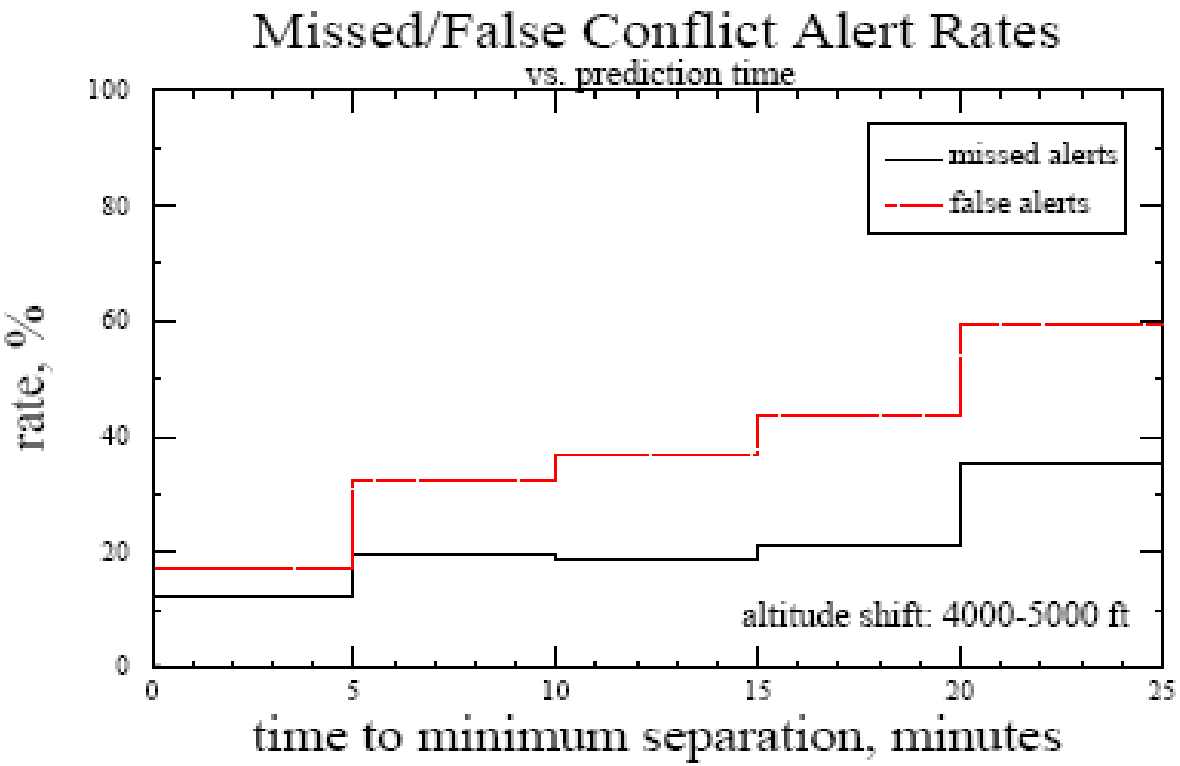
Empirical test of conflict probability estimation
Rusell Paielli NASA Ames 1998

The positions and velocities are currently based on radar tracking, and are provided, along with the flight plans, by the FAA at their ARTCC facilities. The wind predictions are provided by the Rapid Update Cycle (RUC) [10], a weather prediction system operated by the National Center for Environmental Prediction (NCEP) for the National Oceanic and Atmospheric Administration (NOAA). The algorithm to be presented in this paper requires predictions of position and velocity for pairs of aircraft at their point of minimum separation. Those predictions are provided by the CTAS Trajectory Synthesizer [8].

CTAS prediction data was collected on over 9500 aircraf

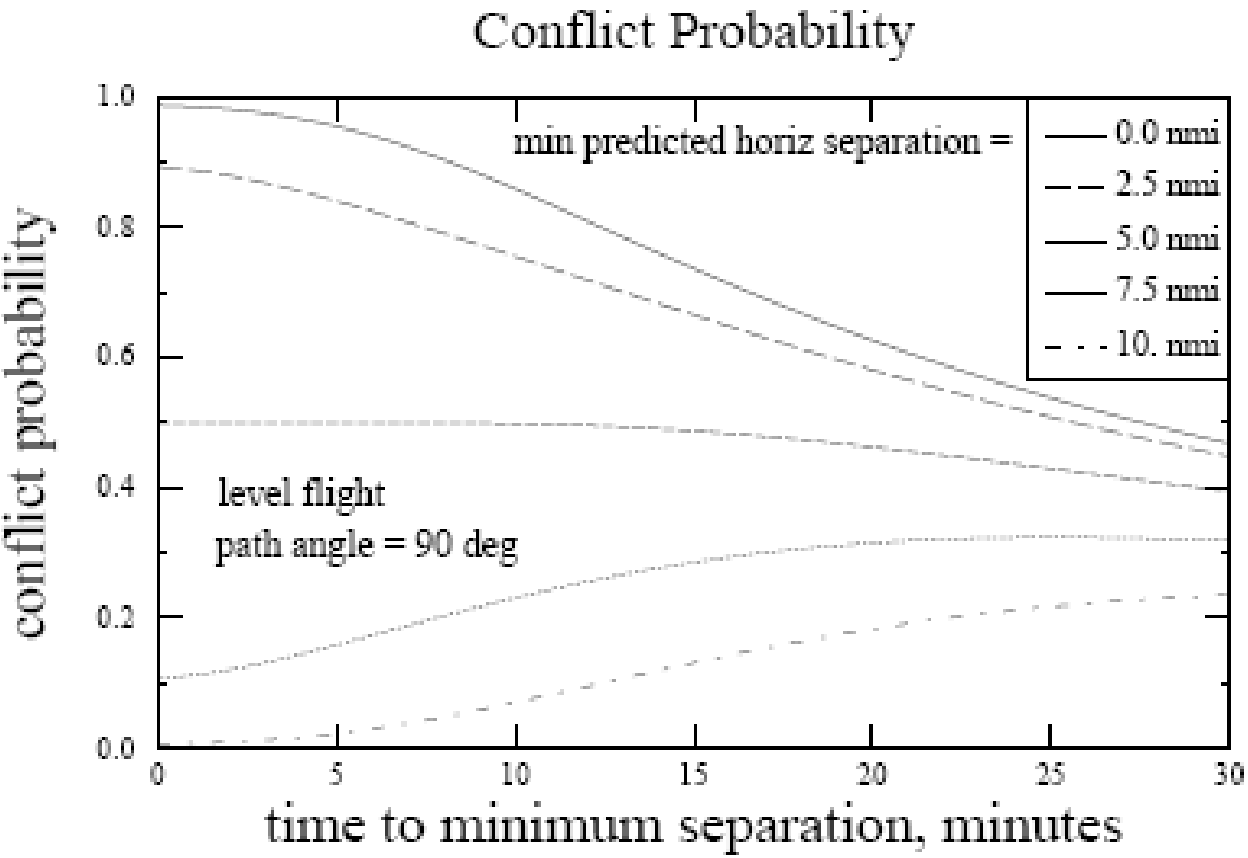
En route anti collision

Empirical test of conflict probability estimation
Rusell Paielli NASA Ames 1998



En route anti collision

conflict probability generalised to non-level flight
Rusell Paielli & Heinz Erzberger NASA Ames 1999



Controlled Time-of-Arrival Flight Trials

Joel K. Klooster & Ana Del Amo /Patrick Manzi

	CTA Accuracies				
	IAF	*Threshold (All)*	*Threshold (ETA)*	*Threshold (ETA+2)*	*Threshold (ETA-2)*
Rel. Mean	-0.4 sec	3.3 sec	7.6 sec	-6.6 sec	3.1 sec
Rel. σ	5.9 sec	17.3 sec	10.9 sec	19.7 sec	23.6 sec
Abs. Mean	4.0 sec	14.7 sec	10.9 sec	17.0 sec	19.4 sec
Abs. σ	3.9 sec	9.4 sec	7.1 sec	9.1 sec	11.4 sec

TABLE I. COMPARISON OF CTA ACCURACIES

32 flights

Time based versus relative arrival management

Time based

Paper N°/ Title/ Organization

- 14/ Time-Based Arrival Management for Dual Threshold/ DLR
- 16/ Impact of future time-based operations on situation awareness of air traffic controllers/ LVNL NLR
- 38/ Use of Linear Aircraft Intent Response for Tactical Trajectory Based Operations/ MITRE
- 64/ Controlled Time-of-Arrival Flight Trials/ LFV

Relative

Paper N°/ Title/ 0rganization

- 37/ fight desk based spacing and merging during en route descend/ MITRE
- 59/ Near-Term Terminal Area Automation for Arrival Coordination /MITRE
- 61/ Support Continuous Descent Arrival Operations/ MITRE
- 92/ Evaluation of an Airborne Spacing Concept to Support Continuous Descent Arrival Operations/ NASA
- 110/ Evaluation of Triple Closely Spaced Parallel Runway Procedures for Off-nominal Cases/ NASA
- 116/ Scheduling Aircraft Landings to Closely Spaced Parallel Runways/ University of California
- 132/ Analysis of Continuous Descent Benefits and Impacts During Daytime Operations/ MITRE

With

- Fast time simulations
- Real time simulations
- Very few flight trials

Do we demonstrate feasibility of
Global synchronization
Local synchronization
En route
Arrival
?

Forget
Concepts
Roadmaps

Be scientific

- **Models**
- **Large live data samples**

Contact

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